

INTEGRATED LANDSCAPE MANAGEMENT PLAN

FOR GREATER PANNA LANDSCAPE, MADHYA PRADESH AND UTTAR PRADESH

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Plan Period: Ten Years
2022/23 - 2032/33

भारतीय वन्यजीव संस्थान
Wildlife Institute of India

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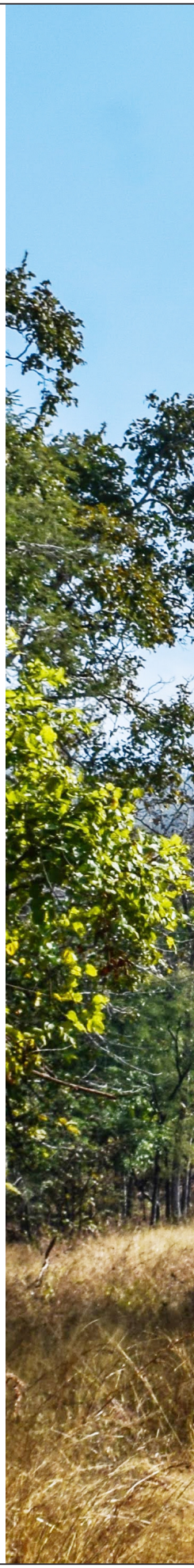
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Preface

Landscape is defined as the heterogenous visible features of geographic space, with its variable composition and configuration, often integrating natural and anthropogenic characteristics. Because of these diversities in terms of structure and interactions, landscape management approach is essentially viewed as an integration of different stakeholders present in the landscape to address biodiversity conservation, development, climate change, food security, and a host of other local, regional and global issues. It is particularly relevant to the field of conservation of biodiversity in human-dominant landscapes, especially when developmental projects directly impact on native biodiversity, and both are of public interest. India has the second largest human population and comes among the fastest growing economies in the world. Currently, India is passing through a critical phase in its developmental history with poverty alleviation and sustainable development. Ambitious developmental projects to improve rural livelihood are among the most sought-after measures, especially when it comes to the issue of poverty and water security. In this context, Ken-Betwa Link Project (KBLP), proposed by the Government of India, was conceived to meet the water demand for drinking and irrigation purpose in one of the India's most drought prone areas i.e., Bundelkhand.

Apart from its rich cultural history, Bundelkhand harbors diverse assemblage of biodiversity and conservation history which includes the remarkable conservation success story of tigers in Panna Tiger Reserve (PTR), Madhya Pradesh. Further, PTR is also a stronghold for the remaining populations of vultures in central India. However, the proposed KBLP will submerge a part of PTR and will cause habitat loss and fragmentation. A balanced strategy to such development projects would also require appropriate measures to reduce the negative impacts based on landscape approach. The tiger population in PTR has recovered rapidly and is also dispersing into the landscape, invoking a necessity for landscape level strategies to ensure long-term viability of the population. Therefore, to conserve tigers and other key biodiversity in a metapopulation framework a Greater Panna Landscape (GPL) (consisting of eight districts in Madhya Pradesh; three districts in Uttar Pradesh) has been envisioned. And for the management of GPL with focus on biodiversity conservation and people welfare, the present Integrated Landscape Management Plan (ILMP) has been drafted.

The ILMP specifically aims at (1) Providing better habitat, protection, and management for flagship species (tigers, vulture, and gharial), (2) Consolidating landscape for biodiversity conservation and human well-being including identification of new areas for wildlife conservation and providing livelihood options to forest dependent communities, and (3) Providing species-specific and site-specific monitoring protocols. Drafting of the plan was an exhaustive process, ensuring stakeholder involvement and scientific backstopping. Extensive field surveys were carried out following a robust study design and well-established methodology involving spatial and aspatial analyses. During the writing process, the emphasis was laid on representing details of both current situation and proposed recommendations, graphically wherever possible. Being the focal species, the strategic actions for tiger conservation were proposed both in PTR and in the landscape including suitable protection, population management and habitat consolidation strategies. For crocodilians with special focus on gharial,





suitable habitat management and population recovery strategies have been suggested. In case of vulture and overall biodiversity, prioritized areas have been identified in the landscape and suitable conservation measures have been suggested. Substantial effort was also given to explore and evaluate existing status and proposing possible suitable options to improve the livelihood of communities. Emphasis was also laid on human-wildlife interface issues like human-wildlife conflict and zoonotic diseases, introducing One-Health Concept for the area. This plan attempts to connect the dots between science-based applications and practical management interventions to come up with an adaptive management strategy, taking in view, current knowledge and possible future research outcomes. The very essence of the ILMP was to integrate and coordinate with different stakeholders (such as different line agencies, institutions and community representatives), and was attempted to engage in the best possible ways. This plan is expected to be a guiding document for conservation practitioners and decision makers to devise action plans involving multiple stakeholders in the GPL. Any technical and administrative gaps, if encountered, can be addressed during the implementation stage, as we have specified adaptive management as one of the key components to account for limitations and uncertainties. This may also offer potential learning opportunity to scale up in other parts of the country, where win-win situation can be aimed at when alternate options for development agenda is not possible or viable.

The plan preparation was not possible without the support and inputs of several people. We are grateful to each one of them and would especially like to place on record the unstinting support extended by National Water Development Agency, Madhya Pradesh Forest Department, National Tiger Conservation Authority, and Uttar Pradesh Forest Department. The plan process also benefited by significant inputs from various experts, resource persons, forest officers, district collectors, community representatives, project interns and field assistants. At the end, the support extended by all concerned at Wildlife Institute of India is much appreciated.

-Project Team
Wildlife Institute of India

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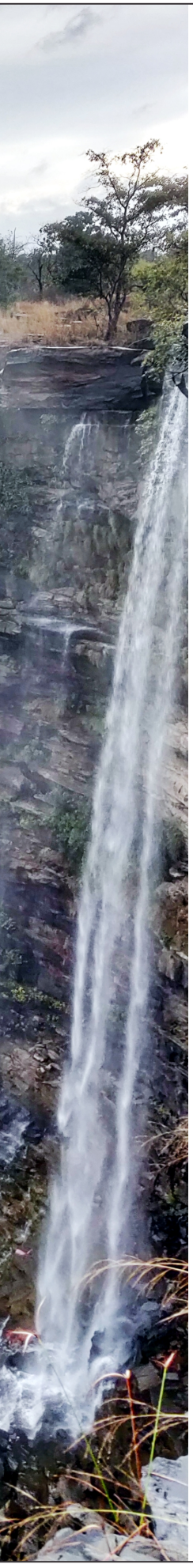


Dr. S.P. Yadav
Director
Wildlife Institute of India

The integrated landscape approach is aimed to bring diverse natural and man-made features of landscape as well as their functional attributes under one umbrella to facilitate better and effective management. India has highly varied biogeographic zones rich in biodiversity and a long history of wildlife conservation. India is also home to a myriad of people with their diverse socioeconomic and cultural attributes. Such that the developmental needs of people and conservation of biodiversity, are often at loggerheads. In this context, integrated landscape management approach plays a pivotal role to formulate a comprehensive plan involving multiple stakeholders in an integrated and coordinated manner, to fulfil its broader goal of achieving better and sustainable livelihood and biodiversity conservation.

Bundelkhand is a region of rich floral and faunal diversity along with high cultural value of global importance. Panna Tiger Reserve (PTR), situated over three districts of Bundelkhand, sets an outstanding example of reviving its tiger population and became critically acclaimed worldwide. However, this region also heavily suffers from perennial water stress, resulted in one of the most draught-prone areas in the country. In this view, the Ken-Betwa Link Project (KBLP) was envisaged as a means of poverty alleviation (through irrigation) and sufficient supply of drinking water in Bundelkhand. Apart from its much-anticipated noble purpose, the proposed KBLP would also cause irreversible damage to the critical tiger and vulture habitats of PTR, which goes much beyond its estimated submerged area in PTR. Hence to ensure the protection of tigers and other focal species (vulture and crocodilians) and overall biodiversity-rich areas, with mutual beneficial engagement of communities, this plan was envisioned and came into existence. The plan reflects the dire need of conserving biodiversity along with upliftment of local communities through engaging and coordinating with multiple sectors. Equipped with rigorous literature review and scientifically sound methodologies, this plan envisages conservation of tiger in a metapopulation framework and for the purpose of which, has identified important habitats that can serve as satellite cores and corridors. In a nutshell, this plan marks a significant step towards conservation of tigers and other biodiversity of great importance, while keeping in view the needs for sustainable development of vulnerable communities.







Mr. Bhopal Singh
Director General
National Water Development Agency

Water is recognized as one of the human rights and required for food security, health, and personal hygiene as well as agricultural purposes and energy production. Hence, adequate supply of water is a mandate to improve the rural livelihood and expanding economies. Bundelkhand region is characterized by rocky and barren lands interspersed with hillocks and possesses a relatively high percentage of uncultivable lands. Due to sparse rainfall and low surface water holding capacity, this region faces severe perennial water scarcity, which strongly impacts livelihood in the form of unemployment, poverty and deteriorated health.Therefore, there is a need for a project of a scale which will help in harnessing the flood water during monsoon period and stabilize the water availability in the region in lean period particularly during drought years. The Ken-Betwa Link Project (KBLP) envisages enormous benefits to the water starved Bundelkhand region by providing annual irrigation of 10.62 lakh ha, drinking water supply to a population of about 62 lakhs and other benefits.

For the conservation of flood water during monsoon period, a little portion of Panna Tiger Reserve (PTR) is getting impacted in this project. Various alternatives were explored to minimize the submergence in PTR. KBLP will cause submergence of about 4141 ha core area of PTR and another 1620 ha area in PTR buffer. The other component will impact another 65.50 ha of core area. This loss of core area of PTR is being compensated by providing equal non-forest land in the vicinity of PTR for compensatory afforestation. The loss of buffer area is also being compensated by double the degraded forest land in the vicinity.The water lake created under the project shall also form part of PTR thus increasing the overall area of PTR and it's carrying capacity. As per assessment made, about 43 % of the submerged area will be available as pasture land after November which would lead to significant increase in herbivorous population in PTR. The project shall improve the environmental flows during lean period.

The government is very serious for conserving the ecosystem of the region particularly the PTR. Apart from taking mitigation measures as per approved Environmental Management Plan (EMP), the Wildlife Institute of India (WII) has prepared a comprehensive Landscape Management Plan for the conservation of wildlife and biodiversity not only in the PTR area but also in surrounding area.The Integrated Landscape Management Plan (ILMP) in Greater Panna Landscape is one of the major and unique conservation measures being initiated in the conservation history of India.

An authority shall be created to implement the ILMP scientifically in a time bound manner. EMP and ILMP are very important components of KBLP, earmarking substantial cost of the project for these components. Thus, the project is aimed at not only providing water security in the Bundelkhand region, but also ensuring the overall conservation of the region and especially for landscape dependent species such as tiger, vultures and gharial. It may very well be a template for future development - ***Vikas bhi Paryavaran bhi.***



Mr. Jasbir Singh Chauhan
Chief Wildlife Warden
Madhya Pradesh

Madhya Pradesh has a long conservation history owing to its rich biodiversity and the extent of forest cover. The cultural and spiritual heritage of the state is equally diverse. Being an umbrella species, importance of tiger and its conservation is deep rooted in our society. Tiger conservation efforts have gained substantial focus in the last few decades. Madhya Pradesh, with its six tiger reserves and highest tiger population in the country, is a pioneer state in tiger conservation and its habitat management.

Among the tiger reserves, the Panna Tiger Reserve (PTR) located in Bundelkhand region has its unique significance and as it has successfully re-established its wild tiger population through reintroduction of wild and semi-wild tigers. Reintroduction efforts such as ensuring best protection and post-release monitoring with sound scientific inputs have earned global recognition. However, the Bundelkhand is a drought-prone region and thus, local communities face acute water scarcity. To address this problem, Ken-Betwa Link Project (KBLP) was envisaged to meet the acute shortage of water for drinking and irrigation purpose in the region. The KBLP will have a negative impact on biodiversity, especially on the critical tiger habitat of PTR in terms of submergence and permanent functional fragmentation. In this context, a comprehensive Integrated Landscape Management Plan was proposed with sound scientific monitoring framework. The plan will address the aspects of biodiversity conservation and will ensure the engagement of local communities as a part of its mitigation and adaptive management strategy.

The plan highlights the scale of efforts required in terms of coordination and integration of different stakeholders. The plan also identifies suitable habitats for key species such as tiger, vulture and gharial, which are going to be impacted from the KBLP. Tiger conservation in Greater Panna Landscape has been devised by applying best available scientific methodologies. Apart from these key species, assessment of overall biodiversity and conservation priorities of the areas have been incorporated in the plan.

Additionally, the plan also evaluated the existing socio-economic conditions of the local communities and proposed possible pathways to enhance livelihood security and address other pressing socio-economic and environmental issues. This document would serve as a guideline for the line agencies to prepare future Landscape Management Plan involving multiple stakeholders.





Executive Summary

Introduction: Landscape is defined as an area that is physically, historically, culturally, and ecologically exclusive which includes human activities and their institutions as an integral part of the system rather than as external agents. Though not completely new, integrated landscape management (ILM) is an increasingly popular approach for addressing development, climate change, food security, and a host of other global issues. Realizing the importance of conservation and sustainable use of biodiversity in India, as well as fair and equitable sharing of benefits arising out of it, an ILM approach would be imperative. The Greater Panna Landscape (GPL) encompassing Panna Tiger Reserve (PTR) and surrounding areas offers significant biodiversity, historic, cultural, and conservation values. With local extinction and successful reintroduction of tigers and presence of other diverse wildlife, PTR becomes the centre of significance of this landscape. However, the proposed Ken-Betwa Link Project (KBLP) with its implication for habitat loss and fragmentation of wildlife in PTR, necessitates the preparation of a comprehensive integrated action plan at landscape level.

GPL is mainly a part of Vindhayan plateaus and distributed over eight districts of Madhya Pradesh (MP) i.e., Sagar, Damoh, Panna, Chhatarpur, Satna, Katni, Rewa, Narsinghpur, and three districts of Uttar Pradesh (UP) i.e., Banda, Chitrakoot, and Lalitpur. Apart from PTR, it includes four Protected Areas (PAs) i.e., Ken Gharial Sanctuary (KGS), Nauradehi Wildlife Sanctuary, Veerangna Durgawati Sanctuary and Ranipur Wildlife Sanctuary, and 13 forest divisions.

The landscape is characterised by barren hill terrain and sparse forest cover (dry deciduous forest, dominated by teak and other miscellaneous species). This landscape harbours rich faunal diversity which includes tiger, leopard, sloth bear, wild ungulates, gharial, mugger and many species of birds including vulture. A major portion of the landscape is dominated by agriculture and forest land, while the rest of the area is covered with settlements, water bodies, and scrub land.

Goals and Objectives: The goal of the Integrated Landscape Management Plan is to ensure a "winning" situation for conservation through integration with the development process based on balanced approach and considering the diverse stakes. The objectives to achieve this were: (1) To enable betterment of habitat, protection, and management for flagship species viz. tiger, vultures, and gharial in the landscape; (2) To consolidate the landscape for overall biodiversity conservation through spatial prioritization and well-being of forest dependent communities; and (3) To provide species specific and site-specific monitoring strategies under the integrated landscape management context with feedback loop and adaptive management options.

Plan Framework and Structure: The preparation and writing of the LMP has been an iterative process that went through rigorous scientific brainstorming and robust field work. The plan process started with identification of thematic context and delineation of landscape boundary, followed by consultation with the government stakeholders, deployment of technical manpower, desk review and reconnaissance, and primary and secondary data collection. Data collection was followed by aspatial and spatial analyses, categorisation and prioritisation, stakeholder consultations, mid-term review and course correction. Finally, the draft plan was prepared, after which the shared vision was incorporated and negotiated to achieve legitimization and convergence. At the end, the draft plan was finalised and reviewed by independent experts, following which the final plan is being submitted along with implementation strategies.

In terms of methodology, the landscape was divided into four blocks of 8x8km grids (64 sq. km), nested within which were 2x2km grids (4 sq. km). In PTR, intensive sampling was done within 1.4x1.4 km grids (2 sq. km). A combination of different field methods such as camera trapping, line transects, systematic vegetation plots, area search, systematic sampling in Ken River, visual encounter survey, pitfall trap and bioacoustics were employed for different target species/ species groups. Spatial data analysis resulted in identification of satellite cores and corridors for tigers, biodiversity richness and spatial prioritization for tiger, vultures, and biodiversity. For socio-economic data collection, a questionnaire survey (10% of villages in each 8x8 km grid) was carried out throughout the landscape. Additionally, consultation workshops and periodic review meetings were also conducted involving multiple stakeholders.

Tiger Conservation: Currently, PTR holds around 60 tigers (>1year of age) and an additional 37 adult/sub-adult tigers (which includes translocated individuals to other Protected Areas (PAs) are believed to have dispersed in the landscape. This necessitates management interventions regarding habitat consolidation, up-gradation/declaration of existing or potential forest areas and identification of satellite core and corridors for tigers. The reintroduced tiger population in PTR was found to have higher average litter size, low cub mortality, short inter-birth interval and an annual growth rate of ~31%, which perhaps led to the rapid population recovery. Tigers utilised more open mixed forest areas as compared to dense vegetated habitats. Carrying capacity of tigers varied in the core and buffer zone of PTR, being more in core zone. Population Viability Analysis indicated a high chance of survival probability of the tiger population in PTR, with different scenarios. As for recommendations/prescriptions for tiger conservation in PTR, it is suggested that firstly, protection for tigers should be enhanced by Special Performance Unit (SPU), Continuous Camera Trap Monitoring System (CCMS), Crime Deduction and Alert System (CDAS), Intelligence Network and Incentives, Un-manned Aerial System (UAV) for Monitoring and Supply of Essentials, Strengthening Staff Infrastructure and Logistics, Virtual Fence Network (VFN), and Social Fence Network (SFN). Secondly, the population should be managed through fine-scale distribution mapping and monitoring, spatially explicit estimation and monitoring, demographic management, genetic management, protection of denning sites, and establishment of controlled population management facility. Thirdly, prey augmentation and periodic translocation of prey species from higher to lower density areas should be done. And lastly, the habitat should be consolidated and restored through landownership transfer of compensatory village area, landownership transfer of revenue open areas to be developed into conservation or community reserve, restoration of consolidated village areas, construction of structural connectivity across Ken River, diversion of road traffic volume, and strategic fencing and alert system. For conservation of tigers in the landscape, satellite cores, steppingstone and corridors delineated by this project, should be protected, landscape-level assessment and capacity building should be intensified and repeated annually, an

interstate tiger reserve (Ranipur-Satna Tiger Reserve) should be established, Kalda Conservation Reserve should also be established, Veerangna Durgawati Wildlife Sanctuary should be expanded by inclusion of areas from Damoh Forest Division, riparian corridor zone must be protected and restored, under-passes and over-passes should be created where highways cut through proposed corridors.

Vulture Conservation: PTR and the surrounding landscape hold a significant population of seven species of vultures, three of them are Critically Endangered (Indian, White-rumped, and Red-headed Vultures), one is Endangered (Egyptian Vulture) and two are Near Threatened (Himalayan Griffon and Cinerous Vultures). Movement pattern of radio-tagged vulture during this study shows that the vultures utilise large areas in the landscape, due to availability of several suitable nesting and roosting sites within the landscape. PAs in the landscape serve as refuges, however, human-dominated areas are also extensively utilised due to presence of several dumping sites and gaushalas. Therefore, for conservation of vultures in GPL, it is suggested that firstly, protection of population (from poaching, breeding loss, and diseases), habitat (from destruction and anthropogenic disturbances, fire incidents) and forage (from non-targeted poisoning and feral dogs) should be enhanced. This can be done by establishment of surveillance tower, deployment of alert system, aerial surveillance of fire and prevention using UAV, fencing of carcass dump sites and establishment of Gaushala Coordination Committee (GCC), establishing a Network of Vulture Champions (NVC) to ensure community based protection. Secondly, population management should be done through robust population estimation and monitoring, demographic and genetic structure profiling, nest-site monitoring, biochemical analyses and monitoring, establishment of Rapid Response Team (RRT) and Vulture Rehabilitation Centre (VRC), awareness and engagement of people and veterinary professionals to prevent use of harmful drugs, implementation of Flyway Action Plan, and disease surveillance and monitoring. Thirdly, habitat management for vultures should be done through regular update of nesting and roosting sites, augmentation of riparian tree species, management of dumping site/ feeding point, and developing community/ conservation reserves. Lastly, emphasis should be laid on promoting vulture-centric tourism both within and outside PTR.

Crocodilians Conservation: Although patchily distributed, mugger is common in Ken River, however, only one gharial was recorded from KGS during the study. Despite reintroduction of several individuals in Ken, the gharial population has failed to establish in the past. Given the situation, for Gharial conservation in PTR and KGS, it is recommended that firstly, for enhancement of protection, crocodile priority and restricted zones should be created, ban on fishing and sand/ boulder mining should be enforced, river habitats need to be protected and co-managed, and unmanned aerial system can be deployed for security-based monitoring. Secondly, for population management, it is suggested to estimate and monitor the population and focus on demographic and genetic management, and for population recovery a Coordinated Gharial Recovery Program should be designed, and Crocodile Rehabilitation Centres should be established. Thirdly, for habitat management, environmental and sediment flow should be maintained, prey population should be managed, and artificial sandbanks should be created. lastly, for community engagement in gharial conservation outreach programmes should be designed and river dependent communities involved in monitoring activities.

Biodiversity Conservation: The biodiversity conservation strategies included community group prioritisation, conservation of Species of Conservation Significance (SCS) and spatial prioritization through recognition of important biodiversity areas. Initial steps of biodiversity conservation involved robust assessment of multi-taxa in terrestrial, aquatic, and riparian ecosystems. Landscape level vegetation survey revealed the presence of diverse species with a distinct area-specific richness and rarity. As for herpetofauna, species diversity and richness, were found to be high in specific habitats (such as grasslands and paddy fields) in PTR and four species of reptiles were recorded for the first time in PTR. In terms of habitat management, widely distributed invasive and native weed species should be controlled at village relocation sites and at different preidentified habitats in PTR, following different techniques. Different management interventions of riparian zones are proposed with a combination of methods viz. delineation of zones at varying lengths alongside the main rivers and creation of buffer (vegetated) strips around those sites. Similarly, wetlands are an important habitat/ecosystem in the landscape, various wetland-specific management interventions suggested in the plan should be followed. Amongst the

species of ichthyofauna, identification of certain key species (such as mahseer) and targeted actions such as regulation of fishing activities, present and future research priorities and awareness campaigning should be carried out.

Community Engagement: The socio-economic survey in Panna landscape revealed preponderance of tribals and other castes, who are mainly engaged in farming and manual labor. Surveyed groups reported several social and forest/ wildlife related issues related to health, water scarcity, education, human-wildlife conflict, restrictions on fuel wood and Non-Timber Forest Product (NTFP) collection, restricted developmental activities and non-functionality of Ecodevelopment committees. Apart from the forest department and local communities, inclusion of other stakeholders of the landscape in the management process was proposed to make it more participatory and independent. To improve the livelihood of local people, various measures such as implementation of government schemes, development of pasture lands and integrated farming can be taken up by different stakeholders. Promotion of social forestry- silvi-pastoral system by forest department in wasteland/barren lands can help to meet the demand for fuel and fodder. Since NTFPs are a major source of income of local people in Panna landscape, setting of minimum support price and community cooperatives and growth centres under 'One District One Product' initiative, would help in supporting the local economy. Furniture making from lantana, bamboo crafts and making of Murabba from Amla should be promoted on a larger scale, which would help to generate alternative incomes. The forests of Panna landscape harbour several plant species with well-known medicinal properties and opening a citizen's portal for medicinal plants at panchayat level could help initiate medicinal plant related businesses. Creation of seed banks for uncultivated indigenous food crops would be helpful to preserve food sources for local use. Strengthening of ecodevelopment committees and formation of theme-based committees are proposed. Formal skill development and capacity-building programmes, like Green Skill Development Program, should be conducted after identifying current and future employment capacities. Development of infrastructure and knowledge building among local people should include technological support, village level energy production, redesigning of educational curriculum etc. Since addressing human-wildlife conflict is important for ensuring community support in wildlife conservation, major conflict causing species (along with spatial distribution of conflict) in PTR were identified, and different conflict mitigation measures were suggested accordingly. In order to enhance the wildlife management for the health and well-being of wildlife, livestock and humans in the landscape, adoption of a one health approach was proposed. Current prevalence and future emergence of different zoonotic and epizootic diseases that occur at human-wildlife interface have been identified around PTR, and recommendations for prevention and mitigation of emerging health impacts proposed. Furthermore, the proposed one health approach discusses the improvement of existing health burdens and justifies the need of devising a One Health Action Plan through the formation of a "One Health Coordination Committee" for the Panna Landscape.

Integrated Landscape Management: GPL is mainly an agriculture dominated landscape, however, the forest patches within the landscape are aggregated and hold potential for supporting diverse wildlife. Although the forest cover has been increasing in GPL since 1990, the edges around the large patches and small linear forest patches which are important for connectivity have been decreasing. The forest areas of the landscape store large carbon stocks and high sediment retention, however, there is considerable variation in annual water availability in the landscape, because of which many parts of the landscape are not drought resilient. GPL holds great conservation value for key species like tiger and vultures, and potential for gharial recovery. However, there are several conservation and socio-economic challenges that need to be overcome to achieve long term conservation and community development goals. The plan has identified different mechanisms and strategies to address these challenges, focussing on enhancing protection, consolidating habitat, community engagement, education and tourism and capacity building. With prescribed protection and management, a total area of 7380.16 km^2 can be consolidated which would support 150-200 tigers in the GPL. District-level recommendations are provided to ensure relevant implementation in each district, involving all stakeholders. Lastly, implementation strategies have been provided along with details of implementation agency, duration (based on NSL principles) and summary of budget requirements.

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CHAPTER 1

CONCEPT AND BACKGROUND

Chapter 1: Concept and Background

1.1. Definition: Landscape is defined as the spatial dimension of a specific area, composed of heterogenous elements of land features repeated over and over, and as one sees from the bird-eye-view perspective, it reflects certain uniformity with diversity and mosaics of several natural and anthropogenic elements. It will functionally include the physical elements (such as mountains, rivers, lakes, ponds and the sea), biotic elements (such as natural vegetation cover, human land use, buildings and structures) and abiotic elements such as surrounding weather conditions. Landscape can also be defined as an area that is physically, historically, culturally, and ecologically unique and includes human activities and their institutions as an integral part of the system rather than as external agents. Combining their physical origins and the cultural overlay of human existence, created over thousands of years, landscapes reflect a living synthesis of people and place that is vital to its identity.

The concept of landscape management or the 'landscape approach' as it is frequently called, is not new, emerging as a scientific concept in the 1980s through the development of landscape ecology, although ancient literatures highlight that the way of life of people in the past had close integration with nature, as people took the intrinsic relationship with nature seriously. Also, for much of human history since the rise of agriculture, many rural communities have managed land at a landscape scale. Their management of land and resources for agriculture, grazing, forest production, water, and all other uses were closely interconnected. However, even a few years ago, the term 'landscape' was rarely used within the agricultural and rural development communities. But, today, the term, the management and policy approaches underlying it are beginning to gain prominence as the limits of narrowly sectoral approaches become more apparent in our interconnected, crowded, resource-constrained, and climate-chaotic world. The concept hence, in its true sense focuses on a shared vision of land managers and different stakeholders to achieve their multiple objectives and expectations within the landscape for conservation, maintaining ecosystem integrity, local livelihoods, health and well-being, agricultural production, ecosystem services, cultural heritage, and values, etc. The National Wildlife Action Plan (2017-2031) by the Ministry of Environment, Forest and Climate Change (MoEF&CC), Government of India underscores landscape approach as one of the key components of the Plan (Ministry of Environment, Forest and Climate Change, Government of India, 2017). Over the past decade, a variety of frameworks and terms have been developed to describe a vision for the integration of agricultural, environmental, and rural livelihood

outcomes. Field-level innovations began to be implemented at the landscape scale, while conservation-oriented landscape approaches began to incorporate production elements more systematically (Scherr *et al.*, 2013; Reed *et al.*, 2017).

Given the large-scale environment and development problems, landscape approach is an increasingly popular approach to addressing development, climate change, food security, and a host of other global issues. It also refers to a set of concepts, tools, methods, and approaches deployed in landscapes in a bid to achieve multiple economic, social and environmental objectives (multifunctionality) through processes that recognise, reconcile and synergise the interests, attitudes, and actions of multiple actors (FAO 2013; Scherr *et al.*, 2013; Reed *et al.*, 2015). Therefore, landscape approaches usually involve some form of a multi-stakeholder process (Minang *et al.*, 2015). Integrated Landscape Management (ILM) is the management of production systems and natural resources in an area large enough to produce vital ecosystem services and small enough to be managed by the people using the land and producing those services (FAO, 2013). ILM thus involves long-term collaboration among different groups of land managers and stakeholders to achieve their multiple objectives and expectations within the landscape for local livelihoods, health and well-being, agricultural production, the delivery of ecosystem services, cultural heritage, and values, etc. (Landscapes for People, Food and Nature Initiative, 2012; Scherr *et al.*, 2013). ILM supports integration across sectors and scales, increasing coordination; similarly, it ensures the harmonisation of planning, implementation, and monitoring processes at the landscape, sub-national and national levels, essentially following appropriate administrative units.

1.2. Global Context and Relevance: The term integrated landscape management was coined by the Landscapes for People, Food and Nature Initiative, and is now widely used. As an umbrella concept, it aims to describe the diverse approaches which exist on landscape management (Landscapes for People, Food and Nature Initiative, 2012). Forman and Godron (1986) produced a seminal book on the distribution patterns of landscape elements or ecosystems; they described the flows of animals, plants, energy, mineral nutrients, and water, as well as the ecological changes in the landscape over time (Forman and Godron, 1986). By the 1990s, ‘community-based natural resource management’ became more popular in the fields of forestry, watershed management, and biodiversity conservation, as resource managers sought to accommodate human activities in and around important habitats and protected areas (Sayer and Campbell, 2002; Van Noordwijk *et al.*, 2002). By the 2000s, the role of agriculture and food production systems in landscape management was increasingly recognised as

essential to any comprehensive and integrated land management approach (McNeely and Scherr, 2003; Jordan *et al.*, 2007; Alder *et al.*, 2012). More recently, private investors and companies have begun to recognise the importance of using a landscape approach to mitigate environmental, health and social risks that threaten the profitability and long-term viability of their business models. By participating in ILM, the private sector lowers environmental and social risks, builds community goodwill, and secures the long-term sustainability of supply regions. For example, the Initiative for Sustainable Landscapes (ISLA), funded through the Dutch Sustainable Trade Initiative (IDH), engages companies as key partners in the management of six resource-vulnerable sourcing areas around the world (The Sustainable Trade Initiative, 2014).

Several of the most prominent international policies, conventions, and strategies aimed at conserving and enhancing the world's natural resources and ecosystems – such as the Convention on Biological Diversity (CBD) and its Aichi targets, the United Nations Framework Convention on Climate Change (UNFCCC) and the Intended Nationally Determined Contributions (INDCs), the UN 2030 Agenda for Sustainable Development, and the United Nations Convention to Combat Desertification (UNCCD) with its emphasis on SDG target 15.3 on land degradation neutrality – are highly aligned with the principles and elements of ILM. The 2030 Development Agenda, and other international conventions, call for integrated approaches, based on partnership and coordination across traditional sectors, to help manage the complexity, reduce the trade-offs, as well as, to build on the synergies inherent to such interrelated goals and targets. Sayer *et al.* (2013) listed ten principles for landscape approaches adopted by the Convention on Biological Diversity, and these are *(1) Continuous learning and adaptation, (2) The common concern entry point, (3) Multiple scales, (4) Multifunctionality, (5) Multiple stakeholders, (6) Negotiated and transparent change logic, (7) Clarification of rights and responsibilities, (8) Participatory and user-friendly monitoring, (9) Resilience and (10) Strengthened stakeholder capacity*.

ILM has been implemented and tested in a wide range of environments and cultures across the globe, providing practical examples of place-based implementation. Continental reviews of landscape initiatives were conducted between 2012 and 2016 by the Landscape for People, Food and Nature Initiative so that lessons and best practices could be analyzed, disseminated and, eventually, replicated or improved upon. The reviews – completed in Africa, Latin America, and the Caribbean, South and Southeast Asia, and Europe – identified 436 programmes that are utilising methods and practices that characterize them as integrated

landscape initiatives (ILIs). Results from the continental reviews show that simultaneous improvements in conservation, agriculture, livelihoods, and institutional capacity and coordination can be achieved using an ILM approach (Thaxton *et al*., 2019).

1.3. National Context and Relevance: India is a unique blend of tradition and modernity. It is one of the oldest civilizations in the world and presently among the fastest growing economies. It has the second highest population, the third largest economy by purchasing power parity (PPP) and the seventh largest area in the world (World Bank, 2019, 2020). The country has made remarkable strides on the socio-economic front since its independence in 1947. The country is currently passing through a critical phase in its developmental history with poverty alleviation, sustainable development and inclusive growth being major objectives of public policy. India's endeavour for sustainable management of natural resources is nested within this complex socio-economic and political context. India's polity and governance framework are designed to accommodate these diversities and complexities. The Constitution of India apportions responsibilities of governance between the union government and states. Matters such as forests, over which both these governance institutions have the power to legislate, are termed as 'concurrent' matters. Following the Constitution (73rd Amendment) Act, 1992, considerable powers have also been devolved to the democratically elected Panchayati Raj Institutions (PRIs) at the village, intermediate and district levels.

Realizing the importance of conservation and sustainable use of biodiversity as well as fair and equitable sharing of benefits arising out of it, India has developed a relatively robust legislative and policy framework for biodiversity governance. Although some measures date back several decades, concerted action on this front started from the 1970s onwards. The idea of protection of the environment, including biodiversity, is enshrined in the Constitution of India. It enjoins both the State and the citizens to take appropriate steps in this direction. Article 48-A of the Constitution of India states that `the State shall endeavour to protect and improve the environment and to safeguard the forests and wildlife of the country', and Article 51-A (g) states that `it shall be the duty of every citizen of India to protect and improve the natural environment including forests, lakes, rivers and wildlife and to have compassion for living creatures. The policy framework for biodiversity governance comprises a number of sector-specific and cross-sectoral policy statements issued over the years. Some of the key policy statements are: (i) National Forest Policy, 1988; (ii) National Conservation Strategy and Policy Statement on Environment and Development, 1992; (iii) National Policy and Macro-level

Action Strategy on Biodiversity, 1999; (iv) National Agriculture Policy, 2000; (v) National Seeds Policy, 2002; (vi) National Water Policy, 2002; and (vii) Comprehensive Marine Fishing Policy, 2004. In 2006, India brought out a comprehensive policy statement, the National Environment Policy, to `infuse a common approach' and to achieve `balance and harmony between economic, social and environmental needs of the country'. It has seven main objectives: (i) conservation of critical environmental resources; (ii) intragenerational equity: livelihood security for the poor; (iii) inter-generational equity; (iv) integration of environmental concerns in economic and social development; (v) efficiency in environmental resources use; (vi) environmental governance; and (vii) enhancement of resources for environmental conservation. The policy also lays down a number of principles including inter alia the 'public trust doctrine', 'precautionary approach', 'polluter pays', 'equity' and 'entities with incomparable values'. The crucial laws that provide the legal framework for biodiversity governance include: (i) the Indian Forest Act, 1927; (ii) the Wildlife (Protection) Act, 1972; (iii) the Forest (Conservation) Act, 1980; (iv) the Environment (Protection) Act, 1986; (v) the Panchayats (Extension to the Scheduled Areas) Act, 1996; (vi) the Protection of Plant Varieties and Farmers' Rights Act, 2001; (vii) the Biological Diversity Act, 2002; and (viii) the Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006.

The management of forests in India started during the British rule with the Charter of Indian Forestry, which was meant to restrict and regulate the unchecked exploitation of forests by private individuals (Patnaik and Singh, 2000). Subsequently, the first forest legislation (Indian Forest Act) was passed in 1865, with the basic aim of managing the forests of India. However, this Act was subsequently revised in 1878, and then finally, in 1927. After the passing of the 1878 Act, the Britishers brought out the first formal Forest Policy in 1894. Subsequently, the Indian Forest Act, 1927 was passed, which was in line with the aims as mentioned in the Forest Policy of 1894. After India gained independence from British Rule in 1947, there was a need to rethink the forest policy. Therefore, after a scrutiny of the forest policy, the Government of India brought forth the first National Forest Policy of Independent India in 1952. The Policy laid down that "India, as a whole, should aim at maintaining one-third of its total land area under forest", marking a visionary approach influencing the world's 30% target (IUCN World Parks Congress, 2014; Convention on Biological Security, 2021). It further focused upon the ecological and social aspect of forestry, while at the same time cautioning that "village

communities should under no circumstances be permitted to use forests at the expense of national interest."

A major paradigm shift was seen in the mindset of the government, with the passing of the National Forest Policy of 1988, envisaging larger role for local communities including their involvement in activities related to forest development and protection. Similarly, access and benefit sharing has also been balanced. Unlike the use-oriented approach as under the 1952 Policy, this Policy focused upon the ecological aspect of forests. A major enunciation in the 1988 policy was the idea of Joint Forest Management (JFM). While the policy laid down the idea, the major guidelines regarding the JFM came in the year 1990 and through a circular, the MoEF&CC encouraged the involvement of village communities and voluntary agencies in the regeneration of forests. Finally, in the year 2018, the Central Government released the draft National Forest Policy, 2018. The new policy addressed the new challenges that the country had come to face in the recent past. These challenges are climate change, human-animal conflict and declining green cover.

Conservation efforts in India were constrained due to near absence of an integrated approach to land and natural resource management. Recognizing this, India started experimenting with participatory approaches for managing biodiversity conservation and has achieved global recognition through programmes such as Joint Forest Management and Ecodevelopment. Over the years, a need has been felt to expand such approaches to larger landscapes with multiple land uses, to integrate the range of development and livelihood concerns with biodiversity conservation. To achieve this objective, the MoEF&CC, Government of India started the World Bank assisted project on 'Biodiversity Conservation and Rural Livelihood Improvement Project (BCRLIP)' in India for managing large landscapes having conservation values. It was a multi-sector and multi-theme project, based on landscape approach to conservation and emphasizes collaboration between Forest Department, local communities, and different development agencies for its success. Further the third National Wildlife Action Plan 2017-2031 (NWAP) added two themes to conservation discussions, (1) a landscape approach to wildlife conservation and (2) incorporating the impact of climate change. The NWAP states that taking the landscape approach to wildlife conservation can help in looking at the issue of human-wildlife conflicts, which have been increasing in frequency in recent years, in its broader context.

1.4. Local Context and Relevance: Panna's conservation history starts from the erstwhile Chhatrasal state which existed in 15th century (1662). Earlier kings of this area used to reserve this forest for hunting purposes, which is evident in Pakkagharh and other constructions especially made for hunting purposes. This hunting culture continued through the British period. In 1907, the Panna Rajas had a shooting preserve near village Madla by the name Baharganj. After the formation of Vindhya Pradesh, all the forests of Panna district were included in Panna division that was later divided into North and South Panna Divisions on 26 January 1962. Consequent upon the reorganisation of the forest department of Madhya Pradesh, North and South Panna Divisions were again merged to form Panna Forest Division, vide M.P. Govt. Forest Department Notification No. 7330/9/7/X, dated 1/10/1976. Panna Forest Division was once again divided into North Panna and South Panna divisions, vide Govt. order No. 7840/x-11/82, dated 20.9.82. This order also provided for creation of a Plantation Division in Panna. In between, there also existed Panna (Production) Division over the entire district during 1976 to 1982. The production division was later wound up by merging its sub-divisions (production) with respective territorial divisions by government order No. 110/x-1/6-1-83. The plantation division, on the other hand, was later converted to the social forestry division and extended to cover Satna district as well. All forest divisions of Panna, including the park became part of Sagar circle with effect from 1.4.1989. Creation of Chhatarpur circle saw the inclusion of Panna forests with it, effective from 1.4.1996. Most of the forests in Panna, Bijawar, Ajaygarh, Chhatarpur and other states were traditionally known by the nearby villages or hills and in many cases were protected, though there was no attempt on their demarcation, survey and reservation. They were mainly worked for obtaining revenue through timber and fuel on long period contract basis.

In 1975, Gangau Game Sanctuary was carved out from the forests adjoining the Ken River at Panna district for the birds and animals of the areas (285.337 sq. km) which was revised in the year 1979 to increase the area to 478.81 sq. km. In the year 1981, major areas from the Gangau Sanctuary (373.55 sq. km) were carved out by adding another 169.12 sq. km area from the other side of the Ken River of Chhatarpur district to form Panna National Park (area 542.66 sq. km) on 17 October 1981 by MP forest Department notification no. F. 15-21-77-X (2) dated 16 April 1979. The Notification was published in Gazette of Madhya Pradesh Government dated 1 January 1982 (No. 15-08-80-II). Till then major portions of the present national park were managed as a part of the North Panna Territorial Forest Division. Panna National Park got the 'Tiger Reserve' status (management) in the year 1994. Portions of Gangau Sanctuary were also

transferred to Panna Tiger Reserve (PTR) administration in the year 2004. Similarly, Ken Gharial Sanctuary (KGS) further in the northern direction along Ken was also transferred to PTR administration, but this is not contiguous with the rest of the reserve. The State Government added 33.47 sq. km of Gangau Sanctuary to the entire national park area and declared the same as the core of PTR. In the year 2012, an area of 1002.42 sq. km. from North and South Panna (T-1 divisions), Damoh (T-4 division) and Chhatarpur (T-1 division) forest divisions was declared as buffer area of PTR. Madhya Pradesh Government later amended this area on 24 July 2014 by Forest Department Notification No. 15-21-2010-X-2 to 1021.97 sq. km. The national park legally got its full Tiger Reserve status in the year 2012 with core area of 576.13 and buffer area of 1021.97, totalling 1598.1 sq. km (Madhya Pradesh Forest Department, Government of Madhya Pradesh, 2007, 2014).

Wildlife Institute of India (WII) collaborated with the park management in conducting various research projects (tiger ecology, sloth bear ecology, ecotourism, environment impact assessment, etc.) which continued up to 2004. With a proper coordination between the then forest management and WII research team, monitoring based security resulted in better protection and PTR came into the limelight with respect to tiger conservation. However, in 2005, controversies on tiger population decline erupted in PTR and thus, the then Chief Wildlife Warden (CWLW), Madhya Pradesh ordered a count of tigers in Panna using the pugmark method. The estimation in March 2005 concluded that there were 35 tigers in Panna (14 males, 23 females and one cub). This number was vehemently contested by several professionals and conservationists because of the poor quality of pugmark and that such sampling procedures involving pugmark is subject to huge errors. As the disagreement regarding the methodology surfaced, the Chief Wildlife Warden through a letter dated 31 March 2005 requested WII to undertake a scientifically robust tiger estimation exercise. WII deputed a team in the first week of April of 2005, but the team's work remained limited to a reconnaissance visit including scat collection and specific results were not produced. It was only in the winter months of 2005/2006 that the camera trap-based estimation exercise was undertaken, as a part of All India Tiger Estimation and Monitoring Project by NTCA and WII. This exercise threw up a figure range of 8 to 15 tigers in an area of 185 sq.km. of the best tiger habitat in Panna and declared a figure-range of 15 to 32 tigers in 787 sq.km of 'Panna Landscape', which besides PTR included pockets of areas in Panna and Chhatarpur districts where evidence of individual tigers was encountered. Dr. H. S. Pabla who visited the park as Additional Principal Chief Conservator of Forest (Wildlife) in December 2007 suggested

reasonable presence of tiger in PTR. In January 2008, NTCA deputed a two-member team to assess the tiger situation in PTR and suggested the presence of up to seven tigers (most being males) based on pugmark evidence and interaction with staff and local people. However, the controversy on the tiger number did not subside with more voices indicating that the Panna tiger is going the way of Sariska Tiger Reserve, where the population was discovered to have been extinct due to poaching and other ecological constraints.

To put to rest the controversy, Madhya Pradesh Forest Department (MPFD) sought WII to investigate the status of tiger in PTR. Accordingly, a study was undertaken by WII (lead by Dr. K. Ramesh) involving various methods including pugmark and camera trapping, that concluded that the last male in PTR also disappeared in February 2009. The study called for active species recovery programme as other required conditions were suitable. After the local extinction of tigers in Panna, tiger recovery programme was collaboratively initiated by MPFD, WII and NTCA. Implemented in two phases over 10 years, seven tigers were translocated from other areas within Madhya Pradesh and with concerted efforts, the population has rapidly grown. This is registered as one of the fastest tiger recoveries anywhere in the world. Tigers have also started dispersing out of PTR and that given the isolation of PTR from larger context with absence of strong connectivity with other source sites (Tiger Reserve), long-term tiger conservation in the PTR relies on the landscape level strategies, without which future extinctions cannot be prevented. Tiger is a landscape species and thus, landscape level management is imperative.

The area is also crucial for other landscape-depended species such as vultures and gharial, in addition to representative species for the Central Indian Highlands dominated by Vindhyan elements. PTR has seven out of nine vulture species of the country, of which Long-billed, White-backed (both highly endangered and susceptible to diclofenac), Egyptian and Red-headed vultures are resident, while Himalayan griffon, Eurasian griffon, and Cinereous vultures are migratory. The annual vulture estimations from recent years revealed a good amount of breeding population of all the resident vultures, which are otherwise highly endangered and whose numbers has gone down drastically in the rest of the country. Gharial is a critically endangered species, and a small population is known to occur in KGS, but despite regular augmentation from National Chambal Sanctuary, the conservation status has not improved, necessitating the need to focus on the landscape context to ensure population recovery and long-term conservation.

The landscape is mainly occupied by rural population, engaged in farming and agricultural practices, small-scale industries, working in mines, various companies and government services or businesses. People-forest interface is very strong as the forest dependency is very high, and there are other interest groups, focusing on development and economic activities. Thus, biodiversity conservation strategies need to understand the interest of various stakeholders and accommodate these in the planning and implementation process. Since conventional Protected Area management has limited scope for such integration, the landscape approach is inevitable, both for biodiversity conservation and societal development in the region.

1.5. Rationale: The National Water Policy in 2002 suggested linking of rivers for appropriate water management strategy (Ministry of Water Resources, Government of India, 2002). Accordingly, under the National Perspective Plan (NPP) by the National Water Development Agency (NWDA), 30 river linking projects, 16 in peninsular and 14 in the Himalayas, have been proposed to address the nation's water security and agricultural productivity concerns. Of these, the Ken-Betwa Link Project (KBLP) covering the states of Madhya Pradesh (MP) and Uttar Pradesh (UP) is rooted in PTR area, with implications for habitat loss from submergence and fragmentation, while the functional impacts of the project are far reaching beyond the conventional expectation around the immediate project site (Fig. 1.1). KBLP, primarily an irrigation and poverty alleviation project, was conceived in 1994/95 and subsequently, a joint project was developed by National Water Development Agency (NWDA), Ministry of Water Resources (which is now the Ministry of Jal Shakti), Central Water Commission (CWC) and State Governments of Madhya Pradesh and Uttar Pradesh, to realise the project objectives and components. The project involves construction of a Dam at Dhaudan village, Chhatarpur district (within PTR). Besides construction of the dam, two power houses, one at the body of the dam and the second at the exit of the lower-level tunnel of 1.1 km is proposed to be constructed and a two-kilometre-long upper-level tunnel will also be constructed within PTR. From the exit of the tunnel, Ken-Betwa link canal of 221 kms long will be constructed, to support drinking water and irrigation needs enroute and in the command area (Fig. 1.1). After reserving 2,266MCM for upstream use in Madhya Pradesh (MP) in Ken basin upstream of Daudhan dam, and accounting for mandatory releases for environment and reservoir losses at Daudhan dam, the rest of the water in Ken basin up to Bariyarpur Pick Up weir shall be utilised by the states of MP and UP in Ken and Betwa basin. In a normal year, the State of MP shall utilise total of 2,350MCM (83 TMC) while State of UP shall utilise total of

1,700 MCM (60TMC) annually from the Ken system. The committed release to MP and UP from the storages in Daudhan reservoir during non-monsoon period (November to May) shall be 1,834 and 750 MCM respectively. The project envisages to utilise 4050 MCM water from Daudhan dam through Ken-Betwa link canal to create irrigation facilities in Chhatarpur, Panna, Damoh and Tikamgargh districts of MP, and Jhansi, Banda, Lalitpur and Mahoba Districts of UP. The link canal after providing irrigation in the enroute of the link and drinking water supply in the enroute towns/villages for 40 lakh population utilising 127 MCM of water, the remaining 57 MCM of water will be diverted to Betwa river upstream of existing Parichha weir. The water diverted to Betwa River will be utilised in the water scares areas of Lalitpur district of UP for providing irrigation to about 3533 ha. The total 4.51 lakh ha irrigation facilities will be developed in MP and about 2.51 lakh ha irrigation will be developed in UP through Daudhan dam.

The total submergence area indicated in the Detail Project Report (DPR) is 90.00 sq. km, out of which core area of PTR is 41.41 sq.km and 16.20 sq.km is other forest area. The remaining 32.39 sq.km is coming under the revenue area (DPR of NWDA). 0.655 sq. km area under PTR is also to be diverted but won't be submerged, instead it is coming under other component (road, spill over, etc.). Submergence area is part of critical tiger and vulture habitats. Besides the above submergence area, the entire Kishangargh Range (Core Critical Tiger Habitat) with an area of 56.23 sq. km and Bhusor and Palkoha circle of Chandranagar Range with an area of 49 sq. km will lose direct connectivity. Thus, around 105.23 sq. km of the CTH area on the western side of the Ken River will be functionally fragmented from large mammal perspectives, unless structural interventions are made. In this project, 10 villages (including Palkohan, Daudhan and Kharyani-Mainari which are inside core area of PTR) will be submerged after completion of the project, causing dislocation of 1913 families and 8339 persons as per DPR of NWDA.

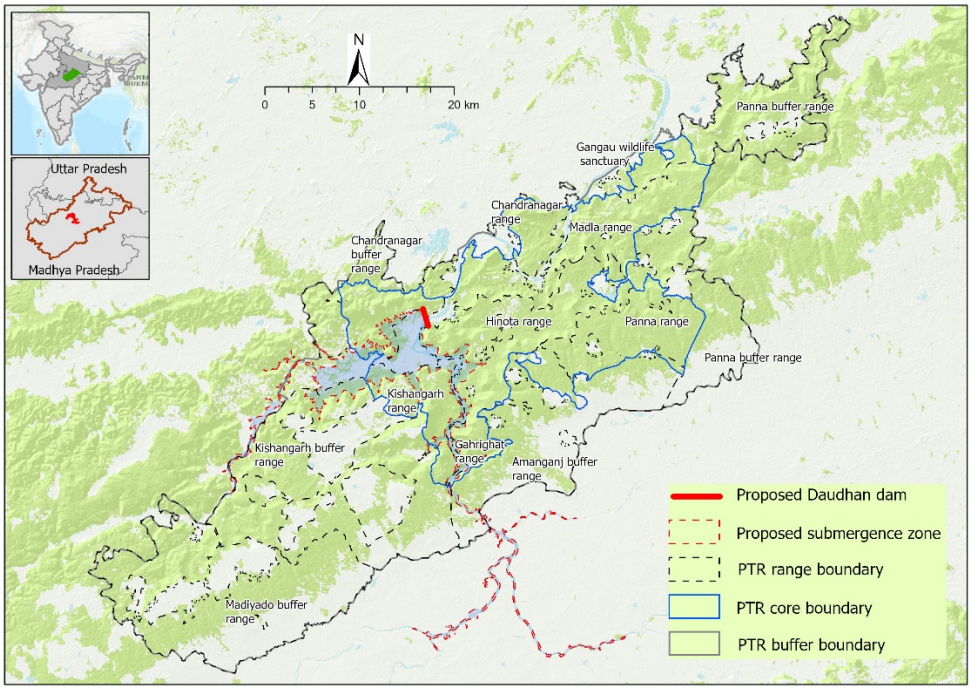


Figure 1.1. Map showing submergence area of Daudhan dam within Panna Tiger Reserve

In addition to tiger (*Panthera tigris*), which has been recovered following concerted efforts over the past ten years, the significant nesting habitats of vultures are also likely to be affected by the project. In 2013, NTCA vide letter F. No. 1-6/95-PT (Vol.II) dated 18th December 2013 constituted a four-member committee (Mr. D.K. Sharma, Superintending Engineer, NWDA; Mr. O.P. Singh Kushwaha, Superintending Engineer, NWDA; Dr. K. Ramesh, WII; Mr. R. Sreenivasa Murthy, MPFD) with the terms of reference *To ascertain feasibility of adding new areas to the tiger reserve in lieu of the area proposed for Ken-Betwa project and falling under submergence vis-à-vis space use pattern of reintroduced tiger habitats of Panna Tiger Reserve.* The committee in its report submitted in August 2014 pointed out that PTR is emerging as an important source population of tiger in the entire landscape and the proposed project will certainly cause habitat loss and fragmentation to the entire tiger population in the landscape. Current Environment Management Plan considers only about 10 km radius from the project site and 1km on either side of canal and this is clearly inadequate to address the ecological impacts of the project. Therefore, a comprehensive Landscape Management Plan (LMP) is necessary, enhancing the scope of Environment Management Plan, with scientific monitoring and certain mitigation measures towards adaptive management strategy. Subsequently during 2016-2017, the Expert Appraisal Committee (EAC), National Board for Wildlife (NBWL) and Forest Advisory Committee (FAC), while granting conditional permission to KBLP, also highlighted the need for development and implementation of LMP as a part of the mitigation

strategy. Since the project is expected to cause specific impacts on wildlife of the area including tigers, vultures, gharial, and other habitat obligate species, this work was mandated by NTCA to WII through an MoU signed between UP Government, MP Government, NTCA, NWDA and WII in 2018. Thus, the proposed Integrated Landscape Management Plan (ILMP) was envisioned, to consolidate and protect forest areas and habitats with significant biodiversity values, to facilitate conservation of tiger in a metapopulation framework and to conserve other focal species such as vultures and gharial with mutually beneficial engagement of local communities/stakeholders in the Greater Panna Landscape (GPL), mainly covering forested areas of eight districts in Madhya Pradesh and three districts of Uttar Pradesh.



CHAPTER 2

LANDSCAPE DESCRIPTION AND SIGNIFICANCE

Chapter 2: Landscape Description and Significance

2.1. Location, Extent and Justification: The GPL, lies between 81°53'25.706"E to 78°17'12.562"E longitude and 24°53'13.772"N to 24°14'4.787"N latitude, and is distributed over eight districts of MP *i.e.*, Sagar, Damoh, Panna, Chhatarpur, Satna, Katni, Rewa and Narshinghapur, and three districts of UP *i.e.*, Banda, Chitrakoot, and Lalitpur (Fig. 2.1 and Fig. 2.2). However, only Damoh, Panna and Satna districts of MP and Chitrakoot district of UP are fully covered in the landscape. Its extent is defined by Sagar district (MP) at the western side and Rewa (MP) and Chitrakoot (UP) districts at the eastern side, Katni at the southern side (MP) and Chhatarpur at the northern side (MP). The total geographical area of GPL is 47621 sq. km. with ca. 11,500 villages and forest area coverage is 12125.7 sq.km which includes one Tiger Reserve (*i.e.*, Panna Tiger Reserve, including Panna National Park and Gangau Wildlife Sanctuary) and four Wildlife Sanctuaries (Ken Gharial, Nauradehi, Veerangna Durgawati and Ranipur Wildlife Sanctuaries) and adjoining/intervening twelve forest divisions (Fig. 2.3). However, KGS also comes under PTR administration.

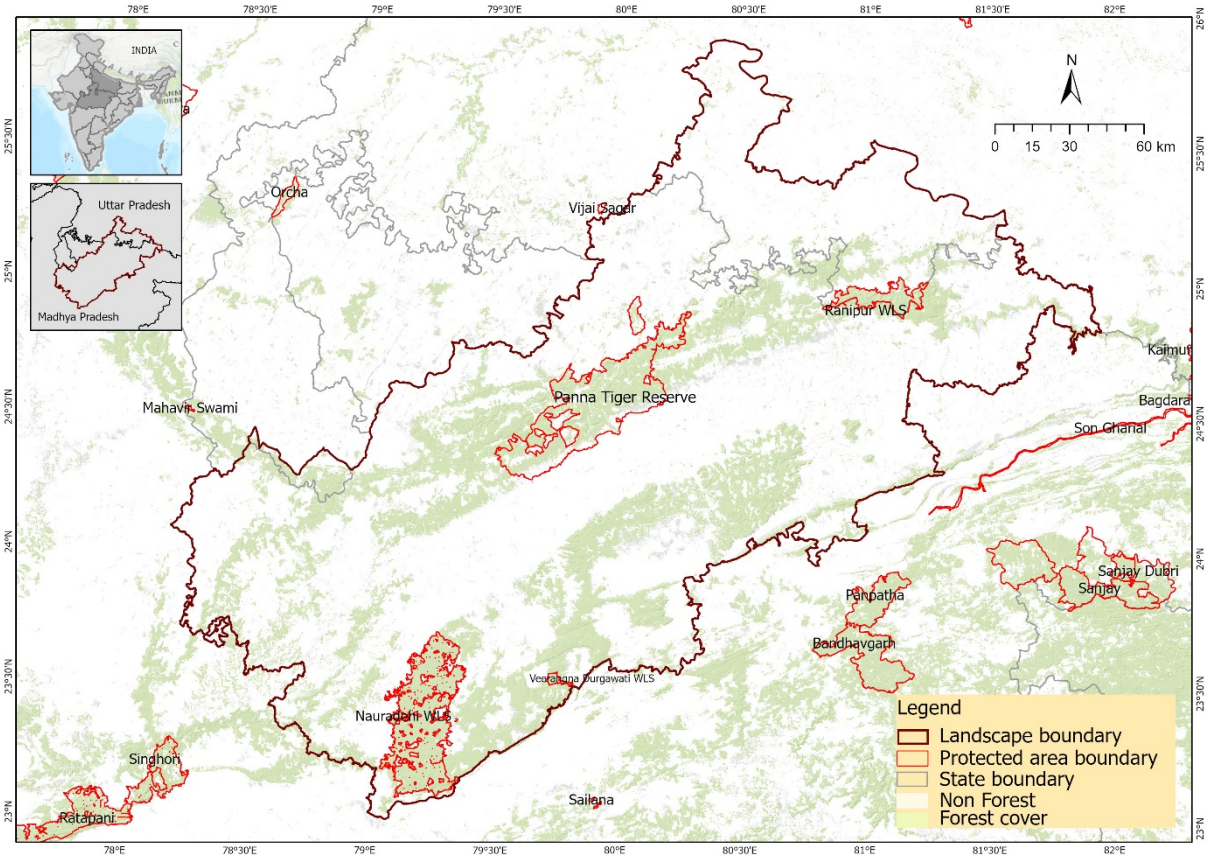


Figure 2.1. Location and extent of Greater Panna Landscape (GPL)

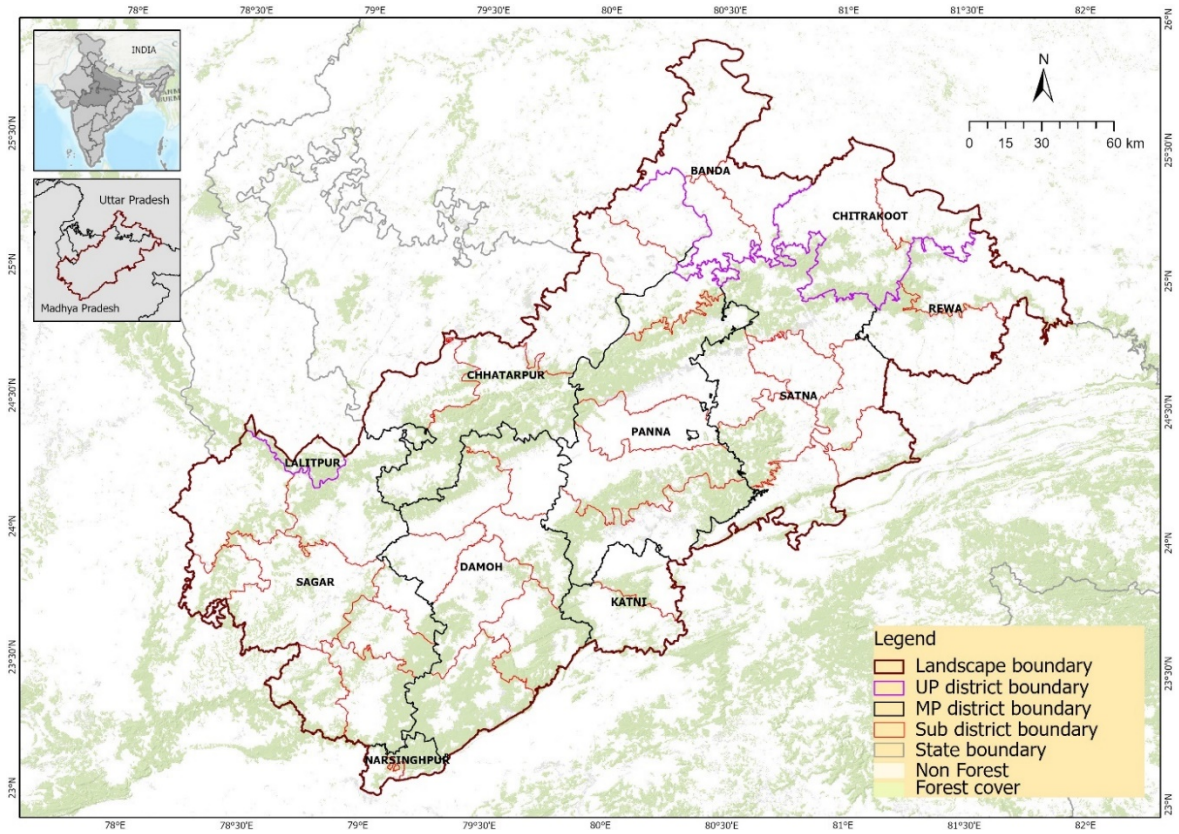


Figure 2.2. Civil administrative coverage of Greater Panna Landscape (GPL)

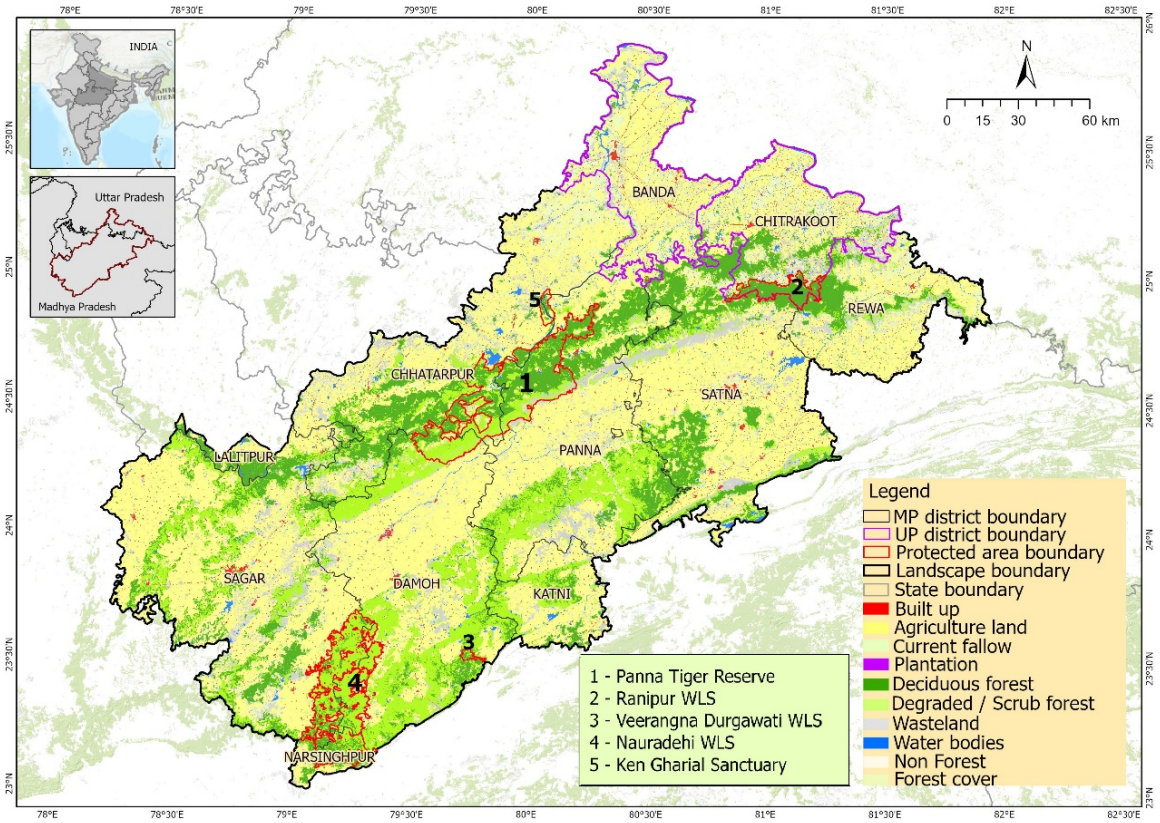


Figure 2.3. Forest and Protected Area coverage of Greater Panna Landscape (GPL)

The GPL boundary was earlier demarcated by the NTCA committee and in addition to PTR, all the adjoining forest divisions and sanctuaries, it also included Mahavir Swami Wildlife Sanctuary (Fig. 2.1). However, Mahavir Swami Wildlife Sanctuary was later excluded following a field survey, considering insignificant value addition from the landscape context. While defining the landscape boundary, we also considered (a) past dispersal evidence of tiger, (b) distribution information on vultures, (c) conservation opportunities for gharial, and (d) extent of Ken River from start to end with reasonable terrestrial and aquatic continuum. Finally, the landscape was defined based on sub-district boundaries of the districts wherein either Ken River or part of forest area was falling.

2.2. Physical Attributes: GPL is mainly a part of Bundelkhand carton of central India with barren hill terrains, sparse forest covers, and dry climatic zone. This landscape is more a part of the typical Archaean carton of Bundelkhand. This carton consists of intrusive granites, with scattered small enclaves, mainly of banded iron formations (BIFs), metaultrabasics, rare quartzites, some carbonates and calc-silicates; and rarely pelitic rocks (Singh and Slabunov, 2015). Other critical lithological units of this landscape include rhyolite, intrusive granitoid, calc-silicates, amphibolite, etc. Some part of the Panna and Rewa area comes in the Vindhyan plateau. Vindhyan rocks are sedimentary in nature, mainly made of sandstone, limestone, and shale (Ray, 2006). These rocks are resistant to sand erosion. The Camor (Kaimur/Kymore) range is a perfect example of this. Limestone and rock are less resistant to rock erosion. It is generally found in the valley areas and rugged low-altitude areas. The alluvium is seen prominently in Rewa district adjoining Satna (Sharma, 2000). These plains are mostly being used in agriculture. Most of this landscape area is covered by red soil (alfisols and entisols), which has very low water holding capacity and coarse and gravelly in nature. Other soil types found in this region are black soil, mixed red and black soil with medium to deep texture. In the Lalitpur area of UP, rakar, parwa, kabar, and maar soils are also found (Government of Uttar Pradesh, 2021). Lateritic soils are also found in the plateau.

Ken, Bearma and Sonar are the major rivers in the GPL. The Vindhyan sandstone makes a very good medium to recharge underground aquifers. This water keeps oozing out throughout the year through several springs to provide good potable water. Water is available in springs or small pools in nala beds. Such sensitive spots in key areas of the reserve require high attention. More such sites occur along the river course, streams or wherever nalas or water holes or falls. Details on other physical characteristics (with statistical attributes) of the landscape is given in Table 2.1.

Table 2.1: Physical characteristics of GPL

Physical attribute	Value
Elevation Maximum	740m
Elevation Minimum	29m
Elevation Mean	384m
Slope Maximum	61º
Slope Minimum	0º
Slope Mean	2.7º
Drainage Density	250m/km^2

This landscape is a hot and semiarid landscape with significantly less humidity and a wide range of seasonal temperatures. This landscape has four major seasons *viz*., Winter (November to February), Summer (March to Mid-June), Monsoon (Mid-June to September) and Post Monsoon (October). The minimum temperature goes to 6 degree Celsius in December to a maximum of 45 degrees Celsius in summer, usually in May/June. Local climates can be felt even more depending on the geological characters of that place. Banda is one of the hottest places in the landscape as well as in India. Many areas also experience short extreme local squalls in the peak summer season with a cloud of thick dust. The landscape receives an average of 1071.7 mm of annual rainfall from June to September. A major portion of the landscape is dominated by agriculture and forest land, while the rest of the area is covered with settlement, water bodies and scrub land (Table 2.2).

Table 2.2: Land use and Land cover (LULC) in GPL

S. no.	LULC Classes	Area (km^2)
1	Agriculture	22353
2	Forest	6767
3	Built-up	570
4	Scrub	7465
5	Water	780
6	Fallow land	2653

2.3. Biological Attributes: The landscape is dominated by dry deciduous forest along with significant patches of teak (*Tectona grandis*) forests (Mahalaha, 1965; Rai, 1996). Panna Tiger Reserve has a long stretch of pure Kardhai (*Anogeissus pendula*) patch. Other important tree

species are Babul (*Acacia Nilotica*), Khair (*Acacia catechu*), Palas (*Butea monosperma*), Ber (*Ziziphus varieties*), Tendu (*Diospyros melanoxylon*), Mahua (*Madhuca longifolia*), Semal (*Salmalia malabarica*), Salai (*Boswellia serrata*), Seesham (*Dalbergia sissoo*), Dhau (*Anogeissus latifolia*), Jamun (*Syzizium cumini*), and Seja (*Lagerstroemia parviflora*) (Mahalaha, 1965; Bhil, 1976; Srivastav, 2018; Jain, 2008). In Damoh and Sagar plateaus, dominant trees are Dhawda (*Anogeissus latifolia*), Tinsa (*Augenia delbergiodes*), and Bija (*Pterocarpus marsupium*) (Mahalaha, 1965; Rai, 1996). Tendu, which provides seasonal income to people living in and around forests, is found in abundance in Panna and Chhatarpur Districts (Bhil, 1976; Srivastav, 2018). Another beneficial tree for people living around forests is Mahua. Good teak forests are found mainly in Sagar and Damoh Districts in some small patches (Mahalaha, 1965; Rai, 1996)

This landscape is very rich in wild fauna. Many species of carnivores, herbivores, birds, and other small mammal species are found throughout the landscape. The carnivore guild is large, consisting of the tiger (*Panthera tigris*), leopard (*Panthera pardus*), sloth bear (*Melursus ursinus*), dhole (*Cuon alpinus*), striped hyena (*Hyaena hyaena*), jackal (*Canis aureus*), wolf (*Canis lupus*), jungle cat (*Felis chaus*), wild cat (*Felis silvestris*) (Bhil, 1976; Rai, 1996; Srivastav, 2018). Nilgai (*Boselaphus tragocamelus*), sambar (*Rusa unicolor*), chital (*Axis axis*) and chinkara (*Gazella bennettii*) are some of the ungulates found (Bhil, 1976; Srivastav, 2018). A good variety of Galliformes are also found in this landscape, along with other avifauna including large representation of vultures. A large number of amphibians and reptiles reside in the thick teak forests of Panna Tiger Reserve. A wide variety of fish is found in rivers of this landscape, including rohu (*Labeo rohita*), mrigal (*Cirrhinus mrigala*), tingar (*Mystus cavasius*), singhi (*Heteropneustes fossilis*), mangur (*Clarias magur*), baam (*Mastacemelus armatus*), sooja (*Xenentodon cacila*) and mahseer (*Tor tor*) (Dubey *et al.*, 2012; Johnson *et al.*, 2012; Jha *et al.*, 2014; Bose *et al.*, 2013). The landscape is also known for the great variety of herpetofauna, along with crocodiles and gharials. KGS one of the critical conservation grounds for gharials. There are various and unique habitat types are seen in this habitat starting from hilly terrain, open grassland, dense forest, riparian forests, riverine habitat, etc. These habitats provide particular and unique trophic niches to many animals and small vertebrates as well as invertebrates and provide a home for many endemic species.

2.4. Socio-Cultural Attributes: The landscape is mainly occupied by rural population. There are several ethnic communities in the landscape, most important of which are Gond

(Rajgond, Nandgond, and Saurgond) and Khairuas among the tribes and Yadavas (Dauvas) among the backward classes. Other major communities are: Bhīl, Basors, Chauhān, Ghasi, Kāchhi, Kol, Kurmi, Lodhi, Panka, Kushwahas and Dhimars (Russell, 1916). Approx.75% of the population is engaged in farming or are agricultural labourers. Apart from farming and agriculture a section of the population also works in mines, various industries, businesses and government services. Most of the people in this landscape are vegetarian. People in this landscape mainly follow Hinduism although a substantial number of people also follow Islam and Christianity. The forest dwelling communities are heavily dependent on the forest for resources like fodder, fuelwood and NTFPs like mahua, achar, amla and tendu.

2.5. Overview of Civil Administrative Units: While landscape management takes the form of different thematic contexts of the values and priorities relevant to the landscape, the functional aspects require specific administrative mechanism. In India, the framework of District Administration provides for an ideal mechanism as it would allow integration of civil as well as forest administration. Therefore, district administrative unit is taken as a basis for this implementation strategy in addition to existing Forest and Protected Area management. As stated above, the landscape comprises 11 districts (8 in Madhya Pradesh and 3 in Uttar Pradesh), and these are described below.

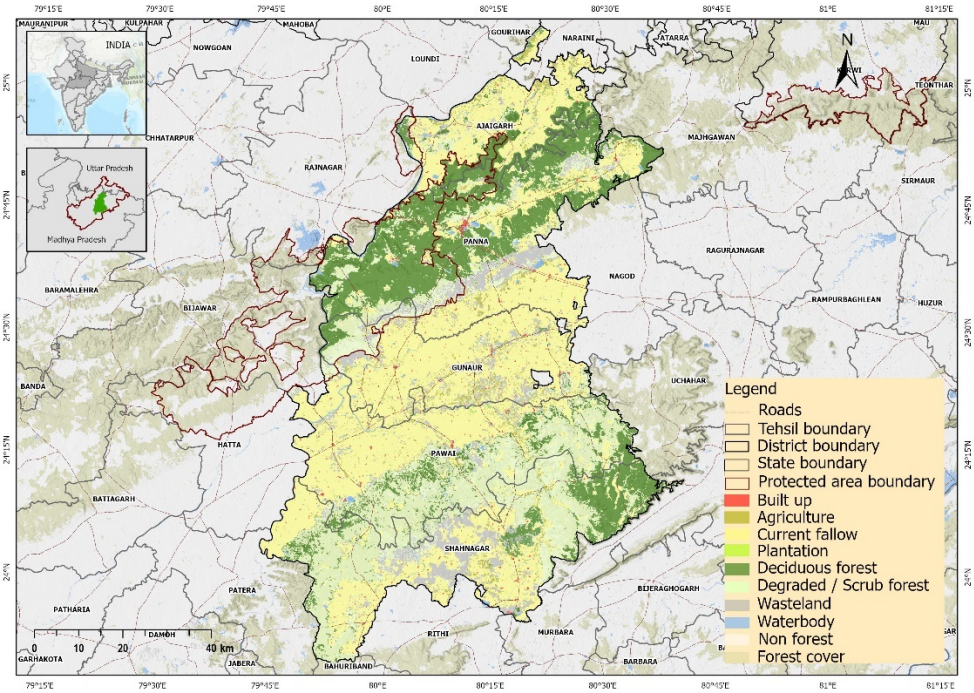


Figure 2.4. Map of the Panna District

Panna District: Panna District has an area of 7135 sq. km. with nine tehsils (Ajaygarh, Amanganj, Panna, Devendranagar, Gunnor, Pawai, Raipura, Shahnagar and Simariya) and

1033 villages all of which have been included in the landscape (Fig. 2.4). South Panna Forest Division, North Panna Forest Division and a large part of Panna Tiger Reserve fall within Panna District. Panna is known as 'The City of Diamonds', due to the presence of India's only diamond mines (run by National Mineral Development Corporation). Panna was part of the state of Vindhya Pradesh which was merged into Madhya Pradesh on 1st November 1956. On the establishment of Sagar division on October 20, 1972, it was included in the Sagar division. Apart from its forests, Panna is also famous for its ancient and beautiful temples. For this reason, it is also called 'City of Temples' (Government of Madhya Pradesh, 2022).

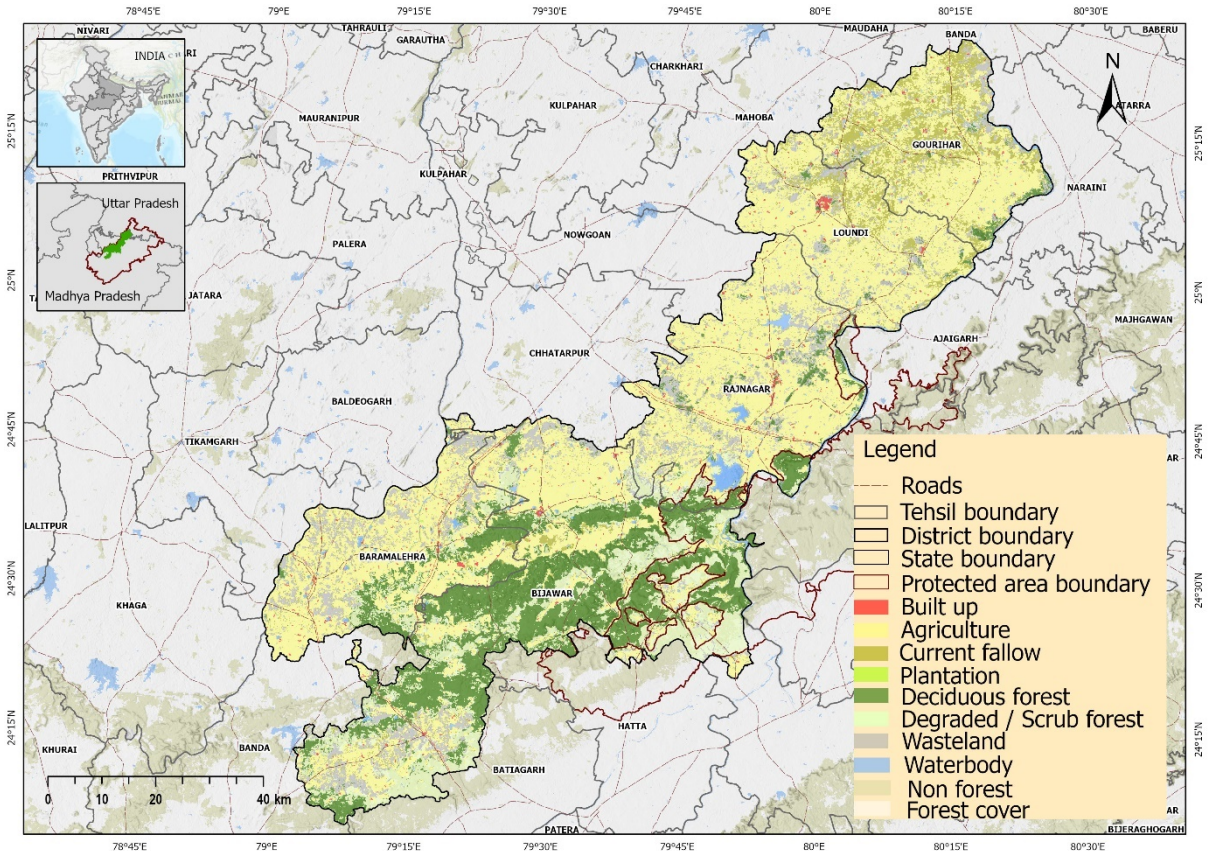


Figure 2.5. Map of the part of Chhatarpur district included in GPL

Chhatarpur District: Chhatarpur District has 11 tehsils and 1210 villages, of these, eight tehsils (Bada Malhera, Bijawar, Buxwaha, Chandla, Gaurihar, Ghuwara, Maharajpur and Rajnagar) and 897 villages have been included in the GPL (Fig. 2.5). Four ranges of Chhatarpur Forest Division and a large part of Panna Tiger Reserve fall within Chhatarpur district. The district Chhatarpur was named after the great warrior of the region 'Maharaja Chhatrasal'. Chhatarpur is also famous for its ancient temples, the most prominent of which is the Khajuraho

temple complex. Chhatarpur was also previously under the then Vindhya Pradesh and included in Madhya Pradesh at the time of its formation.

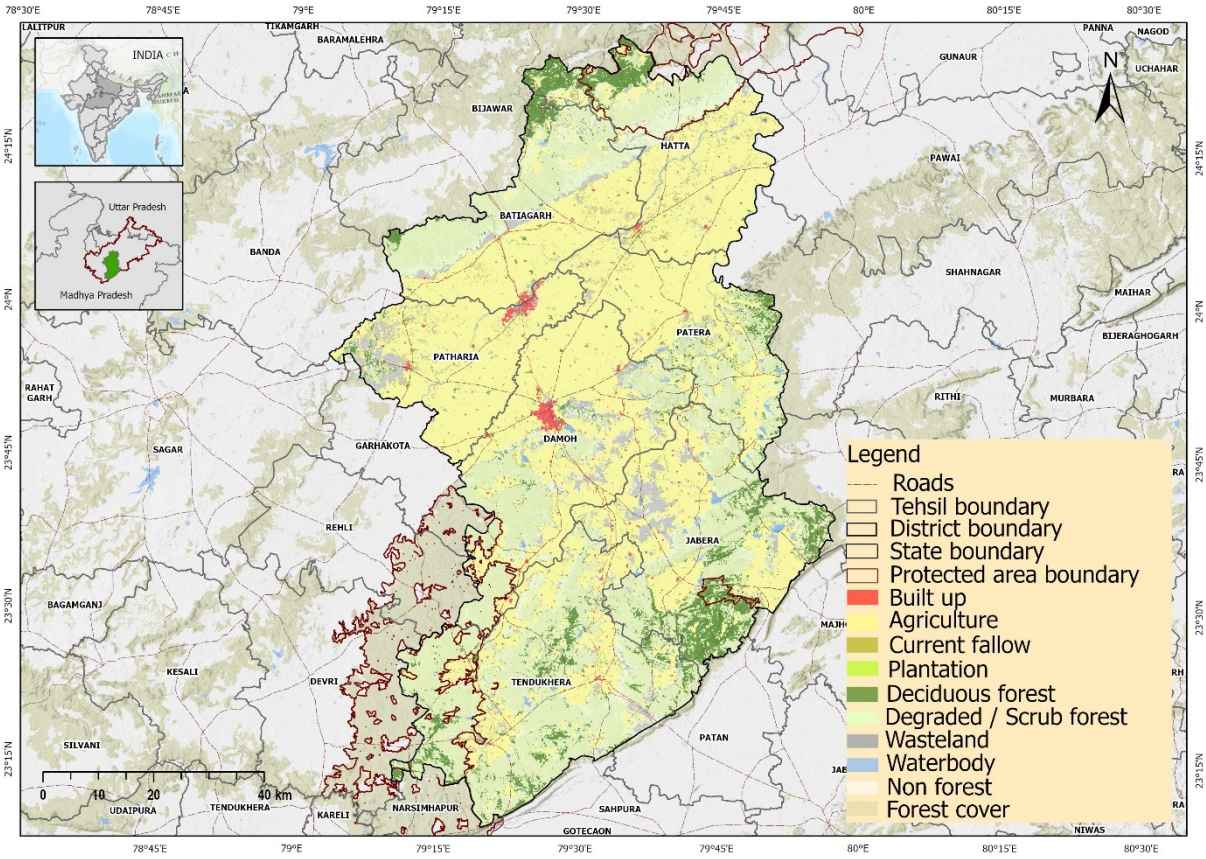


Figure 2.6. Map of Damoh District

Damoh District: Damoh District has a total area of 7306 Sq. Km (Fig. 2.6). It has eight tehsils (Damoh, Damyanti Nagar, Hatta, Pathriya, Jabera, Patera, Batiyagarh and Tendukheda) and 1229 villages, all of which are falling within the landscape boundary. Damoh Forest Division (Veerangana Durgawati Wildlife Sanctuary is also part of Damoh Forest Division) and one range of Panna Tiger Reserve (Madiyado) fall within the district. The district has great historical significance.

Katni District: Katni is a conglomeration of culture from three different cultural states *viz.* Mahakausal, Bundelkhand, and Baghelkhand. Two tehsils (Rithi and Bahoriband) of Katni District have been included in the landscape as they provide continuity to forest in the landscape (Fig. 2.7). These two tehsils include 297 villages and two forest ranges.

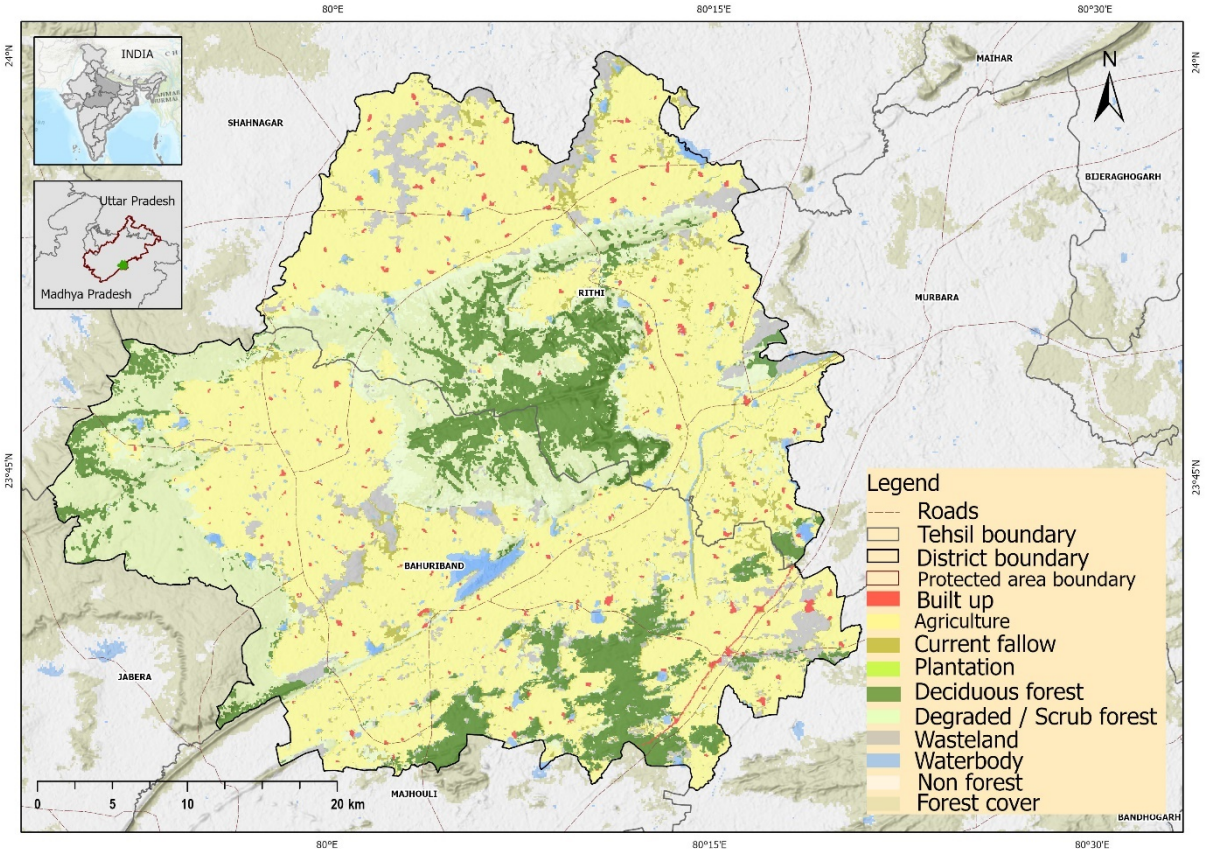


Figure 2.7. Map of the part of Katni district included in GPL

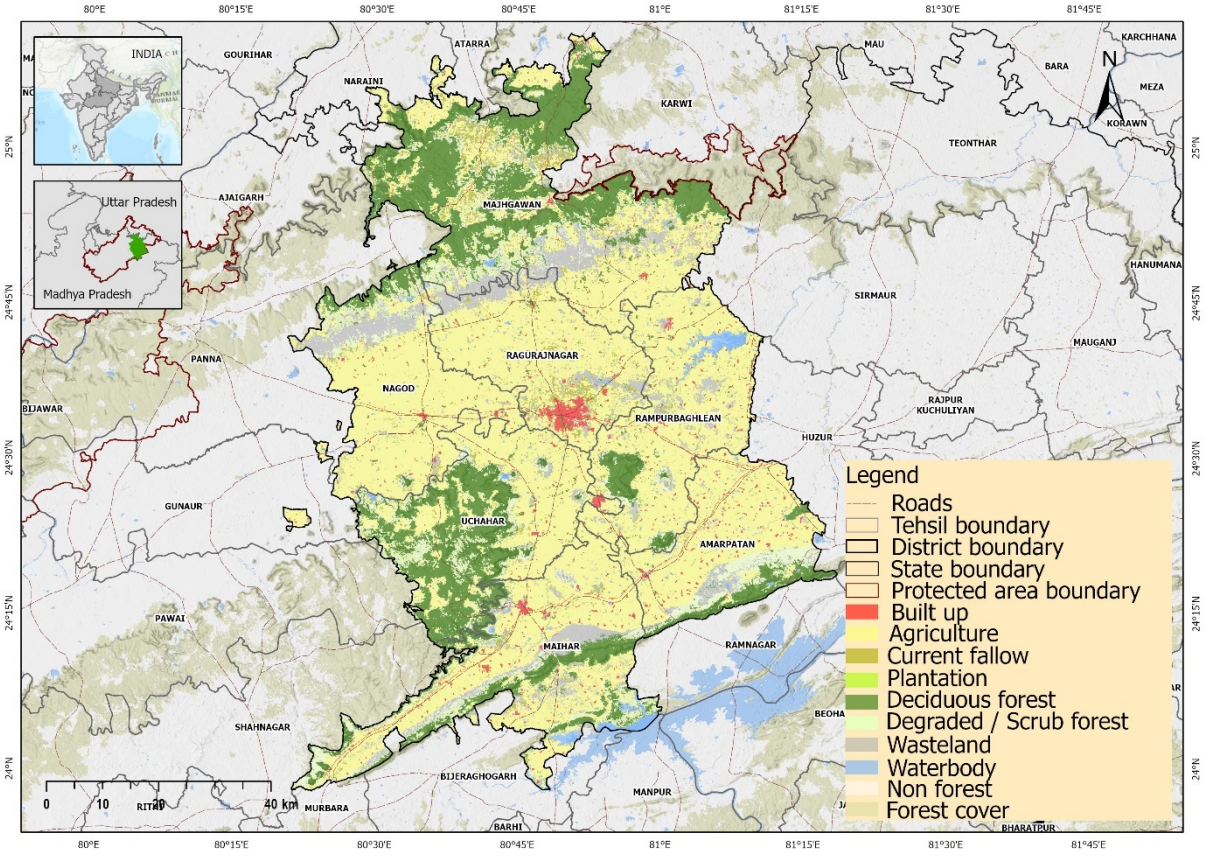


Figure 2.8. Map of Satna District

Satna District: Satna District has an area of 7502 sq. km. with 11 tehsils (Rajhurajnagar, Amarpatan, Maihar, Majhgawan, Nagod, Rampur Baghelan, Ramnagar, Unchehara, Kotar, Birsinghpur and Kothi) and 2125 villages (Fig. 2.8). The entire district but for a small part of Amarpatan tehsil falls within the GPL. Satna District is part of the region known as Baghelkhand since it was under the rule of the Baghels of Bandhavgarh for centuries.

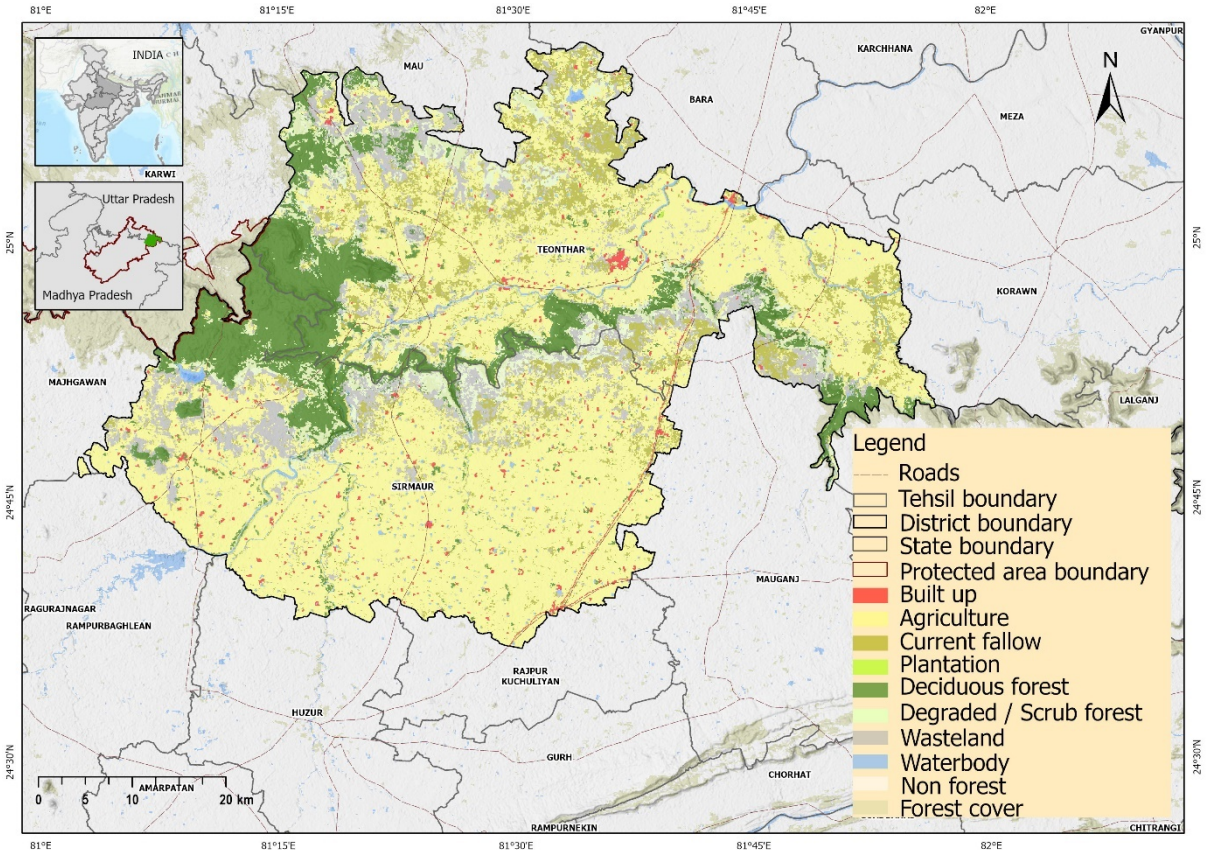


Figure 2.9. Map of the part of Rewa district included in GPL

Rewa District: Rewa District has an area of 6240 sq. km (Fig. 2.9). It has 11 tehsils and 2817 villages and of these, seven tehsils (Semariya, Jawa, Sirmour, Teonthar, Hanumana, Naigarhi and Mangawan) and 1985 villages have been included in the GPL. The Rewa city, which is situated in the central part of the Vindhya region, has been known worldwide for its white tigers. Baghel Rajputs established the former Rewa kingdom (Government of Madhya Pradesh, 2022). Rewa was also the capital of erstwhile Vindhya Pradesh.

Sagar District: The district of Sagar lies in the north central region of Madhya Pradesh (Fig. 2.10). It forms the western boundary of GPL. Sagar District has 11 tehsils out of which Bina Tehsil is not part of the landscape. The other ten tehsils *viz.* Banda, Malthone, Khurai, Shahgarh, Rahatgarh, Sagar, Garhakota, Rehli, Deori and Kesli are part of the landscape.

Totally, 1920 villages from these tehsils are included in the GPL. Sagar District includes South Sagar and North Sagar Forest Divisions and 3 ranges (Mohali, Singpur and Nauradehi) of Nauradehi Wildlife Sanctuary.

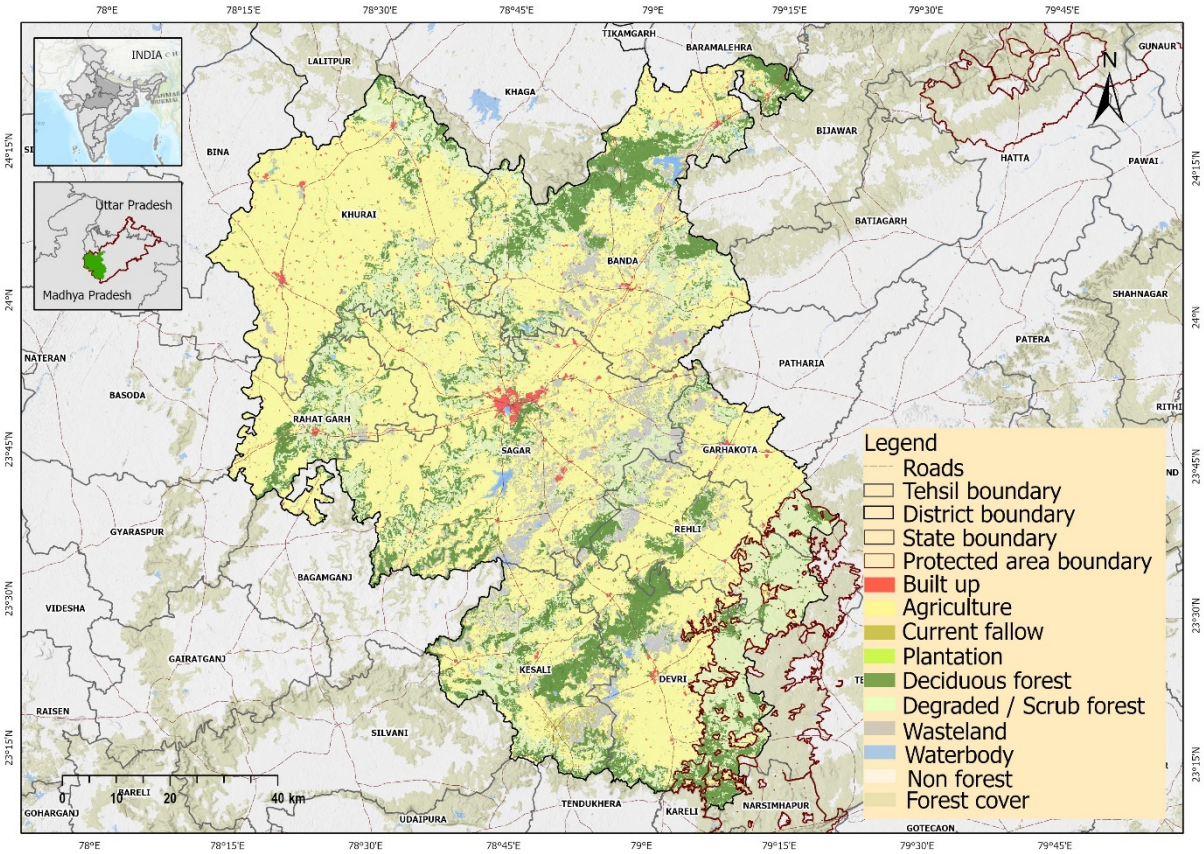


Figure 2.10. Part of Sagar District which has been included in GPL

Narsinghpur District: Narsinghpur District has been partially included in the Greater Panna Landscape as it includes one range of Nauradehi Wildlife Sanctuary (Dongergaon Range) (Fig. 2.11). Narsinghpur and Kareli Tehsils of the district falling north of the Narmada River have also been included in the GPL, due to habitat contiguity.

Banda District: Banda district falls within Uttar Pradesh (Fig. 2.12). Ken River joins Yamuna in Banda district. It has an area of 4408 sq. km. with four tehsils and 761 villages, of which three tehsils fall within the landscape (Banda, Naraini and Atarra). Adivasis, or indigenous people use to inhabit the region in prehistoric times. A very well-known Chinese traveller Hiuen Tsang (641-642 AD) mentions this region as Chih-Chi-to and its capital at Khajuraho. After the rule of Harsha-Vardhan, Kalchuris and Pratiharas over this tract, a long kingship of the famous Chandelas was established (Government of Uttar Pradesh, 2021).

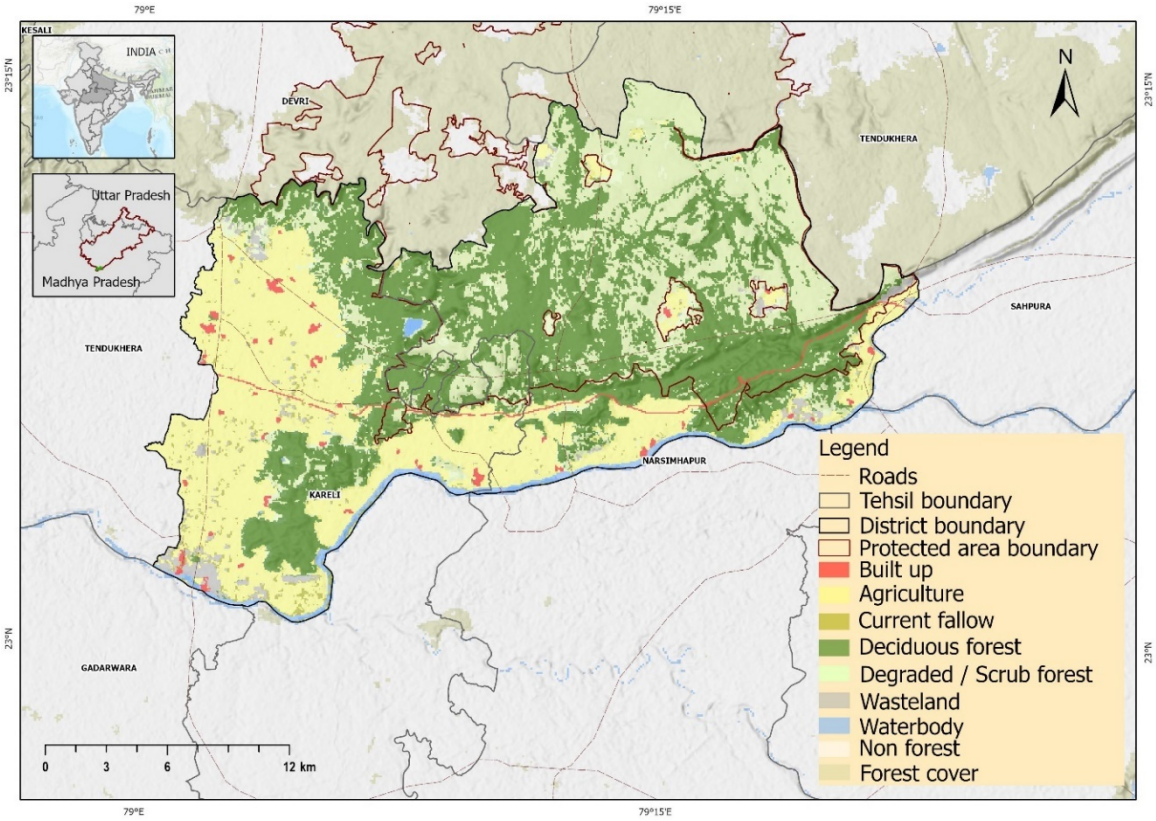


Figure 2.11. Map of the part of Narsinghpur district included in GPL

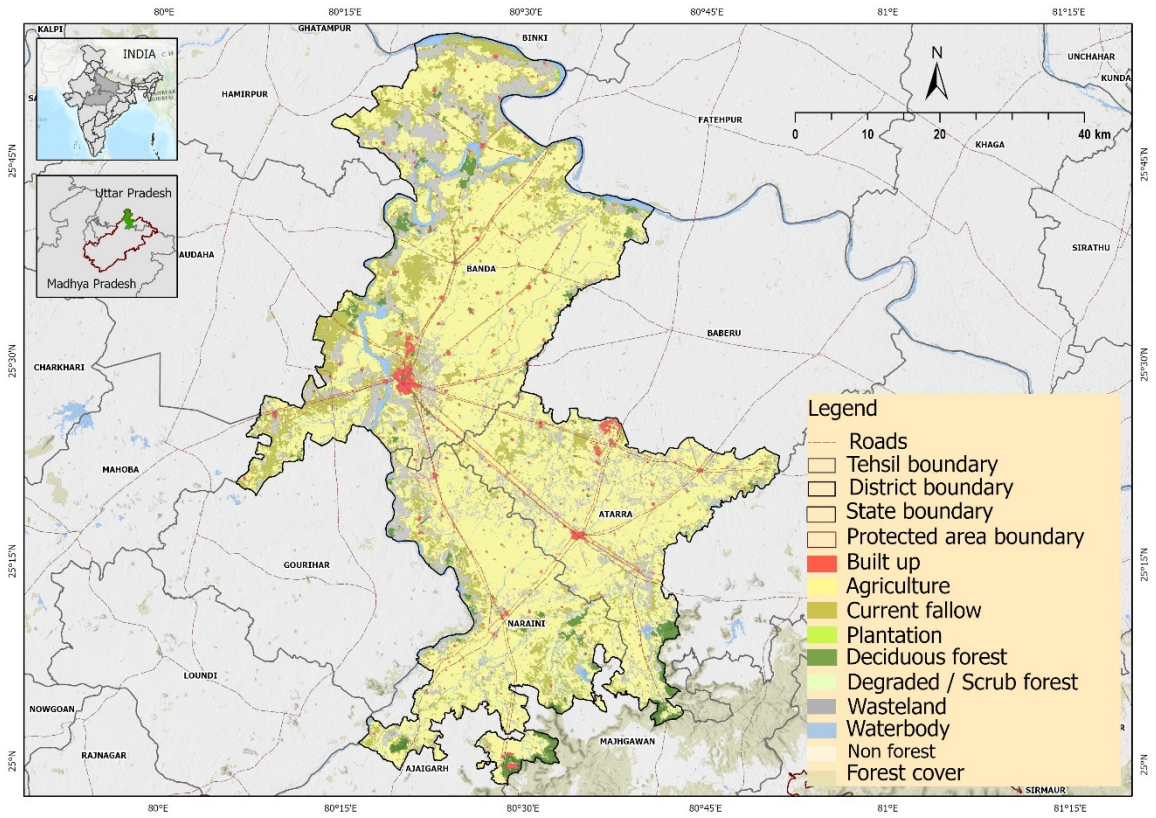


Figure 2.12. Map of the part of Banda district included in GPL

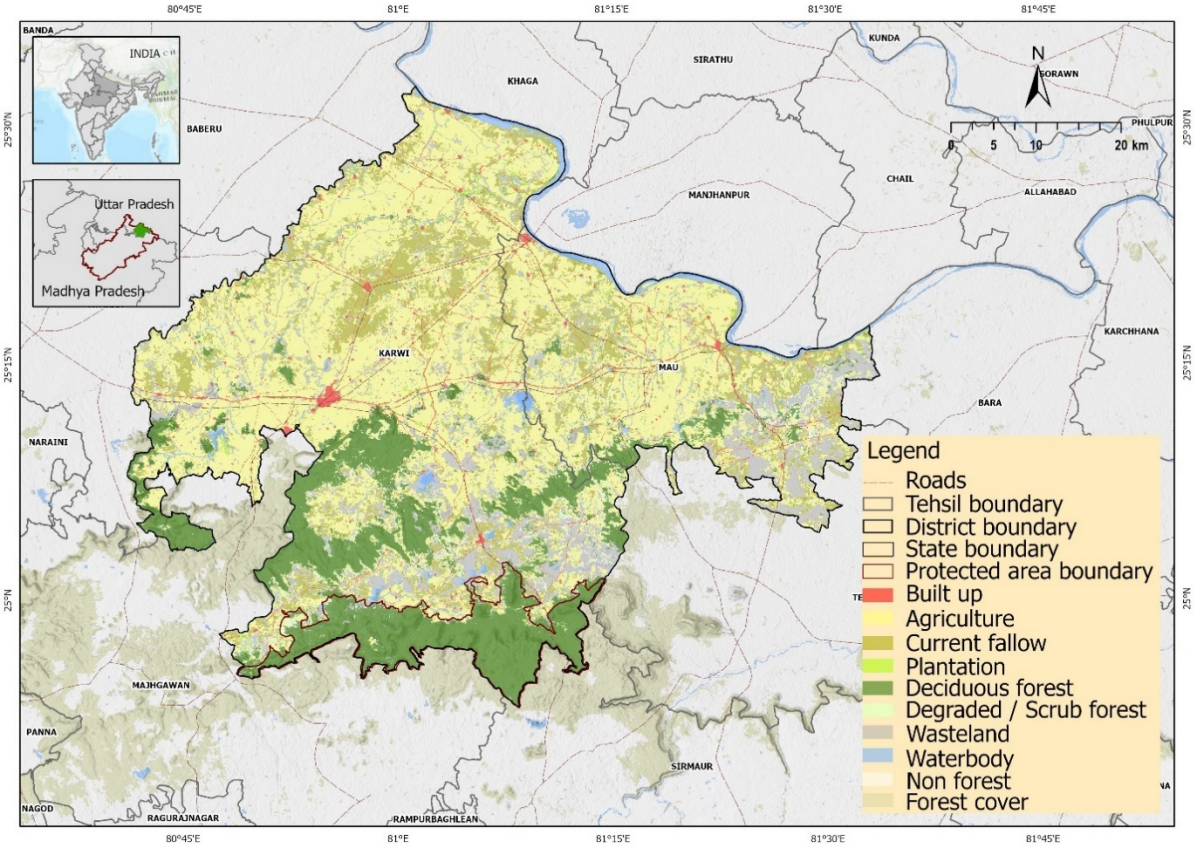


Figure 2.13. Map of the part of Chitrakoot district included in GPL

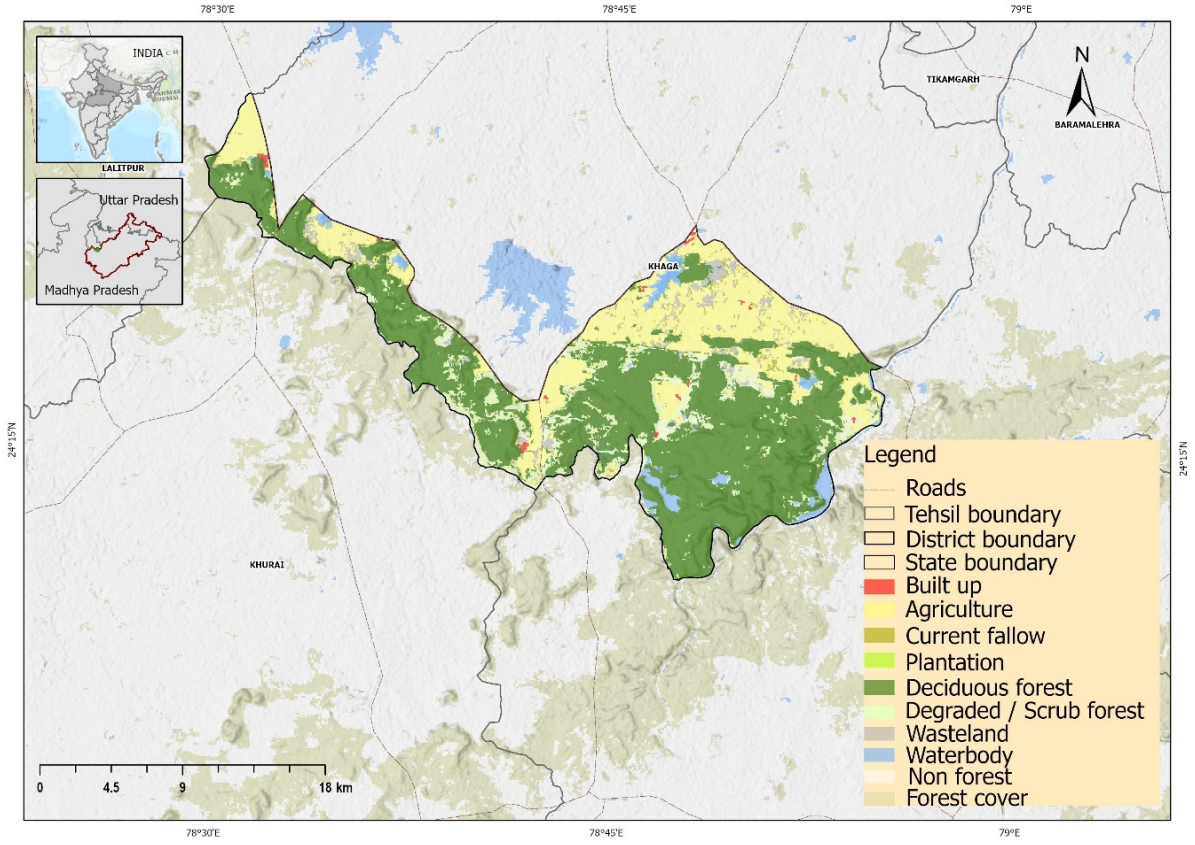


Figure 2.14. Map of the part of Lalitpur district included in GPL

Chitrakoot District: Chitrakoot District also falls within Uttar Pradesh. It has an area of 3164 sq.km with 4 tehsils and 653 villages, of which two tehsils fall within the landscape (Karwi and Mau) (Fig. 2.13). Ranipur Wildlife Sanctuary falls within the district. Carved out of Banda district in 1998, Chitrakoot is a holy place famous both for its natural beauty and temples.

Lalitpur District: Lalitpur District falls in the state of Uttar Pradesh. It has an area of 5039 sq. km. It has 5 tehsils and 764 villages (Fig. 2.14). Only a small part of Mehrauni Tehsil has been included in GPL to maintain the forest continuity.

2.6. Forest and Wildlife Administration:

Forest and wildlife are managed as separate entities from districts for their specialised service requirements and governance principles based on various specialised legislations and notifications. These areas are described below.

Protected Areas

Panna Tiger Reserve: Panna Tiger Reserve (PTR) is located in the Vindhyan ranges that extend from Southwest to Northeast in the civil districts of Panna, Chhatarpur and Damoh of Madhya Pradesh (Fig. 2.15). The total area of PTR is 1598.10 sq. km (Table 2.3). It is the 22nd Tiger Reserve to be declared in 1994 and is the only Tiger Reserve in the entire Bundelkhand Region. Panna National Park along with a part of Gangau Sanctuary (33.46 sq. km) form the core area or critical tiger habitat (CTH) of PTR (Madhya Pradesh Forest Department, 2007). The area of Panna National Park is 542.66 sq. km. of which 373.54 sq. km lies in Panna district and 169.11 sq. km. in Chhatarpur District. The total core area of PTR which is 576.13 sq. km., includes 281.87 sq.km. of Reserve Forest, 261.14 sq. km. of Protected Forest and 33.10 sq. km. of village area (Daudhan, Palkoha, Khariyani and Mainari). Gangau Dam area is being used by Uttar Pradesh Irrigation Department under some agreement. The CTH have two sub-divisions (Panna and Madla) and seven forests ranges (Panna Core, Hinauta, Madla, Chadranagar, Geharighat, Kishangargh and Gangau (Part). A total area of 1002.42 sq. km has been declared as “Buffer Zone of Panna Tiger Reserve” by Madhya Pradesh Government (Madhya Pradesh Forest Department, 2012). The buffer have two sub-divisions (Chhatarpur and Kishangarh) and four forests ranges (Panna Range formerly part of North Panna Forest Division, Amanganj Range formerly part of South Panna Forest Division, Kishangarh Range formerly part of Chhatarpur Forest Division and Madiadho Range formerly part of Damoh Forest Division). Of the total geographical area of buffer zone, 191.86 sq. km. is Reserved Forest, 681.58 sq. km. is Protected Forest, and 128.98 sq. km. is village area. In 2014, the total geographical area of buffer zone was increased from 1002.42 sq.km. to 1021.97 sq. km. which

includes 197.43 sq. km. of Reserve Forest, 695.25 sq. km. of Protected Forest and 129.29 sq. km. of village area. Additionally, an Eco-sensitive zone has also been declared around PTR (Table 2.3, Fig. 2.15). The adjoining forested landscape of the tiger reserve is contiguous with North Panna, South Panna, Chhatarpur and Damoh territorial forest divisions.

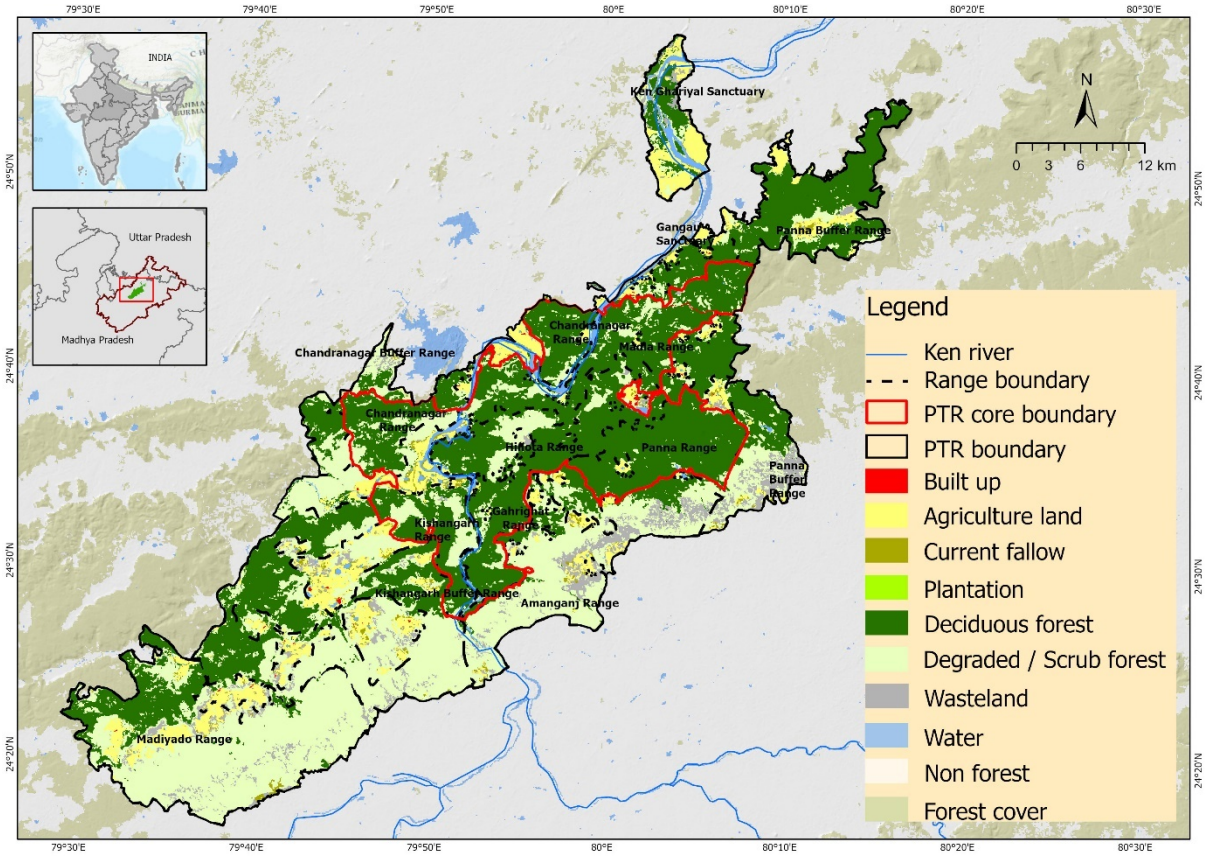


Figure 2.15. Map of Panna Tiger Reserve

Table 2.3: Management Zones in and around Panna Tiger Reserve

Zone	**Area (In sq. km.)**	**Status**	**Control**
Core Zone (Critical Tiger Habitat)			
Panna National Park	542.67	Inviolate Area	Panna Tiger Reserve
Gangau Wildlife Sanctuary	33.47		
Total Core Zone Area	576.13		
Buffer Zone			
District Panna	399.04	Multiple use area	Panna Tiger Reserve
District Chhatarpur	344.93		
District Damoh	277.99		

Total Buffer zone Area	1021.96		
Total Area of Tiger Reserve **Eco-Sensitive Zone**	**1598.1** **1081.48**		

PTR has step like topography. It consists of distinct topographic characteristics at the southern bank of Ken River - Upper Talgaon plateau (Panna Range), Middle Hinauta Plateau (Hinauta Range), and Lower Ken Valley (Madla Range). These plateaus are separated by steep and rocky escarpments of varying height ca. upto 80m. The elevation of PTR ranges from 123 meters to 566 meters and the slope varies between 0° to 48° (Table 2.4). PTR is located a little north of the Tropic of Cancer hence temperature during summer months of March to June remains above 32 °C and can exceed 45° C. The average rainfall is 1100 mm and the monsoon is active from July to September months. Winter season starts from November to mid-February, the minimum mean temperature remains around 7- 8^0 Celsius and average diurnal range of temperature varies between 15-20 degrees.

Table 2.4: Physical characteristics of PTR

Physical attribute	**Value**
Elevation Maximum	566m
Elevation Minimum	123m
Elevation Mean	344m
Slope Maximum	48º
Slope Minimum	0º
Slope Mean	5º
Drainage Density	230m/km^2

PTR is a part of the Indo-Malayan Realm and it is a member of the Oriental region and lies in Zone 6 E - 'Deccan Peninsula – Central Highlands' Zoo-geographically. It is categorized as tropical dry-deciduous forests (Meher-Homji, 1990). Champion and Seth (1968) also broadly classified it as group 5 'Tropical Dry Deciduous Forest'. The dominant species of PTR are Teak (*Tectona grandis)*, Khair (*Acacia catechu*), Tendu (*Dyospyros melanoxylon*), Moyan (*Lannea coromandelica*), Ghont (*Ziziphus xylopyra*), Kardhai (*Anogeissus pendula)*, Lendia *(Lagerstroemia parviflora*), and Dhaora (*Anogeissus latifolia*).

The tiger reserve has a diverse carnivore population, including tiger (*Panthera tigris*), leopard (*Panthera pardus*), sloth bear (*Melursus ursinus*), dhole (*Cuon alpinus*), grey wolf (*Canis lupus*), striped hyena (*Hyaena hyaena*), jungle cat (*Felis chaus*) and Indian fox (*Vulpes bengalensis*)**.** Major herbivores in the reserve are sambar (*Rusa unicolor*), chital (*Axis axis*), wild pig (*Sus scrofa*), nilgai (*Boselaphus tragocamelus*), Four-horned antelope (*Tetracerus quadricornis*) and chinkara (*Gazella bennettii*) (Chundawat and Sharma, 2008). PTR also supports a significant vulture population, the common species found here are Long-billed vulture (*Gyps indicus*), Egyptian vulture (*Neophron percnopterus*), Red-headed vulture (*Gyps calvus*) and Himalayan griffon (*Gyps himalayensis*) (Gurjar and Gawande, 2011). Over 150 bird species and 10 reptile species are recorded in PTR. Apart from 50 species of fishes that includes Mahasheer (*Tor tor*) and other riverine/aquatic species, Ken river passing through the centre of PTR also provides suitable habitat to Mugger *(Crocodylus palustris)* and Gharial (*Gavialis gangeticus*) (Johnson et al., 2012).

Ken Gharial Sanctuary: KGS is a small sanctuary with an area of 45 sq. km (Fig. 2.16), but is of great importance to the conservation of crocodilians in the landscape. Although the gharial population here is limited to very few (most likely one) individuals. It is dominated by deciduous forest and agriculture land. It comes under the administrative control of Field Director, PTR.

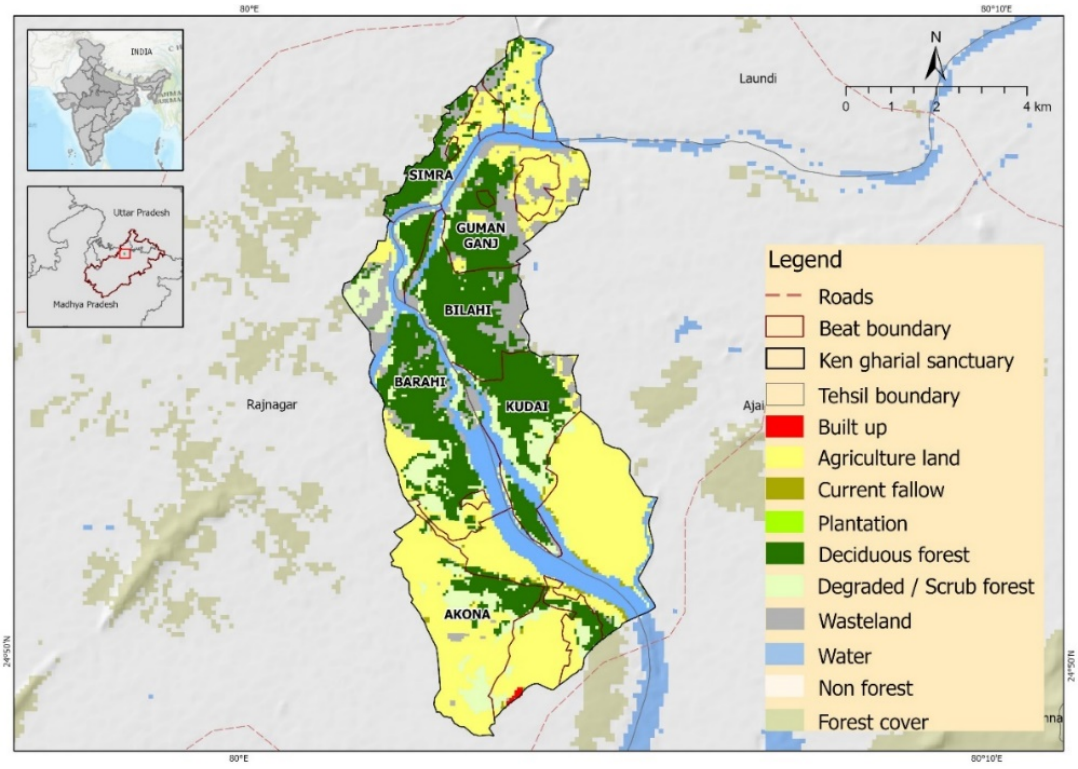


Figure 2.16. Map of Ken Gharial Sanctuary

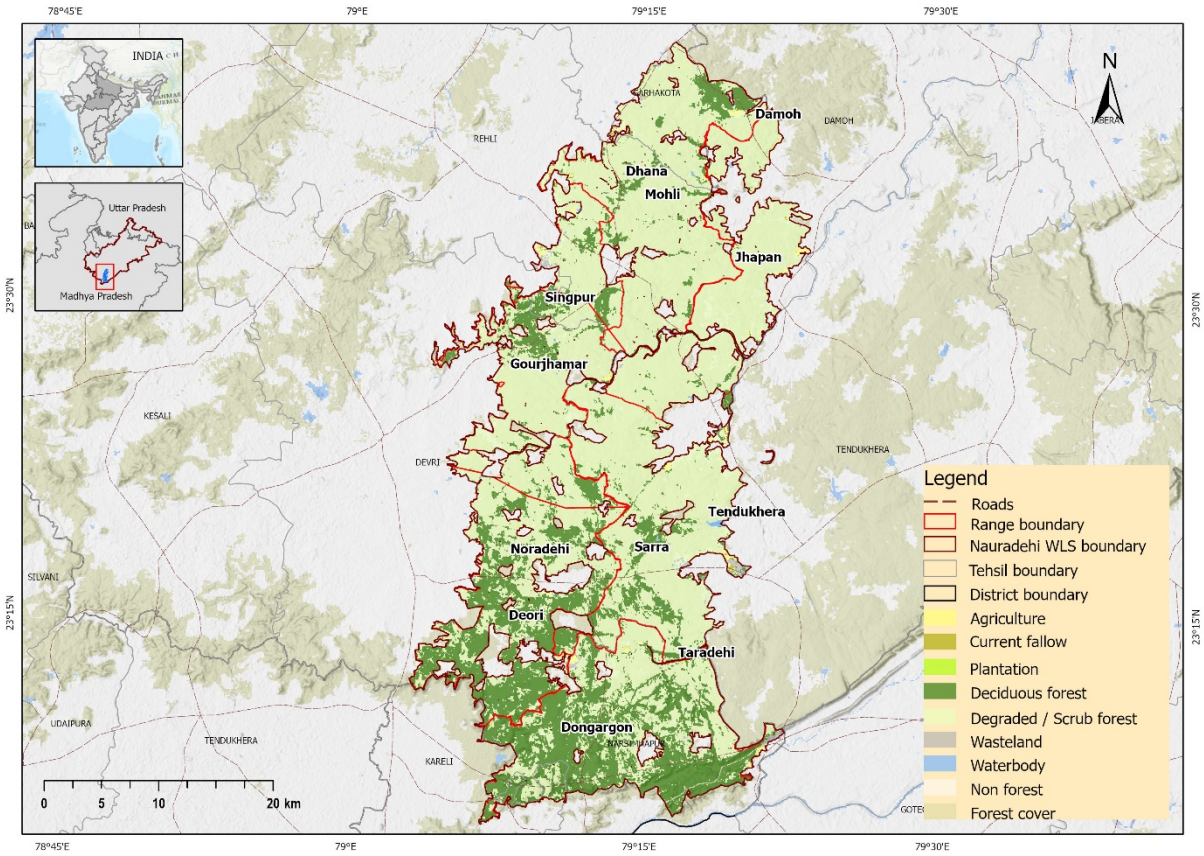


Figure 2.17. Map of Nauradehi Wildlife Sanctuary

Nauradehi Wildlife Sanctuary: The sanctuary was established in 1975 vide government of Madhya Pradesh Notification no. 700-624-Ten-2-75/17-2-1975. and is distributed over three districts *viz*., Sagar, Damoh and Narsinghpur (Fig. 2.17). In 1984, the sanctuary was given the status of wildlife division vide notification 1912-10-1-84 dated 2-3-1984. The Narsinghpur part was included finally to the sanctuary in 2006 by Madhya Pradesh govt. order no. F-15-9/2006/10-2 dated 6-5-2006. The total area of the sanctuary is 1197.287 sq. km. The sanctuary is mostly situated on Vindhyan hills with undulating planes, perennial rivers and mixed dry deciduous forest (Table 2.5). The sanctuary is very rich in flora and fauna with 250 species of animals, birds, reptiles, amphibians and fishes (Shukla, 2007). This place is also a very good tiger habitat with presence of tiger and leopard population. In Bamner River, crocodile is found. Despite such diverse and rich faunal diversity, this place is under huge anthropogenic pressure due to 57 villages present in and around the sanctuary (Shukla, 2007).

Table 2.5: Area under different land cover classes within Nauradehi Wildlife Sanctuary

S. no.	Land cover class	Area (km^2)
1	Water	4.7
2	Non-forest	229.72
3	Scrub forest	12.38
4	Open forest	562.88
5	Mod. Dense forest	582.75

Veerangana Durgawati Wildlife Sanctuary: Veerangana Durgawati Wildlife Sanctuary is under the administration of Damoh Forest Division (Fig. 2.18). The area of the sanctuary is 24 sq. km. The sanctuary was notified by the Government of Madhya Pradesh in 1996. The sanctuary has a varied landscape consisting of hills, valleys and plains with several streams flowing through them. The vegetation is predominantly tropical mixed dry deciduous forest and some teak forests. *Pterocarpus marsupium, Terminalia tomentosa, Anogeissus latifolia, Madhuca longifolia, Butea monosperma* and *Lagerstroemia parviflora* are the most common trees in the sanctuary. The Singorgarh fort is located within the sanctuary.

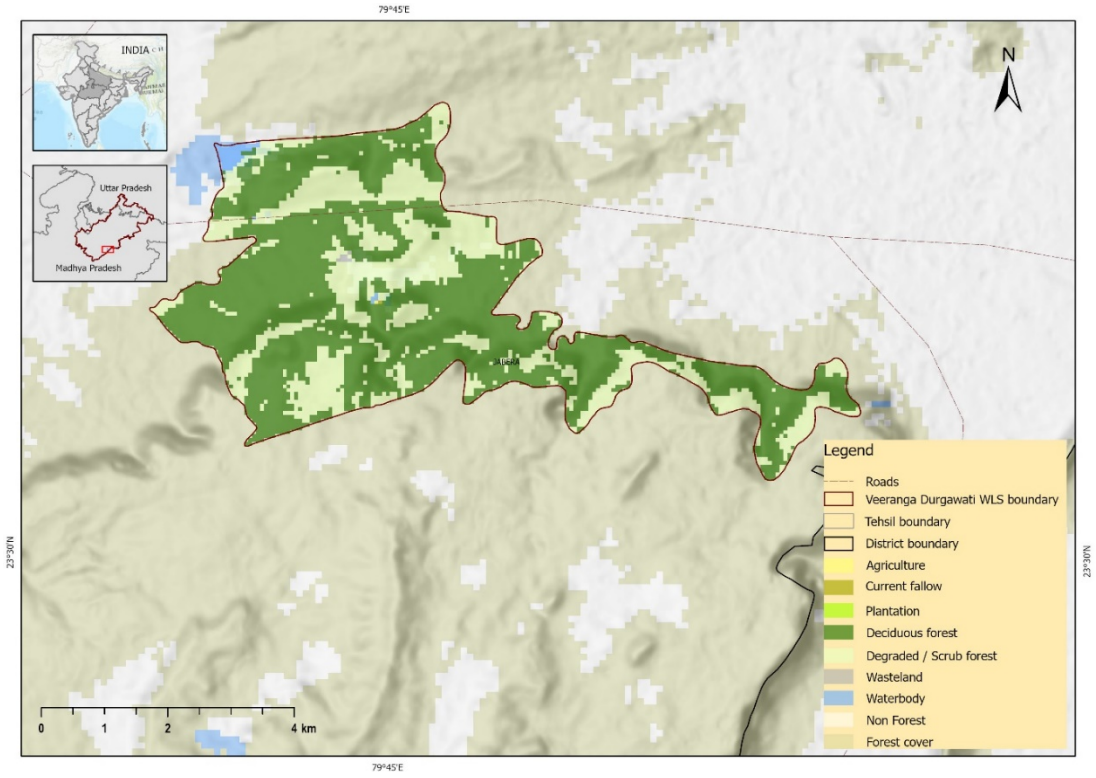


Figure 2.18. Map of Veerangana Durgawati Wildlife Sanctuary

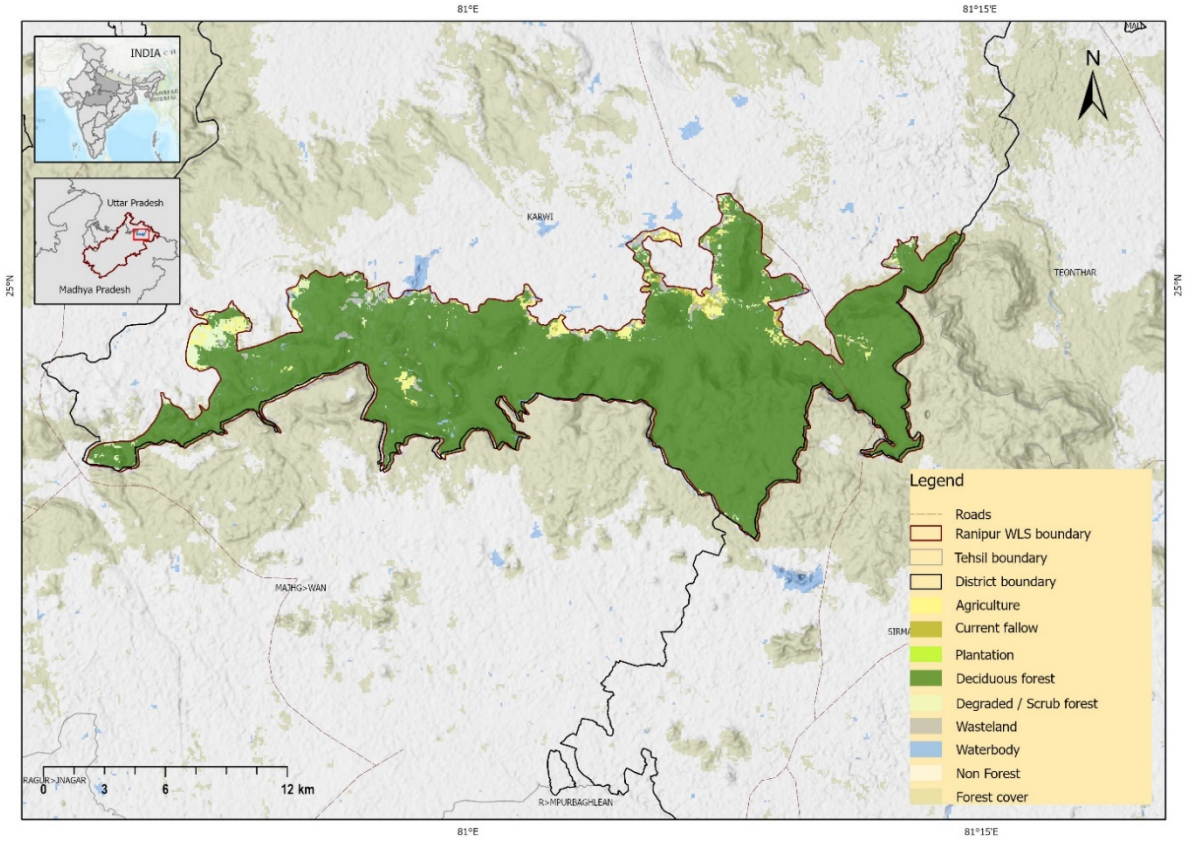


Figure 2.19. Map of Ranipur Wildlife Sanctuary

Ranipur Wildlife Sanctuary: Ranipur Wildlife Sanctuary is in Chitrakoot District of Uttar Pradesh (Fig. 2.19). It was notified by Government of Uttar Pradesh in 1976. It is under administrative control of DFO Kaimur Wildlife Sanctuary. It has an area of 236 sq. km. Several animals inhabit the sanctuary including tiger, leopard, sloth bear, sambar, blackbuck, peafowl, spur fowl, jungle fowl, painted partridge, fishing cat and chinkara.

Forest Divisions

Apart from the protected areas, twelve forest divisions also fall within the landscape. Their maximum elevation ranges from 554m to 740m, minimum elevation ranges from 41m to 317m. Drainage density ranges from 0.24 to 0.28 km/km^2 (Table 2.6). Of the nine forest divisions of Madhya Pradesh, four fall completely within GPL, viz. North Panna, South Panna, South Sagar and Damoh; three are mostly inside GPL viz. Satna, Chhatarpur and North Sagar; and two are only partially inside GPL viz. Rewa and Katni (Fig. 2.20). Characteristics of these forest divisions are discussed in detail below. All the three forest divisions falling within Uttar Pradesh (Banda, Chitrakoot and Lalitpur) have their boundaries completely overlapping with the district boundary, hence they have not been described in detail separately.

Table 2.6: Physical characteristics of the forest divisions within the GPL

Division	Elevation (m) Max	Elevation (m) Min	Elevation (m) Mean	Slope (degrees) Max	Slope (degrees) Min	Slope (degrees) Mean	Drainage Density
Madhya Pradesh							
Katni	665	305	485	43.2	0	2.93	0.24
North Panna	555	84	320	44.23	0	3.28	0.27
South Panna	648	247	448	43.13	0	2.92	0.26
Rewa	669	41	350	60.89	0	2.96	0.26
Damoh	740	278	509	49.15	0	2.44	0.27
Satna	700	87	396	51.84	0	3.27	0.24
Chhatarpur	554	53	304	50.03	0	2.59	0.24
North Sagar	647	310	477	42.62	0	2.42	0.26
South Sagar	680	317	500	37.32	0	2.55	0.28
Uttar Pradesh							
Chitrakoot	439	29	153	38.07	0	2.7	0.23
Banda	411	34	117	41.47	0	1.61	0.24
Lalitpur	613	343	438	42.78	0	3.86	0.21

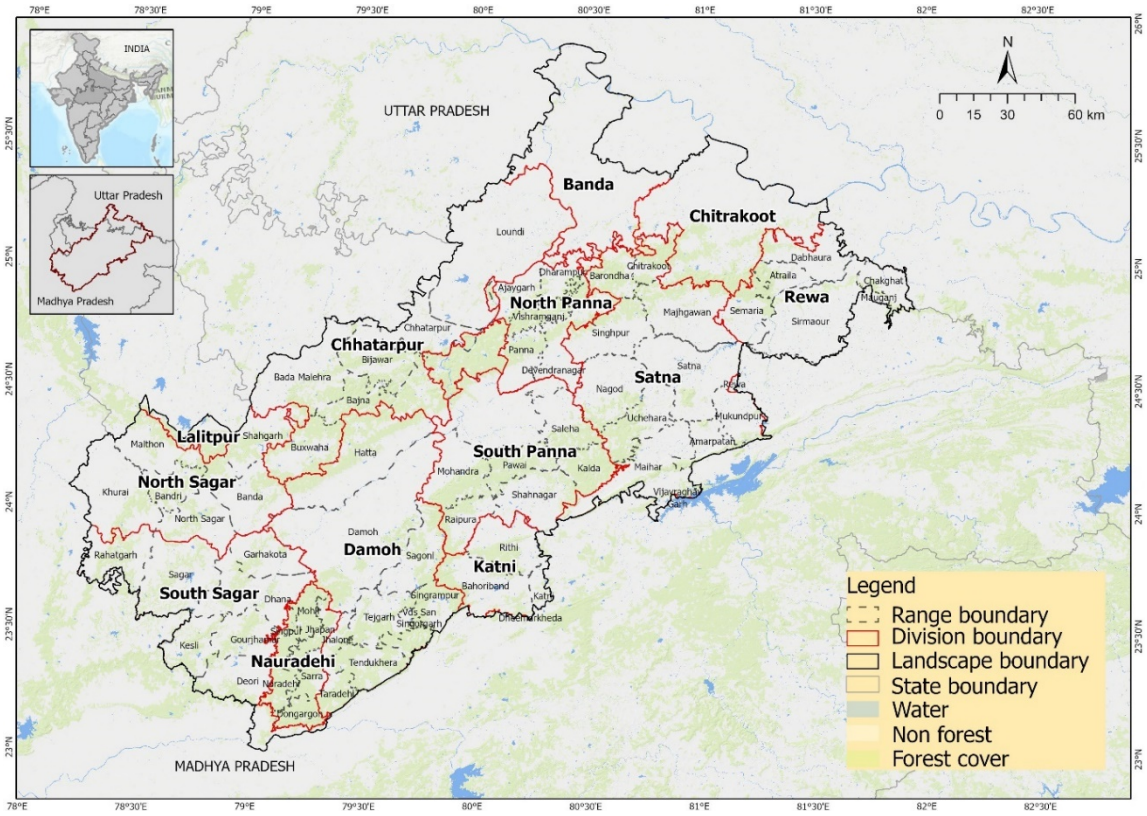


Figure 2.20. Forest divisions falling within Greater Panna Landscape

1. **Damoh Forest Division (Madhya Pradesh):** Damoh Forest Division comprises of two sub-divisions (Damoh and Tendukhera) and nine forest ranges (Hatta, Singrampur, Tendukhera, Tejgarh, Jhalone, Damoh, Sagoni, Singorgarh and Taradehi). With an area of 6813.38 sq. km, it is one of the largest forest divisions in the landscape. It also has the largest forest cover (2377 sq. km.) as compared to other forest divisions of Madhya Pradesh completely falling within the landscape (Table 2.7)

Table 2.7: Area under different land cover classes within Damoh Forest Division

S. No.	Land cover class	Area (km^2)
1	Water	56.90
2	Non-forest	4378.60
3	Scrub forest	123.10
4	Open forest	1491.70
5	Mod. Dense forest	760.60
6	Dense forest	2.50

2. **Satna Forest Division (Madhya Pradesh):** Satna Forest Division comprises of three sub-divisions (Satna, Chitrakoot and Maihar) and ten forest ranges (Majhgawan, Singhpur, Satna, Nagod, Uchehara, Mukundpur, Amarpatan, Maihar, Baronda, and Chitrakoot). It is the largest forest division among all forest divisons of Madhya Pradesh falling within the landscape (6841.26 sq. km) with a forest cover of 1840.18 sq. km (Table 2.8).

   Table 2.8: Area under different land cover classes within Satna Forest Division

S. No.	Land cover class	Area (km^2)
1	Water	59
2	Non-forest	4941.80
3	Scrub forest	187.20
4	Open forest	746.70
5	Mod. Dense forest	894.40
6	Dense forest	11.90
7	Unclassified	0.30

3. **Chhatarpur Forest Division (Madhya Pradesh):** Chhatarpur Forest Division comprises three sub-divisions (Bijawar, Buxwaha and Chhatarpur) and seven forest ranges (Bijawar, Bada, Malehra, Buxwaha, Bajna, Chhatarpur and Loundi). It has the third largest area (6510.03 sq. km) as compared to other forest divisions of Madhya Pradesh within the landscape and a forest cover of 1744.04 sq. km (Table 2.9).

Table 2.9: Area under different land cover classes within Chhatarpur Forest Division

S. No.	Land cover class	Area (km^2)
1	Water	59.20
2	Non-forest	4706.60
3	Scrub forest	209.60
4	Open forest	654.90
5	Mod. Dense forest	729.30
6	Dense forest	150.30
7	Unclassified	0.20

4. **South Panna Forest Division (Madhya Pradesh):** South Panna Forest Division comprises two sub-divisions (Pawai and Kalda) and six forest ranges (Mohandra, Raipura, Kalda, Pawai, Saleha and Shahnagar). The forest division has an area of 4523.55 sq. km and forest cover of 1630.54 sq. km (Table 2.10).

Table 2.10: Area under different land cover classes within South Panna Forest Division

S. No.	Land cover class	Area (km^2)
1	Water	35.10
2	Non-forest	2857.90
3	Scrub forest	150.90
4	Open forest	817.60
5	Mod. Dense forest	658.80
6	Dense forest	3.30

5. **South Sagar Forest Division (Madhya Pradesh):** South Sagar Forest Division comprises two sub-divisions (South Sagar and Deori) and seven forest ranges (Sagar,

Rahatgarh, Dhana, Kesli, Deori, Garhakota and Gourjhamar). The forest division has an area of 4672.62 sq. km and forest cover of 1204.27 sq. km (Table 2.11).

Table 2.11: Area under different land cover classes within South Sagar Forest Division

S. No.	Land cover class	Area (km^2)
1	Water	33.40
2	Non-forest	3435
3	Scrub forest	55
4	Open forest	699.40
5	Mod. Dense forest	450

6. **North Sagar Forest Division (Madhya Pradesh):** North Sagar Forest Division comprises two sub-divisions (North Sagar and Banda) and six forest ranges (Banda, Khurai, Shahgarh, Malthon, Bandri and North Sagar). The forest division has an area of 4183.38 sq. km and forest cover of 1075.05 sq. km (Table 2.12).

   Table 2.12: Area under land cover classes within North Sagar Forest Division

S. No.	Land cover class	Area (km^2)
1	Water	16.90
2	Non-forest	3091.40
3	Scrub forest	48
4	Open forest	651.80
5	Mod. Dense forest	373.70
6	Dense forest	1.50
7	Unclassified	0.03

7. **North Panna Forest Division (Madhya Pradesh):** North Panna Forest Division comprises two sub-divisions (Vishramganj and Panna) and five forest ranges (Ajaygarh, Dharampur, Vishramganj, Panna and Devendranagar). The forest division has an area of 2130.27 sq. km and forest cover of 803.39 sq. km (Table 2.13).

Table 2.13: Area under different land cover classes within North Panna Forest Division

S. No.	Land cover class	Area (km^2)
1	Water	14
2	Non-forest	1312.60
3	Scrub forest	72.10
4	Open forest	199.30
5	Mod. Dense forest	527.60
6	Dense forest	4.50
7	Unclassified	0.30

8. **Rewa Forest Division (Madhya Pradesh):** Rewa Forest Division comprises two sub-divisions (Rewa and Mauganj) and seven forest ranges (Atraila, Semaria, Sirmaour, Chakghat, Dabhaura, Rewa and part of Mauganj). The area of forest division falling within Panna Landscape is 3117.24 sq. km, with forest cover of 586.76 sq. km (Table 2.14).

Table 2.14: Area under different land cover classes within Rewa Forest Division

S. No.	Land cover class	Area (km^2)
1	Water	29.50
2	Non-forest	2501
3	Scrub forest	87
4	Open forest	173.40
5	Mod. Dense forest	267.90
6	Dense forest	58.50
7	Unclassified	0.20

9. **Katni Forest Division (Madhya Pradesh):** Katni Forest Division comprises two sub-divisions (Katni East and Katni West) and three forest ranges (Katni, Rithi and Bahoriband). The area of forest division falling within the landscape is 1652.76 sq. km with forest cover of 481.46 sq. km (Table 2.15).

Table 2.15: Area under different land cover classes within Katni Forest Division

S. No.	Land cover class	Area (km^2)
1	Water	18.70

2	Non-forest	1152.60
3	Scrub forest	13.40
4	Open forest	279.80
5	Mod. Dense forest	187.80
6	Dense forest	0.50

2.7. Significance of the Landscape: GPL is a typical Vindhyan landscape. It has a tabletop topography. According to Champion and Seth (1968), the landscape lies within the dry deciduous forest type. However, the landscape offers a mosaic of habitat starting from hilly terrain, open grassland, dense forest, riparian forests, riverine habitat, etc. which can provide unique trophic niches to a large variety of species. PTR is the only tiger reserve of Vindhyachal Ranges and Bundelkhand region. If this tiger reserve is lost, connectivity between eastern and western tiger reserves of the landscape will be lost all together. Despite continuous warnings, local extinction of tigers took place in this reserve in the recent past (2009). But the government immediately responded by formulating the Panna Tiger Reintroduction Project which brought back the tigers in the landscape in less than three years. Panna Tiger Reintroduction programme had a component of successful experimentation of re-wilding the two orphaned tigers which is a first ever such accomplishment in tiger conservation history in the world. Thus, the successful tiger reintroduction/tiger rewilding programme is a path breaker for reviving low tiger density areas on a national and global scale. The landscape also hosts tigers in Ranipur Wildlife Sanctuary and Nauradehi Wildlife Sanctuary. The GPL also harbours many vultures, which need to be protected. Additionally, Ken River in the landscape holds a significant population of muggers and is a potential habitat for gharials.

Culturally much of the landscape falls under Bundelkhand (Chhatarpur, Panna, Damoh and Sagar districts in MP, and Lalitpur, Banda, and Chitrakoot districts in UP). However, parts of the landscape also fall within Baghelkhand (Rewa and Satna districts in MP). The GPL has various unique values, traditions, and practices that makes this region culturally significant. It is well known for its archaeological monuments and religious sites. The rulers of Bundelkhand (Chandelas and Bundelas) left behind a rich heritage in form of numerous forts, palaces, and temples. Chhatarpur district was named after Chhatrasal, the Bundela chief who contributed to making Panna district as the ‘town of temples’. He constructed several temples devoting them to Lord Shiva in honour of Saint Prabhunath in Panna because of which the district is now a

popular place of tourist attraction (Centre of Excellence, 2018). Additionally, some of the major festivals of great meaning are held in this landscape at different times during the year. These include- Gour festival in Sagar; Bundeli Mela in Damoh; Mela Jal Vihar and Khajuraho dance festival in Chhatarpur; International Sharad Purnima festival and Rath yatra in Panna; Navratri Mela in Satna; Maha Mrityunjay festival, Malmaas festival, Bindhya Mahotsav in Rewa; Dashhera of Kymore in Katni; Burman Mela in Narsinghpur; Bhuragarh fair, Nawab Tank fair; Kalinjar fair in Banda etc. (Tour my India, 2020). Many other sacred and religious sites are located within the forests, dedicated to unique deities and belief-systems.

The average per capita income of MP districts falling within the landscape is INR 72,631 which is higher than the average per capita income of UP districts falling within the landscape (INR 49,268) (Indiastat, 2019). However, the average per capita income of GPL (INR 66,260) is much lower than the national per capita income (INR 1,26,406) (Indiastat, 2019; PTI, 2020). The economic condition of the region is poor owing to frequent droughts and lack of development. Out of 13 districts falling within Bundelkhand, ten are labelled as “backward” and “human development poor” by Government of India and NITI Aayog (Ministry of Panchayati Raj, Government of India, 2009). The annual health survey has recorded undernourishment in young children within six districts of Madhya Pradesh (Boiroju *et al.*, 2018). The marginalised rural population of the region faces extreme poverty with lack of livelihood options and low industrialisation. The economy functions on agriculture which is severely affected by migration of locals towards cities. Therefore, the region needs economic and social development while ensuring conservation of its natural heritage.



CHAPTER 3

PLANNING PROCESS AND TOOLS

Chapter 3: Planning Process and Tools

3.1. Vision Statement: Conservation value of Greater Panna Landscape (GPL) is strengthened and advanced towards long-term viability and ecosystem services.

3.2. Goal: The goal of Integrated Landscape Management Plan is to ensure "winning" situation for conservation in the development process based on balanced approach and considering the diverse stakes.

3.3. Objectives: The vision and goals are aimed to be achieved with the following specific objectives keeping in view local and regional contexts:

1. To enable betterment of habitat, protection, and management for flagship species *viz.* tiger, vultures, and gharial in the landscape.
2. To consolidate the landscape for overall biodiversity conservation through spatial prioritisation and well-being of forest dependent communities.
3. To provide species-specific and site-specific monitoring strategies under the integrated landscape management context with feedback loop and adaptive management options.

3.4. SWOT Analysis

3.4.1. Strength: The GPL represents Vindhyan Hill Range with unique geomorphological, biological and sociological characteristics, possesses ancient cultural symbols such as rock paintings that are hundreds of years old, records the most successful tiger recovery project with meta-population dynamics requiring landscape approach, contains several inviolate habitats and populations of vultures across the landscape, holds potentials for recovery of gharials with vast riverine habitats, has a people-forest relationship that has significant resilience capacity, and has a well-established network of professionals with administrative and institutional mechanisms to implement integrated landscape management strategies effectively.

3.4.2. Weakness: The GPL is more connected along east-west axis, while the land area on the north and south of the landscape is a mosaic of human habitation, agriculture, and industrial establishments, making the landscape area to be large habitat islands unless structurally and functionally connected. Except for a small proportion of the area, human population is scattered among the forest areas, causing forest dependency to be a continuing phenomenon over ages, and making habitat integrity to be affected by fragmentation. People dependency of the forest

for animal husbandry practices and minor forest produces makes the people and wildlife vulnerable to human-wildlife conflicts.

3.4.3. Opportunities: GPL has 12125.70 sq.km of forest area, distributed across 11 districts. Protected Areas (PA) covers 3100.40 sq.km area (26% of existing forest area) and of which, Panna Tiger Reserve (PTR) alone contributes to 50% of this coverage and acts as source for many wildlife species. Local extinction of tiger in PTR was responded with active recovery programme which resulted in rapid recovery of the species from zero to over 80 individuals in the last one decade, marking this as one of the fastest and successful recovery of tigers in the world. Around 37 tigers have already dispersed, highlighting the connectivity, satellite habitats and other source sites. This indicates that consolidation of GPL is imperative for long-term viability of tiger in the landscape. In fact, long-term survival of tigers in PTR depends on the landscape level management of tiger population. Similarly, the population of vulture in the Indian sub-continent was reported to have declined by more than 90% (Prakash *et al*., 2003), however, GPL remains an important strong-hold for the several vulture species (both resident and migrant). These are landscape-dependent species and occur across the landscapes in the form of roosting/nesting sites but exploits the entire region for foraging including wild as well as domestic carcasses. Gharial is another key species in the landscape but is restricted to few individuals (rather can be termed functionally extinct population but for supplementation) in KGS and thus, the need for species recovery in the landscape context has recently been called. Ken-Betwa Link Project and related condition to execute landscape management strategy provides for the scope to enhance the conservation scope with potential increase in the conservation areas (from 26% to 36%) and inputs for several other conservation requirements through dedicated resources and institutional mechanism. Overall, the landscape context, meta-population dynamics of key species and the emerging development agenda need to be converted as an opportunity to advance conservation agenda.

3.4.4. Threat: Ken-Betwa Link Project will cause habitat loss and fragmentation, and nothing can compensate the loss of riverine habitats and related biodiversity. Thus, adequate safeguards and interventions as proposed in this plan and elsewhere by various agencies are critical. Further, with poor socioeconomic and education status, caste imbalance, political volatility etc, direct and indirect exploitations of forest and wildlife including poaching risk continue to pose challenge for conservation management in the landscape. GPL is also a repository of limestones and diamonds among other minerals, and thus under target of open cast/sand mining activities and can undermine landscape integrity and quality of life of people if not guarded

well. Similar is the case for other development activities such as construction or expansion of roads and rail tracks. There can be a conflict of interest with multiple stakeholders and thus, absence of governance and monitoring mechanisms at the landscape level would affect the objectives of landscape management implementations. Disease risk and climate change impacts in the future may alter the current priorities and thus, long-term research and monitoring has to be in place. Consequent feedback should be incorporated as an adaptive management strategy through existing arrangements. With increase in water availability, traditional agricultural/horticultural practices in the region may disappear and therefore require safeguarding.

3.5. Scientific Foundation: Landscape is an extremely complex concept used in many ways. However, landscape ecology, which deals with spatial pattern and process as two-way process (i.e., process determines the structure and structure influences the process), is the science behind advancement of the landscape approach, details of which have also been elaborated in the introductory section of the plan. Its holistic nature has been recognised in the previous geographical and landscape ecological studies (Troll, 1950; Naveh and Liebermann, 1993; Antrop, 1997). Accordingly, the landscape approach aims at conceptualising and evaluating the interconnectedness of societies and their environment, like the resilience approach, the socio-ecological system, the driving forces-actors analyses, the landscape agronomy concept, integrative planning and modelling, and sustainable land management. The development of scientific concepts was paralleled by the promotion of integrated management approaches since the 1990s, ranging from agro-landscape ecology, integrated ecosystem management or the landscape service framework. The term “integrated landscape approach” obviously has been filled with various meanings, which share some common ground, but a clear definition, which can easily be explained to stakeholders ranging from practitioners to donor agencies, is lacking. Attempts to overcome this limitation go in various directions. This plan is also an attempt to address the gap, accommodating shared goals and benefits, through a combination of thematic foci for key species and integrated framework and structure for holistic consideration.

3.6. Examples of Existing Landscape Management Models: Given that landscape management involves a shared vision and diverse stakeholders, previous attempts to implement landscape approach has taken different shapes depending on who drove the agenda. There are a few popular examples that are often taken as case studies for working landscape model but

these are fraught with challenges in terms of the complexities with local contexts and the inability to adopt such models elsewhere. The following examples provide some of the landscape models that can be considered for additional learnings.

3.6.1. The Great Barrier Reef Marine Park (GBRMP), Australia: GBRMP and its management by the Great Barrier Reef Marine Park Act, 1975 followed by the Great Barrier Reef Marine Park Authority is one of the initial and model arrangements made for large area management. GBRMP is a multiple-use marine PA extending over 344,000 km^2 along low water mark of the Queensland coast extending to the Coral Sea. The area encompassed within the Park's outer boundaries is managed as a single ecosystem through agreements between the Commonwealth and the Queensland Government relating to Marine Parks and Island National Parks**.** The advantage of GBRMP model of large area management for ecologically sustainable use, including recognition and balancing of all interests and legitimate extractive activities, and providing for protection of significant areas where resource extraction is prohibited, is evident. The model includes legislative support of the complementary management arrangements of the State and Federal Agencies (e.g., Fisheries). The Great Barrier Reef Marine Park Act established the Great Barrier Reef Marine Park Authority. The Authority consists of two Federal nominees and one Queensland nominee. There is provision for a Great Barrier Reef Consultative Committee comprising of representatives of major user groups, some nominated by the Federal and some by the Queensland Government. The overall goal of the Authority is to provide for the wise use, protection, and understanding of the Great Barrier Reef in perpetuity through the care and development of a Marine Park. One of the aims is to involve the community meaningfully in the care and development of the Marine Park. While the GBRMP may not be a perfect, or only, model, it is a working model of ecologically sustainable use. In April 2018, the Australian Government announced $500 million funding for the Great Barrier Reef. This included a $443.3 million partnership to invest in projects to tackle key risks to the Reef and seek co-funding from private investors and philanthropists. This partnership is founded on the premise that the organisations - the GBR Foundation and the GBR Marine Park Authority, can deliver far greater benefits to the Reef by working together.

3.6.2. Eno River and New Hope Creek Watersheds, USA: Located in the Piedmont of North Carolina, Eno River and New Hope Creek Watersheds, encompasses 65 Natural Heritage Natural Areas, recognised by North Carolina Natural Heritage Program (NCNHP). The wildlands and natural open spaces owned by the local, state and national agencies, universities, land trusts and private landowners, support a range of rare flora and fauna consisting of birds,

bobcats, mink, weasels, box turtles, amphibians, white-tailed deer and the coyotes. However, habitat loss, fragmentation due to development activities and climate change pose a threat to the ecologically significant forests, wetlands, and other rich biodiversity habitat areas of the region. Therefore, to ensure connectivity of habitat patches allowing the movement of wildlife across the landscape, a Landscape Plan for Wildlife Habitat Connectivity was set up in 2019 by the Eno-Hope Conservation Group. The plan is being funded by North Carolina Wildlife Resources Commission and Orange County, NC under the administration of North Carolina Botanical Garden Foundation, inc.

3.6.3. Chilika Development Authority (CDA), Odisha: Chilika, the largest brackish-water lake of Odisha, is a hotspot of biodiversity and a Ramsar site. Chilika is a highly productive lake ecosystem and supports the livelihood of more than two lakh local communities. With the passage of time due to ecological and anthropogenic pressure, the lake ecosystem had been degrading. For preservation of its ecology and conservation as well and to bring an all-round development in and around the lake which calls for multi-dimensional and multidisciplinary developmental activities, the Chilika Development Authority (CDA) (a Registered Society under the Indian Societies Act, 1980) was established in 1992 to undertake measures for the eco-restoration and management of Chilika Lake. CDA, a Government of Orissa Agency, works under the administrative control of Forest and Environment Department of Government of Odisha. An Integrated Management Plan was implemented, and a strong support network was created with seven state government organisations, 33 NGOs, three national government ministries, six other organizations, 11 international organisations, 13 research institutions and 55 different categories of community groups. The Governing Body of the Authority is chaired by the Hon'ble Chief Minister, which signifies the high priority accorded by the government to wetland conservation. Secretaries to the state government departments of forests and environment, fisheries and rural husbandry, tourism, revenue and finance; members of legislative assemblies of Bramhagiri and Chilika; collectors of Puri, Khurda and Ganjam; Agriculture Production Commissioner and Director, WISA are members of the Governing Body. The Chief Executive of the Authority is the Member Secretary. The Governing Body is entrusted with the task of general superintendence of the affairs of the Authority. In 1998, an Executive Committee of CDA was constituted with financial authority, supplemented with financial support to the management initiatives taken up by CDA. This facilitated a coordinated approach to plan and implement effective ameliorative management actions. The Executive Committee chaired by the Principal Secretary (Forest and Environment) is responsible for

taking executive decisions pertaining to CDA. The Chief Executive of the CDA is entrusted with implementation of various programmes and workplans, and management of the CDA Office. CDA has facilitated federation of local NGOs and CBOs at multiple levels which support the organization in delivering its various programmes, primarily those related to livelihoods and outreach. CDA and the Forest Department have also facilitated formation of Watershed Associations in 12 catchment villages. These Associations function to manage the forests, water resources and implement developmental projects for overall welfare of communities. In 2010, the CDA undertook a major initiative in the form of establishing Chilika Fishermen Central Cooperative Society Limited as an apex organization to meet the credit and infrastructure needs of fishers in Chilika and thereby warding-off the notorious nexus between profiteering middlemen and poverty entrapped primary producer communities.

3.6.4. Attappady Hill Area Development Society: Attappady Hill Area Development Society (AHADS) was registered under Societies Registration Act of 1860 with a Memorandum of Association and a Byelaw (vide Number 390 dated 31.10.95 before the District Registrar, Palakkad). According to the directions issued by the State Government, the AHADS has been considered as the Project Implementation Agency (PIA) for the implementation of Attappady Wasteland Comprehensive Environmental Conservation Project, with focus on poverty alleviation and environment development. The Society has a Project Directorate with minimum Technical and Ministerial Support Systems under the Project Director. The society has a Governing Body with due representation of the Panchayats, Member of Legislative Assembly (MLA), Member of Parliament (MP), Scientific Organizations, selected experts, other people's representatives etc. Policy making at the project level, issuing of directions for implementation of activities, monitoring of activities etc., are the responsibilities of this committee. There is a High-Power Committee with the Honourable Chief Minister as the Chairman and the Ministers of developmental departments, MLA, MP and Government nominees as members. The Principal Secretary to Government, Rural Development Department is the Secretary to the committee. The Committee upholds the principles and obligations of bilateral agreement between the Government of India and the Overseas Economic Cooperation Fund (OECF), Government of Japan. The committee envisages the activities of the project within the broad format of the eco-restoration principles.

3.6.5. Gulf of Mannar Biosphere Reserve Trust (GOMBRT): Global Environment Facility (GEF) - UNDP aided project on "Conservation and sustainable use of Gulf of Mannar Biosphere Reserve's coastal bio-diversity" was implemented in Gulf of Mannar Biosphere

Reserve (GOMBR) from 2002 to 2012. The project aimed to "Conserve and sustainably utilise the globally significant biodiversity in the multiple use area of the GOMBR through establishment and effective participatory management of the GOMBR through application of the strengthened conservation programme in the core area and economically feasible and socially acceptable sustainable livelihood development in Biosphere Reserve as a whole". The project was designed to demonstrate how to integrate biodiversity conservation into coastal marine management plan and implement the same in a large Biosphere Reserve with various multiple uses and users. The project stipulated establishment of Gulf of Mannar Biosphere Reserve Trust (GOMBRT) as a Special Purpose Vehicle, a new government owned Institution registered under Tamil Nadu Societies Registration Act 1975 to implement the activities and to play more than an advisory role as a flexible transparent system to facilitate appropriate integrated coastal development action in the Biosphere Reserve. The Board of Trustees is the apex body for management of various activities of the Trust. The Trust is presided by the Chief Secretary to the Government of Tamil Nadu. The Secretary, Environment and Forests is the Vice-chairperson of the Trust. The Trust Director is the Member Secretary of the Trust. The major responsibilities of the Trust include review of legal, policy and procedural issues and suggesting solution. The Board of Trustees also review coordination between departments, priority allocation of programmes, schemes all other interventions as needed. The Board of Trustees also review external monitoring report and progress of work plans etc. In addition to the Board of Trustees, the Government of Tamil Nadu issued orders specifying roles and responsibilities of Empowered Sub Committee, District Level Coordination Committees for Ramanathapuram and Tuticorin Districts, GOMBRT, NGOs and Research Organizations with a view to ensure speedy and efficient implementation of the Project.

3.6.6. Biodiversity Conservation and Rural Livelihood Improvement Project (BCRLIP):

BCRLIP supported by GEF, and the World Bank has provided an opportunity to test multi sector and multi-use approach to conservation management in four important landscapes in the country [Askot in Uttarakhand; Little Rann of Kutch in Gujarat; Agasthyamalai in Tamil Nadu and Kerala and Satpura in Madhya Pradesh] in a time bound project mode, the first of such efforts in the country. This novel conservation project was a blend of conservation and local rural livelihood improvement considerations, with a project span of seven-years (2011-2018). The implementation and monitoring of project activities at the State level were planned through State Landscape Societies (a registered society) or Tiger Conservation Foundations available in the States. State Landscape Societies have a high-level Governing Body, to provide strategic

guidance and facilitate implementation of projects at the landscape level, help resolve financial and procurement hurdles and ensure timely release of funds and reporting. The Governing Body was envisaged to facilitate coordination of planning activities across different sector agencies that operate in the landscape. At the landscape level, project activities were to be implemented through the Executive Body (EB) of the State Landscape Society/Foundation. A senior Forest Department Official functioning as Chief Executive Officer (CEO) of the Society/Foundation would have the responsibility for the coordination and implementation of project activities at the respective landscapes. The unit heads of the other PAs and managed forests in the landscape will implement the activities and assist the CEO. The CEO will be assisted by a planning and management team consisting of specialists and community mobilisers to help facilitate PA management, micro-planning and livelihood activities in the select landscape, mainstreaming of conservation outcomes in production activities, and participatory monitoring and documentation.

In Agasthyamalai landscape, Tamil Nadu, the state government established State Level Project Implementation Committee (SPIC) under the chairmanship of the Principal Secretary, Environment and Forest Department to steer and guide project implementation an effort to replicate the KMTR Ecodevelopment Project (1994-2001), and as well as, the establishment of District Level Coordination Committees (DLCC) under the leadership of District Collectors in all 5 districts in the landscape to facilitate involvement of line departments and convergence of funding in target villages. With effective and proactive lead, the implementing agency could secure convergence and mainstreaming of biodiversity consideration in other departments planning and execution of various developmental initiatives even after the project is closed. At the community level, planning and implementation of livelihood and small-scale conservation investments at the village level were implemented through the existing or new village level institutions (e.g., user groups in LRK; Van Panchayats in Askot, Village Forest Committees (VFC), Ecodevelopment Committees (EDC), and Joint Forest Management Committees (JFMC) in Agasthyamalai; JFMCs, BMCs and VSS in Satpura landscapes). Households at each village were organised into user or community groups and were collectively responsible for formulation of community/village level micro-plans, prioritisation of investments and participatory monitoring of biodiversity and socio-economic impacts. Services of local and national NGOs with appropriate expertise were also utilised to assist in micro-planning and livelihood related activities.

In Satpura landscape, Madhya Pradesh, decentralised and integrated planning was adopted to mainstream biodiversity concerns in sector and village level planning. The implementing agency provided capacity building to the officers nominated by the District Collector, as well as, to the officials of Panchayat and Block levels. At the district level Master Trainers Trainings were conducted. At the Village Panchayat a Technical Support Group (TSG) was given training. TSG for 2-3 village Panchayats comprised of a group of 4-6 officers of line agencies and a local NGO. Forest department officials participated in all meetings and training programmes. The implementing agency could successfully establish vibrant relations with the stakeholders and a close link could be facilitated with the decentralized planning in the three Tier Panchayat Raj. The development needs of the target villages thus became part of the District/Block/Panchayat annual plans. This is a unique effort taken up by the implementing agency to build rapport with district administration and other key stakeholders to mainstream biodiversity considerations in the district level planning. The efforts of decentralized planning through capacity building of line agencies, NGOs and planning for target villages, funding support of Rs.4,52,48,811/= could be mobilized through convergence from line agency programmes in the landscape benefitting 14,608 people.

3.6.7. Meghalaya Community Led Landscape Management Plan (CLLMP): Drafted in 2017, the Meghalaya Community Led Landscape Management Plan is to be implemented by the Meghalaya Basin Development Authority across the state in 11 districts covering 140 villages. With the aim to strengthen community led landscape management, the project consists of three major components, each extending support at a different spatial scale: (i) strengthening knowledge and capacity building for natural resource management, to be implemented in the entire state; (ii) Community led planning and implementation of CLLMP, for developing models of Landscape Management in limited villages; and (iii) project management and governance, in a few critical areas of financial management, monitoring and evaluation, establishment of social and environmental safeguards. The State Institute of Rural Development, Department of Soil and Water Conservation and Water Resource Department involves the major authorities for executing the safeguards, management and community natural resource management plan preparation along with providing technical inputs for the same.

3.7. Approach and Tools: Given that landscape management aims at “reconciliation of competing social, economic, and environmental objectives” (Sayer *et al.*, 2013), it is to be approached from the landscape specific contexts and objectives. In this case, the landscape

vision focusses on enhancing the conservation value due to the prevailing conservation opportunities and emerging development challenges. Therefore, the process of landscape management planning and implementation strategies took the following steps:

(i) Identification of Thematic Context: Following the background analyses and goal setting, the thematic context was identified to be (a) conservation of key species (Tiger, Vultures and Gharial) through habitat consolidations and metapopulation framework, and (b) people-forest relationship with bottom-up approach where relevant.

(ii) Delineation of Landscape Boundary: The Greater Panna Landscape boundary was already determined by the committee constituted by NTCA and was subsequently approved by all concerned, in terms of the outer extent of the limit which took the shape of district boundary and in some cases tehsil boundary as described in the preceding section. However, based on the goal and objectives, the landscape boundary followed the thematic context and accordingly the boundary was determined including exclusion/inclusion of the area keeping in view conservation considerations.

(iii) Consultation with the Government Stakeholders: The landscape management plan development is a result of a joint Memorandum of Understanding (MoU) by the National Water Development Agency (NWDA), National Tiger Conservation Authority (NTCA), Wildlife Institute of India (WII), Madhya Pradesh Forest Department (MPFD) and Uttar Pradesh Forest Department (UPFD). The plan process was initiated with a launch workshop at WII wherein the Government Stakeholders specifically the representatives of the signatories of MoU and experienced officers/professionals participated (Appendix 3.1), deliberated and approved on the strategies, components, and structure of the plan.

(iv) Deployment of Technical Manpower: Considering the multidisciplinary components of the plan, large number of technical manpower (full-time researchers) and resource persons (part-time experts and professionals) with diverse backgrounds and expertise were hired to undertake various activities to be taken up over a four year period, with certain impediments due to Covid-19 induced impacts and lockdowns.

(v) Desk Review and Reconnaissance: Desk review of the landscape concepts and the specific situations including the development of Ken-Betwa Link Project was undertaken. WII has been working in the region since 1995 and more intensively in collaboration with MPFD since 2008 for tiger recovery project. Also, there have been site inspections to various parts of the landscape as mandated by the Government of India. These exploratory visits allowed for clear

understanding of the landscape area and potential issues that needed to be focussed. This also allowed for final delineation of the landscape boundary and subsequent strategies for data collection framework and intensity.

(vi) Primary and Secondary Data Collection: The landscape was divided into different grid sizes. Data collection for tiger and related species, other mammals, vultures, vegetation characteristics and socioeconomic conditions was carried out systematically covering the entire landscape, involving specialised sampling tools and equipment. In the PTR, more intensive data collection was done also including other taxonomic groups such as herpetofauna and birds. Satellite telemetry study for tigers and vultures have also been initiated. A survey for Gharial was undertaken in major parts of Ken River. We also deployed Unmanned Aerial Vehicle (Drone) for surveying rivers for crocodiles and riverine habitat mapping. Details of the sampling methods and efforts are described in the following section.

(vii) Aspatial and Spatial Analyses: Voluminous data collected over the years were subjected to basic and advanced statistical analyses and interpretations were drawn accordingly to describe the components and to support prescription. Remote Sensing and GIS tools and relevant spatial analysis models were also used for reflecting the results in spatially explicit form and prioritization strategies.

(viii) Categorization and Prioritisation: Given the understanding of thematic context, the landscape area was categorised into altered and unaltered regions, and mapping of core habitats, satellite cores, stepping stones, connectivity pathways and various zones was done, to rationalise and prioritise interventions and management. Also identified were hotspots and vulnerable points for management attentions and community engagement strategies.

(ix) Stakeholder Consultations: Mapping of stakeholders and consultations with different level of stakeholders was undertaken, with a combination of top-down and bottom-up strategies depending on the contexts and priorities. Consultations involving managements from across the landscape, experts with experience and knowledge in landscape management and communities in the key PAs were consulted intensively on the status and issues to be addressed for a win-win situation for landscape management (Appendix 3.2).

(x) Mid-term Review and Course Correction: With the initial results and interpretations, the plan process was subjected to mid-term review involving experts from diverse discipline and identified data and analytical gaps (Appendix 3.3). Based on the inputs, necessary course

corrections were made as per requirements in terms of addressing the gaps and fine tuning the results.

(xi) Preparation of the Draft Plan: A zero draft plan was prepared by different thematic team and was compiled as one primary document and six supplementary plans, and these were subjected to review by the concerned experts/professionals who have been a part of the plan process and other independent professionals. Based on the inputs, the zero draft was improved to first draft and was shared with all concerned.

(xii) Incorporation of Shared Vision and Negotiations: The thematic focus of conservation objectives may overlap with development targets, and thus, district level consultations involving district administration, forest administration and line agencies were undertaken (Appendix 3.7-3.9). Site specific discussions were also held with the communities to understand the nature of the relationship with the specific conservation targets. Accordingly, changes in the prescriptions were made and the draft plan was finalised, with options for further consultations and negotiations during the implementation stage.

(xiii) Legitimization and Convergence: While the thematic context would cover the entire landscape, the plan implementation would be carried out through existing administrative framework such as PA management, Forest Administration, District Administration and Panchayat Administration. This process would legitimise the landscape planning and implementations in the immediate and long-terms. Also, if the Ken-Betwa Link Project is to be implemented, the Special Purpose Vehicle (SPV) that has been visualized, will serve as a medium for legitimising the plan implementation. Also, by incorporating the existing governance principles and mechanism, convergence of resources (manpower and finance) could also be achieved even beyond the plan period and allocated budget provision.

(xiv) Finalization of Draft Plan and Independent Review: Considering the above-mentioned points and suggestions, the plan was finalised, and the Final Draft Plan submitted to all concerned. The plan was subjected to independent review by professionals/experts within and outside country, and the gaps highlighted addressed. A workshop was also organized with experts and their inputs incorporated (Appendix 3.11). Finally, a meeting with all the principal signatories was held (Appendix 3.12), wherein the plan was approved and whatever comments were received from them, including Global Tiger Forum, have been incorporated and the plan have been finalized.

(xv) Final Plan and Implementation Strategy: The final plan includes Integrated Landscape Management Plan, with Supplementary Plans with details of different thematic components. The plan has the implementation strategy including by establishing a dedicated technical support and monitoring institution in Panna Tiger Reserve, and accordingly the implementation would have to be advanced. Research and monitoring of all components long with certain indicators would serve as a feedback mechanism. This along with the consultation process will enable necessary adaptive management interventions as per emerging requirements.

3.8. Details of Data Collection and Efforts:

Hierarchical grid-based approach was conceived to ensure representation of data collection from the potential habitats from the entire landscape. Nested grids of 8 x 8km, 2 x 2km and 1 x 1km were considered for data collection across the landscape. Keeping in view manpower and equipment, the landscape was stratified into meaningful blocks (Fig. 3.1) and these blocks were systematically surveyed by a multidisciplinary team. The survey involved camera trapping for mammals including tiger, co-predators and prey species; targeted searches for vultures; line transect and plot sampling for vegetation parameters and random sampling of villages for socio-economic status and forest dependency of people. Data collection in the landscape area focussed on 8km (a total of 417 grids) within which 2km grid cells (a total of 1003 grids) were sampled, while in the PTR, it was focussed on 1.4 km grid cells due to higher sampling intensity as per the objectives (Table 3.1, 3.2). Details of the data collection for various components and sampling efforts (Fig. 3.2, 3.3) are described below.

Table 3.1: Summary of data collection efforts in GPL

Theme/ Target species	**Sampling tool**	**Number of sampling grids/locations covered**	**Data collection efforts**		
			Total effort	**Number of man-days spent**	**Number of people involved**
Tiger (Co-predators, prey and other mammals)	Camera trap	759 grids	20119 trap nights	417	8
Vulture	Area search method, mapping of gaushalas	1281 grids	2232.27 km trail walked, 76 Gaushalas were visited	562	5

Gharial	Information on working of Gharial Ex-situ hatchery facility	Morena Gharial hatchery centre		9	3
Habitat	Vegetation plots on transect	739 grids/transects	739 km and 3695 plots	852	4
Riparian zone	Habitat survey	44 locations	20 km	36	3
Community	Questionnaire survey	416 grids (399 villages)	2479 interviews	509	3
Consultation	Landscape level workshop		2 days, 75 participants	90	20
Secondary data collection and Spatial database	Compensation data, plans and other management related data, One health related data, Remote sensing/GIS data	Entire landscape		337	11
Total				2812	57

Table 3.2: Summary of data collection efforts in PTR

Theme/ Target species	**Sampling tool**	**Number of sampling grids/locations covered**	**Data collection efforts**		
			Total effort	**Number of man-days spent**	**Number of people involved**
Tiger (Co-predators, prey and other mammals)	Camera trap, radiotelemetry, Scat collection	474 grids (two consecutive years), 143 beats	23670 trap nights	228	27
Vulture	Ad libitum and Focal-animal sampling, population count, radiotelemetry		179.46 km trail walked, 90 hours of behavioural observations	775	18
Gharial	River walk survey, UAV	13 locations		75	5

Habitat	Vegetation plots	413 grids/ transects (1934 plots)	375 km	930	6
Environment	Data loggers	98 locations		240	4
Avifauna	Distance sampling, Trail/transect survey	418 points		430	8
Herpetofauna	Bioacoustics assessments, Visual Encounter Surveys, Pitfall traps	44 grids		474	7
Aquatic fauna	Fish and benthic invertebrate capture using cast and gill nets	50 locations (two replicates)		270	3
Community	Socio-economic survey, target village visit to understand EDC and other issues	38 villages	407 interviews	55	6
Consultation	Range-level workshop	141 beats and 153 villages (268 forest staff and 231 village representatives)	13 days, 142 (forest staff questionnaire), 101 (village representative questionnaire)	200	10
Secondary data collection and Spatial database	Compensation data, plans and other management related data, One health related data, Remote sensing/GIS data	PTR and surrounding areas		264	7
Total				**3941**	**162**

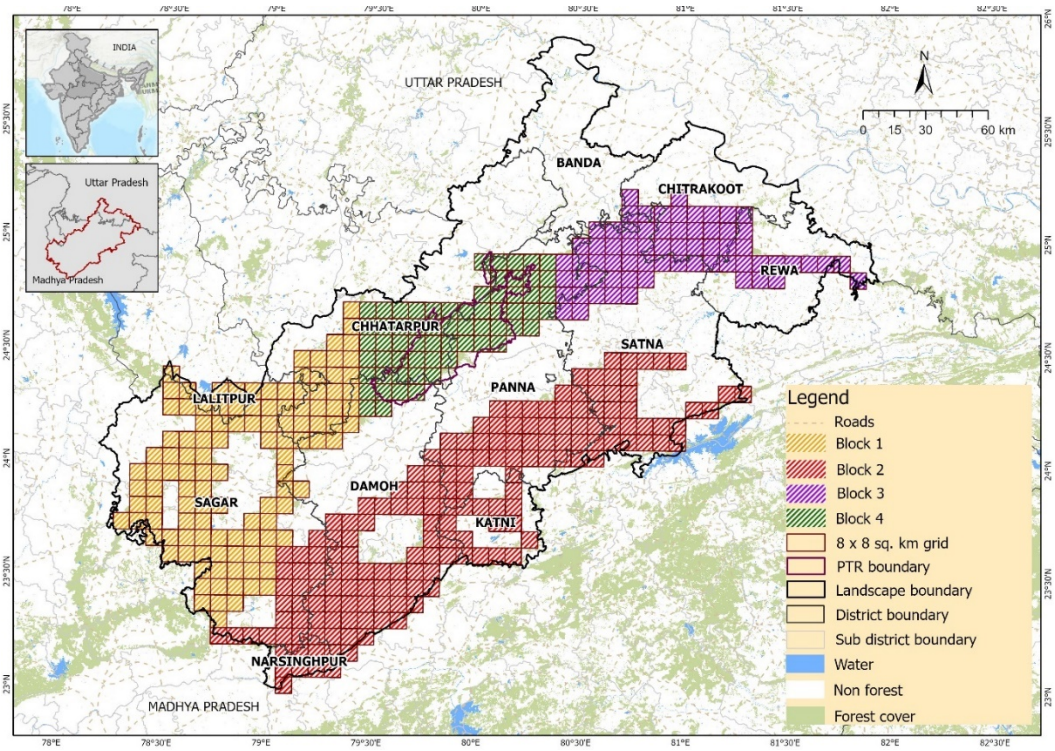


Figure 3.1. Map of grid-units for systematic data collection in GPL

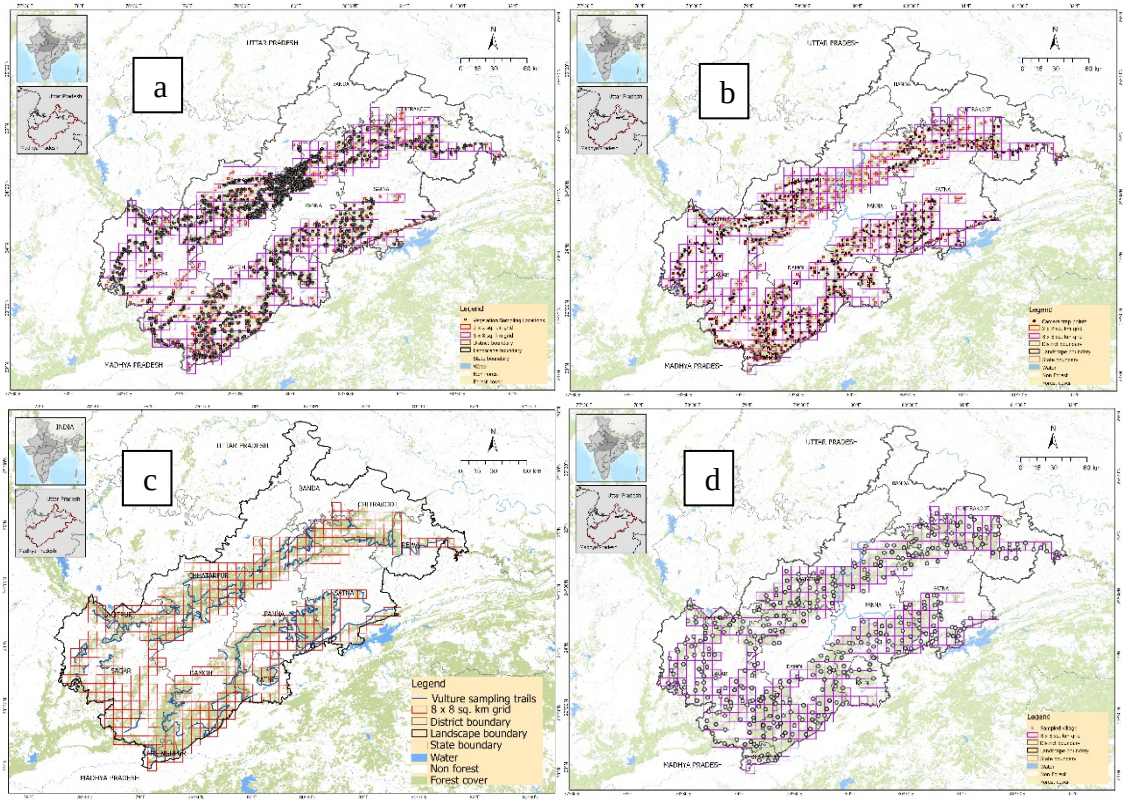


Figure 3.2. Map showing sampling locations in GPL for **a)** vegetation and habitat quality assessment, **b)** camera traps for tiger, co-predator, prey and other mammals, **c)** vultures, **d)** villages (socio-economic survey)

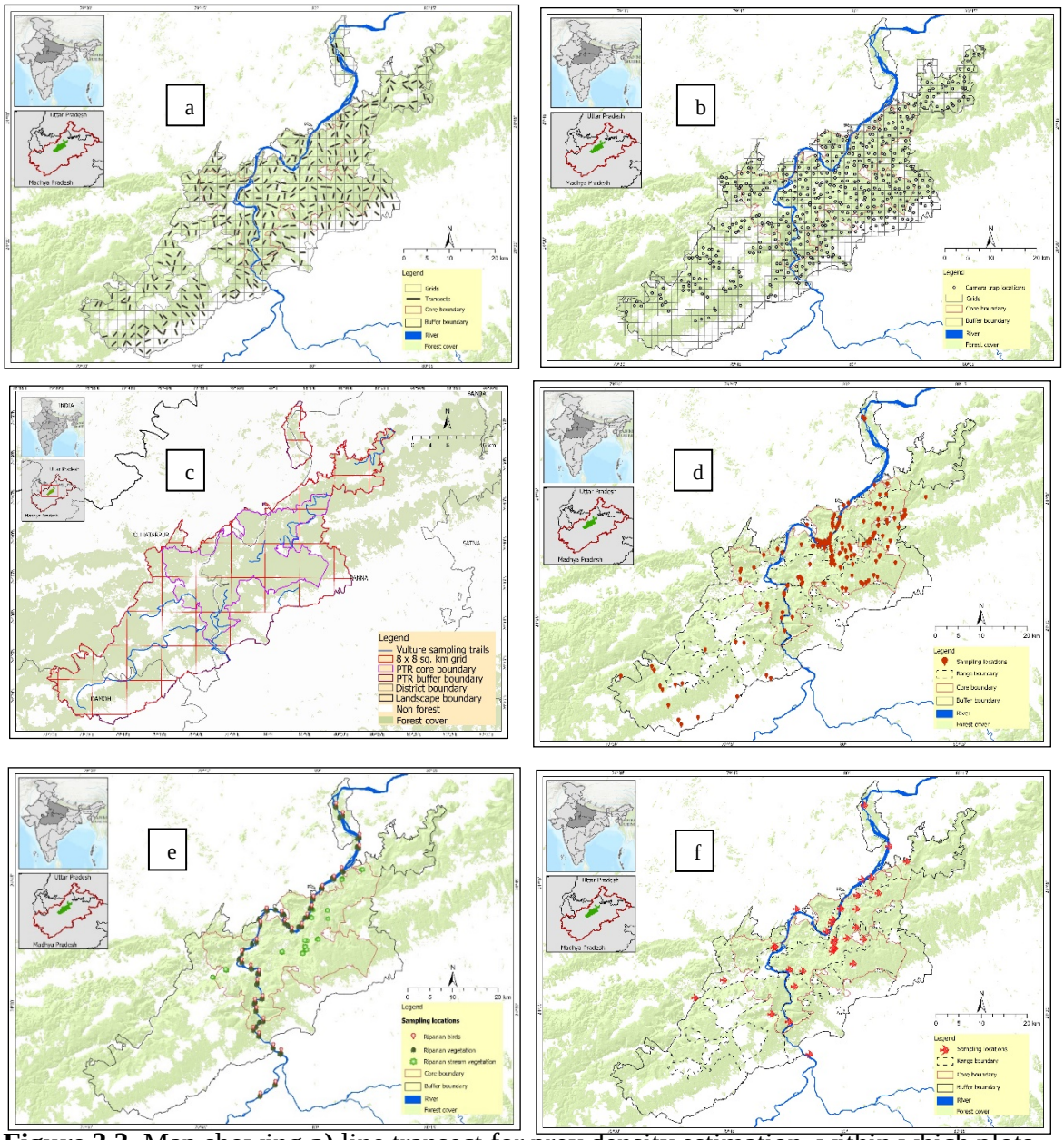


Figure 3.3. Map showing **a)** line transect for prey density estimation, within which plots were laid for vegetation and habitat quality assessment, **b)** camera traps for tiger, co-predator, prey and other mammals, **c)** sampling trails for vulture **d)** sampling locations for herpetofauna, **e)** sampling locations for riparian vegetation and avifauna, **f)** sampling locations for aquatic indicator species, in PTR

(i) Vegetation and Habitat Quality: A total of 1037 grid/line transects (one transect per grid) were sampled across the landscape for assessing the habitat quality survey (Fig. 3.2. a). Each transect was one km long, sampling was done at every 250m on the transect, thus a total of 5185 points were sampled for vegetation and habitat quality survey. For the first phase of data collection in three blocks, a total number of 739 grids/transects were covered in the landscape (12 divisional forest). For the second phase of data collection in fourth block (*i.e.*, PTR region),

298 grids/transects were covered (Fig. 3.3. a). Forest structure and composition, forest resources, forest physical environment, and the prevailing anthropogenic disturbances were considered as indicators of habitat quality.

For sampling of tree species, 10mx10m quadrat were used. Nested within the 10mx10m quadrat were, one 5mx5m quadrat for sampling of shrubs, and two 1mx1m quadrats, for sampling of herbs. Within the 10mx10m quadrat (n=5), circumference at breast height (CBH) and height, of all trees, were measured by measuring tape and range finder, respectively. Number of saplings and seedlings along with species name were also recorded. Ocular estimation of canopy cover (%) was made from the midpoint of each 10mx10m quadrat. Ground cover and litter cover (high, medium, low) were recorded in each 1mx1m quadrats. Anthropogenic disturbances lead to fragmentation of the forest and restrict the movement and suitable habitat of wild animals. Human signs were observed in each 10mx10m quadrat of the line transect. For quantifying the signs of anthropogenic disturbances in the forest, parameters such as human/livestock trails, number of cattle dung, human presence, presence of fire, livestock presence, NTFPs collection signs, number of cut trees, number of lopped trees and distance from the nearby village and road were quantified. Cluster analysis shows different community composition in each area. Hierarchical cluster analysis was done using hclust function (d = Euclidean; Method = Ward) in R software (R Core Team, 2020).

(ii) Land Use/ Land Cover (LULC) and Landscape Characteristics: LULC map for the landscape was drawn from NRSC AWIFS land use land cover product (2015-16) available at the scale of 1:250000, while for PTR, atmospherically corrected sentinel data with 10m spatial resolution were downloaded from ESA Copernicus open hub for the date 25th November 2017. Layer stacking was performed in Erdas imagine 2016, followed by an unsupervised classification. The images were classified into twelve LULC classes. Forest type classification for PTR was done using field data as reference with multi-temporal sentinel 2A data. The output result classified into nine classes. The focus of the classification was to identify and map the different forest types to reduce the noise land uses. The overall accuracy achieved was 74.34% with the Kappa statistics of 0.6250. Based on forest cover (NDVI) and elevation (DEM), PTR was divided into habitat classes. And according to these classes, Hobo Onset U-23 Pro v2 data loggers were installed in 97 locations within PTR, for long term monitoring of air temperature and relative humidity.

The LULC map was then used in Fragstats 4.2.1 along with a class descriptor file. The landscape matrices were calculated for individual categories at class levels (McGarigal *et al.*, 2019). The landscape matrices used were:

i. **Percentage of Landscape (PLAND):** PLAND is the fundamental measure of landscape composition; it quantifies the proportion of the landscape occupied by certain LULC class (0 < PLAND < 100%).

ii. **Largest Patch Index (LPI):** LPI is the simple measure of dominance; it quantifies the percentage of total landscape area comprised by the largest patch. The unit of LPI ranges from 0< to <100 %.

iii. **Mean Patch size AREA_MN:** Area_MN calculates mean area of patches of the same LULC class.

iv. **Radius of Gyration (GYRATE_MN):** GYRATE_MN defines the patch extent and it is influenced by patch size as well as patch compaction. It ranges from 0 to without limit, GYRATE_MN will be 0 when the patch consists of only one cell and the rising value of GYRATE_MN defines the increase in patch extent.

v. **Aggregation Index (AI):** AI refers to the degree of aggregation or clumping of patch types. It ranges from 0 to 100 % and maximum values are obtained when the class is maximally clumped into a single, compact patch.

vi. **Number of Patches (NP):** NP indices of a class quantify the subdivision or fragmentation. The unit of NP is $N \geq 1$.

vii. **Edge Density (ED):** ED represents the total length (m/hectare) of all edge corresponding to patches of a class. It ranges 0 when there is no class edge present in the landscape and increases without limit as the edges of patch types are abundant.

viii. **Mean Euclidean Nearest Neighbor distance (ENN_MN):** ENN_MN is the simplest measure of patch isolation. It calculates the mean of minimum edge- to- edge distances to the nearest neighbouring patch of the same type of LULC class (m).

(iii) Mammal Survey: Camera traps were deployed in all the grids (that were described) above to ascertain presence of tiger, co-predator, prey and other mammalian species in the landscape. Based on the percentage of forest cover, a minimum of 3 to 5, 2x2km grids were selected inside the 8x8km grids. Within these grids, two single side, white flash camera traps with motion sensor, were deployed. Minimum distance between any two camera traps was 1 km. Cameras operated for a minimum of 15 to a maximum of 20 days. Camera traps were set to function 24h per day, and delay between two consecutive captures was kept at, fast as possible (FAP) mode.

A total of 1463 single-sided camera traps were deployed in 732 (2x2 km) grids in 12 forest divisions of the landscape, for a total of 19,638 trap days (Fig. 3.2b). Simultaneously, 1008 double-sided camera traps were deployed in 504 (1.4×1.4 km) grids in the PTR core and buffer (but the data successfully retrieved from 474 locations) (Fig. 3.3b). The camera trap data was then sorted and photographic capture rates for all the species were calculated, in addition to other population estimation parameters.

(iv) Population Viability Analysis (PVA) of Tiger: We modeled PVA of tiger based on the demographic data from 2009 to 2020 in PTR, using open-source modelling software Vortex ver. 10 (Lacy and Pollak, 2014). Vortex is appropriate for modelling species with low fecundity and long-life spans and is the most used software in published reintroduction models (Armstrong and Reynolds, 2012). We defined population extinction as only one sex remaining. Inbreeding depression (O'Grady *et al.*, 2006) was included in the baseline scenario using the default values in Vortex (6.29 lethal equivalents, with 50% due to lethal alleles). The initial population sizes counted as 51 individuals in the year 2020, of which 20 were male and 31 were female. Both female and male reproductive year was set between 3 to 12 years and 4 to 13 years respectively. The maximum age of survival for both sexes was set as 17 years. The mean progeny was 2.7 with 45% female in the breeding pool, while 40% male were in the breeding pool. Furthermore, we considered environmental catastrophes as a detrimental factor. We set all scenario with no supplementation option, as the population is quite stable with constant recruitment. However, we considered harvest model in scenario combination, due to dispersal events and possible sink situation. All the models were predicted for 25 years with 500 simulations.

(v) Habitat Suitability Modelling for Tigers: Reintroduced tigers in PTR are being monitored by radiotelemetry and systematic grid-based camera trap techniques**.** We used the tiger photo-captured camera trap locations as the presence point, while others camera trap locations (without tiger photo captured) were used as the absence points. Here, we used different habitat co-variates such as elevation, forest type etc. We extracted the co-variates data at a 250m radius from each camera trap point to perform the generalized linear model (GLM), using 'raster' and 'MuMIn' package. A total of 539 camera trap points were used for the habitat selection analysis, out which, 179 were present points and 360 were absent points. After data extraction, a correlation test was carried out to detect the level of correlation among the variables. The result revealed a high degree of correlation (appx. LULC: LST 85%) between LULC and LST covariates, therefore LST was dropped from the model.

(vi) Prey Density Estimation: To determine the abundance of herbivores, distance sampling method through line transect was followed (Buckland *et al.*, 2001). In order to do this, line transects (2km each) were laid at each forest beat covering all the ranges in core and buffer zones of PTR (Fig. 3.3.a). Each transect was walked two to three times with an interval of 2-3 days, in the early mornings for three consecutive years (2018-2020) (Table 3.3).

Table 3.3: Number of line transects walked and total effort for prey density estimation in PTR (2018-2020)

Zone	Year	Season	No. of lines walked	Total effort (km)
Core	2018	Winter	56	336
	2018	Summer	61	366
	2019	Winter	40	240
	2019	Summer	71	426
	2020	Winter	68	408
Buffer	2018	Winter	54	324
	2018	Summer	60	360
	2019	Winter	60	360
	2019	Summer	63	378
	2020	Winter	68	408

(vi) Satellite Core and Connectivity for Tiger: All the forest classes of the Forest Survey of India were merged to obtain a single habitat file. The obtained spatial layer was analysed in FRAGSTAT class metric, using the non-disjunct core area tool. Habitat patches greater than 23.5 sq km (lowest recorded annual home range of Tiger in PTR) were retained to be used as core area, for further analysis. The spatial layers of Land use/Land cover, Land Surface Temperature (LST), Terrain Ruggedness, Human Footprint and Euclidean distance to stream were weighted and were given resistance scores after rescaling to 1x1 km cell size (Table 3.4).

Table 3.4: Spatial layer used for creating resistance surface

Data Layer	Class Description	Weightage score	Resistance score
Land Cover	Built up	0.30	50

Land Cover	Kharif crop/rabi crop/zaid crop/double/ triple crop/ current fallow		40
Land Cover	Plantation		10
Land Cover	Deciduous forest		0
Land Cover	Degraded/ scrub forest		10
Land Cover	Wasteland		10
Land Cover	Waterbodies max/ waterbodies min		0
LST (Degree Celsius)	0-10	0.10	80
LST	10-20		60
LST	20-30		0
LST	30-40		10
LST	40-50		100
LST	50-60		100
LST	60-70		100
Terrain Ruggedness Index	0-10	0.20	0
Terrain Ruggedness Index	10-20		10
Terrain Ruggedness Index	20-30		20
Terrain Ruggedness Index	30-40		30
Terrain Ruggedness Index	40-50		40
Terrain Ruggedness Index	50-60		50
Terrain Ruggedness Index	60-70		60
Terrain Ruggedness Index	70-80		70
Terrain Ruggedness Index	80-90		80
Terrain Ruggedness Index	90-100		90
Human Footprint	0-10	0.35	0
Human Footprint	10-20		0
Human Footprint	20-30		10
Human Footprint	30-40		20
Human Footprint	40-50		30
Euclidean distance to stream (meter)	0-500	0.05	0

Distance to stream	500-1000		10
Distance to stream	1000-1500		40
Distance to stream	1500-2000		60
Distance to stream	2000-2500		80
Distance to stream	>2500		100

Resistance scores reflect the cost incurred upon the movement of tigers, scaling from 0-100, *i.e.*, lower values representing higher permeability to movement, and higher values representing obstruction/ higher resistance to the movement. Weightage scores assigned to the layers represent the contribution of layer to the final resistance layer, *i.e.*, lower scores define lesser influence of the variable on movement while higher weightage scores define high influence on the movement of tigers across habitat classes. Connectivity within the landscape was mapped using the software, Linkage Mapper, using Cost-weighted mode and as the network adjacency method. Additionally, connectivity was also analysed by current flow mapping among the identified cores using Circuitscape, following pair-wise method. After mapping the corridors, centrality scores for each habitat patch and the connectivity link, obtained as an output from Linkage Mapper, were calculated using the tool Centrality Mapper. The current flow centrality scores reflect the importance of the links or the core area polygon in maintaining connectivity across the network of habitat patches available in the landscape. Higher the centrality score, more crucial is the habitat patch in keeping the network connected.

(vii) Vulture Survey and Modelling: In the first phase of data collection, each 2x2 km grid within the sampling blocks was visited in the landscape, and, nesting vultures and nesting sites, were recorded (Fig. 3.2 c, 3.3 c). “Area search” methodology was followed to observe the occupancy of the vultures (Ralph *et al.*, 1993; Dieni and Jones 2002). A survey was conducted from half an hour after sunrise to 10:30-11:00 am. To be sure about the occupancy of the vultures, strict methodology was followed, such that the vultures in flight were not considered to occupy the place where they were seen in flight. However, the observations were noted carefully to confirm the presence of the respective species in the landscape. Only those grids, where vultures were seen nesting, roosting, or perching, were recorded as occupied. Additionally, information on vulture presence was collected by consulting beat guards and old census data (collected by the Forest Department). Vulture sites so identified, were visited, even if those areas were out of the grids. However, during the landscape survey, equal effort could not be made in the cliff area and non-cliff area, since cliffy terrain demands much more physical

and temporal effort than non-cliffy areas. As a result, occupancy of tree nesting vulture, *i.e.*, the White-rumped Vulture (*Gyps bengalensis*) could not be estimated. As part of the second phase of data collection, vulture abundance survey was carried out at cliff-nesting and roosting sites in PTR. At the cliffs, the number of nests and the height profile of the nests (distance from bottom and the top of the cliff to the nest) are also being recorded. Based on the occupancy data collected during the first phase, Species Distribution Modelling (of nesting and roosting) using GLM which is a robust model (Elith *et al.*, 2008; 2011), was done for the cliff-nesting vultures using ArcGIS Pro ver. and SDM package in R Studio (Naimi and Araújo, 2016). To study the micro habitat features and how it affects nest site selection of vultures, 14 HOBO Pro v2 data loggers were also deployed at 14 cliff-nesting sites of vultures, inside PTR. *Ad-libitum* sampling to record some specific and crucial behaviours (like bathing and roosting) of vultures, was also done in PTR, according to Altmann (1974) and Lehner (1992). Population estimation was also carried out for cliff-nesting and tress-nesting vultures in PTR, separately, with three replicates according to Direct Counting Method (Bibby *et al.* 1992).

(viii) Woodland Bird Diversity: Woodland birds within PTR were surveyed based on Point Transect Sampling (n=222 points) under the 'Distance Sampling' framework (Buckland *et al.* 2004). The points were laid randomly and spatially covering all forest types of PTR. Additionally, 30 line-transect surveys of varying number and lengths were conducted for avifauna assessment in 14 different relocated village sites of PTR (Manakadan, 2014). The length and width of transects depended upon the size of the village area. Bird species, their perpendicular distance from the transect and group size were recorded. Birds flying above sampling location were not recorded unless they appeared to be hunting or hovering. Transects were laid with a minimum distance of 200 m to each other to avoid double counting and at least 50 m far from the boundary of the village to minimise edge effect. Sampling of birds was conducted during morning hours in the post-monsoon period. Adverse climatic conditions for bird detection like rainfall or cloudy weather were avoided.

(ix) Herpetofauna Diversity: Field data of herpetofauna was collected in PTR for summer, monsoon and winter seasons from May 2019 to January 2020 (Fig. 3.3. d). During monsoon season from June to September 2019, time constrained nocturnal Visual Encounter Surveys (VES), bioacoustics assessments and frog call recordings, pitfall traps combined with drift fences and opportunistic surveys were employed. This enabled collection of field data of herpetofauna in variety of habitats such as streams, temporary and perennial ponds, muddy

areas of grasslands, rocky outcrops, puddles, leaf litter and agricultural field in the buffer and core area of PTR.

i. **Visual Encounter Surveys (VES):** Time constraint VES at each potential location were conducted in the form of line transect or randomised walk wherein two observers walked at a slow pace scanning the potential habitats for herpetofauna (Fig. 3.4 A).

ii. **Bioacoustics Assessments:** Male anurans advertisement calls were recorded in real-time (16-bit, 44.1 kHz) using Sennheiser MKH 416 unidirectional handheld microphones and Marantz MK II digital recorder between 1900 and 00:00 hours during monsoon season from July to September 2019 (Fig. 3.4 B).

iii. **Pitfall Traps:** Another method to sample amphibians was pitfall traps combined with drift fence wherein we installed pitfall array (a set of 10 buckets at each installation) with drift fence (1m of height) at five locations in three ranges of PTR namely Panna, Hinauta and Madla (Fig. 3.4 C). A set of ten buckets were buried in the ground with their open fringe faced with surface of ground.



Figure 3.4. Images shows various types of field survey methods conducted in PTR during the study: **A**. Team performing Visual Encounter Surveys, **B**. Bioacoustics surveys and anuran advertisement call recordings, **C**. Pitfall traps combined with drift fences method to record secretive reptiles and amphibians, **D**. River walk surveys to assess distribution of *Crocodylus palustris* (Mugger) and *Gavialis gangeticus* (Gharial)

(x) Crocodile Status and Distribution: River walk surveys were conducted to assess the status and distribution pattern of Muggers (*Crocodylus palustris*) and Gharials (*Gavialis gangeticus*). The stretch of Ken River starting from the southern most limit of PTR in Kishangarh Range (GPS coordinate N 24.461177° E 79.864740°) to the northern most limit of KGS (GPS coordinate N 24.941590° E 80.060928°) was surveyed from January to February 2018 (Winter Survey) and again from May to June 2019 (Summer Survey). Survey points were marked approximately 1km distant to each other using Google Earth and GIS tools. The survey was conducted between 06:00 am and 11:00 am in the morning. During the survey, observers counted the number of sightings of Muggers (*Crocodylus palustris*) and Gharials (*Gavialis gangeticus*) (Fig. 3.5 D) and other environmental and ecological variables. Total of ca. 85 marked points were surveyed in the river Ken along PTR. In addition, an aerial survey was undertaken to count crocodiles and map riverine habitats, using Trinity Advance Drone with Vertical Takeoff and Landing (VTOL) model, also known as Hybrid Model of UAV. This UAV has high resolution optic sensors with less than 5cm spatial resolution and flight capability of 50km per hour. Thus, we could cover large extent of stretches specifically inaccessible ones through the UAV survey. The survey covered an area of 8.6 km in PTR, generating an orthomosaic map of 70.7907 hectares, and 16.40 km in KGS generating an orthomosaic map of 1170.564 hectares.

(xi) Fish Diversity and Benthic Fauna: Fish species and benthic macroinvertebrates were taken as indicator to ascertain the presence of RET species and aquatic biodiversity value. Approximately about 2-3 hours were spent on fish sampling at 52 locations from February-March 2020 (post-winter) and then again from November 2020-January 2021 (post-monsoon) along main Ken River and its adjoining major streams (Fig. 3.3 f). As a part of habitat assessment, certain key river meso-habitat characteristic, *i.e.*, runs, riffles, pools, and cascades were measured in all the sampling sites. A sampling segment consists of 150-200 m in length wherein key river characteristics were measured including channel morphology (Hauer and Lamberti, 2007; Johnson and Arunachalam, 2010) such as, river width (m), depth (average), river flow (average), riparian cover (%) and substratum (proportion of rocks, boulders, cobbles, pebbles, sand, slit and woody vegetation if any). The average river flow was measured using flow probe (YSI, USA). Photographs were taken for each site for further habitat analysis. Fish sampling was done using different types of fishing gears, such as, cast net and gill net with different mesh sizes (0.5 × 0.5 mm, 1 × 1 cm, 1.5 × 1.5 cm). Captured fishes were photographed in the field, identified and released back into the same location. Certain complex groups of

fishes are yet to be identified. Benthic invertebrate sampling was performed using drift net with fine mesh size (Trivedy and Goel, 1984). Collected benthic invertebrate samples were preserved in 70% Ethyl alcohol for further identification in the laboratory. The physico-chemical variables, namely dissolved oxygen (mg/l), pH, water temperature (°C), specific conductance (µS/cm), total dissolved solid (ppm), and electrical conductivity (µS/cm), were measured at each of the sampling sites, using YSI water quality kit (YSI, Proportional Plus, USA).

(xii) Assessment of Riparian Vegetation: Assessment of riparian flora includes evaluation of qualitative, as well as quantitative attributes. In riparian zone along the main Ken River channel, both banks (right and left) were sampled for vegetation from Pandavan in PTR buffer area till KGS. The Ken River was divided into 2 km segments and 32 such segments were identified in this whole stretch. Sampling was done in each segment by laying a trail/transect of 250 m**.** In each of these, three quadrats of size 10 x 20 m were placed with equal distance from each other. Thus, a total of 96 quadrats were laid (Fig. 3.3 e). All trees with circumference at breast height (cbh) ≥ 30 were sampled in each 10 m x 20 m quadrat and cbh and height (h) were measured by measuring tape and range finder respectively. Each 10 x 20 m quadrat comprises one nested quadrat of size 5 x 5 m for sampling of shrubs and another nested quadrat of size 1 x 1 m for sampling of herbs and grasses. Number of saplings (cbh = 10 to 30 cm and h > 1 m) and seedlings (h < 1 m) and their species were recorded in each 5 x 5 m quadrats. Ground cover and litter cover were recorded in each 1 x 1 m quadrat. Abundance data for all the life-forms and other parameters were recorded in a pre-constructed sampling format. Riparian Vegetation Index (RVI) (Kemper, 2001), which is a scoring-based framework, was computed for evaluating riparian vegetation status, as per the formula below.

RVI = [(EVC) + ((SI x PCIRS) + (RIRS))], where EVC is extent of vegetation cover**,** SI is structural intactness**,** PCIRS is percentage cover of indigenous riparian species and RIRS is recruitment of indigenous riparian species. The RVI is 20 score framework provides for assessment class in six classes indicating (1) A Class - Unmodified, natural area, (2) B Class - Largely natural with few modifications, (3) C Class- Moderately modified, (4) D Class - Largely modified, (5) E Class – Loss of natural habitat, (6) F Class – Modification has reached critical level or lost resilience capacity.

(xiii) Water and Riverine Bird Survey: Several ponds are located within the core region of PTR. Assessment of avifauna was done in four major ponds in the winter season (2020-21) through opportunistic surveys. The 32 trail/transects used to assess vegetation were also used

to assess avifauna along Ken River (Fig. 3.3 e). Mackinnon's Species Richness Method (Mackinnon and Phillips, 1992) was used for avifauna assessment in the riparian ecosystem.

(xiv) Surrogate Biodiversity Assessment: A grid-based approach was adopted to assess the biodiversity potential of the landscape. A composite of systematic indicators encompassing topographic, biological and anthropogenic factors were used to synthesize a cumulative biodiversity value. Based on literature, ecological significance and expert discussion, a total of seven indicators were finalised for assessment. These indicators included elevation, Normalized Difference Vegetation Index (NDVI), Normalized Difference Water Index (NDWI), drainage system, land cover, forest cover and human footprint. These indicators were derived from different remote sensing datasets (Table 3.5). The most recent data available for the study area was used in all cases. The results of the assessment were presented in the spatially explicit cumulative biodiversity richness value/index.

Table 3.5: Satellite data products used in the computation of variables for biodiversity richness.

Data layers	**Source**	**Rationale**	**References**
Elevation	ASTER	Topography influences the regional biodiversity by generating environmental gradients and determining the pattern of vegetation productivity and species distributions.	Temini *et al.* 2010; Anderson and Ferree 2010
Forest Cover 2015	FSI	Land cover maps provide direct and indirect indices of biodiversity and can differentiate broad plant communities.	Latifovic *et al.*, 2008
LULC 2015-16	NRSC, ISRO		
NDVI 2015	Landsat Data	Vegetation productivity is directly linked to biodiversity and can identify the regional hotspots of biodiversity. Areas with high productivity have greater concentration of species and higher species diversity as compared to areas with low productivity.	Rocchini *et al.*, 2007; Goward *et al.* 1985; Coops *et al.* 2008

Human Footprint 2009	WCS	Disturbances from natural and human factors alter the landscape structure and functioning of ecosystems which in turn impacts the biodiversity and species distributions	Kuuluvainen, 2002; Linke *et al.*, 2007
NDWI 2015	Landsat-8 OLI	Water distribution/moisture level would reflect micro-habitats for several taxonomic groups, indicating biodiversity potential.	
River Drainage	DCW	Stream distribution with diverse orders is a function of habitat diversity and thus would be an important indicator of biodiversity,	

The datasets were clipped for Panna landscape and pre-processed using reprojection, resampling and rescaling techniques. The NDVI layer was processed to include only the vegetation NDVI values (values > 0, values < 0 were converted to 0). NDWI layer was also similarly rescaled to include only water areas. The land use land cover (LULC) layer was reclassified, and similar classes were grouped together. For example, all types of forests including plantations were grouped into a single class. The forest cover layer was reclassified into two classes namely forest and non-forest. The elevation layer was used to derive slope information and the slope layer was further reclassified into 10-degree interval classes. Human footprint and drainage data were used directly in the analyses. All the analyses were performed in ArcMap 10.2 Since the datasets had different spatial resolutions, a uniform and systemic grid size of 2x2 km was selected for Panna landscape for further assessments. Data values were assembled at this common grid size. A total of twelve final set of indicators were derived from the seven indicators mentioned above and for every grid cell, value of these indicators was estimated (Table 3.6).

Table 3.6: Rank and weight score assigned to the variables in computation of biodiversity richness

Indicators	Normalization (0-1)	Rank Assigned	Weight Score
Elevation (standard deviation)	Low to High	6	0.04
Slope (diversity)	Low to High	1	0.14
NDVI (mean)	Low to High	2	0.12
NDVI (standard deviation)	Low to High	2	0.12
NDWI (mean)	Low to High	5	0.06
NDWI (standard deviation)	Low to High	5	0.06
Land use land cover (diversity)	Low to High	3	0.10
Stream length	Low to High	7	0.02
Stream diversity	Low to High	5	0.06
Human footprint (mean)	High to Low (1-0)	4	0.08
Human footprint (standard deviation)	High to Low (1-0)	4	0.08
Patch density (mean)	Low to High to Low	3	0.10

Each of the indicators was then standardised on a 0-1 scale using a minimum-maximum standardisation technique. Human footprint indicators were scaled from 1 to 0. For patch density values the “low to moderate” values were scaled from 0 to 1 while the “moderate to high” values were scaled from 1 to 0. A weighted sum of all the twelve indicators was estimated for every 2 x 2 km grid cell to get the biodiversity richness values. This resulted in each grid cell having a value ranging from 0 to 1; 0 indicating low biodiversity and 1 indicating high biodiversity. The biodiversity values were then clustered into three classes namely high,

medium and low biodiversity areas using Quantile breaks algorithm in ArcGIS. The biodiversity index thus synthesised represented a comprehensive measure of the status of potential biodiversity in each 4 sq. km grid of the Panna landscape. To validate the accuracy of the obtained results, species occurrence data of both plants and mammals (downloaded from GBIF/field data) were overlaid on the richness data. The number of points falling in each biodiversity class was estimated and percent representation was estimated. A similar exercise was done for PTR with finer scale analyses.

(xvi) Landscape change detection for identification of restoration priority areas: Change detection analysis was done over a time span of 30 years starting from 1990 to 2020 using the Landsat data at 30 meters of spatial resolution acquired from USGS earth explorer (https://earthexplorer.usgs.gov/). Change detection analysis was performed using union matrix tool in Erdas imagine in between 1990 – 2020. And four classes were identified: non-forest, forest remained same, increased forest cover, and decrease in forest cover (Fig. 3.5).

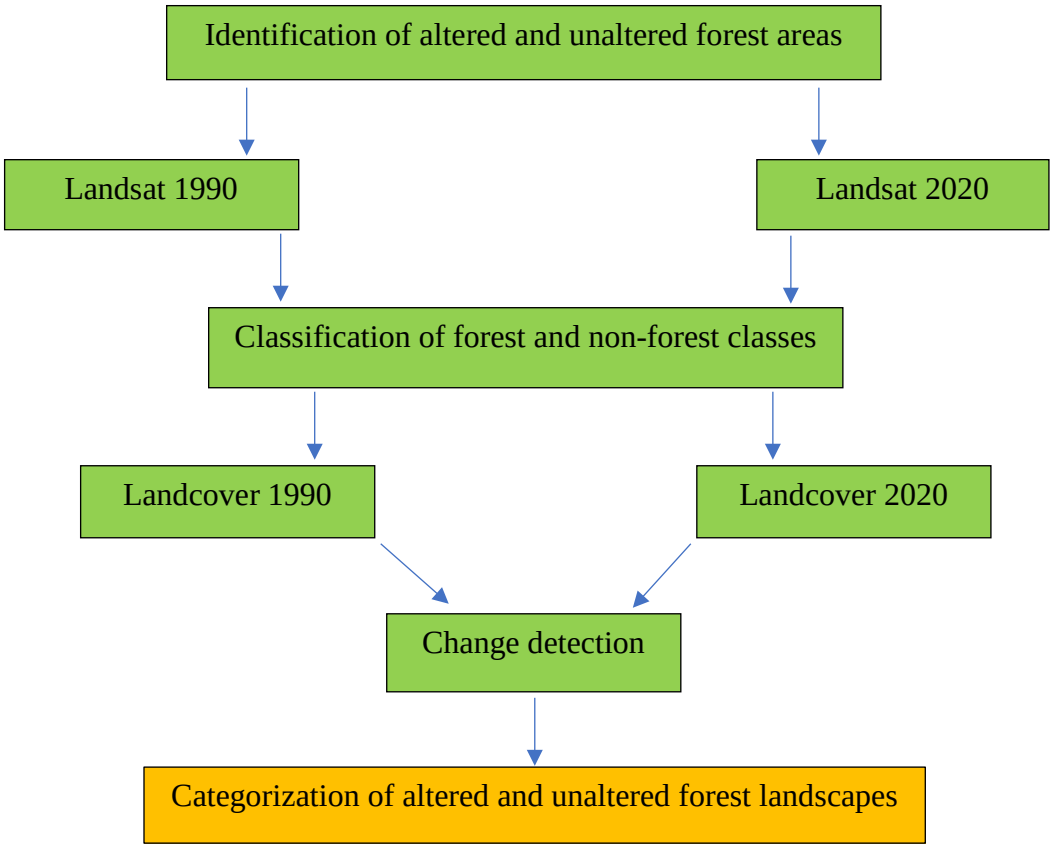


Figure 3.5. Flow chart depicting methodology followed for change detection analysis

Simultaneously the whole study area was divided into one-hectare grids. The reason was to visualise the output at a possible restoration unit. The results of change detection analysis were

extracted grid wise and based on the area falling within the grid different classes were assigned grid wise. The description of categories is given below.

1. **Non-forest**: The grids having agriculture, water, open land, built-up etc. classes.
2. **Unaltered forest**: Grids where forest remained the same in between 1990-2020.
3. **Positively altered forest**: This class includes all the grids where forest areas have shown increase in density or cover from 1990.
4. **Moderately negatively altered forest**: Grids where the pixel showing decrease in forest cover or density occupy more than 10% and less than 50% of the total area of the grid.
5. **Fully negatively altered forest**: Grids where pixels showing forest decrease from 1990, cover more than 50% of the total area of the grid.

(xvi) Spatial Prioritisation for Systematic Conservation Planning: Systematic Conservation Planning is a framework that supports effective resource allocation for long term biodiversity persistence and efficient use of conservation resources (Margules and Pressey, 2000). Several decision-making tools have been developed over the past decades to aid conservation planning through a transparent, inclusive, accountable, and rigorous process (Pressey and Botrille, 2009). 'Marxan Connect' (Daigle *et al.*, 2020) is a new open source, open access Graphical User Interface (GUI) tool designed to assist conservation planners with appropriate use of data on ecological connectivity in PA network planning. Marxan Connect broadly provides two ways to estimate connectivity; (1) demographic connectivity (*e.g.*, derived from animal tracking data, dispersal models, or genetic tools) and/or (2) structural landscape connectivity (Daigle *et al.*, 2020). This is accomplished by calculating (1) metapopulation-relevant connectivity metrics (*e.g.*, eigenvector centrality) and treating those as conservation features or (2) by including the connectivity data as a spatial dependency amongst sites in the prioritisation process. In this assessment, we have estimated structural landscape connectivity and included the connectivity data as a spatial dependency, with due conservation considerations as below.

Planning Area: Planning area is the spatial extent over which planning process occurs or can also be called study area. For the present assessment, planning area is the Greater Panna Landscape. Planning area is usually sub-divided into smaller planning units for management or conservation actions.

Planning Units: The analysis was carried out using planning units composed of square grids of 5 x 5 km and 4 x 4 km. Each planning unit was assigned a unique ID, availability status for conservation, and cost associated with conservation or restoration. Traditionally, each planning unit is assigned a status (Conserved, Excluded, and Available). Conserved units refer to the area which already have sufficient protection. Excluded areas refer to the areas which cannot be included in the planned reserve, *e.g.*, areas with high pollution, areas heavily infested with invasive species etc. Available units refer to the planning units that can be considered by the algorithm to be included in the reserve design. All the units were considered "Available" regardless of protection status assigned to some forest patches in the landscape.

Conservation Features: Conservation features are features for which a target is set *e.g.*, habitats, species or processes. Since our objective was to conserve tiger habitat patches in the entire landscape that are connected, we used broad land cover classes as conservation features namely Forest cover data of Forest Survey of India (2014) available at 100 m spatial resolution. We consolidated the six available classes (Very dense forest, moderately dense forest, open forest, scrub, non-forest and water) into four habitat classes - forest, non-forest, water and scrub. Before converting the habitat features to vector, we used clump and eliminate tools in Erdas IMAGINE 2014 to remove pixel groups smaller than 1 km^2, followed by boundary clean tool in ArcMap to smoothen the boundary between two classes. To avoid connectivity between streams and reservoirs, we re-assigned the reservoirs to non-forest class.

Conservation Cost: Conservation cost is the cost of including a planning unit in the reserve design. It can be defined as simply as the planning unit area, as the actual fiscal cost required to purchase the land, or as the opportunity cost of displaced incompatible ecosystem uses (Daigle *et al.*, 2020). The cost values were assigned based on Global Human Footprint data (Last of Wild). Three classes were created using 95^{th} percentile and 90^{th} percentile of sum of human footprint per km^2 (to account for smaller planning units at the edge of landscape boundary) and costs were assigned as 3 (higher than 95^{th} percentile), 2 (between 95^{th} and 90^{th} percentile) and 1 (lower than 90^{th} percentile).

Conservation Targets: Conservation target is the minimum quantity or proportion of the conservation feature in the study area to be included in solutions. A review by Woodley *et al.* (2019) suggests that the minimum targets of 17% terrestrial and inland waters, and 10% marine and coastal targets from Aichi Target 11 of the Strategic Plan for Biodiversity 2011-2020 are not considered adequate to conserve biodiversity by any research findings, either for ocean or

for land. The global protection of a minimum of 30% and up to 70%, or even higher, of the land and sea on earth is supported in the literature, whether by species-area curves, systematic conservation planning, or minimum system size approaches (Woodley *et al.*, 2012). We assigned a target of 70% for Scrub, 70% for Forest and 0% for water and non-forest, to be conservative in our long-term strategies.

Connectivity as Spatial Dependency: We computed connectivity between habitat class polygons using Least Cost Path and Euclidean Distance in Marxan Connect. A square resistance matrix was provided based on expert knowledge for computing the Least Cost Path Connectivity Matrix. The connectivity values in each case (Least Cost Path and Euclidean Distance) were used to calculate new spatial dependencies for the final analyses.

Marxan Input File and Parameters: Marxan input files were created in QGIS 3.10 using plugin Conservation Land-Use Zoning software (CLUZ) (Smith, 2019). The Boundary Length Modifier (BLM) values were tested (50, 75, and 100) and a value of 100 was used for providing maximum connectivity in the final solution. A species penalty factor (SPF) of 1000 was assigned to each conservation feature. The model was run using 100000 iterations and 100 runs (Table 3.8).

Table 3.8: Model parameters for the four scenarios assessed.

Scenario	PU size (sq.km)	Total PUs	Connectivity	BLM	Iterations	Runs	Target			
							Forest	Non-Forest	Scrub	Water
1	25	2105	Least Cost Path	100	1000000	100	70%	0%	70%	0%
2	25	2105	Euclidean	100	1000000	100	70%	0%	70%	0%
3	16	3236	Least Cost Path	100	1000000	100	70%	0%	70%	0%
4	16	3236	Euclidean	100	1000000	100	70%	0%	70%	0%

Configuration Assessment using Fragstats: We computed class-level metrics in Fragstats for objectively analysing the resulting configurations of the planning units for conservation

prioritisation. Number of Patches, Mean Patch Area, Patch Area Standard Deviation, Mean Radius of Gyration, Standard Deviation of Radius of Gyration, Mean Contiguity Index, Mean Proximity Index, Clumpiness Index, Connectance Index and Patch Cohesion Index were calculated for best solution configuration. Mean Perimeter Area Ratio was additionally calculated for selection frequency-based patches of planning units. A search radius of 10 km and 8 km was used for the grids of 5 km and 4 km respectively for calculating metrics.

(xvi) Ecosystem Services Mapping: InVEST 3.10.1 software from Natural Capital Project (Sharp *et al.*, 2020) was used to map the ecosystem services for GPL and three ecosystem services were selected: Carbon stock, sediment retention and water provision.

Carbon Stock: Carbon stock mapping for the landscape was done using the FSI forest cover classes (2017) and the reference values of carbon stored in aboveground, belowground, deadwood and soil belonging to each forest class were taken from the India State of Forest Report (ISFR, 2017).

Sediment Retention: Sediment Delivery Ratio (SDR) model in InVEST framework was used to model soil erosion by water in the landscape. The SDR model uses RULSE (Revised Universal Soil Loss Equation) expression to determine the soil loss following the given equation (Winchell *et al.*, 2018).

$$A = R*K*L*S*C*P$$

Where, A is the annual soil loss, R is the rainfall erosivity factor, K is the soil erodibility factor, L is the slope length factor, S is the slope steepness factor, C is the cover management factor; and P is the supporting practice factor.

Rainfall erosivity (R) is the kinetic energy of raindrop's impact and the rate of associated runoff or it can be said it is the capacity of rain to produce erosion. Dataset for R factor was extracted from the global rainfall erosivity dataset from the European Commission (https://esdac.jrc.ec.europa.eu/content/global-rainfall-erosivity). The K factor also known as soil erodibility is the susceptibility of the soil to be eroded and it is highly dependent on the soil texture. The topsoil texture and organic matter content data was downloaded from BHUWAN portal and for each soil texture, values were assigned following the OMAFRA fact sheet (http://www.omafra.gov.on.ca/english/engineer/facts/12-051.htm). The L and S factor were extracted from the digital elevation model and C and P factors were assigned to the LULC classes based on the published literature (Marques *et al.*, 2021; Khan *et al.* 2018).

Water Provision: The InVEST water yield model determines the annual average quantity of water produced by a watershed/sub-watershed. The data used are precipitation raster taken from Worldclim (https://www.worldclim.org/data/bioclim.html), evapotranspiration raster from MODIS (https://lpdaac.usgs.gov/products/mod16a3v006/). In the absence of root restricting layer depth to bedrock was taken (https://data.isric.org), plant available water content (PAWC) was calculated using the derived available soil water capacity (https://data.isric.org), LULC from NRSC and sub-watershed shapefile were obtained from the HydroSHEDS (https://hydrosheds.org/).

Resilience: Resilience analysis was done at landscape level and the areas which were able to maintain or increase its water use efficiency during the driest year were categorized as resilient and other areas were categorised as non-resilient classes. The water use efficiency for GPL was calculated by the following equation from year 2000 to 2019 and the mean was calculated (WUE_m).

$$\mathbf{WUE = NPP/ET}$$

The driest year was identified using the standard precipitation index (SPI6) and the daily gridded rainfall dataset obtained from Indian meteorological department were used. This index is negative for dry condition and positive for wet conditions.

For categorisation of resilience classes, R_d index was calculated by dividing the water use efficiency of driest year from the mean water use efficiency as represented in the give equation (Sharma and Goyal, 2017).

$$R_d = \frac{WUE_d}{WUE_m}$$

The results of R_d were categorized within four classes.

i. **Resilient**: R_d is greater than or equal to 1
ii. **Slightly non resilient:** R_d lies between 0.9 and 1
iii. **Moderately non resilient:** R_d is between 0.8 and 0.9
iv. **Severely non resilient:** R_d is less than 0.8

After identifying the driest year R_d index was calculated for entire landscape and results were later segregated for forest and cropland classes.

(xvii) Socioeconomic Assessment of Communities: There are approximately 11,500 villages in the entire landscape (Chandramouli, 2011). These villages come under the administrative boundaries of 11 districts – eight in Madhya Pradesh and three in Uttar Pradesh. Of these villages, nearly 4000 villages were located within the 8x8 km sampling grids (Fig. 3.2d). For

the socio-economic data collection, a systematic method was followed to select a village(s) for each grid in the landscape. An average score was calculated for each grid based on total number of households in each village. Villages were then selected based on their proximity to grid's average score. Based on this method, 10% of villages in each grid were selected for sampling. The geographical location of villages with respect to forest (villages inside the forest, adjacent to the forest and outside the forest) was also considered while selecting these villages (Nagendra *et al.*, 2006). Villages outside the forest were considered in sampling, to keep a check on how forest dependence changes with distance from forest. These selected villages were categorised into 3 classes; small sized (1-120 hh, n = 147), medium sized (151-284 hh, n = 192), and large sized (>285 hh, n = 97) villages, based on the number of households in the village. Within the village, household was chosen to be the sampling unit. Three percent of the households were selected based on stratified random sampling for questionnaire surveys (Krejcie and Morgan, 1970). Pilot surveys were conducted in PTR before executing the field work in the landscape. Following this methodology, interviews were conducted in a total of 2696 household in 436 villages, in the entire landscape. The focal points for the socio-economic assessment were socio-economic status of people, forest dependency, forest-agriculture interfaces, ecodevelopment, and skill development activities, eco-tourism and interpretation activities, and identification of gender specific issues. The questionnaire was designed using mixed methods (Creswell and Creswell, 2017) and questions were divided into 16 categories and there are (1) Demographic information, (2) Sources of income, (3) Agricultural practices, (4) Irrigation practices, (5) Animal husbandry practices, (6) NTFP/Fuelwood and Timber Collection, (7) People's view on forest nearby, (8) Animal worshipping practices, (9) Most threatening species in the area, (10) Tiger presence in the area through people's experiences, (11) Wildlife causing losses caused to people, (12) Feral cattle menace, (13) Compensation information, (14) Suggestions given by people to mitigate conflict, (15) People's understanding of conservation agendas, and (16) People's understanding of eco-tourism activities and prospects. There were three interviewers for the entire landscape, and we tried to eliminate our personal biases as much as possible (Hammersley and Gomm, 1997). The field work was carried out from September 2018 to June, 2019 in the landscape. We sampled 3.44% of the total households in the 37 villages, in and around PTR. In all households, the head of the household was interviewed. Data was compiled and entered into MS Excel, and appropriate analyses were done using relevant analytical software.

(xviii) Assessment of Human-Wildlife Conflict: Both primary and secondary data were compiled for the entire landscape with a focus on PTR. During the questionnaire survey that was conducted in the entire landscape (as discussed in the previous section), people were asked about their wildlife related losses and experience with the compensation scheme run by the forest department. To get more detailed information on PTR, compensation data on wildlife attack on human and livestock was collected from various ranges of PTR, translated and compiled. Furthermore, range-level workshops were organised for all the forest guards and support staff of all the 12 ranges in PTR, and village representatives of villages inside or adjacent to these ranges. During the workshop various socio-economic and forest related issues were discussed with both forest guards and village representatives, one of which was wildlife related losses and experience with the compensation scheme. All of this data was compiled and summarised to draw meaningful conclusions about the status of human-wildlife conflict in Panna Landscape with focus on PTR.

3.9. Stakeholder Consultation: A series of Stakeholders/Experts Consultation Workshops at the Range Level and Landscape Level were organised at Panna Tiger Reserve from 3rd to 19th January 2020. Range Level workshops were organized for all the forest guards and support staff of all the ranges, and village representatives of all villages inside or adjacent to these ranges. A landscape-level workshop was organized for all the government stakeholders [National Tiger Conservation Authority (NTCA), Madhya Pradesh Forest Department, Uttar Pradesh Forest Department and National Water Development Agency (NWDA)] and experts/professionals with the relevant expertise. The range-level workshops were organized at different venues within PTR, covering one range per day, starting from 3rd and continuing up till 15th of January 2020. It was organised to understand grass-root level issues related to management and infrastructure from forest staff, and, forest dependence and conflict issues from local communities. During the range-level workshop all twelve ranges of PTR were covered, encompassing 141 beats and 101 villages. A total of 268 forest staff and 231 village representatives attended the workshops (Appendix 3.2). Workshop with forest guards and villagers were organized, separately, to provide an environment, where both can openly discuss their issues (Fig. 3.6). For the same reason, it was ensured that no high-level officials were present during the discussion. During the pre-lunch sessions, workshops with forest staff were organized. In the opening of the session, they were briefed about the project, and aims of the workshop. This was followed by the breakout session, in which each beat guard was asked to fill up a questionnaire, detailing issues specific to them and their beat, facilitated by the team.

During the exercise, they were also asked to indicate fire, encroachment and NTFP (non-timber forest produce) collection areas, in A3 size beat maps provided to them. Following the breakout session, a synthesis session was organised, in which, open discussion was done with all the forest staff present, wherein the major issues common to all the beats of the range, as well as, their possible solutions, were discussed. Similarly, during the post-lunch session, workshop with village representatives was organized. They were first briefed about the project and aims of the workshop. This was followed by, the breakout session, in which all representatives from a village were asked to fill up one questionnaire by consulting amongst themselves, detailing issues specific to them and their village, ensuring one questionnaire was filled for each of the villages. They were actively facilitated by the project team since many did not know how to write. After the filling of the questionnaire, open discussion with all the village representatives was done. During the discussion, the major issues common to all the villages falling in the purview of the range, as well as, their possible solutions, were discussed. The efforts to undertake consultation with hotel/resort owners on 5th January 2020 for tourism related issues turned futile as they refused to cooperate under the current framework.

A Landscape-level Stakeholders/Expert Consultation Workshop was organized on 18th and 19th January 2020 at Tendu leaf Jungle Resort, Madla (Fig. 3.7). It was organized to identify gaps in completed work and prepare outline of the LMP and Conservation plans. The landscape-level workshop was attended by 75 participants, including scientists, researchers and experts from various fields, DFOs/SDOs from all the forest divisions in the landscape, veterinarians from various tiger reserves and representatives from NTCA, NWDA, UP and MP Forest Departments (Appendix 3.3).



Figure 3.6. Workshops conducted with forest staff and village representatives at PTR



Figure 3.7. Workshops conducted with stakeholders and experts at PTR

3.10. Review and Feedback: Since the inception of the project all the stakeholders and experts were consulted in the plan preparation on regular basis. Project activities were monitored by all the signatories of the MoU *viz.* NTCA, NWDA, Madhya Pradesh Forest Department and Uttar Pradesh Forest Department. The first meeting of experts and government organizations was organized on 21st September 2018 before the start of field activities (Appendix 3.1). All the methodology and data collection processes were presented to the experts during the meeting and their comments were invited. Another meeting was held with experts and faculty members of WII on 1st February 2019 and the process was reviewed (Appendix 3.4). A series of consultations with stakeholder (range level forest staff, villages representatives and forest officers) and experts as detailed above was held between 3rd January 2020 and 19th January 2020. All the results and analysed datasets were presented to experts and opinions were sought from all present. Another review meeting was held with the PCCF Madhya Pradesh on 17th February 2020 (Appendix 3.5). Again, at the end of phase one of field data collection, a review meeting with NWDA, NTCA and Forest administration representatives was held virtually on 21st July 2020 (Appendix 3.6). Periodic consultation/review meetings have been conducted virtually during 2021 as well. On 29th January with NTCA representatives, 9th April with NWDA representatives, and 10th September with NWDA, NTCA, UPFD and MPFD representatives (Appendix 3.7). And again on 15th February 2022 with DG NWDA and Senior Joint Commissioner MoJS, at WII.

A series of consultation meetings/writing workshops have been organized with experts/resource persons starting from September 2020 to March 2022, to plug data and analyses gaps and seek inputs on plan writing.

Furthermore, a series of consultation meetings have also been organised with district administrations and other line agencies including the forest department, in hybrid mode (some team members present physically, other joining virtually) starting from Panna District administration on 15th December 2021, followed by Damoh District administration on 17th December 2021 and Chhatarpur District administration on 17th January 2022 (Fig. 3.8) (Appendix 3.8-3.10).



Figure 3.8. Consultation meetings with district administration and line agencies

Before the finalization of the plan, a workshop was also organized with several experts from 4-5th April 2022, and their inputs incorporated (Appendix 3.11). Finally, a meeting with all the principal signatories was held on 6th April 2022 (Appendix 3.12), wherein the plan was approved and whatever comments were received from them (including from Global Tiger Forum), have been incorporated and the plan have been finalized.

3.11. Finalisation and Implementation of the Plan: The Integrated Landscape Management Plan (ILMP) will be the overarching guiding document with details on conservation, management and monitoring strategies for targets including tiger, vulture, aquatic indicator species, overall biodiversity and local communities as provided in the following sections. While the thematic focus of the plan will involve entire landscape as there are spatially related components, the operation units for implementation strategies would be existing administrative units such as PA management, Forest Administration, District Administration and Panchayat Institution. This would bring about legitimacy, institutionalization and convergence which are key ingredients of integrated landscape management with diverse components and stakeholders. However, a competent authority that can oversee the entire process of implementation is visualised to be integrated as a part of Special Purpose Vehicle, in the form of Greater Panna Landscape Council (GPLC) or Authority whichever is appropriate. Likewise, a dedicated technical support unit in the form of 'Integrated

Research and Learning Centre (IRLC)' with scientific and capacity building priorities is expected to support the implementation. This Centre would address the gaps, provide feedback on regular basis, and provide technical support for adaptive management interventions. The ILMP would be supported by several Supplementary Plans with elaborate details that are beyond the scope of the ILMP.



CHAPTER 4

TIGER CONSERVATION STATUS AND PRESCRIPTIONS

Chapter 4: Tiger Conservation Status and Prescriptions

4.1. Situation Analyses

4.1.1. Introduction: Tiger (*Panthera tigris*) is an apex predator, remarkably resilient to different habitats and is an umbrella species for the conservation of forest ecosystems throughout its distribution range. The global populations of tigers have witnessed severe declines as a result of hunting (poaching for illegal trade of body parts and trophy hunting), depletion of prey and habitat destruction (Dinerstein *et al.*, 2007; Wikramanayake *et al.*, 2010). To address this global crisis, world leaders and conservation practitioners met at St. Petersburg, Russia in 2010 and came up with tiger conservation strategies in the form of Global Tiger Recovery programme (Joshi *et al.*, 2016; Global Tiger Initiative, 2011). Fortunately, amongst tiger range countries, India took the lead to recover its wild tiger population through implementation of various conservation plans. Further, local/functional extinction of tigers in Sariska and Panna Tiger Reserves in early 2000s led to the implementation of a landscape approach to conserve tigers in India by means of creation of larger tiger reserves, with a critical tiger habitat or core area (inviolate spaces to hold a viable tiger population), and a sink area or buffer zone surrounding the core, along with ensuring functional habitat connectivity (or corridors) between source populations (Gopal *et al.*, 2007).

4.1.2. Population Status of Tiger in Panna Tiger Reserve: Tigers in Panna now are a result of an active recovery programme, which began with three individuals in 2009 following local extinction, has shown remarkable recovery, marking as a global example. As of 2021, the population of tiger in Panna Tiger Reserve (PTR) was around 60 individuals, including known cubs (Fig. 4.1). Tigers were widely distributed in the core area of PTR and were captured in 157 camera trap locations (63%), out of 248 camera traps deployed in the core area during winter 2018-19. The tigers were most frequently captured in Panna, Madla, Hinauta and Gahrighat Ranges, which are located on the eastern part of Ken River. Ten of the tigers were radio collared. Together with camera trap data, the tigers were utilising almost the entire core area, with large concentration being on eastern side of the reserve (Fig. 4.2, 4.3). As for buffer, tigers are mostly distributed towards the south-eastern and north-eastern parts of PTR, especially, Akola circle of Panna buffer, eastern part of Amanganj, and northern side of Kishangarh Buffer (Chandranagar area) (Fig. 4.2). This could be attributed to the higher availability of wild ungulates in terms of their distribution, and low human disturbance and better protection measures in these areas.

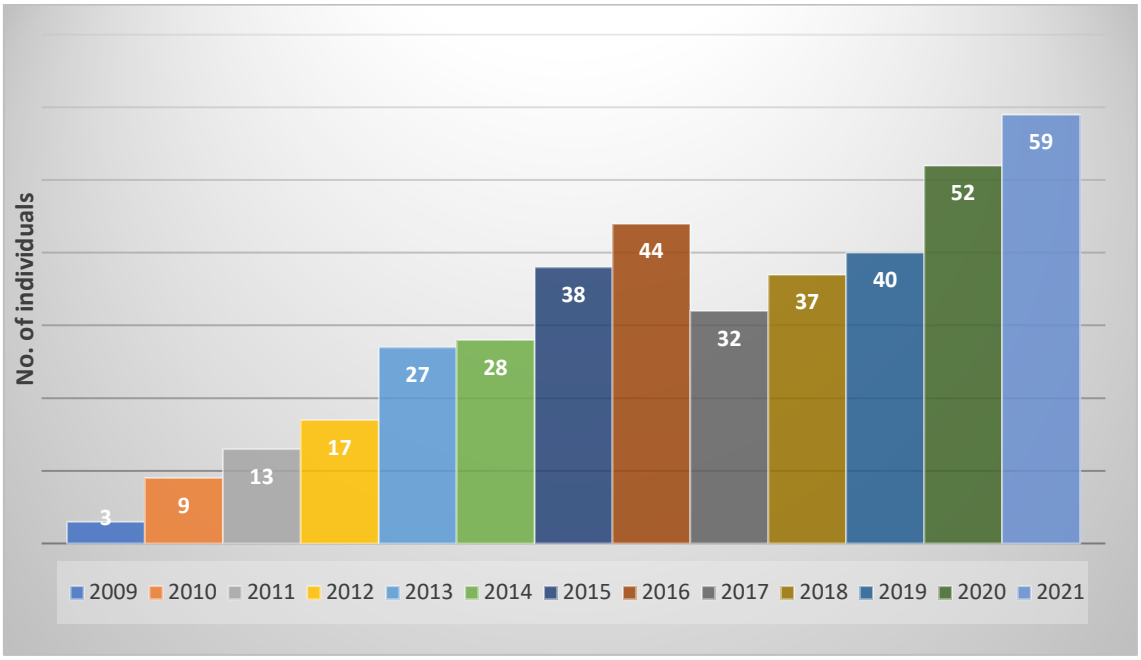


Figure 4.1. Population status of tigers in Panna Tiger Reserve

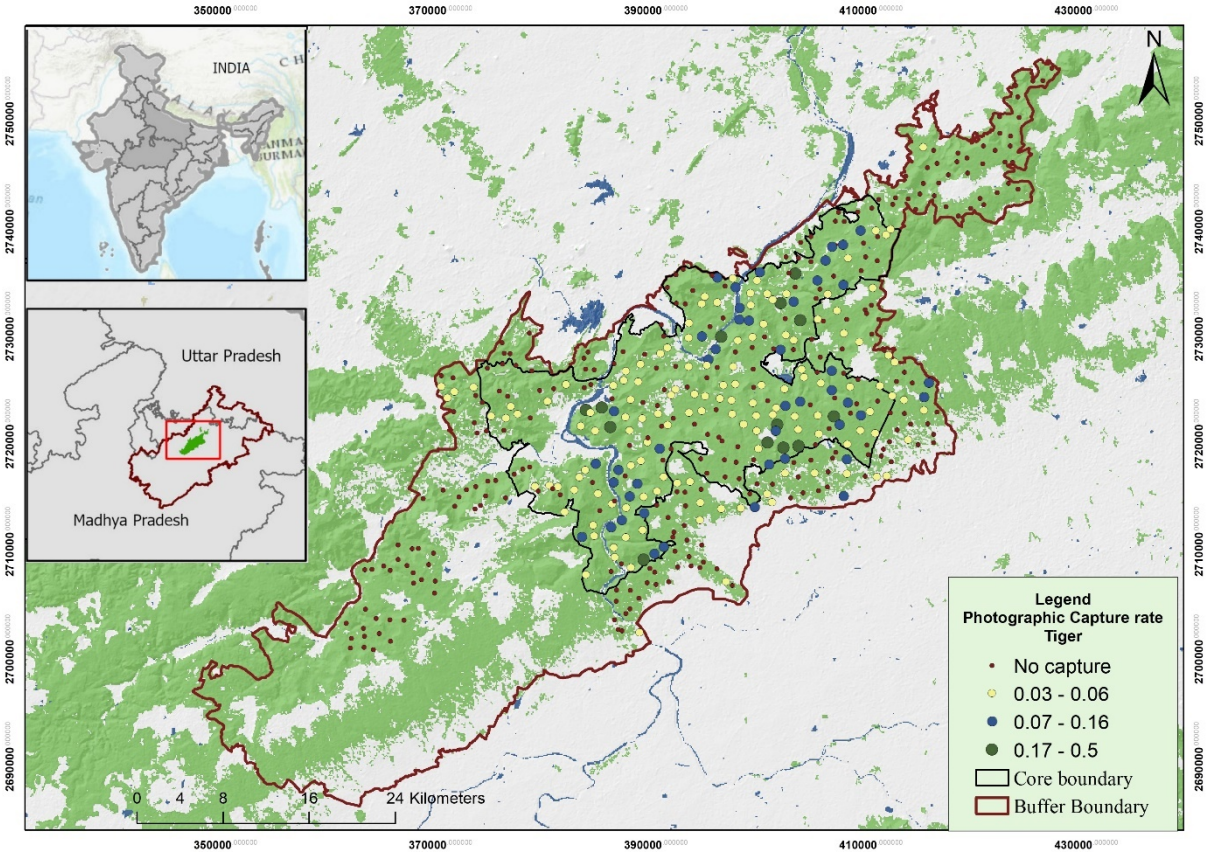


Figure 4.2. Capture rate of tigers in Panna Tiger Reserve (2018-19)

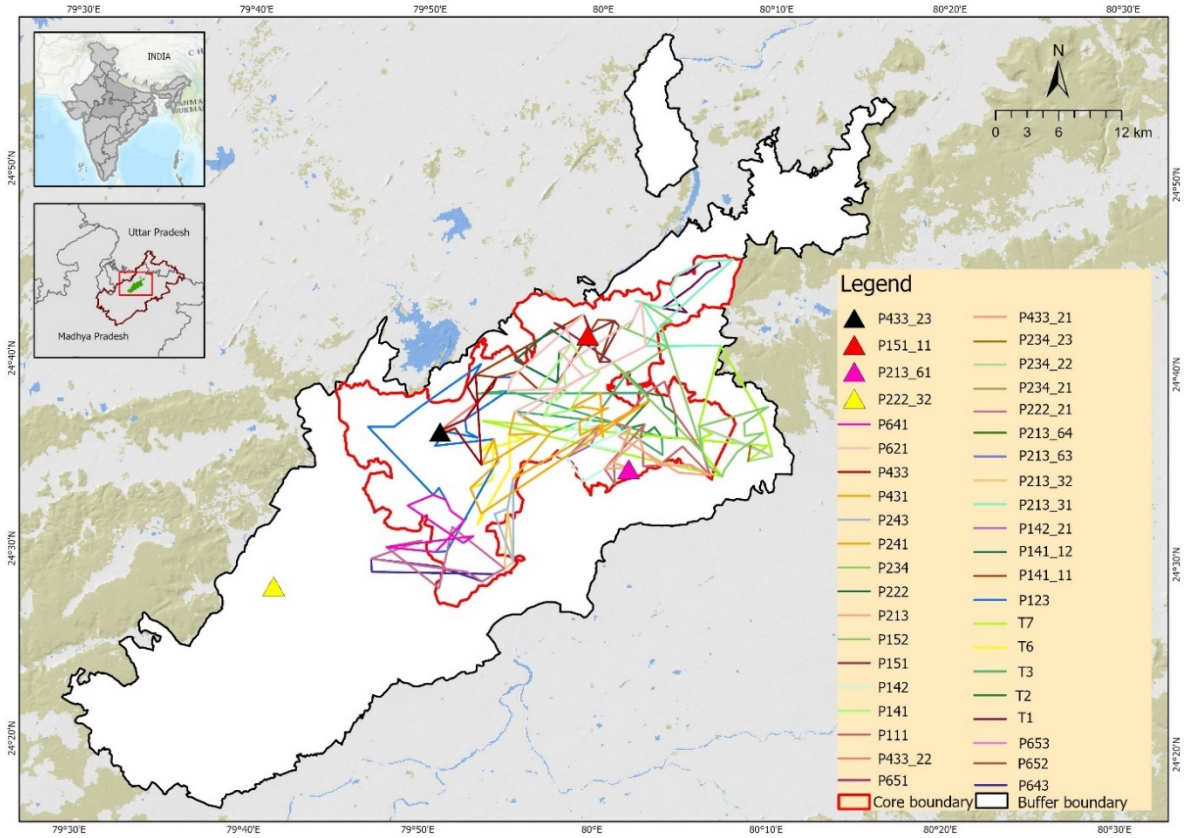


Figure 4.3. Camera trap-based home range of tigers in Panna Tiger Reserve (2018-19)

4.1.3. Demographic Patterns: As per the demographic data, the male: female ratio of tiger in PTR was 1:1.5 i.e., 0.64. As for fecundity, from early 2010 to 2020, within a decade, PTR has recorded 42 litters from 13 female tigers, including 5 reintroduced females and 8 progeny females. Tiger gave birth throughout the year except for September (Fig. 4.4). Maximum (n=19) litters were delivered during the summer season, indicating the peak mating season for tigers was winter especially late December to February.

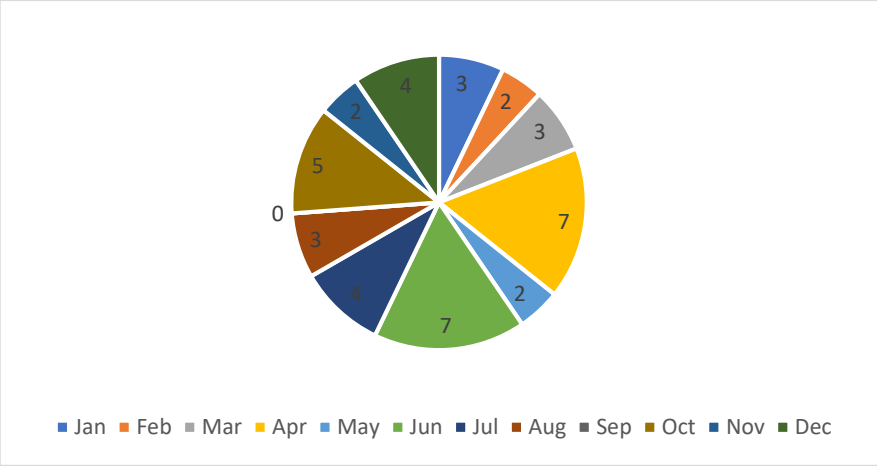


Figure 4.4. Months representing the birth (litter) events of tigers from 2010-2020

The average litter size for tigers was 2.75±0.10 (SE), as calculated from 37 litters and 102 cubs. An earlier study from PTR suggested comparatively lower average litter size of 2.3 (Chundawat *et al.*, 2002). The average inter-birth interval for PTR tiger population (the time between two successive litters) was 20.5±0.86 (SE) months or 1 year 8 months. However, the earlier study from Panna had shown slightly higher inter-birth interval (Chundawat *et al.*, 2002). Almost the same time-gap was observed from others park outside India, such as Chitwan National Park, Nepal (Smith *et al.*, 1991) and Sikhote-Alin Biosphere Zapovednik, Russia (Amur Tiger) (Kerley *et al.*, 2003). Other tiger reserves from central India have also reported much higher inter-birth interval (Fig. 4.5), possibly reflecting density dependent factors. The reintroduced tiger population in PTR, thus has a higher average litter size, low cub mortality, and short inter-birth interval, which has resulted in high population growth rate and thereby quick population recovery.

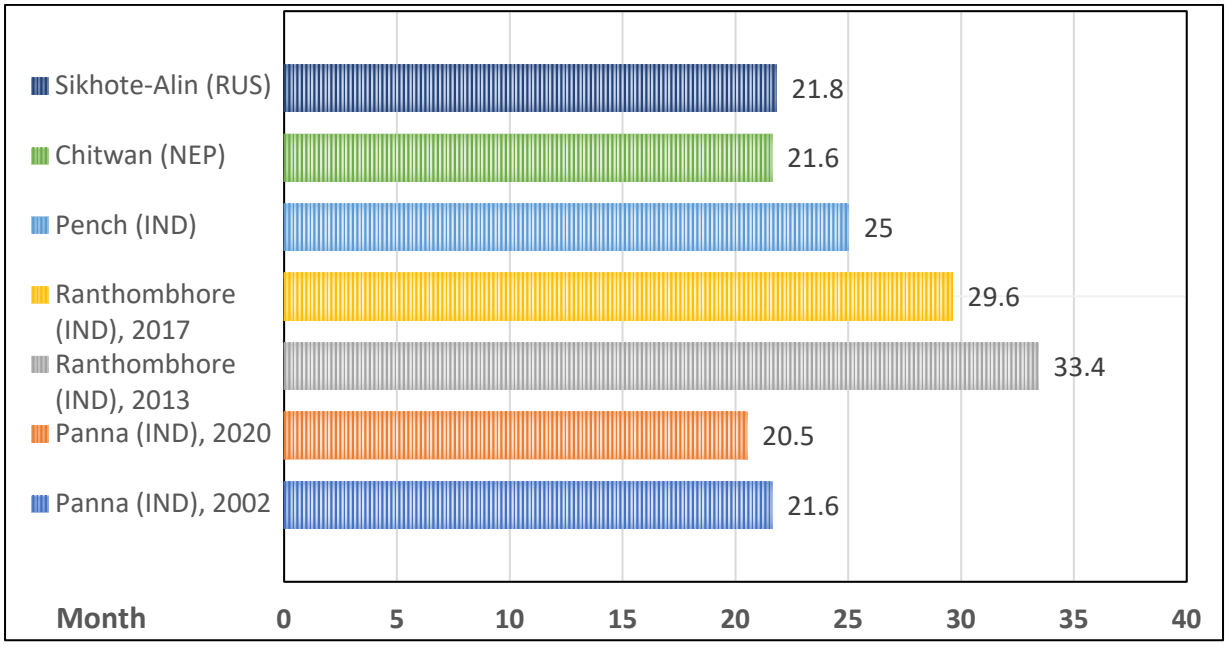


Figure 4.5. Average inter-birth interval of the tigers from different areas

For the initial 3 years after reintroduction (2009-2012), the tiger population was growing at a high rate of around 61% possibly due to abundant resources and lack of competition for space and food. After 5-6 years (2015-2016) when the population became stable and tigers were settled across the reserve, due to increasing competition for food, space and associated resources, the growth rate came down to 25%, which is comparable to the stable population growth model. However, due to the presence of a good number of breeding females, the population again increased, and the average growth rate for the past four years (2017-2020) is 32%. The overall population growth rate was ~27% across the years with an annual growth

rate of 31%, indicating a healthy population model. The R_0 determined from life table analysis of the mean rates of reproduction and survival is 5.40 indicating stable population trends.

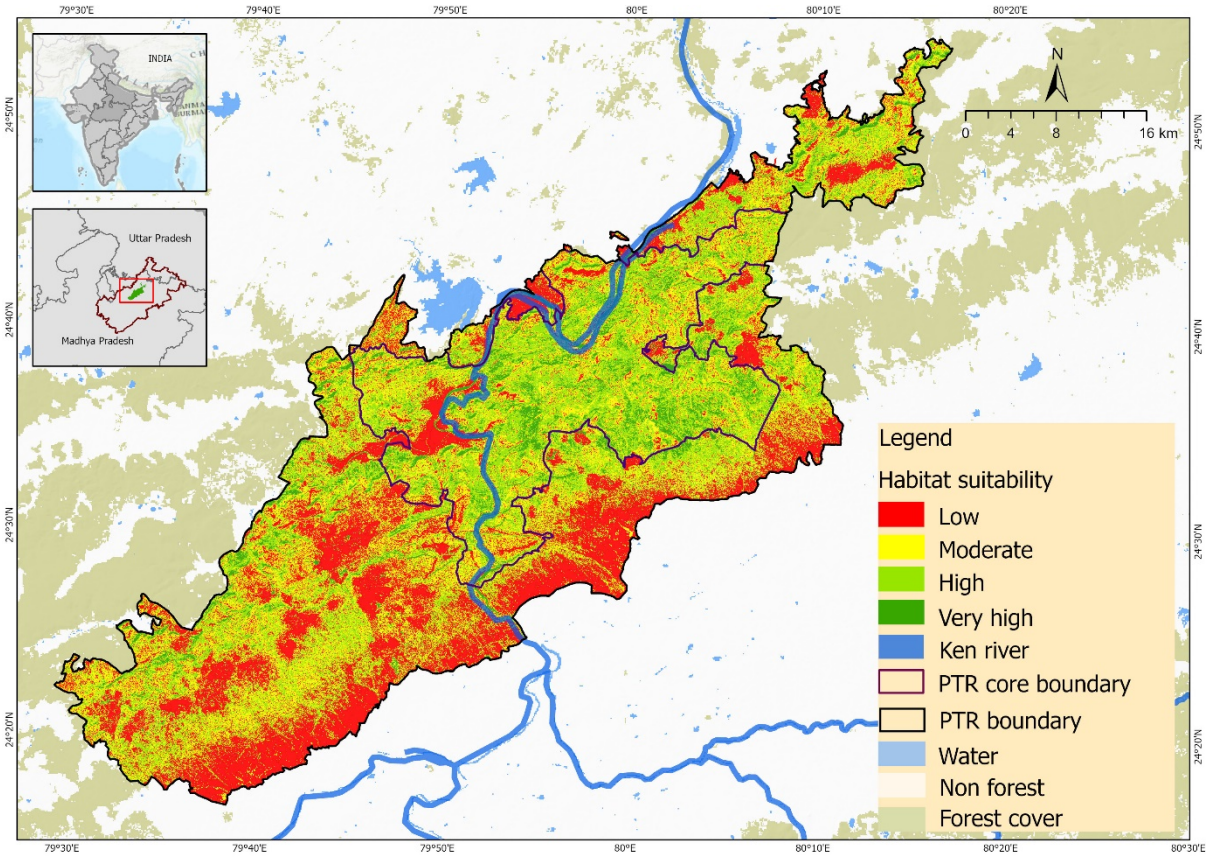


Figure 4.6. Map showing the suitable habitat of tiger within Panna Tiger Reserve

4.1.4. Habitat Suitability: We fitted a logistic model (estimated using ML) to predict habitat suitability with elevation, slope, aspect, NDVI and LULC. The Tjur's R2 was 0.10. The intercept was statistically significant and positive, whereas elevation (beta = -8.97e-04, 95% CI [-3.26e-03, 1.47e-03], p = 0.46) and slope (beta = -0.05, 95% CI [-0.13, 0.02], p = 0.19) were statistically non-significant and negative. The effect of aspect was also statistically non-significant although positive (beta = 0.01, 95% CI [-4.57e-03, 0.03], p = 0.172). On the other hand, NDVI and LULC were statistically significant and negative with beta = -19.84, 95% CI [-30.28, -9.70], p < 0.001 and beta = -1.08, 95% CI [-1.43, -0.76], p <0.001 for NDVI and LULC respectively. The GLM revealed significant factors for habitat suitability for tigers were NDVI and LULC, with negative association indicating that tigers tend to avoid dense areas. Given the NDVI value ranges from 0.49 (moderately dense) to -0.19 (non-forest) in PTR and that tiger preferred 0.26 to 0.16 range, habitat selection was in favor of open mixed forest and grassland, which offer high prey density. The resultant map of habitat suitability revealed that the highly suitable area was mostly distributed sporadically, especially in Panna and parts of

the Hinauta and Jhalar Ranges (Fig. 4.6). The moderately suitable habitat was mostly falling within Panna Buffer, Amanganj Buffer and parts of Kishangarh Buffer (Fig. 4.6). Panna Buffer is indicated as a potential area for critical tiger habitat. An earlier study by Sarkar *et al.* (2017) also indicated that the area is potential tiger habitat, though it is currently vacant due to lack of prey availability. The low suitability habitats are mostly the villages and barren lands in and around PTR (Fig. 4.6).

4.1.5. Carrying Capacity: Carrying capacity of PTR in terms of tiger was calculated based on Hayward et al. (2007) equation constructed for large carnivore (e.g., lion) i.e. Y = -2.158 + 0.377x (considering biomass of preferred prey species), where y is log of predicted predator density and x is log of preferred prey biomass. As per Hayward et al. (2007) equation, predicted tiger density was 13 individuals /100 km^2 (range 11-15) and predicted abundance was 72 tigers (range 61-80) in the PTR core area, and for the buffer area, the predicted density was 13.5/100 km2 (range 11-14) and the predicted abundance was 60 (range 49-63). As per these calculations, PTR (both core and buffer) can have around 130 tigers (range 110 – 143), which is way higher than current number of around 60 tigers. However, the equation developed by Karanth et al. (2004) based purely on prey density without taking into account biomass ((Tj = AUjbδj, where A = 0.25 (95% confidence interval 0.18 to 0.34), Uj= prey density/km2, b= 1 and δj=1, derived from the relationship between tiger and prey densities, based on harvest rate by tiger (i.e. 50 ungulates per year)), predicted tiger density in PTR core was 6 individuals/100 km^2 (range 4– 8) and predicted abundance was 32 (range 19 - 44). For PTR buffer, predicted tiger density was 4 individuals/100 km^2(range 2 - 6) and predicted abundance was 17 (range 9 - 25), accounting for total predicted abundance of 49 (range 28 – 69) in PTR which appears to be on the lower side, though it corresponds to current population size, if we consider the upper limit. We, therefore, consider the predicted carrying capacity of tigers can be upto 140 individuals as per biomass-based model, which translates into the option for doubling of the current population of tigers in PTR. However, this is to be reviewed in due course of time.

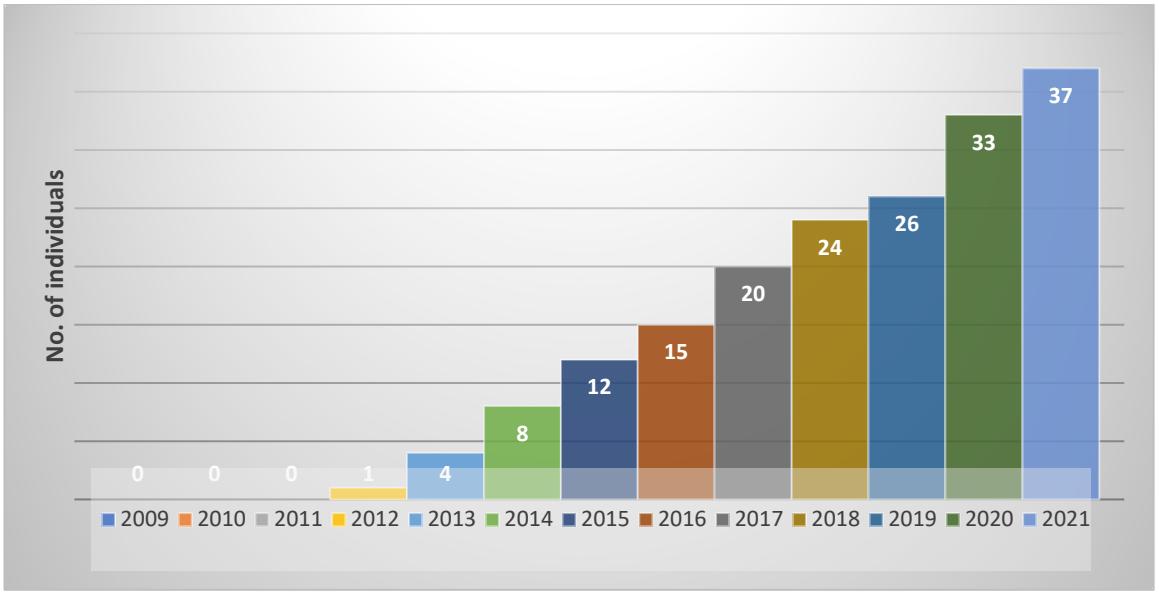


Figure 4.7. Number of dispersed/translocated tigers from PTR since reintroduction

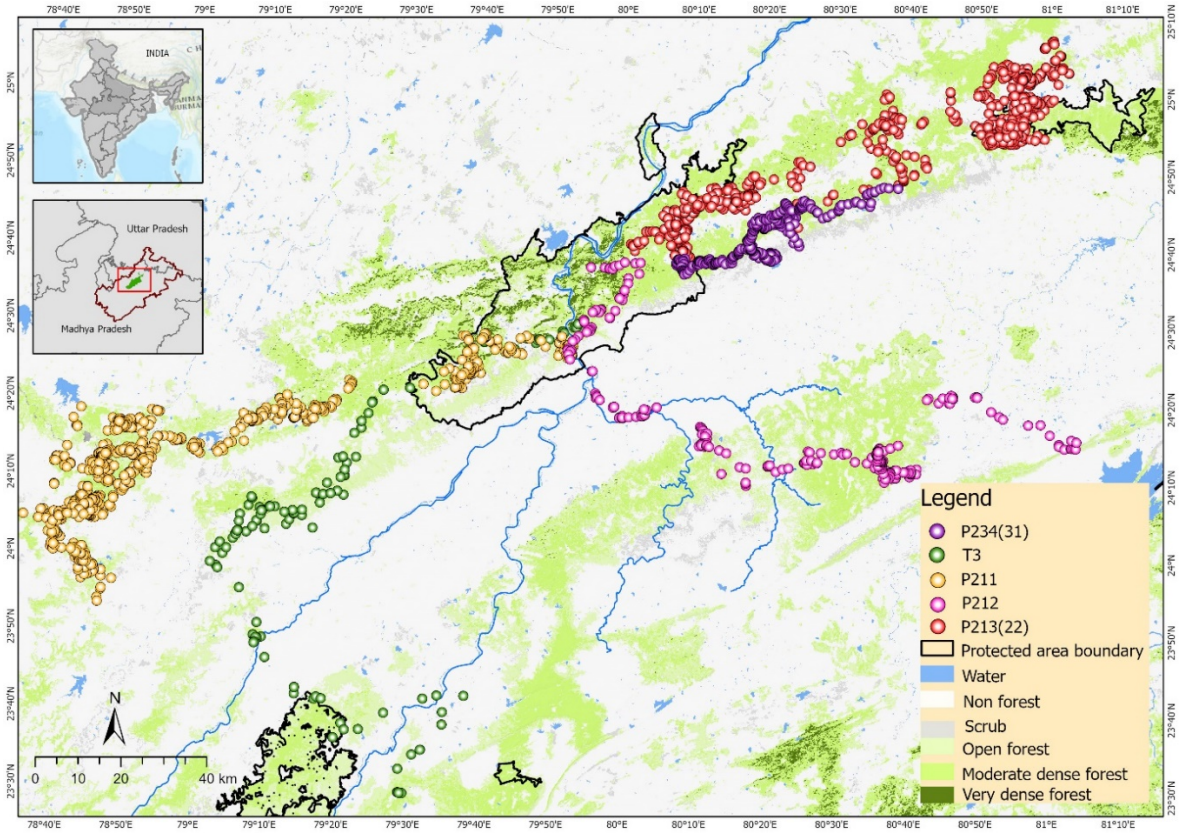


Figure 4.8. Dispersal movement of radio-collared tigers outside PTR

4.1.6. Dispersal: With the growing population, tigers have dispersed from PTR and are believed to be distributed in the landscape. Earlier studies suggested that Panna has connectivity with Nauradehi and Ranipur Wildlife Sanctuaries (Dutta *et al.*, 2016;

Krishnamurthy *et al*., 2016). The contiguous forest patch of North Panna and Satna forest division facilitate the animal movement towards Ranipur Wildlife Sanctuary (WLS). Since 2013 and until 2021, 37 adults/sub-adults have dispersed in the landscape (Fig. 4.7). Two of these dispersing tigers became 'conservation concern' due to conflict or electrocution risk and were captured. One was translocated to Sanjay-Dubri Tiger Reserve and another to Satpura Tiger Reserve within Madhya Pradesh. There was a report of a tiger reaching Bandhavgarh Tiger Reserve, while some have dispersed to Ranipur Wildlife Sanctuary, Uttar Pradesh (Fig. 4.8), and rest are believed to be in the landscape, although complete evidence is not available, despite efforts.

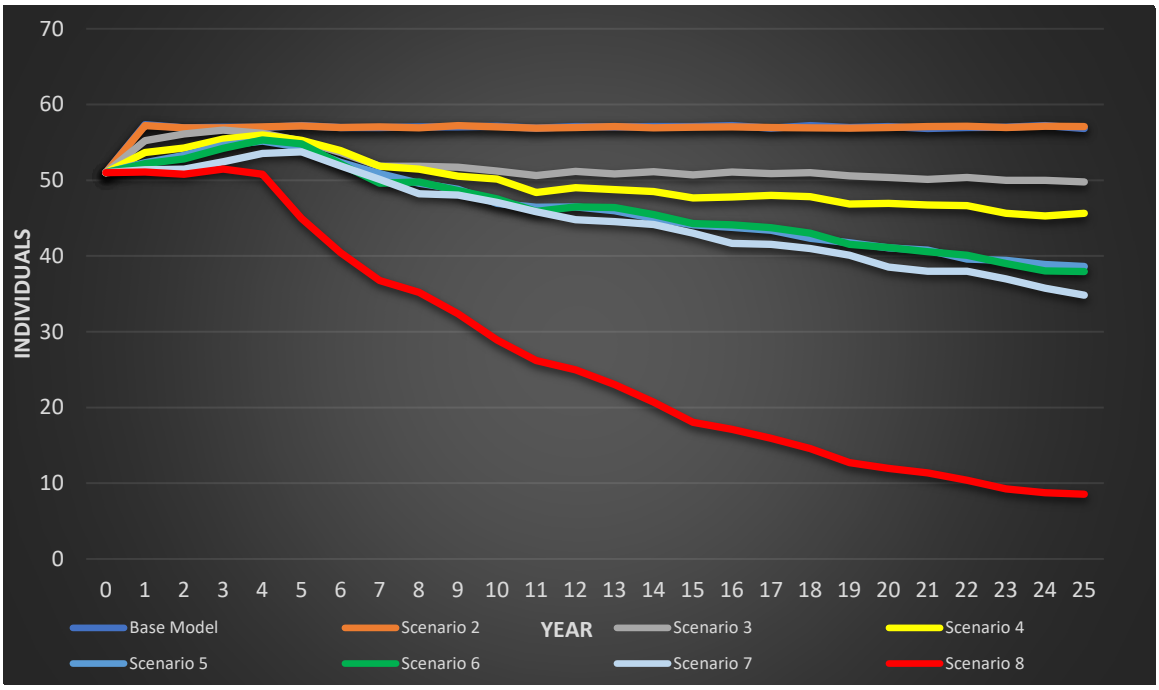


Figure 4.9. Mean population size as predicted by various scenarios

4.1.7. Population Viability: Population Viability Analysis (PVA) allows for predicting survival probabilities of the species in the long-term based on several scenarios. There were eight scenarios considered in this case with 25 years period. The base model (Scenario 1) consisted of current demographic details without any other consequences. The 2nd scenario was the same as the base model with inbreeding factors of 6.29 of lethal equivalent per individual and 2 catastrophic effects per year. The 3rd scenario was composed of the 2nd scenario details along with three individuals harvested (poaching/translocation/dispersal) every year. Among three individuals, we set the sex ratio as 1:2 for female: male, from the age class of 2-4 years. The 4th scenario consisted of the inbreeding effect, two catastrophic events and four individuals harvesting event (poaching/translocation/dispersal) from both males and females at a 1:1 ratio. The harvesting event considered to take place from 2 to 4 years of age in both sexes. In the 5th

scenario, the harvesting frequency remained the same with four individuals every year event but included removal of two males from 1-4 years and females from 1-3 years age class including a breeding individual. The 6th scenario was composed of population demography, carrying capacity, inbreeding depression, two catastrophic events per year and harvesting of four individuals every year (two males from 1-4years and two females from 1-3 years). The last two scenarios (7th and 8th) were quite like the 6th scenario, but in the 7th scenario, we increased the harvesting probability for females with 25% probability and in 8th scenario, we increased the harvesting probability with zero percentage of survival.

The results revealed that under the scenario 1 and 2, the tiger will reach carrying capacity sooner and will have 100% survival (Fig. 4.9). Even scenario 3 was almost close to the previous two scenarios. However, all other scenarios which had harvest (dispersal/poaching) may have a significant effect on population decline and long-term viability (Fig. 4.9), indicating that the survival of dispersing tigers need to be ensured and that the focus on landscape context is critical not only for ensuring protection of the dispersing tigers, but also for long-term survival of tigers in PTR.

4.1.8. Status of Co-predators in PTR:

Leopard: Being a co-predator and a highly adapted species, leopard was distributed more widely both in core and buffer in PTR (Fig. 4.10 a). It was most frequently photo-captured from Madla and Kishangarh core region, especially in the areas where tiger capture rate was lower. The middle plateau was well occupied by leopard. It was moderately photo-captured from Kishangarh, Amanganj, and Panna Buffer Ranges.

Hyena: Hyena is the true scavenger in this ecosystem and plays a vital role in the food web. The movement of hyena was mostly concentrated within the core (Fig. 4.10 b). However, presence of hyena was recorded in almost all of the buffer camera trap locations. High capture rate was found from the central plateau and along the river side.

Jackal: Like hyena, jackal was mostly photo-captured from the core, this species is widely spread over the core area, including all three plateaus within the core (Fig. 4.10 c). Jackal is evenly distributed on either side of the Ken River.

Sloth Bear: Sloth bear is sparsely distributed in PTR (Fig. 4.10 d). It is mostly surrounding the relocated village sites, alongside the river, near the gorges.

Dhole: Dhole is a group living carnivore. In PTR group sizes were comparatively lower, ranging from 4-10. We found low capture rate from the entire sampled area. Photo-captures were mostly confirmed from the core, including central, upper plateau and Chandranagar Range (Fig. 4.10 e).

Wolf: Wolf was photo-captured from parts of Panna core and adjacent Akola circle under Panna buffer. Another population was captured from the western side of the river, in Chandranagar and Kishangarh Core Ranges (Fig. 4.10 f).

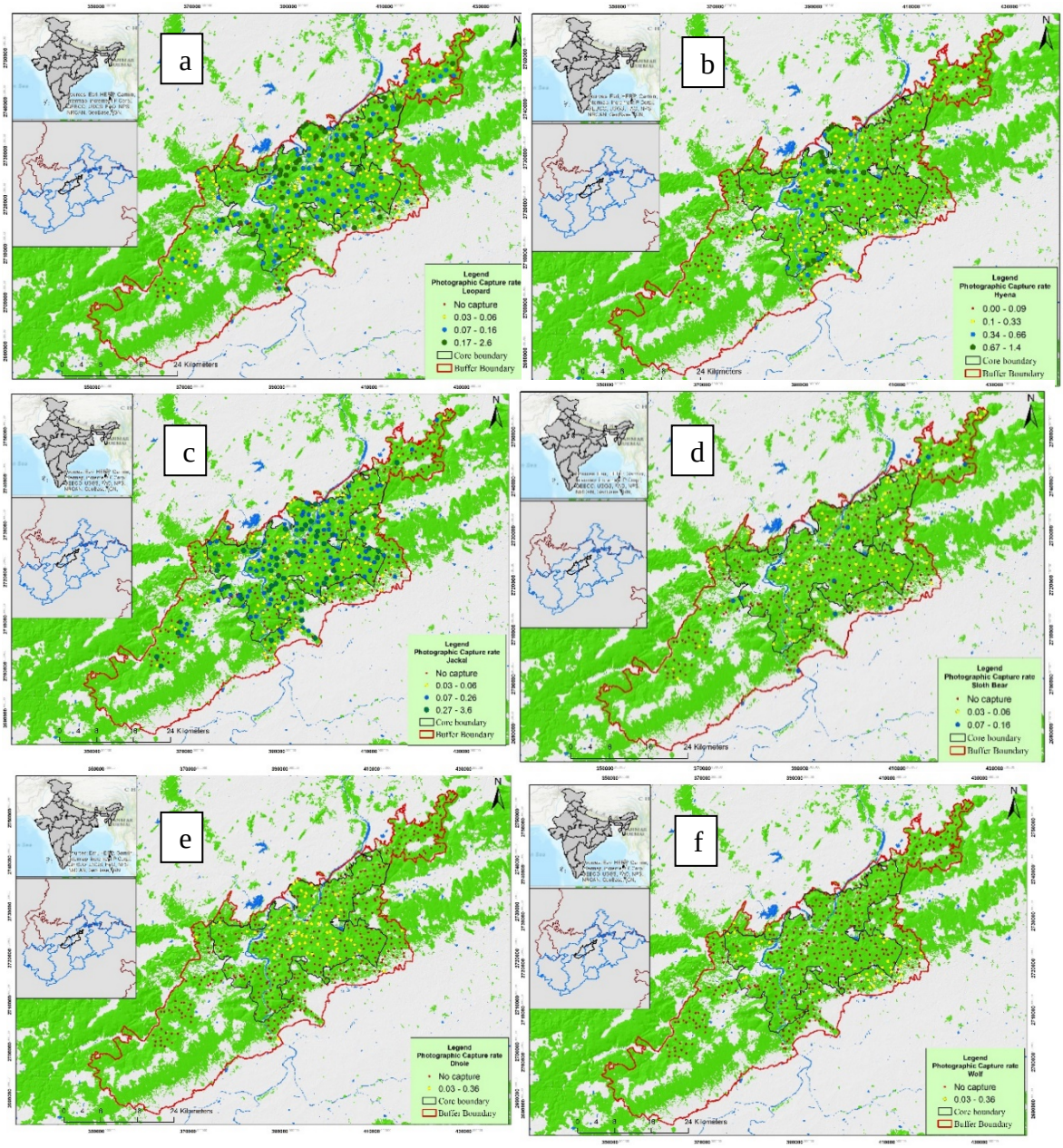


Figure 4.10. Photo-capture rate distribution of co-predators in Panna Tiger Reserve (a) Leopard; (b) Hyena; (c) Jackal; (d) Sloth Bear; (e) Dhole; (f) Wolf

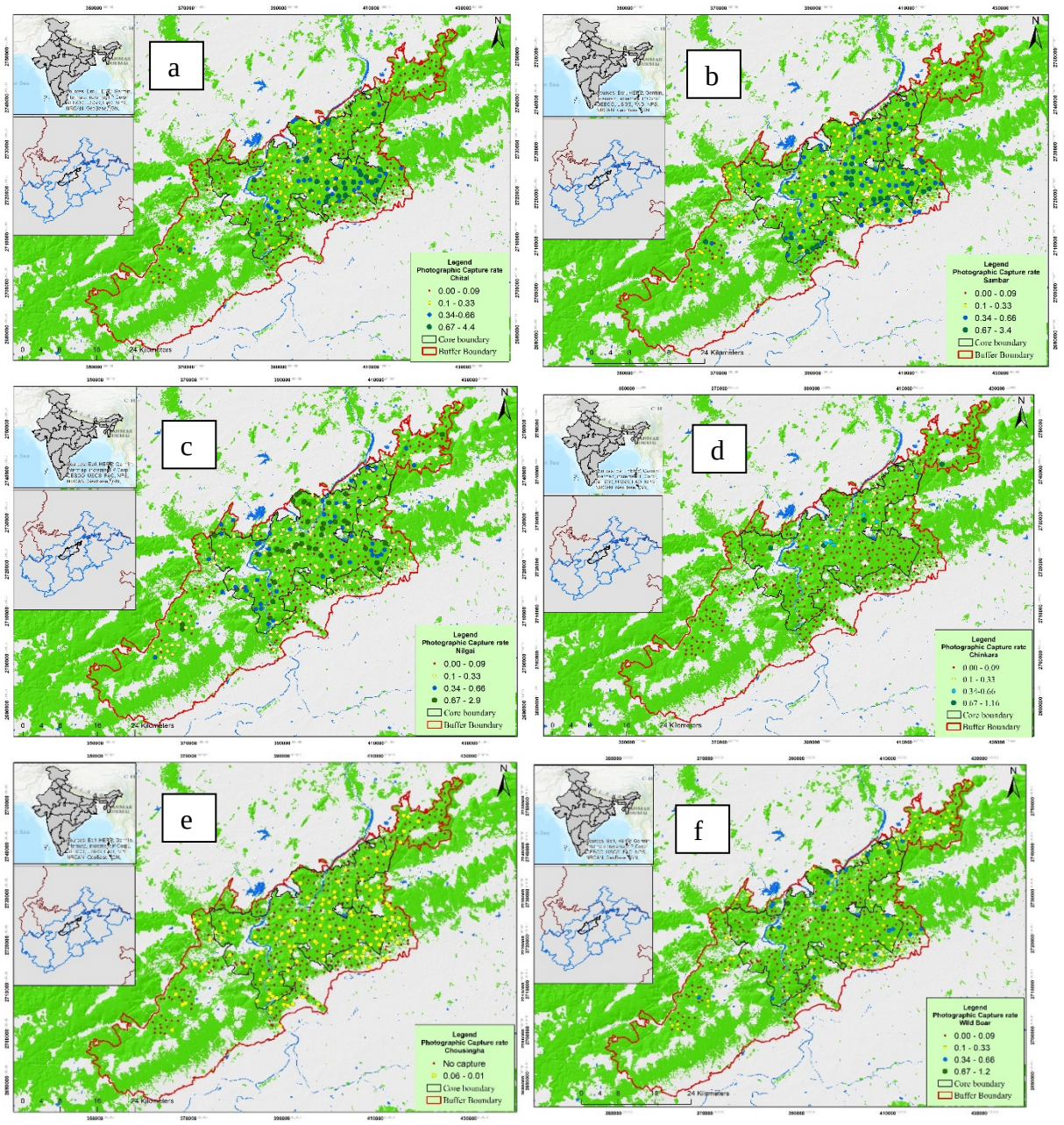


Figure 4.11. Photo-capture rate distribution of prey in Panna Tiger Reserve (a) Chital; (b) Sambar; (c) Nilgai; (d) Chinkara; (e) Chousingha; (f) Wild pig

4.1.9. Status of Prey in PTR:

Chitals were widely distributed in PTR. Photographic capture rate obtained from camera traps revealed that chitals were more frequently detected in the core zone of PTR, in comparison to the buffer zone (Fig. 4.11 a). In the core zone, Panna and Madla ranges showed highest number of photo-capture of chitals. This could be attributed to the avoidance of anthropogenic

disturbance especially livestock grazing (Dave and Jhala, 2011). Also, chitals were found to be primarily distributed in forest lands. They largely avoided areas close to human habitations, as also indicated by previous study (Bagchi *et al*., 2003). Similar to chital, a greater number of sambars were photo-captured from the core zone, in comparison with buffer zone of PTR, perhaps to avoid human pressure and avail better protected, well-wooded areas (Fig. 4.11 b). (Bagchi *et al*., 2003; Chatterjee *et al*., 2014). In PTR, nilgai was mostly detected in core zone, as well as some parts of the buffer zone (Fig. 4.11 c). Although nilgai is more tolerant towards anthropogenic activities (Bagchi *et al*., 2003; Karanth *et al*., 2009; Lamichhane *et al*., 2020), however, preference for the least disturbed forested areas (as observed in PTR) has also been reported from elsewhere in Indian sub-continent (Lamichhane *et al*., 2020). Apart from nilgai, two other species of bovids i.e., chinkara and chousingha were also detected in PTR, with a wider distribution of the latter (Fig. 4.11 d, e). Although chousingha is cryptic and occurs in low-density, widespread distribution of this species in PTR could be associated with the presence of tree-savanna deciduous forest types (Krishna *et al*., 2008), which is fairly common in PTR. However, chinkara was only detected from some patches of the core zone and a few areas in buffer zone (Panna buffer). Interestingly, despite its known tolerance towards the human activities (Bagchi *et al*., 2003), chinkara was not detected frequently in the buffer zone. Wild pig was frequently detected in both core and buffer zone of PTR (Fig. 4.11 f), indicating its ubiquitous nature of occurrence and tolerance towards anthropogenic pressure (Karanth *et al*., 2009).

From distance sampling (line transect) it was revealed that, in the core area of PTR, the density estimates (in 2019-2020, the latest estimate) for chital was 10.67 ±2.32 /sq.km. (320.10 ± 69.60 kg / sq.km), for sambar was 6.98 ± 1.09 (1047 ± 163.50), for wild pig was 3.99 ± 1.22 (159.60 ± 48.80) and for nilgai was 7.46 ± 1.22 (939.96± 153.72). In the buffer area of PTR, the density estimates (2018-19 and 2019-20, the latest estimate) for chital was 3.28 ±1.03 /sq.km. (97.5± 30.9 kg / sq.km), for sambar was 1.65 ± 0.61 (247.50±91.50), for wild pig was 3.10 ± 1.23 (124± 49.20) and for nilgai was 10.38 ± 1.34 (1310.40± 168.84).

4.1.20. Population Status of Tiger in the Landscape: Out of the 37 animals that were recorded to be out of PTR, the status of only 09 could be ascertained (Table 4.1). Apart from these 37 dispersed individuals, two tigers were translocated to Nauradehi Wildlife Sanctuary (these have produced three cubs) in April-May 2018 from Bandhavgarh and Kanha Tiger Reserve, taking the total number in the landscape to 96. During the plan process, we carried out camera trap survey between October 2018 and May 2019 and subsequently in 2020 in

strategic locations, but camera traps captured only 8 individual tigers in the landscape (five in Ranipur Wildlife Sanctuary, one in Satna Forest Division, and two in Nauradehi Wildlife Sanctuary). This was quite revealing and certainly requires focus, given that the recent efforts in the landscape by the WII team and the efforts under All-India Tiger Population Estimation (AITE) have not captured photographs of these animals. This again reinforces the need for landscape level conservation focus here.

Table 4.1: Status of tigers dispersed from PTR, in the Panna Landscape

S.No.	Animal ID	Sex	Year	Initial Information	Current Status	Remarks
1	P124	M	2012	Van Vihar, Bhopal	Van Vihar National Park	Orphaned, Rescued and Translocated
2	P211	M	2013	Sagar District	Satpura Tiger Reserve	Partially translocated
3	P411	M	2013	*Not known*	*Not known*	-
4	P412	M	2013	*Not known*	*Not known*	-
5	P121	M	2014	Damoh District	*Not known*	-
6	P122	M	2014	Ranipur Wildlife Sanctuary	*Not known*	-
7	P212	M	2014	Satna District	Sanjay Tiger Reserve (Died)	Partially translocated, died on 31/7/2015
8	P221	M	2014	*Not known*	*Not known*	-
9	P231	M	2015	*Not known*	*Not known*	-
10	P232	M	2015	*Not known*	*Not known*	-
11	P432	M	2015	*Not known*	*Not known*	-
12	P213(22)	F	2015	Ranipur Wildlife Sanctuary	Ranipur Wildlife Sanctuary	Natural dispersal
13	P213(21)	M	2016	South Panna	Bandhavgarh Tiger Reserve	Natural dispersal
14	P213(23)	F	2016	Satpura Tiger Reserve	Satpura Tiger Reserve	Translocated
15	P213(24)	F	2016	*Not known*	*Not known*	-
16	P242	M	2017	Ranipur Wildlife Sanctuary	Ranipur Wildlife Sanctuary	Natural dispersal
17	P622	F	2017	*Not known*	*Not known*	-

18	P623	F	2017	*Not known*	*Not known*	-
19	P222(11)	M	2017	*Not known*	*Not known*	-
20	P222(12)	F	2017	*Not known*	*Not known*	-
21	P213(33)	F	2018	Sanjay Tiger Reserve	Sanjay Tiger Reserve (Died)	Translocated, died on October 2019
22	P222(22)	F	2018	*Not known*	*Not known*	-
23	P234(11)	M	2018	*Not known*	*Not known*	-
24	P234(12)	F	2018	*Not known*	*Not known*	-
25	P261	M	2019	*Not known*	*Not known*	-
26	P262	M	2019	*Not known*	*Not known*	-
27	P213(61)	M	2020	*Not known*	*Not known*	-
28	P213(64)	F	2020	*Not known*	*Not known*	-
29	P222(32)	F	2020	*Not known*	*Not known*	-
30	P222(33)	UK	2020	*Not known*	*Not known*	-
31	P433-21	F	2020	*Not known*	*Not known*	-
32	P433-22	F	2020	*Not known*	*Not known*	-
33	P433-23	F	2020	*Not known*	*Not known*	-
34	P234(31)	M	2021	North Panna	Singhpur, Satna (Died)	Natural dispersal, poached on 15/10/2021
35	P234(32)	M	2021	*Not known*	*Not known*	-
36	P213(32)11	M	2021	*Not known*	*Not known*	-
37	P213(32)13	M	2021	North Panna	North Panna	-

4.2. Recommendations and Prescriptions

4.2.1. Measures for Enhancement of Protection: Tiger population in PTR has notable experience of population growth due to concerted efforts during 1990 to 2000, decline to extinction from 2000 to 2009, and exemplary population growth from 2010 until now due to active recovery efforts. Protection has been an important ingredient of the population growth and consolidation in PTR. This needs enhanced attention since the risks related to population decline cannot be said to be resolved and that given increasing human-tiger interface issues on account of population growth and development activities, the risk is only likely to be on the rise including from human-tiger conflict issues. The following protection measures are recommended with prescription under the plan to enhance protection towards consolidating the current and growing population in PTR:

(i) Special Performance Unit (SPU): Daily patrolling as practised by Forest Guard and support staff at beat level should continue, along with PIPs (Pugmark Impression Pad). At each patrolling camp, a register should be maintained to record all the activities during daily monitoring on a day-to-day basis including details of signs and sightings with GPS coordinates and other relevant parameters concerning threats to tiger. However, given the sensitivity along certain areas around buffer and porous core areas, it is recommended to constitute three Special Performance Units (SPU), under the direct control of Deputy Director/Field Director, to exclusively look after eastern zone, central zone and western zone respectively (as administratively decided by the Field Director, PTR) (Fig. 4.12). These units, consisting of five-member team with fixed tenure system, drawn from Deputy Ranger/Forest Guards from concerned Ranges, will be equipped with all logistics including sophisticated vehicle with necessary tools including UAV and monitor. These units would deal with protection as direct measure and managing human-large carnivore conflicts as indirect measure including community mobilization where required for awareness and consultations. However, any legal procedure and compensation payment would be dealt by the concerned forest guard of the beat where the incident is recorded, to ensure consistency and accountability.

(ii) Continuous Camera Trap Monitoring System (CCMS): Large parts of PTR are under Continuous Camera Trapping Monitoring System, as initiated under the tiger recovery project. However, due to limitation of resources for establishment and recurring cost, certain trade-off is practiced. This is an important component and needs to be expanded to the entire reserve, including buffer area. Additionally, sophisticated interface units with automation process and local network needs to be established to reduce physical access to each camera and to avoid

data loss. This shall ensure continuous monitoring of tiger and would deter human elements with ill-conceived intention, which is against the protection of tigers. The CCMS will need to be supported with dedicated workstation and manpower in each forest range and integrated with Decision Support System (DSS) at Head Quarters and linked to Special Performance Units. This prescription would require over 3000 camera traps with necessary accessories and 20% recurring cost, and dedicated hardware/software along with dedicated manpower (contractual under the plan) with training support in all range offices and headquarter.

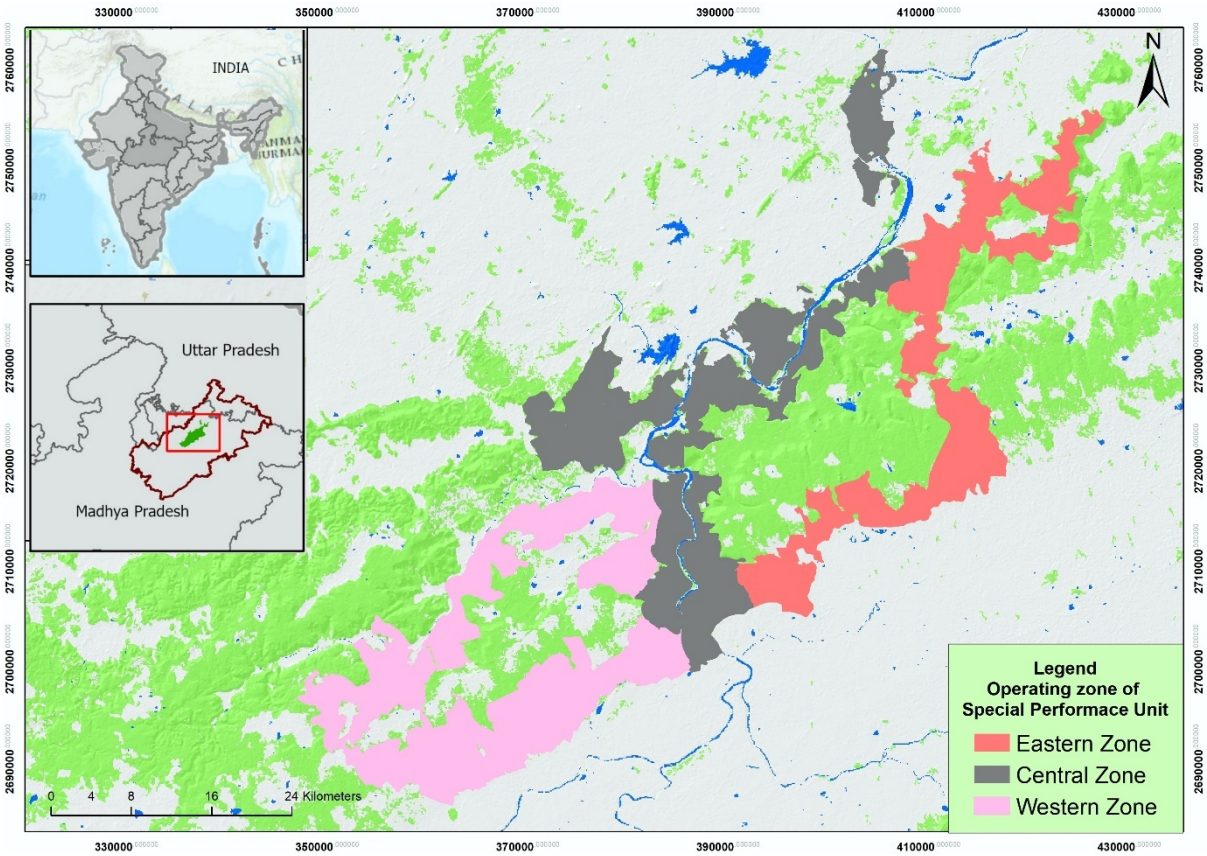


Figure 4.12. Map indicating the zones for deployment of Special Performance Unit within PTR

(iii) Crime Deduction and Alert System (CDAS): Currently, 'M-STrIPES' application is being used as mandated by National Tiger Conservation Authority for digital recording of patrolling activities and related information obtained during the survey. There are modules for dedicated purpose and the data is currently being used to understand intensity of patrolling and other parameters. In most cases, post processing involving several other parameters with time lag, limit ready use of the information. While this may continue to be used for the intended purpose, it is prescribed to develop site-specific application for various purposes proposed in the line of Enterprise Resource Planning (ERP) and with specific advance module for Crime

Deduction and Alert System (CDAS) for various responses that can range from green to red categories depending on the specified response requirements. Local Area Network may also be created to support the seamless information flow for effective responses. The CDAS, either exclusive or a part of ERP, can have interface solution that can communicate with existing and emerging requirements as may be mandated by Central and State Governments for various purposes.

(iv) Intelligence Network and Incentives: Developing an intelligence network is a pre-requisite for the prevention of wildlife crime or post-incident monitoring. The formation of intelligence network broadly involves identification and appointment of "contact" and "source". "Contacts" are the suppliers of more casual information regarding any suspicious incidents, whereas "sources" are more definite in nature in terms of factuality of those incidents. Selection of such personnel from local communities should be done with extreme caution as it would facilitate to build confidence among other people to provide such information to the source. Ideally, to get accurate information, a source should be either an insider or the one who is about to be engaged with some unlawful activities. Both the contacts and sources are usually paid incentives based on the quality information supplied.

(v) Un-manned Aerial System (UAV) for Monitoring, Protection and Supply of Essentials: PTR has steppe topography with steep escarpments and long stretch of rivers posing challenges for foot patrolling. Further, the area becomes inaccessible during monsoon and fire is recurring event in summer. The lag in responding to any events make the actions redundant. Therefore, taking advantage of Government of India's policy for Drone (UAV) Application and genuine requirement in PTR, it is prescribed to deploy two sophisticated units of UAV – one with Thermal Camera and one with Mapping Camera, supported by live transmission, in each of the Protection Zones (East, Central and West) and have this linked to SPU and DSS at the Head Quarters. Application of UAVs in the field of wildlife conservation has proven to be effective in many cases worldwide from monitoring breeding success of canopy-nesting birds (Weissensteiner *et al.*, 2015) to surveying elephants (Vermeulen *et al.*, 2013). In terms of accuracy of data collection, collection efficiency and cost effectiveness, UAVs have outperformed the traditional methods (Koh and Wich, 2012; Anderson and Gaston, 2013; Marris 2013; Bryson *et al.*, 2014). In PTR, UAVs can be involved in surveillance in strategic places and remote areas, night patrolling using thermal cameras, animal counting, tracking of animals, habitat mapping and monitoring including fire detection. Tiger movement towards village and territory fight between tigers may also be monitored and UAV can also be

used as deterrent tool. More importantly, supply of food items and medicine can be delivered to permanent and temporary camps, and this would be very helpful during monsoon and also during crisis management situations. Each year during dry season, PTR and its adjoining areas face substantial number of forest fire incidents. Hence, to strengthen the existing fire management team, integration of technology such as application of UAVs (equipped with visual and thermal sensors) would be effective. Application of drones would be especially useful to create situational awareness to fire management team in tough terrains (e.g., Kishangarh core and buffer) and help in decision making, as well as ensuring protection of ground team and villagers during uncontrolled fire. Also, future strategies to control the fire incidents in PTR should incorporate specially customized fire-fighting drones.

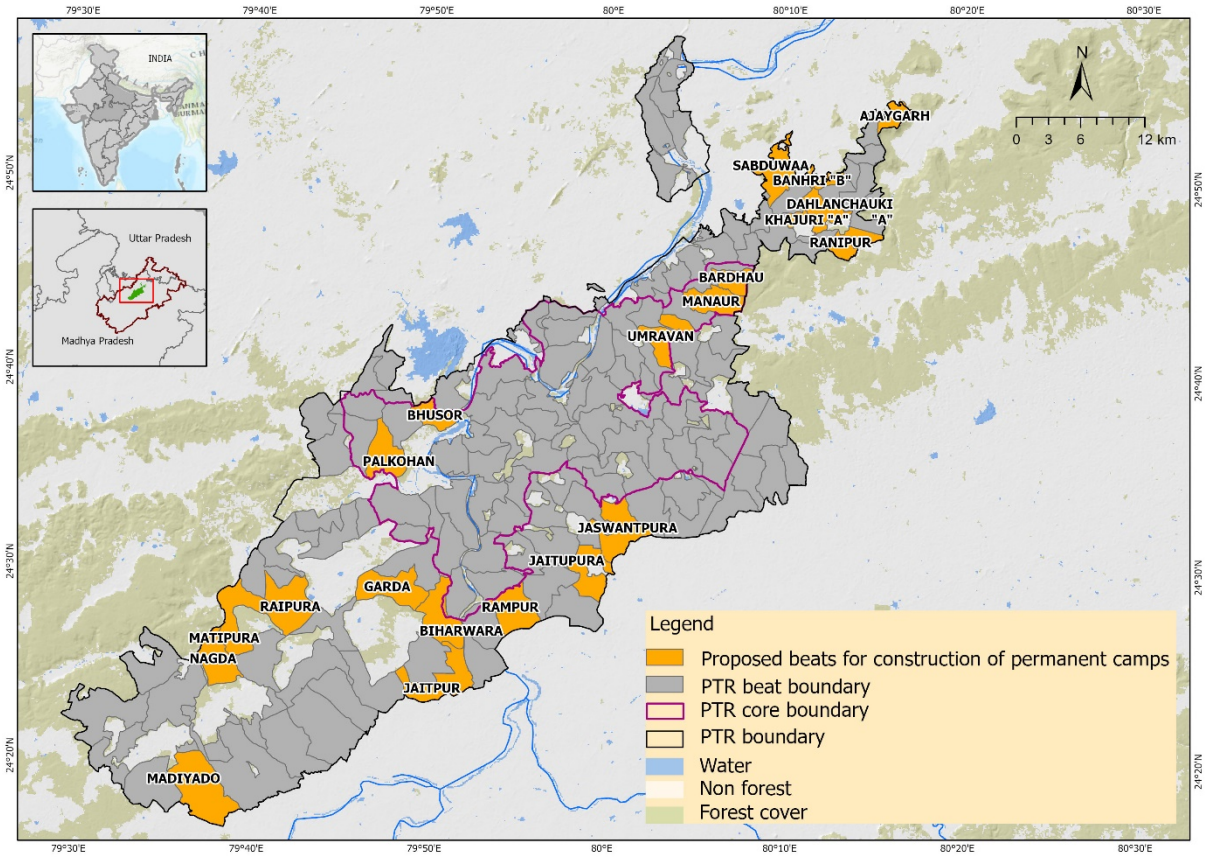


Figure 4.13. Map showing proposed forest beats within PTR where permanent camps can be established

(vi) Strengthening Staff Infrastructure and Logistics: PTR has dedicated establishment across the area, but current support system requires strengthening including facilities such as clean drinking water, toilet, electricity, gas for cooking, etc. Positioning of camps require

review and there is need to establish permanent camps in strategic locations so that more than one beat guards can form a team to deal with protection and other management issues (Fig. 4.13). Most importantly, range-level facilities such as line quarters should be created for the forest staff, with hospital, school, etc. so that they can live with their families and with better motivation. Health, as well as life insurance should be institutionalized. Like the Veterinary Doctor on deputation posting, efforts should be made to have Public Health Doctor on deputation to PTR to support the health requirement of the staff or district level medical officer can be mandated to support PTR for health requirement. A dedicated 'Mobile Hospital' with dedicated ambulance is to be established in PTR to endure the health facility reaches each of the camps and other establishments to ensure health and motivation of the staff. Regular inputs on law enforcement and self-defence training should be given to the forest staffs, with enhanced focus on women. Domestic Elephant Unit (DEU) is an important component of protection, management, and monitoring, and thus, this unit needs to be strengthened with additional elephants and manpower (specially Mahavats) with proper financial package.

(vii) Virtual Fence Network (VFN): PTR boundary (both core and buffer) should be fenced virtually with Wireless Sensor Network and Communication Tool (WSNCT). There are many options available such as GSM or Wireless Network Camera Traps and Fibre-Optic Cable Sensors with artificial intelligence wherein the objects of our interest can be classified and reported on real-time basis. Primary classification can be tiger and human so that any intrusion of human in sensitive locations and excursion of tiger outside can be detected and dealt with appropriately and more importantly, immediately. However, other species can also be integrated in the virtual fence network. Some of the sophisticated radio-collars are available with proximity sensors and such options can be exercised to monitor the tigers that are using human-interface areas. Establishment of E-eye surveillance system is also suggested. E-eye is a large-scale intelligent technology which can operate 24x7 basis and in all weather conditions. This is primarily designed to enhance the protection regime of PAs, especially in sensitive areas. In India, three Tiger Reserves (Corbett Tiger Reserve, Kaziranga Tiger Reserve and Ratapani Tiger Reserve) have already established the E-eye surveillance system and found it quite effective in terms of better monitoring and protection. Installation of such units in the vulnerable areas of PTR, especially where manpower/logistics and applications of UAVs are limited, could reduce the chance of poaching and other unlawful activities by alerting the response team/CDAS or SPU units before the violations take place. Apart from the dedicated central server station for E-eye, authorized users can access the data recorded by the cameras

of E-eye tower and also control every monitoring feed, as the whole process of data recording, storing and receiving is remotely connected via 4G networks and satellite technology.

(viii) Social Fence Network (SFN): Social fencing can be viewed as a means of developing sense of collective responsibilities towards protection of forest or a particular ecosystem, mostly through patrolling by people from local communities, which gained its popularity in India during mid-1980 (Mishra and Sarin, 1987). Engagement of local communities through Ecodevelopment Committee (EDC) under forest management or Support Institutions (SI) under Panchayat Administration to reduce the pressure of constant surveillance from forest staff would be especially helpful to protect pre-identified sensitive areas (in terms of poaching, illicit felling or unauthorized cattle-grazing or resource extraction) of tiger reserves or fragile ecosystems as well as building up long term trust between forest department and local people. More importantly, implementation of this concept would also generate income sources for the local people and build knowledge on settlements of communities' rights of access on forest resources, in an institutionalized way. In PTR, Social Fencing Network (SFN) will have to be established in each of the villages in and around PTR, and this would require investments related to awareness, capacity building and incentives for the communities.

4.2.2. Measures for Population Management: The vital goal of population management is to maintain a viable population of tiger which is often defined in the form of carrying capacity and with appropriate demographic and genetic variabilities. Therefore, population management is not only related to specified numbers but also with balanced age pyramid that allows for insensitive to dispersal events and other individual related anomalies. Therefore, the prescription for existing and growing tiger population would involve (i) fine scale distribution mapping and monitoring, (ii) spatially explicit estimation and monitoring, (iii) demographic management, (iv) genetic management (v) protection of denning sites and (vi) establishment of controlled population management facility.

(i) Fine-scale Distribution Mapping and Monitoring: Current patterns of distribution has already been mapped based on camera trapping method and GIS-based modelling approach. These would serve as baseline and needs to be updated every year so that the tiger population changes in terms of space and habitat occupancy including change in the pattern with habitat improvement, can be understood and managed accordingly. As of now, the suitable habitat in the southern and western portion of PTR is minimal, but habitat improvement and removal of

anthropogenic disturbance would increase the suitability and thereby, increase tiger movement and population growth.

(ii) Spatially Explicit Population Estimation and Monitoring: As per the NTCA protocol being followed in PTR, the Phase IV monitoring allows for understanding minimum number and estimate of tiger number. However, this protocol needs to be enhanced with site-specific intensity, since the population has grown rapidly and dispersal events are taking place, including habitat occupancy in the adjoining areas. Therefore, a credible system is to be put in place in PTR whereby the sampling intensity is to be increased and analyses at local level is to be done to understand the population size. Effect size of population change should be minimal so that the change in population size can be detected quickly and suitable measures can be implemented.

(**iii) Demographic Management:** Currently, tiger population of PTR is demographically stable and would not experience any deleterious effects despite of a high rate of dispersal (animals at pre-reproductive phase) events, which was evident from PVA. However, since the population has already reached carrying capacity (and still growing), management of tigers in the context of demographic parameters should be carried out. It is recommended that, breeding females of pre-identified areas (such as buffer zone and some parts of core zone) should be closely monitored (possibly involving GPS-satellite telemetry) regarding the sex-ratio of the litters produced. In case of male-biased litters (which was the case during early stage of reintroduction in PTR), individuals (males) can be selected for future reintroduction/translocation to other tiger reserves and PAs. Sub-adult males which are likely to disperse due to insufficient space or competition would be suitable for such translocation. Similarly, sub-adult females could also be targeted from buffer zone, since buffer zone is supposed to be sub-optimal habitat and act as cushion for core. Local translocation of tigers (from high density areas to low density areas based on habitat suitability including prey availability) should also be done if infighting becomes a recurring event and in situations where male-female ratio is skewed beyond expected, such experiment may be carried out and further actions taken adaptively.

(iv) Genetic Management: Genetic population structure should be monitored regularly, and intervention can be made by translocating animals and/or strengthening connectivity. As of now, there is no genetic stress in the population since the reintroduced population has diverse source populations with geographic and genetic diversity. However, it is prescribed to

undertake genetic monitoring of tigers in PTR and undertake PVA every five years to understand genetic effects of the population. In case of any genetic anomalies, exchange of individuals from other source populations may be considered. Since, PTR holds the only source population of tiger in this landscape, the present high heterozygosity may not ensure long-term genetic vigour, especially in the context of dam construction under the KBLP. Genetic diversity assessment in combination with individual-level genetic relatedness are proposed in PTR, and in case of any genetic anomalies, exchange of individuals from other source populations or local translocation (between eastern and western zone of PTR) may be considered, which has also been proposed and practised elsewhere to maintain the genetic diversity and population viability of large carnivores (Diefenbach *et al*., 2015; Saremi *et al*., 2019). Another natural process would be to enable tiger movement (immigration/emigration) by strengthening movement pathways and habitat connectivity within and across landscapes (further discussed in section 4.2.4.). Also, similar to PTR, periodic genetic assessment should also be carried out in the GPL, especially those pre-identified satellite cores and stepping stones (see section 4.2.4).

(v) Protection of Denning sites: Den site is another important aspect for cubs' survival, fitness, and social structure (List and Macdonald, 2003) of the species, which eventually affects the population dynamics. However, the availability of such sites may be limited by habitat features and human activity. Though the availability of these sites may be dependent on habitat variables, topography, presence or density of other co-predators (Kitchen *et al.*, 2006) and prey species (Wang *et al.*, 2008; Márton *et al.*, 2016). The physical and functional characteristics of a den may vary according to species, individuals and season. Based on that den site can be divided as the breeding den and resting den (Meia and Weber, 1992).

Since reintroduction, 18 tigresses were radio-collared in PTR, long-term collar data of 10 tigresses revealed a total of 28 den sites, used by the tigresses. Long-term collar data helps us to understand the den use pattern by the tiger. Repetitive uses of the same den site by the same tiger, was also recorded. Most of the denning sites are located at gorges, the high degree of slope makes them inaccessible to many co-predators. Gorge sites were typically covered with dense vegetation and high canopy, which entrapped a good amount of humidity. Moreover, gorge and slopy areas were comparatively cooler than the open areas.

Protection of denning site is a serious management concern in terms of protection of newly born cubs, which is necessary to maintain a viable population within the PA. High disturbance

surrounding the denning site may force the tigress to abandon the den, the tiger may even abandon the entire litter, which has a direct effect on the population abundance, density, sex ratio and species assemblages. Being a tiger reserve, conditional tourism (vehicle movement within a defined zone, twice a day) is allowed in PTR, especially at Hinauta and Madla plateau. We have recorded seven denning sites that fall under the tourism zone. Regular monitoring of the active denning sites and intervention in tourism, by means of restricted movement near the den site, need to be practised. Restriction should be implemented at least for 4-5 months once the pregnant tiger is settled in the den or during the active den periods. Simultaneously, restriction in movement of humans and cattle must be implemented and strongly monitored near the den sites. As per the experience of recorded denning sites, four den sites are falling within the 2 km radius from the villages. Giving birth and rearing of cubs under lantana bushes and comparatively in flat terrain was also recorded. Cattle grazing and fodder collection must be controlled in areas surrounding the denning sites. Restrictions on movement around the denning site can be imposed in the buffer zone as well, where anthropogenic pressure is quite high in comparison to the core area.

(vi) Establishment of Controlled Population Management Facility: Population growth is a constant process unless faced with impediments and thus, even with improving habitat condition and strengthening connectivity, the population growth often leads to increased human-tiger interface. Infighting in prime habitats with high density also become cause for loss of high-quality individuals. To manage such individuals, it is proposed to establish Controlled Population Management Facility within an area with no connectivity value and sub-optimal habitat with human interface. This would be a large, fenced area of 50 to 100 sq.km. and would also serve as reserve population for PTR, in case of demographic and genetic crisis. The site selection for this would need to consider conservation and tourism potentials, and thus, it is best to establish such facility in the Panna District where it is technically feasible, administratively efficient and increases tourism benefits. This requires further consultation with field officers and technical experts, and to be implemented through a dedicated Detailed Project Report (DPR). However, the construction of Controlled Population Management Facility is to be done only in buffer zone or outside the reserve limit based on legal and policy directions (Fig. 4.14). Individuals that are transient in high density areas, potential conflict tiger and the ones that are likely to be in poaching/electrocution risk may be the choice for such facility. The facility will also serve as temporary holding facility for such animals. However,

major focus of conservation efforts here would be in-situ with such facility playing support role during crisis management.

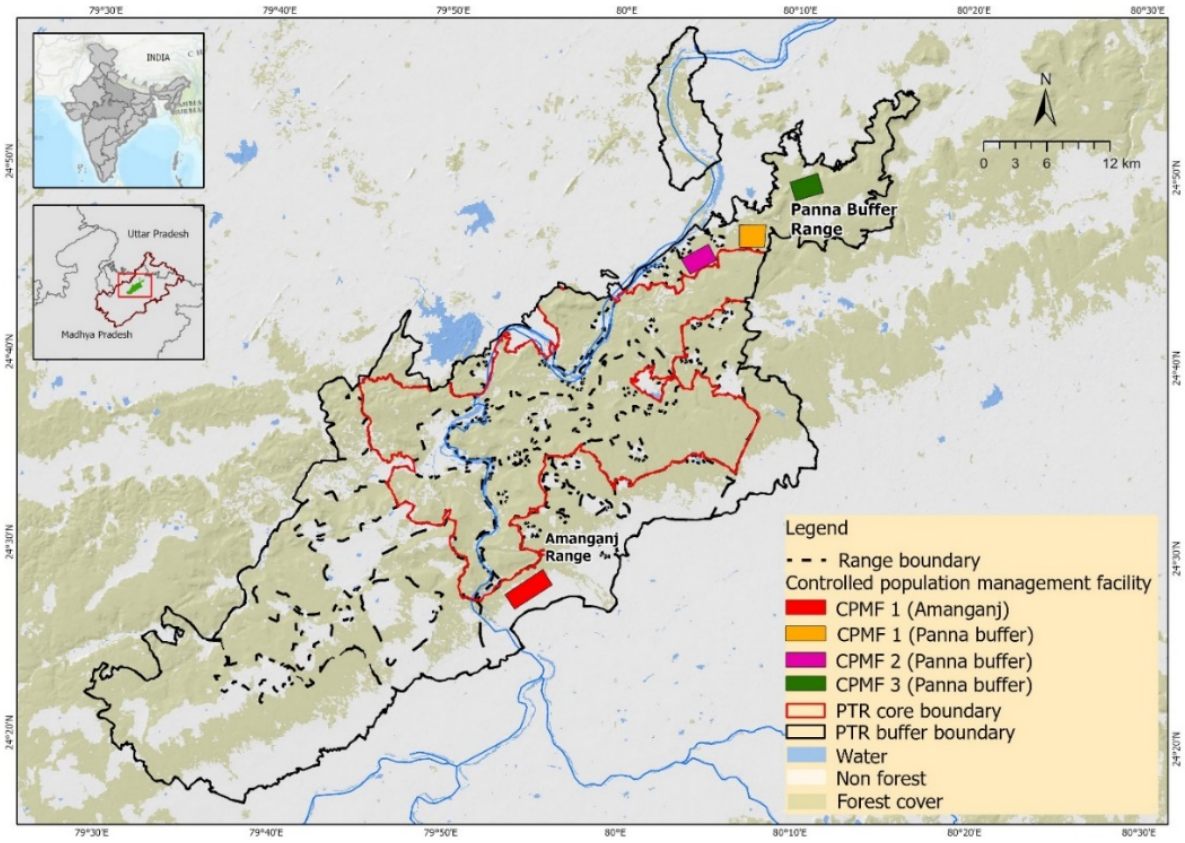


Figure 4.14. Map indicating proposed sites for establishment of Controlled Population Management Facility in PTR

(vii) Disease Surveillance: Wildlife disease surveillance can be a useful component of human and animal disease monitoring, prevention and control programmes, as well as conservation efforts. The surveillance and monitoring of disease outbreaks in wildlife populations are particularly relevant in these days of rapid human and animal interaction when the contact between wild and domestic animals are frequent (Mörner *et al.*, 2002). In context to animal health, wildlife disease surveillance may provide sufficient information on domestic and wild animal morbidity and mortality, and identify the changes in patterns of disease occurrence over time. Wild mammals are also a source of several emerging diseases (Daszak *et al.*, 2001; Cleaveland, 2003; Cunningham, 2005). Comprehensive epidemiological investigations and disease surveillance of wild mammal populations will enhance the capacity to detect and control infectious diseases that may emerge in the future in human and domestic animal populations. For these reasons, the development of effective programmes for the surveillance of disease in wildlife populations is becoming increasingly important, in terms of their

objectives, concepts and methodology to those undertaken for domestic animal health surveillance and monitoring. In Canada, a national programme of monitoring and surveillance of pathogens and diseases in wild animals has been carried out since 1992 by the Canadian Cooperative Wildlife Health Centre (CCWHC), with a collaboration of Canada's five veterinary colleges and federal, provincial and territorial government agencies (Leighton *et al.*, 1997).

Monitoring of wildlife health in the buffer zone is more crucial, where wild animals live in close proximity to human and their livestock. In the peripheral villages around PTR, a large number of livestock comes in contact with wild animals especially herbivores transmitting diseases to wild animals. The livestock in the villages sharing the water holes should be immunized to avoid the transmission of disease to wild animals. There is every chance that the communicable diseases from the cattle are transmitted to the wild animals such as Foot and mouth disease (FMD), Bovine tuberculosis (bTB) and Rabies. The growing number of stray dogs inside the reserve is a major problem. the effects of feral dogs on local wildlife are harmful, since wild ungulates are often hunted by dogs. To make things worse, it was found that some local people train these stray dogs to hunt wild ungulates on purpose. Problems of feral dogs were found to be most frequent in areas close to human settlements. Apart from these threats to local wildlife, feral dogs are the source of contagious canine diseases (Canine Distemper Virus (CDV) and rabies) and other zoonotic diseases which are fatal to tigers and other wildlife. In order to prevent these contagious diseases, the immunization and sterilization of stray dogs should be carried out in the buffer zone. Capture, vaccination and transportation of feral dogs should be carried out from buffer zone following the SOP mentioned by NTCA. From the previous knowledge, one tiger died due to the CDV, a morbillivirus that causes one of the most contagious and lethal viral diseases known in canids, in PTR. CDV had been identified in populations of wild tigers in Russia (Gilbert *et al.*, 2015), which was responsible for the decline in wild tiger population from 25 in 2008 to 9 in 2012 in Sikhote-Alin Biosphere Zapovednik.

Capacity building of ground staff is highly recommended to acquire some basic skills to collect samples from carcasses, its storage and transfer to the nearest wildlife veterinary centres or forensic laboratories for detailed investigation. Simultaneously, the development of a disease surveillance system in buffer and the peripheral zone of PTR is equally important for early detection and better monitoring practice to be integrated with the management system.

4.2.3. Prey Augmentation and Population Management

The prey-predator relationship consists of the interactions between two species and their consequent effects on each other. It is likened to an evolutionary arms race-the prey become more difficult to capture and eat, while the predators perfect their abilities to catch and kill their prey (Taylor, 1984). In the prey-predator relationship, one species is feeding on the other species. The survival of any predator is directly related to its habitat, presence of other competitor species and quality and quantity of its prey (Melville *et al.*, 2004). Prey selection is critical for understanding the life-history strategies of any carnivore (Miquelle *et al.*, 1996).

The prey population is not equally distributed in PTR, even within the core, due to the different terrain complexity, vegetation patterns etc. Grasslands are mostly situated in the relocated village sites, which is distributed sporadically within the core. As the grasslands are not interconnected and distributed in a distance from one another, prey density is also high in these pockets. Lack of canopy cover and dense vegetation also affects the distribution of prey population. The prey capture rate data obtained from the camera trap revealed irregular distribution of the prey species. Moreover, the middle plateau of PTR (Hinauta and Gahrighat range) has low canopy cover and low tree density. Strategic plantation of riparian vegetation such as Jamuneri (*Syzygium salicifolium*), Khinni (*Manilkara hexandra*) and Arjun (*Terminalia arjuna*) should be implemented in terms of the dense canopy. Continuous monitoring of managed grassland is required to ensure the food and protection of prey species.

Crop raiding by the herbivores is common surrounding the core. Systematic capture, translocation and release can be practised regularly. Captured individuals would also be shifted to the ex-situ free-ranging facilities in buffer zone to maintain an optimum prey base for tigers. In the core, areas with low prey density (Fig. 4.15), but that can potentially hold tiger or other carnivores (leopard, wild dog etc.), translocation of wild ungulates would be carried out after the health screening. Organized prey augmentation and periodic translocation of prey species from higher to lower density zone are also recommended with appropriate sex ratio and associated demographic parameters (Fig. 4.15). Before prey augmentation, site quality assessment at local scale should be done and accordingly the specified number to be translocated should be determined. Continuous assessment of prey species distribution through line transect and camera trap method must be implemented to understand the space use pattern of the prey species.

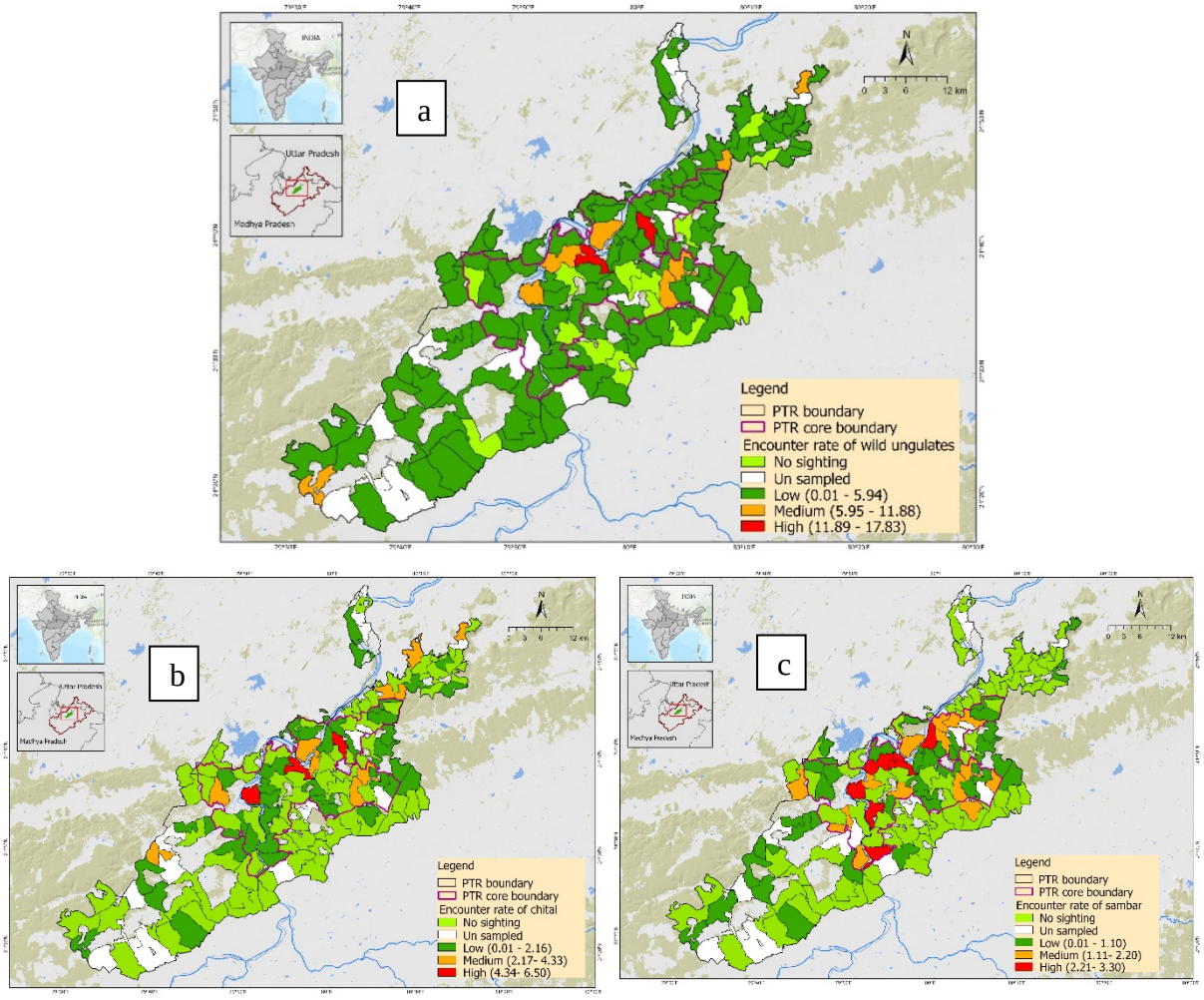


Figure 4.15. Map showing encounter rate of **a)** wild ungulates **b)** chital **c)** sambar in PTR across forest beats

4.2.4. Habitat Consolidation and Restoration: Core area of PTR has already been freed of 14 villages over several years in the last two decades. Since the Relocation and Rehabilitation (RR) protocol does not specify management prescription for vacated villages, these are being managed variably, with limited success. There are still four more villages (Palkohan, Daudhan, Kharyani, Mainari) to be freed of establishment. Further under the KBLP, 11 villages have been identified to be shifted for providing compensatory area as one of the conditions (Fig. 4.16). Therefore, under the habitat consolidation and recovery strategies, following specific inputs are provided:

(i) Landownership-transfer of Compensatory Village Area: A total area of 6017 ha has been identified by NWDA as compensatory area for the KBLP project, which is falling within eleven villages with varying landuse/landcover (Fig. 4.16). Since the area is already included

in the calculation of PTR, only the landownership will change if these villages are relocated through adequate compensation and voluntary process. However, it will surely increase the conservation value of PTR significantly and would reduce human-wildlife conflict issues as well.

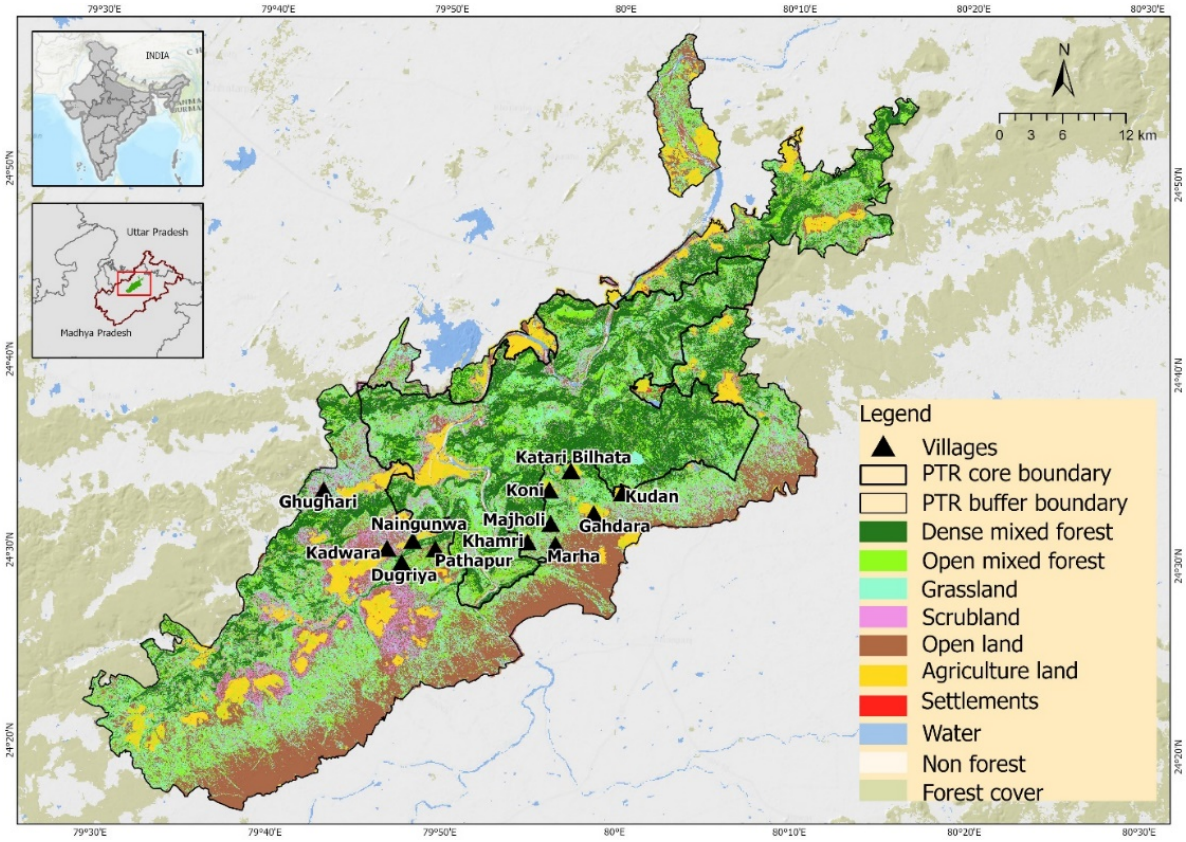


Figure 4.16. Location of villages identified for compensatory area by NWDA

(ii) Landownership-transfer of Revenue Open Areas and Community Reserve: There are five major patches of revenue areas in the western part of PTR, forming enclaves and having strong anthropogenic impact on PTR (Fig. 4.17). The ownership of these areas is with the Revenue Department. The total area of these five patches is 137.46 km^2 (13746 ha), but large portion of the area represent grassland, scrub land and open habitat (Table 4.2). Excluding the agriculture area and settlements, the total area that can be consolidated would be 93.57 km^2 (9357 ha). These areas need to be transferred to forest department and in case of community concerns, these five patches together as a cluster can be declared as Community Reserve under the unified control of Field Director, PTR, and possibly a dedicated officer at SDO level to manage this area. Given the benefits of Chhatarpur District in the development based on PTR, this land-transfer and establishment of Community Reserve will go a long-way in the sustainable development of the reserve and the people in the area.

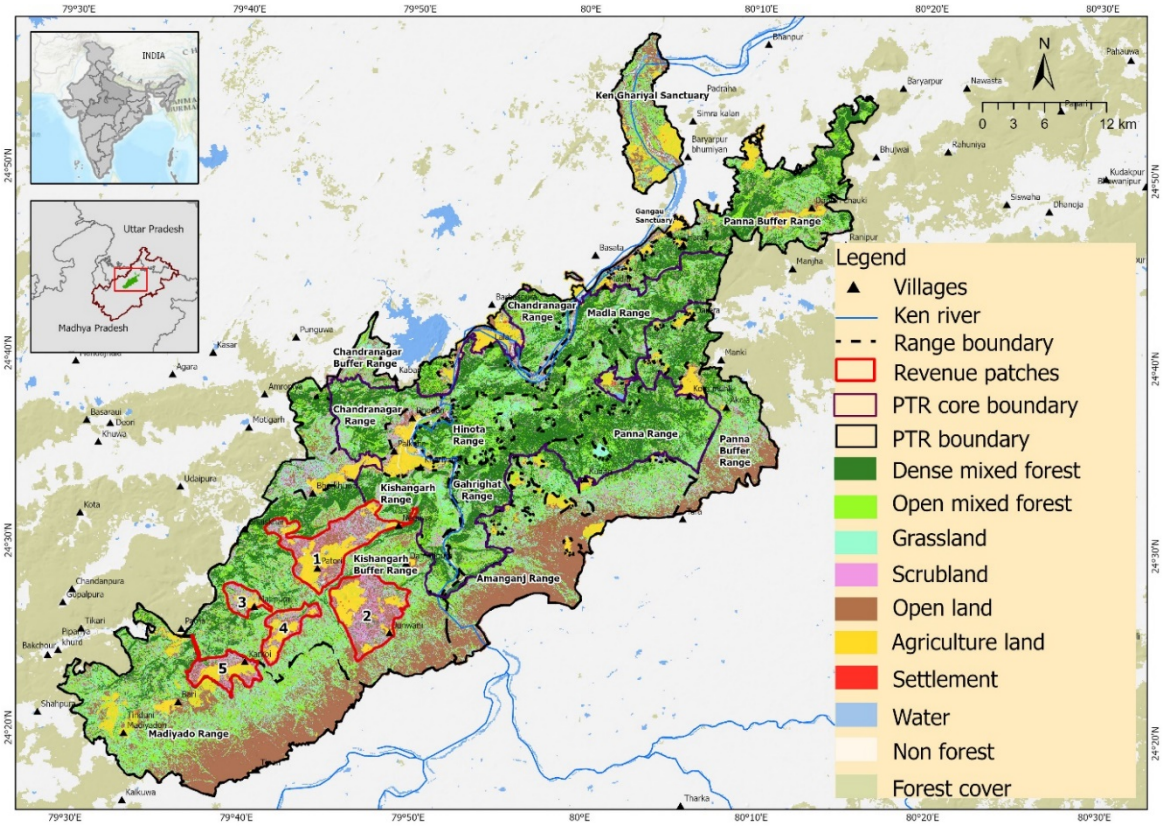


Figure 4.17. Location and extent of revenue areas within buffer of PTR

Table 4.2: LULC classes of revenue patches falling within PTR

S. No.	LULC Class	Patch 1 (km^2)	Patch 2 (km^2)	Patch 3 (km^2)	Patch 4 (km^2)	Patch 5 (km^2)	Total (km^2)
1	Dense Mixed Forest	0.98	1.59	0.68	0.70	1.12	5.07
2	Open Mixed Forest	1.39	1.07	1.02	0.80	2.89	7.17
3	Grassland	4.78	2.92	1.32	0.72	2.30	12.04
4	Scrubland	9.37	11.98	2.87	3.39	5.56	33.17
5	Water	0.47	0.10	0.07	0.07	0.01	0.72
6	Open Land	13.29	11.57	0.52	2.99	7.75	36.12
7	Agriculture Land	15.57	11.53	1.98	5.40	8.18	42.66
8	Settlements	0.24	0.09	0.02	0.06	0.10	0.51
	Total Area	**46.09**	**40.85**	**8.48**	**14.13**	**27.91**	**137.46**

(iii) Restoration of Consolidated Village Areas: The village areas (that have been vacated in the past and those that are proposed to be relocated) have experienced intense grazing and anthropogenic interferences, including fire. Therefore, once vacated, these areas show effects of these issues and often return with invasive weeds. It is not enough to vacate the areas without undertaking management interventions subsequently over a period until the resilience capacity is ensured. But it is not known exactly as to when the resilience capacity would be restored as there are site specific responses. However, the vacated habitats can become excellent grassland, offering mosaic of grassland and woodland in the larger context. Therefore, we prescribe experimental management of the vacated villages for (a) controlled grazing, (b) grass cutting, (c) grass burning, (d) exclusion of all and (e) status-quo with no intervention. Details of which are provided in the Biodiversity Management Chapter of this plan.

(iv) Construction of Structural Connectivity across Ken River: From historic and recent contexts, tiger population is more concentrated on the eastern side of PTR across Ken River and only few individuals are found on the western part. Steep escarpments along the Ken River and high anthropogenic pressure on the western side appear to limit movement of tigers and other animals across Ken River. Even after removal of disturbance, the physical constrains and barriers would continue to limit the movement. With KBLP causing submergence, the connectivity in the upstream would be made totally unviable. Therefore, it is proposed that structural connectivity is ensured by construction of over-bridges/over-passes across Ken River in three places – (1) Chaukan Rapta, (2) along with dam in the downstream and (3) one above Gahrighat. These overbridges/roads would also serve the purpose of management by forest staff and tourism specially in the Chaukan Rapta area as it connects Madla and Chandranagar ranges (Fig. 4.18).

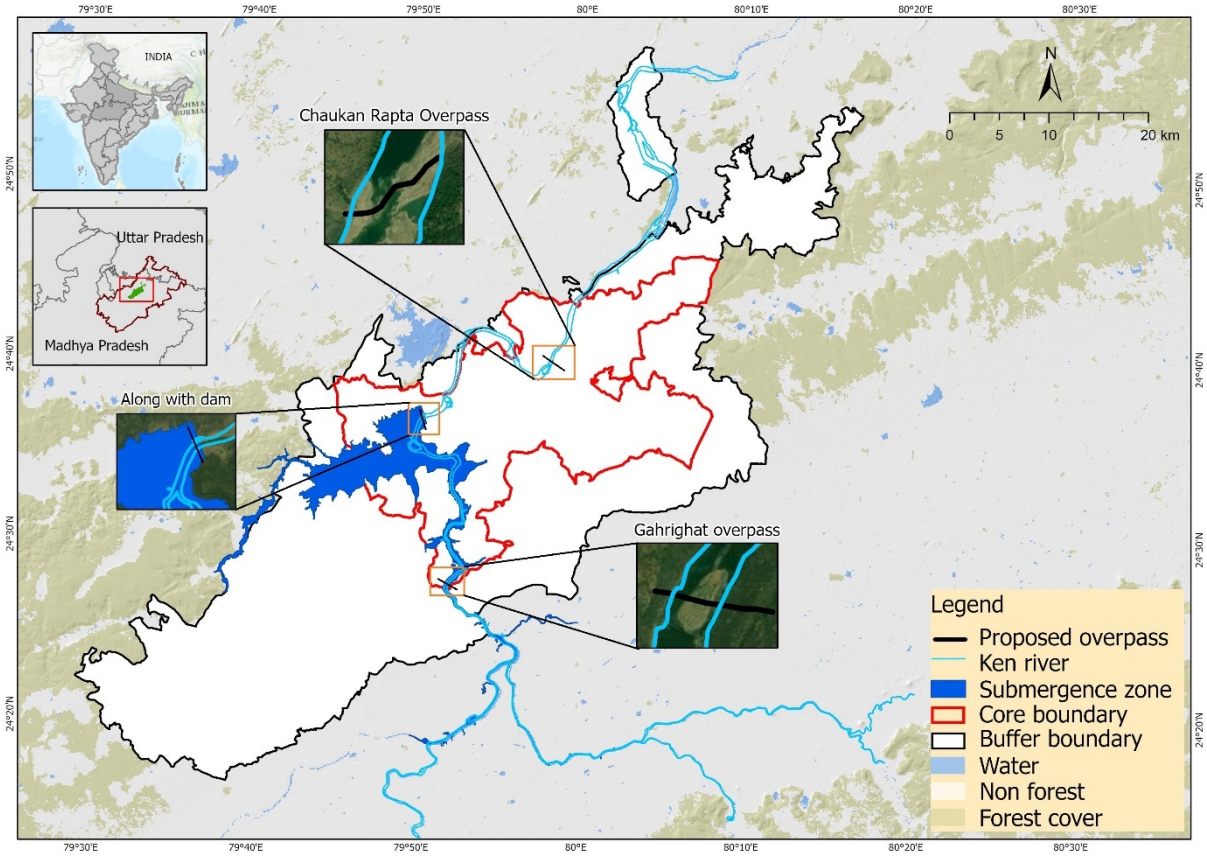


Figure 4.18. Map indicating proposed locations for constructing over-bridges/over-passes across Ken River

(v) Diversion of Road Traffic Volume, Strategic Fencing and Alert System: Road is the major linear infrastructure that overlaps with tiger conservation interest in PTR. There is ample evidence that roadkill (including of tiger) is a recurring feature on the roads passing through the reserve. Traffic volume is only increasing and the process of widening of road in underway. All these developments do not auger well for PTR specifically for movement of wildlife and will increase roadkill, especially in the buffer zone (Akola Circle) which is being improved, attracting more wildlife including tigers. It is therefore proposed that night traffic should be stopped between Amanganj and Panna (SH49) between 6 PM and 6 AM with option to divert through Gunaur. The eight kilometer stretch between Panna and Madla can be made as elevated road or alternative route can go from Bamitha to Panna Buffer or through other alternate options. Similarly, the Amanganj to Bijawar road passing through PTR buffer in Kishangarh and Chandranagar Ranges either need to be diverted to alternate road (Fig. 4.19) or underpasses or over passes to be established in the sensitive wildlife crossing areas along this road.

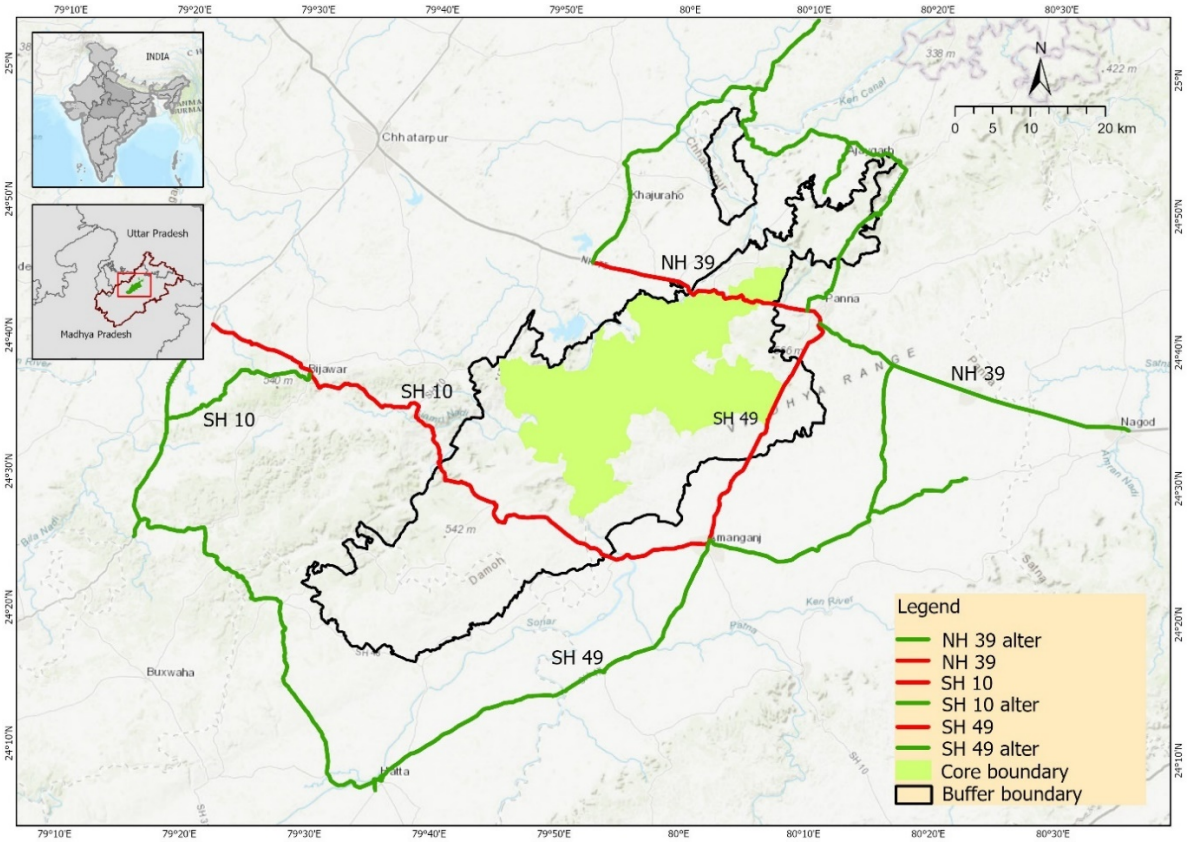


Figure 4.19. Proposed options of management of linear infrastructure in PTR

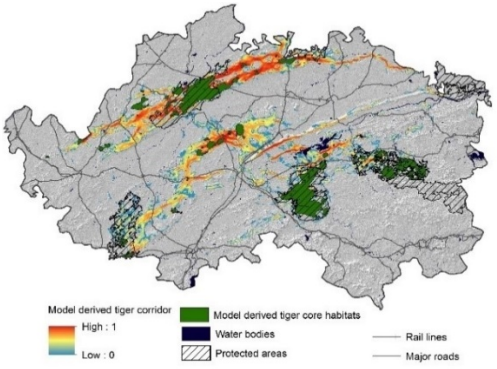
All these roads passing through PTR require strategic fencing and this can be a combination of biofence involving bamboo and/or chain-link on one side or either side of the road, depending on the local situation. Site selection and choice of the fencing (depending on the species involved) will have to be worked out during the implementation phase as it would involve further consultation process. All these roads are required to be deployed with sophsiticated technology such as Wireless Sensor Network including live-transmission camera traps and UAV, and these are to be integrated with alert system so that check-post on the either side of the road gets the information on animal movement close to the road and accordingly, the drivers are informed of the same. Digitial sign board with interface with animal movement information on real-time basis can also be linked to Alert System to minimize speed and suitably respond to animal crossing.

4.2.5. Measures for Conservation of Tiger in the Landscape: Several areas have been identified within the landscape based on tiger movement and habitat suitability, that can be consolidated for ensuring tiger conservation in a metapopulation framework. However, all

these components would lead to protection and enhancing the population growth of the tiger in the landscape under meta-population framework. Like the PTR, GPL would need following actions to ensure long-term viability of tiger in the landscape:

(i) Protection of Satellite Cores, Stepping stones and Corridors: Satellite cores are defined as potential habitat patches located in the vicinity of source population which can support and sustain dispersing individuals. Connectivity among such patches can further be aided by presence of isolated habitat fragments, called stepping stones. Steppingstones are often referred to as an inclusion to corridors (Scotts and Drieslma, 2003). A tiger corridor is a stretch of land linking tiger habitats, allowing movement of tigers. Without the corridors, tiger habitat can become fragmented and tiger populations isolated leaving the tigers vulnerable to local extinction. Previous corridor connectivity studies in central India (Fig. 4.20) have employed surrogate based regional-scale approaches for assessing connectivity among metapopulations. However, those studies failed to appreciate the ultimate contribution of connected local populations at landscape scale to connectivity across a heterogeneous land-use matrix at regional scale. Considering site-specific management requirements, we recognize the importance of scattered and unprotected forest fragments in aiding connectivity for future management of tiger population in the GPL.

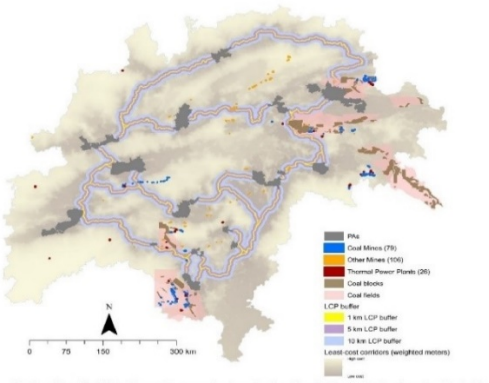
In GPL, 28 habitat core areas have been identified based on non-disjunct core area metric (Fig. 4.21). Of these, 9 habitat cores (core id 2, 4, 6, 10, 15, 18, 21, 26 and 28) can act as satellite cores; 5 habitat cores (core id 7, 12, 14, 22 and 23) can act as stepping stones; while 5 habitat cores (core id 8, 11, 16, 19 and 20) can act as both satellite core and steppingstone. The identified satellite cores and stepping stones hold promise of facilitating future colonization and dispersal events, thus being crucial to long term persistence of tigers in the landscape. Additionally, 67 probable connectivities were identified between the delineated habitat cores, of these 57 can serve as potential corridors (nine priority I, nine priority II, nine priority III, seventeen priority IV, and thirteen priority V) (Fig. 4.22). The predicted corridors represent shortest distance (EucD) of 0.101 km, average distance of 26.6 km and maximum distance of 105 km. Overall, the corridor length was much shorter for patches in the northern region of the landscape due to contiguity of forest as opposed to those between the northern and southern regions of the landscape.



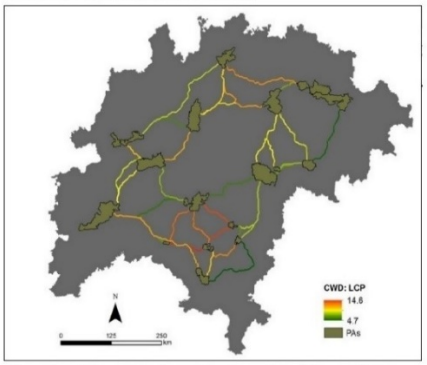
Panna Landscape and Probable Connectivity Pathways (Sarkar et al. 2019)



Map of the predicted landscape resistance, ranging from a low resistance of full black areas (i.e. high movement possibility) to a high resistance of full white areas (i.e. low/no movement possibility) (Ramesh et al. 2016).



The location of existing thermal power plants and mines in relation to the least-cost paths in the landscape (Dutta et al.2018)



The quality of linkages shown by the ratio of cost-weighted distance (CWD) to least-cost path (LCP). Higher values represented in red indicate higher cost of movement along the path of least resistance and lower values represented in green indicate higher quality of linkages along the least-cost path (Dutta et al. 2016)

Figure 4.20. Maps showing corridors/connectivity as predicted by other studies (published literature) in areas encompassing the GPL

The current flow map obtained as output from Circuitscape shows high current conductivity among the aggregated polygons (23, 22,20,15,14,11,10 and 8). Current flow is also high among the core pairs (5 and 7), (7 and 6), (5 and 4), (21 and 19). Overall, current flow is high among habitat patches in the northern part of the landscape and among the southern part of the landscape, indicating a high intra-patch connectivity among them. In contrast, there is a lower current flow across the non-forest area, indicating poor inter-connectivity among the northern and southern parts of the landscape (Fig. 4.22). Pinch point analysis with corridor width of 1km predicted a high extent of crucial connectivity zones in the predicted links (Fig. 4.23). Centrality analysis showed highest current flow centrality among the habitat cores (5 and 8). Centrality score was significantly high for cores 2, 4, 5, 8, 21 and 26 indicating greater importance of these patches in maintaining connectivity among network of habitat patches in the landscape (Fig. 4.23).

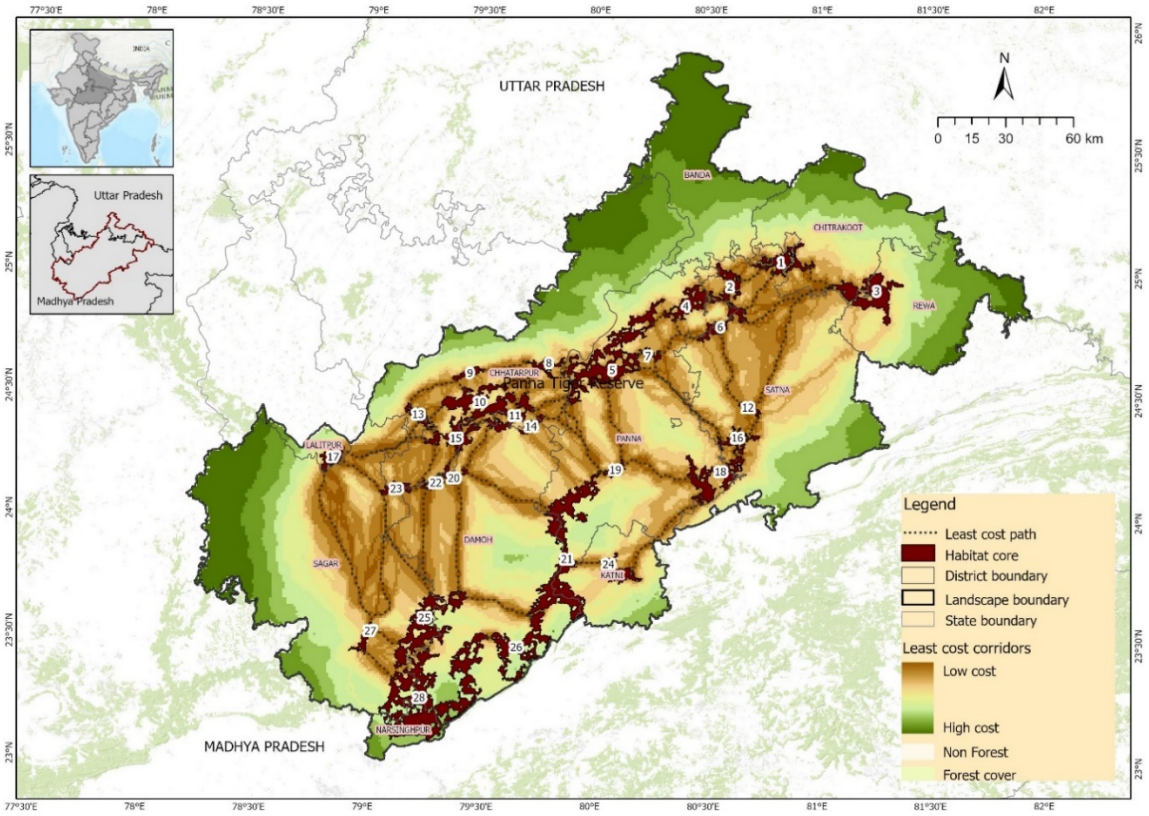


Figure 4.21. Map showing habitat patches and least cost corridors (paths)

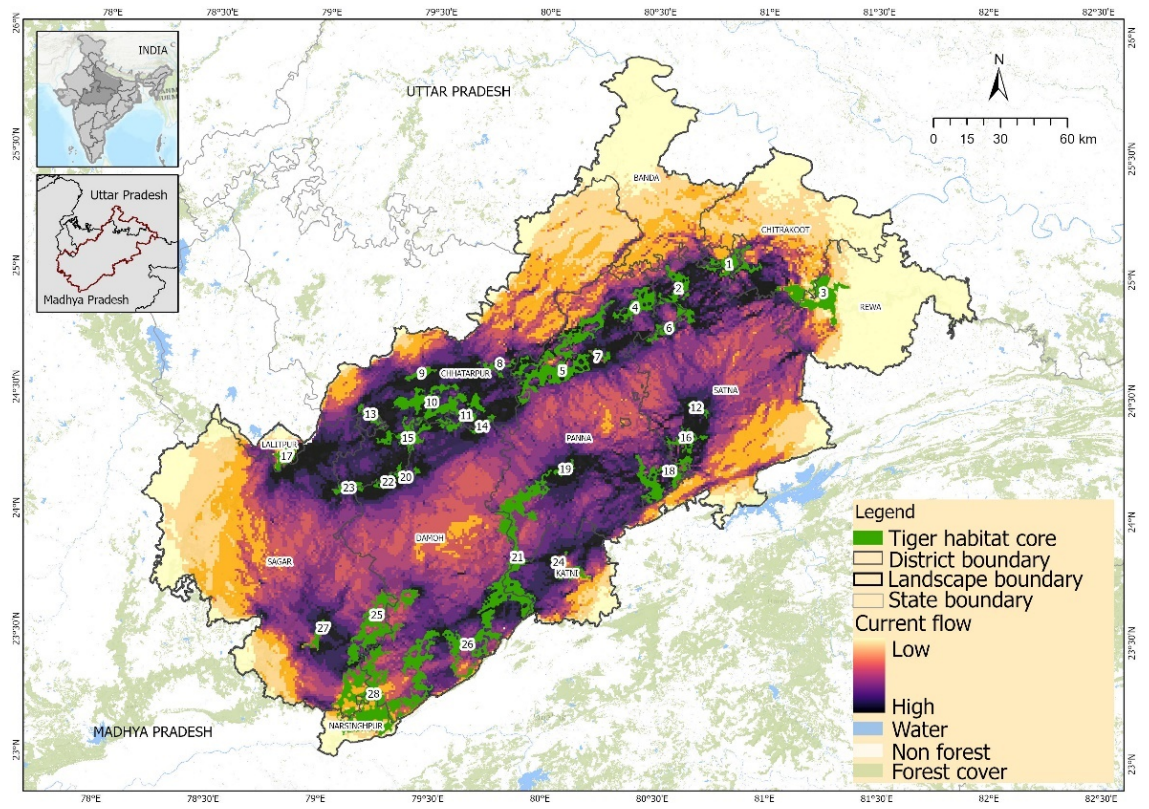


Figure 4.22. Map showing crucial connectivity zones as areas of high current flow

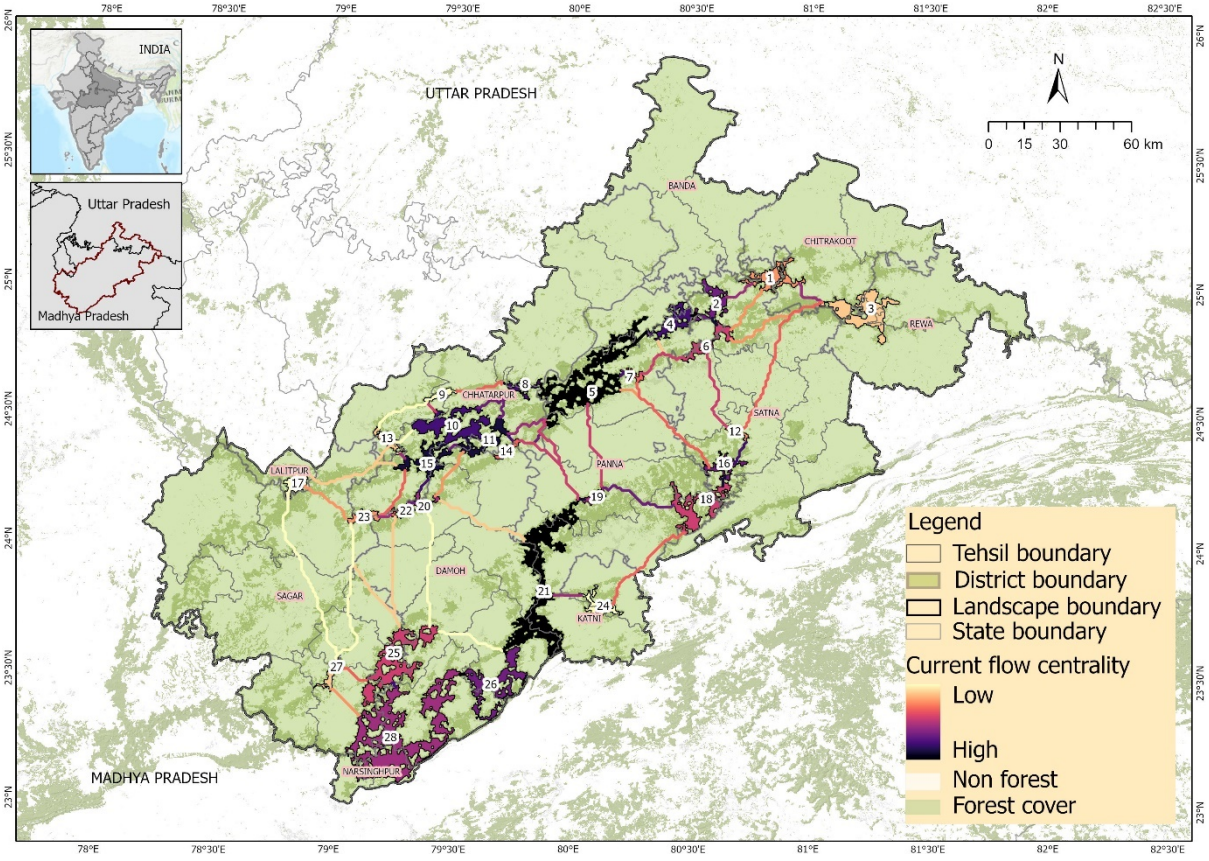


Figure 4.23. Map showing crucial connectivity links and habitat patches

(ii) Intensification of Landscape-level Assessment and Capacity Building: Landscape level assessment of habitat occupancy and population estimation for tiger, co-predator, prey species and habitat conditions should be done annually in the entire landscape specifically in the identified satellite core, stepping stones, and corridors. There is a need to (1) strengthen protection in the forest divisions in the landscape, (2) capacity building of staff in various protection and monitoring methods, and (3) implementing proper and appropriate monitoring protocols for tiger, co-predator, prey species and the habitat. Because PTR is an isolated tiger reserve from the meta-population context, the long-term survival depends on the consolidated population in the landscape and a secure environment both within and outside the PA network. It is becoming clear that hunting and poaching continues to be a major threat for wildlife in the landscape. Electrocutions, snare traps, poisoning by Organo-Chloro insecticide (Endosulfan) etc., are among the common means for accidental or targeted deaths of tiger, which is substantiated by the recent case of death/poaching of dispersing collared tiger. This aspect requires clear focus and dedicated actions including engaging local NGOs and community leaders. The staff needs to be provided with adequate awareness and capacity building, while expanding the scope of EDC activities in the targeted areas.

(iii) Establishment of Interstate Tiger Reserve (Ranipur-Satna Tiger Reserve): Tigers from PTR have dispersed and settled in Ranipur Wildlife Sanctuary, Uttar Pradesh. Surrounding forest in Rewa and Satna district of Madhya Pradesh also provide good tiger habitat and tiger presence has been recorded in Satna Forest Division. Ranipur Wildlife Sanctuary currently holds six tigers, including breeding individuals, and it will be the eastern-most population in the landscape, offering an important source population. Therefore, it is proposed to establish an Interstate Tiger Reserve (in the name of Ranipur-Majhgawan Tiger Reserve) with an area of 277 sq. km. In any case, establishing Ranipur Wildlife Sanctuary as tiger reserve is among the conditions laid out by NTCA and others *wrt* to KBLP. In this proposed reserve, Ranipur Wildlife Sanctuary (Uttar Pradesh) will constitute the Core Area while Majhgawan, Semariya, Atraila Ranges of Satna and Rewa Forest Divisions (Madhya Pradesh) will constitute the Buffer Area (Fig. 4.24 a). Operationally, it will be feasible following the Standard Operating Procedure for Interstate Coordination issued by NTCA and through the Integrated Landscape Management Plan under the Special Purpose Vehicle of KBLP. A proposal for making Ranipur a tiger reserve has also been proposed by UP forest department, but it entirely lies within the boundary of UP (Fig. 4.24 b).

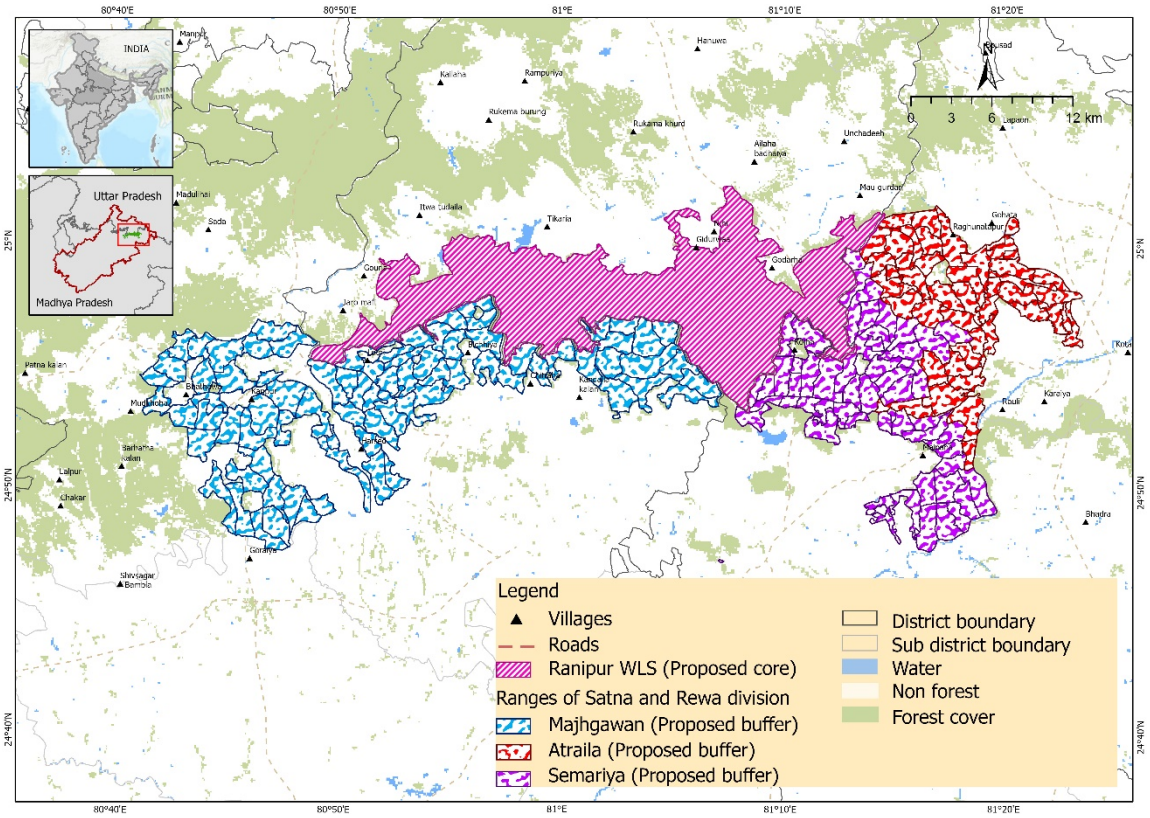


Figure 4.24.(a) Proposed Interstate Tiger Reserve with Ranipur WLS (UP) as core and Ranges of Rewa and Satna Forest Divisions (MP) as buffer

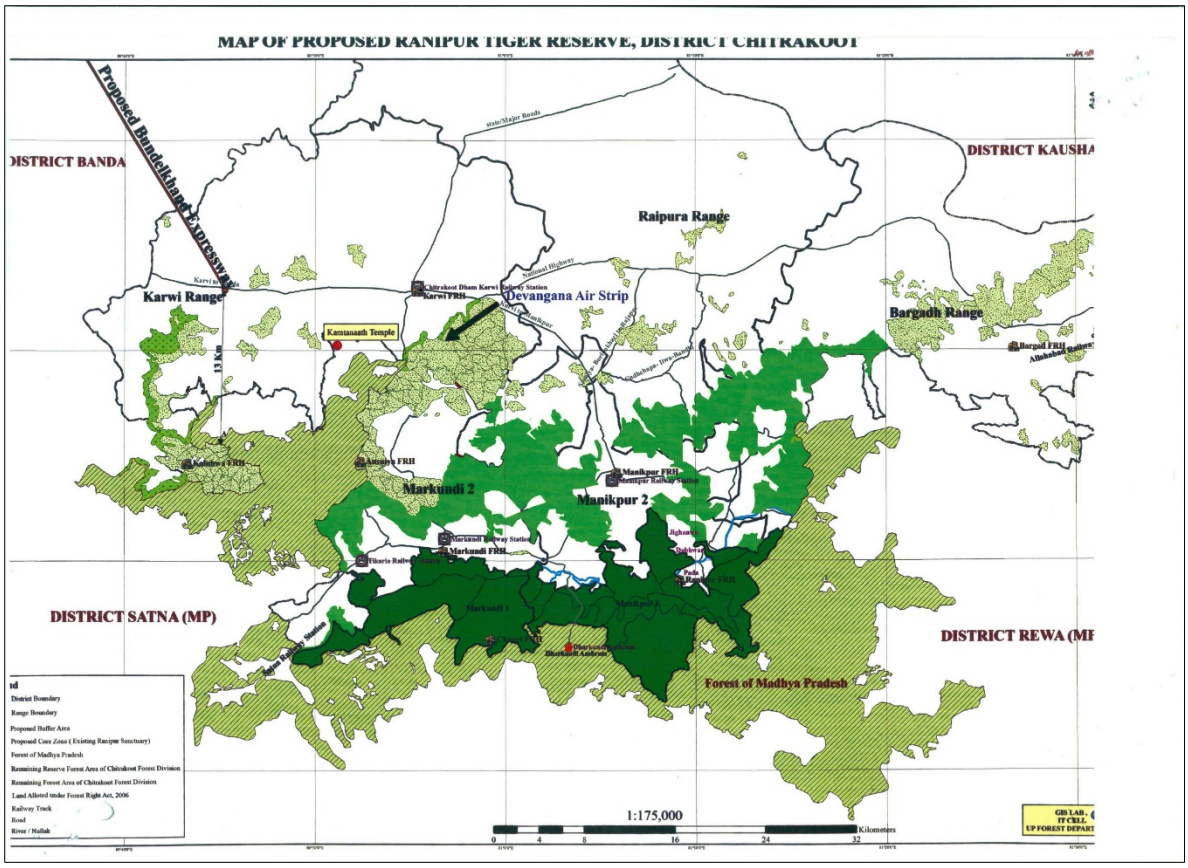


Fig. 4.24. (b) Ranipur Tiger Reserve proposed by UP forest department

(iv) Establishment of Kalda Conservation Reserve: The lifeline of the southern part of the landscape including connectivity with other source population such as Bandhavgarh Tiger Reserve lies in the better conservation status of South Panna and Damoh Forest Divisions. Kalda and Saleha Ranges of South Panna Forest Division have comparable habitat conditions as that of PTR and have minimal human interference in the form of low intensity livelihood activities. In terms of current and future management and livelihood prospects, the entire Kalda and parts of Saleha Ranges need to be declared by notification as Kalda Conservation Reserve (Fig. 4.25), and it can also take the name of 'Maihar Sharada Devi', to enable connection with community-based tourism or religious tourism. Tigers, including breeding individuals, are sporadically reported here. People are currently dependent on the forests for minor forest produces but under the clutches of moneylenders. With organized arrangement under the Conservation Reserve, the conservation objectives as well as livelihood agenda can be advanced towards overall development of the region.

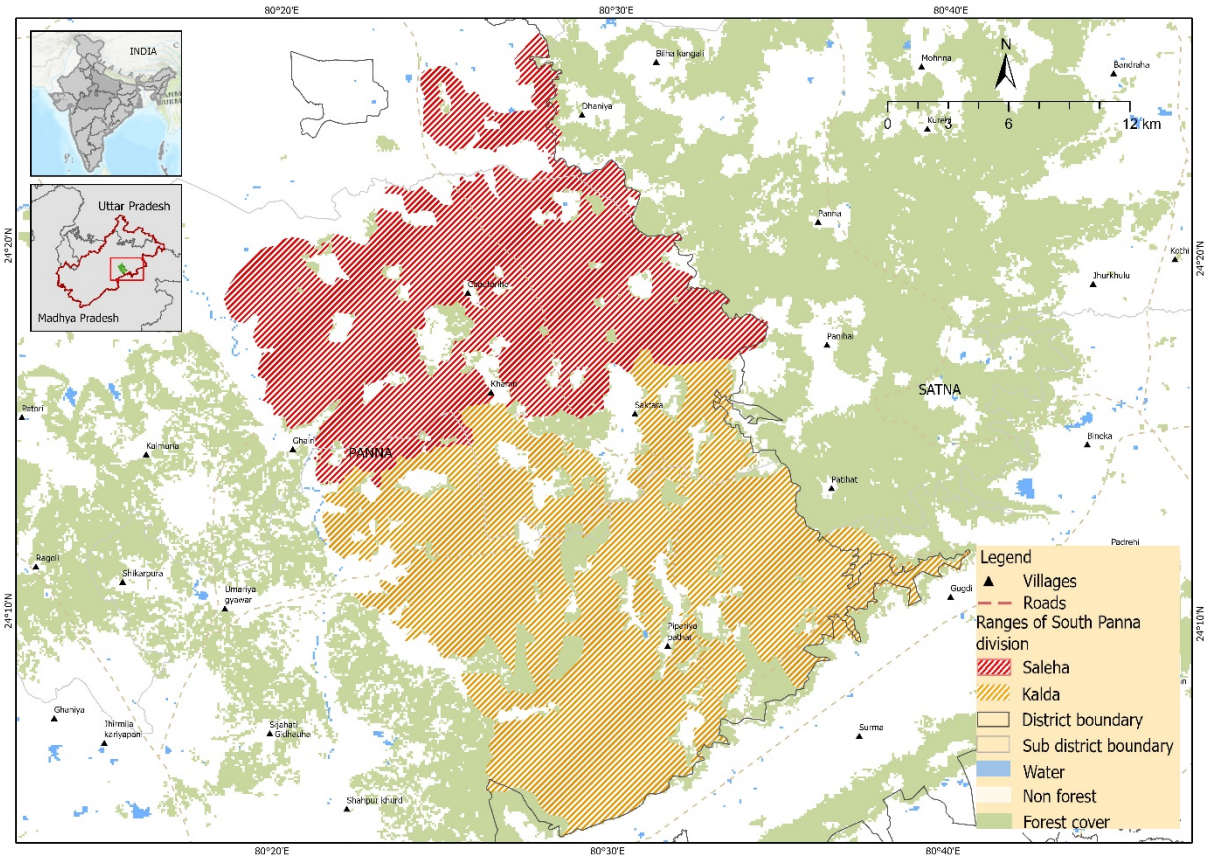


Figure 4.25. Map of proposed Kalda Conservation Reserve

(vi) Expansion of Veerangna Durgawati Wildlife Sanctuary: The area of Veerangna Durgawati Wildlife Sanctuary is currently 24 sq. km., but has significant wildlife values including connectivity for tiger and breeding population of vultures. The centrality score reflecting landscape integrity is high in this Wildlife Sanctuary. Therefore, it is proposed that Singrampur Range of Damoh Forest Division should be included in Veerangna Durgawati Wildlife Sanctuary, this will add another 200 sq. km of area, making the Wildlife Sanctuary area 224 sq.km., as the current size is not viable in the long-term. Since the Sanctuary is contiguous with Nauradehi Wildlife Sanctuary, the overall conservation value would be strengthened. It is pertinent to mention that NTCA has already recommended Nauradehi to be brought under Tiger Reserve category (Fig. 4.26). If the efforts are to move towards this direction, Veerangna Durgawati Wildlife Sanctuary would offer credible core area, and surrounding forest potential buffer area.

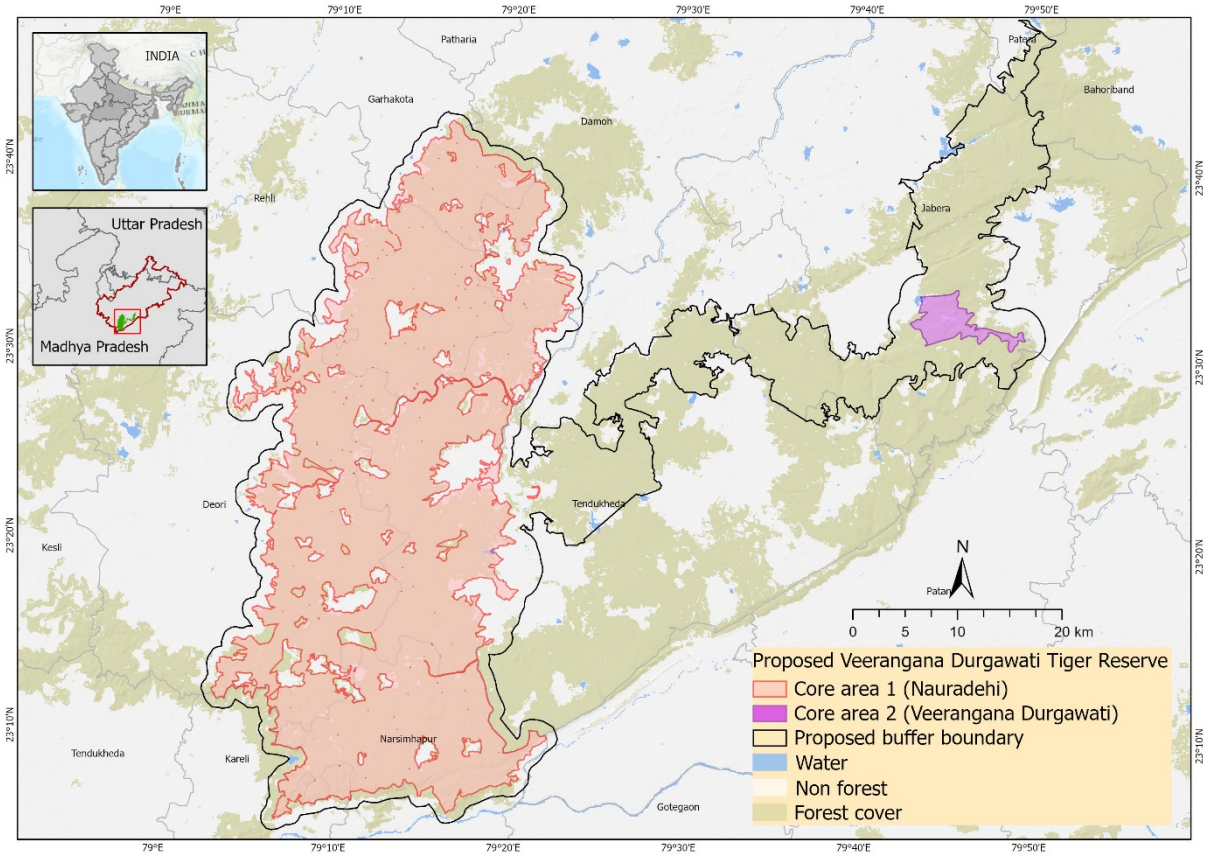


Figure 4.26. Proposed expansion of Veerangna Durgawati Wildlife Sanctuary to tiger reserve

(v) Protection and Restoration of River Corridor Zone: Tiger movement south of PTR follows the river course and agriculture areas. However, these are currently unprotected and with increasing human interference, the corridor value would be lost and would create a hard boundary causing human-tiger conflict. To ensure connectivity value for tiger and water security for the people, it is proposed to establish River (Corridor) Zone of 1 km width around part of Ken and Bearma Rivers, which connects South Panna Forest Division, and Panna Tiger Reserve (Fig. 4.27). This one km river zone is divided in 500m buffers on each bank of the river, comprising three zones of 0-25 metres (Afforestation Zone, 25m width), >25-250 meters (Social Forestry Zone, 225m width) and >250-500 meters (Status Quo Zone, 250m width) (Fig. 4.27). This River Zone can take the form of Community Reserve, considering the interest and consent of local communities. The proposed area is of 496 sq. km., represented by a variety of land use land cover classes (Table 4.3).

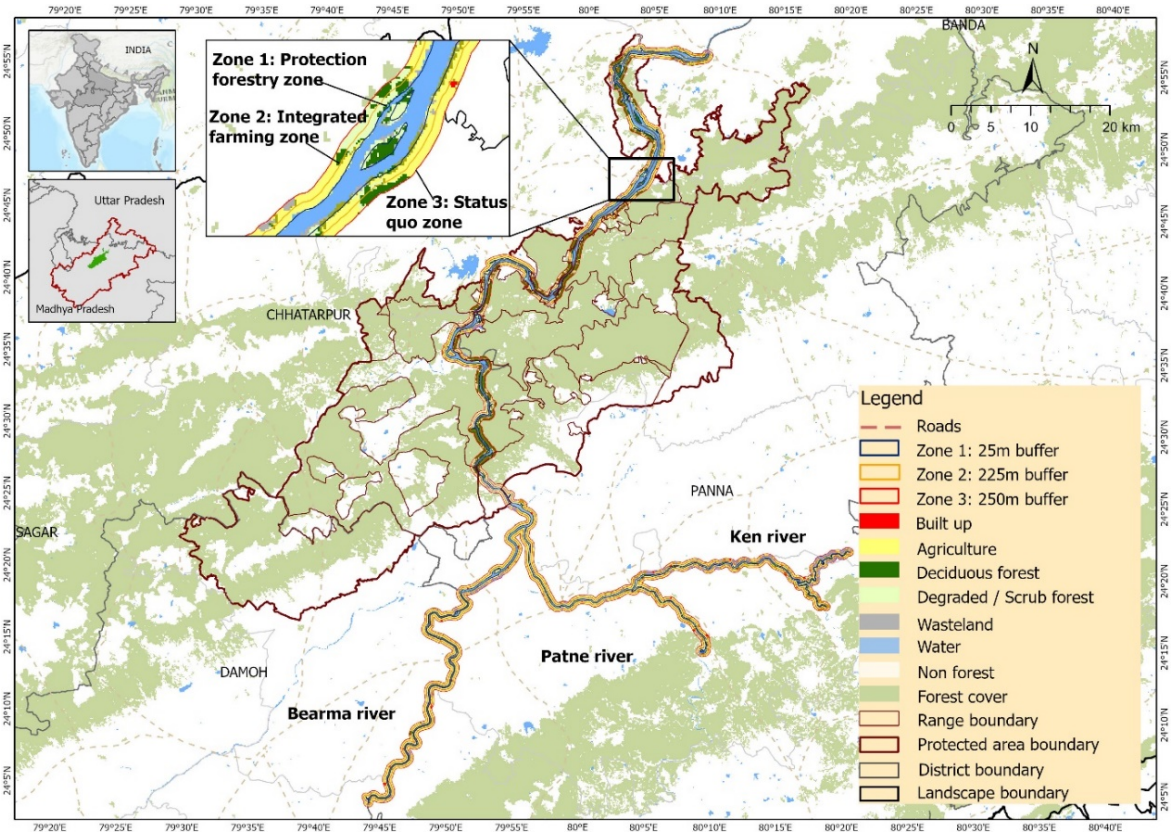


Figure 4.27. Proposed River Conservation Zone

Table 4.3: Area under different Land-use Land-cover category in the River Zones (Source: NRSC)

S. NO.	LULC CLASS	ZONE 1 (0-25 M)	ZONE 2 (25-250M)	ZONE 3 (250-500M)
1.	Built up	0.0371	0.806625	0.998325
2.	Cropland	3.03205	65.3915	72.66978
3.	Current fallow	2.59007	11.0469	6.91633
4.	Plantation	0.0215	0.331075	0.390875
5.	Deciduous forest	1.2884	17.7065	19.8291
6.	Degraded / Scrub forest	1.14833	11.2276	13.7455
7.	Wasteland	1.0546	9.26505	9.44058
8.	Waterbody	5.125845	4.64908	1.24313
9.	Total	14.297895	120.42433	125.23362

(vi) Retrofitting of Under-passes and Over-passes: Based on landscape analyses and connectivity mapping, 23 intersection points have been identified across the landscape area (Fig. 4.28). and these are to be retrofitted with under-passes and over-passes as per technical feasibility. Any new road in the landscape is to have a greenbelt and take appropriate mitigation measures even in the satellite cores, stepping stones and corridors.

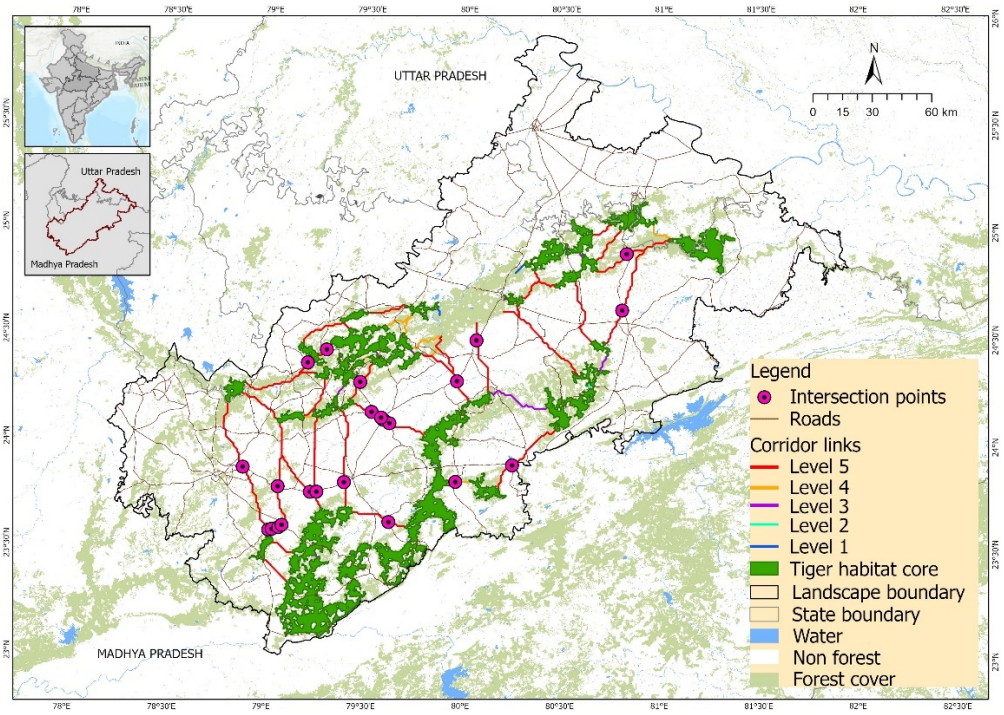


Figure 4.28. Road-corridor intersection points for over/under-passes

4.3. Synthesis and Conclusions: Tiger is the flagship species and driver of conservation agenda in PTR even though several other key species exist in the area. It is even more significant because of local extinction and successful recovery over the last one decade. Any intervention in PTR including the KBLP, needs to ensure the long-term viability of tiger population. Therefore, the measures proposed above come from the knowledge not only during the plan period but also over the years of tiger monitoring in the landscape. Each of the measures proposed have specific focus on population, habitat and anthropogenic impediments, and involve a rational approach keeping in view the interest of tiger conservation and livelihood options including development aspiration in the landscape. All these safeguards suggested would not only enhance the conservation value of tiger but would also support quality of life of local people given the green and clean environment and the conservation of all biodiversity within GPL.



CHAPTER 5

VULTURE CONSERVATION STATUS AND PRESCRIPTIONS

Chapter 5: Vulture Conservation Status and Prescriptions

5.1. Situation Analyses

5.1.1. Introduction: Vulture is a large 'Bird of Prey', though they don't usually hunt, rather depend on carcass of animals killed by other carnivores. Depending on the nature of feeding habit, they are categorised as either 'obligate' or 'permanent' scavenger (Campbell, 2016). Large carnivores, after fulfilling their need, usually leave behind large portion of their kill. Vultures are among the first to surround the area to feed upon such carcasses, alongside other scavengers such as hyena, jackal and wild pig. Vultures also feed on carcass of cattle disposed outside villages and dumping areas. Vultures, being such efficient scavengers (clearing off the entire remain), keep our environment clean in a natural way and therefore, are an important constituent of the ecological system, providing a rare kind of ecosystem service. However, their very dependency on carcass has also resulted in the deaths of numerous vultures in the Indian sub-continent (up to 95% population decline), specifically the foraging on carcasses of cattle that have been treated with Diclofenac drug, a common drug used to treat cattle for pain, swelling etc. Diclofenac causes kidney failure by accumulating uric acid in the blood, leading to large scale mortality of vultures (Prakash *et al.*, 2007). This has become a great cause of concern for the scientific community and conservationists alike. In addition to the known ecological implications, experts have also linked enhanced health-sector expenditure to loss of Gyps vultures. The absence of vultures lead to an increase in feral dog population due to higher availability of carcasses to them. This is one of the factors that lead to an increase in the spread of rabies resulting in huge expenditures by the medical sector, such that over a period of 14 years (1993-2006), India has reportedly incurred a cost of Rs. 104600 crores (1046 billion INR/ 34 billion USD [at the exchange rate prevailing from 1993-2006]) in the health sector (Markandya *et al.*, 2008). Therefore, vultures represent key elements of 'One Health Approach' (the linked concept of environment health, animal health and public health) and thus should be viewed beyond species-specific conservation focus.

5.1.2. Vulture Richness and Behavior: Seven species of vultures are found in the landscape. These are: (1) Indian Vulture (*Gyps indicus*), (2) White-rumped Vulture (*Gyps bengalensis*), (3) Red-headed Vulture (*Sarcogyps calvus*), (4) Egyptian Vulture (*Neophron percnopterus*), (5) Himalayan Griffon (*Gyps himalayensis*), (6) Eurasian Griffon (*Gyps fulvus*) and (7) Cinereous Vulture (*Aegypius monachus*). Three of them are Critically Endangered (Indian, White-rumped, and Red-headed Vultures), one is Endangered (Egyptian Vulture) and three are

Near Threatened (Himalayan Griffon, Eurasian Griffon, and Cinerous Vulture). Of these, Himalayan, Eurasian and Cinereous are winter migrants, although over-wintering populations also occur, while the rest are resident species. All of these are reported in PTR. Based on their feeding habits, these vultures can be categorised into three groups such as (1) the large sized tearers, (2) the large and medium-sized pullers and (3) the small pickers (Campbell, 2016). The 'tearers' (Red-headed and Cinereous Vultures) ideally are the first to feed on any available carcass because their beaks are structured in such a shape that helps them to tear apart the thick and hard skins of the carcass. The 'pullers' (Indian, White-rumped, Himalayan Griffon and Eurasian Griffon Vultures) prefer the softer flesh or organs of a carcass. The 'pickers' (Egyptian Vulture) generally come at the last to feed on the left-over small particles of flesh which are generally found stuck with the bones of the carcass (Campbell, 2016). With all these different kinds of feeding strategies, vultures act as excellent scavengers by removing the carcass from the ecosystem which helps in keeping the environment clean and preventing the spread of zoonotic diseases.

5.1.3. Population Status of Vultures in PTR: The count of vultures obtained during winter of 2018/2019 as part of this study, focusing on permanent nesting and roosting sites, accounted for a minimum count of 993 individuals of vultures (both resident and migratory species) (Table 5.1), which is below the average number (1410) recorded by the Forest Department from 2011 to 2015 through coordinated surveys involving large numbers of volunteers (Table 5.2). The count during 2019/2020 during this study was done with three repeats in each of the sites and represent average value, reflecting more accurate abundance of vulture (709), although tree-nesting species (which were around 60 in the previous count) could not be covered on account of priority sampling with cliff-nesting species. This broadly corresponds with the recent estimate obtained by the Forest Department through the coordinated survey. However, there have been fluctuations in the minimum number recorded over the years by the Forest Department, but this needs further verification with appropriate methods since there have been variations in the manpower deployed and consistency of count. In any case, maintaining a stable population is certainly a matter of great concern given that some of these vultures are Critically Endangered and Endangered.

5.1.4. Population Status of Vultures in the Landscape: The landscape is composed of substantial elevation and slope diversity, with a series of escarpments and tall trees, offering wider options of roosting and nesting for vultures. Accordingly, the vultures are also found widely, although with varying concentrations, with Protected Areas contributing to it

substantially. Of the total number of 2905 individuals recorded during 2018/2019 (winter) survey, PTR alone accounted for 34% and Nauradehi Wildlife Sanctuary accounted for another 10%. Of the Divisions, North Panna and Chhatarpur adjoining PTR (18%) and South Panna, South Sagar and Damoh including Veerangana Durgawati Wildlife Sanctuary contiguous with Nauradehi Wildlife Sanctuary (25%) together contribute to the maximum percentage of population in the landscape (Table 5.3). It appears that while the entire landscape provides scope for the vultures in terms of foraging opportunity, the protected areas serve as crucial refuges. However, the earlier in the landscape survey by the Forest Department in 2015/2016 reported relatively lower numbers (Table 5.4). The recent coordinated counts across the landscape by the Forest Department has shown notable increase (Table 5.5.), partly to be attributed to count efforts and partly to the reflection of more scavenging opportunities created through large carnivore population increase and establishment of 'gaushalas' (cow-welfare camps) across the landscape. However, the cause-and-effect relationship of these patterns with definitive statements requires further investigations.

Table 5.1: Vulture count carried out in PTR by WII team (count in 2019/2020 was limited due to other restrictions and thus does not reflect representation of all species and all sites)

S. No.	**Species**	**Number of Vultures**	
		2018/2019	**2019/2020**
	Residential		
1	Indian Vulture	600	451
2	White-rumped Vulture	41	-
3	Egyptian Vulture	68	26
4	Red-headed Vulture	17	-
	Total	**726**	**477**
	Migratory		
5	Eurasian Griffon	129	145
6	Himalayan Griffon	116	84
7	Cinerous Vulture	22	3
	Total	**267**	**232**
	Grand Total	**993**	**709**

Table 5.2: Vulture count carried out in PTR by forest staff/volunteers (Source: PTR)

S.No.	Species	Number of Vultures				
		2011	**2012**	**2013**	**2014**	**2015**
	Residential					
1	Indian Vulture	966	630	726	484	1191
2	White-rumped Vulture	127	235	146	54	45
3	Egyptian Vulture	90	161	76	77	12
4	Red-headed Vulture	57	127	67	61	20
	Total	**1240**	**1153**	**1015**	**676**	**1268**
	Migratory					
5	Eurasian Griffon	44	379	64	62	139
6	Himalayan Griffon	50	162	184	148	144
7	Cinerous Vulture	6	1	06	01	01
	Total	**100**	**542**	**254**	**211**	**284**
8	Unidentified	0	102	78	6	124
	Grand Total	**1340**	**1797**	**1347**	**893**	**1676**

Table 5.3: Vulture count in the landscape by WII team for 2018/2019 winter

S. No.	Division / Protected Area	Number
1	**North Sagar**	85
2	**South Sagar**	152
3	**Damoh**	224
4	**Katni***	0
5	**North Panna**	330
6	**South Panna**	339
7	**Chhatarpur***	193
8	**Rewa***	153
9	**Satna**	139
10	**Nauradehi Wildlife Sanctuary**	296
11	**Panna Tiger Reserve**	993
	Total	2904
*Only parts of divisions that were included within GPL were surveyed		

Table 5.4: Vulture count in the landscape by Forest Department during 2015/2016

S.No.	Division / Protected Area	Winter	Summer	Average
1	**North Sagar**	278	43	161
2	**South Sagar**	24	17	21
3	**Damoh**	105	85	95
4	**Katni**	32	107	70
5	**North Panna**	10	16	13
6	**South Panna**	384	31	208
7	**Chhatarpur**	73	262	168
8	**Rewa**	92	88	90
9	**Satna**	118	109	114
10	**Nauradehi Wildlife Sanctuary**	203	195	199
11	**Panna Tiger Reserve**	488	1134	811
	Total	**1807**	**2087**	**1947**

Table 5.5: Vulture count in the landscape by Forest Department during 2018/19 and 2020/2021

S.No.	Division	2019	2021
1	**North Sagar**	274	50
2	**South Sagar**	163	115
3	**Damoh**	127	190
4	**Katni**	83	61
5	**North Panna**	190	438
6	**South Panna**	481	614
7	**Chhatarpur**	514	441
8	**Rewa**	135	345
9	**Satna**	208	474
10	**Nauradehi Wildlife Sanctuary**	164	300
11	**Panna Tiger Reserve**	629	722
	Total	**2968**	**3750**

5.1.5. Nest-site and Roost-site Suitability: Following the extensive survey of the entire landscape including more intensive search in PTR and based on spatial analyses, the predictive modelling of nest-site and roost-site suitability reflected wider opportunities for these species, with sparse distribution of highly suitable sites (Fig. 5.1 and Fig. 5.2). Due to limited sample

size, such modelling was not possible for tree-nesting/roosting species, however, forest conservation would offer surrogate conservation approach for these species in any case. Ruggedness, steep slope, lower regime of nightlight or less anthropogenic pressure and higher regime of NDVI, *i.e.*, dense vegetation relate to preference for these predicted sites. Ruggedness and steep slope make the terrain more inaccessible for other animals which makes nests more secure from predators. Furthermore, the model indicates that areas closer to gaushala and carcass-dumping sites, away from powerline and high wind power density are preferred by these vultures for nesting. Interestingly, although the landscape has considerable area under medium and high suitable classes, PTR holds significant proportions of these classes (Table 5.6.).

Table 5.6: Area estimation of predicted suitability classes

Target Area	**Suitability Class**	**Cliff-nesting Area (km^2)**	**Cliff-roosting Area (km^2)**
Gretater Panna Landscape	High	69.01	36.87
	Medium	354.13	167.39
	Low	48811.08	49029.96
Panna Tiger Reserve	High	9.85	6.15
	Medium	78.45	68.60
	Low	1757.16	1770.71

Looking deeper into the patterns of nest-site and roost-site suitability of cliff-nesting species in PTR reveal significant potentials for the vultures, which is not surprising, given the much higher population estimate of the species in PTR as compared to any other area in the landscape (Fig. 5.3. and Fig. 5.4).

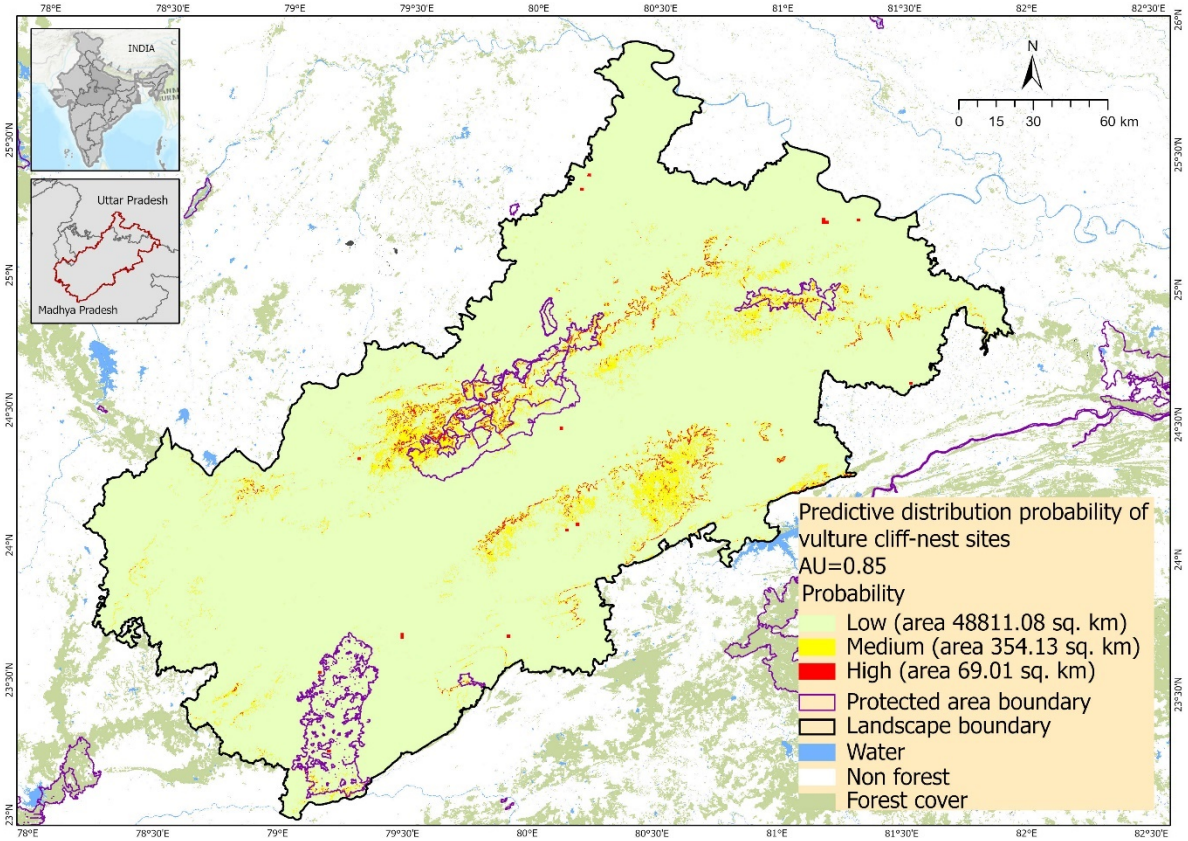


Figure 5.1. Predicted distribution of cliff-nesting site suitability in the landscape

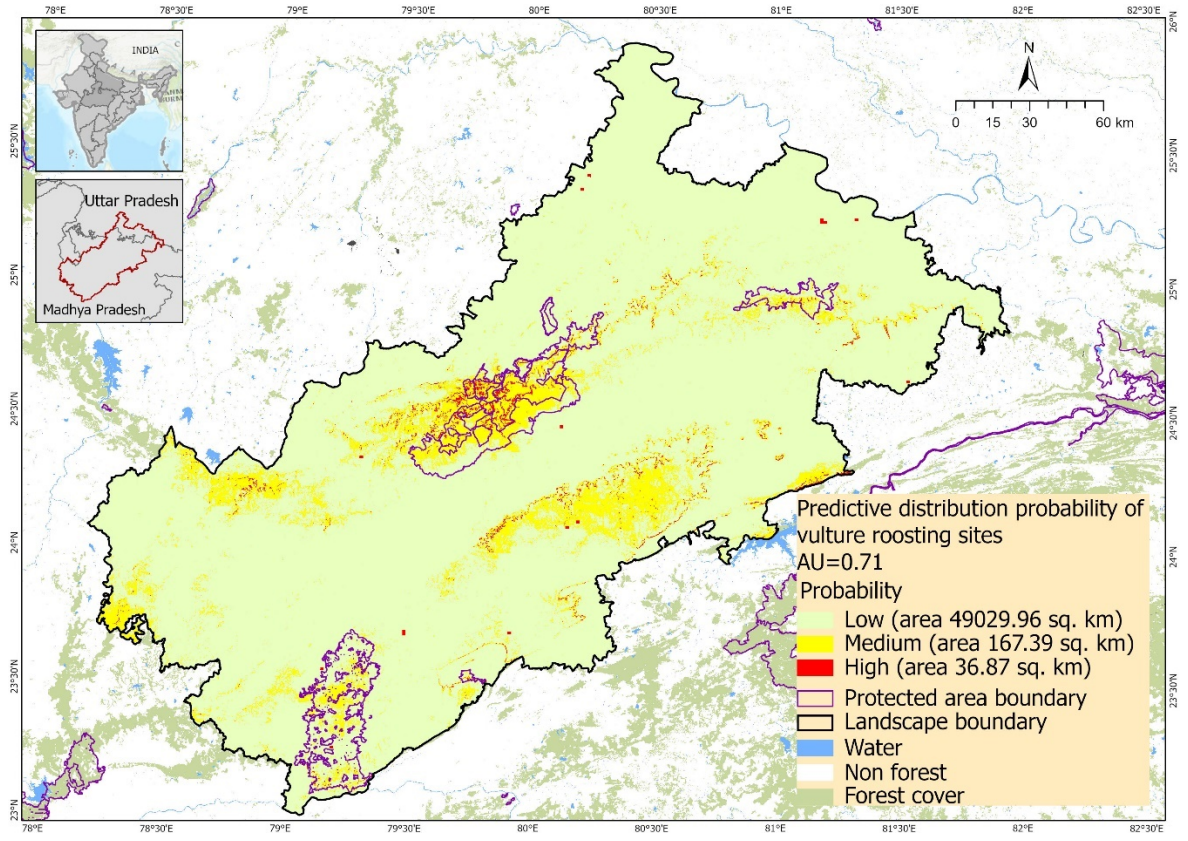


Figure 5.2. Predicted distribution of roosting-site suitability in the landscape

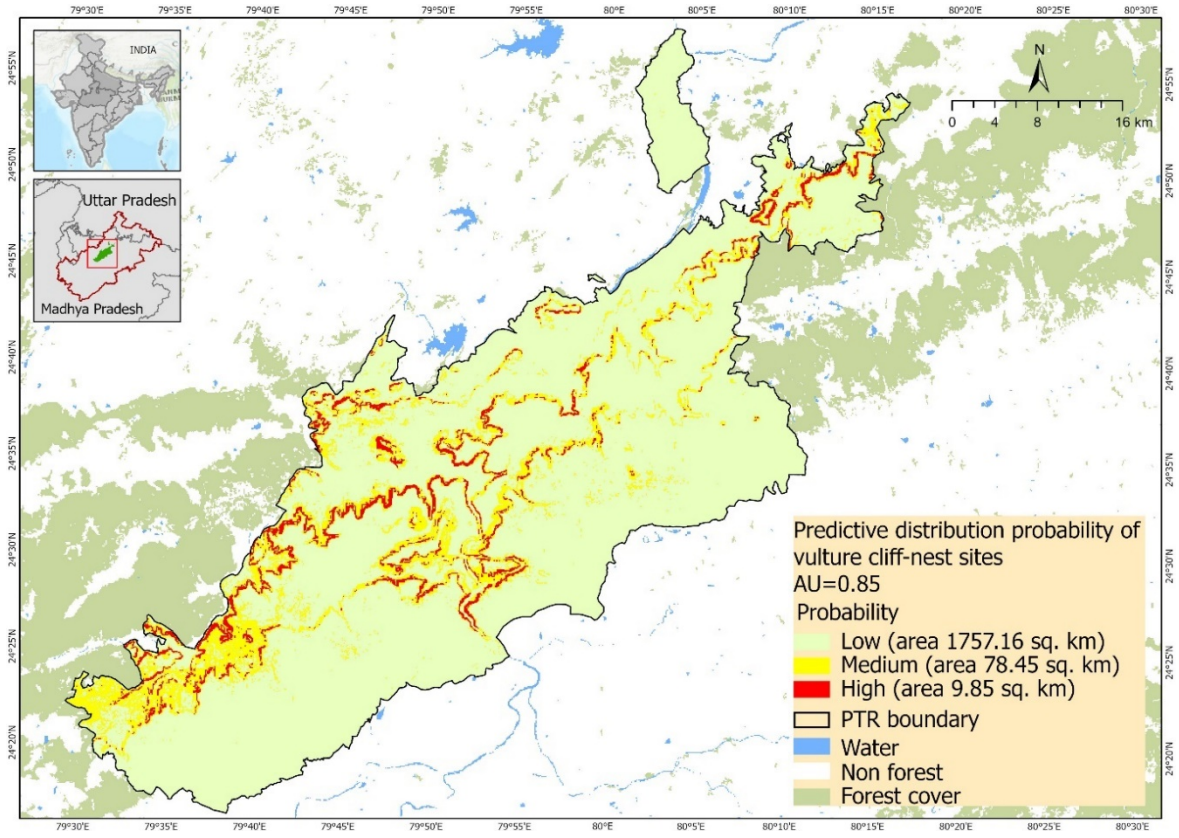


Figure 5.3. Predicted distribution of cliff-nesting site suitability in PTR

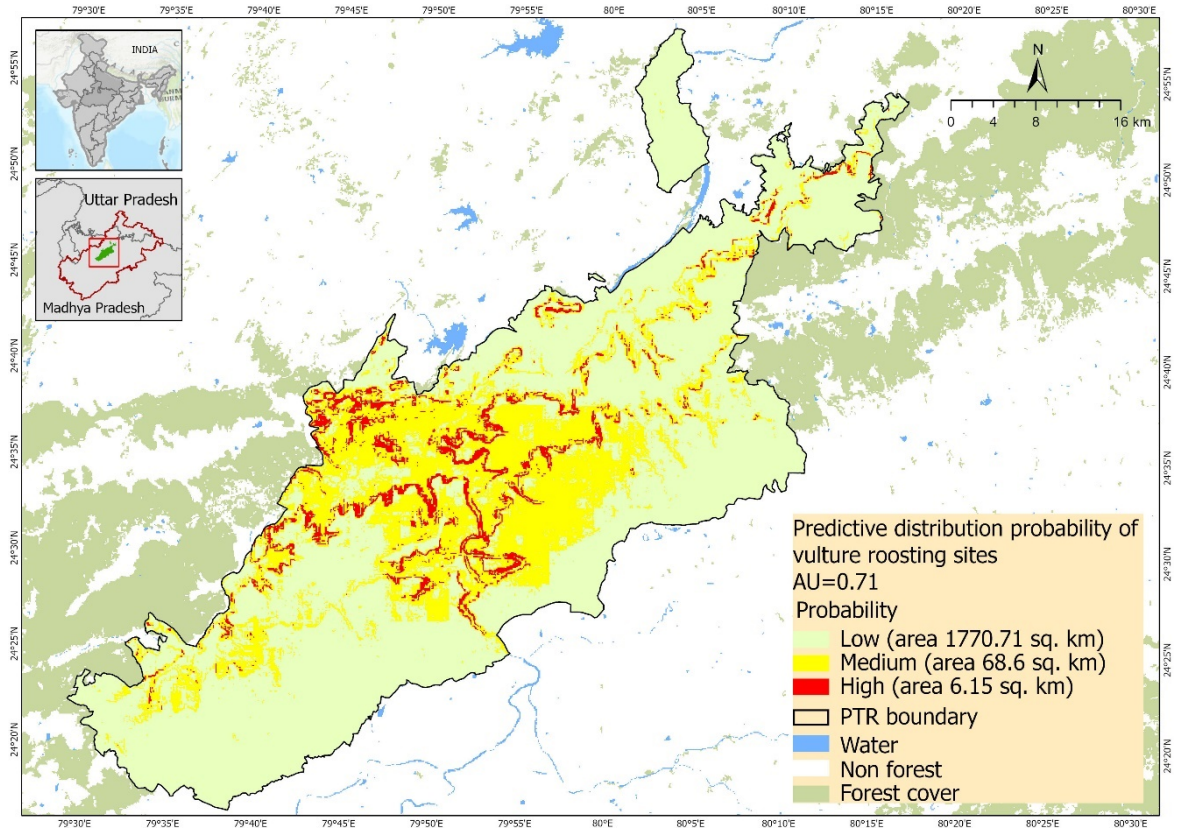


Figure 5.4. Predicted distribution of cliff-roosting site suitability in PTR

5.1.6. Status of Tree-nesting Species: Very few nesting sites of White-rumped Vultures were found in the landscape, but, wherever these were found, it was generally near a river or on the dried riverbed, on some Koha tree (*Terminalia arjuna*). Similarly, Red-headed Vultures are sporadically distributed, and this species was seen to occupy tall trees in undisturbed environment. Dead or leafless trees have also been found to be a major basking or perching site for the vultures and the reason for this can be attributed to the fact that leafless and/or dead trees do not obstruct the view of the vultures due to absence of canopy. Apart from this, vultures werealso found to roost/perch most frequently on some of the medium and tall-sized trees such as Gunja (*Lannea coromandelica*), Mahua (*Madhuca longifolia*), Tendu (*Diospyros melanoxylon*), Kullu (*Sterculia urens*) and Teak (*Tectona grandis*). Further, Jha et. al. (2020) also recorded in their study that the vultures use Semal (*Bombax ceiba*), Banyan (*Ficus benghalensis*), and Peepal (*Ficus religiosa*) trees in different part of Madhya Pradesh. In a recent study, Jha *et. al.* (2021) found that in open forest, with 40-60% canopy cover, large trees like arjun, peepal, saj, kaim, mahua, baheda, are used for nesting by vultures. Given the limited information, it is essential to direct further research and management focus on the riverine vegetation specially keystone species.

5.1.7. Ranging and Movement of Vulture: In PTR, three vultures were tagged with GPS-satellite telemetry devices during the month of December 2020. Two of these were Red-headed vultures and one was an Indian Vulture. In addition to these, 22 vultures were also tagged in February 2022 (Table 5.7). The resident vultures are exhibiting a wide-ranging pattern, going even beyond the landscape boundaries, some going as far as Kuno-Palpur Wildlife Sanctuary in Rajasthan (Figure 5.5). Among the migratory vultures, Eurasian Griffons have gone to Pakistan and the flight is still continuing, whilst the Himalayan Griffons have travelled to Nepal and China, crossing over the Mt. Everest (Figure 5.6). However, conclusions about the ranging and movement ecology have been drawn based mainly on the earliest three tagged vultures. Data retrieved for the last one year from these three birds offer useful insights for management of vultures in PTR and the landscape. During the observation period, Indian Vulture was recorded to have covered a cumulative distance of around 12,000 km with average distance of 41.60 km per day, whereas, both the Red-headed Vultures covered twice the distances as that of Indian Vulture (Table 5.8). However, the Indian Vulture mostly kept its movement confined within PTR and occasionally moved around PTR in Chhatarpur and North Panna Forest Divisions (Fig. 5.7 and Fig. 5.8). On the other hand, both the Red-headed vultures showed significant movement outside PTR, traveling up to 159 km. The first tagged Red-headed

Vulture has covered Chhatarpur, South and North Panna, and Satna Forest Divisions, even moving outside the landscape (Fig. 5.9 and Fig. 5.10). The second tagged Red-headed Vulture showed variable movement throughout the landscape and beyond (Fig. 5.11 and Fig. 5.12). Although these two birds (Red-headed Vultures) are closer to adult stage in their growth phase, the wide-ranging behaviour offers the species wider choices of resources in the landscape and makes the population count and management challenging.

Table 5.7: Summary of vultures tagged with GPS-satellite telemetry devices during the project period

S. No.	Species	Number of individuals tagged
1	Indian Vulture	13
2	Red-headed Vulture	2
3	Himalayan Griffon	8
4	Eurasian Griffon	2
Total vultures tagged		**25**

Table 5.8: Statistics of movement of tagged vulture (till December 2021)

Parameter	Indian Vulture	Red-headed Vulture-1	Red-headed Vulture-2
Cumulative Distance (Km)	12229.08	23931.44	25456.41
Average Distance Per Day (Km)	41.60 (± 6.93 SD)	80.31 (± 26.77 SD)	87.48 (± 29.10 SD)
Minimum Distance Moved (Km)	13	26	19
Maximum Distance Moved (Km)	78	127	159
Maximum Distance in Single Flight (Km)	46.23	53.37	75.29
Maximum Distance Between Two Farthest Points in the Home Range (Km)	109	213	311

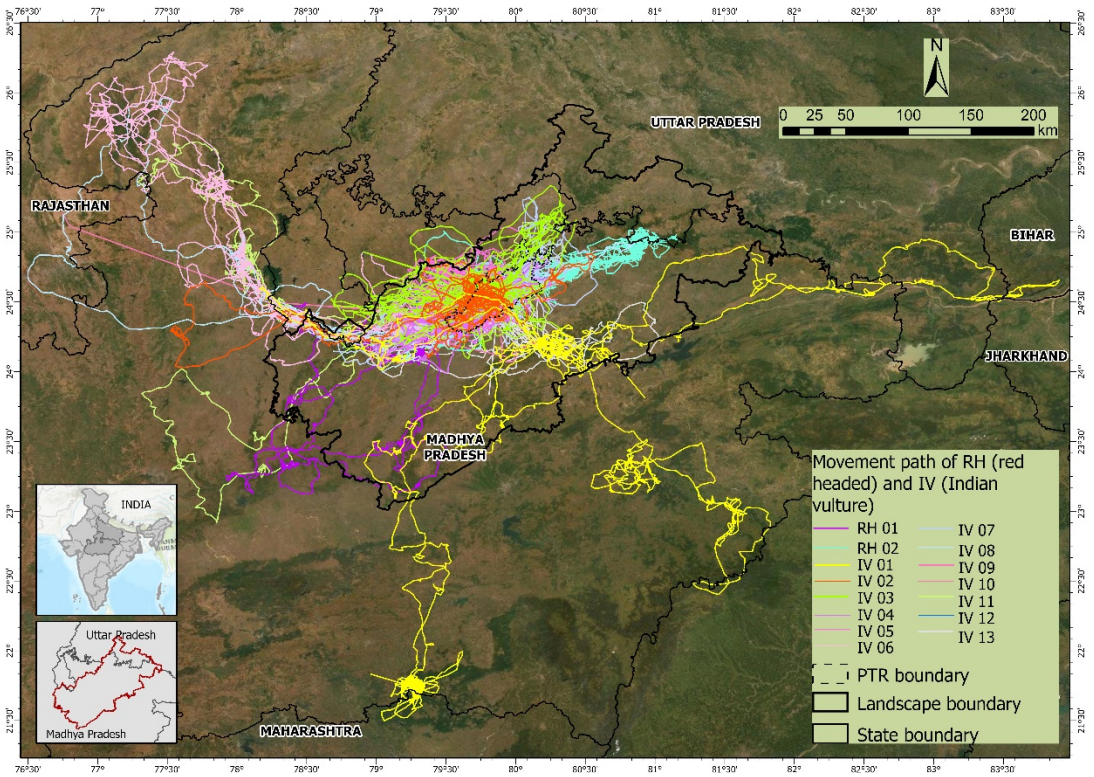


Figure 5.5. Movement Paths of Residential Vultures from March to April, 2022, Tagged in Panna Tiger Reserve by WII Team

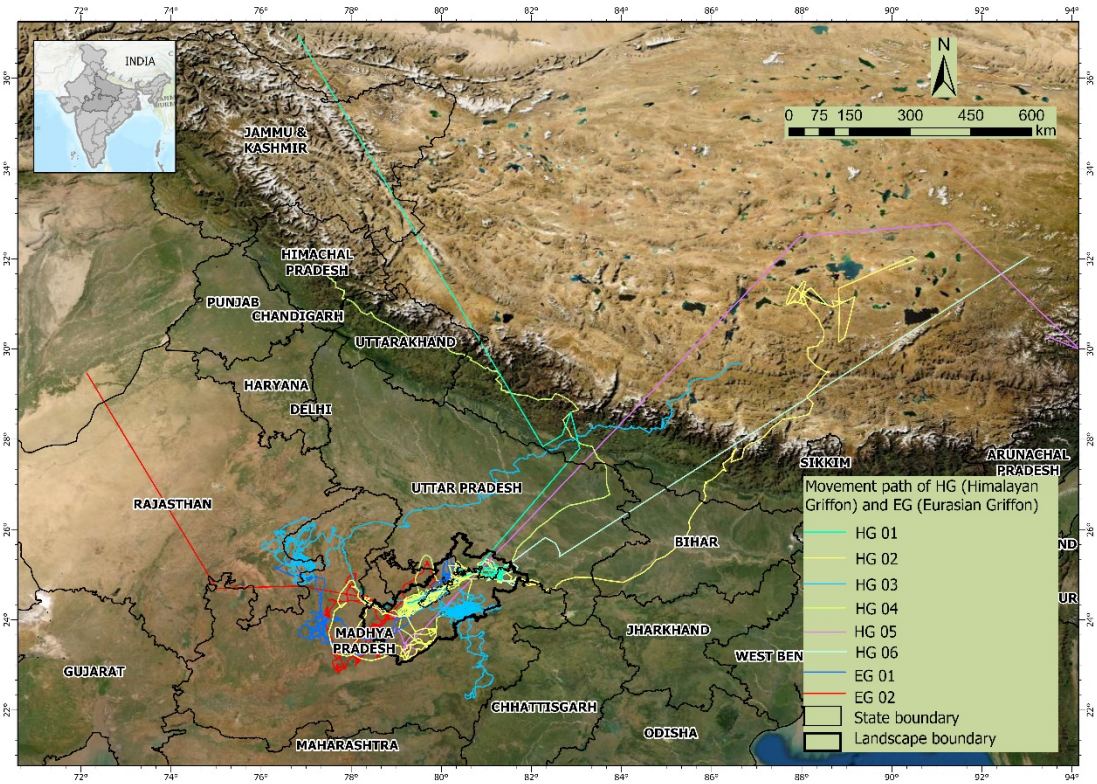


Figure 5.6. Movement Paths of Migratory Vultures from March to April, 2022, Tagged in Panna Tiger Reserve by WII Team

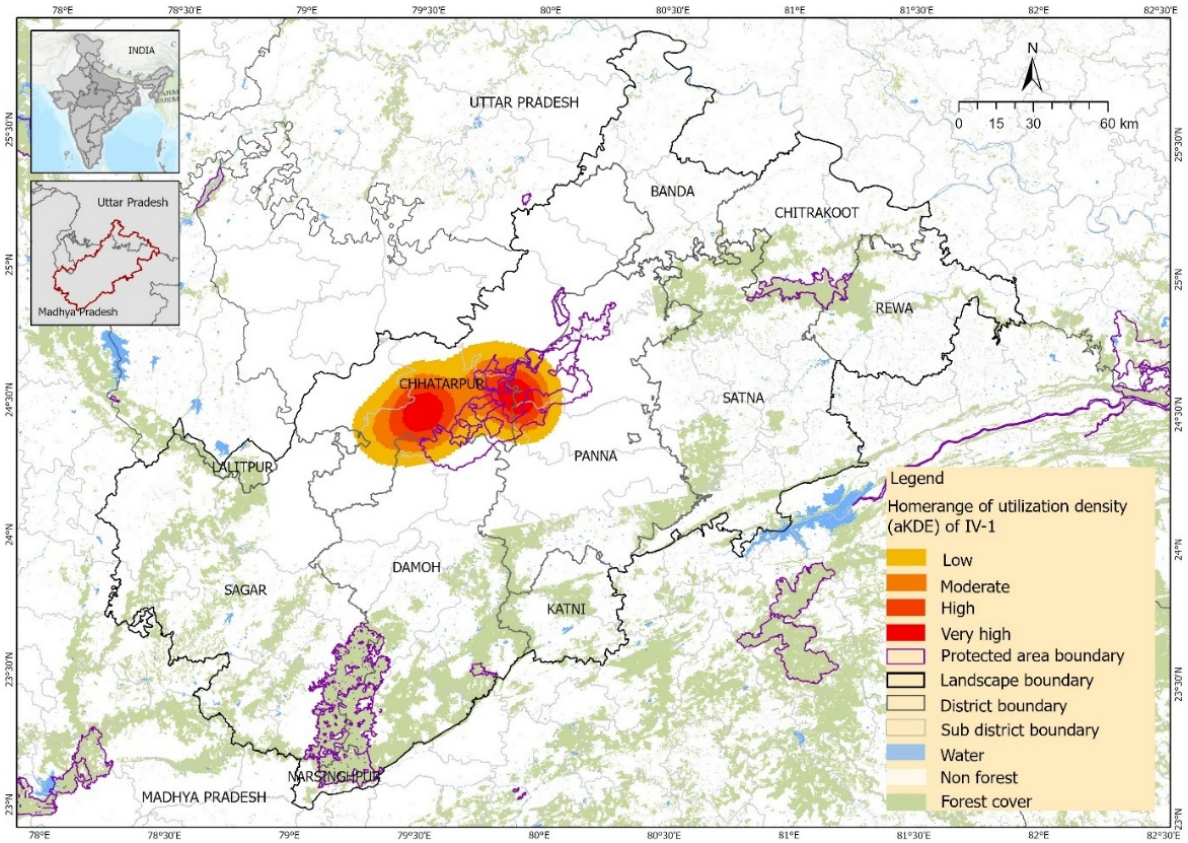


Figure 5.7. Movement and ranging of tagged Indian Vulture

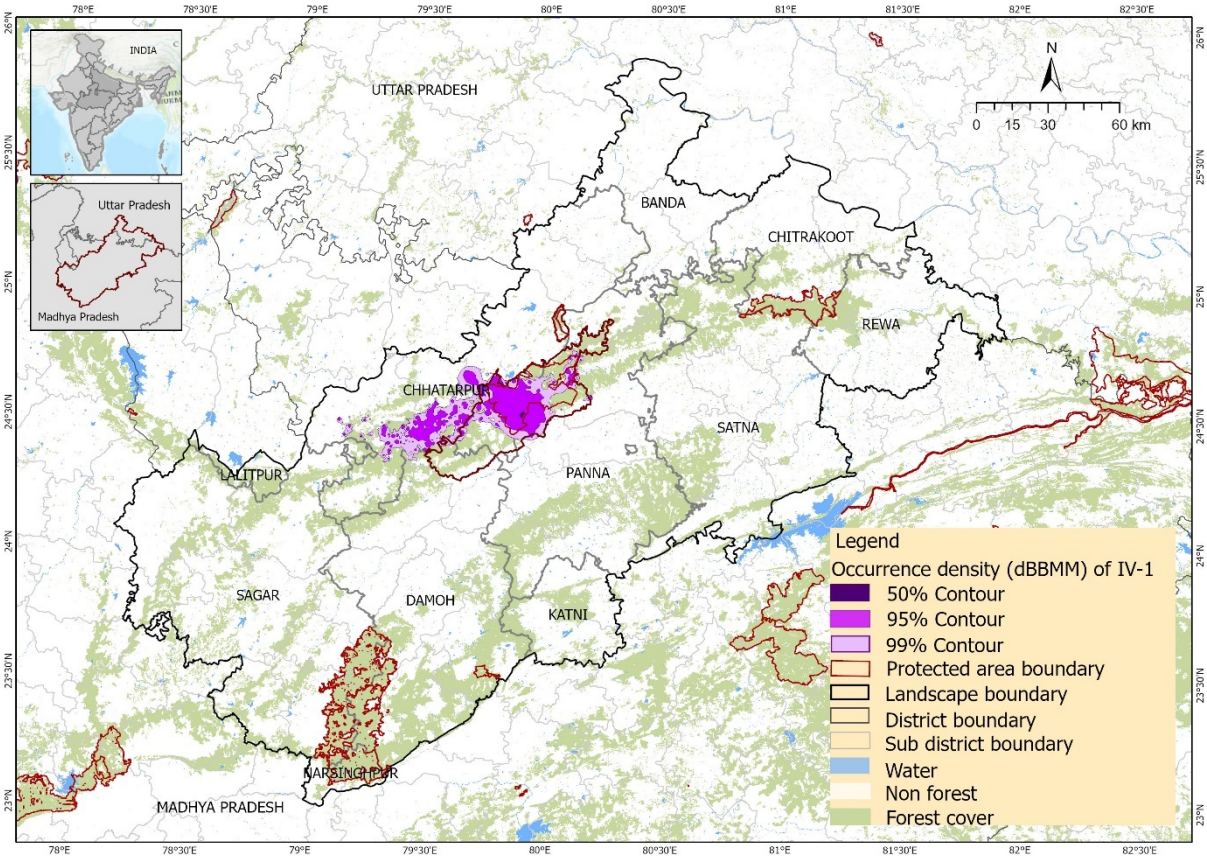


Figure 5.8. Movement intensity of tagged Indian Vulture

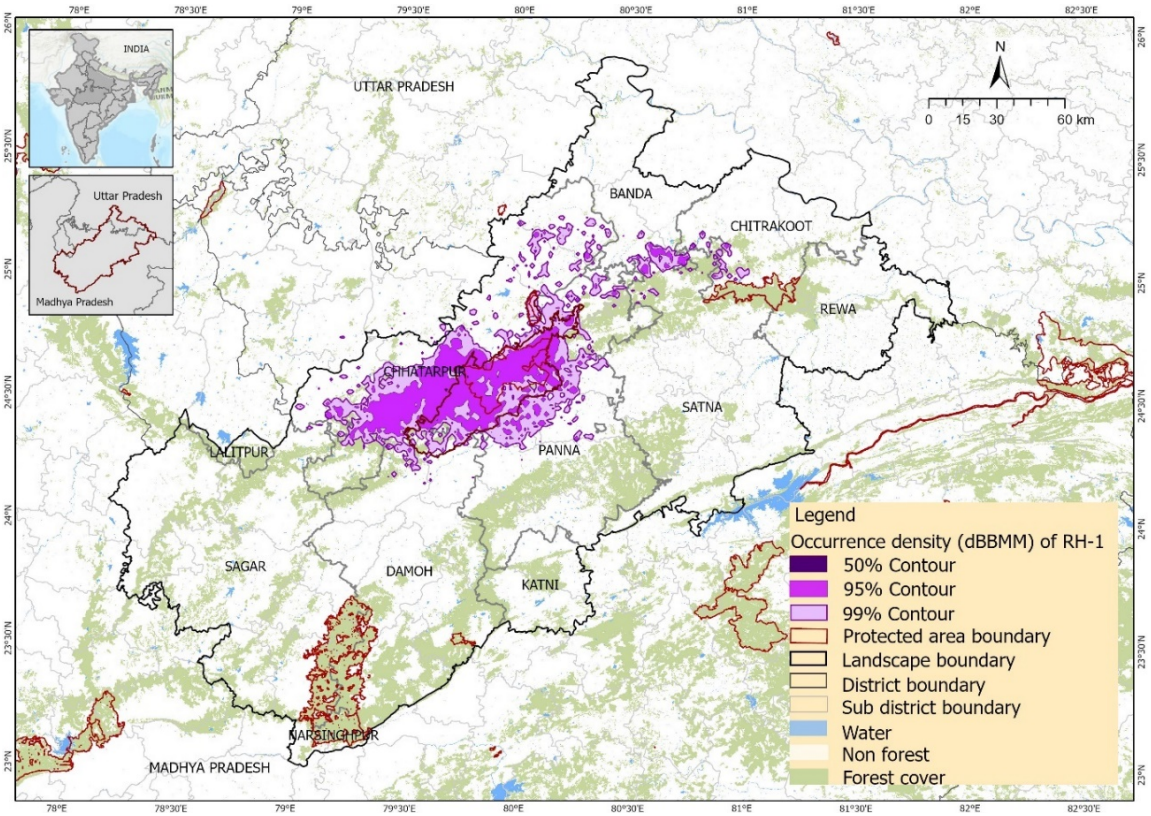


Figure 5.9. Movement and ranging of tagged Red-headed Vulture-1

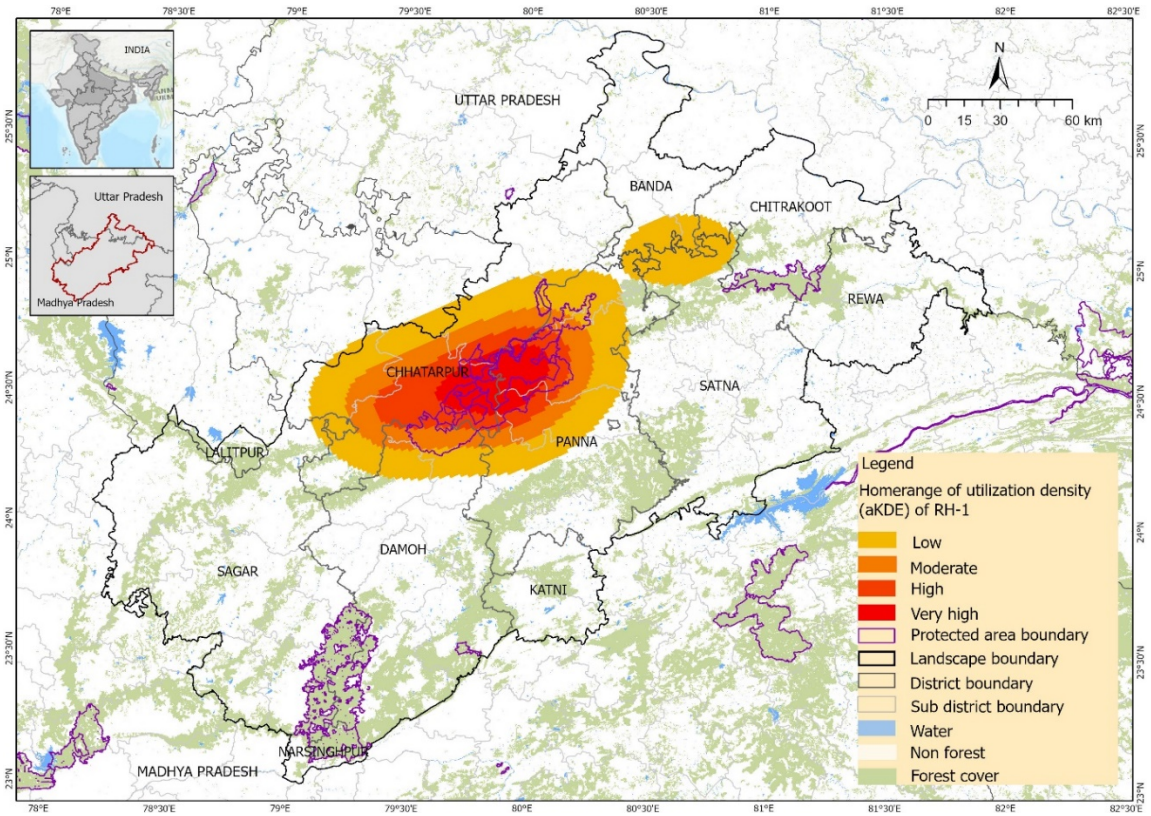


Figure 5.10. Movement intensity of tagged Red-headed Vulture-1

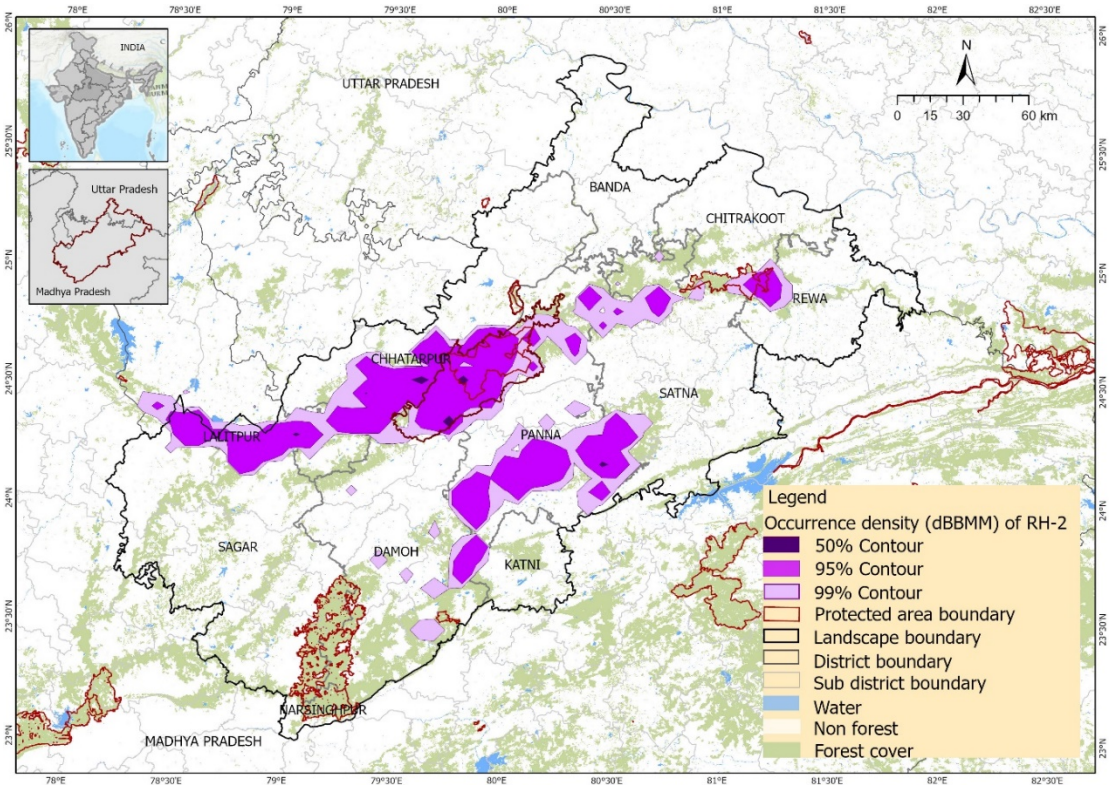


Figure 5.11. Movement and ranging of tagged Red-headed Vulture-2

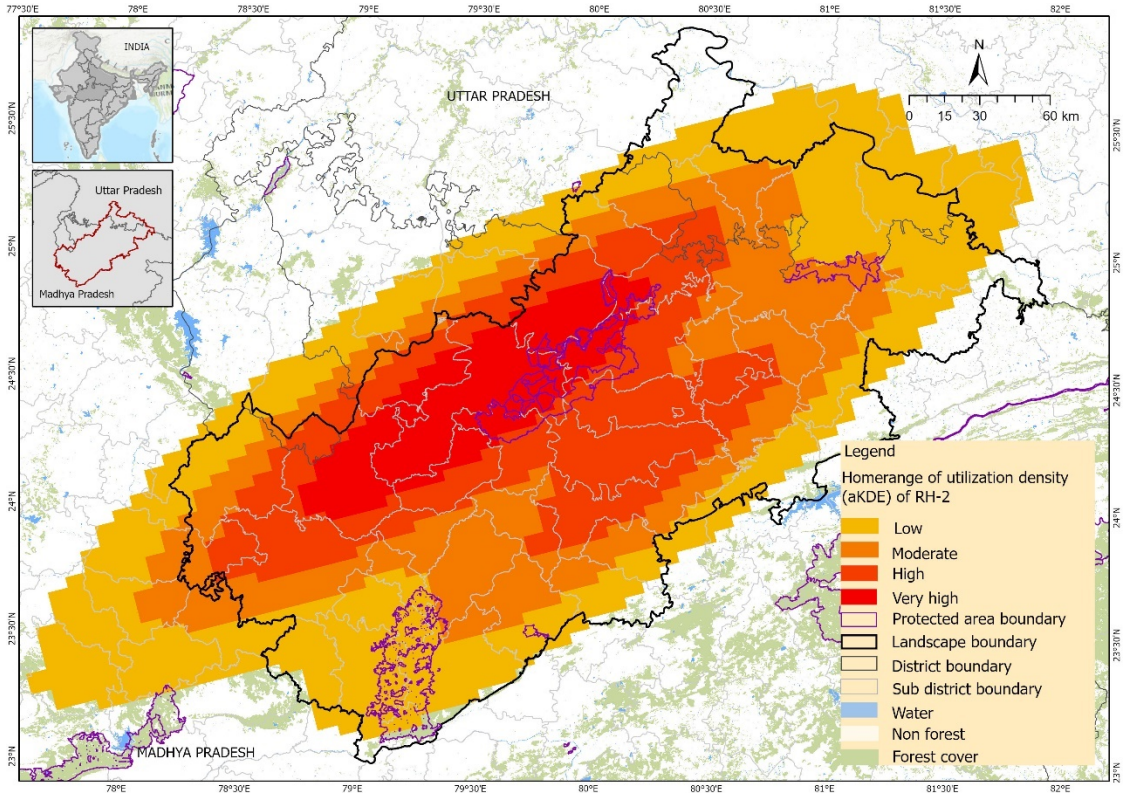


Figure 5.12. Movement intensity of tagged Red-headed Vulture-2

5.1.8. Population Viability of Vultures: Population Viability Analysis (PVA) of the resident vulture population of PTR based on available population parameters with 100 iterations allowed for understanding the population growth of these species over 50 years. Scenario-1 assumed the current population of vultures to be only 5% of the historical population and included 100% reproductive rate and 100% survival rate. With the same population level, Scenario-2 considered 90% reproductive and 90% survival rates, Scenario-3 considered 80% reproductive and 80% survival rates, Scenario-4 includedScenario-1 parameters (100% reproductive and survival rates) along with catastrophes of poisoning, disease and habitat loss/destruction, and Scenario-5 included Scenario-3 parameters (80% reproductive and survival rates) along with catastrophes of poisoning, disease, and habitat loss/destruction causing 40% reproductive and survival rates. However, in the case of Egyptian Vulture, the effect of catastrophes (poisoning, disease, and habitat loss/destruction) was 90% survival, instead of 50% for other species. The current population may be much nearer to the carrying capacity. Therefore, all these above scenarios were subjected to 50%, 95%, and 100% of the carrying capacity (K) and thus, a total of 20 scenarios were produced together for each species. Given the current protection status, Scenarios 1 and 2 predicted to take two decades to reach carrying capacity for all four species while considering current population is the 5% of carrying capacity (Fig. 5.13, 5.14, 5.15 and 5.16). Further, any catastrophe (poisoning, disease, and habitat loss/destruction) coupled with low survival and high mortality will force the population to decline and lead to probable extinction from the area. In case of the other base populations with 50%, 95% and 100% carrying capacities, the population will be stable without certain catastrophe, except for the Red-headed Vulture which may show decline because of the low population size. However, all these are hypothetical models and hence, taking cue from these, the best conservation strategy to facilitate long-term survival of these species would be to consolidate the existing population by way of protection, ensuring food security, and support population growth to their carrying capacity. Since the population depends on resources from around the landscape area, Vulture conservation needs to be directed at landscape level, with special focus in Protected Areas, involving diverse stakeholders.

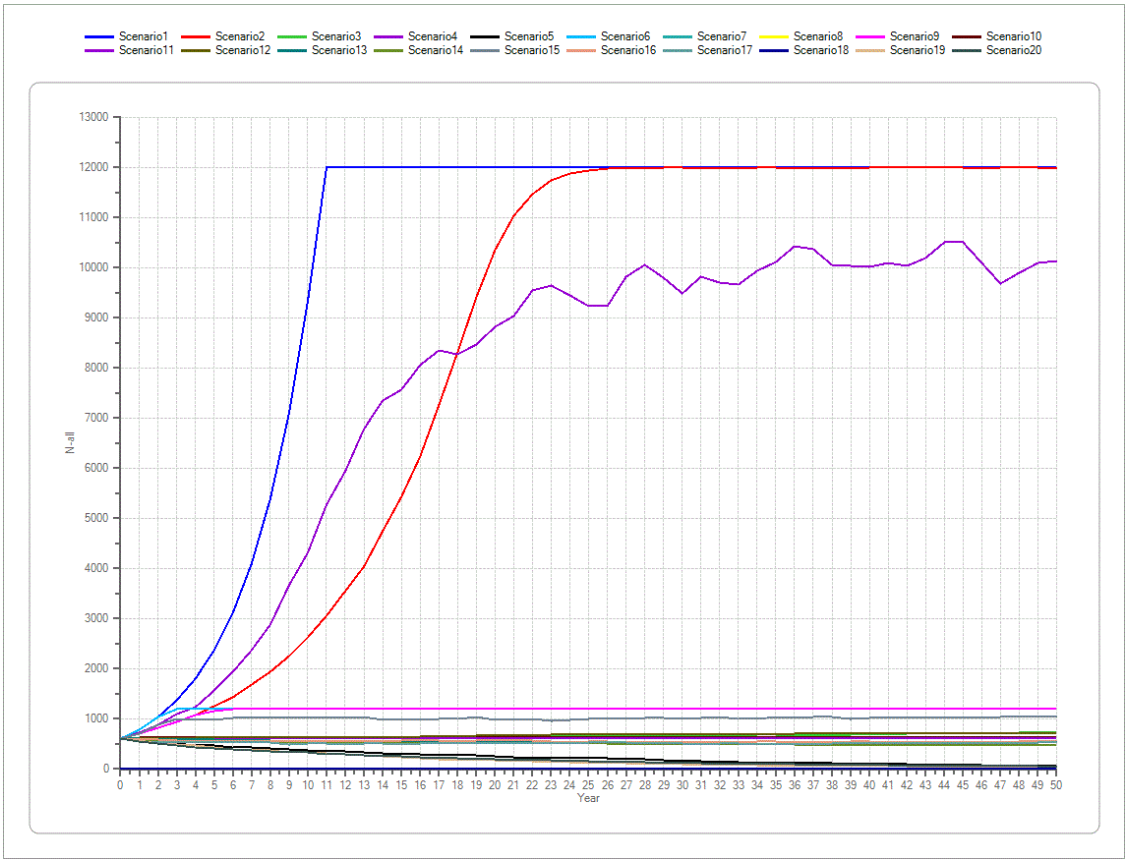


Figure 5.13. PVA-based population growth of Indian Vulture in PTR

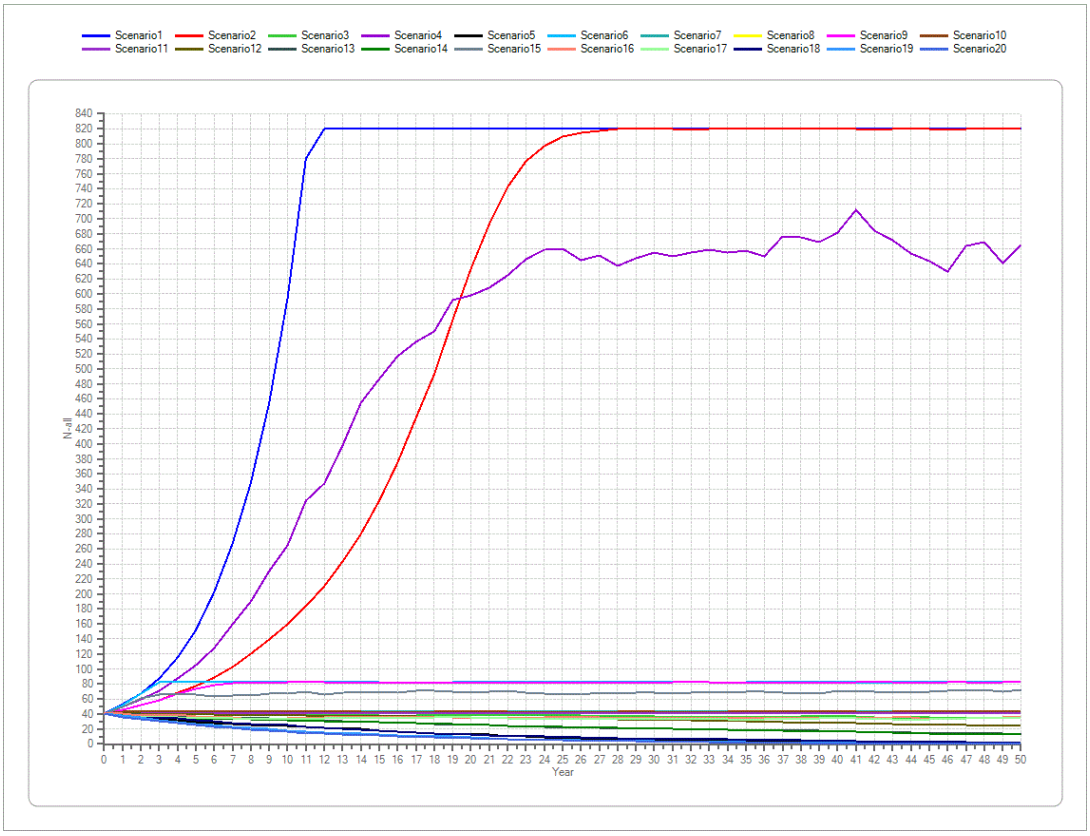


Figure 5.14. PVA-based population growth of White-rumped Vulture in PTR

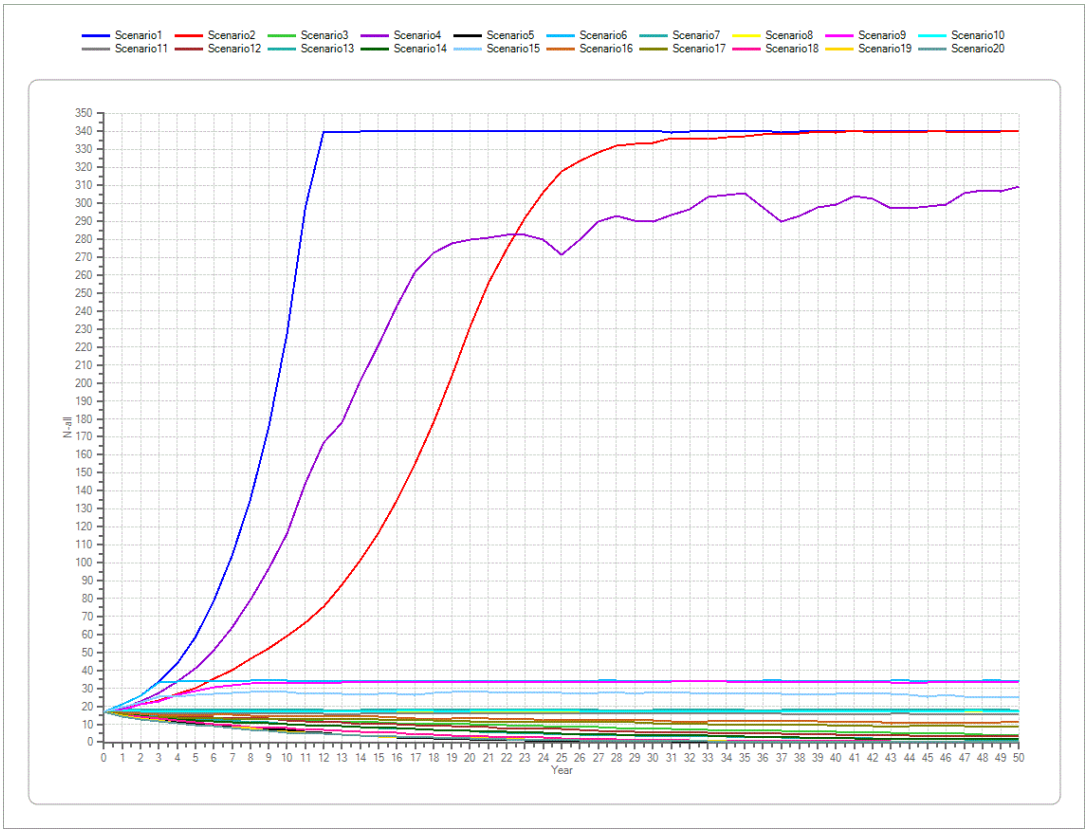


Figure 5.15. PVA-based population growth of Red-headed Vulture in PTR

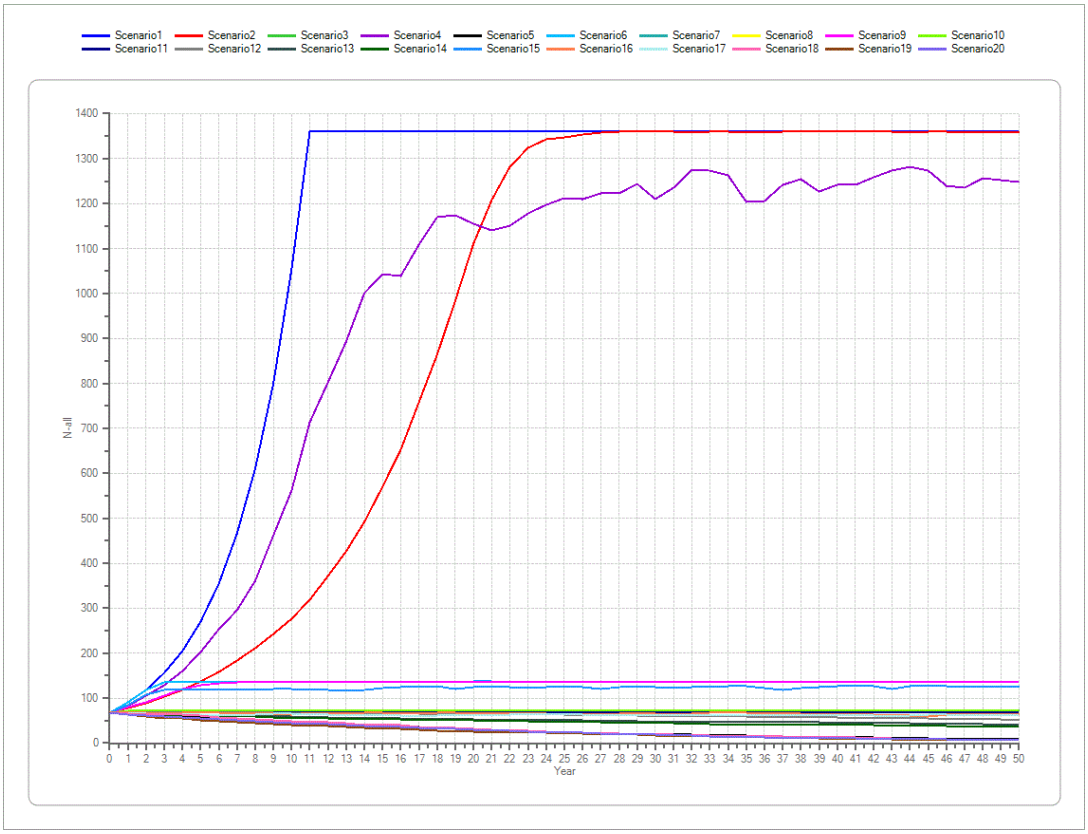


Figure 5.16. PVA-based population growth of Egyptian Vulture in PTR

5.19. Spatial Prioritisation: Nesting and roosting of cliff-dwelling species were modelled together in Zonation Software (version GUI 4.0. rec1_compact) to understand the priority sites for vulture conservation. The entire landscape (GPL) was taken as ***Planning Area***, 1km grid cells were taken as ***Planning Unit***, 1km x 1km planning unit, suitability of vulture distribution (for nesting and roosting) was considered as ***Conservation Feature*** and the human footprint was taken as ***Conservation Cost***. The goal was to define the planning unit in rank order with reference to conservation features. The Zonation Software runs a deterministic algorithm where it checks the conservation feature value against the cost of each planning unit and gives rank to each unit. While the entire landscape has conservation value, the cost of conservation allows for prioritising resource allocation and efforts and thus priority may be specified accordingly. Top ranking areas shown in Fig. 5.17 reflect contiguous forest and cliff mosaic to be considered for consolidation, while other areas may require considerable efforts to safeguard the vulture populations. Since the model has also included forest cover, it has indirectly covered the priority for tree-nesting species as well. Given that the survival of vultures not only depends on the nesting and roosting habitats, but also foraging grounds which are both inside and outside forest areas, the resultant map should guide conservation of vultures in the landscape, as we cannot afford to ignore even the high-cost areas due to the precarious status of the vultures with significant vulnerability to stochastic and anthropogenic events.

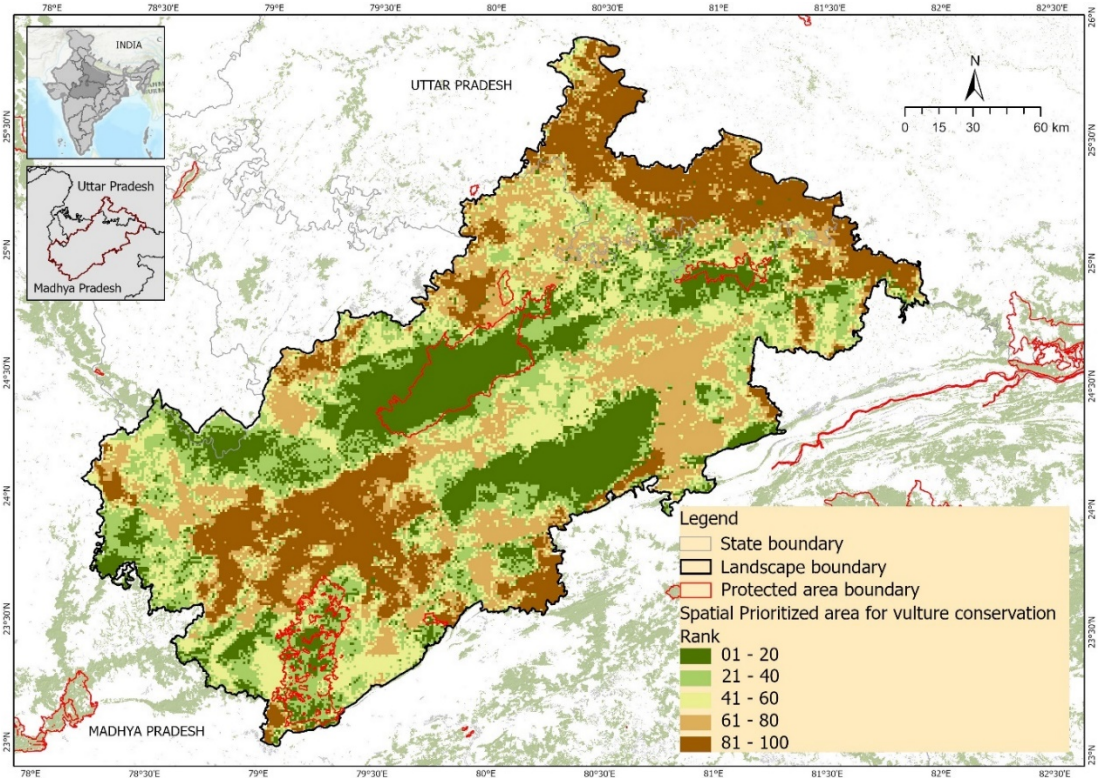


Figure 5.17. Spatial prioritization of vulture sites in the landscape

5.2. Recommendations and Prescriptions

5.2.1. Measures for Enhancement of Protection: Protection measures for vultures essentially relates to (i) protection of population (from poaching, breeding loss, and diseases), (ii) protection of habitat (from destruction and anthropogenic disturbances, fire incidents) and (iii) protection of forage (from non-targeted poisoning and feral dogs). These are required to be addressed with both conventional and modern methods.

(i) Establishment of E-Surveillance System: Vulture populations located in the Protected Areas can be protected from poaching (medical and other unknown purposes) based on existing protection mechanisms, but such protection needs to be enhanced in the landscape area outside the PA, based on increased patrolling in and around to the vulture sites. Mortality due to diseases and other causes and breeding loss can only be avoided by preventive mechanisms by regular monitoring and identification of indicators. Although there is no definitive option available, with continuous monitoring and disease surveillance, this can be resolved. Therefore, in addition to ground-based monitoring by field staff or organised volunteers or NGOs, Electronic Surveillance System (ESS) with optical and thermal cameras with 24x7 web-enabled monitoring need to be established, and this can be planned in both Protected Areas as well as outside, in other parts of the landscape. These towers, which can be unidirectional or multidirectional, located away from the nesting or roosting sites can also be used for promoting conservation education and tourism.

(ii) Management of Carcass Dump Sites: Carcass dumping sites include smaller sites around villages and larger sites around Gaushalas (Fig. 5.18). Depending on the feasibility, such sites need to be fenced off using natural materials and nets (with access points) so that these carcasses can be protected from the domestic/feral dogs and to avoid the spread of zoonotic diseases and other ill effects, without causing any injury or damage to the vultures. At least, key concentration sites need to be protected. However, this intervention needs to be evaluated carefully within local context as it should in no way interfere with free movement and landing/taking off of vultures, and accordingly such an intervention (which is to be temporary in nature) needs to be implemented. Where possible, the dump sites should be supported with large enough elevated wooden platforms so that only vultures can access the carcass, while preventing domestic/feral dogs.

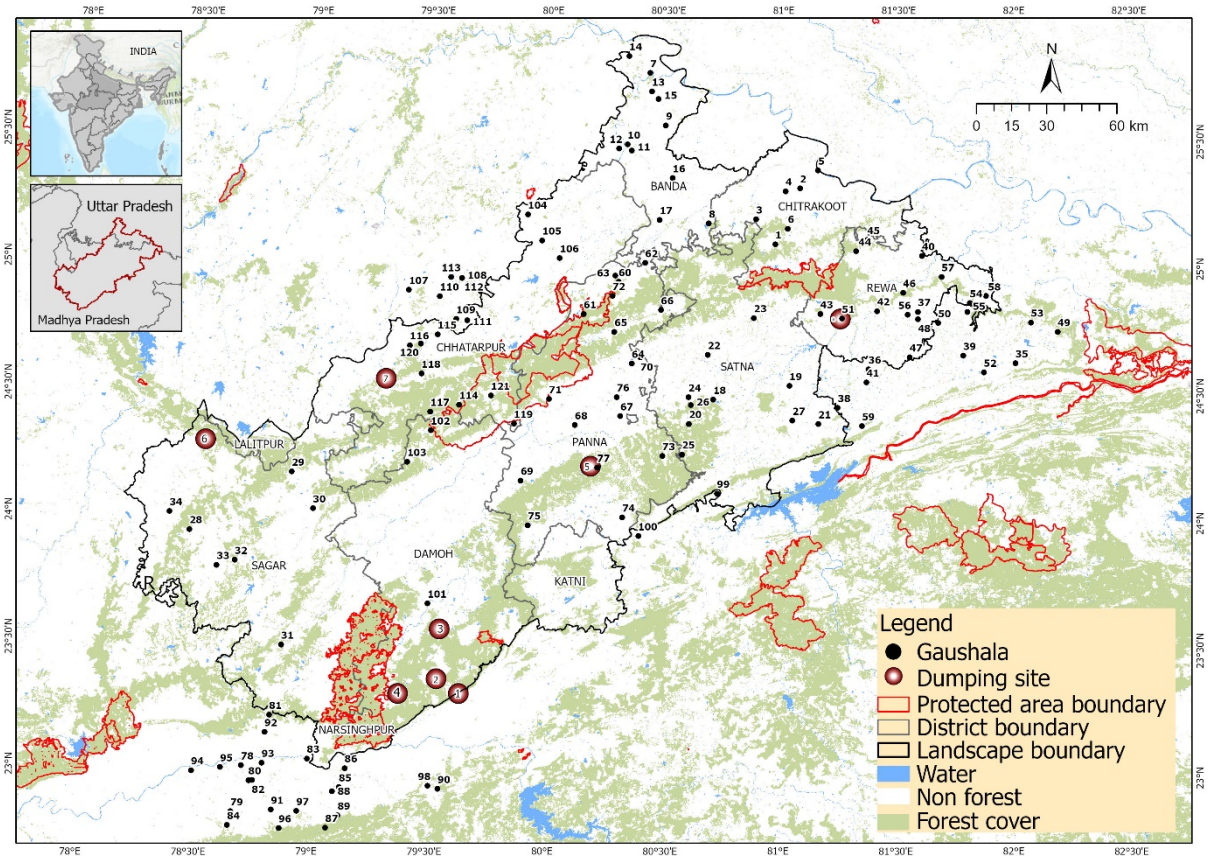


Figure 5.18. Map depicting location of gaushalas and major dumping sites in the landscape (name of the sites is provided in Appendix 5.1 & 5.2)

(iii) Deployment of Alert System: The vultures venture into village areas for carcasses and other forest fringes for kills of large carnivores. Many of the nesting/roosting sites are also visited by local people for various purposes. These areas need to be monitored and protected from anthropogenic disturbances. GSM-based or local Network-based Camera traps need to be deployed in such sites to alert officials if undesirable actions occur and to prevent against the same.

(iv) Aerial Surveillance of Fire and Prevention: Fire is a major problem in central Indian forests, but usually it takes time to respond based on the scale of fire. However, a small scale fire can affect the tree nesting species and dead trees/logs, that are used as perch by both cliff-nesting and tree-nesting species. Therefore, fires need to be monitored regularly and even a small-scale fire in the nesting/roosting and regular foraging sites should be prevented. Sophisticated Un-manned Aerial Vehicles (UAV) or Drones with noise reduction and object deduction technology, can be integrated as a part of monitoring mechanism and put into action along with appropriate response strategy.

(v) Network of Vulture Champions: There is increasing awareness about wildlife conservation across the communities, specifically on vultures, as they interact with human areas for foraging and water bodies. Community involvement is crucial for conservation of vultures across the landscape and thus, it is proposed to set-up a Network of Vulture Champions (NVC), which may be locally called 'Jatayu Mitra' consisting of volunteers and full-time personnel. While the Volunteers may include School/College Students and other interested community members (who may be given Certificate of Participation), the full-time personnel with fixed emolument can function as a link between the forest department and local communities. Based on resource availability and sustainability options, NVC needs to be prioritised for PTR and the landscape based on spatial prioritization and significance.

(vi) Gaushala Coordination Committee: There are a large number of Gaushalas in the landscape, and these are important sources of forage for the vultures, including for the populations that live in the Protected Areas. Therefore, without adequately managing the Gaushala and dumpsites, the threats to vulture population cannot be removed. Therefore, it is recommended to establish a Gaushala Coordination Committee (GCC) at landscape level with regular engagement and support system as may be required. The existing mechanism to manage the gaushala needs to be reviewed and GCC which will be represented by the owner/manager of gaushalas, public representatives, biologist, and representatives from the forest department, animal husbandry department, and public health department. GCC can be integrated in the One-Health Coordination Committee to be headed by the district collector. Representatives from GCC can be involved in the Biodiversity Management Committees to ensure that (a) the cows are not treated with diclofenac, (b) carcasses are disposed of properly and (c) dumpsites are protected from feral dogs and anthropogenic disturbances.

(vii) Enhancement of Protection Status Outside PA Network: There are several falls and river escarpments in the landscape that serve as potential nesting/roosting sites for vultures. It is recommended that these, as well as any other newly found vulture nesting be protected by declaring them as Community Reserve or Conservation Reserve depending on the respective land use, its ownership and use of resources by the local communities. Program 02 of the Visionary Perspective Plan (VPP) discusses "Conservation of Important Bird and Biodiversity Areas (IBAs) of the Country outside the Protected Area Network". Therefore, this recommendation will serve both local and national goals. Following are the potential sites for conservation priority areas for vultures (Important Vulture Sites) in the landscape outside the

Protected Areas (Fig. 5.19) and these can be developed as a Community or Conservation Reserve:

1. Pawai Range in South Panna Division
2. Purwa Fall in Rewa Division
3. Rahatgarh fort in South Sagar
4. Baghdari Fall in Damoh Division

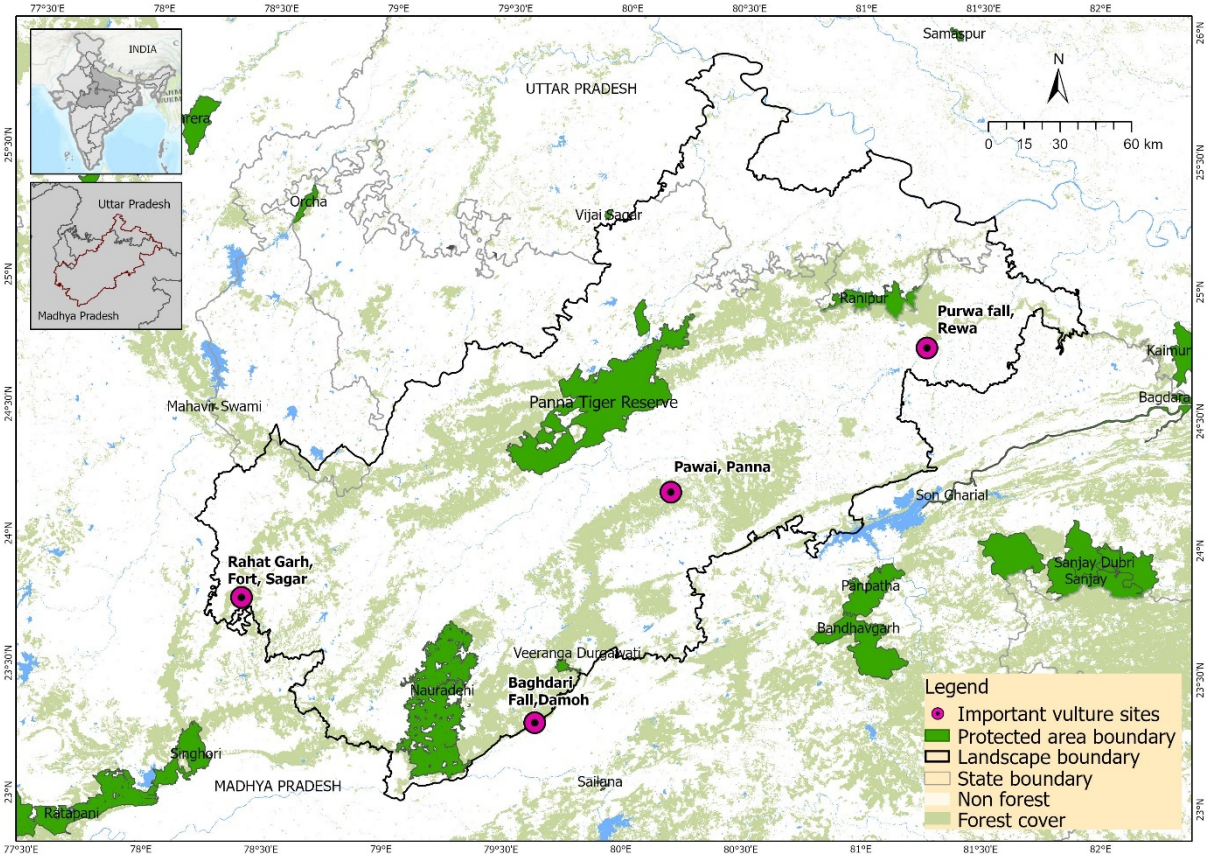


Figure 5.19. Proposed conservation priority sites (Important Vulture Sites) in the landscape

The Pawai site is a dumping site and has little protection from feral dogs and human activity. With joint management of this site with the Gaushala Unit, it can be developed as feeding ground with Conservation Reserve status. Purwa Fall has high human activity and an electric power generation unit is coming up near the fall. It should be secured so that this new development doesn't disturb the vulture habitat there. Site specific impact assessment on the vulture population needs to be done and mitigation measure should be proposed, accordingly. The back side of Rahatgarh fort harbours the vulture population and is mostly secured due to its height and steep slope. Baghdari Fall area is used as a dumping ground and therefore, it has

become a vulture foraging and roosting ground. However, these proposals require further discussion and consultation with all concerned stakeholders and a separate Detailed Project Report (DPR) needs to be developed for each of the sites during plan implementation stage.

5.2.2. Measures for Population Management: There is a lot to be understood about the population parameters of all the vulture species both within PTR and in the landscape. Therefore, the prescriptions for population management of vultures would involve adaptive strategies based on regular monitoring, focussed studies, and consultation process. However, based on available information, the following recommendations are made:

(i) Robust Population Estimation and Monitoring: Currently population size of vultures in MP, is being estimated based on coordinated survey involving forest staff, volunteers and professionals but mostly it is a one-time survey. Therefore, during this study an attempt was made to estimate the population by replicates. However, this needs to be scaled up and should also cover the tree-nesting species. Population estimates at site level, reserve level and landscape level are required to be done, and it needs to be done for different seasons every year to understand demographic structure and local level population dynamics. A dedicated team of staff and professionals need to be identified and trained to implement the estimation process. Representative individuals of these birds should be tagged with GPS-GSM/Satellite tags and Patagial Tags, and monitored long-term to understand the survivorship, movement and social interactions, in the entire landscape including the human-interface areas.

(ii) Demographic and Genetic Structure Profiling: Species conservation including recovery strategies require information on demographic and genetic parameters. These are not available for the vultures in the landscape, as it requires long-term dedicated efforts. Therefore, based on conventional as well as sophisticated technology, the populations of vultures need to be profiled for their demographic characteristics. UAV-based photographic monitoring can also be done. Similarly, non-invasive fecal samples of vultures are to be collected and processed. These need to be done annually. Incorporating these two population parameters in the Population Viability Analyses, population level interventions should be decided upon as may be required.

(iii) Nest-site Monitoring: Breeding success is an important determinant of population status and thus, it is recommended to undertake close monitoring of representative sites. Nests should be counted throughout the breeding season along with the monitoring of successful breeding, *i.e.*, survival of the chicks. Reasons for mortality of chicks as well as adults should be recorded.

Nest-site monitoring should be conducted by any of the following means: (a) Physical monitoring, (b) Fixing camera at nest-site, (c) Thermal camera at nest-site and (d) Drone monitoring (after ensuring the birds are not disturbed). These sites should also be installed with "data loggers" to gain better insight on the microhabitat requirements and management of vultures.

(iv) Biochemical Analyses and Monitoring: A holistic management can only be achieved by taking into consideration the biology of the species. In addition to the key parameters recommended above, (a) Gastrointestinal physiology (effect of prey availability, effect of food deprivation and energetics of prey procurement and nutrient value), (b) Haematology (blood profiling, immune suppression parameters and disease indicators), (c) Disease ecology (focusing on emerging disease including zoonotic ones, interaction with pathogen and their effect on behaviour and reproduction, ectoparasites and endoparasites under the One Health Concept) (d) Toxicology (effect of pesticides, banned veterinary drug and other chemicals on the vultures through the food chain) and (e) misuse of veterinary drugs, should also be monitored. Local institutions in Jabalpur, Sagar, Rewa and Banda can be involved as collaborator for implementing this component.

(v) Establishment of Vulture Rehabilitation Centres (VRC): Facilitating the growth of the vulture population must be accompanied by a rescue and rehabilitation programme for the birds found in distress, given the conservation value of the species and the opportunity to augment the population in low density areas. In addition to the actions proposed by Action Plan for Vulture Conservation 2020-2025 (APVC 2020-2025) of Ministry of Environment, Forest & Climate Change (MoEF&CC), Government of India, it is recommended to set up Rapid Response Team (RRT) with the dedicated mandate of rescuing stranded and injured birds and rehabilitating them in dedicated Vulture Rehabilitation Centres (VRC). Depending on the size of the administrative units and resource availability, more than one such centre can be established. The rescue and rehabilitation centres essentially need to incorporate exclusive functioning with dedicated experts/manpower in form of veterinarians and trained handlers; necessary medication and infrastructure; handling and housing of injured vultures; clinical examination of injured vultures; treatment of wound, broken or dislocated bones, nutrition deficiencies, emaciation or head trauma, paralysis and poisoning; management of admission of injured or sick vulture; and release protocol for a running a successful centre. In PTR, VRC can be built near Kishangarh buffer range office as it will be near main road and will give access to the main vulture sites of PTR, *i.e.*, Gahrighat, Kishangarh and Amanganj Ranges.

A strong information network needs to be built by the VRC with the railway division and highway authorities so that any carcass lying on railway tracks and roads can be removed as soon as possible to avoid mass death of vultures on the rail lines or roads. The rehabilitation centre should be following standard norms to secure the safety of the vultures and the workers (Wolter *et al.*, 2019). We propose some tentative locations for VRC in the landscape (Fig. 5.20, Table 5.8) and these can be developed in a phased manner. These sites have been selected because of their proximity to major vulture nesting/roosting sites and have good road connectivity. Additionally, in the landscape, several veterinary hospitals and dispensaries are functioning. Though they are mostly responsible for the treatment of domestic animals, some of these can be developed with the capacity to treat vultures and other wildlife. The hospitals and dispensaries which are nearer to the vulture sites should be given priority since during the time of emergency, it will be easier for these centres to respond.

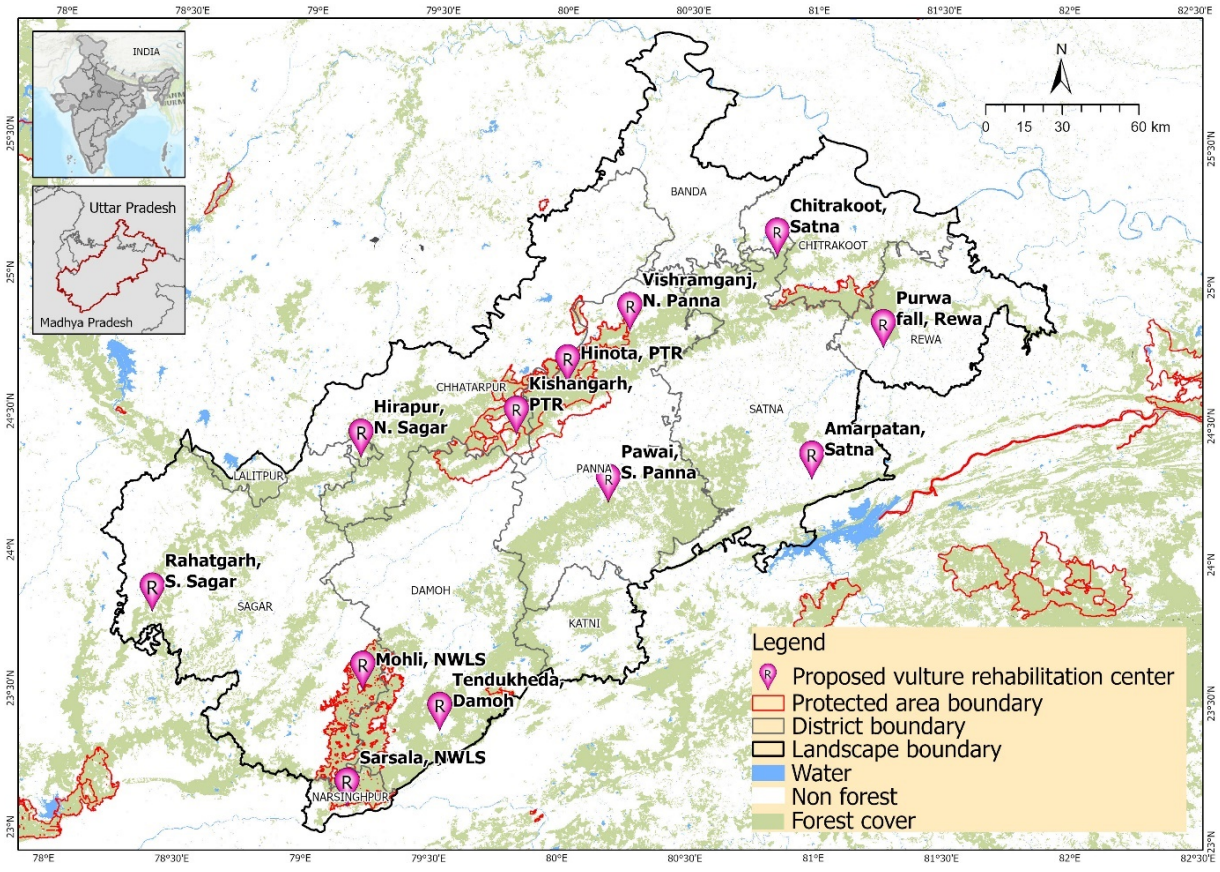


Figure 5.20. Proposed Vulture Rehabilitation Centres in the landscape

Table 5.8: Proposed vulture rescue and rehabilitation centres in the landscape (Madhya Pradesh part)

Phase	Location	Forest Division
Phase-I	Kishangarh	PTR
Phase-I	Sarsala	Nauradehi Wildlife Sanctuary
Phase-I	Purwa Fall	Rewa
Phase-I	Hirapur	North Sagar
Phase-II	Pawai	South Panna
Phase-II	Tendukheda	Damoh
Phase-II	Chitrakoot	Satna
Phase-II	Rahatgarh	South Sagar
Phase-III	Vishramganj	North Panna
Phase-III	Hinauta	PTR
Phase-III	Amarpatan	Satna

(vi) Awareness and Engagement of People and Veterinary Professionals: Apart from Diclofenac, Flunixin is another Non-Steroidal Anti-Inflammatory Drug (NSAID) which is now available in India and is found to be associated with the death of Eurasian Griffon in Spain. Other than these, Aceclofenac, Ketoprofane, Nimesulide etc. have also been found to be harmful to the vultures. Therefore, it is important to make local people and veterinarians aware about the harmful effect of these medicines on vultures and ensure compliance to ban on the same. Regular surveys as well as systematic awareness programmes should be conducted for the concerned people and authorities. In this regard, the APVC 2020-2025 should be consulted, which discusses in detail the prevention of poisoning of cattle carcasses, the principal food of vultures. This also needs to be integrated in the Gaushala Coordination Committee.

(vii) Implementation of Flyway Action plan: Convention on the Migratory Species (CMS) mandates the Parties (signatory countries that include India) to implement Flyway Action Plan to conserve the migratory species. MoEF&CC's Programs 07 and 15 of Visionary Perspective Plan (VPP) exclusively emphasize upon implementation of the international protocols and conventions for migratory birds in India. Therefore, it is mandatory to take conservation measures for vulture species that migrate. Since the landscape is the wintering ground for three migratory species (Eurasian Griffon, Himalayan Griffon, and Cinereous Vultures), it is

mandatory to protect the sites utilised by these species and mitigate all prevailing threats at these sites.

(viii) Disease Surveillance and Monitoring: MoEF&CC's VPP Program 11 has emphasized on the "Surveillance and Monitoring of Avian Diseases" because of multiple events like catastrophic deaths of over 17,000 birds at Sambhar Lake in Rajasthan due to avian botulism caused by *Clostridium botulinum*. World Health Organization (in 2016) highlighted that pathogen which originates from animals, or its derivative products has contributed to the emergence of 75% of the infectious diseases. Keeping an eye on the zoonotic diseases, the 'One Health Program' demands the inclusion of monitoring and management of avian diseases too. The concept should gain much relevance in the light of the ongoing Covid-19 pandemic, which is believed to have originated in a wildlife market at Wuhan, China (Zhou *et al*., 2020). Specific to vultures, it has been reported that as a consequence of the decline in vulture population in India, the increase in the population of the feral dogs has resulted in the increase in the cases of 'rabies'. Therefore, the protection of the population of vultures is instrumental in controlling of the surge of feral dogs and the nuisance created by them. Therefore, Disease Surveillance and Monitoring Programme should be implemented in all the nesting/roosting and foraging sites, with focus on PTR and other priority sites.

5.2.3. Measures for Habitat Management: Vultures' choice of habitats for roosting/nesting are mostly based on natural advantage of higher visibility and the opportunity to utilise the thermal updraft enabling easy take-off and lift. Therefore, measures for habitat management largely relate to enhancing the protection of the habitats and certain level augmentation where possible. The following measures may be taken up for habitat management for vultures:

(i) Regular Update of Nesting and Roosting Sites: Vultures tend to use the nesting/roosting habitats variably and non-use of some area cannot be taken as permanent rejection of the area. Therefore, it is important to regularly update the nesting/roosting sites. This also includes seasonal status, as there is a possibility that migratory species during winter can displace resident species or force constraints for habitat occupancy and foraging.

(ii) Augmentation of Riparian Tree Species: Riparian zone in the landscape has variable heights and visibility, and thus, vultures tend to use such zones. Therefore, augmentation of riparian trees and other tall trees need to be promoted either as a part of afforestation/restoration by the Department and by community activity when planning campaigns.

(iii)Management of Dumping Site/ Feeding Point: Since sufficient food availability is very crucial for the survival of a species, it is imperative to secure food sources for the vultures in the landscape. In this regard creation of 'feeding points' for vulture and managing dumping sites for vulture to forage is very essential. An efficient mechanism can be set up for the food supply of vulture in accordance with the existing acts and rules of animal husbandry in Madhya Pradesh. The Gaupalan Evam Pashudhan Samvardhan Board in Madhya Pradesh is responsible for the registration and quality control of gaushalas. On the other hand, VPP in its 'Program 14' has proposed "Mainstreaming Conservation of Avian Diversity with Other Government of India Schemes and Programmes". Therefore, integrating the disposal of carcass from the gaushala with the establishment of feeding points for the vulture can ease the goal of food security.

5.2.4. Vulture-based Tourism: The landscape is to be promoted for vultures, although the focus of tiger will continue to be there. Since vulture distribution is across the landscape and in the human-dominated areas, it is more practical to develop vulture-based tourism which can promote local economy. New vulture viewing points have been identified and improvement of existing tourism in PTR is also suggested, keeping in view animal welfare. Vulture points in KGS and Machhareau in Udla Beat of PTR (Fig. 5.20) should be developed as education tourism sites. A watch tower and an interpretation centre can be set up in Udla Beat at least 2-3 km away from the vulture nesting sites along the ledges of the escarpment. A feeding point can be developed in KGS as it is regularly visited by the vultures to feed on the carcass dumped by the people in nearby villages. An observation centre for the tourists can be set up at a sufficient distance from the feeding point. Nature-trails can also be developed along the Ken River in Udla Beat and in KGS to attract the tourist and to use it as an instrumental for 'Nature Education and Awareness' in accordance with the 'VPP's Programme 12. In this regard, it should be considered that KGS already has a nature trail which needs to be complemented with proper bird-watching instruments and guidelines and relevant signboards. The observation points should be equipped with multiple spotting-scopes and vulture identification leaflets should be provided to the tourists. The leaflets should also include relevant content to create awareness about vultures and appropriate visitor behaviour. Tourists should be accompanied by trained guides.

The man-made structure in Dhundwa Seha of Hinauta Range, should be dismantled because it lets the tourists reach very close to the vulture sites which is disturbing for the vultures. Instead, an observation point can be developed in `Chhota Dhundwa', to watch the vulture of Dhundwa

from an appropriate distance without causing any disturbance to the vultures in Dhundwa. The current observation point is within less than 50 m of vulture site. It has been observed that the timing of the vulture's bathing in the “Dhundwa fall" partially coincides with the timing of the tourists mostly during the winter. During the winter the Dhundwa fall harbours around 250 of Himalayan and Eurasian Griffon vultures apart from other residential ones. For all the residential and migratory species of vulture bathing is one of the most essential activities after feeding on the carcass. And during the second half of tourist time, *i.e.* 3:30 PM onwards, it has been found that as the tourists approach the view point of the fall the vultures taking bath or basking near that point get disturbed and start flying away. Therefore, either the tourism needs to be stopped there in Dhundwa or the observation point for the tourists need to be shifted. Therefore, `Chhota Dhundwa' is a better option as the observation point will be at least at a distance of 300m from the nesting and roosting site. The observation point can have live-transmission video network so that viewers will have a better experience.

5.3. Synthesis and Conclusions: Presence of seven out of nine species of vulture (78%) found in India makes PTR and the landscape to have outstanding conservation value for this important group of species, with a clear ecological and public health role. Therefore, there is a need to have enhanced conservation focus for these species than what is being done and therefore, this integrated landscape management plan offers an important opportunity to convert this vision to action. Because vulture is a large ranging species and utilises diverse land use areas for various purposes, the management strategy requires a comprehensive approach. Protection of the species population requires mostly protection of the existing habitats and other measures would partly involve further knowledge taking adaptive management strategies. However, vultures provide options to expand the scope of tourism and community-based economy, and thus, the strategy proposed for considering Conservation/Community Reserves for Vultures would go a long way in the conservation of vultures. Also, vultures are linked to high human interface and ecological health and thus, can play an important role for taking forward One Health Concept to practice, expanding the conservation goals to larger public health and wellbeing in the long-term.



CHAPTER 6

CROCODILIANS CONSERVATION STATUS AND PRESCRIPTIONS

Chapter 6: Crocodilians Conservation Status and Prescriptions

6.1. Situation Analyses

6.1.1. Introduction: India is home to three Crocodilian species *viz*. Gharial (*Gavialis gangeticus*), Mugger or Marsh Crocodile (*Crocodylus palustris*) and Estuarine or Saltwater Crocodile (*Crocodylus porosus*). Although rarer now, the Gharial was historically abundant until the early 1900s in the Himalayan Rivers of North India and the surrounding region (Vos, 1984; Stevenson, 2015). The Mugger or the Marsh Crocodile is the most widespread, distributed across the South Asian countries. The Estuarine Crocodile is found across Southeast Asia and northern Australia. In India, estuarine crocodiles are only present in Odisha's Bhitarkanika National Park, the Sundarbans in West Bengal, and the Andaman and Nicobar Islands (Webb *et al.*, 2019). The Gharial is the sole member of the family Gavialidae and is stated as 'Critically Endangered' by IUCN since 2007. The Mugger is also stated as 'Vulnerable' by the IUCN and is protected under the Wildlife Protection Act, 1972 of India, which lists the Mugger in Schedule I (as serial 1D of Part II Amphibians and Reptiles) and bans export of wild-caught specimens.

Crocodilians act as a keystone species for the aquatic ecosystem and benefit the freshwater and estuarine ecosystems by maintaining the balance in the complex web of life (van der Ploeg *et al.*, 2011). Studies suggest that Crocodilians have a positive impact on the fish abundance, by preying on the ailing fishes over the healthy fishes, thus enhancing a healthy fish population (Somaweera *et al.*, 2020). The proportion of fish species is also well maintained because of predation of the over-growing fish species (van der Ploeg *et al.*, 2011). The loss of such a huge predator is thought to alter key ecological processes and harm the entire ecosystem. Alternatively, juvenile crocodiles are also prey to other animals such as turtles, birds, mammals, and even other crocodiles. Muggers occasionally end up in conflict with humans during fisheries operations, occasional predation of livestock and habitat modification. They are frequently treated as a nuisance to inland fisheries and thus often get killed (Santiapillai and Silva, 2001). Habitat destruction due to agricultural and industrial expansion, accidental entanglement in fishing equipment, predation of the nests by humans, illegal poaching for skin and meat, and the use of body parts in medicine are some major threats to these species (Jelden *et al.*, 2014).

The population of gharial has drastically declined over the last 60 years (Choudhury *et al.*, 2007). Over-hunting for skins and trophies, egg collection for consumption, killing for indigenous medicine, and opportunistic killing by fishermen when caught in fishing nets are the leading causes for this rapid decline of the gharial population (Choudhury *et al.*, 2007; Biswas, 1970; Whitaker, 1975). Many farmers seasonally take over riverbanks for agriculture, leading to deprivation of basking and nesting sites for gharials. Toxins or other pollutants were highly doubted to play a role in the death of >110 juvenile gharials during the winter of 2008-2009 on the lower Chambal (Whitaker *et al.*, 2008) and possibly the loss of additional gharials in 2012 (<10-15 individuals; Nair *et al.*, 2016). The gharial is sympatric with mugger in the river systems of the Ganges, Chambal, Son, Ramganga, Girwa and eastern Mahanadi, as well as in the Rapti and Narayani Rivers (Choudhary *et al.*, 2018). While the anthropogenic pressure has affected both the species in terms of habitat loss and fragmentations, gharial has suffered population declines and local extinctions, and muggers are increasingly involved in conflicts with humans. Thus, gharial requires recovery efforts and mugger requires population management including conflict mitigation efforts.

6.1.2. Status of Crocodilians: Mugger is common in Ken River, though patchily distributed across the Ken River stretch. In January and February 2018, there were 59 sightings of muggers in PTR (along 55 km of river stretch) and 3 in KGS (along 8 km river stretch) during river walk surveys (Das *et al.*, 2019). The population was estimated to consist of 20 adults, 11 sub- adults, 4 juveniles and 1 yearling (rests could not be estimated of size as they were mostly swimming and submerged) (Das *et al.*, 2019). During the survey in May and June 2019, 27 muggers were sighted in PTR and 11 in KGS, with 5 in 4-6 ft size class, 10 in 6-8 ft size class, 4 in 8-10 ft size class (rest could not be estimated of size as they were mostly swimming and submerged). An aerial survey using high-resolution UAV across PTR and KGS resulted in recording 62 muggers, represented by 3 in 2-4 ft size class, 10 in 4-6 ft size class, 29 in 6-8 ft size class, 13 in 8-10 ft size class and 7 in 10-12 ft size class, reflecting healthy population with a high number in the mid-size class. Muggers were mostly encountered from Magara Dabri to Judi in Madla (Fig. 6.1) and there are slight variations in the records across seasons (Fig. 6.2), with conflict in some sites like Baharpura and Madla. In a large pond in the Raipur Beat of Chandranagar, two additional adults were constantly seen in August 2017. Sightings of muggers were fewer at locations where the human disturbance was high (such as Daudhan village) due to fishing, farming, and water pumping by electric motors, etc. by local villagers.

A crocodile bite was reported in 2017 near Madla village, although such cases are extremely rare in the Ken River in PTR.

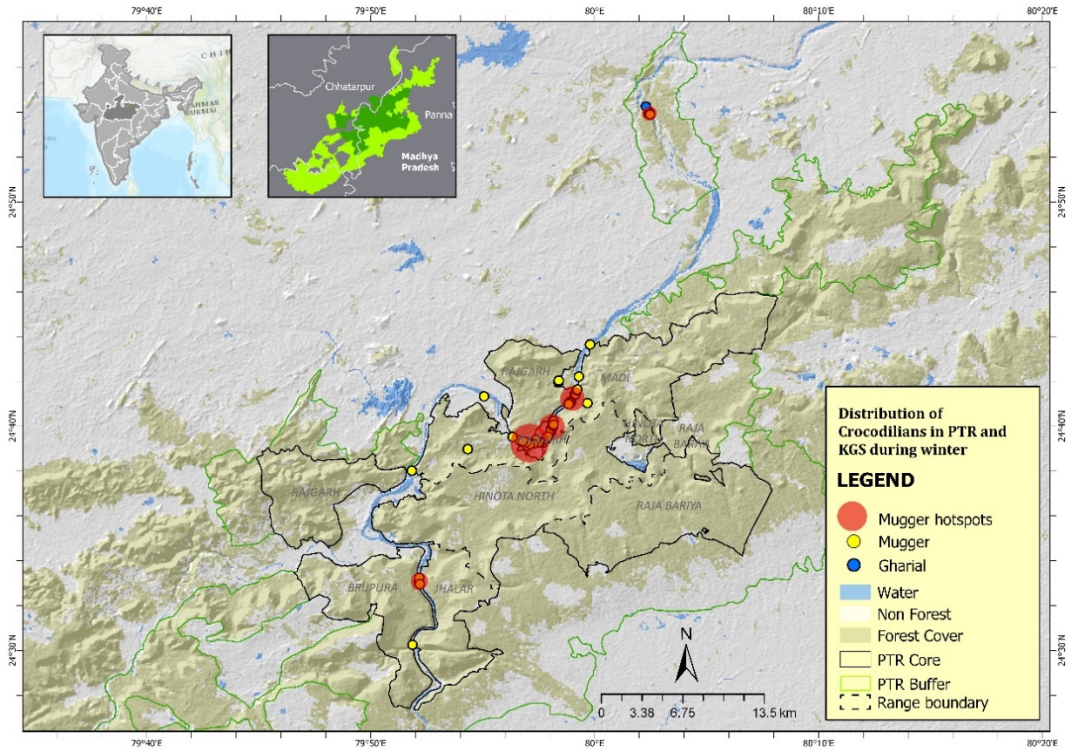


Figure 6.1. Map showing the distribution of crocodilians during winter

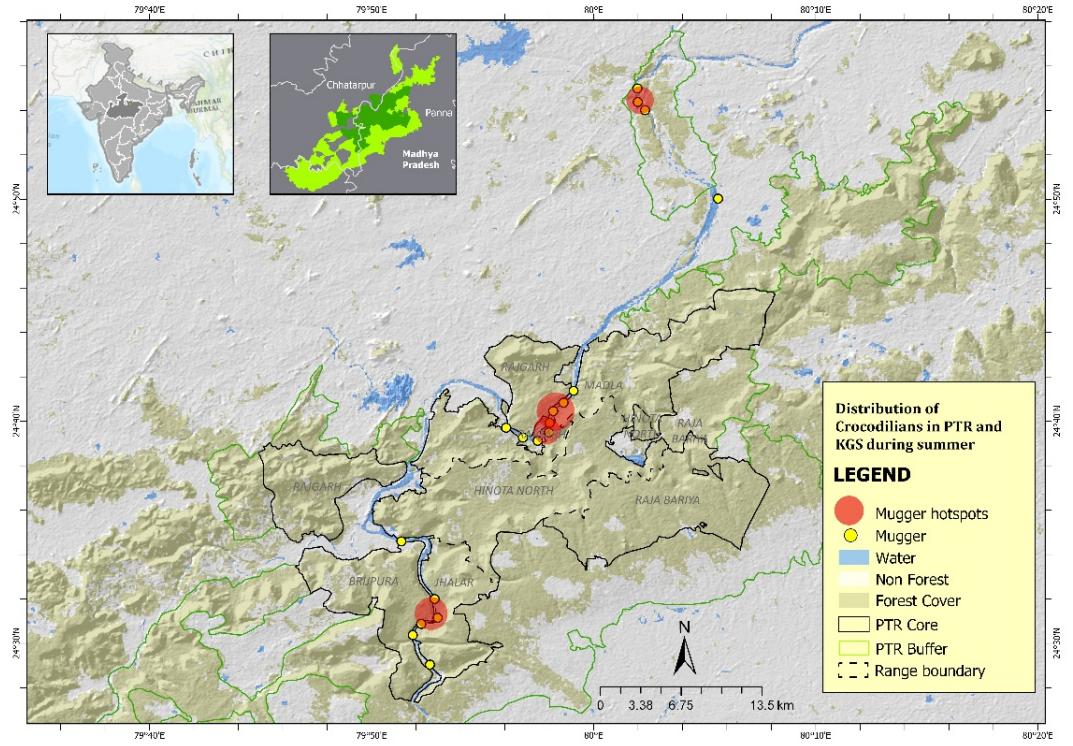


Figure 6.2. Map showing the distribution of crocodilians during summer

Gharials were never an abundant species in this part of the Ken River (Nair and Katdare, 2013). The populations recorded in the KGS have been of released individuals over years since 1983 (Table 6.1) and the population is still to be established (Sharma, 2000; Whitaker and Rajamani, 1976; Whitaker and Daniel, 1978). During the plan process, a large female individual of gharial was recorded from Muhare ghat in KGS and it was the lone individual reportedly seen regularly over the last decade (Das *et al.*, 2019). Therefore, even in the current situation, the population of gharial is highly precarious and requires concerted efforts to recover the species. So far, the efforts have been restricted to KGS, while there are suitable habitats available in PTR and therefore, the scope of conservation efforts for the species needs to be expanded to include the habitats available in PTR. However, because muggers are widespread in the PTR section of Ken River, recovery efforts require careful consideration of protecting hatchlings and young ones which may become prey to muggers. As stated above, both the species are sympatric and co-exist in many parts of their range, and so, this concern can be negated with careful release strategies and protection mechanisms. Therefore, an enhanced focus has been given to gharial in this plan.

Table 6.1: Release and count record of Gharial in Ken River
(Source: Official records of KGS, and Nair and Katdare, 2013)

S.No.	Date of Release	Number of Release	Gharial Count	Location
1	09-1983	08	-	KGS
2	03-1985	04	-	KGS
3	01-1987	10	-	KGS
4	1989	10	-	KGS
5	12-1993	15	-	KGS
6	09-1994	01	19	KGS
7	01-1995	15	-	KGS
8	11-1995	01	22	KGS
9	1996	15	-	Bhauradoh (PTR)
10	1998	18	-	Bhauradoh (PTR)
11	11-1999	20	15	KGS
12	03-2007	25	26	KGS
13	12-2019	25	1	KGS
Total number of releases in Ken River – 167				

6.1.3. Habitat Suitability: Gharial is a specialist species with certain habitat features such as sandy banks and considerable food supply (mostly of fish). Although gharials have been released regularly in KGS since 1983, no efforts have been made to understand the habitat availability, and neither there have been any systematic surveys prior to nor post the release of gharials. During the plan process, an extensive survey of the entire Ken River across PTR and KGS found that most of the banks of Ken River have rocky facets, but locations such as Suda, Magra Dabri, Saksuma, Surajpura, etc. have sandy banks with potential nesting site for muggers and gharials.

As a special focus on gharial, a rule-based model was developed to map suitable habitat for gharials and to identify potential sites for establishing artificial sandbanks and subsequently for release programmes. Elevation, slope, vegetation cover, water depth and river width were considered for model building. Based on the analyses, the entire stretch could be characterised for suitability with five classes with habitat area of 3.4 sq.km in very high suitability class, 9.4 sq.km in high suitability class, 10.0 sq.km in moderate suitability class, 6.4 sq. km in low suitability class and 0.4 sq. km in very low suitability class (Fig. 6.3). This is a promising result reflecting much higher potential than what is currently being visualised. Based on the results, it was possible to identify certain stretches in the core area of PTR that can be considered for habitat development and gharial release (Fig. 6.6). These stretches ranging from 4 to 10 km are without cascades or falls and hold potential for recovery efforts. However, these stretches need to be supported with the preparation of barricaded artificial sandbanks before releasing any gharials. Even though anthropogenic disturbance is absent in the core region, the released gharial tends to swim downstream or will get carried with the monsoon floods or may be affected by fishing and other anthropogenic effects. Other potential habitats upstream of Ken River inside PTR, which could have been developed as potential nesting sites, fall under the submergence zone of the proposed Daudhan Dam under the KBLP. However, there are habitats available further upstream of Gahrighat but conservation interventions here require concerted efforts towards habitat management and protection from anthropogenic disturbances. Water impoundments at Gangau Dam, Ranguwan Dam, Madla Causeway, and Bariarpur Weir have affected river flow and the proposed KBLP may further exacerbate the situation unless adequate environmental flow is ensured, keeping in view the flow requirements of gharials.

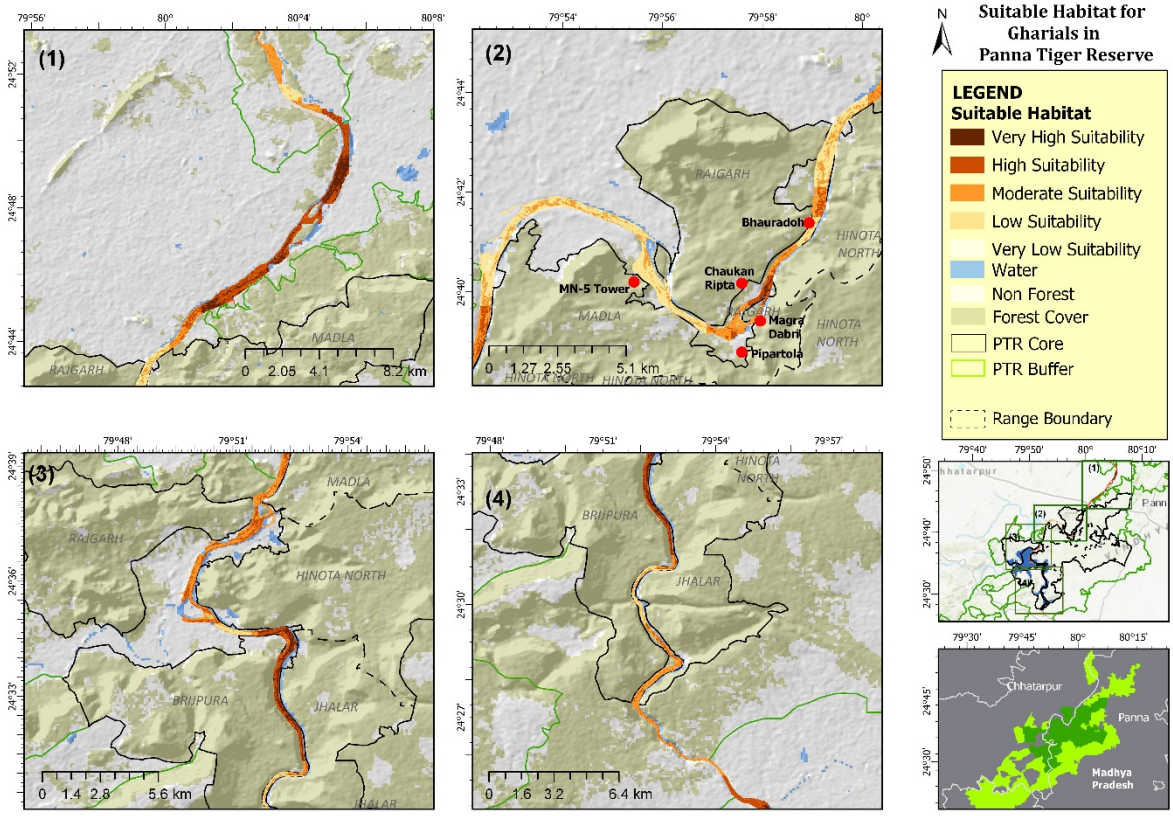


Figure 6.3. Map showing suitable habitat for Gharial in PTR (1 – KGS to Madla, 2 –Madla to Lalar, 3 – Lalar to Jhalar and 4 – Jhalar to up-stream of Gahrighat)

6.1.4. Population Viability Analysis of Gharial: Population Viability Analysis (PVA) was performed for predicting the probability of survival of gharial in the long term for the given release strategy in PTR. Eleven scenarios were considered, which tested multiple re-introductions, the significance of *ex-situ* hatchling of the nest and carrying capacity (K). After 100 iterations, it revealed that the current population requires supplementation, as well as, support from an *ex-situ* hatchling facility once a nesting population is formed in PTR. A single catastrophe was included which included flooding and strangling in fish nets with a frequency of 5% for 50 years (Rao *et al.*, 1995). The baseline scenario (Scenario 1) was generated with an estimated carrying capacity (K) of 50 individuals. Scenario 2 is with no support from re-introduction program and a hatchery. Scenario 3, 4 and 5 includes a regular re-introduction of 15, 25 and 40 juveniles respectively for 10 consecutive years, without support from an *ex-situ* hatchling facility. Scenario 6, 7 and 8 includes a similar re-introduction of 15, 25 and 40 juveniles every year, and with an *ex-situ* hatchery facility. Scenario 9, 10 and 11 considers a carrying capacity of 100 along with 25 reintroductions each year. Scenario 9 does not support with the *ex-situ* hatchery facility, while scenario 10 considers the development of the facility.

Scenario 11 also includes the *ex-situ* hatchery facility but assumes a decline in the percentage of adult females breeding every year.

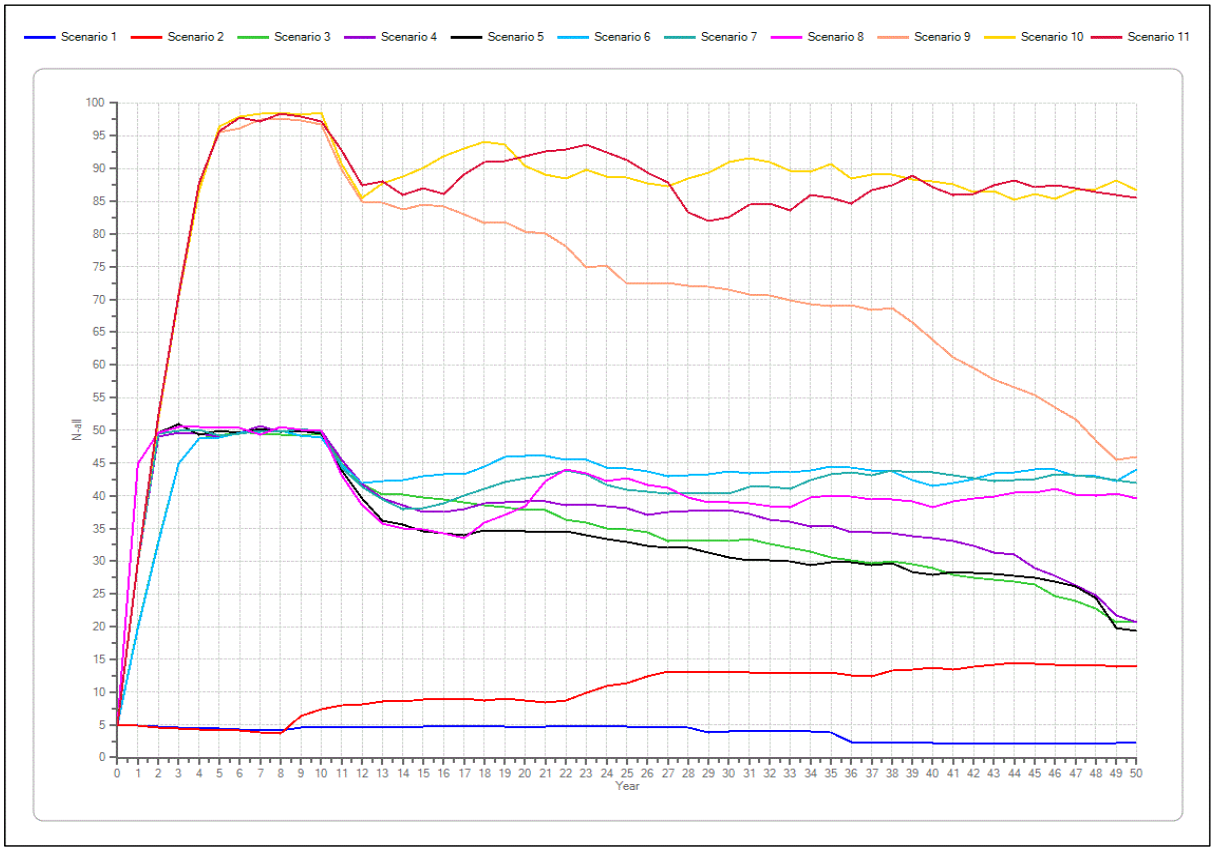


Figure 6.4. Population growth model from PVA of Gharials in PTR

6.2. Recommendations and Prescriptions

The implementation of the recommendations collated for the conservation of the crocodilians requires a rational approach involving stringent measures for enhancement of protection to the habitat, improvement of degraded habitats, research based on movement and population dynamics for both the crocodilians, along with a coordinated and adaptive recovery programme for Gharials. Implementation of strategies in a phase-wise manner will provide opportunities for constant adaptions and strategize further actions for habitat consolidation and population management. Surveys for population estimation, enhancement of protection, and recovery of degraded habitat needs immediate attention. Post-release monitoring for Gharials by deploying satellite telemetry techniques along with setting up of a rehabilitation centre for crocodiles in this phase will help provide effective strategies for the long-term recovery programme. Based on the results of the first phase, further coordinated recovery programme for Gharials, along with establishment of an *ex-situ* hatchery for Gharials can be implemented for recovery of the species in the Ken River.

6.2.1. Measures for Enhancement of Protection: The human encroachment and activities like dynamite and gill-net fishing, sand mining on an industrial scale, riverbank agriculture and livestock herding have left the non-protected sections of the Ken River very disturbed and hostile to permit gharial and crocodile populations to establish themselves. Policy or regulatory and protection interventions are required to safeguard the major and minor potential habitat for the crocodilians, especially for gharial recovery.

(i) Protection of Crocodile Priority and Restricted Zones: It is suggested to designate Crocodile Priority Zones in PTR including the stretch up to KGS and refrain or regulate anthropogenic activities in those areas. National Chambal Sanctuary (NCS) safeguards ~500 km of the river for gharials and it is one of the major reasons for the survival of these species in the sanctuary. It is notable that an adult female gharial requires an average of 10-12 km of river stretch for regular movement and it is even higher for males, which have been found to travel up to 200 km (Lang, 2015), a continuous stretch that the Ken River cannot provide due to natural non-availability of water along some sector of the river and its rugged terrain. Thus, any potential connecting stretches of the Ken River should be protected. Given the limitation, the stretch from Gangau Dam to Chaukan Rapta, with artificial breeding and release site upstream of Pipartola, needs to be declared as 'Crocodile Priority Zone' and protected accordingly. Additionally, the stretch from Madla to Bariarpur Weir needs to be declared as

'Crocodile Restricted Zone' wherein protection and habitat management interventions should be taken up in coordination with other stakeholders including local communities and tourism industries. Regulation of solid and industrial waste disposal into rivers and mining of gravel/ sand from the proposed 'Crocodile Restricted Zone' along with regular patrolling and monitoring of the populations and interface issues.

(ii) Enforcement of Ban or Strategic Regulation on Fishing: Discarded fishing nets and the use of dynamites for fishing have major impacts on fish populations leading to mortality of crocodiles (Nair and Katdare, 2013). Fishing is also one of the livelihood activities for the local communities. Therefore, strict enforcement of the ban on fishing in Protected Areas should continue, and the community-based regulatory mechanism along with alternate livelihood options, should be established for fishing in the Restricted Zone and other stretch of Ken River from Madla to Bariarpur Weir. Some of the aspects on fisheries management as specified in the Environment Management Plan may be considered on a case by case basis to augment fish population in the river.

(iii) Enforcement of Ban or Strategic Regulation on Sand/Boulder Mining: Sandbanks and sandbars are the main requirement of Gharials. Even though sand mining is a major issue even in NCS, the influx of sand is extremely high in the Chambal River which reduces the effects on the species and has managed to support the population of gharials. In contrast, Ken River has very small stretches of river with optimal sandbanks/ sandbars, and major extents of these are outside the PA. Sand mining in these areas is affecting the movement of gharials, specifically in downstream of KGS. Therefore, it is important to work with the District Administration and concerned stakeholders to restrict sand mining in strategic stretches so that gharials can have options to escape from floods and can establish breeding populations in the downstream of the release sites. It will also enable supporting long-term viability of gharials in PTR and KGS.

(iv) Protection and Co-Management of River Habitats: Riparian forests along the river provide shade and hiding cover for crocodile, especially summer months. It also provides bank stability and prevents siltation in the river. Soil erosion (due to cattle grazing and loss of vegetative cover), agricultural interventions, and other anthropogenic activities affect a significant stretch of the Ken River outside the Protected Area limit. Even in the Protected Areas, bank erosion and loss of bank vegetation are found, perhaps due to occasional floods. Thus, maintaining a riparian buffer along the rivers to improve the river habitat and minimise/

prevent serious anthropogenic activities. In addition to conservation management of tigers and other biodiversity components, River Conservation Zone will ensure a better habitat for Crocodiles by improving the microhabitats along the river. Hence it is recommended to establish one-km River Conservation Zone representing 500m buffer width on both banks that comprises three parallel zones of 0-25m (Protected core zone, 25m wide), >25-250m (Integrated Farming and Social Forestry Zone, 225m wide), and >250-500m (Status Quo Zone, 250m wide) on each bank of the river (Fig. 6.5). RVI map (Fig. 7.6) provides a basis for developing the protected core zone. The zone outside the PA could be designated as a Community Reserve or Co-management Zone involving all concerned stakeholders including tourism industries especially in the stretch from Madla to KGS. Based on further consultations during the implementation phase, even these stretches could be prioritised, but the implementation of this zonal strategy is important to ensure a viable population of the crocodiles in Ken River.

(v) Deployment of Unmanned Aerial System for Security-based Monitoring: The rugged escarpments of the Ken River make it difficult for proper foot patrolling. During the monsoon, many areas remain inaccessible due to flooding. Therefore, it is recommended to utilise a Special Purpose Unit with a sophisticated Un-manned Aerial System (UAS) to monitor river stretches to ensure protection for crocodiles from anthropogenic and illegal activities.

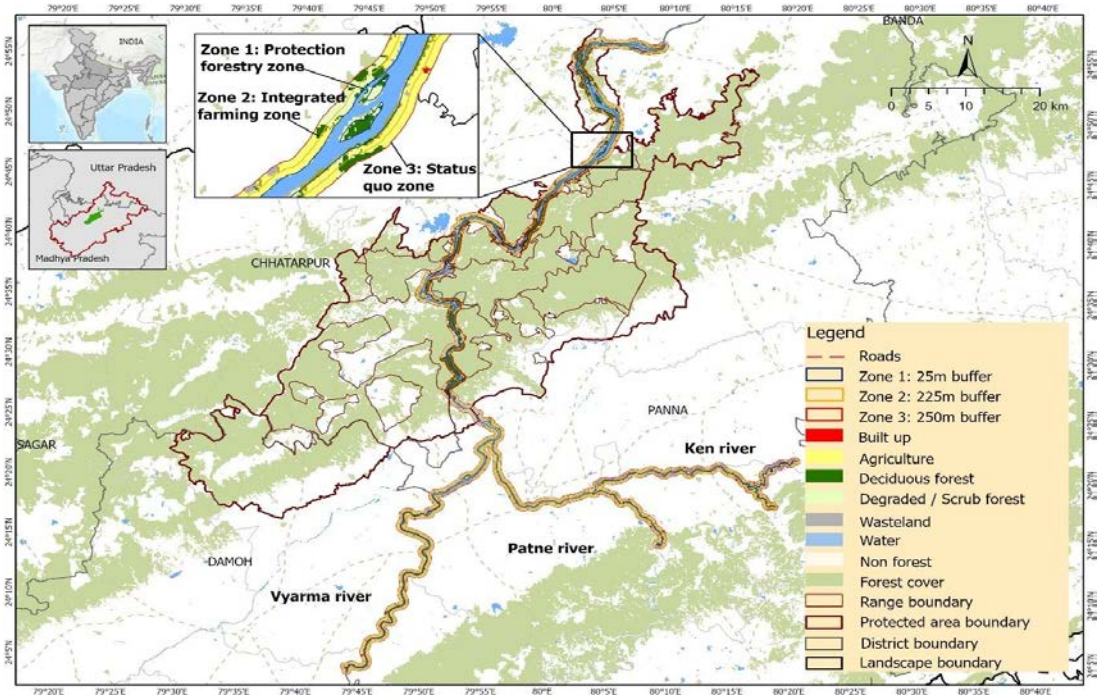


Figure 6.5. Proposed River Conservation Zone/Community Reserve

6.2.2. Measures for Population Management: Of the two Crocodilian species found in this landscape, the gharial population is precariously low and even the release efforts have not yielded desired results (Nair and Katdare, 2013; Sharma *et al.*, 1999). On the other hand, the mugger population is widespread and is also involved in human-wildlife conflicts. Therefore, both these species require entirely two different strategies such that gharials require recovery efforts, while mugger population requires stability and population control to some extent to avert conflict situations in current and future contexts. However, population management requires a clear understanding of the population size, trend, demographic characteristics, etc., but these are not often available due to the absence of long-term planning and implementation. Therefore, the following measures are proposed to support the adaptive management of crocodiles.

(i) Population Estimation and Monitoring: Current information on population size and trend of crocodiles are from foot-survey, aerial surveys, and records by the forest department. However, its robustness still needs to be improved and only an aerial survey can provide accurate information on size class monitoring. During the plan process, the sampling protocol has been established and this needs to be intensified with multiple temporal replicates both by foot survey and aerial survey so that location-specific, as well as river scale monitoring, can be ensured. Based on the initial repeat survey, appropriate sample size can be worked for a more precise and accurate estimate of crocodiles.

(ii) Demographic and Genetic Management: The maintenance of an appropriate sex ratio is necessary for a viable population to sustain and maintain demographic and genetic variability. Currently, muggers in the PTR stretch of Ken River do not need extra efforts for demographic management, as it appears to represent optimum population structure, but needs to be monitored and if it becomes a problem animal, population control efforts must be made during nesting stage. Gharials in KGS have a non-breeding population without any meta-population influx and are supported by translocation from the Chambal River. Therefore, the population management for Gharial would continue to be in the form of translocation and release strategy until the population becomes viable within PTR and KGS.

(iii) Coordinated Gharial Recovery Program: The part of Ken River which flows through KGS has mostly rocky facets. The sandy banks and deep creeks which are essential for the nesting of gharials are inadequate and are not connected due to geography and man-made barriers and disturbances, so the individuals that move downriver in the monsoonal flood do not possibly return to the relatively protected confines of the KGS. Based on these

observations, the survival of a population of gharial seems difficult and any future reintroduction plan of gharial must be critically assessed, considering all these aspects. Despite the release of about 167 gharials in the area since 1983 (Table 6.1), there is no evidence to suggest that this effort has helped sustain a breeding population here.

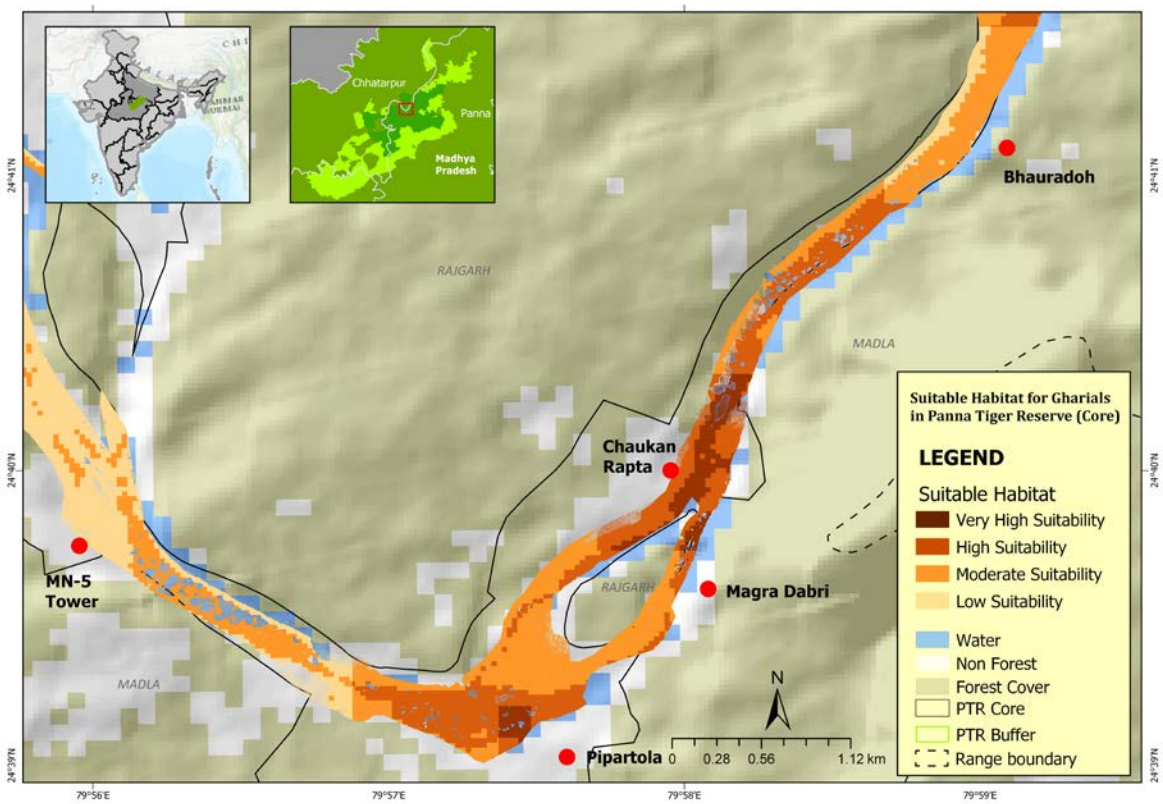


Figure 6.6. Map showing habitat suitability for preparation of artificial sandbanks and release program for Gharial in PTR

Therefore, we recommend a Coordinated Gharial Recovery Programme involving both PTR and KGS. We suggest Magra Dabri in PTR to be considered as a soft release site. Along with that, growing gharials could be released along the stretch from Kanheri (MN5) tower up to Pipartola and from Chaukan Rapta up to Bhauradoh (Fig. 6.6). This area of the river has 0.18 sq. km of very high suitability class, 0.79 sq. km of high suitability class and 1.15 sq. km of moderate suitability class. KGS has a carrying capacity for 10-15 breeding females, so planning a continuous release of moderate number of individuals in each batch to maintain the retention of population is required (as recommended by Sharma *et al.*, 1999). Based on PVA, it is necessary to supplement the current population with about 15 juvenile gharials (age class of 2.5-3 years) with a female to male ratio of 4:1 for the next 10 years to ensure viable population. Also, an *ex-situ* hatchery facility will be necessary to reduce the high mortality rate of hatchlings when a breeding population is established in PTR. Reintroduction protocol must be

prepared and implemented covering all aspects of capture, handling, size, sex, release site, time, and season. Post-release monitoring is required along with the re-introduction under the movement ecology and population dynamics framework as a part of the recovery program. A separate DPR needs to be prepared to implement this coordinated Gharial Recovery Program, considering different scenarios developed based on PVA.

(iv) Crocodile Rehabilitation Centre: It is proposed that a Crocodile Rehabilitation Centre (CRC) should be established at KGS with trained staff to handle, monitor, and control conflict issues. The centre should have good rescue equipment, rehabilitation tanks etc. Clinical facilities should also be established, and veterinary staff deployed to monitor regular health status and basic treatment. CRC will serve as temporary holding facility for rescued Crocodiles (stranded or involved in conflict) and the Gharials brought for release, based on age and health condition. Only grown-up juveniles should be released to decrease mortality rates. The CRC can act as a reservoir population for a coordinated release programme in the surrounding rivers. The centre should (a) Train and capacitate staff on animal welfare and management techniques to ensure quality handling of animals and management of the centre, (b) Handle monitoring of the released individuals, (c) Management of artificial sandbanks in PTR and KGS, (d) Prepare and follow management guidelines for ex-situ conservation and maintain the minimum stock in the holding facility and (e) Attempt soft release of certain hatchling soon after hatching on an experimental basis and encourage release after monsoon.

6.2.3. Measures for Habitat Management:

Distribution and population growth of crocodiles relate to water quality in terms of flow and pollutants, prey population availability and breeding ground such as sandy banks. Therefore, the following measures are proposed to address these key habitat characteristics.

(i) Management of Environment Flow: There is tremendous pressure on gharial habitats both from natural forces and anthropogenic factors leading to alteration or degradation of habitat. Nothing can be done to prevent natural process such as yearly flooding of Ken River during monsoon, but major management interventions should be undertaken to reduce anthropogenic pressure in gharial habitats so that enough sandbanks for nesting and basking are protected in the confinements of KGS and PTR. The breeding season of gharials coincides with the dry-season period of the Ken River. Unseasonal and lower release of water from dams disrupts the seasonal breeding cycles (Nair and Katdare, 2013). If prescribed amounts of natural flow of the rivers are maintained even while construction of mega dams, it will ease upstream and

downstream movement of aquatic fauna. An average minimum flow required for Gharials in the Chambal River is 164.34m^3/sec (Hussain *et al.*, 2011). The environmental flow in the Ken River is naturally very low than the above. In any case, the NWDA accepted average monthly environmental flow for the lean season (February- May), non-monsoon and non-lean season (October- January), and for the monsoon season (June- September) as mentioned in table 6.2. as per MOEF&CC terms to address habitat requirement of other aquatic fauna should be maintained (NWDA, 2015), and an automated monitoring equipment with alert system should be deployed, as it is closely related to conservation of aquatic species and more specifically for the recovery of gharials. Monitoring of water quality is an important consideration for habitat management and thus, need to establish automated monitoring stations in representative river stretches across the Ken River. For continuous monitoring of water quality and flow, two monitoring stations will be required, one in PTR and other in KGS.

Table 6.2: Mean monthly average present flow available in Ken River and NWDA agreed environmental flow below Daudhan Reservoir (NWDA, 2015)

Sl. No.	Month Proposed	Present natural discharge (Monthly average in MCM) as per EIA, 2015	Proposed Environmental Flows for Daudhan reservoir (Monthly average in MCM) suggested within EMP, 2015	Proposed Environmental Flows for Daudhan reservoir (Monthly average in MCM) committed by NWDA
1	January	32.69	7.70	7.70
2	February	1.89	7.70	7.70
3	March	1.89	7.70	7.70
4	April	1.89	7.70	7.70
5	May	1.89	7.70	7.70
6	June	32.69	26.44	17.63
7	July	331.52	123.60	123.60
8	August	331.52	257.49	257.49
9	September	320.83	65.15	36.17
10	October	32.69	4.81	4.81
11	November	32.69	7.70	7.70
12	December	32.69	7.70	7.70

(ii) Prey Population Management: Fish is the major prey species for mugger and gharial, although water birds and small mammals are consumed, more by mugger. Water quality, bank vegetation characteristic and nature of fishing determine the population growth of prey species including the water birds. Pollution from solid and industrial wastes and agricultural runoff affect the water quality of Ken River. In order to understand the fish stock in Ken River, it is proposed to regularly estimate fish diversity and population, and plan augmentation of native

fish species through fishery practices, for which, a suitable establishment must be created either in KGS and PTR, with the support of the Department of Water Resources, Department of Fisheries and Forest Department.

(iii) Artificial Sandbanks: Artificial sandbanks and sandbars should be created and managed for Gharial basking and to provide refuge against natural and anthropogenic induced impacts by enhancing the microhabitats available to the crocodiles. Flood conditions should be considered during the preparation of sandbanks to provide efficient basking and nesting sites throughout the season. This also involves the removal of certain problematic vegetation to create accessible nesting and basking sites for Gharials in the area (Vashistha *et al*., 2021). Degraded sites between Kanheri (MN5) tower and Bhauradoh should be considered for preparation of sandbanks/ sandbars, along with sand addition (Fig. 6.6).

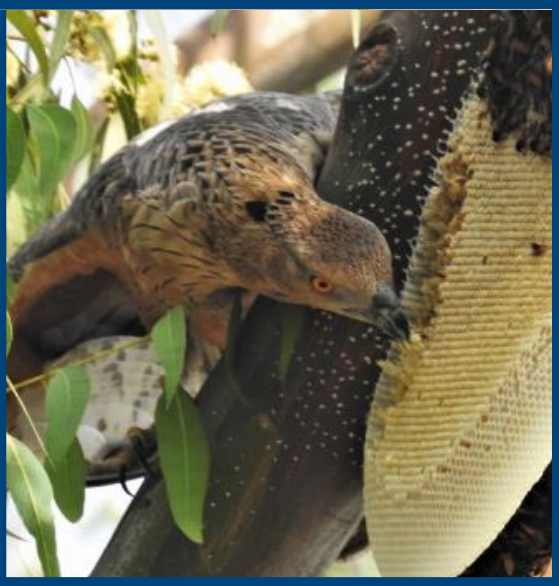
6.2.4. Community Engagement: Involvement of local people is very much required for dealing with human-crocodile conflict management and to enhance conservation opportunities for gharial. River-dependent communities can be involved in monitoring crocodiles (more so for gharial), their nests/eggs and habitat. Gathering the support of river-dependent communities for crocodile conservation may also benefit them by providing livelihood options in form of joint monitoring, river patrolling, tourist guide, and habitat conservation activities.

It is recommended to design and conduct intensive outreach programmes for school children, eco-clubs, and river-dependent communities. Documentary films on crocodile conservation may reach a wider audience emphasising the critical situation of these species as indicators of a healthy river system. Conducting regular workshops and meetings on crocodile conservation issues to sensitise relevant stakeholders such as Buffer Zone Institutions, District Coordination Committee (DCC), municipalities, industries, hoteliers, and developmental projects, are necessary.

6.3. Synthesis and Conclusions: Crocodiles are keystone species for the aquatic ecosystem and are an important group of species for maintaining the ecological health of the ecosystem. The presence of the critically endangered gharial in the PA signifies enhanced conservation focus and support for the overall species recovery. The proposed measures consider the protection of the habitat, species recovery programme, and population management along with adaptive management strategies. It also provides opportunities to manage community-based ecotourism and strategise for long-term conservation of the crocodilians.













CHAPTER 7

BIODIVERSITY STATUS AND PRESCRIPTIONS

Chapter 7: Biodiversity Status and Prescriptions

7.1. Situation Analyses

7.1.1. Introduction: Biodiversity conservation in the 21st century is a challenge owing to the domination of human beings and ever shrinking space for the natural world. The establishment of Protected Areas (PAs) has become a standard practice for safeguarding biodiversity during the past century (Lovejoy, 2006). Most of the PAs are designed for conservation of some specific threatened species or species at risk of extinction. Some promote flagship species which garners public attention and support that can then be used to protect their ecosystems. Protection of communities or habitats also can be achieved by conserving umbrella species, whose habitat requirements and range also encompasses the requirements of other conservation targets. The perfect example of such species is tiger, the pursuit for conservation of which, lead to the formation of tiger reserves in India. Although in the recent years, the PAs have evolved from creation of designated areas for refuge to species to protection of entire ecosystem and inhabiting biodiversity. According to Lambeck (1997), multiple species are likely to serve as better "umbrellas" than individual taxa. The concept of multispecies conservation or biodiversity have recognised the ecological role of each species in maintaining the viability of trophic structure and functionality of a particular ecosystem. Also, a multispecies conservation approach promotes integrated management of multi-habitats utilised by different taxa including flora and fauna. In the context of GPL, the conservation agenda is driven by tiger but increasingly other species such as vultures and gharials are highlighted as important surrogates. However, there are many other taxa that represent the landscape with varying distribution and abundance based on the habitat availability and anthropogenic effects. This section summarises biodiversity and related components in PTR and the landscape area based on direct and surrogate methods and provide options for conservation of these elements to be considered under the integrated landscape framework.

7.1.2. Land Use and Vegetation Types in Panna Tiger Reserve: PTR is dominated by dense mixed forest (407.41 sq.km) and open mixed forest (405.58 sq.km) (Fig. 7.1). Being savanna type landscape, open land (310.83 sq.km) and grassland (299.99 sq.km) covers substantial area. Scrub land (132.13 sq.km) is also widely found around village areas. Because the villages are interspersed within the forest system, Agriculture land (48.84 sq.km) represents considerable portion of the PTR. Water distribution (9.45 sq.km) is mostly in the Ken River, reservoir, and smaller tanks around the area. This land use description is based on remote sensing satellite

data with 90% accuracy (Kappa: 0.89). Dense forest represents forest with crown coverage of over 60%. Open forest represents with crown coverage of 40% to 60%. In terms of vegetation types, the land cover includes eight types (teak forest, teak-mixed forest, mixed forest, bamboo-mixed forest, kardhai (*Annogessius pendula*) forest, riverine forest, scrub forest and grassland) (Fig. 7.2). There are also trees outside forest type, which are scattered across the area.

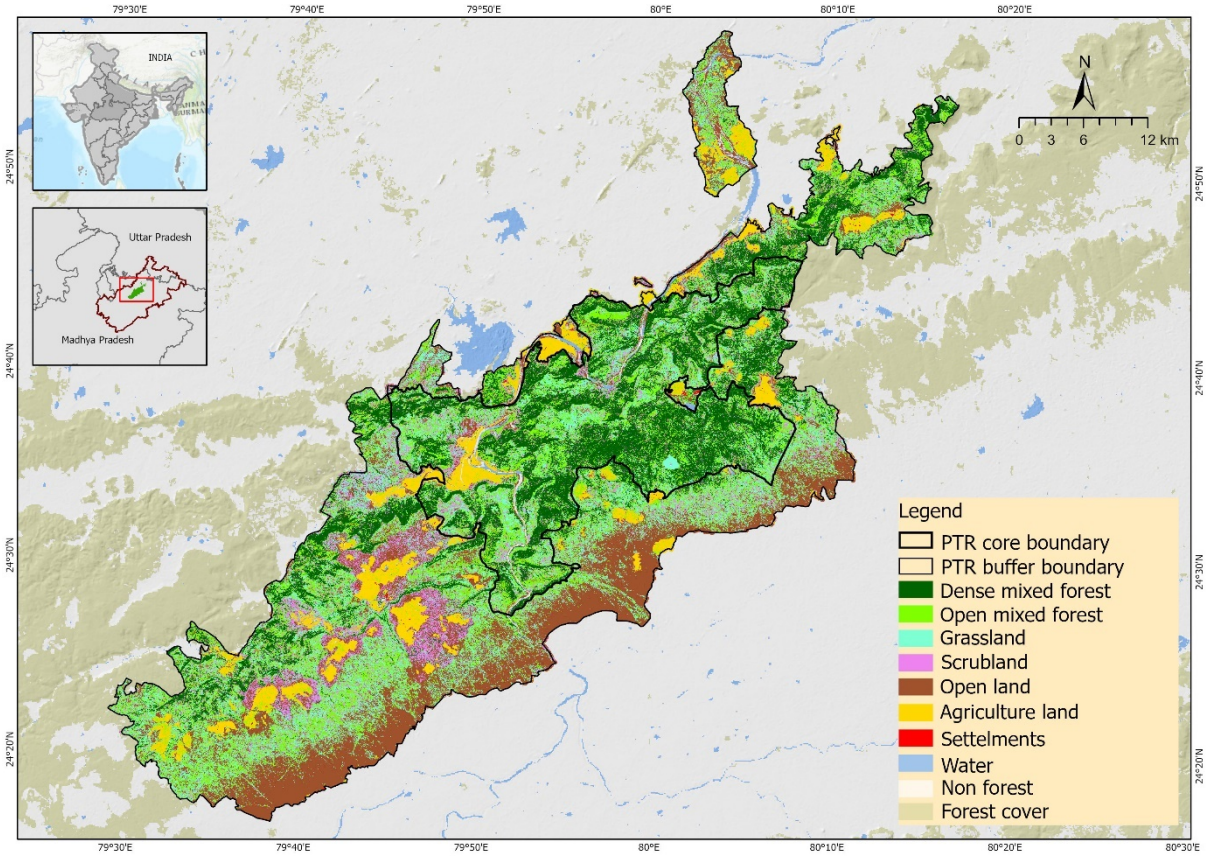


Figure 7.1. Map showing Land Use Land Cover Classes of Panna Tiger Reserve

7.1.3. Vegetation Diversity and Abundance in Panna Tiger Reserve: PTR represents a diverse forest ecosystem composed of a variety of life forms and as per the estimate during the plan process, it includes 96 tree species from 38 families, 33 shrub species from 19 families, 144 herb species from 42 families, 67 grass species from 1 family, 8 sedge species from 1 family and 15 climber species from 8 families, accounting for 363 species belonging to 109 families. Spatial patterns of the species richness of all these life forms reflect higher gradient in the protected core habitats, while buffer habitats or the areas with proximity to villages are poorly represented (Fig. 7.3). The poorly represented areas have potential for species recovery, with appropriate management interventions. Abundance distribution of these life varied highly from buffer areas to core areas being 282.40 (± 9.60) to 503.30 (± 14.90) individuals per hectare for tree species, 604.80 (± 33.90) to 686.50 (± 35.30) for sapling, 1949.50 (± 80.10) to 2103.90

(± 114.80) for seedling, 1940.40 (± 79.90) to 2095 (± 91.50) for shrub species and 7 lakhs to 8.6 lakhs for herb species**.** Girth class of tree species was poor in the 11 to 29 cm category, reflecting that the regeneration at sapling stage is less, in the areas used by local communities for fuelwood or fodder purposes.

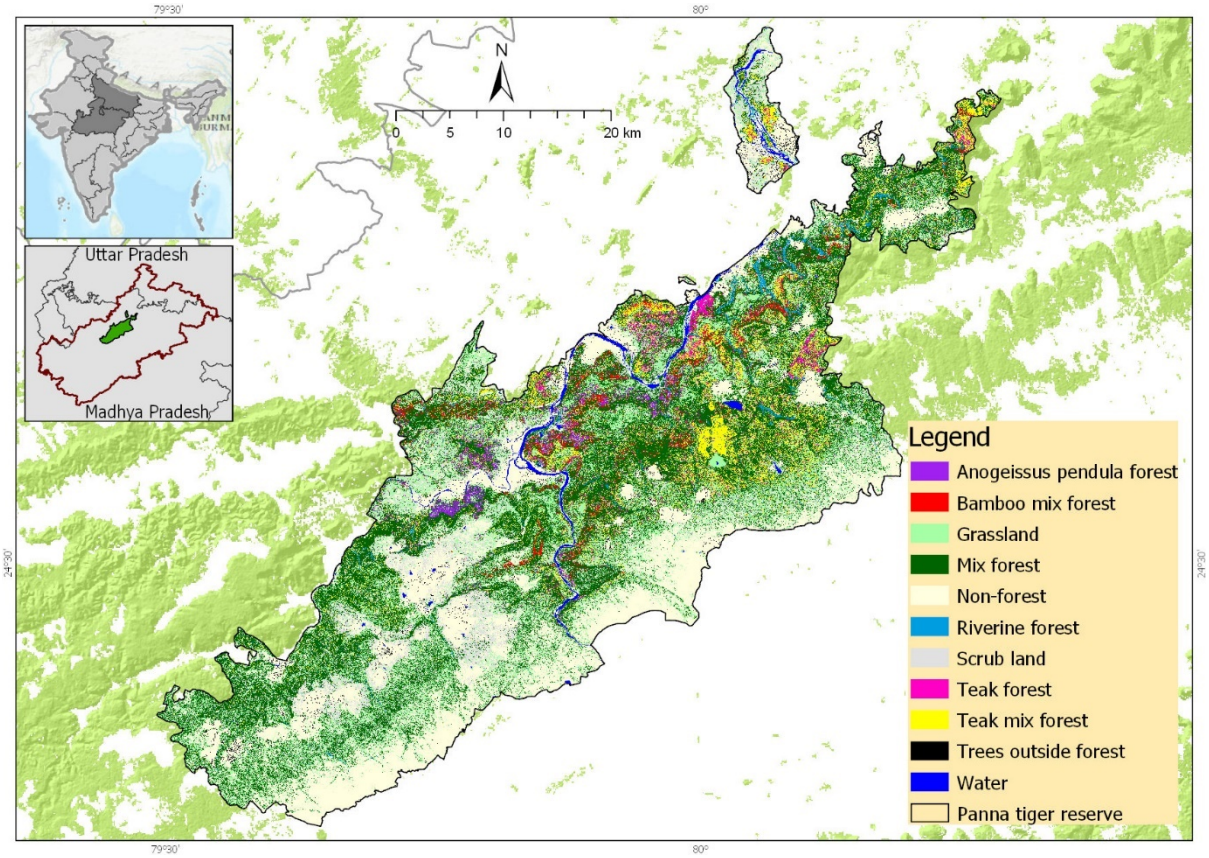


Figure 7.2. Map showing Forest Type Classes of Panna Tiger Reserve

Regeneration is mostly confined to *Diospyros melanoxylon* (Tendu), *Holarrhena pubescens* (Doodhia), *Lagerstroemia parviflora* (Seja), *Cassia fistula* (Amaltas), *Ziziphus xylopyrus* (Ghont), *Flacourtia indica* (Kankher), *Butea monosperma* (Palash) etc. Absence of regeneration was observed in many species such as *Sterculia urens (*Kulu*), Albizia excelsa* (Mahrukh), *Dalbergia lanceolaria* (Dhamasi), *Gmelina arborea* (Gamari) etc. In both core and buffer areas, sapling and seedling species composition is dominated by *Tectona grandis, Diospyros melanoxylon, Ziziphus xylopyrus, Aegle marmelos, Holarrhena pubescens* and *Lagerstroemia parviflora*. PTR also has areas that have been vacated by villages as a part of land-sparing conservation strategy and there are 14 such villages. According to Dabadghao and Shankarnarayan (1973), the grasslands of Panna come under Sehima - Dichanthium grasslands which are spread over the Deccan plateau, Chota Nagpur plateau and Aravallis, with an elevation range of 300-1200 m above mean sea level. During this study, a total of 159 species

belonging to 59 families were recorded in 14 relocated villages of PTR. Total number of tree species ranges from highest (n=6) in Motachaukan and Gangau to lowest (n=0) in Talgaon; shrubs species ranges from highest (n=6) in Motachaukan to lowest (n=1) in Raipura, Surajpura, and Badgadi; herbs species ranges from highest (n=35) in Bardodh to lowest (n=19) in Sakra, while grass species ranges from highest (n=26) in Kaneri to lowest (n=8) in Gangau. These species distribution patterns in both the natural areas as well as vacated village areas provide an important baseline for habitat management across PTR.

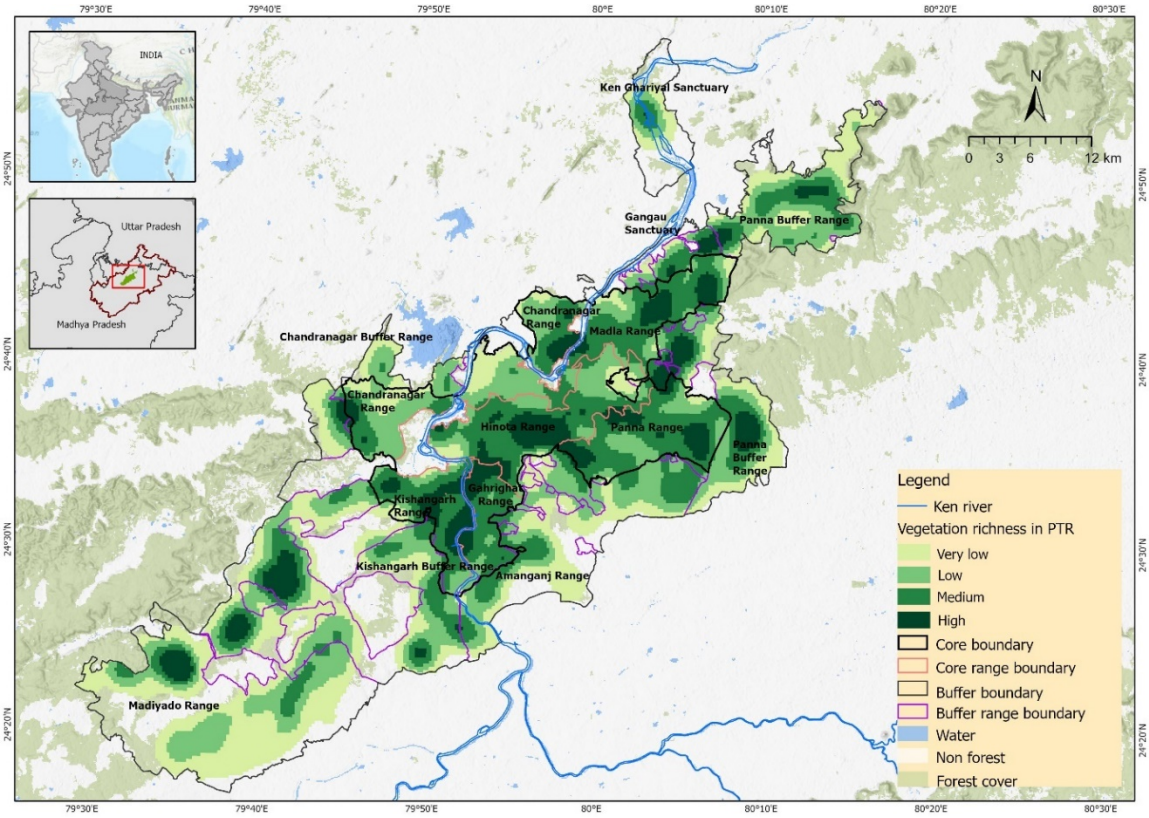


Figure 7.3. Spatial pattern of vegetation richness in Panna Tiger Reserve

7.1.4. Mammalian Diversity and Abundance in Panna Tiger Reserve: A total of 30 mammal species were recorded in PTR, represented by 18 carnivores, 7 herbivores, 2 primates and 3 rodents. While all of these were found in core, 28 species were recorded in buffer (17 carnivores, 7 herbivores, 2 primates and 2 rodents). Further, the density of mammals in buffer was found to be low which can be attributed to less protection and higher anthropogenic disturbance (Fig. 7.4, 7.5). Indian pangolin and Madras tree shrew have been placed in carnivore group due to feeding habit and management imlications. Among the carnivores, hyena had the highest capture rate in both core and buffer, followed by jackal (*Canis aureus*),

leopard (*Panthera pardus*), jungle cat (*Felis chaus*), small Indian civet (*Viverricula indica*) and tiger (*Panthera tigris*). Indian fox (*Vulpes bengalensis*), dhole (*Cuon alpinus*), sloth bear (*Melursus ursinus*) and Indian wolf (*Canis lupus pallipes*) had comparatively lower capture rates. Rusty spotted cat (*Felis rubiginosa*), gray mongoose (*Herpestes edwardsii*), ruddy mongoose (*Herpestes smithii*), honey badger (*Mellivora capensis*) and Indian pangolin had the lowest capture rates**.** However, wolf and Asiatic wild cat (*Felis lybica*) were photo captured more in Panna buffer. Among herbivores, all major prey species of tiger (sambar, nilgai and chital) had the highest capture rate in core, while the same pattern exists in buffer as well except for chital which has a low capture rate, instead wild pig was captured more frequently. Interestingly, chinkara and rhesus macaque had lower capture rates in buffer.

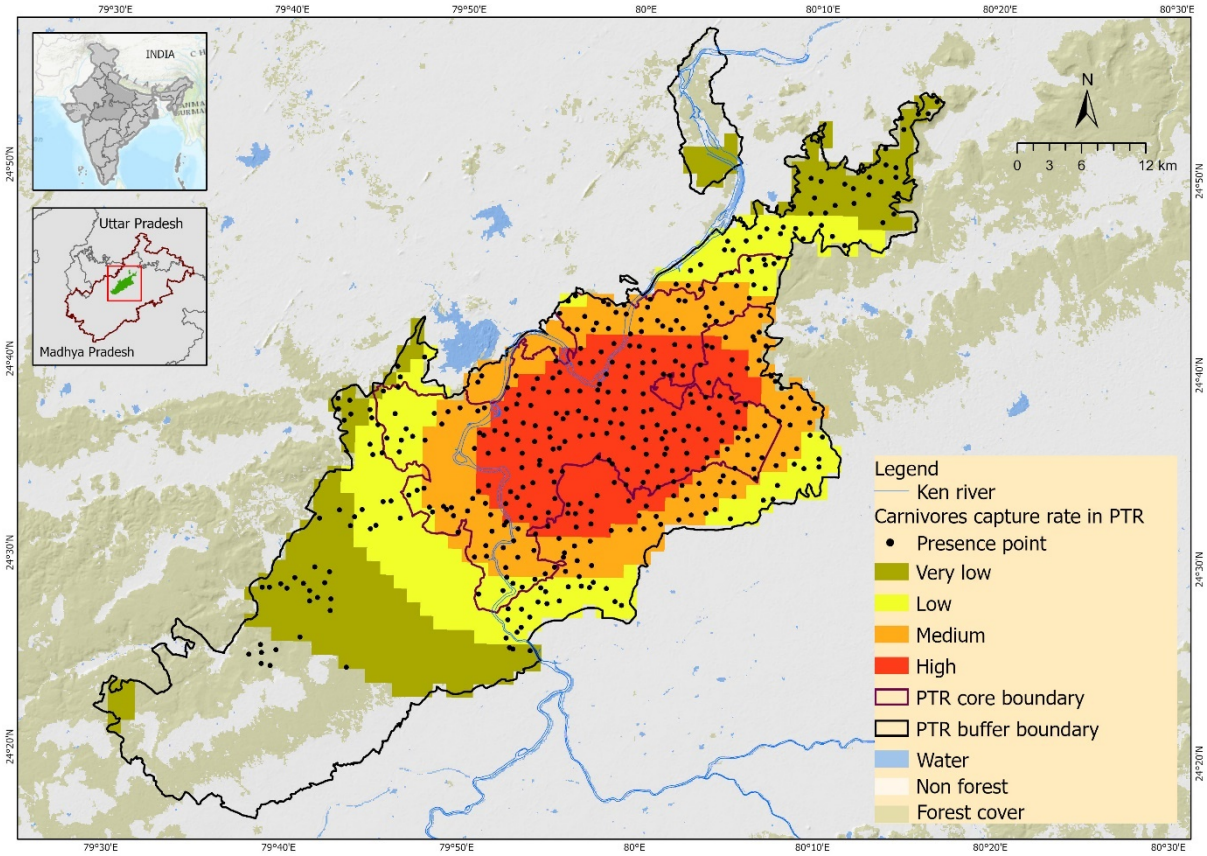


Figure 7.4. Map showing carnivore species photo-capture rate in PTR

Although, there is low population of herbivores and other carnivores in the buffer, it supports a sizable population of sloth bear. Like vegetation parameters, the assessment in vacated village sites lead to a record of a total of 22 mammalian species (12 carnivore, 9 herbivore and 1 rodent). In all these villages, jackal had the highest capture rate followed by small Indian civet, jungle cat and sloth bear, while wild dog and honey badger had the lowest capture rate. Dhole (wild dog) was recorded only in Badgadi and Indian fox in Raipura, while grey mongoose in

Badgadi and Khamariya. Kheriya had the highest capture rate of tiger, followed by Gangau and Bardodh. Bhadar and Gangau had the highest capture rate of leopard, followed by Pipartola and Motachaukan. Hyena had the high capture rate in Jhalar and Kaneri, and sloth bear in Kaneri, Bardodh and Motachaukan. Among the herbivores, chital had the highest capture rate followed by wild pig, nilgai, and sambar. Chausingha and chinkara had the lowest capture rates, reflecting effects of habitat change. Chausingha was recorded in Badgadi, Kaneri and Talgaon. Kaneri had the highest capture rate of chinkara, grey langur and rhesus macaque. Gangau had the highest capture rate of nilgai and sambar. Chital was captured the highest in Badgadi. Indian crested porcupine had the highest capture in Gangau followed by Bhadar and Raipura. Livestock was recorded in eight out of the 14 of these villages. Kaneri had the highest capture rate followed by Jhalar, but these were feral cattle, abandoned by the villagers.

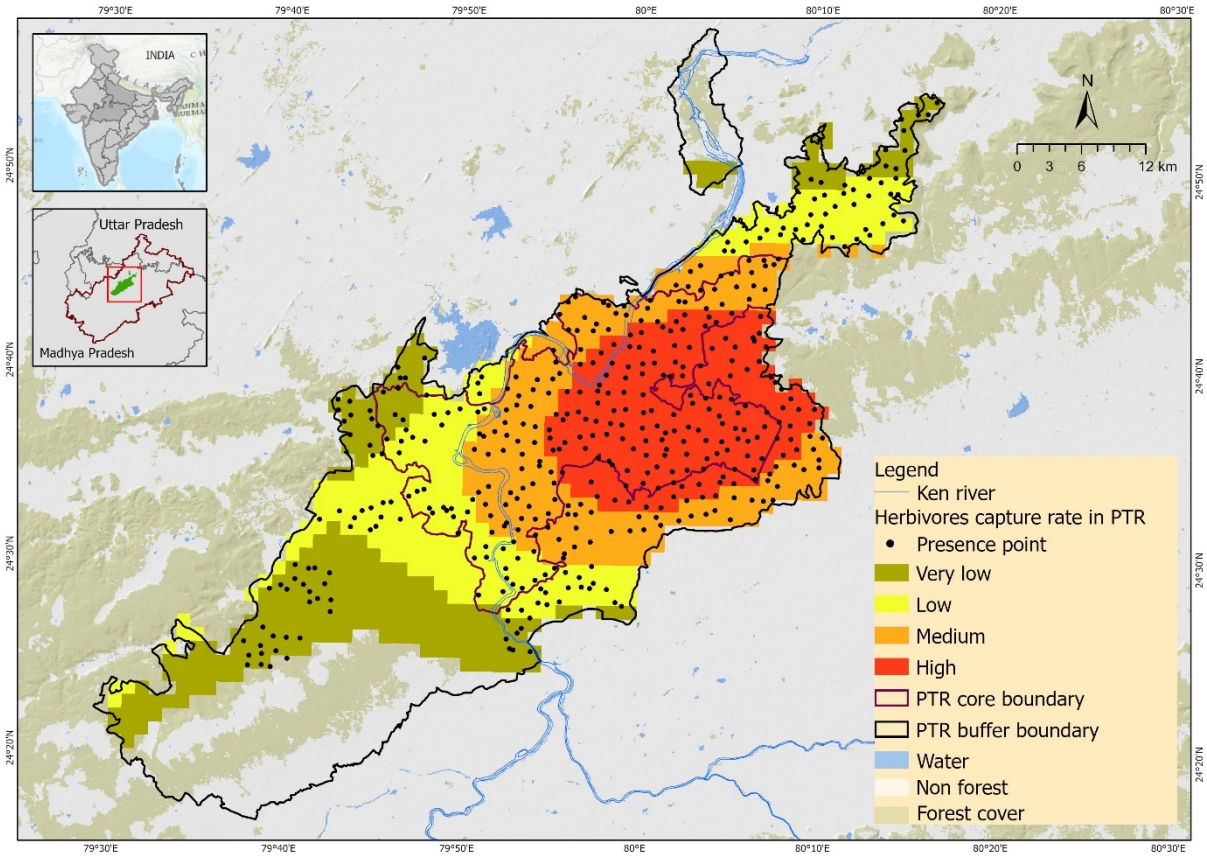


Figure 7.5. Map showing herbivore species photo-capture rate in PTR

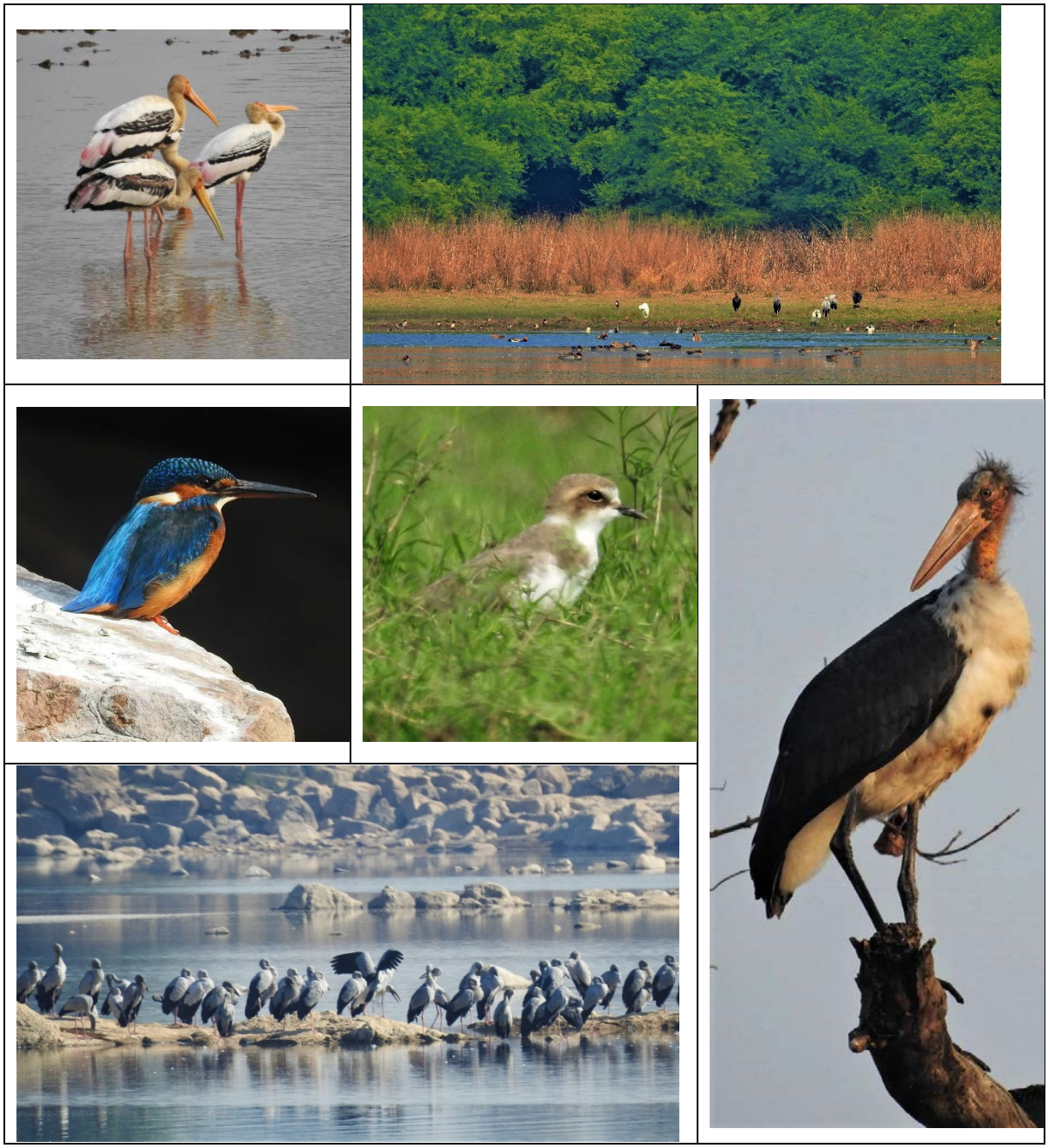
7.1.5. Avian Diversity and Abundance in Panna Tiger Reserve: PTR is one of the Important Bird Area (IBA) for conservation of birds (Rahmani *et al.*, 2016). This is not only due to presence of many vulture species that breed in this region, but also because it falls in the Central Asian Flyway (CAF) for migratory birds. Bird species survey (both systematic sampling and opportunistic observation) in PTR accounted for migratory status, feeding guilds and

endemicity of all bird species and were drawn from the state of India's Birds Report (2020). A comprehensive checklist of the total species (206) was prepared following IUCN red list (2021).

Plate 7.1: Photos of grassland birds recorded in PTR (Left to right: Jungle bush quail *(Perdicula asiatica*), sirkeer malkoha (*Taccocua leschenaultii*), painted francolin (*Francolinus pictus*), scaly-breasted munia (*Lonchura punctulata*), chestnut munia (*Lonchura atricapilla*), crested bunting (*Emberiza lathami*), zitting cisticola (*Cisticola juncidis*), crested lark (*Galerida cristata*), desert wheatear (*Oenanthe deserti*))



Plate 7.2: Photos of water birds recorded in PTR (Left to right: Painted stork (*Mycteria leucocephala*), Eurasian spoonbill (*Platalea leucorodia*), Red-naped Ibis (*Pseudibis papillosa*), red-crested pochard (*Netta rufina*), northern pintail (*Anas acuta*), Common Teal (*Anas crecca*), common kingfisher (*Alcedo atthis*), Kentish Plover (*Charadrius alexandrines*), Asian Openbill (*Anastomus oscitans*) and lesser adjutant (*Leptoptilos javanicus*))



(i) Grassland Birds: A total of 90 avifauna species belonging to 11 orders and 36 families were recorded in grassland habitat (relocated village sites) (Plate 7.1) and of these, passeriformes dominated the count in terms of species (52 species), while Muscicapidae

dominated in terms of family (9 families), followed by Accipitridae (8 families) and Cisticolidae (7 families). Classification of recorded species among feeding guild revealed that dominant guild was insectivore (37 species), followed by omnivore (15), carnivore (13), granivore (12), frugivore (7), invertivore (2) and nectarivores (1). Three species belonged to more than one guild (insectivore/granivore). Of the total avifauna species recorded, 79 were resident, 9 were local migrant and 4 were long distance migrant. Of the vacated villages/grasslands, Kaneri had the highest number of species (28), followed by Badgadi (27), Kheriya (26) and Jhalar (26).

(ii) Water Birds: A total of 35 species of water birds were recorded in water bodies (Plate 7.2). Passeriformes was the dominating order, and the guild was dominated by insectivore and omnivores. Most species were recorded in Talgaon (28 species) and Gangau Dabri (23 species), while Chamra Dabri hold relatively least number (14 species) of species. The recorded species belong to eight orders and 12 families. Anseriformes and Charadriiformes were the dominant orders, represented by eight species each. Anatidae was dominant among the families, represented by 12 species. Additionally, 91 species of birds were recorded in riparian zone. Classification of observed species among feeding guilds revealed that dominant guild was carnivorous representing highest number of species (11), followed by insectivore (8), omnivore (7) and herbivore (4). Of these species, 23 were resident, 2 were local migrant and 10 were long distance migrant. A total of 40 species of water birds were recorded including ponds and riparian zone.

(iii) Woodland Birds: Woodland here is an umbrella term to define forest areas representing different vegetation types in PTR and most forest bird species fall under this category. A total of 108 species of woodland birds were recorded, belonging to 17 orders and 47 families. Passeriformes formed the most dominant order, represented by 54 species. Cuculidae was dominant among the families, represented by 9 species followed by Accipitridae (Plate 7.3) and Cisticolidae with 7 species each. Of the total species recorded, 93 were resident, 9 were summer migrant, 1 passage migrant and 5 were winter migrant. The dominant guild was bird species feeding on invertebrates (insectivore), representing highest number of species (45), followed by omnivore (24), carnivore (17), granivore (4) and frugivores (9). A total of 206 birds were recorded in PTR which include resident non-endemics (132 species), endemic to India (32 species), non-endemic (24 species) and data deficient (18 species).

Plate 7.3: Photos of raptors recorded in PTR (Left to right: Shaheen falcon (*Falco peregrinus peregrinator*), Crested Serpent-Eagle (*Spilornis cheela*), hen harrier (*Circus cyaneus*), black eagle (*Ictinaetus malaiensis*), crested honey buzzard (*Pernis ptilorhynchus*), short-toed snake eagle (*Circaetus gallicus*), changeable hawk-eagle or crested hawk-eagle (*Nisaetus cirrhatus*), white-eyed buzzard (*Butastur teesa*), Eurasian sparrowhawk (*Accipiter nisus*))



Plate 7.4: Photos of herpetofauna recorded in PTR (Left to right: common sand boa (*Eryx conicus*); common Indian monitor (*Varanus bengalensis*); saw scaled viper (*Echis carinatus*); Indian flapshell turtle (*Lissemys punctata*); Indian bullfrog (*Hoplobatrachus tigerinus*) and Indian python (*Python molurus*))



7.1.6. Herpetofauna Diversity and Abundance in Panna Tiger Reserve: Amphibians and reptiles are commonly grouped together as "herpetofauna," but in fact are phylogenetically quite distinct from one another (Moorman *et al.*, 2011). Amphibians have permeable, moist skin for respiration, but it increases vulnerability to desiccation. Most species require water for egg deposition and development of larvae, which eventually metamorphose into adults that are largely terrestrial (Vitt and Caldwell, 2013). On the contrary, Reptiles have dry scaly skin that protects them from desiccation and require warmer temperatures (associated with higher light levels) for egg incubation and successful development of hatchlings (Vitt and Caldwell, 2013). Therefore, expected response to disturbances and early successional habitats might differ between the two taxonomic classes. In PTR, thirteen species of amphibians belonging to nine genera and four families were recorded. Forty-two species of reptiles belonging to 32 genera and 17 families were recorded. Dicroglossidae is the dominant family (six species) in amphibians followed by Bufonidae (three species) and Microhylidae (three species) (Plate 7.4). Colubridae family of snakes has maximum diversity (11 species) in reptiles followed by Gekkonidae (six species) family of geckos (Plate 7.4). *Fowlea piscator* was the most encountered snake and *Crocodylus palustris* was the most encountered crocodilian in PTR. *Eublepharis satpuraensis, Grypotyphlops acutus, Psammophilus cf blanfordanus, Argyrogena fasciolata, Lycodon striatus, Nilssonia sp., Pangshura tentoria* and *Gavialis gangeticus* were the rarest reptiles observed. New records of *Fejervarya orissaensis, Hoplobatrachus crassus* and *Cyrtopodion cf aravallensis* were found in Madhya Pradesh state. *Eublepharis satpuraensis*, *Hemidactylus sahgali, Pangshura tecta* and *Pangshura tentoria* were recorded for the first time in PTR region.

Highest amphibian species diversity and species richness within habitats was found in paddy fields followed by grassland. The reason of highest diversity and richness of amphibians in the paddy field habitats may be due to provision of retained shallow water for breeding, foraging and egg laying sites to several frogs. In case of reptiles, species diversity and species richness were highest in grassland puddles followed by ponds. Highest diversity and richness of reptiles in grassland habitats may be due the presence of rocky forest fence around grasslands in PTR providing suitable habitat for reptiles. Indian Skipper Frog (*Euphlyctis cyanophlyctis*) had the highest relative abundance amongst amphibians followed by the Cricket Frog (*Minervarya* sp.) and Ferguson's Toad (*Duttaphrynus scaber*) which may be due to their adaptations to wide-ranging habitats and lack of suitable niches for other anurans in a dry deciduous forest. The Marbled Balloon Frog (*Uperodon systoma*) had the least relative abundance and rare amongst

amphibians in PTR, which may be due to its secretive nature and very less activity period outside as it is a strong digger and goes deep in soil. Among reptiles, the relative abundance and encounter rate of spotted house gecko (*Hemidactylus gleadowi*) was the highest and was active in all seasons (except winter) at night followed by Delhi rock gecko (*Cyrtopodion* cf *aravallensis*) that was active only in summers during the breeding season. Checkered keelback snake (*Fowlea piscator*), Oriental garden lizard (*Calotes versicolor*), bark gecko (*Hemidactylus leschenaultii*), and yellow-belly gecko (*Hemidactylus flaviviridis*) were also common because of wide-ranging habitats. Sahgal's termite hill gecko (*Hemidactylus sahgali*) and Satpura eyelid gecko (*Eublepharis satpuraensis*) were rare.

7.1.7. Riparian Biodiversity: Riparian zones are vital habitats providing a range of ecosystem services and should be recognised as unique and important ecosystem. Considering their vast ecological function, the riparian zones need to be protected, restored, and should have separate management strategies (Gilvear *et al.*, 2013). However, multifunctional as well as structural characteristics of riparian ecosystem makes developing management strategies and restoration complex (Reed and Carpenter, 2002). It demands for evaluating the heterogeneity, ecosystem services and identifying conflicts, interactions, and resource use pattern. Riparian buffer composition and structure are the two most important indicators to propose site specific restoration planning (Klemas, 2014). Composition includes vegetation cover, species percentage, invasive species while structure includes width, age, slope, vegetation structure substrate and hydrology (Wahl *et al.*, 2013) etc. The resource use pattern varies with surrounding landscape, demography, and protection level. It is necessary to adapt multi-purpose and site-specific restoration activities.

(i) Physical Characteristics of Riparian Zone along Ken River: Habitat survey revealed that the bank substrate of Ken River is dominated by bedrock (32.8 %) followed by peat/clay (25 %), boulders/cobbles (21.9 %), gravel/sand (20.3 %), while the channel substrate is dominated by bedrock (49.5 %) followed by boulders/cobbles (38 %), gravel/sand (6.3 %) and peat/clay (6.3 %). Average channel width of sampled stretches in the Ken River was 303.4 m while average riparian zone width was 12.2 m. Out of the sampled sites, riparian zone had continuity with forest in 54.7 % sites and with agricultural fields in 45.3 % sites. Along the rivers, either side bars, point bars or mid-channel bars were recorded as vegetated or un-vegetated at each sampling sites. Vegetated bars and un-vegetated bars were recorded at 29.7% and 28.1% sites, respectively.

(ii) Vegetation Characteristics of Riparian Zone along Ken River: A total of 163 species of flora were recorded in riparian ecosystem that included 46 trees, 21 shrubs, 68 herbs and 28 grass species. Mean tree density (per hectare) was 300.40 ± 21.60, mean shrub density was 2147.69 ± 135.5 and mean herb density was 128593 ± 7122. The Shannon Weiner Index was calculated to understand the diversity of the tree species. The index gave the value of 3.30 which represents a diverse ecosystem. Bryophytes were recorded at 109 sampled sites followed by reeds/sedges (n=70), filamentous algae (n=24), water associated plants (n=14), emergent broad leaved (n=11), surface floating (n=5), floating-leaved rooted (n=5) and submerged broad-leaved (n=4). Dominant tree species were *Terminalia arjuna, Mallotus nudiflorus, Holoptelea integrifolia, Ficus racemosa, Tectona grandis, Diospyros melanoxylon, Pongamia pinnata, Lannea coromandelica, Ziziphus mauritiana, Butea monosperma, Syzygium salicifolium* and *Mallotus philippensis.* Dominant shrubs species were *Vitex negundo, Lantana camara, Phyllanthus tenellus, Helicteres isora, Woodfordia fruticose, Ziziphus oenoplia* and *Ipomea aquatica.* Dominant herbs species were *Alternanthera sessilis, Hyptis suaveolens, Sida cordata, Achyranthes aspera, Indigofera linifolia* and *Sida acuta.* Dominant grass species were *Cynodon dactylon, Oplismenus burmannii, Dichanthium annulatum, Chrysopogon fulvus,* and *Imperata cylindrica.* The riparian forest structure was interpreted using girth class distribution and height class distribution. The girth class distribution usually takes reverse J shape, having a greater number of recruiting species than species of moderate girth and a smaller number of mature trees. But in the riparian zone, it deviated slightly, having good number of sapling species. Also, the class of mature trees (> 150 cm) was slightly higher than the previous class. It shows that riparian zone has good amount of old growth trees. The height structure shows that there are a greater number of species with height class of 6.1 to 10 m. But at the same time, the proportion of individuals in class (>22 m) was higher than the previous class which reflects that riparian area has good number of individuals with greater height. Dominant riparian specific trees such as *Terminalia arjuna, Mallotus nudiflorus* and *Holoptelea integrifolia* had more mature individuals. Although, the riparian zone is dominated by the riparian specialist species, but the saplings regeneration is concentrated towards some terrestrial species such as *Diospyros melanoxylon, Tectona grandis* etc. Whereas the proportion of regeneration among seedling species is shared dominantly by some riparian species such as *Terminalia arjuna, Ziziphus mauritiana, Syzygium salicifolium* and terrestrial species such as *Diospyros melanoxylon*. Recruits of other terrestrial species such as *Tectona grandis* is also very high indicating that there is invasion of recruits of the terrestrial species from the surrounding

terrestrial land. These terrestrial species are among the 10 dominant species of riparian zone and produce good number of recruits.

(iii) Status of Avifauna in Riparian Zone along Ken River: A total of 91 species of avifauna were recorded in the riparian habitat, belonging to 16 order and 38 families. Passeriformes was the dominant order, represented by highest number (40), followed by Accipitriformes and Pelecaniformes. Strigiformes order had the lowest number of species. Muscicapidae family was dominant among the families represented by 12 species followed by Ardeidaea and Ciconiidae. Strigidae family had the lowest number of species. Classification of observed species among feeding guild revealed that dominant guild was insectivore representing highest number of species (30 species). It was followed by carnivore (23 species), omnivore (21 species), frugivore (5 species), granivore (5 species), invertivore and piscivore representing 3 species each. One species was recorded from the nectarivore guild. Of the total avifauna species recorded 74 were resident, 11 were migratory-local and 5 were long distance migrants. For recommending habitat management of riparian zone both inside and outside the PA, results of riparian zone assessment along Ken River and its tributaries, have been summarized separately for the stretch within PTR and the stretches outside PTR, in the following sections.

(iv) Riparian Vegetation Index of Riparian Zone along Ken River: Riparian Vegetation Index (RVI) was used for evaluation of riparian zone status in Ken River from Ken-Gharial Sanctuary (KGS) to PTR. RVI values range between 0 (low) and 20 (very high), quality of riparian zone was categorised into low (0 to 7), medium (8 to 12), high (13 to 15) and very high (>15). In KGS, the northern region (Barahi, Kudai and Bilahi beats) has low RVI value (Fig. 7.6) due to rugged terrain of the gorges, while in the southern region, Akona Beat has low RVI due to poor quality riparian habitat as it is surrounded by agricultural lands. The stretch, where it leaves PTR till it enters KGS, has medium to low RVI value (Fig. 7.6). Near Nehri, in Bagounha beat area, some of the riparian area is surrounded by forest in right bank and agricultural fields in left bank. But after that, the river-stretch passes through agricultural field on both banks till it enters KGS. Due to which it has lower RVI value. Inside PTR core region, most of the river stretch has medium to high RVI values. Judi, Raipura, Motachaukan, Jhalar, Magrela and Khamri Beats have river stretch of very high RVI value, while it is low in Lalar, Bhusor, Mahadev Ghati, Gangau and Palkoha areas. Although most of this riparian zone lies within PTR core, the left bank of river stretches in this region has agricultural fields. This is the reason that the riparian area has lower quality habitat. The river stretches in buffer region (Biharwara, Baronha and Udla Beats) has medium value of RVI. The reason is that the riparian

zone is surrounded by open forest and scrub land. Also, the river channel is narrow, forming gorges and has rocky banks.

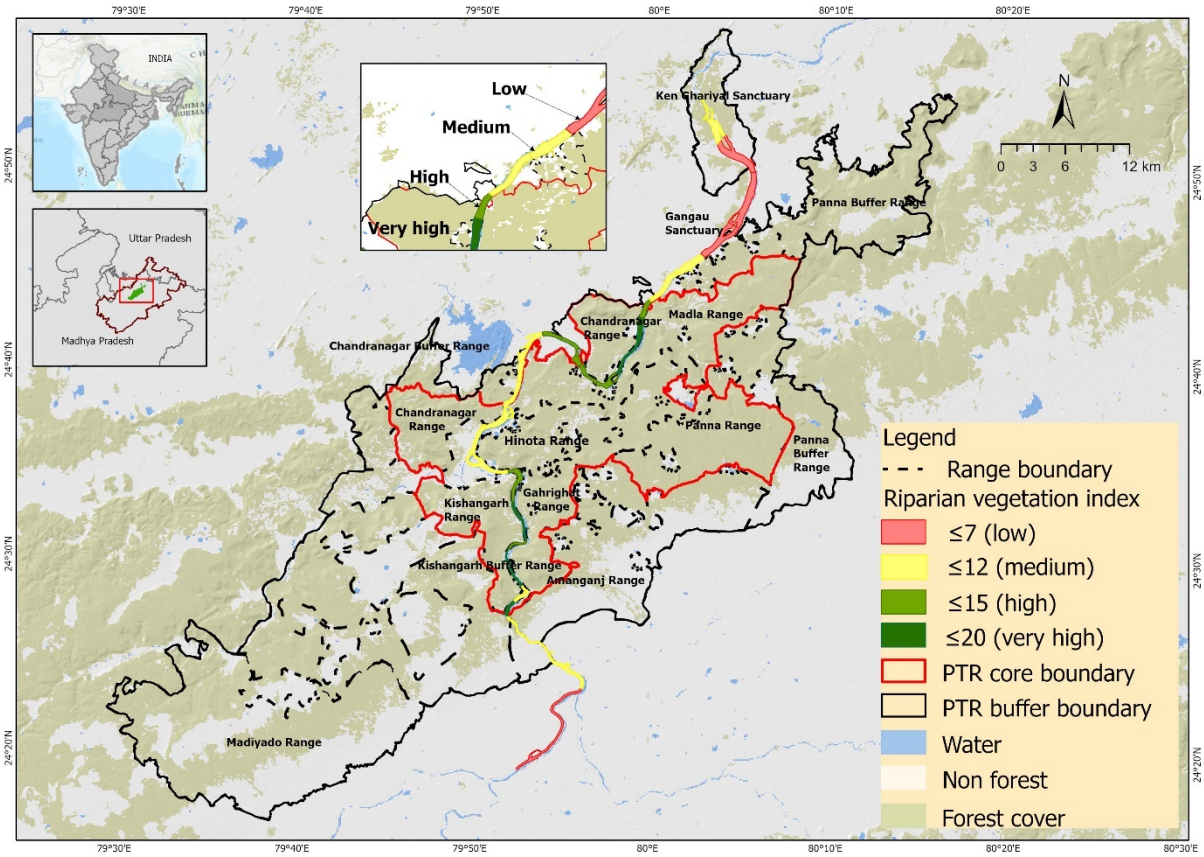


Figure 7.6. Riparian Vegetation Index (RVI) of Ken River along PTR and KGS

Upstream of PTR, the Ken River is joined by Bearma and Patne Rivers, adjoining the South Panna Forest Division. All these rivers are surrounded by agricultural fields and only the stretch of Patne River passing through Sunpura and Chaura regions in Shahgarh and Pawai Ranges of South Panna Forest Division have forested areas along the river. In some of the evaluated sites, rock mining and sand mining were recorded. Brick kilns were also present in three sites. In all these cases, excavation of soil was happening from riverbanks. Most of the river sites are used for bathing, washing clothes, livestock bathing etc. especially the areas which have villages in 250 m zone along the river and stop-dams are frequented for such activities. In all the evaluation sites, large water pipes fitted with motors were being used for water extraction from river for irrigation and other purposes. In most of the sites, the erosion level in riverbanks was medium to high. No large-scale fishing was recorded nor reported by local people in the entire stretch. However, in a few places fishing takes place at a very small scale. Agricultural crops farmed on riverbanks are pulses (arhar, gram, masoor), wheat, and vegetables (potato, green chilli, brinjal, onion, garlic, green pea), etc.

7.1.8. Fish Diversity and Significance in Panna Tiger Reserve

Diversity and abundance of in a river typically indicate the good health of the ecosystems. Fish species has been used for ecological monitoring of river systems. Establishing fish assemblage structure at different section of the river habitats is the first step to initiate any aquatic monitoring programme. Ken River in Panna landscape has a diverse fish fauna of high conservation importance. When compared to other sub-basins in the Central Indian landscape, Ken River has high species richness (64 species) than that of Betwa (60 species), however the fish assemblages are almost similar (Dubey *et al.,* 2012). In the past study, it was also revealed that the main Ken River had high diversity of fish compared to its associated streams as it provides the diverse of fish habitat conditions such as rocky and deep pools with continuous flow in the most of the months (Kaemingk *et al.,* 2007). Moreover, it is a well-established fact that high species diversity occurs at the confluence of tributary streams and the main river than in the tributaries (Falke and Gido, 2006; Johnson *et al.*, 2012). Further, the low diversity of fish documented in streams associated with Ken River is mainly due to seasonal nature of streams and most of the streams dry-up during summer months. In addition to that, a variety of factors like water quality, habitat availability, flow variability and nutrient supplies from riparian habitats control the abundance and distribution of stream fishes. Such environmental variables are easier to predict than other biotic variables like predation and competition. Fishes and benthic macro-invertebrates serve as ecological indicators for freshwater ecosystem, therefore, are vital taxonomic groups in any ecological assessment studies (Rajvanshi *et al*., 2012; Dudgeon, 2008). Results of this study are discussed in detail in the subsequent sections.

(i) Species Diversity and Relative Abundance:

A total of 64 fish species belonging to 8 orders, 18 families, and 40 genera were recorded in the Ken River Panna landscape (Plate 7.5), which includes the river sector flowing inside the Protected Areas (PTR and KGS) and aquatic habitats flowing through outside the Protected Areas. Some of the Cyprinidea and Danionidae species such as *Devario aequipinnatus, Esomus danricus, Garra mullya, Salmophasia balookee, Labeo dyocheilus, Petha chonconius* and *Puntius sophore*. were widely distributed in most of the study areas. These species have also widespread distribution in Indian waters (Talwar and Jhingran, 1991; Jayaram, 1999). In addition, Ken River is also home to the Central Indian mahseer known as *Tor tor* and good population of mahseer was observed in the Protected Areas of Ken River. The earlier study on fish diversity revealed that Ken River flowing through PTR alone inhabited 50 species of freshwater fishes (Johnson et. al. 2012). The diverse substrate types like bedrocks, boulders,

gravels and sand provide habitat for many fishes in Ken River. Moreover, the water quality conditions such as good amount of dissolved oxygen content, planktons diversity, optimum water temperature, pH, and conductivity in Ken River are most suitable for warm water fish species. Exotic fish species such as *Ctenopharyngodon idella* and *Cyprinus carpio* were also recorded from the upper, lower and middle stretches of the river. High diversity of fishes was observed in PTR core and KGS as these sections are completely undisturbed. In contrast, low number of species was recorded in Amanganj, Pandavan, Lalhar and Bhapatpur where water dependency rate is high because of high water demand for agriculture, fishing, drinking and other use.

The pH was normal at upper stretch, slightly alkaline in midstream becoming acidic in the downstream. pH varies from 6.85 to 8.85 during the pre- monsoon and 8.19 to 9.14, during post-monsoon seasons. Water temperature varies as expected with seasonal climates from 17.80°C to 29.80°C during pre-monsoon and 14.80°C to 25.50°C in post-monsoon. DO ranged from 6.03 mg/l to 8.93 mg/l during pre-monsoon and 7.42 mg/l to 12.80 mg/l during post-monsoon. SPC ranges from 147.60 µS/cm to 367µS/cm during pre-monsoon and 80.50 µS/cm to 432.50 µS/cm in post-monsoon. Conductivity varies from 158.80 µS/cm to 332.10 µS/cm during pre-monsoon and 67 µS/cm to 373.40 µS/cm in post-monsoon. TDS ranges from 96.20 ppm to 237.90 ppm during pre-monsoon and 51.34 ppm to 280.15 ppm in post-monsoon. Depth varies from 1.10 ft to 57.30 ft during pre-monsoon and 1.60 ft to 69.40 ft in post-monsoon. Overall, bank width and water flow are moderate in both the seasons ranging from 12 mt to 494 mt during pre-monsoon and 16.5 mt to 546 mt in post-monsoon while flow is 0 m/s to 0.20 m/s in pre-monsoon and 0 m/s to 0.30 m/s in post-monsoon.

(ii) Fish Spawning and Rearing Grounds:

Fish spawning in the central Indian rivers are directly related to the monsoon cycle. Adult fishes select spawning grounds, such as wadeable streams with shallow areas, submerged rotting dry grass and plants, suitable water temperature, adequate living space and oxygen, flow refuge area for developing young ones, light and adequate good quality of water. Thus, monsoon discharge provides connectivity and tributary access to select such spawning ground along the main river channel. Perhaps a rising level of water in the river Ken provides suitable conditions to fishes to achieve spawning condition. Peak spawning, however, follows the outbreak of monsoons. In case of PTR, pre-monsoon breeding is recorded only in small stretches towards the southern boundary (Fig. 7.7). However, post-monsoon breeding occurs in almost the entire river stretch passing through PTR and up to KGS (Fig. 7.8).

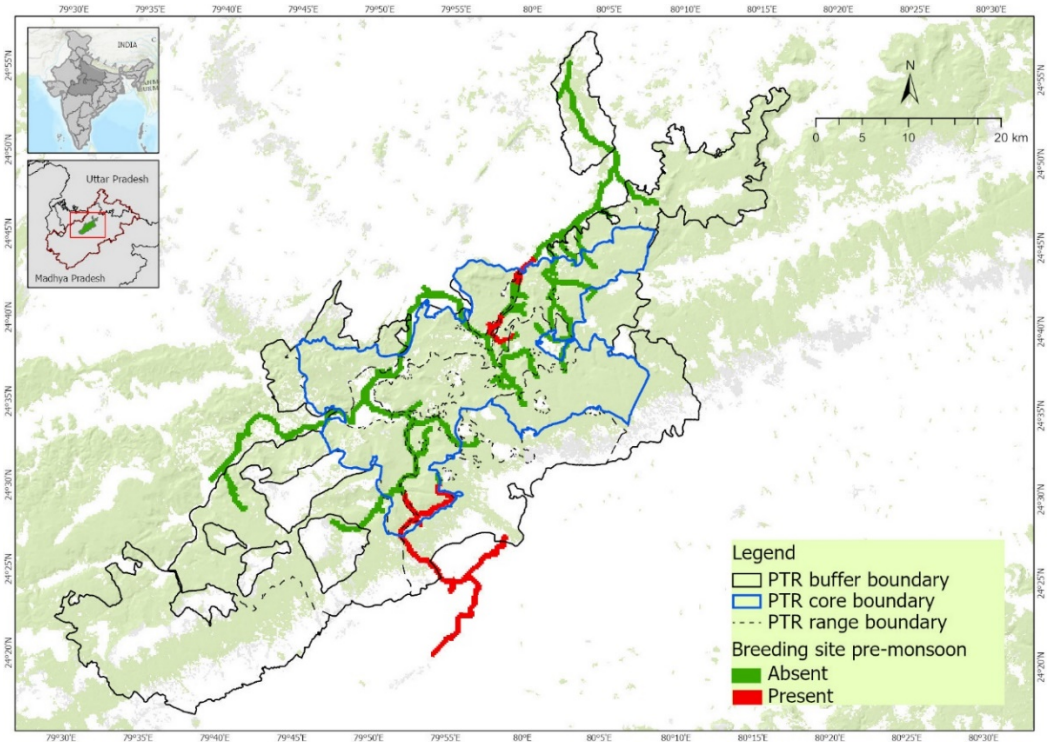


Figure 7.7. Status of fish breeding ground in Ken River during pre-monsoon season

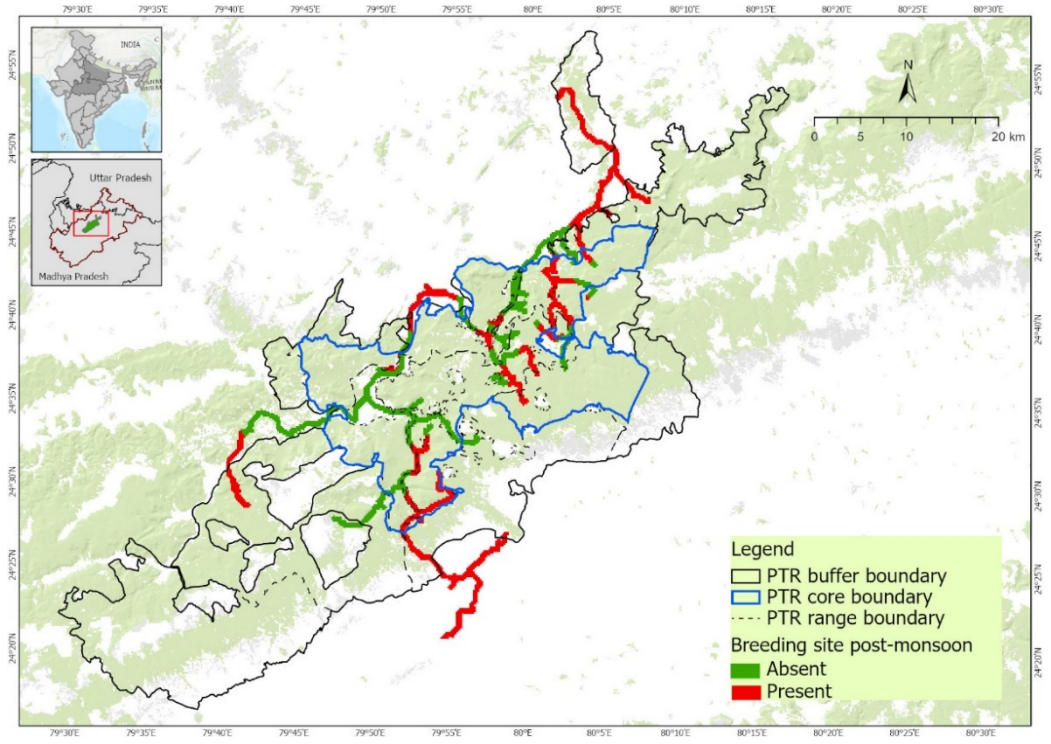


Figure 7.8. Status of fish breeding ground in Ken River during post-monsoon season

Plate 7.5: Some of the economically important fish species recorded from the Ken River

	
Tor tor	*Labeo pangusia*
	
Ompok pabda	*Labeo calbasu*
	
Xenentodon cancila	*Cirrhinus mrigala*

(iii) Status of Mahseer:

Mahseer (*Tor tor*), known as king of freshwater fish, is highly dependent upon the quality and quantum of water in which they have evolved. Presence of mahseer in a river indicates good quality of water, a slight change in the attributes of water quality can lead to the elimination of Mahseer living there. *Tor tor* is found in all the Vindhyan river systems (Narmada, Tapti,

Mahanadi, Chembal, Betwa, Sone, Ken, Tons, Paisuni and others) and in some upland waters of the Deccan plateau. It prefers torrential streams with good oxygenated water and rocky river pools. Among Indian mahseer, *Tor tor* is the most important food and game fish of India after *Tor putitora*. In general, mahseer are declining very rapidly in their numbers and size in central Indian rivers due to overexploitation, water pollution, habitat destruction, and reduction of water flow. However, Ken River holds good population *Tor tor* in the protected stretches (inside PTR and KGS) and occasionally found in the fish catches outside the protected areas.

7.1.9. Surrogate Biodiversity Richness of Panna Tiger Reserve: Spatial patterns of various physical and biological attributes, analysed at 1x1km grid cells, reflects composite value of biodiversity richness potential, represented by low (0) to high (1) index values. Accordingly, PTR is largely represented by 0.15 to 0.69 biodiversity index reflecting mostly low to moderate biodiversity area, while high biodiversity grids are highly scattered and are in restricted pockets (Fig. 7.9).

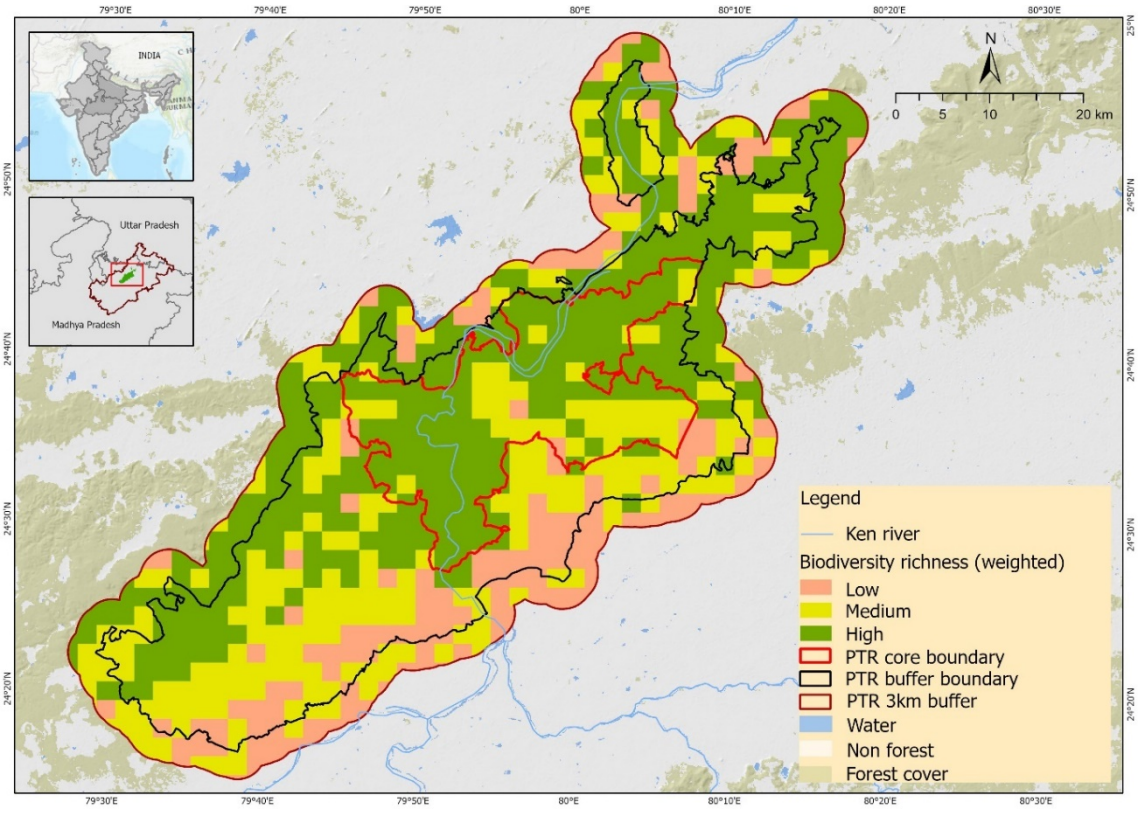


Figure 7.9. Surrogate Biodiversity Richness Index in PTR

7.1.10. Status of Biodiversity in the Greater Panna Landscape: As described earlier, GPL includes the area of PTR as well, and thus the biodiversity status presented in this section provides an overview of the status in the entire landscape, based on large scale sampling and

analyses. Unlike PTR, the biodiversity component here is represented by vegetation and mammalian components, and surrogate biodiversity richness, to guide the conservation management across the landscape. While these components represent thematic processes, administrative units (forest and district) represent the zonal process, as it would allow for integration of biological and societal interests.

Plate 7.6: Photos of vegetation recorded in Panna landscape (Left to right: Palash (*Butea monosperma*), Kullu (*Sterculia urens*), Katbar (*Ficus mollis*), Mahua (*Madhuca longifolia),* Umar (*Ficus racemosa*), Tendu (*Diospyros melanoxylon*), Arni (*Clerodendrum Phlomidis*), gabdu (*Cochlospermum religiosum*) and papda (*Gardenia latifolia*))



(i) Vegetation Diversity and Dominance: GPL represents a diverse forest ecosystem composed of many rare species of vegetative life forms. A total of 368 species of plants (from 109 families) were recorded from the landscape (that include 12 forest divisions). These species include 101 tree (38 family), 33 shrub (19 family) 144 herb (42 family), 67 grass (one family), 8 sedge (one family) and 15 climber (8 family) (Plate 7.6).

Dominant tree species in the landscape were *Terminalia tomentosa* (Saaj), *Tectona grandis* (Sagaun), *Chloroxylon swietenia* (Bhirra), *Diospyros melanoxylon* (Tendu) and *Anogeissus latifolia* (Dhavda). Dominant shrubs were *Lantana camara* (Vidya nashan), *Helicteres isora* (Ainthi) and *Ziziphus oenoplia* (Makora). Dominant grasses were *Cynadon dactylon* (Doob), *Eragrostis tenella* (Bhurbhusi), *Heteropogon contortus* (Lampa), *Themeda triandra* (Gunair) while the dominant climbers were *Bauhinia vahlii* (Mahul) and *Butea superba* (Palash bel). Importance Value Index (IVI) reflecting dominant, co-dominant and rare species across different forest division is given in Table 7.1. Accordingly, the dominant tree species found in GPL are *Tectona grandis, Chloroxylon swietenia, Lannea coromandelica, Aegle marmelos, Madhuca longifolia, Boswellia serrata* and *Anogeissus pendula.*

Table 7.1: Importance Value Index (IVI) of tree species in different forest divisions

S.No.	Divisions	Importance Value Index (IVI)
1	Panna TR	*Tectona grandis (54.50), Lagerstroemia parviflora (32.80), Diospyros melanoxylon (30.0), Lannea coromandelica (27.80), Acacia catechu (18.40), Anogeissus latifolia (16.80), Butea monosperma (14.20), Ziziphus xylopyrus (12.40), Madhuca longifolia (10.90), Terminalia elliptica (10.0), Anogeissus pendula (6.90), Aegle marmelos (6.80), Flacourtia indica (5.40), Buchanania cochinchinensis (4.60), Terminalia arjuna (4.10)*
2	Damoh	*Chloroxylon swietenia (55.30), Lannea coromandelica (34.90), Tectona grandis (31.90), Lagerstroemia parviflora (27.40), Anogeissus latifolia (22.20), Terminalia elliptica (20.30), Diospyros melanoxylon (11.60), Dalbergia lanceolaria subsps. paniculate (10.10), Holarrhena pubescens (7.30), Catunaregam spinosa (7.20)*

3	Katni	*Lannea coromandelica (51.80), Anogeissus latifolia (35.20), Terminalia elliptica (28.40), Dalbergia lanceolaria subspecies paniculata (22.70), Lagerstroemia parvifolia (15.60), Boswellia serrata (14.60), Acacia catechu (10.0), Diospyros melanoxylon (9.80), Miliusa tomentosa (8.90), Holarrhena pubescens (8.20)*
4	Nauradehi WLS	*Tectona grandis (67.54), Terminalia elliptica (32.17), Lagerstroemia parviflora (28.81), Chloroxylon swietenia (28.27), Anogeissus latifolia (23.75), Lannea coromandelica (19.60), Diospyros melanoxylon (16.63), Holarrhena pubescens (13.15), Madhuca longifolia (7.99), Aegle marmelos (7.85)*
5	Veerangana Durgawati WLS	*Aegle marmelos (55.90), Dalbergia lanceolaria subsps paniculate (50.70), Tectona grandis (29.50), Bauhinia racemosa (21.50), Anogeissus latifolia (21.30), Diospyros melanoxylon (19.20), Mitragyna parvifolia (15.20), Lagerstroemia parviflora (12.70), Lannea coromandelica (12.20), Chloroxylon swietenia (11.60)*
6	South Panna	*Lannea coromandelica (60.60), Lagerstroemia parviflora (33.20), Boswellia serrata (28.20), Anogeissus latifolia (17.80), Diospyros melanoxylon (15.30), Terminallia bellirica (13.60), Tectona grandis (13.40), Holrrhena pubescens (2.40), Terminalia elliptica (10.80), Madhuca longifolia (9.80)*
7	Satna	*Lannea coromandelica (72.60), Lagerstroemia parviflora (32.20), Diospyros melanoxylon (22.30), Anogeissus latifolia (21.20), Madhuca longifolia (20.70), Buchanania cochinchinensis (20.40), Boswellia serrata (16.10), Butea monosperma (15.50), Acacia catechu (9.30), Phyllanthus emblica (7.70)*
8	Chhatarpur	*Madhuca longifolia (48.0), Lannea coromandelica (43.20), Anogeissus latifolia (34.50), Boswellia serrata (28.20), Diospyros*

		melanoxylon (23.20), Lagerstroemia parviflora (22.70), Buchanania cochinchinensis (21.80), Tectona grandis (20.60), Aegle marmelos (7.80), Miliusa tomentosa (7.80)
9	North Sagar	*Lannea coromandelica (43.30), Tectona grandis (41.50), Anogeissus latifolia (28.30), Aegle marmelos (26.60), Terminalia elliptica (20.80), Buchanania cochinchinensis (20.60), Madhuca longifolia (16.80), Butea monosperma (14.30), Anogeissus pendula (13.10), Mitragyna parvifolia (9.70)*
10	South Sagar	*Tectona grandis (142.20), Butea monosperma (28.10), Lannea coromandelica (17.10), Anogeissus latifolia (15.40), Terminalia elliptica (14.80), Diospyros melanoxylon (14.40), Boswellia serrata (12.10), Madhuca longifolia (9.70), Buchanania cochinchinensis (7.70), Terminalia arjuna (5.40)*
11	North Panna	*Lannea coromandelica (120.50), Diospyros melanoxylon (53.50), Anogeissus latifolia (29.70), Madhuca longifolia (14.80), Lagerstroemia parviflora (12.10), Bombax ceiba (10.50), Holarrhena pubescens (6.10), Flacourtia indica (5.90), Phyllanthus emblica (5.80), Buchanania cochinchinensis (5.60)*
12	Rewa	*Boswellia serrata (49.10), Butea monosperma (23.40), Anogeissus latifolia (22.50), Anogeissus pendula (18.0), Lagerstroemia parviflora (17.40), Ziziphus xylopyrus (13.80), Buchanania cochinchinensis (13.50), Acacia catechu (12.30), Lannea coromandelica (11.70), Diospyros melanoxylon (11.40)*
13	Ranipur WLS	*Anogeissus pendula (75.20), Acacia catechu (38.60), Lannea coromandelica (22.70), Madhuca longifolia (17.70), Anogeissus latifolia (15.70), Diospyros melanoxylon (12.30), Terminalia elliptica (11.90), Nyctanthes arbor-tristis (10.80), Mitragyna parvifolia (10.50), Flacourtia indica (8.10)*

(ii) Vegetation Density and Regeneration: Mean tree density (number per hectare) ranged from 306.50 (Satna) to 750 (Veerangana Durgawati WLS), mean shrub density ranged from 110.80 (Nauradehi WLS) to 4782 (North Sagar). Mean total basal area of species ranged from 40.11 m^2/ha in Veerangana Durgawati WLS to 10.95 m^2/ha in South Panna Forest Division. Mean sapling density (indicating regeneration status) ranged from the highest of 933.70 individuals/hectare in Chhatarpur Forest Division to the lowest of 260.90 individuals/hectare in North Panna Forest Division. Mean seedling density ranged from the highest of 2590 individuals/hectare in Nauradehi WLS to the lowest of 532 individuals/hectare in Rewa Forest Division. Regeneration was concentrated to some of the species such as *Diospyros melanoxylon* (Tendu), *Holarrhena pubescens* (Doodhia), *Lagerstroemia parviflora* (Seja), *Cassia fistula* (Amaltas), *Ziziphus xylopyrus* (Ghont), *Flacourtia indica* (Kankher), *Butea monosperma* (Palash), etc. Absence of regeneration was found in many species such as *Sterculia urens* (Kulu), *Albizia excelsa* (Mahrukh), *Dalbergia lanceolaria* (Dhamasi), *Gmelina arborea* (Gamari), etc.

(iii) Forest Structure: In the landscape, all the forest divisions had more individuals in seedling girth class (<10 cm) and least number of individuals in the most mature class (>150cm). The sapling girth class (11 to 29 cm) in most of the divisions showed a drop in the curve, which could be probably due to preference of this particular girth class for cutting/lopping for fodder, poles and fuelwood by local people. Tree height class distribution showed the highest number of individuals belong to 6.10 to 10 m class. Mostly because the lanscape is characterised by rocky substratum and less soil depth which does not allow trees to attain natural height. Also, anthropogenic disturbances such as lopping and fire, hinder natural growth of trees.

(iv) Mammalian Diversity and Abundance: A total of 33 mammalian species were recorded in the landscape and it include large representation of carnivores species. Tiger was photo-captured in Nauradehi and Ranipur WLSs. Both areas have resident, as well as dispersed tigers from PTR. What makes these WLSs as important habitats for tigers dispersing from PTR is that these sanctuaries allow for conservation of tigers using metapopulation framework in the landscape. Other co-predators were recorded in almost all the forest divisions, although carnivore concentrations are mostly around protected habitats of PTR (Fig. 7.10) (Plate 7.7). Eleven species of herbivores were recorded across the landscape (Plate 7.8), with higher concentration of herbivores in northern part of the landscape (Fig. 7.11).

Plate 7.7: Photos of carnivores recorded in Panna landscape (Left to right: Indian wolf (*Canis lupus pallipes*), Asiatic wildcat (*Felis lybica ornata*), striped hyena (*Hyaena hyaena*), leopard (*Panthera pardus*), Jungle Cat (*Felis chaus*), small Indian civet (*Viverricula indica*), Indian fox (*Vulpes bengalensis*), Indian jackal (*Canis aureus indicus*) and sloth bear (*Melursus ursinus*))



***Carnivore Abundance*:** Highest number of leopards were photo-captured in Ranipur WLS followed by Rewa and Chhatarpur Divisions. Hyena was photo-captured highest in Rewa, followed by Chhatarpur and North Sagar Divisions. Wolf was photo captured highest in Veerangana Durgawati WLS followed by Nauradehi WLS, Katni and North Sagar Divisions. Jackal and Indian fox were photo captured highest in Nauradehi WLS followed by Damoh, Chhatarpur and North Sagar Divisions. Dhole was recorded only in PTR. Sloth bear, rusty spotted cat, ruddy mongoose, honey badger, small Indian civet and common palm civet were photo-captured most in Ranipur WLS. Indian pangolin was photo-captured highest in North Sagar followed by South Panna and Damoh Divisions. Madras tree shrew was photo-captured highest in Chhatarpur followed by North Sagar, Damoh and South Panna Forest Divisions. Indian pangolin and Madras tree shrew have been placed in carnivore group due to feeding habit and management imlications.

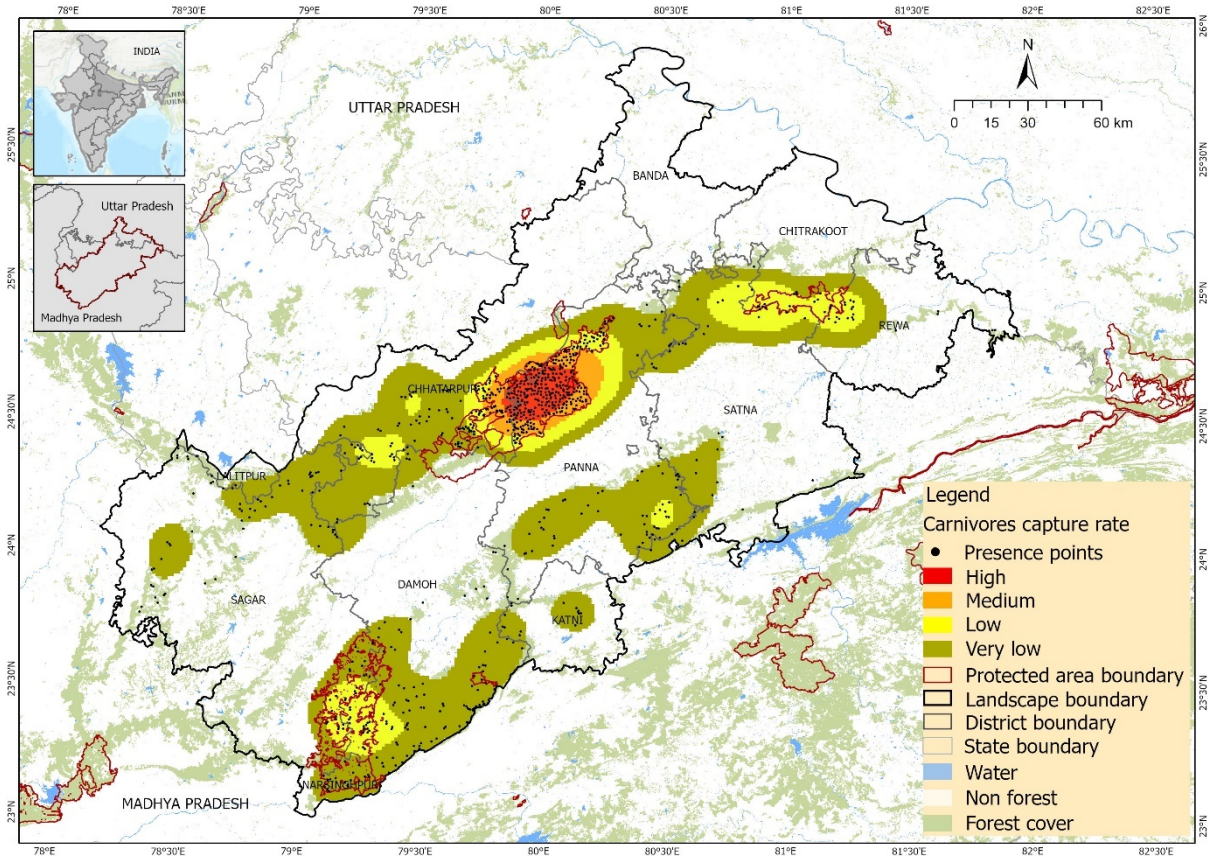


Figure 7.10. Map showing carnivore species photo-capture rate in the landscape

Herbivore Abundance: Black buck was photo-captured only in North Sagar and South Sagar Forest Divisions. Indian Muntjac was photo-captured only in Katni, South Panna, Damoh Divisions and Ranipur WLS with highest photo-capture in Damoh followed by Katni and South

Panna Divisions. Other herbivores were recorded in almost all the forest divisions. Chinkara was photo-captured highest in Damoh followed by North Panna Forest Division, Nauradehi WLS and Chhatarpur Division. Chausingha was photo-captured highest in Katni followed by North Panna, South Panna and Rewa Divisions. Nilgai was photo captured highest in Katni followed by North Panna Division, Ranipur WLS and Damoh Division. Chital was photo-captured highest in Veerangana Durgawati WLS followed by Rewa and South Panna Forest Divisions, and Nauradehi WLS. Sambar was photo-captured highest in Katni, followed by North Sagar Division, Veerangana Durgawati WLS and Satna Division. Wild pig was photo-captured highest in Rewa followed by Chhatarpur, North Panna and Katni Forest Divisions. Among the primates, gray langur was photo-captured highest in Chhatarpur followed by South Sagar and Katni Divisions, while Rhesus macaque was photo-captured highest in Veerangana Durgawati followed by Rewa Division, Nauradehi WLS and Katni Forest Divisions. Indian Hare was photo-captured highest in North Panna Division followed by Ranipur WLS and Rewa Forest Division. These observations reflect that the landscape holds conservation significance and has the potential to support tiger across the landscape, if the anthropogenic issues are taken care of with enhanced protection and co-management strategies.

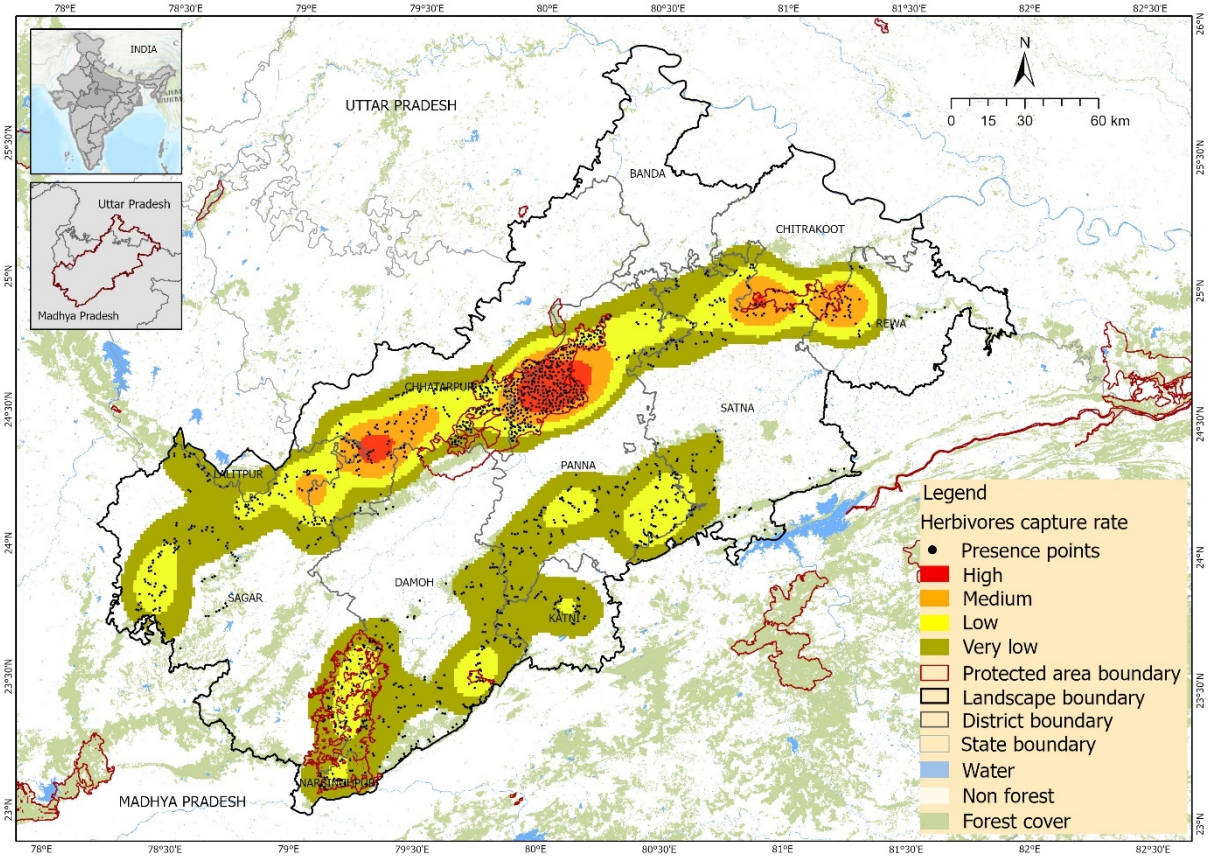
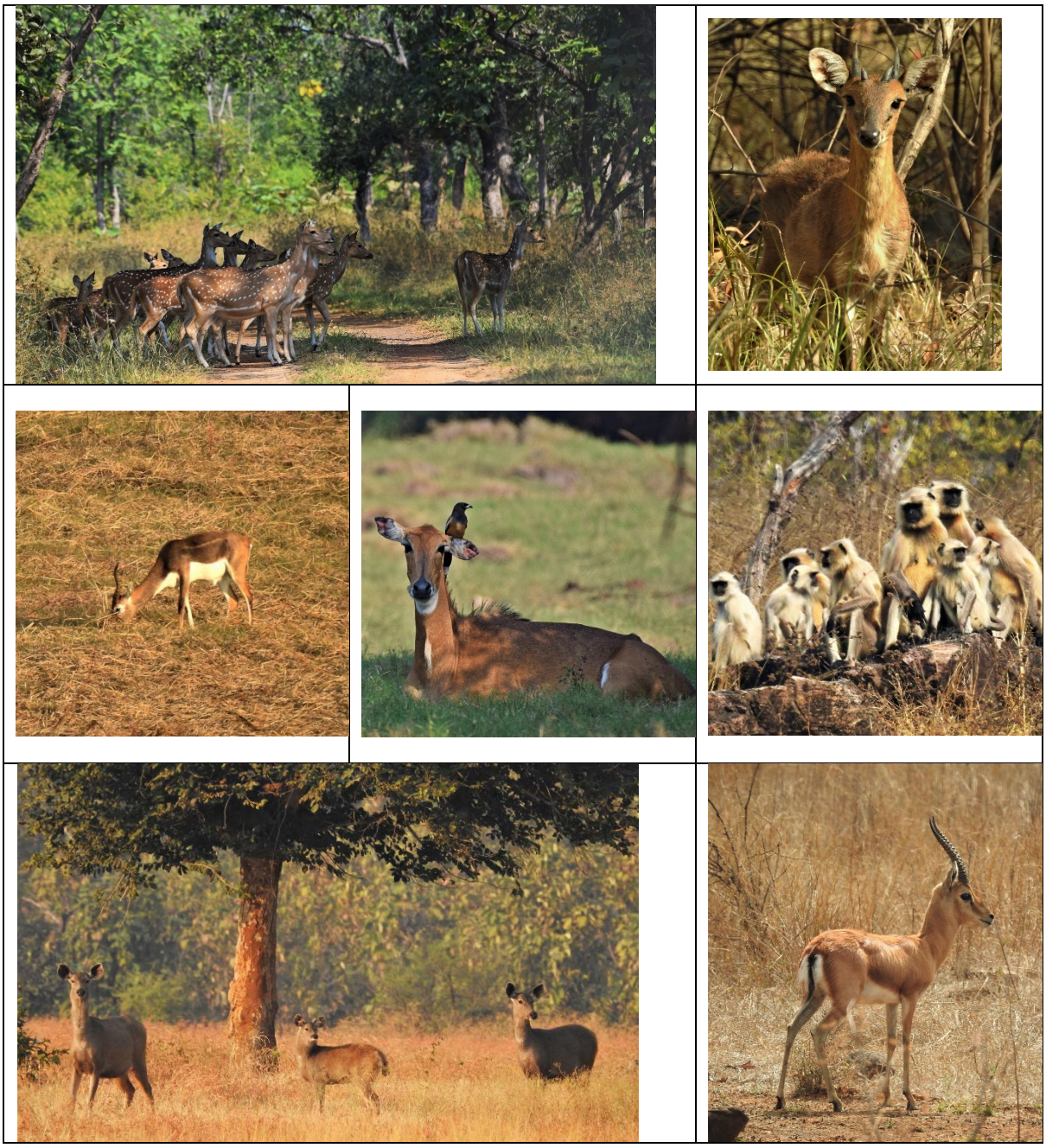


Figure 7.11. Map showing herbivore species photo-capture rate in the landscape

Plate 7.8: Photos of herbivores recorded in Panna landscape (Left to right: Chital (*Axis axis*), Chausinga (*Tetracerus quadricornis*), Black Buck (*Antilope cervicapra*), Nilgai (*Boselaphus tragocamelus*), Grey Langur (*Semnopithecus entellus*), Sambar (*Rusa unicolor*) and Chinkara (Gazella bennettii))



Rodent Abundance: Rodents such as northern palm squirrel/ five striped squirrel (*Funambulus pennantii*) and Indian Gerbil (*Tatera indica*) were not much widespread in this landscape. Five striped squirrel was photo-captured highest in Rewa followed by Chhatarpur and South Sagar Divisions. Indian crested porcupine was photo-captured highest in Ranipur WLS followed by Rewa and Satna Divisions. Indian gerbil was photo-captured highest in South Panna followed by Rewa, Damoh and Satna Divisions.

7.1.11. Biodiversity Richness Potential in the Greater Panna Landscape: The entire landscape is interspersed with rocky and uneven terrain with scrubby vegetation and grass. The vegetation is deciduous and highly fragmented. Based on spatial analyses of various thematic layer, the biodiversity richness potential in the landscape largely varied from low to moderate, and high only in certain areas (Fig. 7.12). The estimated values ranged from 0.10 to 0.54 with a mean score of 0.26. The outcomes of the analysis indicate that Panna district has the largest percentage of area (31.6%) under high biodiversity richness (Lalitpur and Narsinghpur districts are very small districts, so they have not been mentioned), while Banda has the largest area under low richness. Most of the rich areas are found in the districts of Panna, Satna and Chhatarpur Divisions, while poorest biodiversity areas are in Banda, Rewa and Chitrakoot districts (Table 7.2). There are significant areas that are rich in biodiversity, located outside this PA network (Fig. 7.12). The spatial patterns of the biodiversity richness potential reflect overall habitat quality and provide options for recovery strategies.

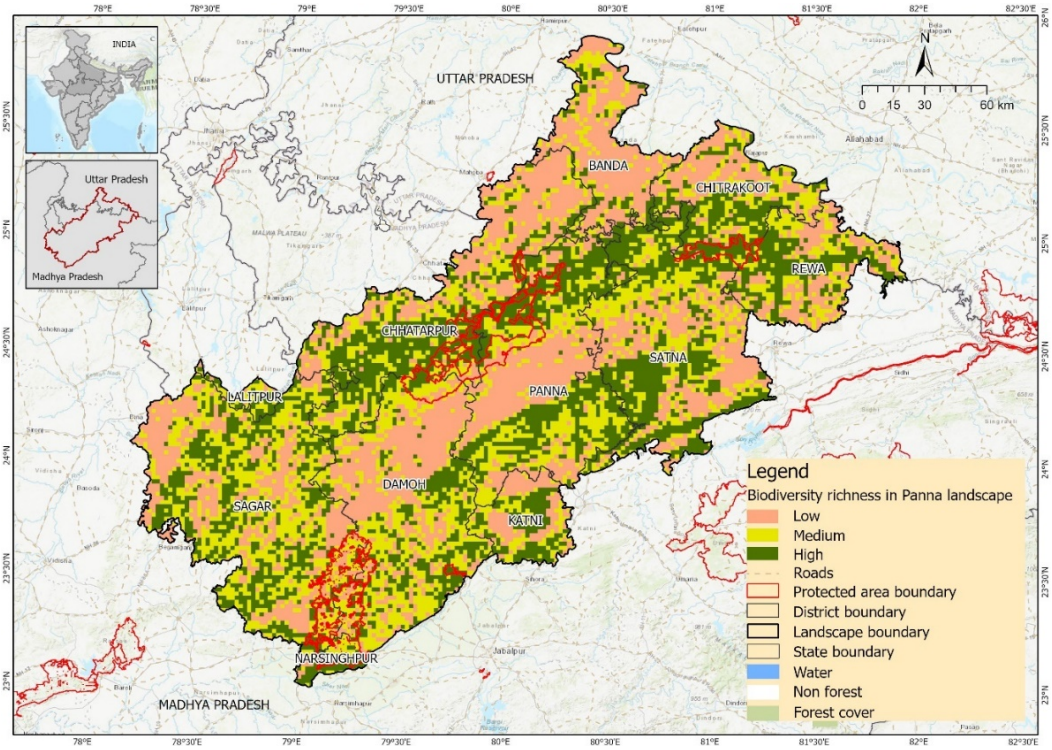


Figure 7.12. Biodiversity richness potential in the landscape

Table 7.2: Area statistics of biodiversity richness potential of the landscape

S. No.	District	Low (Sq. km)	Moderate (Sq. km)	High (Sq. km)
1	Panna	2204.35	2094.03	2510.36
2	Chhatarpur	2339.85	1812.70	2286.20
3	Damoh	2781.44	2625.99	1613.90
4	Sagar	2722.04	3663.06	2782.45
5	Katni	584.22	459.72	556.83
6	Satna	2014.65	2049.81	2599.09
7	Rewa	1006.09	860.96	1100.87
8	Narsinghpur	59.14	171.34	261.92
9	Banda	2038.25	629.54	364.15
10	Chitrakoot	1016.61	890.53	1163.39
11	Lalitpur	38.09	146.78	172.07
	Total	**16804.73**	**15404.45**	**15411.25**

7.1.12. Anthropogenic Status: Based on the camera trapping assessment, anthropogenic parameters such as livestock and human encounters reflected certain spatial patterns in the intensity of use. Livestock photo-capture rate was highest in Chhatarpur Division followed by Ranipur WLS, Nauradehi WLS, Veerangana Durgawati WLS, Satna and North Sagar Divisions. Human photo-capture rate was highest in Chhatarpur Division followed by North Panna Division, Ranipur WLS, Satna, Rewa and North Sagar Forest Divisions.

7.2. Recommendations and Prescriptions

7.2.1. Measures for Terrestrial Habitat Management: Forest management and restoration are aimed at reversing the degradation or loss of ecosystem services towards integrity and natural resilience capacity. These have to be understood with respect to desired goals (Stanturf *et al.,* 2014) and include (a) rehabilitation: restoration of desired species, structure or process to an existing ecosystem, (b) reconstruction: restoration of native plants on land used for other purposes; reclamation: restoration of severely degraded land devoid of vegetation, and (c) replacement: the most radical form of restoration, in which species or provenances maladapted for a given location and unable to migrate are replaced with new vegetation as climates change rapidly. Remedial strategies can be adopted for conservation and management of biodiversity based on threat assessments and also based on current and past land uses. This would include steps such as (1) understanding the habitat ecology of the area by sampling in the adequate period, (2) estimating the stage, level and frequency of degradation, and (3) understanding the ecology of the animal species utilising or avoiding that particular area. Considering all these previous steps, the following measures have been recommended for overall biodiversity management and improvement.

(i) Assisted Regeneration and Plantations: Assisted Natural Regeneration (ANR) is suggested for important tree species which were found to have poor regeneration in the landscape namely, *Dalbergia lanceolaria subspecies paniculate* (Dhobin), *Holoptelea integrifolia* (Chirhol), *Terminalia bellirica* (Baheda), *Careya arborea* (Kumbhi), *Cassine glauca* (Jamrassi), *Limonia acidissima* (Kaithha), *Kydia calycina* (Baranga), *Schleichera oleosa* (Kusum), *Terminalia chebula* (Harra), *Desmodium oojeinense* (Tinsa), *Haldina cordifolia* (Kaim), *Gardenia latifolia* (Papda), *Soymida febrifuga* (Rohan), *Albizia odoratissima* (Yerma), *Boswellia serrata* (Salai), *Grewia orbiculate* (Dhamna), *Sterculia urens* (Kulu), *Bombax ceiba* (Semar), *Casearia graveolens* (Gilchi), *Cordia myxa* (Risalla), *Dalbergia lanceolaria* (Dhamasi*), Dalbergia latifolia* (Pahadi sheesham), *Morinda pubescens* (Aal) and *Pterocarpus marsupium* (Beeja). These trees should also be promoted for plantation purpose and habitat restorations. Shrubs are generally not preferred for plantations by forest department or restoration efforts, but they are as important as tree species in maintaining forest structure and complexity. Based on their habitat suitability species such as *Helicteres isora* (Aithi), *Vitex negundo* (Nirgudi), *Woodfordia fruticosa* (Dhawai), *Ziziphus nummularia* (Jhar beri), *Ziziphus oenoplia* (Makoi) etc. should be promoted for plantation to provide undercover

for mammals and food source for birds and butterflies. These shrubs should especially be promoted in restoration areas after removal of weeds and invasives such as *Lantana camara.*

(ii) Management of Invasive Species: Invasive species cause significant economic and ecological losses. The aggressive spread of invasive species is the result of (A) invasive species over competitive traits in comparison to native species, (B) insufficient knowledge about the growth and spread of the invasive species, (C) insufficient knowledge of control measures and (D) inadequate funding for long term management. Management of invasive species include (1) Eradication: complete removal of the concerned species (all life stages), (2) Control: long-term reduction in population of the concerned species below a pre-set acceptable threshold, and (3) Mitigation: mitigating the impacts of the concerned species by exercising the best way while living with it.

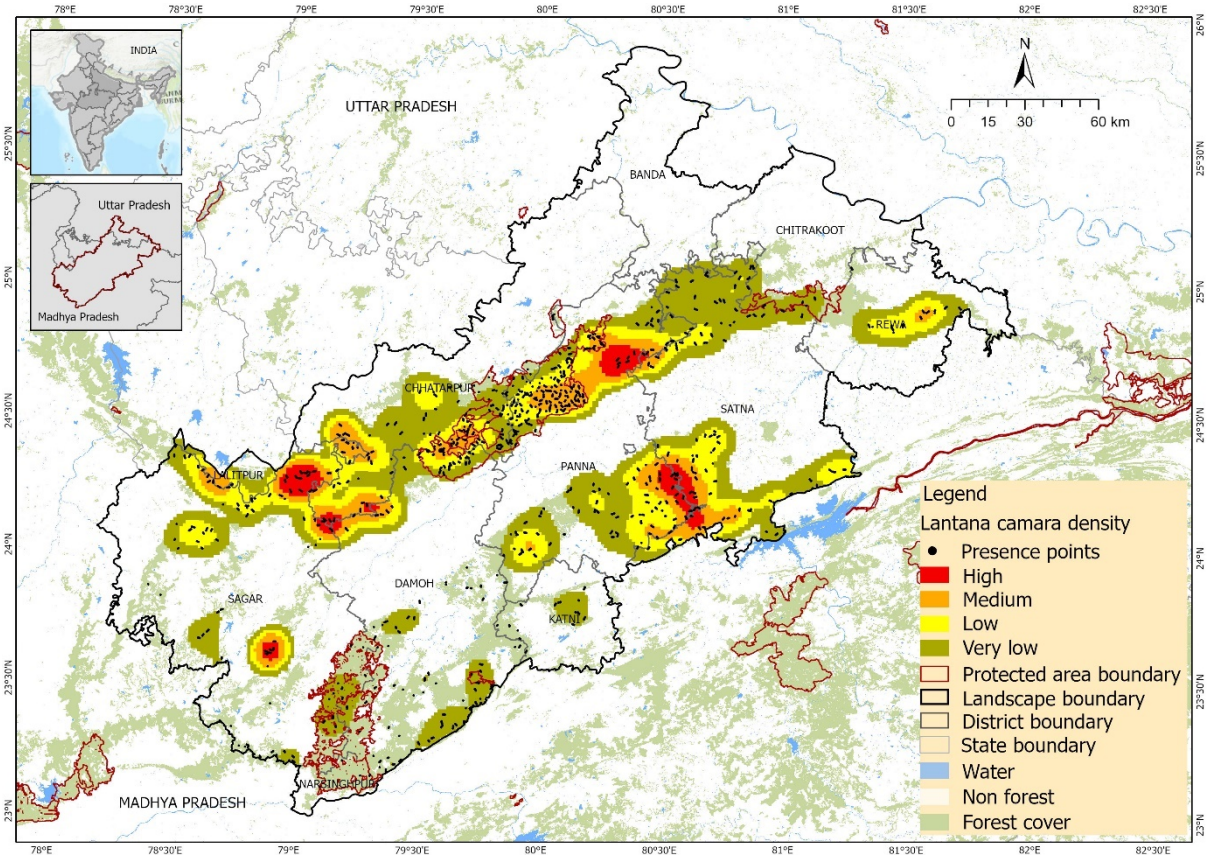


Figure 7.13. Map showing *Lantana camara* density in GPL

***Management of Lantana camara*:** Almost 60 percent of the total sampled area of the landscape have shown presence of *Lantana camara* (Fig. 7.13). Moderately disturbed/ open areas in landscape usually have presence of this species but it is also present in some severely disturbed forests. Such area of occurrence of this invasive species poses tremendous threat to native flora

and fauna. In PTR, *Lantana camara* is patchily distributed in both core and buffer (Fig. 7.14), but some areas of PTR core are among the most densely populated with this species in the landscape. Lantana reproduces primarily by seed and is a copious seed producer. Birds eat fruits of Lantana and passage of the seeds through the gut of dispersers increases its germination rates (Mandon-Dalger *et al.*, 2004). It also reproduces vegetatively through auxiliary shoots. The meristematic zone is the active coppicing zone. Coppicing will be profuse from this zone after burning and chopping at the base. This is the reason behind many unsuccessful removal efforts. Therefore, we recommend 'Cut Root Stock' (CRS) method.

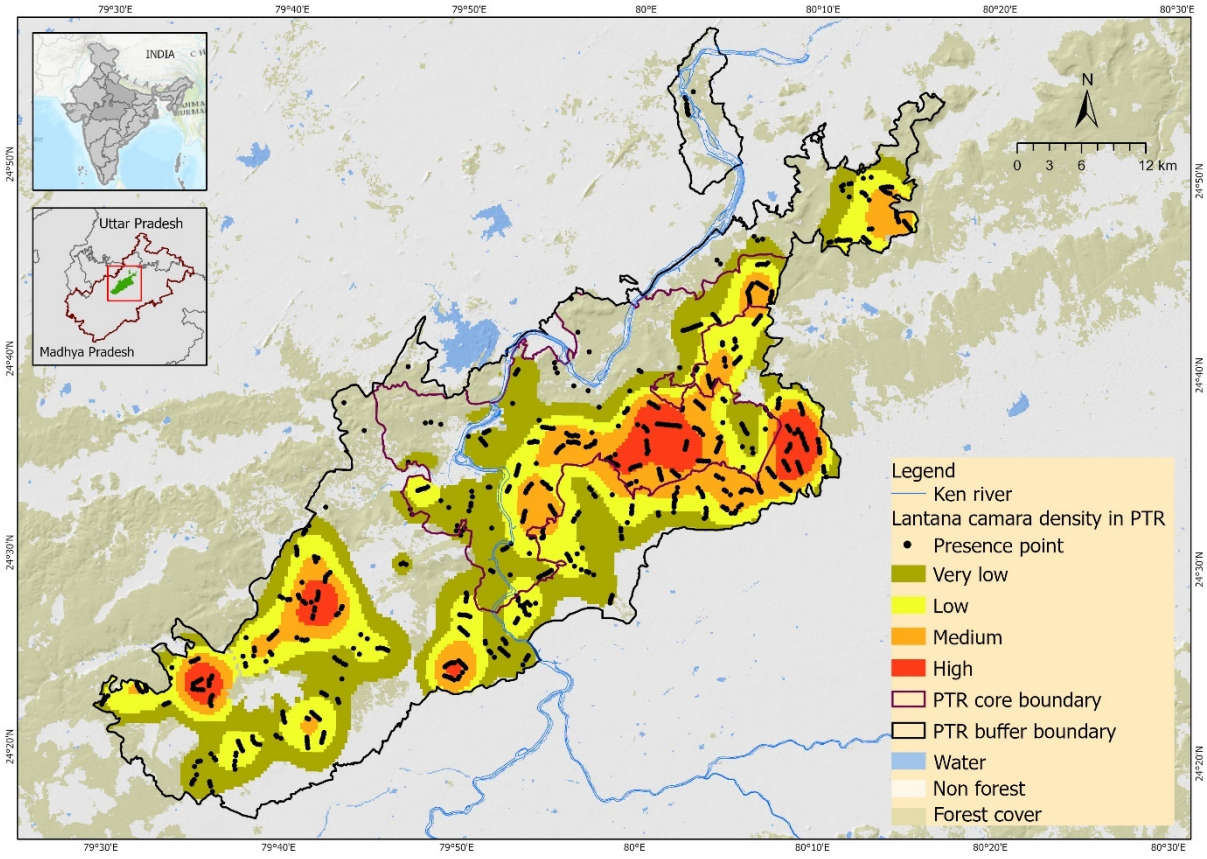


Figure 7.14. Map showing *Lantana camara* density in PTR

Centre for Environmental Management of Degraded Ecosystems (CEMDE) has developed CRS as a cost-effective method for *Lantana removal* (CEMDE 2007, Pathak *et al.*, 2006) (Fig. 7.15). This practice has been successfully implemented in some forest areas by state forest departments. In Corbett TR, a modified strategy was used for the same which involves (1) removal of *Lantana* by CRS and (2) restoration of the same area to grasslands.

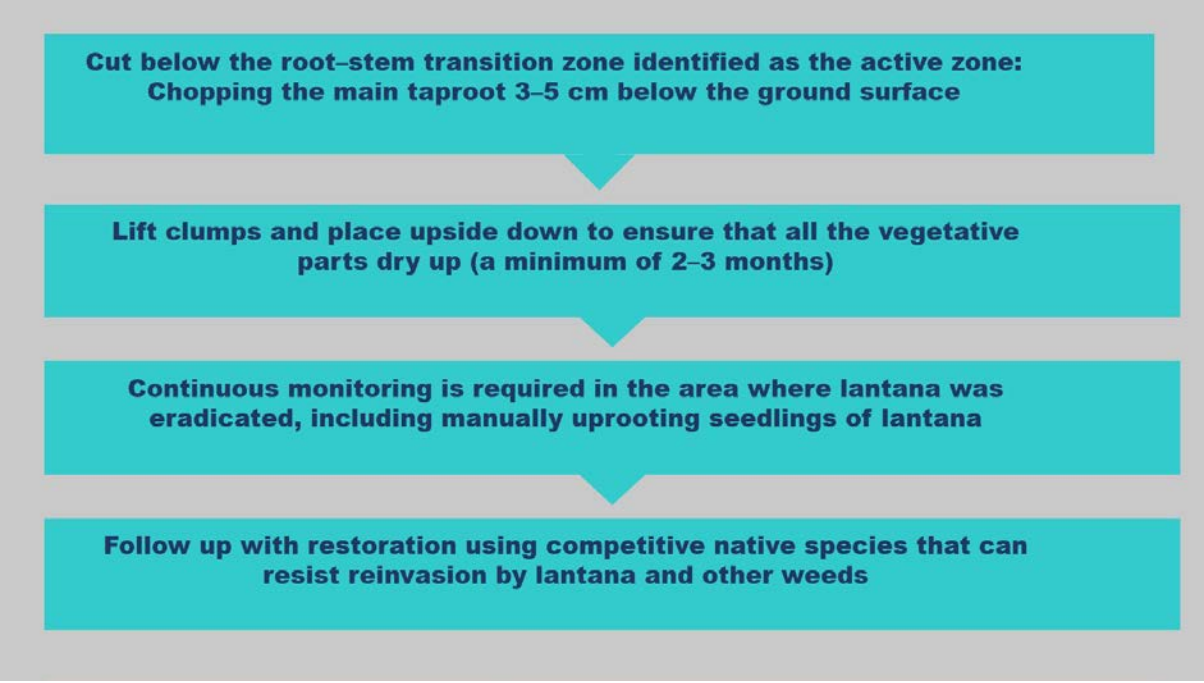


Figure 7.15. Cut Root Stock (CRS) method for *Lantana camara* removal

Decision to remove lantana should be taken cautiously as lantana also provides cover to animals specially in the areas which are disturbed and where no other vegetation is thriving due to prevalent disturbances such as logging, livestock grazing etc. For such areas, restoration should be strategised to take care of it for long-term and with involvement of local people.

CRS method can be used for lantana removal in landscape areas where there is high infestation such as Satna (Unchehra, Maihar ranges), South Panna (Pawai, Shahnagar ranges), North Sagar (Shahgarh, Banda ranges), South Sagar (Deori, Rehli ranges), Damoh (Singrampur, Buxwaha, Hatta ranges) and North Panna (Panna range) Divisions. Again, it is important to consider those areas which already have enough cover for protection of animals and where restoration can be implemented for long-term.

In the buffer region of PTR, as livestock grazing and lopping activities are present, it is important to consider long-term effectiveness of the restoration efforts. In core region of PTR, experimental design for removal of *Lantana camara* has been proposed. Instead of block design as prescribed elsewhere, we propose channel design. As the region where Lantana density is high (Talgaon, Bundela Baba, Katari, Mahua mod, Kandwaha, Kudan, Rampura region of Panna Range) also has a good density of tigers and provides cover for herbivores, the channel design takes care of cover as it does not introduce abrupt changes to animals and to the area itself. Further, it provides passage for movement of animals. As core areas is protected, the long-term strategy can be successfully exercised. A 50 m wide channel, starting from one

forest trail and opening into another, crossing through the lantana infested area provides structure design for this method (Fig. 7.16). Lantana should be removed from the channel using CRS method during monsoon season. The channel should be monitored in each growth season to check further invasion of lantana and the channel should be supplemented with native herbs and grasses. Grasses grow fast and spread over the channel rapidly and compete with weeds for occupying the cleared area. These grasses would also provide forage to the wild animals.

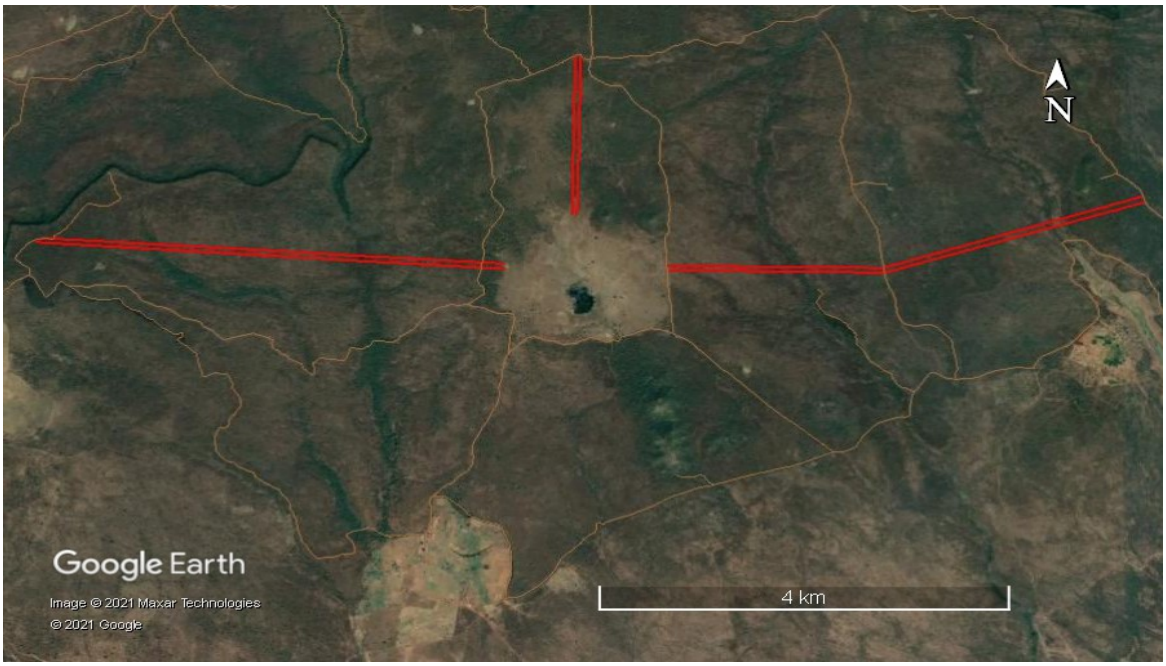


Figure 7.16. Experimental design for *Lantana camara* management in PTR (red line: 50 m wide channels, brown line: forest roads)

Management of Hyptis suaveolens **(Van tulsi):** Van tulsi is another dominant weed in this landscape. It is an annual herb which shows very aggressive invasion and is considered as one of the world's most noxious weeds. It propagates, after monsoon, through root stock or seeds from persistent seed bank on forest floor or from fresh stock (Raizada, 2006). Properties that make it successful invader are prolific seed production, seed dimorphism, probable chemicals and oils resisting various pathogens and it is unpalatable hence avoided by wild and domestic ungulates (Raizada, 2006). It is a major threat to native floras and fauna. In GPL, interpolation map shows the presence of Van tulsi in almost all the forest divisions, but mostly in low to very low density (Fig. 7.17)**.** High density is observed in PTR and adjoining areas. In PTR, Van tulsi is patchily distributed in both core and buffer areas (Fig. 7.18), although buffer areas have denser patches**.** It is the result of high anthropogenic disturbances such as livestock grazing in the buffer areas. Fig. 7.19 provides details of control measures which are found to be effective.

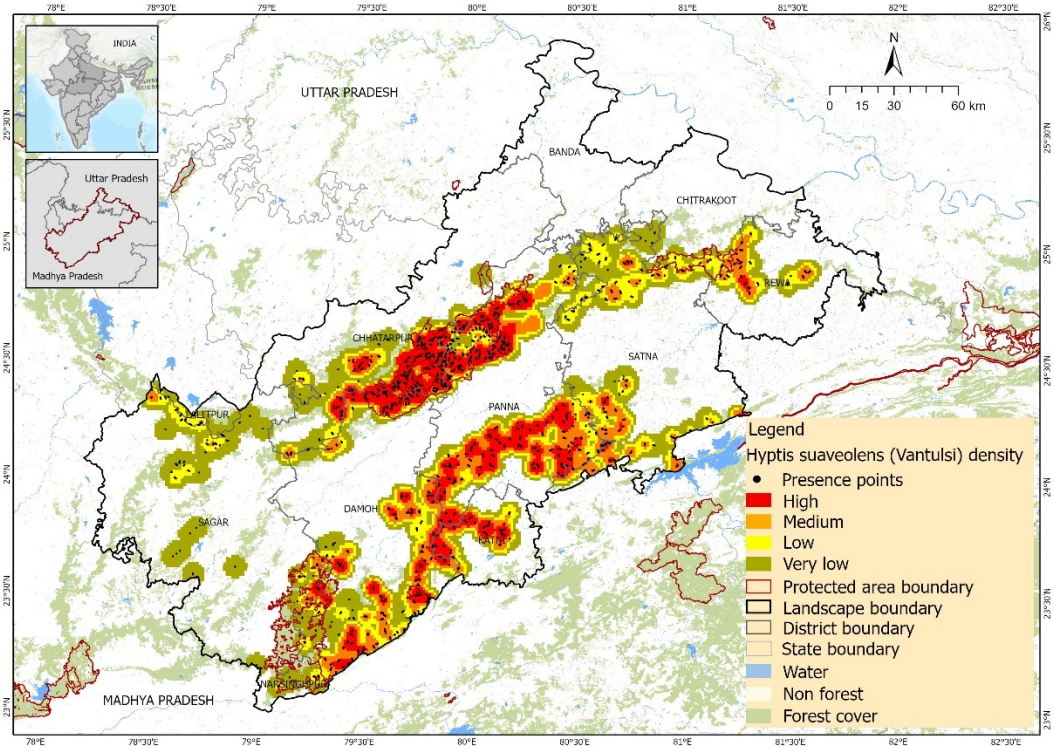


Figure 7.17. Map showing *Hyptis suaveolens* (Van tulsi) density in Greater Panna landscape

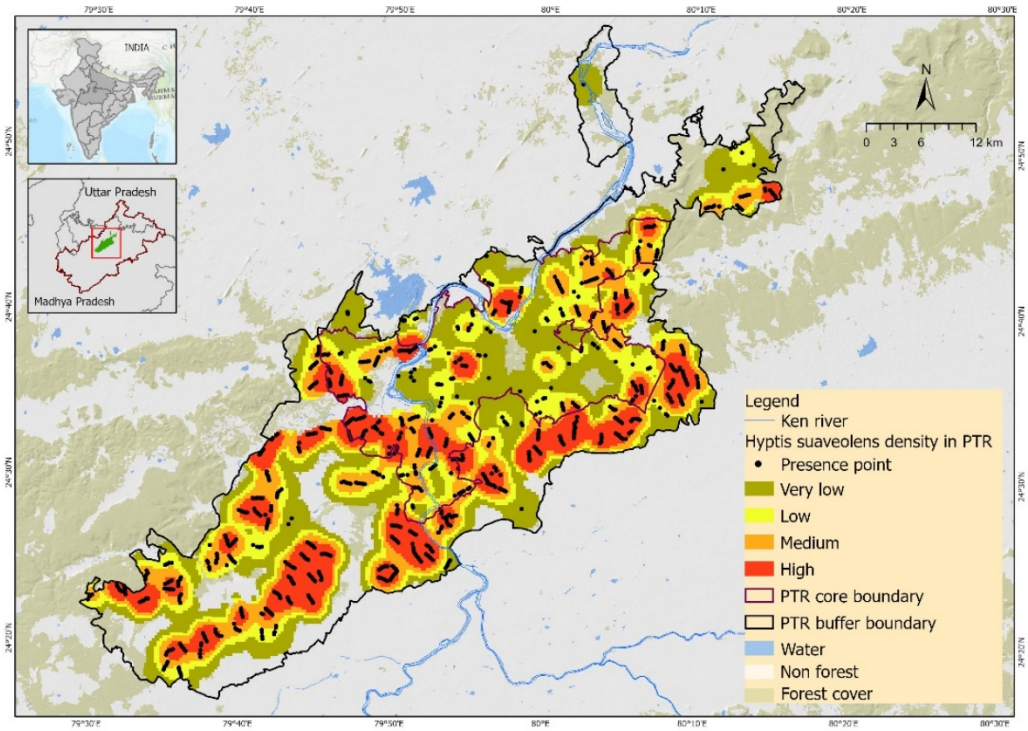


Figure 7.18. Map showing *Hyptis suaveolens* (Van tulsi) density in PTR

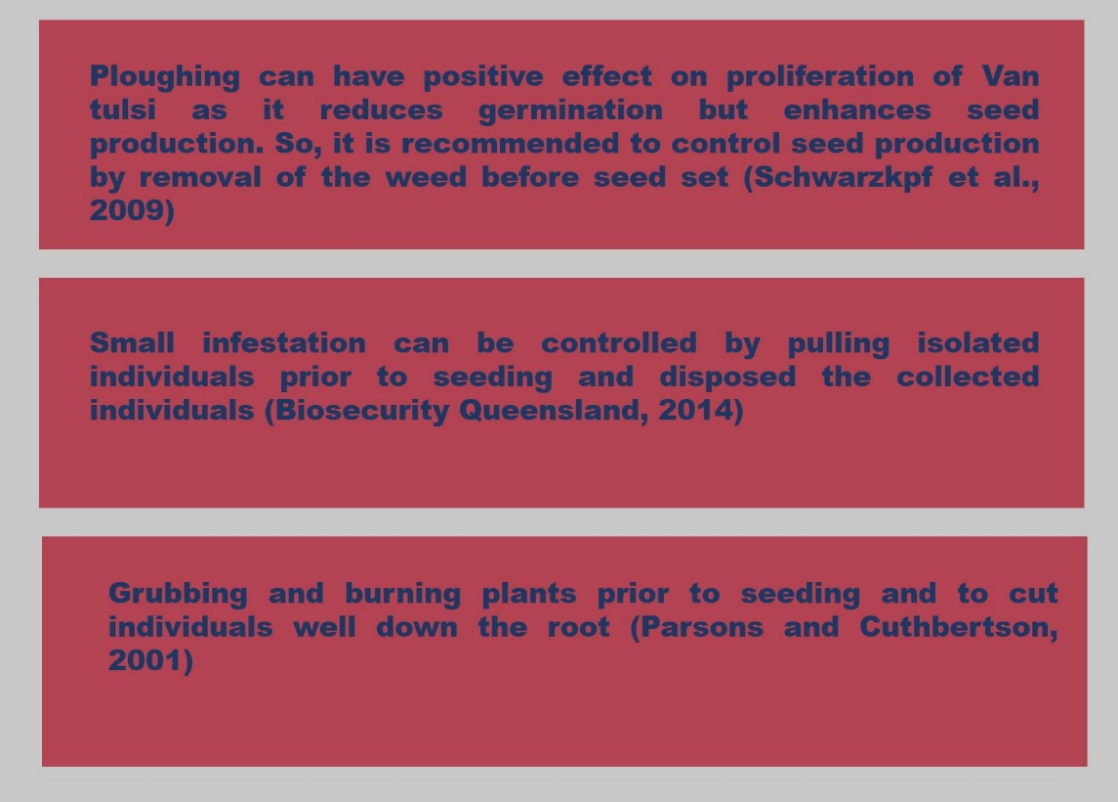


Figure 7.19. Control measures for Van tulsi

It is important to notice that this species can be controlled only if seed production is halted. Areas in GPL and PTR having high infestation can be focussed on, for example in the landscape areas such as South Panna (Pawai, Shahnagar), Katni (Rithi, Bahoribandh), Damoh (Tarradehi, Singrampur, Tendukheda, Sagoni), Nauradehi Wildlife Sanctuary (Sarra, Mohli, Jhapan), Satna (Unchehra, Maihar, Badamalhera, Buxwaha, Singhpuri), North Panna (Panna), Rewa (Semaria), while in PTR core, areas such as Hinauta (Khamri North, Majhauli, Badgadi A, Jhalar), Panna (Mahua Mod, Itwantek), Chandranagar (Motachaukan, Bhusor, Brijpura, Narauli), Madla (Madla, Pathanjhiriya, Umravan, Bakchur, Bardhau) and Gangau Sanctuary (Rampura); and in PTR buffer, areas such as Kishangarh (Biharwara, Purva, Jaitpura, Bila, Vasudha, Matipura), Madiadoh (Piparchowk, Madiadoh, Manikpura Part 1, Udaypura), Amanganj (Siri B, Motowa, Gahdara, Jaswantpura, South Talgaon) and Panna (Bandhi North, Amjhiriya, Ranipur, Dhalanchauki B) can be prioritised for van tulsi removal. Individuals should be removed, before the onset of monsoon, collected and disposed. Then areas can be restored by seeding of native grasses and herbs. Plantation of trees, where it can be successful for long-term should be done. This cycle must be continued each year until the complete removal of the infestation is achieved and native flora has been established successfully. The restored area should be monitored at regular intervals to monitor signs of infestation in future.

(iii) Establishment of Seed Banks and Nursery: Seed banks and nursery are the source of providing seeds or plantings for any restoration purposes. The demand of species for restoration can only be met by an established nursery. As in many restoration activities, it is required to plant species for certain years so that it can establish successfully because the initial success rate is always low. As in the current situation, most of the forest areas do not have dedicated nurseries so their afforestation activities depend on the availability of only a few species in nurseries they have a contract with. This makes it imperative for seed banks and nursery establishment so that recommended species can be available for effective restoration activities at regular interval and when needed.

- Mostly tree species are given priorities in nursery propagation and so in afforestation activities. But it is important to collect seeds of grasses for promoting them for restoration and management of grasslands, riparian areas, wastelands etc. This will also help in pastureland development in future, when needed.
- For collection of seeds of legumes and preferred fodder grasses, September - October is the best period of flowering and fruiting.
- Nursery will provide employment opportunities to local people. It is recommended to establish a nursery in village such as in the case of PTR, it can be the village in the buffer area. The local people will be trained and will be the owner of the nursery.
- A structure can be built collaboratively between the forest department and the local communities in selected villages. The local communities working in the nursery (which can take the shape of dedicated EDC) will collect seeds from the forest and propagate in the nursery. Forest department will state the amount and type of species to be propagated. This not only will engage local people in restoration activities, but also provide them the sense of importance of such activities.
- This will provide a proper channel of demand and supply when needed. And depending upon the demand and location, more than one nursery can be established. In PTR, it can be the villages near Kishangarh and Hinauta. In the landscape, each forest division should follow the same and identify their villages.

(iv) Management of Grasslands: Grasslands refer to vegetation community predominated by graminoids i.e., grasses and grass-like plants. The major families found in the grasslands are Poaceae, Cyperaceae, Fabaceae and Asteraceae. Local communities in GPL have high dependencies on grassland patches for rearing their cattle/livestock as it is one of the major

livelihood options in this landscape. Therefore, it makes this ecosystem a very economically valuable ecosystem. However, high pressure of uncontrolled grazing make grasslands patches vulnerable. This has led to degradation of soil, micro-flora and fauna, extinction of palatable vegetation, proliferation of grazing resistant weed species and ultimately loss of diversity and gene pool of native grass species. GPL and PTR have grasslands mostly in patches, surrounded by open or dense forest and/or scrub land and/or degraded lands. Unless they are in protection as in the case of PTR core, they have huge pressure of over-grazing by livestock. These grassland patches are habitat of wild and domestic herbivores, birds, herpetofauna, etc. The framework for management and augmentation of existing grasslands patches need to adopt the following stepwise approach:

***Step 1 - Inventory*:** Grassland survey for quantifying the vegetation community composition, grazing intensity by wild or/and domestic ungulates, habitat use by wild animals such as mammals, birds, etc. A buffer of 100 m to 500 m around the grassland patches should also be surveyed to assess the vegetation composition around. This will help to understand the current, as well as a probable invasion of species from the buffer into the grassland patches.

***Step 2 – Identification of Dominance and Composition*:** Based on survey, dominant grass community composition in grassland patches can be identified. Dominant grass composition will help to understand the current grass development and successional stages, as also preparation of the list of grasses and other vegetation present with grasses like trees and their recruits (saplings and seedlings), shrubs, herbs, sedges, reeds and climbers etc. Grass species composition can be categorised based on their ecological role, palatability, nutritional value and functional traits. Some of the general attributes which are important for management or restoration purposes are, (1) grass height (tall or short), (2) palatability (high, medium or low), (3) Habit (perennial or annual).

***Step 3 – Determination of Habitat Quality*:** Intensity of grazing by wild and domestic ungulates determine availability of good quality forage and dynamics of native-exotic plant species. Percentage coverage of trees and shrubs species. Identification of species such as trees and shrubs which are infringing in grasslands, their level of spread and their role for grassland integrity and importance in facilitating grasslands dependent wild species like birds, mammals etc. Invasive and weed species are more competitive and adaptive than their native counterparts and hampers their growth. Determining coverage of invasive species will help to understand the level of intervention needed for eradication of such species.

***Step 4 – Habitat Manipulation and Augmentation*:** Managing this productive ecosystem requires a holistic ecological approach, proposing short term, as well as, long term adaptive planning. Such grass patches are seral in nature, hence, can either be invaded by shrubs species or/and weed species or/and woody species. Therefore, management of grasslands require persistent efforts while experimenting with different strategies and can take the following actions:

- All gregarious and fast-growing annual weeds should be uprooted, dried and burnt before the month of May. Second and third round of weed removal should be done during July and September – October before they flower and fruit. Removal of weed species should be done 3-4 times in a year.
- Unsuitable and unpalatable grass composition should be removed each year until the palatable grass cover increases. *Desmostachya bipinnata* (Kush) and *Imperata cylindrica* (Kusa) rapidly invade moist areas and degraded wet areas. *Saccharum spontaneum* (Kans) is a perennial palatable tall grass found in marshes and flood plains. This species out-competes other grasses by formation of dense bunches and limiting light-demanding species. The species tend to colonise exposed silt plains created by the retreating monsoon floods. *S. spontaneum* and *I. cylindrica* colonise areas where wet soil is exposed by persistent burning and grazing. *S. spontaneum* also promotes fire and vice-versa. It is very important to plan control measures to check the growth of these aggressive species.
- Based on grassland area and shrub invasion, some percentage of the total area should be kept under shrub land (native browse species and wild fruit bearing), as such habitat is used by animals for resting, browsing, nesting etc. Excessive shrub coverage can be removed.
- Based on grassland area and tree coverage, some percentage of tree coverage (native browse species and wild fruit bearing) should be maintained, and excessive growth of trees and their recruits should be removed cautiously.
- Propagation of palatable grasses by seeding or planting with formation of mosaic patches after removal of unsuitable grass species, shrubs species and weed species should be done. Mosaics include grasses of different height (tall grasses and short grasses), palatability and habit (annual and perennial).
- Dribbling of good quality seeds before monsoon, and grass tussocks should be planted during monsoon.

- Legumes should be sown before the onset of monsoon (second half of May to first week of June). It is important to decrease the intensity of grazing by livestock, if any. Practices such as rotational grazing etc. should be exercised. Over-grazing in any restored area should be avoided, by fencing the area.

***Step 5 - Monitoring of Grassland Patches*:** The management inputs should be reviewed each year and necessary measures should be adopted based on status of grasslands and habitat use by wild animals. Involvement of local people in management of grasslands and monitoring will be helpful wherever possible.

(v) Grassland Management in Landscape and Buffer Areas: Open forest, degraded and so called waste lands and also areas where afforestation practices can be unsuccessful due to high pressure of local communities on forest for fuelwood, have high potential for development of grassland under the Silvipastural model. Areas such as territorial forests in the landscape and buffer area of PTR comes under such category. Some of the measures for development of grassland in such areas are:

- Under the umbrella of Joint Forest Management/ Ecodevelopment or Social Forestry / Agroforestry/ MGNREGA schemes, grassland development can be carried out in selected villages where land is available.
- Such areas can be developed into grasslands for wild species as well as pasture lands for livestock grazing. Grasslands will be restricted for livestock grazing through fencing. Area of pastureland to be developed can only be determined by knowing the cattle population in the surrounding villages. It has to be ensured that pastureland support carrying capacity of livestock.
- Exclusion of developing grassland from grazing will help in increasing grass productivity, recovery of palatable grasses etc. Fencing of smaller strips till the establishment of grassland patches and shifting of fences is recommended till the larger areas are covered under stable grassland patches.
- In pasture lands, rotational grazing can be exercised so that grass quality and productivity can be maintained, in addition to avoiding degradation due to overgrazing.
- Tree planting with temporary enclosures of wire mesh at frequent intervals can be done for a period of 5 years to allow establishment of tree species (native browsing and fruit bearing). It is important to ensure protection with involvement of local people. However,

species such as *Ziziphus mauritiana* and *Ziziphus nummularia* need to be avoided as this is one of the species, which takes over the grasslands very fast, as their fruits are eaten by Jackal, Sloth Bear, wild pig and after getting treated by passing through their digestive track are dispersed and then grow in clumps. Many of the pure grasslands are also degraded due to this, spread.

- Establishment of grass banks for storage of grasses for fodder use. Grasses from developing pastureland can be cut and stored in go-downs for fodder availability during the scarce period. This will help in formation of organised cattle feed security system. The surplus grass production during monsoon period should be well preserved. Post-harvesting technologies like biomass processing, enrichment and densification may also be practiced. While developing grassland it should be done in blocks and maintained as blocks so that open gazing can be allowed in some and others exclusively secured for cut and storage. All this needs to be planned according to the number of livestock and the fodder demand.
- The stall-feeding practice can be encouraged so as to remove pressure of grazing on forest areas. Gradual reduction of scrub cattle with replacement by local breeds.
- It is important to generate employment for local people by their involvement in different stages of restoration activities. Involvement of local communities in such activities will also gain their support for management and conservation.

(vi) Grassland Management in PTR Core Area: PTR has vacated village sites as major grassland patches dominated by grasses and herbs and scattered trees and their recruits. But these are also occupied by weeds and threatened by increasing invasion of trees. These sites are habitats for resident as well as migratory grassland birds and typical grassland ungulates such as chital, chinkara, nilgai etc. They are an important source of fodder and provide forage during scarce periods but require robust planning and scientific management to sustain these as grasslands. Experimental or adaptive management setup has been proposed for management of relocated village sites.

Experimentation includes use of fencing and some treatments annually. The relocated village site will be divided into four equal parts. Feral cattle are present in few of the sites. One part will be fenced, and few feral cattle will be restricted to that part with the use of fencing (A-Controlled Grazing). All other three parts will be open for grazing by wild animals. Out of the remaining three-part, grass cutting will be done to the next part (B – Cutting), grass burning to the next (C – Burning) and no intervention will be provided to the last part (D- No Intervention)

(Fig. 7.20). One area (square or rectangle) in the middle of the relocated village will be fenced and used as control with no intervention and excluded from grazing (E – Control). An example of which is shown for Jhalar village site (Fig. 7.21). This area will be used for long term monitoring of the grassland. The intervention or treatment will be provided at first year and rotation of each experiment will happen simultaneously in each year. The experiment will be initiated in two vacated village sites (Jhalar and Badgadi). In other relocated villages, augmentation/management can be done as mentioned in the framework above. Species that can be considered for augmentation and restoration are described in the following sections.

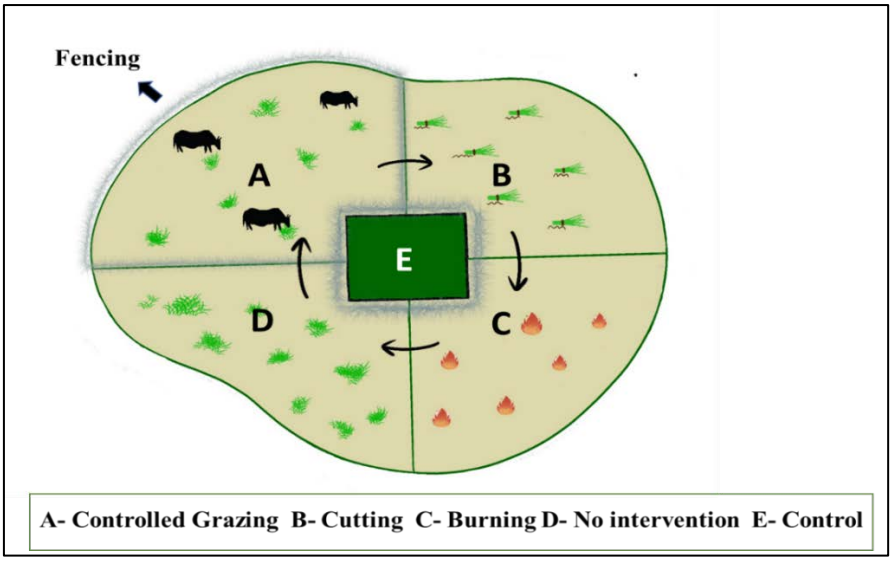


Figure 7.20. Diagrammatic representation of experimental grassland management in vacated village sites

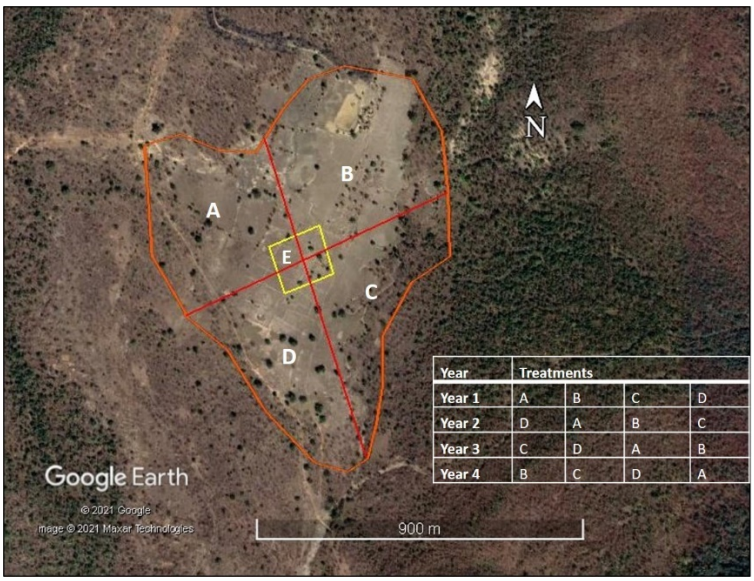


Figure 7.21. Depiction of experimental design for Jhalar village site

(a) Grass species for degraded areas and areas occupied by weeds: *Sehima-Dichanthium* composition should be promoted in degraded areas and areas occupied by weeds, as they are highly palatable and important for this landscape. These species should also be introduced in *Themeda-Heteropogon* large patches to maintain the diversity and habitat suitability of grasslands in PTR. *Chrysopogon zizanioides* (Khas) is another palatable species that can be used for restoration of riparian zones, degraded slopes, shoreline of ponds, swamps etc. *Chrysopogon fulvus*, another perennial palatable species of the same genus can be promoted in rocky degraded areas. *Oplismenus burmannii* (Patta Ghans) and *Digitaria* sp. Such as *Digitaria stricta*, *Digitaria cilliaris,* and *Digitaria sanguinalis* can be used for substrate formation of riparian zone, shoreline of ponds, swamps and also open forest.

(b) Palatable grass species for restoration purpose: Important palatable grass species recommended for restoration purposes are *Cynodon dactylon* (Doob), *Chloris dolichostachya, Chloris virgata, Themeda quadrivalvis, Iselima laxum, Paspaladium flavidium, Bothrichloa sp., Brachiaria sp., Setaria sp., Arthraxon sp., Cenchrus cilliaris, Panicum sp.,* and *Dactyloctenium aegypticum.*

(c) Herb species for restoration purpose: It is equally important to plant native leguminous herbs for restoration purpose in combination with grasses as they help in soil enrichment such as *Echinocloa-Sporobolus-Eleusine-Desmostachya* combinations.

7.2.2. Measures for Riparian Habitat Management/River Conservation Zone: As discussed earlier, based on river ecology, riparian habitat and surrounded landscape, zonation of riverbanks has been proposed along key stretches of Ken River (Fig. 7.22). Accordingly, the riverbanks (both left and right banks) have been divided into three zones from the edge of the river. These are Zone 1 (Protected Core Zone), Zone 2 (Integrated Farming and Social Forestry Zone) and Zone 3 (Status Quo Zone).

***Protected Core Zone*:** It forms the core of the river with 25m on either side of the river, making 50m width zone all along the identified stretch of the river. It will be a protected zone with major focus on restoration and habitat integrity under conservation and forestry framework. The interventions include soil work for bank stabilization, concrete work for prevention of erosion, restoration of bank vegetations involving forested buffer strip, grass buffer strip and combination of forest and grass buffer strips. Riverbanks with less erosion require grass buffer strip while combination of grass and forested buffer strip is recommended in areas with high erosion or mass bank failure. Complete protection and management of plantations must be

ensured with the involvement of local people in this zone, where required. This zone should be restricted from lopping, grazing and other domestic purposes and wherever the communities are currently using, need to be regulated through participatory and incentive approach. Inside PTR, RVI map (Fig. 7.6) provides a basis for developing this zone and accordingly, it is important to focus on low to medium RVI with soil and vegetation restoration activities.

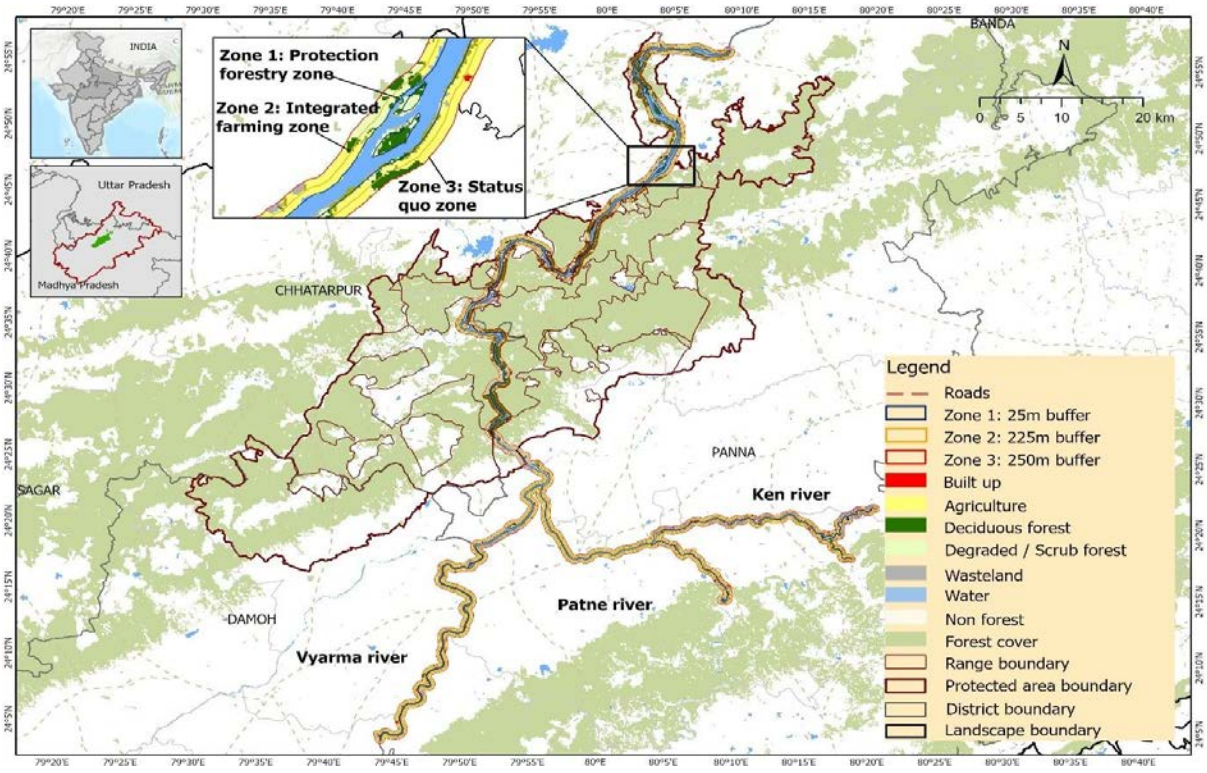


Figure 7.22. Proposed River Conservation Zone/Community Reserve

***Integrated Farming and Social Forestry Zone*:** Along the core zone, there would be two parallel zone of 225m width on either bank, which together with core zone makes 500m width. This is to be promoted for Social Forestry in government as well as private lands and integrated farming in agricultural areas. This zone will help in promotion of additional income from alternative options as well as intercepting contaminants from multiple physical, chemical, hydrological and biological processes. It is a system that connects specialized primary activities such as agriculture farming, poultry, livestock keeping, apiculture, and other livelihood options to meet local needs. It is recommended to examine local capacities for agricultural alternatives at the outset, and then offer tailored choices. Livestock-Fish Integrated Farming, Livestock-Honeybee Integrated Farming, Poultry-Fish Integrated Farming, and so on are some of the conceivable integrated farming combinations. This zone will be used for agro forestry/social forestry as well. Planting trees and other vegetation adjacent to agricultural fields will provide

income including carbon credit system and will also filter and uptake concentrated agricultural runoffs, thus acting as buffer, and maintaining integrity of protected core zone. Some parts of this zone having agricultural fields adjacent to riverbanks such as Akona Beat of KGS and Nehri, Bagounha, Lalar, Bhusor, Mahadev Ghati, Gangau, Palkoha Beats of PTR are already protected by the existing legislation of PTR and KGS, specifically from any development projects. Addttionally, suitable sites and villages along the zone should be selected for promoting conservation awareness and tourism activities which can support the local economy.

Status Quo Zone: Following the parallel zone of 225m on either side of core zone, there would be two parallel zone of 250m on either side of the second parrel zones. All these zones together make up for 1km zone all along the river. It is designated as Status-Quo Zone so that the current land-use can be maintained, and any change should only be towards carbon positive development. No industrial development should take place along these river course.

In riverbanks of Bearma, Patne and Ken River outside PTR, most of the river stretches have agricultural fields reaching close to the river, although there is no village along the river stretch. Further, the riparian vegetation width in most of the stretches is very narrow and if present, mostly less than 10m. The major challenge will be promotion of Core Zone activity in agricultural lands, although it is not impossible if communities are engaged with suitable alternate options such as incentives or buying the small stretch of the area for river conservation. In the Zone 2, there are no industry or large infrastructures in the identified river stretches and this is a big advantage to restore the area. Given that the landuse in all the three zones consists of both government and private lands, it will be important to consider the Riparian Zone (of 1km width *i.e.,* 500m on either side of the identified river stretch) to be declared as Community Reserve and subsequently as Eco-sensitive Zone, and this zone should be managed based on a dedicated Zonal Master Plan. For this purpose, land ownership records must be procured. This would ensure conservation and livelihood security for the local communities in the long-term.

7.2.3. Measures for Management of Wetlands/Ponds: Management of freshwater bodies such as ponds is essential for managing water level, water quality, substratum and surrounding land and conservation of waterbirds, herpetofauna and other wildlife dependent on them. This landscape has many artificial as well as natural ponds, but their management is often neglected. As the landscape is mainly dry, due to scarcity of water in summer season and prolonged dry condition, succession may happen which can lead to increase in vegetation. This further

impacts the pond substratum and pond micro flora and fauna. It will also make the ponds unsuitable for waterbirds and winter visitors. The framework for management and augmentation of wetlands can take the following steps.

Step 1 - Water Source and Quality Survey: Site hydrology is an important factor to be considered for restoration or creation of wetlands. It is very important to know inflows and outflows of ground and surface water, water level, and duration of soil saturation. Based on that, the wetland/ponds can be created, and water level can be maintained in existing ponds during summer through formation of artificial channels and identifying the inputs of materials from surrounding areas to the wetlands/ponds that can influence the water quality. Such inputs should be checked. Livestock grazing and bathing is also common in ponds. Overgrazing can be detrimental to pond substratum and can also lead to weed invasion. Therefore, it must be checked.

Step 2 - Substrate Management*:* Ponds/wetlands are characterised by hydric soils, which remain flooded during monsoon. Most of the chemical reactions happens in soil. To maintain soil chemical composition, moisture and augmenting substratum mulching can be done. It increases soil organic matter and facilitate rapid revegetation by reducing runoff, soil loss, soil erosion, and compaction and crusting of surface. Prior to these interventions each of the water bodies need to be assessed for desilting requirement and should be carried out under relevant expert guidance.

Step 3 - Formation of Vegetative Buffer*:* Vegetative buffer can be formed with certain width around the ponds/wetlands based on adjacent land use and requirement of wildlife. Buffer helps to trap and prevent undesirable materials from entering the surrounding landscape and provide habitat for wildlife. Combination of tree and grass buffers can be very useful for nesting, roosting, and breeding of wild animals. Vegetative buffer will also help in water storage and ground water recharge. Native species adaptable to varying range of water depths should be selected that can rapidly spread and stabilise the substrate and also have potential importance for wildlife.

Step 4 - Monitoring of Ponds*:* Long-term management by careful monitoring of water level, restoration activities etc. should be done annually. For understanding the importance of wetlands/ponds particularly in this landscape, four major wetlands/ponds of PTR (Gangau Dabri, Chamra Dabri, Talgaon and Raipura ponds) were identified as important ones. These are home to herpetofauna, water sources to mammals and attracts resident as well as migratory

birds. Likewise, each forest divisions should identify, protect and monitor their major wetlands/ponds, and these may be done during plan implementation process.

7.2.4. Measures for Conservation of Rare Floral Species: Among the floral species, *Pterocarpus marsupium* (Beeja) is Near Threatened (NT) and its population is declining. *Dalbergia latifolia* (Pahadi Sheesham) and *Chloroxylon swietenia* (Bhirra) are Vulnerable (VU) and their population is declining. Bhirra is not found in PTR and its range is almost restricted to the western area in the landscape including Sagar and Damoh Divisions where there are large forest stands. Otherwise, it is not observed in rest of the landscape (Fig. 7.23). Beeja is a very useful medicinal plant and recorded in very few areas having some level of protection. Beeja cannot survive in this landscape until protected. Pahadi Sheesham has premium quality timber and is present in very few areas now. *Terminalia arjuna* (Arjun) is a specialist and a dominant species of the riparian fringe forest. They are essential for stabilising stream banks and maintaining water quality. Arjun trees usually attain great heights and girth. The huge crown is suitable for aiding in nesting of water birds and vultures and besides providing palatable leaves and fruits to wild animals.

Seven species of Ficus, the keystone species, are found in the landscape including *Ficus benghalensis* (Bar), *Ficus hispida* (Hairy fig), *Ficus microcarpa* (Laurel fig), *Ficus mollis* (Son Pakhad), *Ficus racemosa* (Goolar), *Ficus religiosa* (Peepal) and *Ficus virens* (Pakhad). Other than Bar, Goolar and Peepal, all other Ficus species are very rare. Ficus trees maintain an ecosystem of their own for many taxa like primates, avifauna, herpetofauna etc. *Vitex negundo* (Nirgudi) is a shrub species found in moist and marshy areas such as around streams, ponds and can be considered as a keystone species. It has a high medicinal value. Many birds and butterflies feed on its flowers. Leaves are also palatable to wild animals. Similarly, *Carissa* spp. is another very potential suitable shrub that can be grown in and around these habitats. These are to be protected from lopping and cutting. Some selected tree species that are very rare but important for this landscape are *Dalbergia lanceolaria paniculate* (Dhobin), *Dalbergia lanceolaria* (Dhamasi), *Careya arborea* (Kumbhi), *Kydia calycina* (Baranga), *Terminalia chebula* (Harra), *Desmodium oojeinense* (Tinsa), *Grewia orbiculate* (Dhamna), *Grewia tiliifolia* (Dhaman), *Casearia graveolens* (Gilchi), *Cordia myxa* (Risalla), *Morinda pubescens* (Aal), *Cochlospermum religiosum* (Gabdu), *Alangium salviifolium* (Akola), *Hymenodictyon orixense* (Bhormal), *Schrebera swietenioides* (Mokha), and *Crateva adansonii odora* (Barna). Such tree species have a bleak future specially in territorial and PTR buffer where protection is very less. These species are rare and usually not used in restoration activities by forest

department or other agencies. Such species should be conserved by nursery propagation and promoted for plantation purposes.

The status of *Boswellia serrata* (Selai) is Not Evaluated (NE) in IUCN red list but it is considered Vulnerable (VU) in Madhya Pradesh and Orissa (Biswal and Nair, 2008; Chaubey, *et al.*, 2015) and as Critically Endangered Possibly Extinct [CR(PE)] in the National Red List of Sri Lanka (MOE, 2012). In GPL, selai resin is collected for its high medicinal value. Traditional harvesting method can be very destructive. Considering its over harvesting, less regeneration, patchy distribution and unorganised NTFPs market, it is considered as a species of high threat. Some vegetation species are in huge pressure specifically in territorial forest and PTR buffer, where grazing of livestock, specifically goat is high. *Catunaregam spinosa* (Mainhar), *Ceriscoides turgida* (Karhar), *Flacourtia indica* (Kaanker), *Naringi crenulate* (Bilsena), *Nyctanthes arbor-tristis* (Siharu), *Ziziphus xylopyrus* (Ghont) and *Gymnosporia senegalensis* (Bakul) are highly palatable (leaves, fruit, bark) and are a good food source for both domestic and wild animals. Growth of these species is stunted due to over harvesting as fodder for livestock and continuous browsing. It is quite rare to see a full-grown tree of these species. PTR core has full grown trees of these species due to protection. Mostly stunted form of these species is encountered, as they are foraged regularly and intensively by livestock and even immature coppices are cut by locals for feeding their livestock. Some of these species like Siharu and Bakul are rare and patchily distributed and need conservation.

Tendu leaf and Mahua flower are two major NTFP collected from the forest. Tendu leaf is used for bidi making and mahua for making a traditional drink. Mahua seed is also collected for extraction of medicinal oil. Other forest produce extracted are Bel, Achar and Amla mainly because of their demand in cities. Fruits of these species are sold nationally. Tendu fruit also has a good local demand. Every year, seasonally, a large amount of these species is harvested legally and illegally and sold in the market. Forest department also has working circles for each of these species. These species are the most over-harvested species in this landscape. This has affected the growth, structure, reproduction and regeneration of these species. Not just for humans, these species are very essential food source for wild animals. So, it is important to check and regulate over harvesting and organise the extraction, collection and selling of these species. Although bamboo is present patchily in this area, it is an important NTFP. Bamboo plantations are done by forest department especially in degraded areas where tree plantations may not be successful. Bamboo grows very fast and provides shade to wild animals. It is also a good source of food. *Dendrocalamus strictus* is a predominant species which thrive in this

dry region. Bamboo is used for making various household items and for construction purposes. Propagation of bamboo can be a good alternative for earning of local people. Bamboo should be publicised in this region.

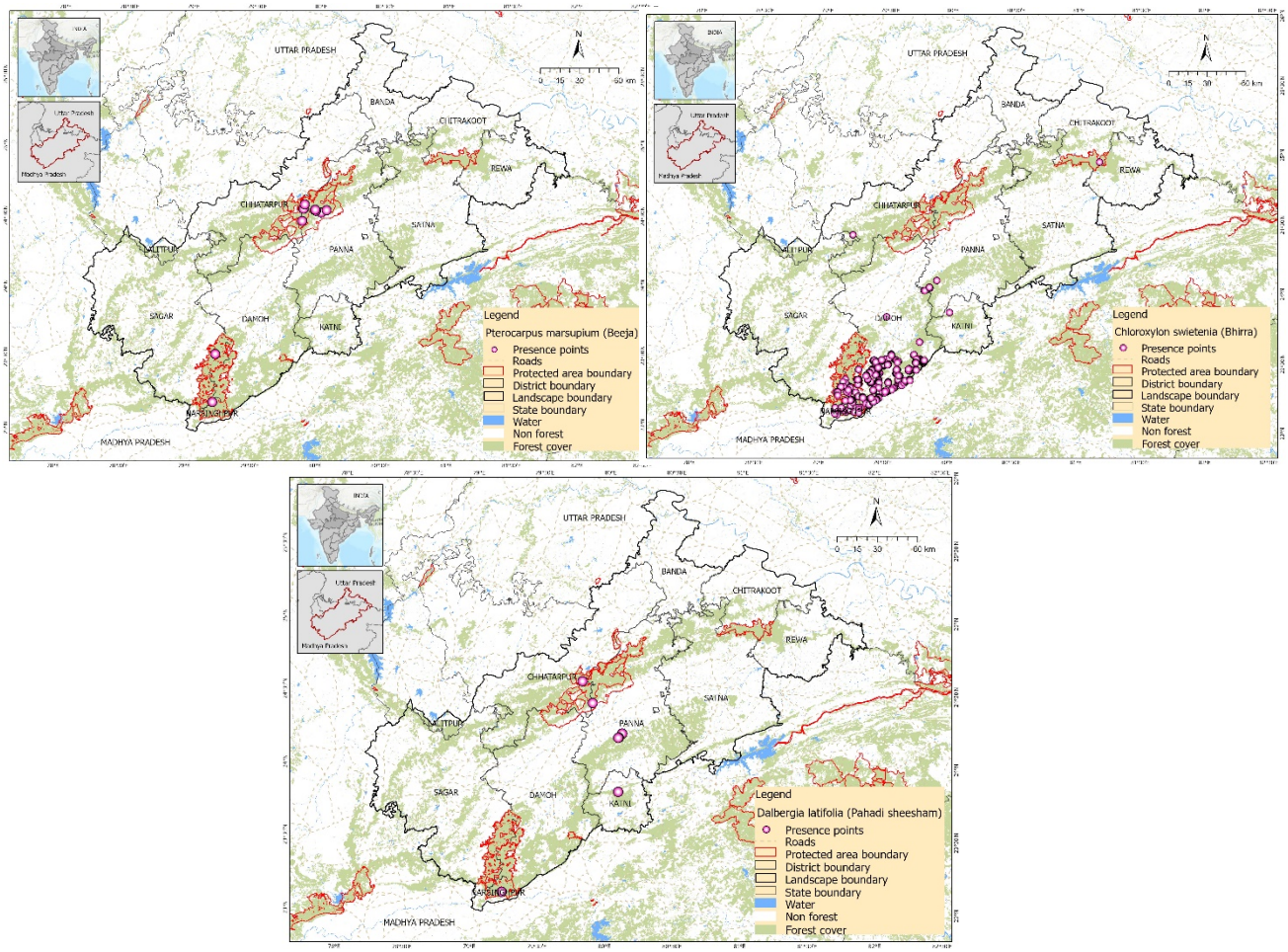


Figure 7.23. Map showing presence of *Pterocarpus marsupium* (Beeja), *Chloroxylon swietenia* (Bhirra) and *Dalbergia latifolia* (Pahadi Sheesham) in Greater Panna landscape

7.2.5. Measures for Conservation of Mammals: Based on the landscape scale survey involving camera trapping methods, baseline data have been obtained. Accordingly, it is recommended to protect the habitats occupied by endangered species like Indian wolf, Dhole (Wild Dog), Indian Pangolin, Sloth bear and indicator species such as barking deer and black buck. Such species can also be preferred for reintroduction in PTR and other suitable areas in landscape. Prioritisation of species groups has also been done towards strengthening overall ecosystem management and conservation goals. Based on relative abundance of the species, Table 7.3 provides the priority areas (ranges in forest divisions) for different species groups, essentially recommending for offering special focus in protection and restoration efforts.

Species have also been prioritised for research and adaptive management in specific priority areas in the landscape (Table 7.4). This will help in initiating and prioritising conservation at species group and species level in different forest divisions. Tiger has been excluded from these analyses as it has been dealt separately in dedicated chapter.

Table 7.3: Species groups and priority sites for conservation management

Mammal	Division	Range
Carnivore	PTR	PTR Core and Buffer
	Ranipur WLS	All Ranges
	Nauradehi WLS	All Ranges
	Damoh	Tendukheda
	Chhatarpur	Buxwaha, Bada Malhera
	South Panna	All Ranges
Herbivore	PTR	PTR Core and Buffer
	Ranipur WLS	All Ranges
	Chhatarpur	Buxwaha, Bada Malhera
	North Sagar	Rahatgarh, Banda
	Nauradehi WLS	All Ranges
	Rani Durgawati WLS	All Ranges
	South Panna	All Ranges
	North Panna	All Ranges
	Rewa	Semaria, Atraila
Primate	Chhatarpur	Buxwaha, Bada Malhera, Bijawar
	Ranipur WLS	All Ranges
	Satna	Majhgawan
	Rewa	Semaria
	Nauradehi WLS	All Ranges
	North Sagar	Rahatgarh, Banda
	South Panna	All Ranges
Rodent	Ranipur WLS	All Ranges
	Satna	Maghgawan
	North Panna	All Ranges
	PTR	PTR core and buffer
	Chhatarpur	Buxwaha, Bijawar
	South Panna	All Ranges

Table 7.4: Prioritized species and potential areas for research and management

Species	Potential Areas (Wildlife Sanctuary/Forest Division)
Leopard	Ranipur Wildlife Sanctuary, Rewa, Chhatarpur
Hyena	Rewa, Chhatarpur, North Sagar
Wolf	Veerangana Durgawati Wildlife Sanctuary, Nauradehi Wildlife Sanctuary, Katni, North Sagar
Jackal and Indian fox	Nauradehi Wildlife Sanctuary, Damoh, Chhatarpur, North Sagar
Sloth bear	North Panna, Chhatarpur, Damoh, Ranipur Wildlife Sanctuary
Rusty spotted cat	Katni, Satna, Ranipur Wildlife Sanctuary, North Sagar
Jungle cat	South Panna, Katni, Damoh, Nauradehi Wildlife Sanctuary
Honey badger	Ranipur Wildlife Sanctuary, Chhatarpur, North Sagar
Ruddy mongoose	Ranipur Wildlife Sanctuary, Katni, Satna, Chhatarpur
Grey mongoose	Satna Nauradehi Wildlife Sanctuary, North Panna
Indian small civet	Ranipur Wildlife Sanctuary, North Panna
Palm civet	Ranipur Wildlife Sanctuary, Chhatarpur, Ranipur Wildlife Sanctuary
Grey Langur, Rhesus Macaque	Chhatarpur, Ranipur Wildlife Sanctuary, Nauradehi Wildlife Sanctuary, Chitrakoot, Rewa
Indian Pangolin	North Sagar, South Panna, Damoh
Madras tree shrew	Chhatarpur, North Sagar, Damoh, South Panna

7.2.6. Measures for Conservation of Birds: Birds are one of the most diverse group of animals having specific habitat requirements, alterations to which lead to drastic changes in their assemblages and population. Therefore, the following measures are proposed to ensure conservation management of birds in PTR.

(i) Grassland Birds: The grasslands of Kheraiya, Jhalar, Badgadi, Talgaon and Pipartola are important habitats for grassland specialists such as the Galliformes for their breeding, nesting, and foraging requirements. Similarly, the grassland of Rajgarh is essential for some of the raptor species which prefer open grasslands. Steppe eagle which is a winter migrant, and an endangered species was detected in this region along with Oriental honey buzzards, changeable hawk eagle, white-eyed buzzard, brown fish owl and red-headed vulture. Therefore, traditional

methods of restoration of grassland such as grass burning should be applied after considering ecology of grassland specialists. Grassland restoration should focus on promotion of native palatable grass species, removal of weeds and invasive species, and maintaining species composition (discussed in the preceding sections).

(ii) Water Birds: Some of the threatened species of water birds identified in the CAF Action Plan (CMS/CAF, 2005) include lesser adjutant and ferruginous duck which are residents or regular visitors to the park in the colder season, which makes the maintenance of all the major water bodies important. It is proposed that a waterfowl census should be conducted every year by the forest department to monitor the wintering birds of this region. Since water birds are also crucial bio-indicators of ecosystem changes, regular monitoring will facilitate in keeping a record of their population and detect early signs of habitat degradation. Water birds use habitats such as riparian zones and ponds in PTR for shelter, breeding, nesting, rearing young and social interactions. It is essential to protect freshwater bodies and riparian zone of PTR for facilitating suitable habitats to such habitat specific species. Water level, quality, sedimentation, substrate composition etc. must be monitored.

(iii) Woodland Birds: This ecosystem, like grassland and freshwater ecosystem, is essential to protect with respect to woodland specialists. Some of the raptor species commonly observed are black winged kite, short-toed snake eagle, crested serpent eagle, shikra and crested hawk eagle. Nesting, breeding and behaviour of woodland birds are affected by trampling, forest fire, logging, lopping, over-grazing etc. Composition of native flora and presence of weeds and invasives, also influence the composition of woodland birds. It is essential to regulate such factors in terms of facilitating suitable habitats to woodland birds.

- Old/dead trees should not be cut and lopping of trees should be strictly prohibited. Many cavity nesting birds and raptors are dependent on these for nesting, roosting, and perching sites. Forest fires should be controlled as dead trees are more susceptible to this threat.
- Old growth forest of *Ficus* spp., Mahua and other fruiting trees are very important sources of food, nesting and breeding requirements of many frugivorous, as well as, raptor species. The forests of Seja, Salaiya and Motigard are an example of such a habitat all of which fall under the buffer zone of PTR. These areas need to be regularly monitored and protected from degradation, fire and encroachment.

- Cisticolidae has been identified as another dominant family of birds within grasslands and woodlands. These birds are typical scrubland species highly prone to degradation due to anthropogenic activities. A large part of the scrubland falls under the buffer zone, from Kishangarh towards Madhiyadoh. These areas should remain as scrublands to maintain the richness of these species and protected from encroachment.
- Birds act as perfect bio-indicators which are used to detect changes in the habitat caused by fragmentation, environmental contamination and degradation and habitat loss worldwide. Therefore, their populations should be regularly monitored to detect these changes early.
- Although all major habitat types in PTR have been surveyed, the information is still lacking in terms of nocturnal species. Owls and nightjars are an essential part of the forest providing ecosystem services. This is a research gap and should be addressed with well-planned studies for such species.

7.2.7. Measures for Conservation of Herpetofauna: Herpetofauna assessment was carried out only in PTR, but the management implications can also be followed in the entire landscape. Because the species composition varies with different geographical areas, habitat specific recommendations are relevant as proposed below:

(i) Paddy Fields: Amphibians and reptiles use agricultural lands to forage or to migrate to other natural habitats. It is important to maintain corridors of suitable habitat connecting natural areas within agricultural lands. Local people should be made aware of conservation of species found in their agricultural lands.

(ii) Grasslands: Grassland management activities should be done when reptiles and amphibians are least active *i.e.*, November to February - prior to emergence from hibernation (Mitchell *et al.*, 2000). Microhabitats can be created in grassland patches. Grazing should be avoided in the microhabitats.

(iii) Ponds: Recommendations for management of wetlands/ponds as provided in the previous section is relevant for herpetofauna as well. Similarly, the measures proposed for riparian zone management would also support conservation management of herpetofauna.

(iv) Microhabitats: Availability of microhabitats is the key factor that determines the species richness rather than the landscape heterogeneity and the composition of dominant plant species (Mitchell *et al.*, 2000). Logging small woody debris, rocks and accumulating litter on the

surface provide microhabitat as refugia to avoid predation. Leaf litter depth, soil moisture, and overstory cover are some of the crucial factors to be considered for herpetofauna habitats. Formation of shallow ephemeral pools near permanent water source to provide herpetofauna with water during drought periods. Brush piles can be placed randomly on land or partially submerged at the water edge. Rocks should be piled (up to few inches high) with logs over the rock pile in certain angles. Hibernacula can be constructed facing south with a hole dug and filled with pile of rocks, logs and debris higher than ground level. The hibernacula (except south) should be covered with soil and seed of native short grasses and forbs. Den trees/logs/snags can be provided to benefit herpetofauna. If not naturally present, trees can be girdled, and logs can be placed in the suitable areas. In PTR, suitable areas for creation of microhabitats are relocated villages, ponds, streams and riparian zone of Ken River. Likewise, forest divisions in GPL should identify the areas for creation of microhabitats. In GPL and PTR, most of the region is dry, hence it is important to manage grasslands and ponds for augmentation of herpetofauna population. Other than that, microhabitat should be created as mentioned to ensure diversity and richness of herpetofauna. Agricultural areas nearby forest lands can be promoted for herpetofauna conservation with proper training and collaboration with local people. Each forest division should support the conservation of their least concerned taxa, which is herpetofauna.

7.2.8. Measures for Conservation of Fishes:

The Madhya Pradesh State has exclusive Fisheries Act, which was implemented in 1948. The Act is expedient to provide for the protection, conservation and development of fisheries (The Madhya Pradesh Fisheries Act, 1948). However, the state is not active in protecting fish in reservoirs and rivers. Illegal and destructive fishing are, additionally, a major menace to native fish population inhabiting reservoirs and rivers. Efforts need to be taken to address this issue. There is a need to strengthen the existing legal provisions to eliminate threats and promote culturing native fish species instead of introducing exotic carps.

(i) Spatial Delineation of Freshwater Fish Safe Zone: The Ken River passing through the protected areas (PTR and KGS) is acting as a Fish Safe Zone as it provides total protection to the fish population inhabiting Ken River. However, the condition of fish population outside the protected areas is prone for overexploitation of fish resources that ultimately leads to a decline in fish stock in Ken River. In order to protect critically important fish habitats of native and threatened fish species, spatial delineation of FFSZs (freshwater fish safe zone) should be delineated in the form of both ‘core area’ and surrounding ‘buffer areas’ outside the protected

area. The buffer areas could be used to satisfy socio-economic use of local stakeholders, *e.g.*, sustenance fishing and catch-and-release angling (spill-over effect from core area). Such an inclusive approach will help target key stakeholders and assist in gathering their long-term support. A Zonal Master Plan (ZMP) for each FFSZ should be prepared in consultation with all relevant stakeholders, and a participatory mode of governance should be practised. FFSZs, including the impacts through protection provided to other freshwater dependent species, *e.g.*, Gharials and Crocodile should be assessed through rigorous field studies. Scientific research also needs to address the issue of environmental flows, as any change in the natural flow of a river can have serious consequences for habitat specialist species, many of which are usually endemic and threatened. Keystone and flagship species connected with FFSZs need to be identified to help gather local, regional and international support for conservation. The possibility of obtaining legislative support for FFSZs should be worked out in consultation with policy makers. A detailed report applicable to the public should also be prepared based on the scientific data obtained to setting up of FFSZs. Regular monitoring of the established FFSZs should be carried out, and research needs to be undertaken to understand additional conservation issues. Preliminary research should be carried out, focussing on ecology and biology of the species in greater details, and such research methods should use state-of-the-art conservation technology and tools including satellite transmitters, DNA studies etc., as per the need for conservation of the Rare and Threatened species. Collaboration and coordination with experts within and outside country for learning and sharing Rare and Threatened species conservation strategies, is also important. Regulation of solid and industrial waste disposal into rivers, no mining of gravel and sand from the selected priority zones/sites, and strict law enforcement in the river segments that needs to be designated as “Restricted/No-Go Zone” in the major habitats, can help to improve the situation. This kind of regulatory system may help revival of degraded habitat as well as reduce stress on spawning grounds of the fishes.

(ii) Conservation Awareness and Recovery of Mahseer: There are significant gaps in the existing knowledge on the distribution, population, migration, and spawning grounds of Mahseer in GPL. A one time field survey was conducted in this project for fishes and other aquatic Indicator species, but long research and monitoring is required to understand their abundance, habitat and threats. Awareness on Mahseer conservation is currently lacking. There is no existing institutional mechanism in place. Local communities will get involved only when they derive benefit (financial or otherwise) from the endeavour. There exists a need to develop a campaign on Mahseer to generate awareness and inspire stakeholders to undertake

conservation initiatives. Given that Ken River is an important habitat for Mahseer, a focused recovery programme needs to be developed and executed during the plan implementation period. Necessary collaboration and expertise need to be sourced for implementing this project. This could also take the shape of community-based conservation measures as it would allow for ecodevelopment opportunities for the local people.

7.2.9. Spatial Prioritisation for Biodiversity Management: Biodiversity is a complex encapsulation of the structure, function, distribution, traits, and composition of all living things at different scales, therefore, measuring and monitoring biodiversity is equally complex (Skidmore *et al.*, 2021). In recent decades, remote sensing techniques and spatial analyses have been used widely to acquire synoptic data on biodiversity (as surrogate approach) which is explicit and can be collected at multiple spatio-temporal scales. Based on such tools, we obtained eight unique combinations of priorities with tiger and biodiversity richness i.e. (1) tiger only, (2) tiger and high biodiversity richness, (3) tiger and moderate biodiversity richness, (4) tiger and low biodiversity richness, (5) Only high biodiversity richness, (6) Only moderate biodiversity richness, (7) Only low biodiversity richness and (8) not selected for tiger or biodiversity richness. These eight categories were merged to obtain six categories as (1) Priority-I (Tiger and high biodiversity richness); (2) Priority-II (Tiger and moderate biodiversity richness; only high biodiversity richness); (3) Priority-III (Only tiger; tiger and low biodiversity richness); (4) Priority-IV (Only moderate biodiversity richness); and Priority-V (only low biodiversity richness) (Fig. 7.24). District Panna held the maximum area under Priority-I followed by Chhatarpur, Sagar and others. Sagar held the maximum area under Priority-II, followed by Satna, Chhatarpur and others. Damoh held the maximum area under Priority-III, followed by Sagar, Panna and others. Sagar held the maximum area under Priority-IV, followed by Chhatarpur, Damoh and others. Panna held the maximum area under Priority-V, followed by Sagar, Damoh and others. District Sagar also held the maximum area under non-prioritised category. Priority-I areas that are important for both tiger and biodiversity must be declared inviolate areas with least human disturbance. These areas must be non-negotiable for any proposed development project as they interfere with tiger dispersal and future natural colonisation. Priority-II area will require enhanced protection since this is contiguous with Priority-1 area. The protection can be offered by the local communities living in the vicinity with support from the forest department. Priority-III area holds significance for tigers but has low biodiversity richness. Therefore, these sites can be targeted for restoration based on population estimates. Priority-IV area holds moderate biodiversity richness and therefore must

focus on protection and restoration activities. Priority-V area largely coincides with the agricultural areas and has low biodiversity richness. Private Land Conservation Area approaches (Shumba *et al.*, 2020), organic farming or agroforestry initiatives are recommended in these sites to restore ecosystem services (Puri *et al.*, 2021; Maheshwari *et al.*, 2020).

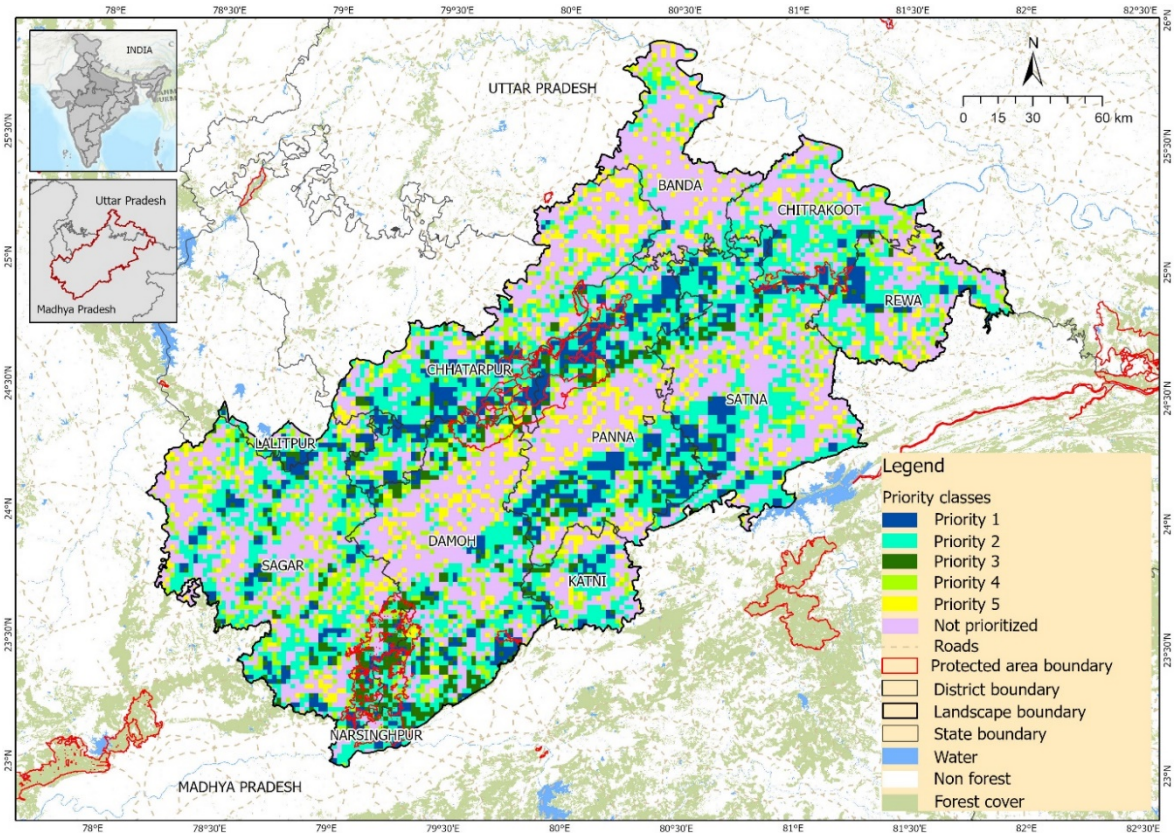


Figure 7.24. Priority areas for conservation in Greater Panna Landscape

7.3. Synthesis and Conclusions: Biodiversity is represented by various taxa in this plan such as flora, mammals, birds, herpetofauna and fish in PTR and flora, vultures and mammals in GPL. Further surrogate biodiversity richness involving remote sensing and spatial analyses provided synoptic view for both the landscape and PTR. Most conservation approaches are targeted at large mammals or some key species but, in the plan, conservation significance of other biodiversity elements have been highlighted and relevant measures have been proposed for conservation management. These include policy level intervention such as designation of Conservation Reserves or Community Reserves, and site-specific interventions for habitat management, weed and invasive species removal and experimentation design for adaptive management. Finally, biodiversity richness combined with conservation priority for tiger has been shown in the form of priority sites with specific management actions.



CHAPTER 8

COMMUNITY PROFILE AND ENGAGEMENT STRATEGIES

Chapter 8: Community Profile and Engagement Strategies

8.1. Situation Analyses

8.1.1. Introduction: In recent years, the management of protected areas has gradually progressed to integrate multidisciplinary approach to conservation biology. This is mostly because wildlife populations and local livelihoods are jeopardised at the expense of the other whilst competing for the same diminishing resources. Communities residing near such protected areas develop a hostile attitude towards wildlife because of tangible economic losses (property damage, income loss, crop raiding, livestock depredation, etc.) and social perceptions (caste, gender, political influence, ethnicity) (Carter *et al*., 2013; Mir *et al*., 2015; Malviya *et al*., 2022), even when they are beneficiaries of multiple advantages in the form of intangible ecosystem services (provisioning services, pollination, aesthetic value, pest eradication, etc.), This causes retaliatory killings, spiteful forest fires, illegal deforestation and hunting for different purposes (meat, game, trade, etc.) (GIZ, 2020; Mogomotsi *et al.*, 2020; Gulati *et al.*, 2021). Thus, it is important to promote the idea of holistic development – balancing sustainable livelihoods with wildlife conservation through community engagement strategies.

Global community-based conservation models range from local consultation on nature-based solutions to awareness generation for knowledge development, to technical training programmes for skill building, to partnership formation and to connect policy advocacy, implementation, and management (GIZ, 2020). Adopting such strategies form a self-sustaining environment for communities, strengthening their existing capacities and achieving the water-forest-energy-food security nexus linking the local, district and national levels together. This participatory approach will help in bridging the gap between top-down and bottom-up methods paving the way towards achieving India's commitment to the Sustainable Development Goals (SDG) and National Biodiversity Targets (NBT) (Future Generations Graduate School of and Applied Community Change and Conservation, 2008; Infield and Tolisano, 2019; Okumu *et al.*, 2021). To enhance the development of communities in GPL, the focus is aimed at three themes i.e. (1) Social and historical context of communities, (2) Understanding the socio-economic conditions of communities and their issues, and (3) Implementation strategies based on the benefits the communities will receive.

8.1.2. Community Description and Socio-economic Status: There are approximately 11,500 villages in GPL (Chandramouli, 2011). These villages come under the administrative

boundaries of 11 districts of Madhya Pradesh (08) and Uttar Pradesh (03). The landscape mainly has a rural population and approximately 75% population is engaged in farming or are agricultural labours. The remaining people are involved in small-scale industries, businesses, or services. All the villages have a subsistence economy based mostly on agriculture and cattle-rearing. People in this landscape are mostly Hindu, but there are also substantial numbers of Muslims and Christians in the population. Various festivals, some unique to the region, are celebrated in the landscape.

(i) Social Groups: Major ethnic groups in the landscape are Gond (Rajgond, Nandgond, and Saurgond) and Khairuas among the tribes, and Yadavas (Dauvas) among the backward classes. There are also a few scheduled castes. A brief description of the major communities in the landscape (Russell, 1916) is given below:

Bhīl: Bhīls reside in the hill ranges of Khāndesh, Central India, and Rajputana, Gujarat. They were traditionally hunters, but most have now taken up labour work. There are both Hindu and Muslim Bhīls, but both worship Khande Rao, the god of war. Bhili is a vernacular dialect used by them, which is derived from Marwari, Gujrati, and Marathi.

Basor: Basors come under the scheduled caste category. They work bamboo to make articles like baskets, furniture, tools, etc.

Chauhān: Chauhan is a caste of laborers and watchmen of the village. They relate to Rajput origin and are known as Chandelas by the outsiders. They are generally followers of Devi Durga and observe fasts in the month of Kunwar (September) and Chait (March).

Ghasi: Ghasi is a caste of people who mostly depends on occupations like cutting grass, tending horses, and playing music on special occasions. They also make Kunch (Loom brush) from babai (khas khas grass) and Rachh (Comb) from Bharru grass and Kathai grass.

Gond: This principal tribe is divided into castes based on the occupation: Agarias (ironworkers), Ojhas (soothsayers), Pradhan (priests and minstrels), Solāhas (carpenters), and Koilabhutis (dancers). The Gond tribe has two major divisions, namely Raj Gond and Khatola. Raj Gonds are thought to have descended from the 'ruling' Gond clan and are considered superior to Nandgonds and Saurgonds, who have been the ruled class. Narayan Deo is the god worshipped, while Chaitra (in March), Nawākhai (in August) and Holi are the common festival associated with the cropping pattern that are celebrated by the tribe. The village gods of the Gonds are generally common to the Gonds and Hindus. They can be in the form of stones or

mud platforms placed under a tree's shade. The place of worship is called as Deo-Khulla. They are mostly engaged in agriculture and selling forest produce but were formerly engaged in hunting and fishing. They speak Gondi language that shares ancestry with Tamil and Kannada.

Kāchhi: Kachhi is a caste that practises cultivation of vegetables and irrigated crops. It is further divided into subcastes depending on the plants they grow: Hardia (those who grow turmeric), Alias (those grow Indian madder), Phūlias (those who grow flowers), Jirias (those who grow Jira or cumin), Murai (those who grow muli or radish), Sanias (those who grow san or hemp), Lilia (those who grow neel or leel *i.e.*, indigo and products they make), Piria (those who make basket) and Mor Kāchhis (those who prepare marriage crowns).

Kol, Munda, Ho: The term Kol is from Santali language, which has its origin in the Indo-Pacific islands and Malay Peninsula. The important subcastes of this tribe are the Rautia and Rautele. Hypergamy is practiced by the Rautia Kols, with the Rauteles. Bagheshwar Deo (the tiger-god) is worshipped by the Kols. Kherwari is the Kol language that has various forms such as Mundari, Santali, Korwa and Bhumij.

Kumhār, Kumbhār: Kumbhar, the term derived from Kumbh meaning a water pot, is a caste of potters.

Kurmi: Kurmi is a prominent caste of cultivators. Many deities such as Vishnu, Mahadeo and Khermata are worshipped by them. Additionally, the goddess of Malaria (Marhai devi) and goddess of Cholera (Sitala devi) are honoured to recover from the diseases.

Kushwahas* and *Dhimars: Kushwahas and Dhimars often indulge in fishing. They are the people who often work for big fish-contractors, catching fish both in tanks leased out for fishing and in other water bodies.

Lodhi/Lodha: Lodhi is an agricultural caste of Rajputs that comprises both cultivators and labourers residing in the Vindhyan Districts and Nerbudda (Narmada) valley. The district head family is called the Kerbanias (derived from Kerbana – a village in Damoh). Head of the house is called Mahdela (the highest title) and brothers of the head of the house are given the title Rao and Kunwar.

Panka/ Panika: Panka or Panika is a Dravidian caste of weavers and laborers. Some of the tribesmen also serve as watchmen and cultivators. It has two separate divisions: the Pan proper (Ganda) and Pankas (Kabirpanth sect followers). The Pankas worship only Kabir.

Pardhis: Pardhis used to be the 'hunting communities' owing to which they have excellent tracking skills. They depended on the forest as a means for livelihood (Dutt, 2019).

Yadav: Yadavs are the people who practice cattle rearing and depend on the selling of milk and milk products. Many of these people have no lands titles with them but possess large number of cattle - both cows and buffaloes, which depend mainly on forests for grazing. Traditionally, Yadavs have been linked to cattle raising and as such were outside the formal caste system (Hutton, 1969). Later, the Yadavs were included in the Other Backward Classes (OBCs) category in the states of Bihar, Chhattisgarh, Delhi, Haryana, Jharkhand, Karnataka, Madhya Pradesh, Odisha, Rajasthan, Uttar Pradesh and West Bengal.

(ii) Population, Demography and Literacy: Most of the districts within the landscape are densely populated (Table 8.1). The population in districts falling within the landscape is increasing at an average rate of 19.85%, with Chitrakoot (Uttar Pradesh) having the highest and Banda (Uttar Pradesh) the lowest rates of increase (Table 8.1) (Chandramouli, 2011). Average sex ratio of districts falling within the landscape is approx. 906, with Katni (Madhya Pradesh) having the highest and Banda (Uttar Pradesh) the lowest (Table 8.1) (Chandramouli, 2011). Literacy rate in the landscape, was higher in the districts of Madhya Pradesh, as compared to districts of Uttar Pradesh (Table 8.1).

Table 8.1: Population and sex ratio in the landscape districts (Source: Census of India, 2011)

S. No.	State	District	Population	Density	Decadal Change (%) (2001-2011)	Sex Ratio (per 1000 males)	Literacy (%)
1	Madhya Pradesh	Sagar	23,78,458	232	17.63	893	76.46
2	Madhya Pradesh	Rewa	23,65,106	375	19.86	931	71.62
3	Madhya Pradesh	Satna	22,28,935	297	19.19	926	72.26
4	Madhya Pradesh	Chhatarpur	17,62,375	203	19.51	883	63.74

5	Madhya Pradesh	Katni	12,92,042	261	21.41	952	71.98
6	Madhya Pradesh	Damoh	12,64,219	173	16.63	910	69.73
7	Madhya Pradesh	Narsinghpur	10,91,854	213	14.01	920	75.69
8	Madhya Pradesh	Panna	10,16,520	142	18.67	905	64.79
9	Uttar Pradesh	Banda	17,99,410	408	17.05	863	66.67
10	Uttar Pradesh	Lalitpur	12,21,592	242	24.94	906	63.52
11	Uttar Pradesh	Chitrakoot	9,91,730	308	29.43	879	65.05

(iii) Socio-economic Condition: According to the socio-economic scoring done by Mission Antyodaya (2019), all the districts in the landscape are below the national average (Fig. 8.1). However, Damoh, Katni and Narsinghpur have scored the best among the districts within Madhya Pradesh and above the average score of the state, while Rewa and Satna have scored the worst (Fig. 8.1). In the case of Uttar Pradesh, none of the districts falling within the landscape have scored same or above the average state score (Fig. 8.1).

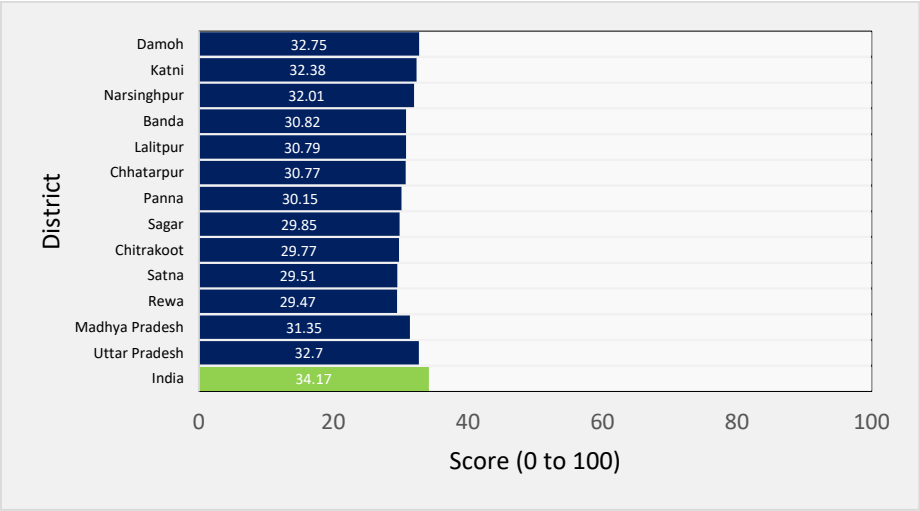
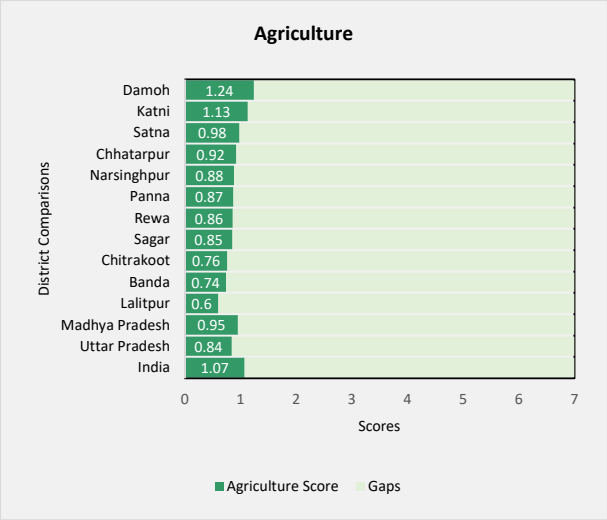
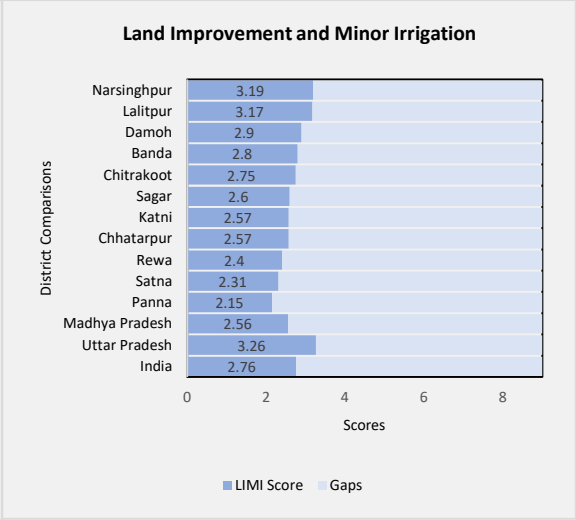
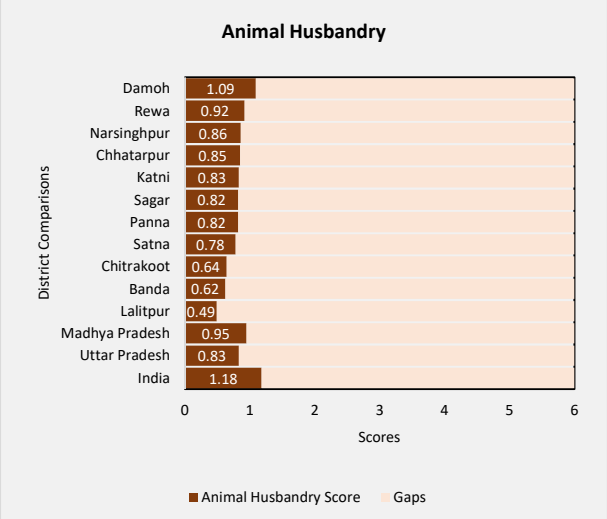


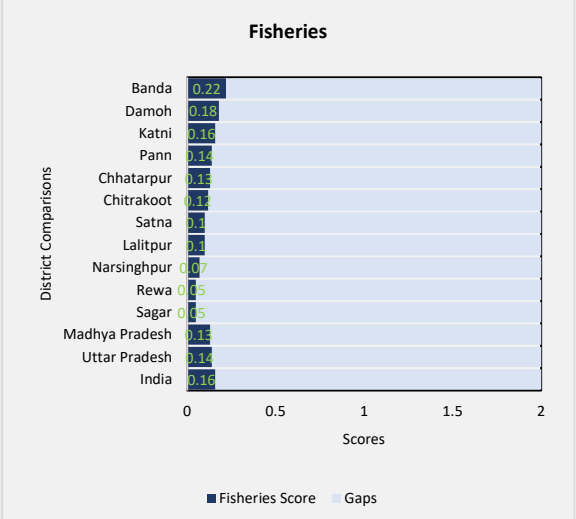
Figure 8.1. District-wise average socio-economic scores for the Greater Panna Landscape (Source: Mission Antyodaya, 2019)

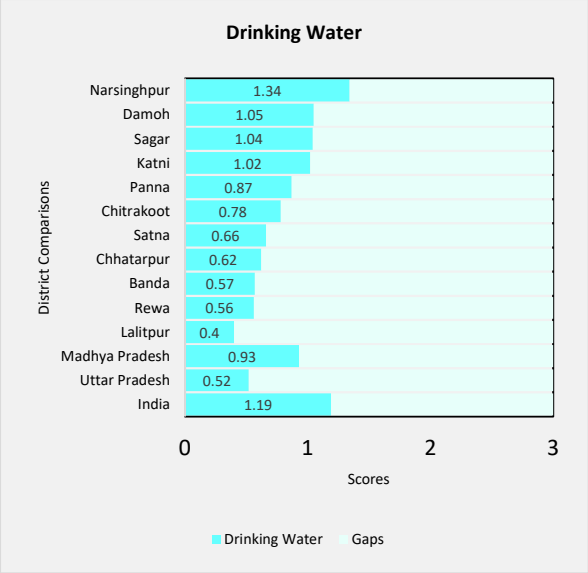
Different districts have scored well across different parameters, however, certain districts have performed better than the rest across several parameters, like Damoh has scored highest in agriculture, animal husbandry, social forestry, non-conventional energy sources, financial and communication infrastructure, family welfare, vocational education, cultural activities, khadi and cottage industries as well as other small-scale industries. Narsinghpur has scored highest in land improvement and minor irrigation, fuel and fodder generation, drinking water, and rural electrification (Fig. 8.2). Panna on the other hand has scored poorly across most of the indicators except women and child development.

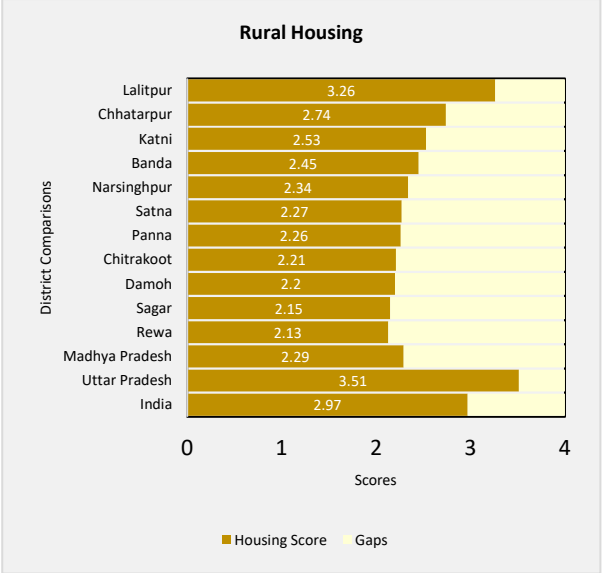


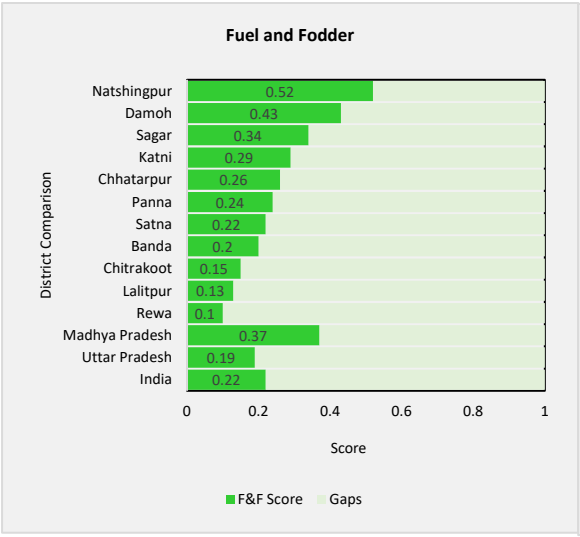


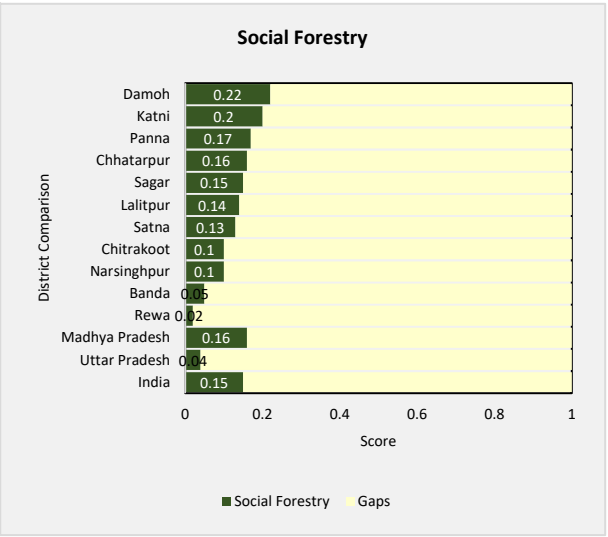


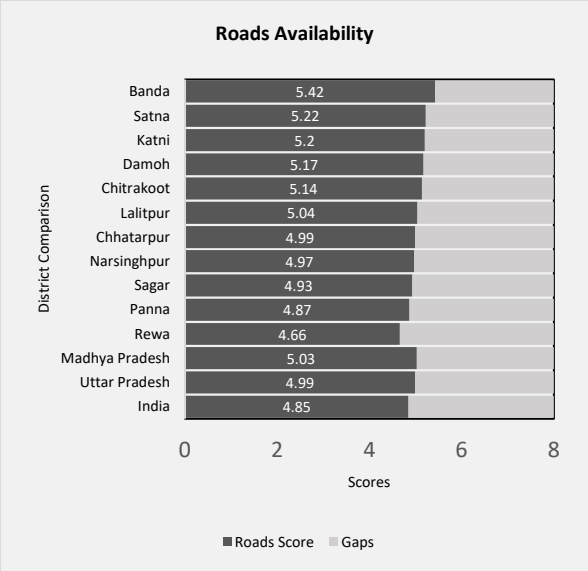


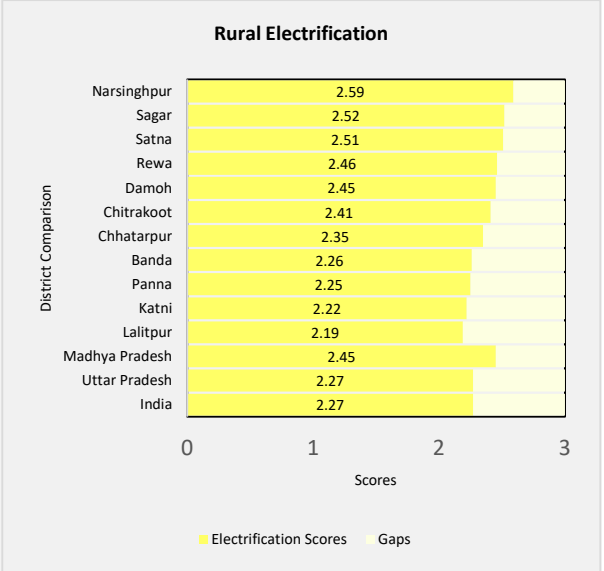

Drinking Water
Narsinghpur 1.34
Damoh 1.05
Sagar 1.04
Katni 1.02
Panna 0.87
Chitrakoot 0.78
Satna 0.66
Chhatarpur 0.62
Banda 0.57
Rewa 0.56
Lalitpur 0.4
Madhya Pradesh 0.93
Uttar Pradesh 0.52
India 1.19
District Comparisons
0 1 2 3
Scores
Drinking Water
Gaps

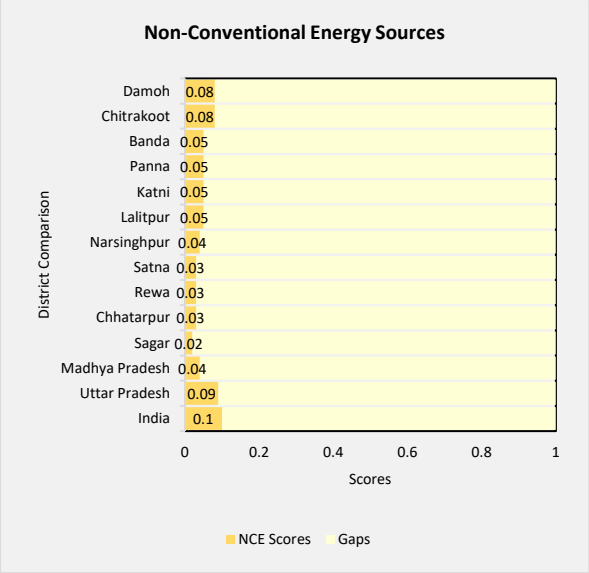

Rural Housing
Lalitpur 3.26
Chhatarpur 2.74
Katni 2.53
Banda 2.45
Narsinghpur 2.34
Satna 2.27
Panna 2.26
Chitrakoot 2.21
Damoh 2.2
Sagar 2.15
Rewa 2.13
Madhya Pradesh 2.29
Uttar Pradesh 3.51
India 2.97
District Comparisons
0 1 2 3 4
Scores
Housing Score
Gaps

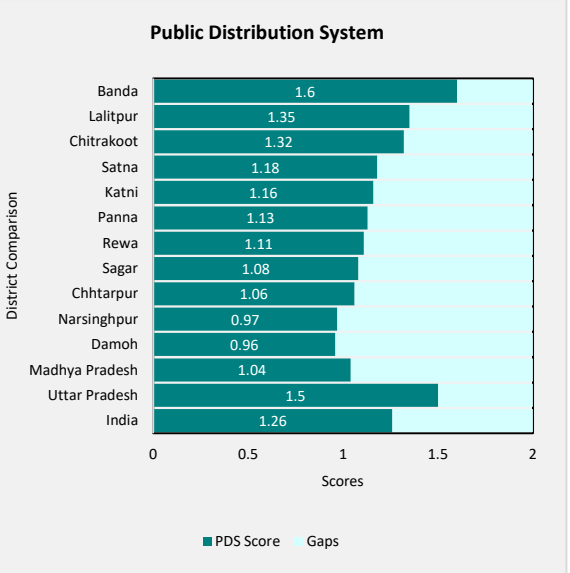

Fuel and Fodder
Natshingpur 0.52
Damoh 0.43
Sagar 0.34
Katni 0.29
Chhatarpur 0.26
Panna 0.24
Satna 0.22
Banda 0.2
Chitrakoot 0.15
Lalitpur 0.13
Rewa 0.1
Madhya Pradesh 0.37
Uttar Pradesh 0.19
India 0.22
District Comparison
0 0.2 0.4 0.6 0.8 1
Score
F&F Score
Gaps

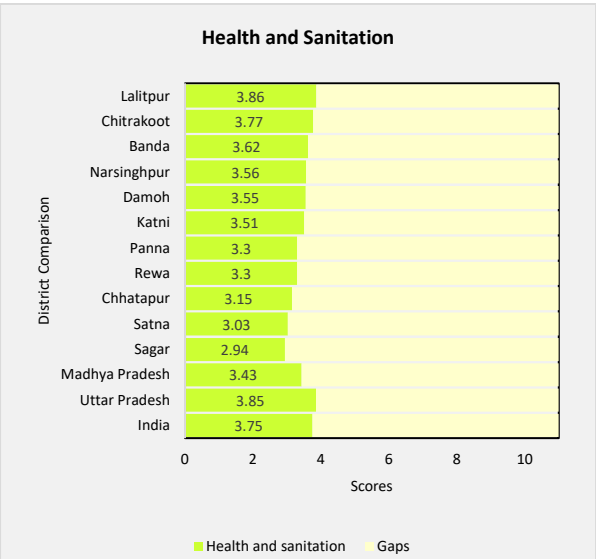

Social Forestry
Damoh 0.22
Katni 0.2
Panna 0.17
Chhatarpur 0.16
Sagar 0.15
Lalitpur 0.14
Satna 0.13
Chitrakoot 0.1
Narsinghpur 0.1
Banda 0.05
Rewa 0.02
Madhya Pradesh 0.16
Uttar Pradesh 0.04
India 0.15
District Comparison
0 0.2 0.4 0.6 0.8 1
Score
Social Forestry
Gaps

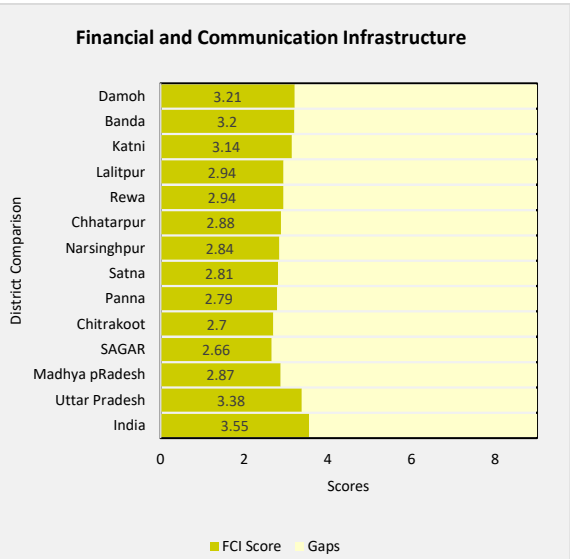

Roads Availability
Banda 5.42
Satna 5.22
Katni 5.2
Damoh 5.17
Chitrakoot 5.14
Lalitpur 5.04
Chhatarpur 4.99
Narsinghpur 4.97
Sagar 4.93
Panna 4.87
Rewa 4.66
Madhya Pradesh 5.03
Uttar Pradesh 4.99
India 4.85
District Comparison
0 2 4 6 8
Scores
Roads Score
Gaps

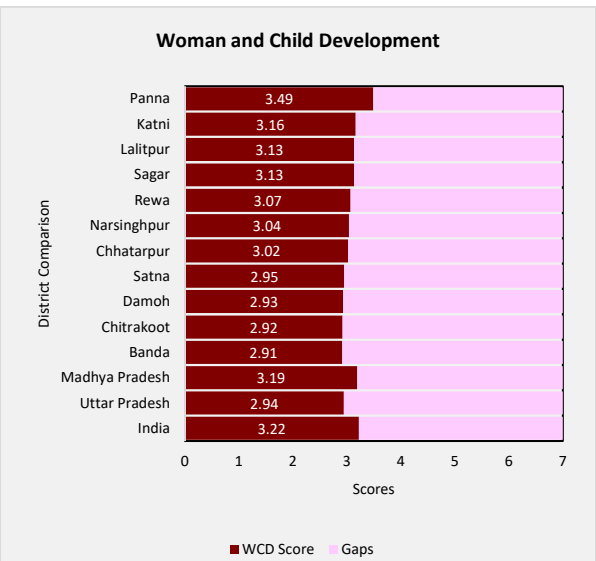

Rural Electrification
Narsinghpur 2.59
Sagar 2.52
Satna 2.51
Rewa 2.46
Damoh 2.45
Chitrakoot 2.41
Chhatarpur 2.35
Banda 2.26
Panna 2.25
Katni 2.22
Lalitpur 2.19
Madhya Pradesh 2.45
Uttar Pradesh 2.27
India 2.27
District Comparison
0 1 2 3
Scores
Electrification Scores
Gaps

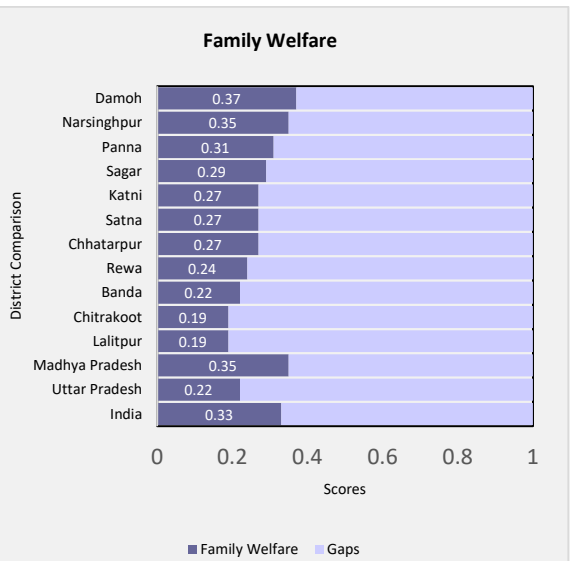

Non-Conventional Energy Sources
Damoh 0.08
Chitrakoot 0.08
Banda 0.05
Panna 0.05
Katni 0.05
Lalitpur 0.05
Narsinghpur 0.04
Satna 0.03
Rewa 0.03
Chhatarpur 0.03
Sagar 0.02
Madhya Pradesh 0.04
Uttar Pradesh 0.09
India 0.1
District Comparison
0 0.2 0.4 0.6 0.8 1
Scores
NCE Scores
Gaps

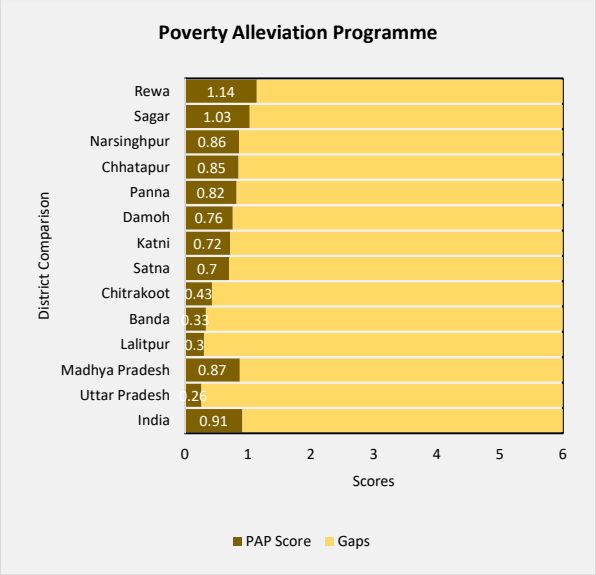

Public Distribution System
Banda 1.6
Lalitpur 1.35
Chitrakoot 1.32
Satna 1.18
Katni 1.16
Panna 1.13
Rewa 1.11
Sagar 1.08
Chhtarpur 1.06
Narsinghpur 0.97
Damoh 0.96
Madhya Pradesh 1.04
Uttar Pradesh 1.5
India 1.26
District Comparison
0 0.5 1 1.5 2
Scores
PDS Score
Gaps

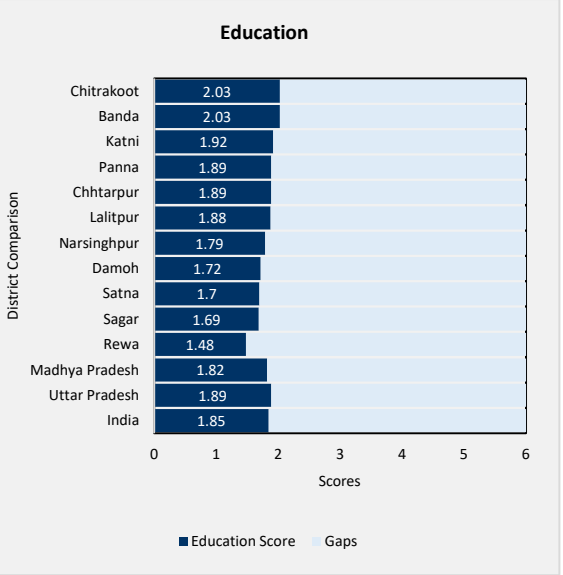

Health and Sanitation
Lalitpur 3.86
Chitrakoot 3.77
Banda 3.62
Narsinghpur 3.56
Damoh 3.55
Katni 3.51
Panna 3.3
Rewa 3.3
Chhatapur 3.15
Satna 3.03
Sagar 2.94
Madhya Pradesh 3.43
Uttar Pradesh 3.85
India 3.75
District Comparison
0 2 4 6 8 10
Scores
Health and sanitation
Gaps

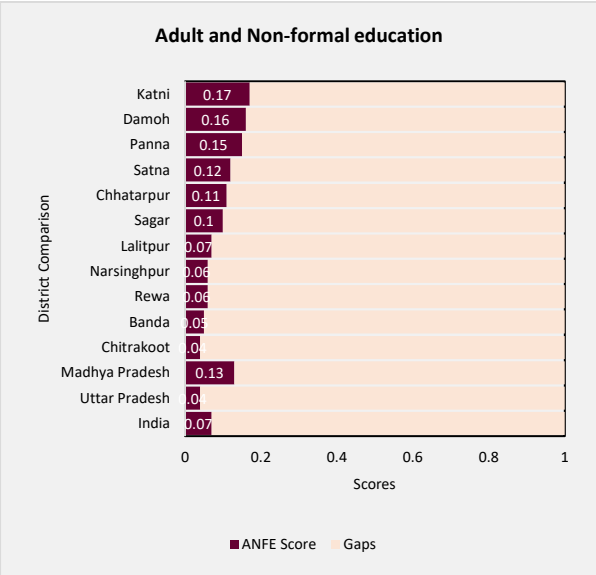

Financial and Communication Infrastructure
Damoh 3.21
Banda 3.2
Katni 3.14
Lalitpur 2.94
Rewa 2.94
Chhatarpur 2.88
Narsinghpur 2.84
Satna 2.81
Panna 2.79
Chitrakoot 2.7
SAGAR 2.66
Madhya pRadesh 2.87
Uttar Pradesh 3.38
India 3.55
District Comparison
0 2 4 6 8
Scores
FCI Score
Gaps

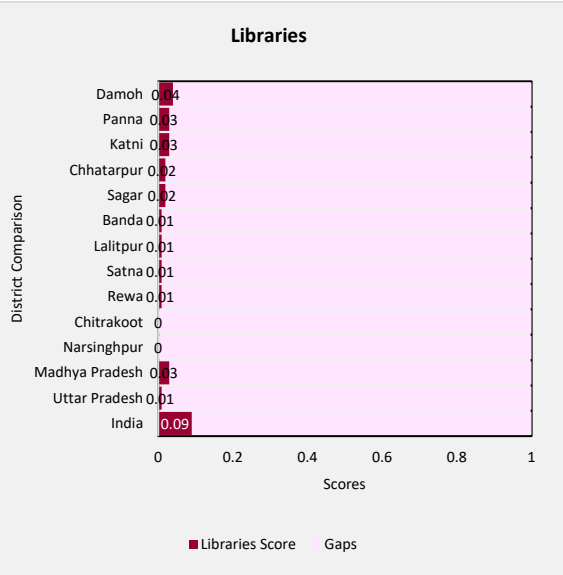

Woman and Child Development
Panna 3.49
Katni 3.16
Lalitpur 3.13
Sagar 3.13
Rewa 3.07
Narsinghpur 3.04
Chhatarpur 3.02
Satna 2.95
Damoh 2.93
Chitrakoot 2.92
Banda 2.91
Madhya Pradesh 3.19
Uttar Pradesh 2.94
India 3.22
District Comparison
0 1 2 3 4 5 6 7
Scores
WCD Score
Gaps

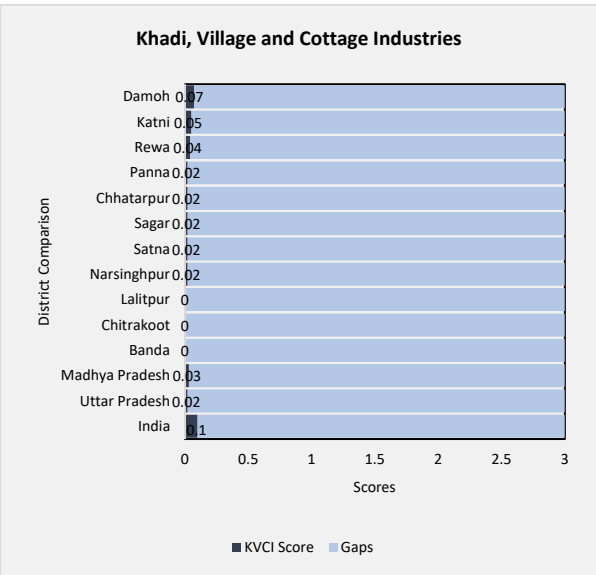

Family Welfare
Damoh 0.37
Narsinghpur 0.35
Panna 0.31
Sagar 0.29
Katni 0.27
Satna 0.27
Chhatarpur 0.27
Rewa 0.24
Banda 0.22
Chitrakoot 0.19
Lalitpur 0.19
Madhya Pradesh 0.35
Uttar Pradesh 0.22
India 0.33
District Comparison
0 0.2 0.4 0.6 0.8 1
Scores
Family Welfare
Gaps

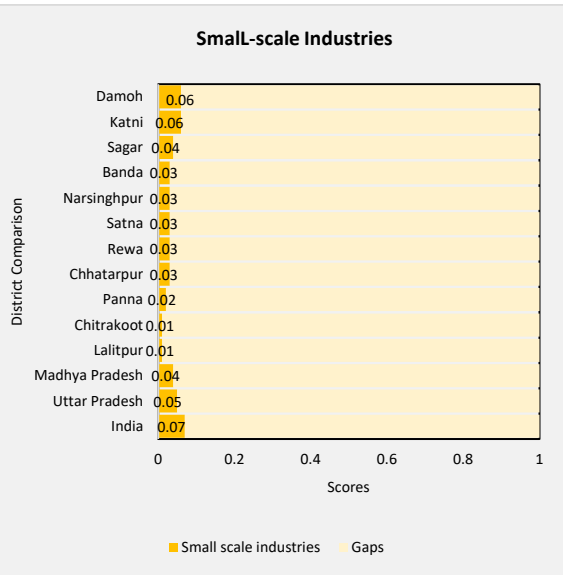

Poverty Alleviation Programme
Rewa 1.14
Sagar 1.03
Narsinghpur 0.86
Chhatapur 0.85
Panna 0.82
Damoh 0.76
Katni 0.72
Satna 0.7
Chitrakoot 0.43
Banda 0.33
Lalitpur 0.3
Madhya Pradesh 0.87
Uttar Pradesh 0.26
India 0.91
District Comparison
0 1 2 3 4 5 6
Scores
PAP Score
Gaps


Education
Chitrakoot 2.03
Banda 2.03
Katni 1.92
Panna 1.89
Chhtarpur 1.89
Lalitpur 1.88
Narsinghpur 1.79
Damoh 1.72
Satna 1.7
Sagar 1.69
Rewa 1.48
Madhya Pradesh 1.82
Uttar Pradesh 1.89
India 1.85
District Comparison
0 1 2 3 4 5 6
Scores
Education Score
Gaps


Adult and Non-formal education
Katni 0.17
Damoh 0.16
Panna 0.15
Satna 0.12
Chhatarpur 0.11
Sagar 0.1
Lalitpur 0.07
Narsinghpur 0.06
Rewa 0.06
Banda 0.05
Chitrakoot 0.04
Madhya Pradesh 0.13
Uttar Pradesh 0.04
India 0.07
District Comparison
0 0.2 0.4 0.6 0.8 1
Scores
ANFE Score
Gaps


Libraries
Damoh 0.04
Panna 0.03
Katni 0.03
Chhatarpur 0.02
Sagar 0.02
Banda 0.01
Lalitpur 0.01
Satna 0.01
Rewa 0.01
Chitrakoot 0
Narsinghpur 0
Madhya Pradesh 0.03
Uttar Pradesh 0.01
India 0.09
District Comparison
0 0.2 0.4 0.6 0.8 1
Scores
Libraries Score
Gaps


Khadi, Village and Cottage Industries
Damoh 0.07
Katni 0.05
Rewa 0.04
Panna 0.02
Chhatarpur 0.02
Sagar 0.02
Satna 0.02
Narsinghpur 0.02
Lalitpur 0
Chitrakoot 0
Banda 0
Madhya Pradesh 0.03
Uttar Pradesh 0.02
India 0.1
District Comparison
0 0.5 1 1.5 2 2.5 3
Scores
KVCI Score
Gaps


SmalL-scale Industries
Damoh 0.06
Katni 0.06
Sagar 0.04
Banda 0.03
Narsinghpur 0.03
Satna 0.03
Rewa 0.03
Chhatarpur 0.03
Panna 0.02
Chitrakoot 0.01
Lalitpur 0.01
Madhya Pradesh 0.04
Uttar Pradesh 0.05
India 0.07
District Comparison
0 0.2 0.4 0.6 0.8 1
Scores
Small scale industries
Gaps

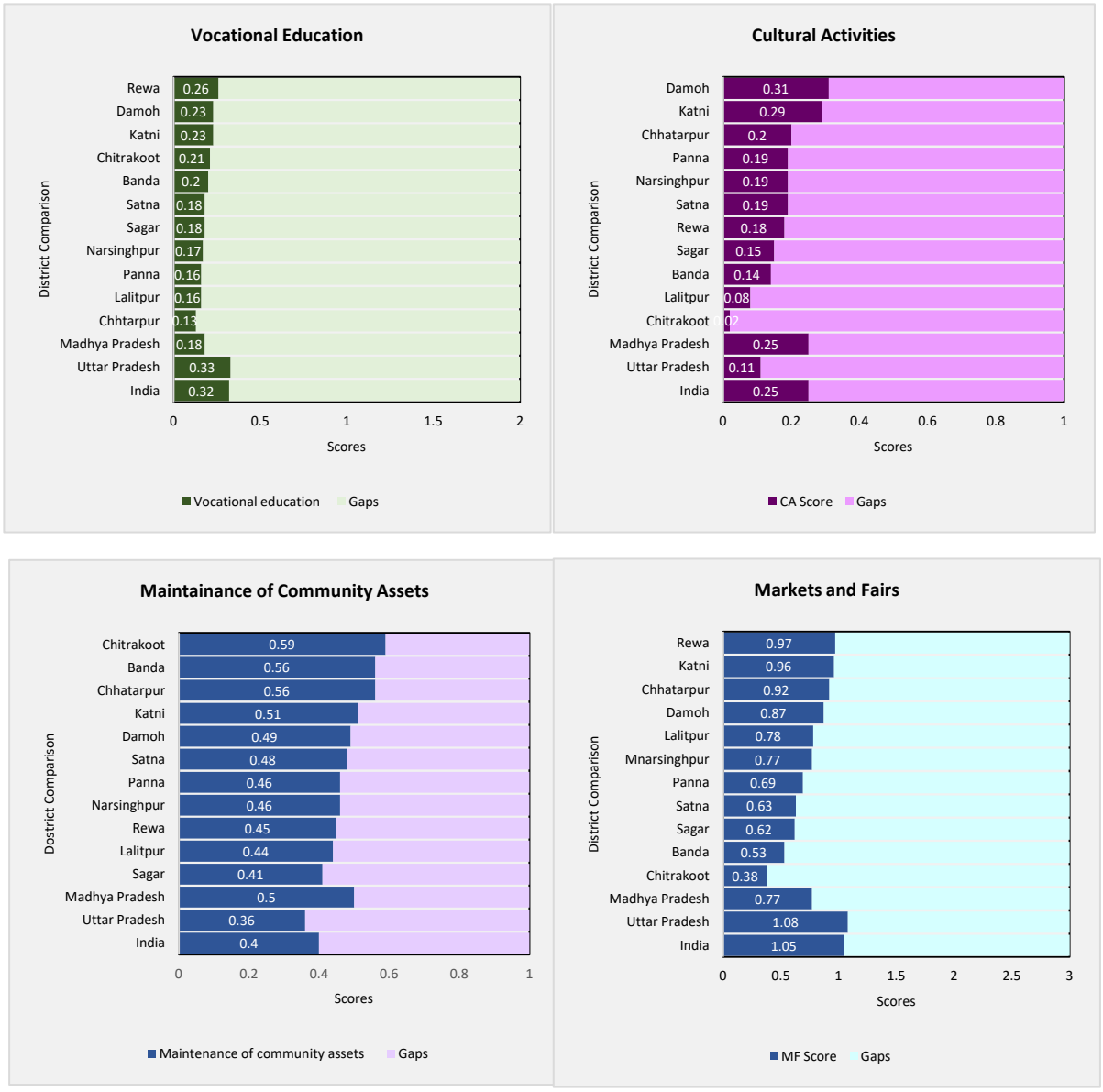


Figure 8.2. District-wise scores of different socio-economic parameters for the Greater Panna Landscape (x axis depicts the score range for the specific parameters) (Source: Mission Antyodaya, 2019)

(iv) Occupations/Livelihood Options: The households in the landscape were found to be dependent mostly on natural resources for their livelihood, for example agriculture, animal husbandry, bidi making, fuelwood selling, basket making, NTFP collection, etc. (Fig. 8.3, 8.4, 8.5). Labour/manual work followed by agriculture was the main occupation of people in most of the districts in the landscape (Fig. 8.4). Labour was divided into two categories, agricultural and non-agricultural labour and 56.94% households were dependent on non-agricultural labour

work (Fig. 8.3). It is important to note that 21.25% of the sampled households at least had at least one member who migrate to cities, seasonally, for livelihood options.

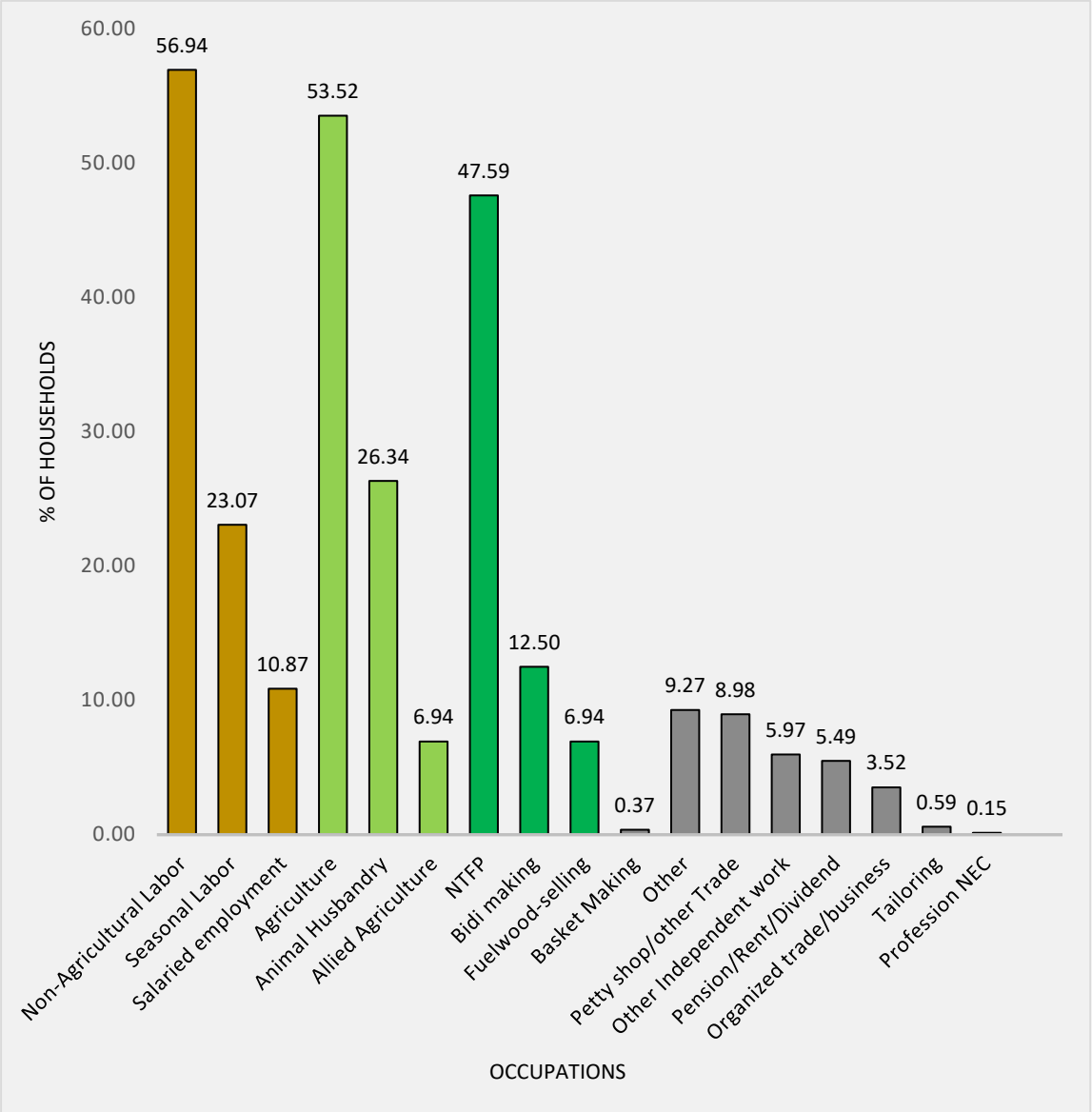
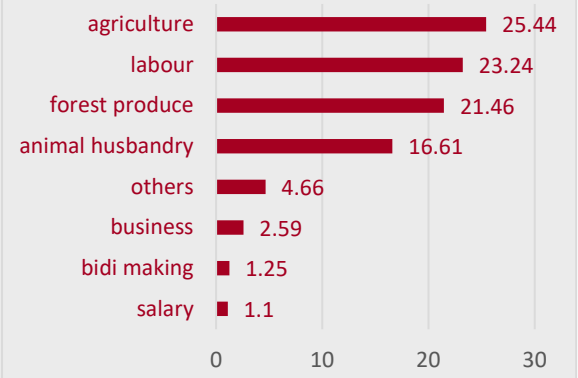
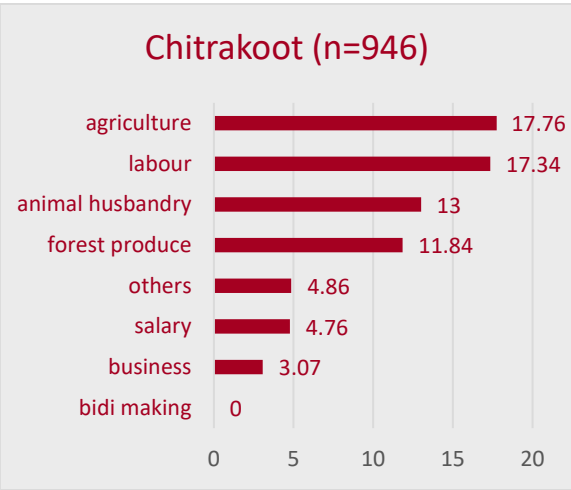


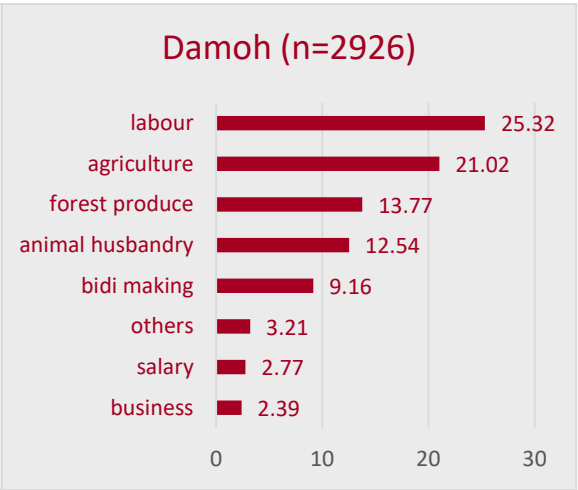
Figure 8.3. Principal sources of income in the Greater Panna landscape

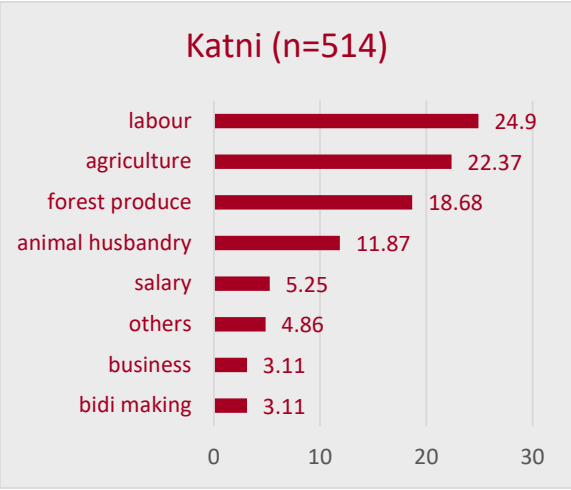
We found that almost the entire sampled population in the landscape was dependent on primary and secondary economic activities. Only 10% of the household in the landscape were found to be earning a fixed income. This indicates the risks and vulnerabilities in livelihood options in the landscape. A brief description of the occupation / livelihood options of the people are given in the following section.

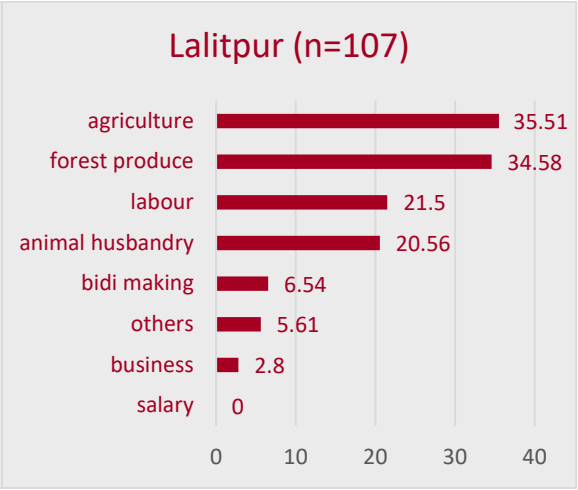

Banda (n=86)
labour 27.91
agriculture 17.44
animal husbandry 13.95
salary 8.14
forest produce 4.65
others 2.33
business 2.33
bidi making 0
0 10 20 30


Chhatarpur (n=2083)
agriculture 25.44
labour 23.24
forest produce 21.46
animal husbandry 16.61
others 4.66
business 2.59
bidi making 1.25
salary 1.1
0 10 20 30


Chitrakoot (n=946)
agriculture 17.76
labour 17.34
animal husbandry 13
forest produce 11.84
others 4.86
salary 4.76
business 3.07
bidi making 0
0 5 10 15 20


Damoh (n=2926)
labour 25.32
agriculture 21.02
forest produce 13.77
animal husbandry 12.54
bidi making 9.16
others 3.21
salary 2.77
business 2.39
0 10 20 30


Katni (n=514)
labour 24.9
agriculture 22.37
forest produce 18.68
animal husbandry 11.87
salary 5.25
others 4.86
business 3.11
bidi making 3.11
0 10 20 30


Lalitpur (n=107)
agriculture 35.51
forest produce 34.58
labour 21.5
animal husbandry 20.56
bidi making 6.54
others 5.61
business 2.8
salary 0
0 10 20 30 40

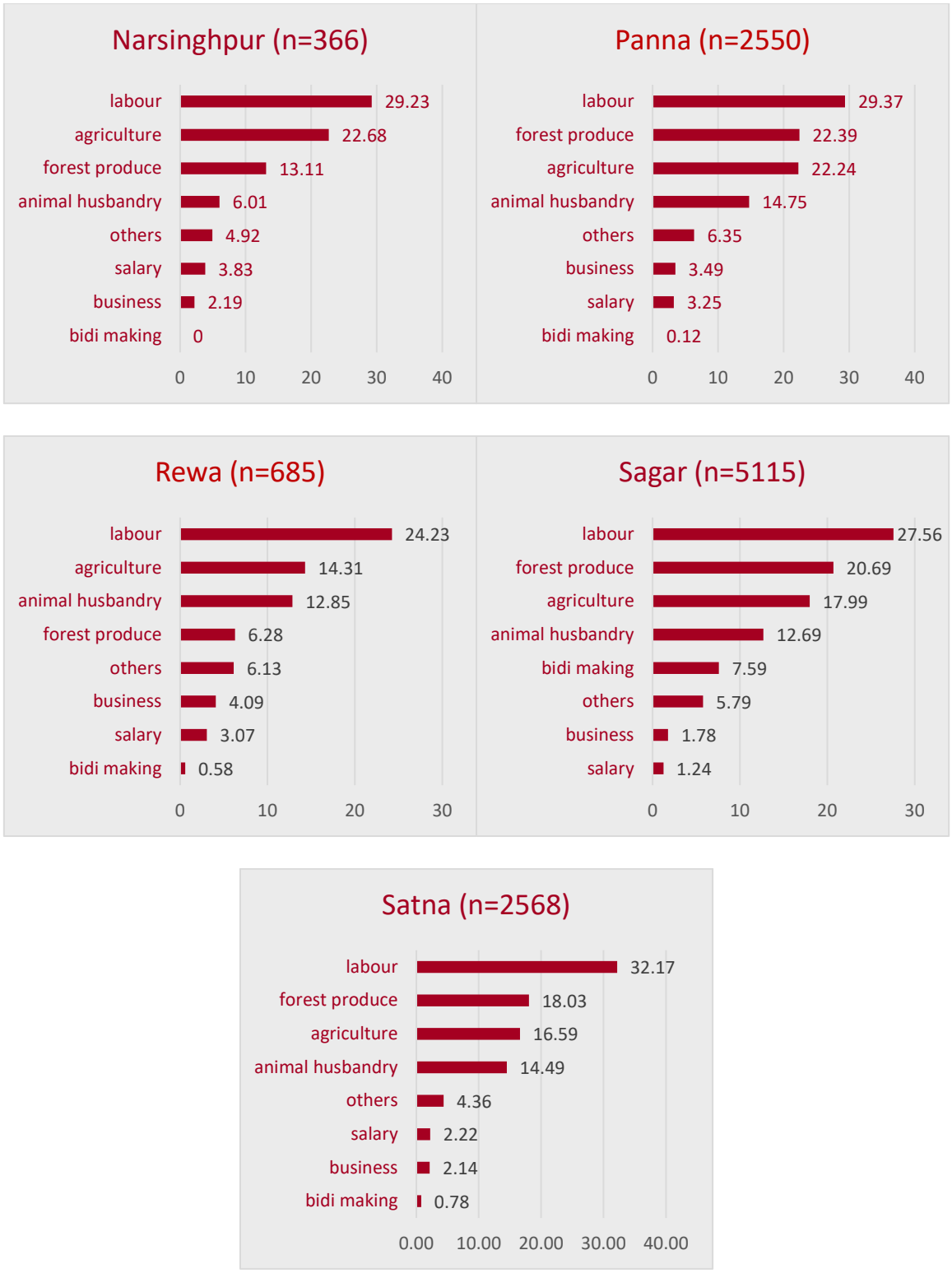


Figure 8.4. District-wise occupational activities in Greater Panna Landscape



Figure 8.5. Some key occupational activities: water chestnut cropping, stone mining, fuelwood selling, carpentering, basket-making, pot-making, and brick-construction

***Agriculture*:** Agriculture is one of the most important occupations on which around 60% population was directly dependent. We divided agriculture into two categories: farmers who own less than 10 acres of land and farmers who own more than 10 acres. We found that only 6.94% farmers own more than 10 acres of land (this includes both patta-land and without patta land). Many farmers were found to be not cultivating any crop throughout the year due to lack of water and presence of wild animals in the area. The source of irrigation primarily was found to be groundwater which included wells, earth boring and ponds. A high proportion of farmers was dependent on rain due to absence of any constant source of irrigation available to them. The agricultural yield for most crops was found to be poor.

***Animal Husbandry*:** Livestock keeping is an integral part of rural economy which provides buffer in unforeseen conditions and contributes majorly to the diet. This has been well documented in pastoral/rural communities all over the world (Waters-Bayer and Bayer, 1992). In GPL also, we found that 26.34% households were dependent on their animal holdings for their livelihood. In addition, there were also households who keep animals for subsistence only. As per the average score for all sampled households, we found that all households hold at least more than one cow, goat or calf (Fig. 8.6). The range of total animal holdings in sampled

households is 0-225. This indicates high variability in governance and available resources in the landscape. Mainly households were found to be keeping cows, goats and buffaloes for milking, meat and agricultural purposes. It was found that people prefer to keep goats than sheep. One of the probable causes might be non-availability of sufficient grasslands in the landscape as sheep are grazers (Ahrestani *et al.*, 2016). We found that pigs were mainly stocked by people from marginal social groups because of which they also sometimes face social stigma. The livestock graze mostly in the forest and people in many villages don't keep an exact count of their cattle. In most villages, cattle go into the forest in large herds on their own and return in the evening the same way. It was observed that keeping buffalo and goat give maximum economic benefits to the owner among all. People complain about lack of common grazing areas and reported that most of the wastelands were either encroached by powerful people or were highly degraded. We were also informed by the respondents about the high number of cattle deaths each year, due to water scarcity and forage unavailability.

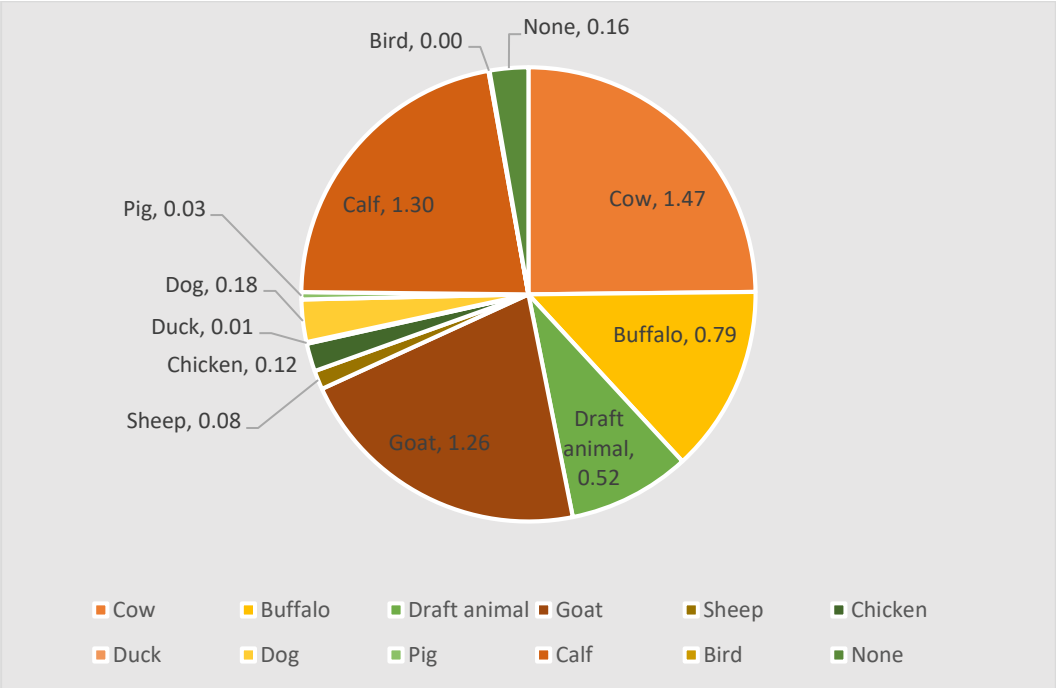


Figure 8.6. A pie-chart indicating average livestock holding by households in Greater Panna Landscape

8.1.3. Forest Dependency and Resource Collection: The forest dependency was found to be high in GPL, as 47.59% sampled households were dependent on NTFPs (Fig. 8.7, 8.8; Plate 8.1). The respondents reported that they were mainly dependent on forest for fuelwood and timber. The fuelwood was needed for cooking purposes and for lighting bonfire in fields for

crop-protection at night. Generally, fuelwood selling is rarely reported as a means of livelihood. Still, a substantial 6.94% households informed us that it is one of the most important occupations. Timber felling was mainly reported for housing and fencing purposes, selling was hardly reported. Almost 80.75% of the households reported that they extract timber from the forest and around 90.76% households responded that they are dependent on fuelwood (Fig. 8.7). We also inquired about people's understanding about degradation of forests in their neighboring area. People reported illegal extraction and forest fire to be the major reasons.

Plate 8.1: Picture depicting minor forest produce that are collected by local communities in the landscape: mahua, tendu, salaiya gum, chewla leaves, and achar



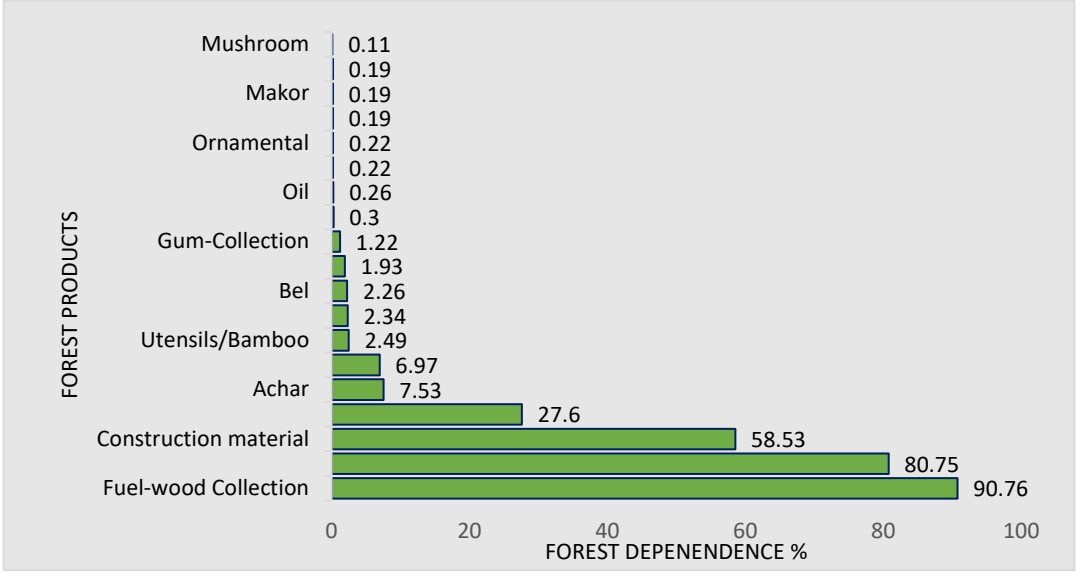


Figure 8.7. Percentage of minor forest produce collected in the landscape

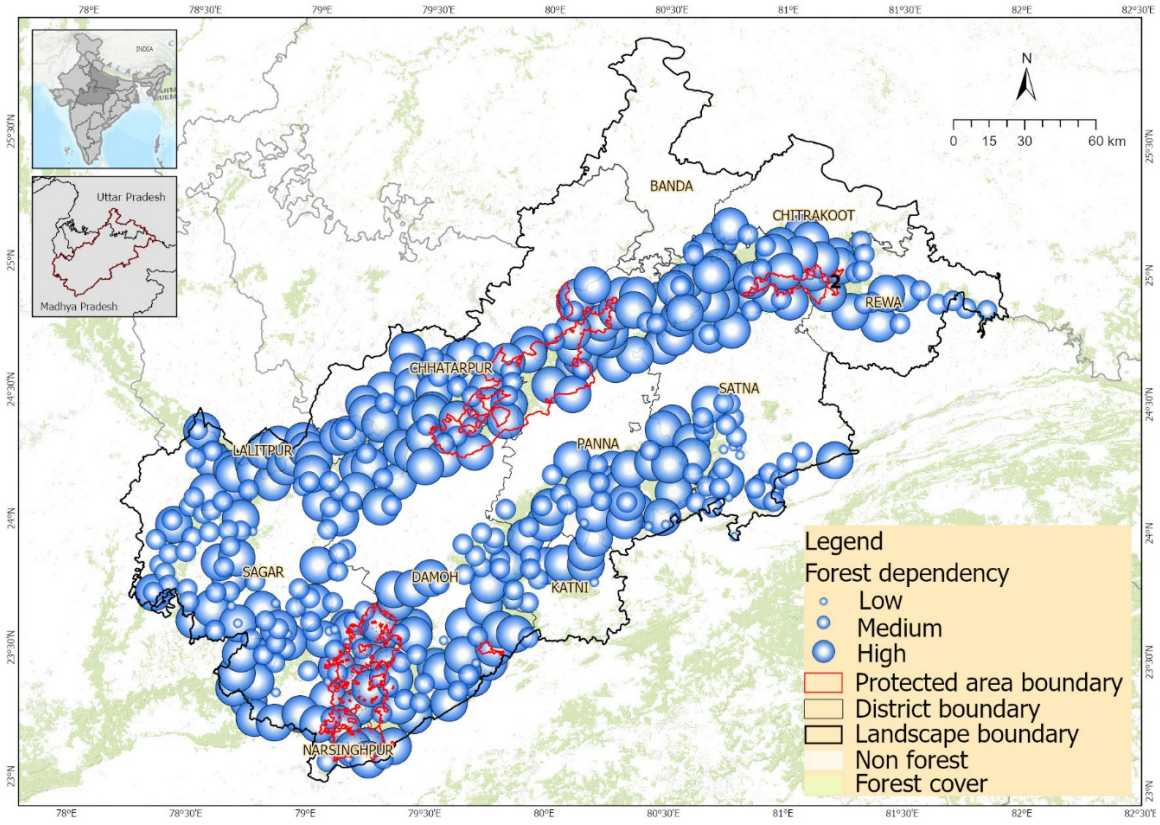


Figure 8.8. Map showing forest resource dependence in Greater Panna Landscape

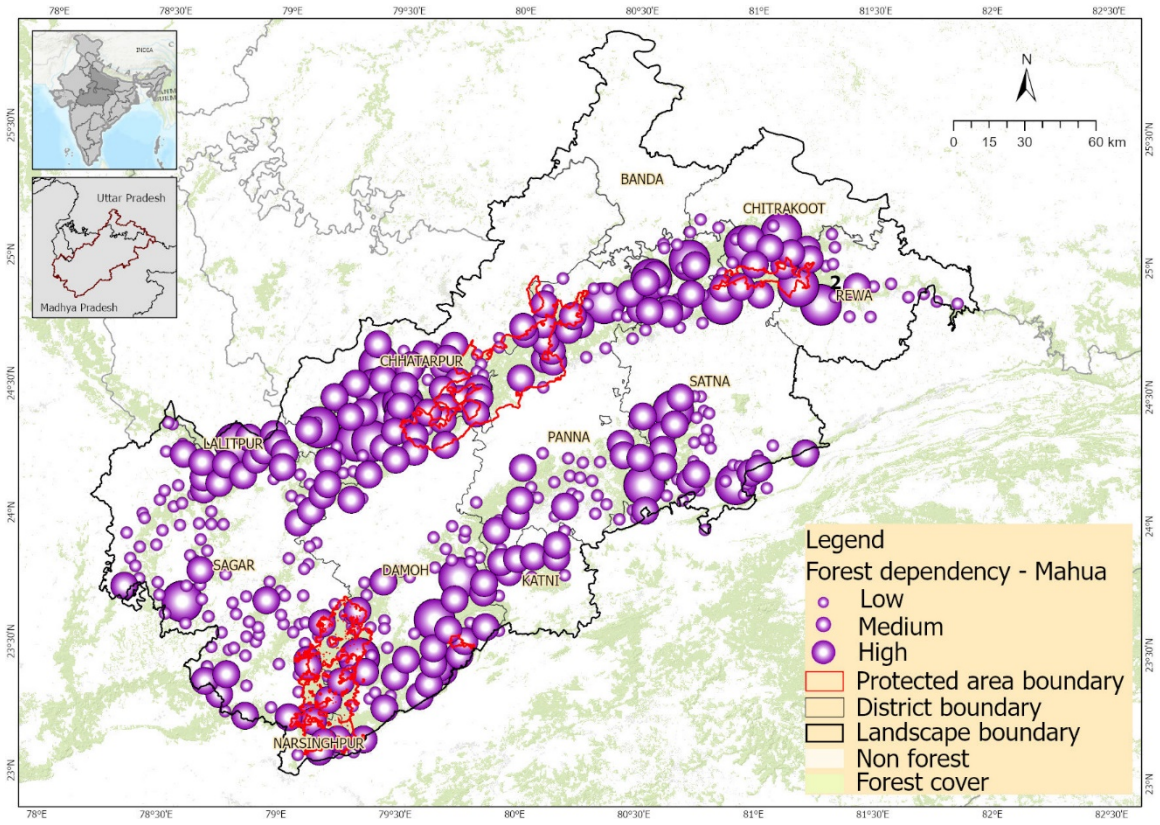


Figure 8.9. Map showing mahua extraction intensity across Greater Panna Landscape

Mahua (*Madhuca longifolia*) collection is one of the major sources of livelihood in the landscape, though it is concentrated in areas which have abundant Mahua trees (Fig. 8.9). Tendu (*Diospyros melanoxylon*) leaf collection was reported in areas where forest department mostly collects it from villagers (Fig. 8.10). Around 44.17% of households informed us about their dependence on tendu-collection for livelihood. Bidi making is one of the major occupations, but this occupation largely depends on tendu agencies in the area and domestic consumption. Achar (*Buchanania cochinchinensis*) and Amla (*Phyllanthus emblica*) collection were also found to be crucial for people's livelihood. Approximately 7.53% and 6.97% households respectively reported that they are dependent on forest for Achar and Amla (Fig. 8.11, 8.12). People also collect herbs, roots, barks, leaves, etc. from the forest for medicinal purposes.

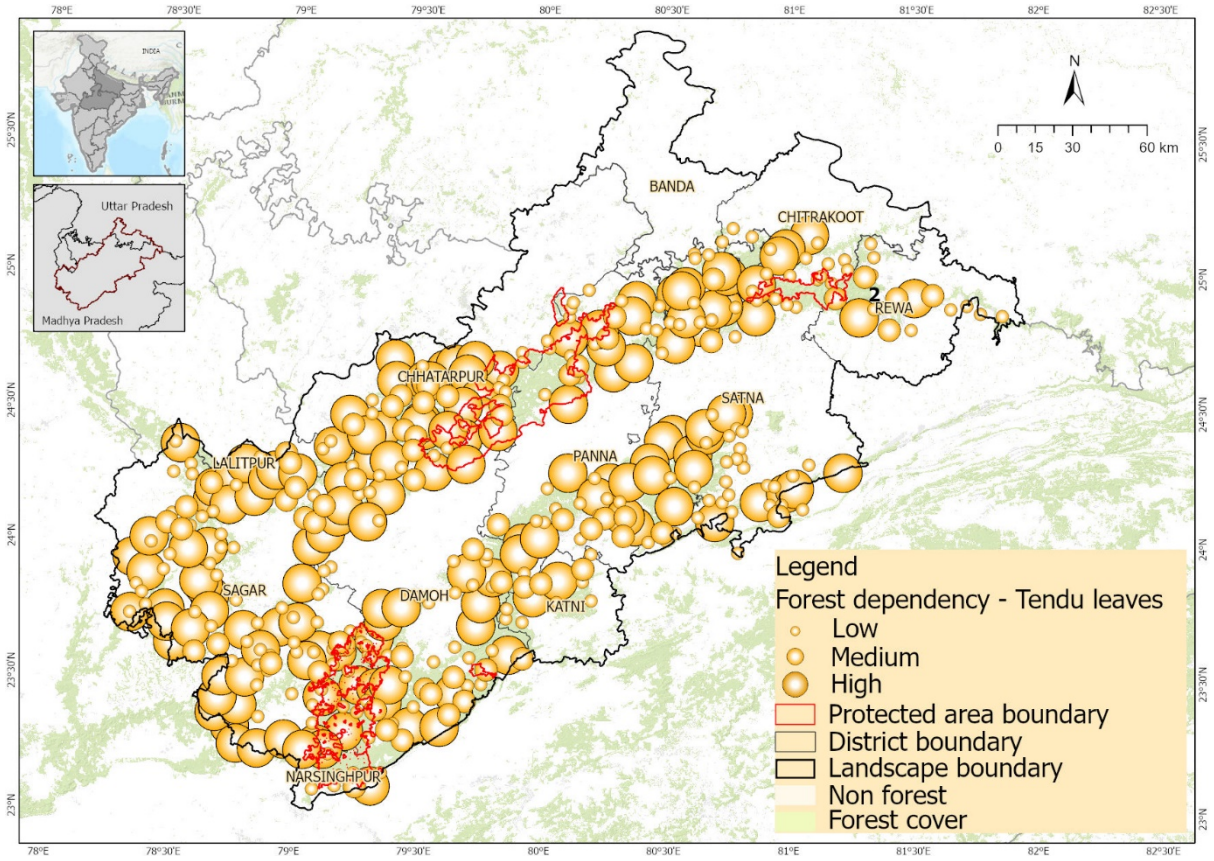


Figure 8.10. Map showing tendu extraction intensity across Greater Panna Landscape

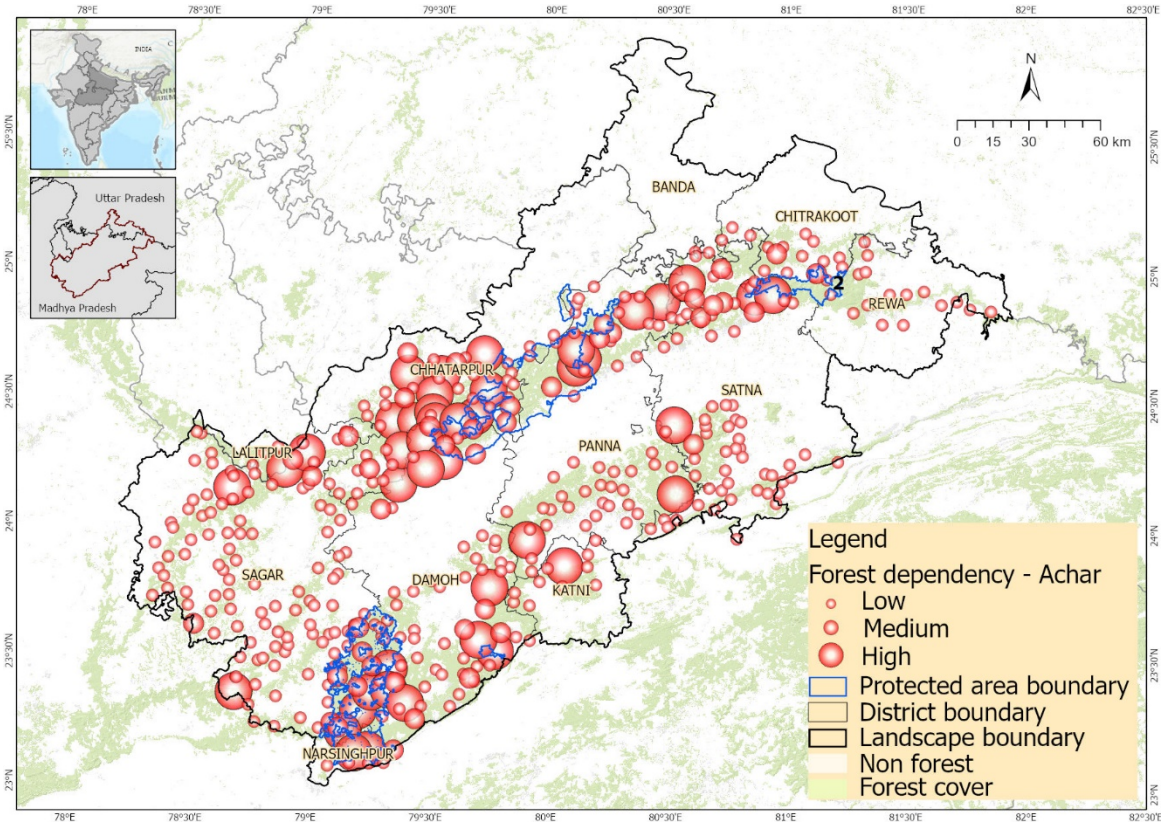


Figure 8.11. Map showing achar extraction intensity across Greater Panna Landscape

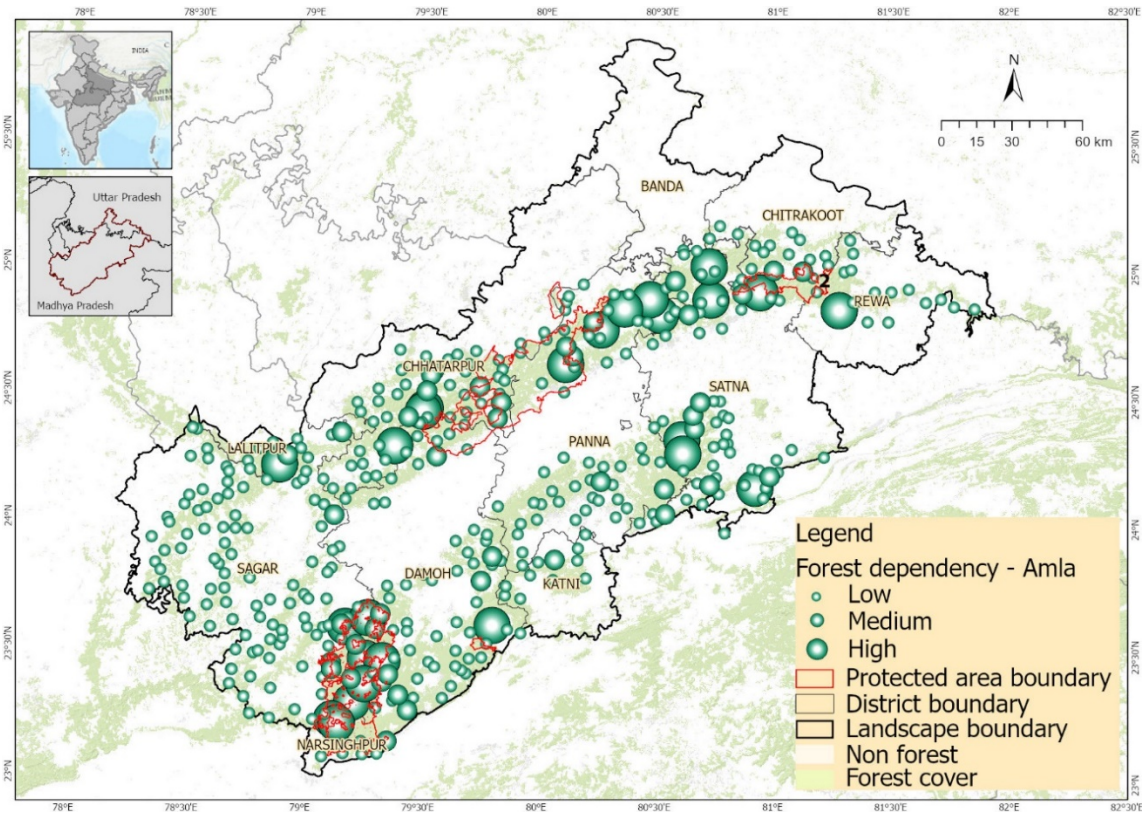


Figure 8.12. Map showing amla extraction intensity across Greater Panna Landscape

8.2. Significant Issues and Challenges

8.2.1. Water-related Issues: Water is one of the key resources in the landscape, as most households are dependent on agriculture in the landscape, and the region is known for frequent droughts. Lack of safe drinking water sources is a big problem in villages, especially for women, who have to travel great distances to procure it. Lack of clean drinking water leads to several water-borne diseases in the villages. In some cases, where a water body flows through a protected area, villagers often find it difficult to access water sources, which leads to conflict with forest department staff. During the workshop with representatives of 101 villages, in and around PTR, we found that on an average almost 60% (ranging from 0-100%) of the agriculture is dependent on rain for irrigation. Very few villages (n=3), did not depend on rain because of availability of ponds, wells and borewells in their village, but most of the agriculture around PTR is rain fed. In many villages (n=22), farming was completely dependent on rain. In many villages, women bear the burden of trekking long distances to fetch water. Water scarcity for both drinking and irrigation is one of the major issues faced by the communities not only in and around PTR, but the entire landscape. Since almost the entire landscape falls within the Bundelkhand region, the region is vulnerable to drought which is a combination of meteorological and hydrological factors. Although several tributaries of the river Yamuna flow through the region, Bundelkhand has been facing the challenge of drought and resulting famine for ages (Gupta *et al.*, 2014). The region witnessed several famines in 19th and 20th centuries due to severe droughts resulting from failure of monsoon (Gupta *et al.*, 2014). And researchers believe that the frequency of droughts are increasing in the 21st century. A study has indicated that two districts of the Panna landscape *viz*. Lalitpur and Banda are vulnerable to severe drought (Gupta *et al.*, 2014). Droughts have been attributed to late arrival of rain, weak or failure of monsoon, poor recharge of ground water and above ground reservoirs (Gupta *et al.*, 2014). The high seasonal fluctuation in discharge of rivers including Ken (carrying almost 800 cu of water during monsoon, which reduces to 300 by winter), increases the water insecurity in the region, such that many villages in these districts completely depend on water tanks during summer months. This situation understandably wreaks havoc in a region, the economy of which is largely agriculture based.

8.2.2. Health Issues: Apart from water insecurity, lack of access to safe clean drinking water leads to several water-borne diseases in the villages. During the socio-economic surveys undertaken in the 436 sampled villages in the landscape, health issues like malaria, typhoid, tuberculosis, and skin-allergies were found to be common in the landscape. Another common

issue raised by the people was the lack of health facilities in their vicinity. The hospitals are at 20-30 km away from the villages which are inside the forest areas. People reported that seeking maternal health care from these far away hospitals during delivery and obstetric complications often result in the death of the mother and baby. In some situations, carrying the pregnant mother on a bike or a bullock cart is risky and time-consuming because there are no tarmac roads available in these areas. Other life-threatening issues included wildlife attacks and snakebites for which access to anti-venom injections was not easy. This led to people relying on traditional healers, which further endangers their lives. More details on health issues are described in the section on One Health.

8.2.3. Waste Accumulation: Many of the health issues in GPL are also caused by large amount of waste accumulation in most villages and towns due to lack of adequate provisions for waste collection and segregation facilities. The waste is generally seen lying around in open spaces or is sometimes burned off by individual households. The provision of dustbins within the rural areas is also sparse. This leads to sanitation and hygiene issues within the areas.

8.2.4. Limited Access to Education: In Panna landscape, the effective literacy rate is 64% and crude literacy rate is 60%. This is lower than the MP state average, *i.e.*, 71% (Chandramouli, 2011). Access to education is limited in the landscape for various reasons. Since there is no school in the area that offers education above the tenth grade, and because of a lack of road and transportation, children are unable to attend distant schools in cities. Most government run schools in the landscape lacked adequate facilities and teaching staff, and parents were disinterested in educating their children and were generally pessimistic about their prospects. Many children were seen helping their families with operations that require a lot of labour like agriculture and NTFP collection.

8.2.5. Lack of Skills: Not only there is limited access to education facility, the education that is imparted also does not provide many usable skills to youngsters that can be converted to employment generation. Most of the people involved in NTFP collection activities in the landscape were found to be semi-skilled. During the consultation workshop in PTR, we ran a questionnaire survey about the existing government schemes on skill development. Surprisingly, most government schemes were unknown to the locals. Even the panchayat secretaries were unaware of certain government procedures and programmes, which we found surprising.

8.2.6. Unemployment and Migration: Lack of education and knowledge about existing skill development programs has resulted in higher unemployment in GPL, because of which villagers are migrating to cities in search of jobs, which is mostly manual labour. During the socio-economic surveys, it was found that manual labour (25.4 %, n=17973) and farming activities (19.9%, n=17973) involve significant proportions of the population in Panna landscape. Labour opportunities are not available throughout the year while farming activities suffer during summers due to water scarcity. It was also found that locals have to migrate to cities (21.25%) in search of work which is challenging. Such is the economic condition of the people that children as young as five years old are involved in activities like NTFP collection and bidi making for income generation in the household. The villagers cited a lack of year-round livelihood opportunities in the region.

8.2.7. Loss of Traditional Knowledge: Traditional knowledge perishes with older generation, unless it is passed on. The medicinal plants, handicrafts, forest goods, and other knowledge bases found in GPL are vast. Bamboo, for example, has been used for decades but nowadays it is only used by a few households to produce handicrafts. People collect herbs, roots, barks, leaves, etc. from the forest for medicinal purposes. However, the traditional knowledge of local medicines was found to be very limited. We could only find two traditional doctors in the landscape and they were old. Additionally, there are several kinds of uncultivated foods. Kodo (kodo millet) and kutki (little millet) are small millets grown as rain-fed crops throughout India. They are known for growing well in dry areas with little soil fertility and moisture. These were the traditional crops of the Gond Tribes of Bundelkhand, as well as other poor forest communities (Verma, 2019). Unfortunately, many villagers couldn't recall any names of edible uncultivated food; only a few elderly people knew about them, like *Bauhinia purpuria* flowers, Wild mushrooms, *Diascorea glabra*, etc.

8.2.8. Forest Related Issues: Given that people in the landscape have a close association with forests, both from traditional and recent necessities, they face issues from multiple facets including direct and indirect threats. These have ramifications for the livelihood of the people which in turn has implications for the conservation of nature and natural resources in the long-term. Some of the key issues are described below.

(i) Restriction on Collecting Fuelwood, Fodder and other NTFP: Forest resources such as mahua, tendu, amla, and achar are some of the most valuable non-timber forest products (NTFPs) in the landscape, with the potential to generate income for a large number of people.

People face challenges in collecting NTFP from PTR and other wildlife sanctuaries in the landscape due to their protected status, and therefore many forest dwellers consider this as a restriction to their rights. Such restrictions are seen as a considerable livelihood threat by the local communities because they are highly dependent on NTFPs especially fuelwood, not only for their own consumption but also as a means of income. Even though the government has disbursed gas cylinders, most cannot refuel the cylinder due to the high cost associated with it.

(ii) Lack of Market Access and MSP: Similar to the charcoal trade in Senegal (Ribot, 1995), it was observed in the landscape that merchants often visit villages to trade NTFPs such as mahua, achar, amla, gum, and so on, with the locals receiving a small portion of the profits. The locals are vulnerable to underpayments due to the lack of any formalised pricing system like Minimum Support Price (MSP) but cannot sell their product directly due to limited market access.

(iii) Human-Wildlife Conflict: Crop raiding by wild animals is the most important issue pertaining to wildlife. Most crop loss is caused by wild pig, nilgai, sambar, chital, and langur. Many villages in and around PTR, report the loss to be severe, amounting to up to 50% of the crop. In many villages the economic loss is so high, that many prefer not to farm their land. The issue is discussed in further details in the next chapter.

Cattle depredation by wild carnivores is the second most frequently stated problem. Most livestock loss is attributed to leopard, tiger, hyena, and wolf. Cattle depredation by wild carnivores is common in villages which has unmonitored cattle grazing. The issue is discussed in further detail in the next chapter. There also reports of attacks on humans by sloth bears and jackal. Villagers therefore perceive sloth bear as the most dangerous animal while accessing the forest-resources.

The forest department does not compensate for crop damage instead the revenue department does. However, people generally do not claim it from the revenue department; and even if they do, the compensation offered is inadequate. Although the forest department does compensate for livestock loss, many do not claim it due to the complex system. Getting post-mortem (PM) report from a veterinarian was frequently stated as the most challenging part of the process. Even if they get compensation, most people are not satisfied because the compensation amount is meagre compared to the market value of the lost livestock. Many respondents in Sagar and Damoh districts reported that the forest department often ignores their requests if the animal that killed their domestic animal is not a tiger.

(iv) Restriction on Developmental Activities: Restriction on developmental activities (*e.g.*, road, hospital, school etc.) inside the protected area is a problem for those who reside inside or nearby the reserve. People often stated that due to lack of road in the village interiors, youth in the villages are not getting married. Moreover, people face problems when social ceremonies like weddings are being performed in villages located inside the core area, because their relatives are restricted from entering. In buffer villages, people expressed grievances for being deprived of freedom and development after their inclusion in the reserve area, especially restrictions on stone mining inside the forest, as it has taken a great toll on the villagers' income source.

(v) Forest Boundary Issues: Encroachment is a complex issue, which is deeply rooted in history, politics, power, caste, economics, governance, ethics, etc. The conflict between revenue and forest boundaries is a frequent problem in deciding land ownership rights in the landscape.

(vi) Non-functional Ecodevelopment Committees (EDCs): EDCs were formed to shift people's dependence on forests to alternative livelihood options. However, such objectives necessitate long-term funding and participation, and most of the conservation projects lack those commitments. Moreover, ecodevelopment projects have been largely inefficient due to lack of awareness of the project's goals among people, a lack of consensus about benefits sharing between the local people and the forest department, and a disparity between incentives offered and conservation outcomes (Mahanty, 2002; Gubbi *et al.*, 2008; Lele and Menon, 2014). During the socio-economic surveys, local people in the Panna landscape questioned why governments conserve wild animals that are dangerous to them, and why the government prohibits them from harvesting NTFPs. Due to shortage of livelihood activities, the villagers recommended that the government support their existing sources of income and use of available forest resources, rather than banning them. In Panna, ecodevelopment programme was started in 1995 and 14 EDCs have been formed. Of these 14, nine committees were taken up under the M.P. Forestry Project for Ecodevelopment and others are functioning through local resources. It was reported during the consultation process that most EDCs in PTR are non-functional, due to lack of funds. People employed as 'shramiks' through EDCs are also underpaid as compared to other shramiks employed by the forest department. Many other villages in the landscape had no committees at all, and others had a few members who had been elected, but had no funding sources, and it was also reported that even when the fund is available, it does not flow into micro-plan activities, instead spent on generic requirements.

(vii) Lack of Local Involvement in Forest and Biodiversity Conservation: As mentioned before, people living in GPL especially in and around protected areas rely on forests for NTFPs and fuelwood while dealing with the pressures of forest degradation, fires and wildlife conflicts. Furthermore, with non-functional EDCs and BMCs the communities within the landscape lack awareness about the role and importance of biodiversity in shaping their lives. This can lead to negative perceptions about the biodiversity and involvement in illegal activities.

8.3. Recommendations and Prescriptions

The proposed recommendations for community engagement for the landscape through field research and secondary data not only aim at local solutions but also attempts to contribute to many of the global treaties and national targets. These prescriptions if implemented relate to Sustainable Development Goals 1, 2, 3, 4, 5, 6, 8, 9, 11, 15 and 17 (United Nations, 2015). Further, the Nagoya Protocol's objective of access to benefit sharing can also be addressed in the prescribed strategies (Convention on Biological Security, 2021). As described below, the recommendations and prescriptions focus on diverse stakeholders and priority actions that may help bridge the conservation and community welfare gaps from local perspectives and would help develop build larger constituency for conservation with win-win strategies.

8.3.1. Stakeholder Mapping and Prioritisation: It is important to include stakeholders in forest/wildlife management and make the process more independent and participatory. Six significant points are essential while engaging the stakeholders (Sterling, 2016). These are (1) how stakeholders are identified and selected, (2) how multiple and diverse stakeholder values are recognised and integrated, (3) the timing and degree of engagement, (4) the drivers of stakeholder motivation, (5) the presence of effective leadership and (6) a strong commitment to building social relationships and trust. It becomes crucial to gain the support of key stakeholders after setting up the plan's goals. Without understanding their interests in natural resources, the implementation process might remain unsuccessful. These interest groups can be linked with forest management based on their forest-use relationships (Fig. 8.14).

(i) Identification of Stakeholders: We have categorised these groups into two major types: Internal and External. In internal class, we have local communities, forest department and other government departments. The external type includes important industries, NGOs, media and other partners (Fig. 8.13). Following are the stakeholders that need to be engaged, however, need to be visualised from the perspective of interest versus power positions (Fig. 8.13) as the interrelationships can influence the overall outcome.

***Local Communities*:** People living in and around forest areas in GPL depend upon the forest resources directly and indirectly for sustenance. As previously discussed, the local communities mainly consist of several social groups like the Gonds, Yadavs, Basor, Bhil, Kacchi Patel, Lodhi, Kurmi, Kumhar, Ahirwar etc. In the landscape, many people follow their traditional occupations, based on which, their interaction with forests vary. For example, among all social groups, the Gonds and Yadavs were found to be most dependent on forests

for livestock grazing and NTFP collection. In the landscape, we have found that local communities in Nauradehi Wildlife Sanctuary are more dependent on forests, followed by villages in South Panna and Chhatarpur Divisions. In the Sagar district, villages outside the Nauradehi Wildlife Sanctuary are more dependent on bidi making than other districts in the landscape. However, local communities believe that there is a reduction in forest-based occupations as the forests have degraded over time.

***Government Agencies*:** The forest department is a primary stakeholder in the landscape and negotiate with other stakeholders on an everyday basis. The Panchayats are an essential stakeholder in the landscape because every village-based policy must go through this department. Each panchayat in the landscape approximately consists of 1-8 villages. Other departments include Tribal Affairs Department, Public Health Department, Education Department, Agriculture Department, Animal Husbandry Department, Tourism Department and Cultural Affairs Department

***Industries*:** Industries dependent on forest products for commercial purposes can be major stakeholders in forest management. Following industries are operating in the landscape:

- Organised and Unorganised Mining Industry
- Furniture Industry
- Brick Kiln Owners
- Small and Medium Enterprises
- Local Vendors
- Open Weekly Market

***Others*:** NGOs, nature enthusiasts, media, scientists, researchers, educational institutions, etc. can be an important part of the stakeholders.

(ii) Priority Stakeholders: Based on the field observations and literature review, we have identified that Mine Owners, Local Communities, Forest Staff, NTFP Buyers, and Industries like Furniture, Brick Kiln, and Pharma should be the top priority in forest management. These interest groups have significant influence over the policies and have high stakes. However, various government departments may have a higher power in influencing the policies but might have lower forest management interests. Researchers, media, and educational institutions play an essential role in shaping policies and have high stakes in the processes. But they might need help in getting access and participation. Keeping these groups informed will be crucial for

knowledge production and innovations. At last, local NGOs working closely at the grassroots level may require minimal effort in monitoring them. The inter-relationships between these stakeholders can be complicated. It is vital to understand when, how to intervene, and at what stage. With government departments and NGOs, constant dialogue is crucial because they can influence and be more impacted. Whereas local communities need regular consultations, which have to be more passive and interactive. The local communities can be more affected due to conservation processes but can have lesser influence. The public can have lesser direct power and can be lesser impacted but can provide essential insights into the conservation policymaking. At last, media or other opinion-formers can be lesser impacted but can have more influence. These stakeholders need to be provided access to appropriate information (Golder and Gawler, 2005).

8.3.2. Water Resource Management: Several programmes and institutions have been setup in Bundelkhand, to either understand the draught vulnerability or devise strategies for water conservation and economic security by several governmental and non-government organisations such as National Watershed Development Project, Integrated Watershed Management Program (IWMP), Artificial Recharge to Groundwater through Dug Wells, Backward Region Grant Fund, WaterAid, Bundelkhand Consortium Watershed Development Programme, SWAJAL and Sustainability Resource Centres or TARA grams. The biggest boost in recent time was given to the region by Bundelkhand Special Package, amounting to 7466 crores awarded to the region during the 11^{th} plan period and continuing in the 12^{th} Plan period with a further influx of 4400 crores (NABCONS; Mishra and Tayal, 2019). The package aimed at draught proofing and covers four out of eight districts of GPL in Madhya Pradesh namely Sagar, Damoh, Panna, Chhatarpur, and all three districts of Uttar Pradesh namely Banda, Chitrakoot, and Lalitpur. Under Bundelkhand Special Package, several irrigation projects were launched. It also focussed on soil and water conservation strategies (IWMP is also now integrated with this package) including forest regeneration activities and improved agricultural practices (Gupta *et al.*, 2014). However, since its inception, it has been marred by controversies and irregularities of funds (Dhar, 2012; HT, 2020). Government has also sought international expertise in resolving the water crisis in the region. In 2020, a 'plan of cooperation' was signed by Uttara Pradesh and Israel Government, to address water crisis in two districts of Bundelkhand (Sahay, 2020). Under this Bundelkhand Water Project, experts would impart training on better farming and irrigation technologies. Since 2019, GIZ India has also implemented a project on 'Water Security and Climate Adaptation in Rural India' (WASCA)

in collaboration with the Ministry of Rural Development (MoRD) and the Ministry of Jal Shakti (MoJS), chalking out the outline of Composite Water Resource Management Plan. However, most of the large-scale government programs have not had the expected impacts on water security in the region, although several traditional and modern practices specified below have been able to improve yearlong water availability in certain pockets. It is these good practices that give us an insight on the working strategies for tackling the water related issues in the GPL.

(i) Traditional Water Conservation Practices: Several traditional practices in the region are focussed on water conservation, from ponds and check dams to special reservoir built by Chandela and Bundela Kings. However, these reservoirs lie either neglected or are not efficient because of lack of maintenance. Existing government programmes (as mentioned above) can focus on rejuvenation of these reservoirs and ensure regular maintenance.

(ii) 'Jal Sahelis' Water Management Program: In around 200 villages in UP and MP, Asia Initiatives in partnership with Parmarth Samaj Sevi Sansthan have initiated a water conservation project with a focus on involvement of rural women as 'Jal Sahelis' (Srivastava, 2019). It works on the methodology of Social Capital Credits, within which women earn credits for doing social activities like planting trees, planning and contributing to sustainable water harvesting projects, which they can redeem for gaining something personal like fuel efficient *chulahs* or as a community, for building check dams and wells in their village. Women are also coming forward as decision makers in 'Pani Panchayat' in several villages, wherein they make crucial water management decisions for their village. The reason this model is hailed as successful because it has not only been endorsed by the local women, but they have become the flagbearers of the program, teaching other women and members of the community. Since the knowledge is imparted by the people, for the people, in their own language and when they can see its successful implementation in their neighbouring village, it has a great impact on the overall success. And once the cycle is started, it does not require any external input, because people themselves take control of their situation, and the better they do the more resources they get, for doing better.

A simple way to harvest water is by desilting and cleaning of existing wells and ponds with the help of local communities. This can increase water security in the landscape and at the same time also provide livelihood to people (Oweis *et al.*, 1999; Machiwal *et al.*, 2004; Yazar and Ali, 2016; Saxena, 2017). A few villages in Banda, motivated by the local administration, have

taken up recharging wells and ponds for improving water availability during dry seasons (Roy, 2019). Similarly, in two blocks in Mahoba, under IWMP, villagers have made bunds for rainwater harvesting, which recharged their wells by recharging ground water (Jitendra, 2020). Another interesting way that farmers have found, again in Mahoba, is by letting government dig their land for soil, the government gets soil for various activities, and the farmer gets a pond for free plus some cash, a complete win-win (Sarkar, 2016).

(iii) Better Agricultural Practices: Water conservation measures alone cannot solely reduce vulnerability of local communities, without better agricultural practices including sustainable use of water (e.g., Drip irrigation) and selection of less water demanding or drought resistant crops (for e.g., Maize, castor, green gram, bean, ground nut) (Lakaria *et al.,* 2012). There is also a need to reduce dependence on agriculture for economic stability and diversify the avenues for livelihood generation by boosting other sectors and providing alternative skills to rural youth. Such simple and traditional measures, their implementation, success, and flaws should be shared by the districts in the landscape with each other. This is where the Landscape Management Authority/Council (with suitable administrative and financial power, perhaps under Special Purpose Vehicle) would play a big role. Moreover, since water conservation have been directly linked with forest conservation, the several funds allocated by the government for water conservation in Bundelkhand, can be utilised to protect and restore key corridors and satellite cores and manage community reserves in the landscape.

8.3.3. Health Management: It is recommended that District Landscape Committee under GPLC should work in collaboration with the hospitals and provide ambulance facilities to the villages in the landscape, focusing more on those villages that are within forested areas and have poor road connectivity. It is possible to engage insurance companies or corporates in delivering health care facilities to the villagers under Corporate Social Responsibility (CSR) and the Public Health Department, and GPLC can facilitate such options. Access to health care will improve trust with the department in the long run and will save lives.

8.3.4. Waste Management: Since waste management is virtually non-existent in most of the villages and urban areas in the landscape, it is proposed that every village should have cleanliness drives at least once a month and people should be made aware of proper waste management strategies. Garbage collectors should be employed by the municipalities/panchayats, and segregation of waste by communities should be promoted. Spaces should be designated within the village wherein the organic/wet waste can be

composted to produce fertilizer and inorganic/dry waste can be utilised for waste to energy conversion plants. It is recommended that the District Collectors of every district should take the responsibility to put these cleanliness measures in place.

8.3.5. Education Enhancement: Education should be made more accessible to rural communities in the landscape, especially education beyond primary school. Where possible transport facilities should be provided especially to girls for reaching distant higher education facilities in towns. It is recommended that a consultation should be done with the education department to customise the coursework, so that it provides necessary required skills to the children, along with their existing educational curriculum. For example, an introductory course on NTFPs, Agriculture, Animal Husbandry, etc., can be part of the curriculum. Involving skill-based training in schools might push parents to send their children to schools and add value to the existing system. It is recommended that attendance of teachers and students should be monitored regularly as well as necessary measures be taken for the implementation of quality education in the GPL. If there are any nomadic/ tribal communities in any area, necessary steps to be taken for hostel facilities to be provided in the area.

8.3.6. Skill Development: We propose some of the following strategic actions to promote existing skill base and develop new skills among local communities.

(i) Higher Education and Technical Skills: In GPL, there is a shortage of higher educational or technical institutions in the vicinity of villages, especially for those that reside inside or close to forests. As a result, most students drop out after tenth grade, leaving them with no technical understanding, training, or skills. To develop skills in the landscape, specific governmental departments might be involved and collaborations with the forest department might be sought. Higher education and technical expertise should be prioritised, which would require significant investment.

(ii) Skill Development/Capacity Building: Skill development programmes will assist young people in cultivating entrepreneurial skills and taking advantage of local opportunities. In Melghat Tiger Reserve, a local NGO set up three computer centres in the villages of Maharastra's Amravati district to provide professional training to local youth. Drawing inspiration from such examples, local civil society could be involved in launching such initiatives at the local level in GPL. Basic literacy, machine data operations, MS Office and, after acquiring some proficiency, remote sensing and GIS training, could be imparted to the villagers. This would provide them with skills and could help them find recruitment with the

forest department or other government departments/offices. Villagers might also receive training in vermicomposting or earthworm culture, horticulture, silviculture, apiculture, marketing, tourism management, wildlife monitoring, waste management, and other fields. National Skill Development Corporation (NSDC) and National Institute for Rural Development (NIRD) /State Institute for Rural Development (SIRD) can be a stakeholder and can help with all the training and consultation identified in the plan.

(iii) Green Skill Development Programme: Union Ministry of Environment, Forest and Climate Change (MoEF&CC) launched Green Skill Development Programme (GSDP) in 2017 as a pilot project and has gradually expanded. It a skill development programme in the environment and forest sector designed to help India's youth find beneficial jobs and/or self-employment (MOEF&CC, 2017). Apart from gaining employment, it is also aimed at Nationally Determined Contributions (NDCs), Sustainable Development Goals (SDGs), National Biodiversity Targets (NBTs) and Waste Management Rules (2016). The GSDP built on the extensive network and knowledge of ENVIS Hubs/Resource Partners and partnered with the National Skill Development Agency for expertise, with an emphasis on Green Skills. Green Skills are those skills that are needed to adapt processes, services, and products to climate change and the associated environmental legislation and specifications. Such skills provide the knowledge, skills, beliefs, and attitudes necessary to live in, develop, and sustain a resource-efficient and productive society. The prospects of these abilities are in the fields of Renewable Energy, Climate Change Readiness, Wildlife Conservation, Wastewater Treatment, Climate-resilient Cities, Green Construction, Solid Waste Management, etc. (OECD, 2014; Dlimbetova *et al.*, 2016; MOEF&CC, 2017; Sern *et al.*, 2018). There are several courses offered under the programme and some of them relevant to GPL are:

1. Value addition and marketing of NTFPs (Plant Origin): Lantana Furniture and Crafts
2. Value addition and marketing of NTFPs (Plant Origin): Bamboo Crafts
3. Value addition and marketing of NTFPs (Plant Origin): NTFP Products / Medicinal Plants
4. Value addition and marketing of NTFPs (Animal Origin): Wild Bee Keeping and Processing
5. Bird identification and basic ornithology

6. Nature conservation and livelihood: Nature Interpretation for Large Zoos and Safari Parks - Zoo Guide Training Programme
7. Nature conservation and livelihood: Ecotourism
8. Propagation and management of bamboo

(iv) Current and Future Employment Capacities: It is recommended that the difference between existing and future demand for human capital be recorded, and that requirements be planned accordingly. Human capital for ecotourism operations, for example, can be measured and local communities can then be trained in catering, communications, cooking, etc. and hired for those activities under the supervision of forest department and respective EDC.

(v) Active Participation of Villagers in Forest Management: It is important to involve people in forest management, especially in protected areas which are sensitive to human population and resource conflict (Roche and Dourojeanni, 1984). This might not only instil trust in them but also encourage people to pursue jobs with forest department. The locals are currently untrained and in dire need of the requisite skill sets. Continuous training is required, and local institutions must be equipped to promote local learning.

(vi) Training Programme for Forest Staff and Villagers: Consultative process allowed us to understand the need for training for forest staff and people. While the staff require skills in technology and handling crisis, villagers require training in tailoring, farming practices, entrepreneurship, driving, marketing forest products, and so on. Based on the Career Guidance Programme of Scheduled Tribes Development Department, Kerala State Government, we propose following action plan for skill development in GPL:

1. A nodal officer for education shall be hired under the IRLC to be set-up in Panna, who would monitor the activities and progress on regular basis. A special career guidance Cell for Tribal areas shall be constituted in the Department of School Education, Madhya Pradesh and Department of Basic Education, Uttar Pradesh.
2. A detailed study on education and exiting skill levels among the households shall be conducted in the initial stage. Accordingly, educational programmes and vocational courses shall be developed.

3. All relevant government schemes and job listings shall be made available and updated on regular basis on a web-based platform developed along with helpline numbers, to help people locate the required skill-based courses, competitive tests, and job postings.
4. After conducting consultations with the villagers, a list of courses shall be made and finalized after further discussions with specific government agencies and programmes like the Skill India.

A suggestive list of training programmes has been prepared for GPL (Table 8.2).

Table 8.2: Suggested training for skill development of local communities in GPL

Sector	Training	Employment Prospects
Product-based	NTFP Processing and Marketing (Amla, Mahua, Achar, etc.)	Self-Employment, Consultant/Trainer
	Medicinal Plants	Self-Employment, Consultant/Trainer
	Bamboo Products	Self-Employment, Consultant/Trainer
	Lantana Products	Self-Employment, Consultant/Trainer
	Apiculture	Self-Employment, Consultant/Trainer
	Modern Agricultural Practices, Techniques and Technological Solutions	Self-Employment, Consultant/Trainer
Service-based	Carpentry	Self-Employment, Consultant/Trainer, Corporates, Other Institutions
	Building Construction	Self-Employment, Consultant/Trainer, Corporates, Other Institutions
	Gardening	Self-Employment, Consultant/Trainer, Nurseries, Botanical Gardens, Corporates, Educational Institutions, etc.
	Masonry	Self-Employment, Consultant/Trainer, Corporates, Other Institutions
	Electrician	Self-Employment, Consultant/Trainer, Corporates, Other Institutions

	Plumbing	Self-Employment, Consultant/Trainer, Corporates, Other Institutions
	Eco-tourism	Self-Employment, Consultant/Trainer, State Forest Departments
	Tailoring	Self-Employment, Consultant/Trainer, Corporates, Other Institutions
	Driving	Self-Employment, Consultant/Trainer, Corporates, Other Institutions
	Protected Area Management	Consultant/Trainer, State Forest Departments
	Computer Training (including MS Office, Tally, etc.)	Clerical work in public and private offices and business establishments
	Preparation of People's Biodiversity Register	Biodiversity Management Committee, Panchayats, Municipalities, Related Agencies

The activities under skill development, can be divided into three stages in order to reach maximum efficiency in terms of training the local people and its implementation.

***Phase I*:** Orientation programme (explaining the local people about GPL and the skill development initiative), preliminary survey and identifying gaps (after conducting an orientation, a detailed survey shall be conducted to assess the local level skill-based requirements. Consequently, identify people-led skill development at local level), and Selecting candidates for training (based on the survey and local interest, a list of individuals shall be made for further considerations).

Phase II: Facilitation and Guidance – The aim should be to foster both conventional and modern skills and techniques. Locally, such guidance may be provided, or the GPLC may provide resources to assist the people. For example, in GPL, we discovered that Traditional Knowledge Systems are fading. They can recruit people that can identify medicinal plants, and these people can further train local youth, who with the help of GPLC can market these medicinal plants.

***Phase III*:** Promoting Panchayats, Theme-based EDCs and Community Cooperatives/Growth Centres as potential employers- Individuals trained through the PLMP's skill development programme can be employed by Panchayats as ecological/social mobilizers or by the Theme-

based EDCs and forest cooperatives/growth centres in the long run. It would offer people an option of working locally which could help to promote green development. Financial literacy should be imparted to local communities, especially those who have received any kind of compensation (like village relocation).

8.3.7. Improving Traditional and Novel Livelihood Options: Villagers can be actively engaged by skill development, capacity building, job creation, technology, and knowledge generation, and theme-based committees. It can be a significant push in addressing the wider socio-economic issues. While these activities are aimed at enhancing the livelihood options and economic upliftment, the overall goal would be to reduce dependency on the forest resources.

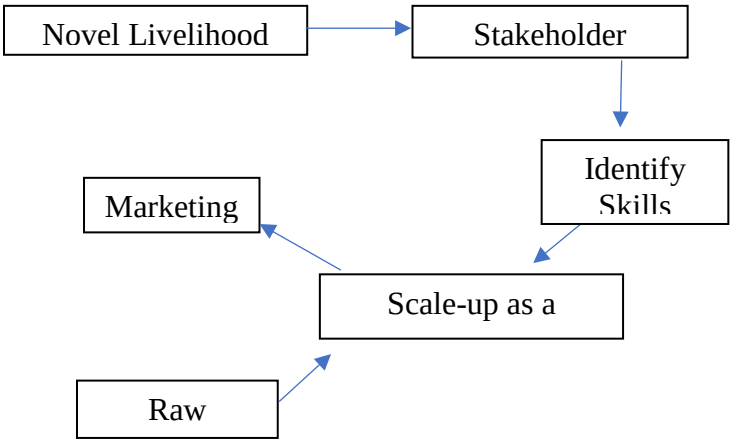


Figure 8.13. Flowchart of suggested steps to employ novel strategies for livelihood generation

For promoting the novel livelihood strategies, stakeholder consultation should be done, after identification of requisite skill, the project can be scaled up, ensuring supply of raw material and opportunities to market the end product (Fig. 8.13).

The specific recommendations/suggestions provided below focusses on various options which will enable the communities to plan and execute short term and long-term alternative livelihood measures:

(i) Agriculture Development: For long-term development, the agriculture sector requires government assistance (Mustaquim, 2020), especially, in an area like GPL, where most of the population is dependent on agriculture even though it is drought prone. Some of the schemes under the government of India which can be utilised by the panchayats are: National Mission for Sustainable Agriculture (NMSA), Pradhan Mantri Fasal Bima Yojana (PMFBY), Pradhan Mantri Krishi Sinchai Yojana (PMKSY), Paramparagat Krishi Vikas Yojana (PKVY). Micro

Irrigation Fund scheme, E-NAM, Kisan Credit Card (KCC), Soil Health Card, PM Kisan Samman Nidhi Yojana, PM-Kusum and Kisan Drone.

(ii) Soil Health Cards: Each cultivator in a village may be given a soil health card by agriculture department, which can be used for registering issues/problems faced in farming a crop and its annual production. Specific agricultural interventions might be suggested based on the existing situation. This can be done under the NABARD's Agriclinic and Agribusiness Centres Scheme.

(iii) Integrated Farming System: The National Agricultural Policy of 2000 defines the need for Integrated Farming in India, and it has the potential to deliver a breakthrough in maximising the use of local resources in GPL. Integrated farming originated in China and is gaining popularity across the world. It is a system that connects specialized primary activities such as agriculture farming, poultry, livestock keeping, pisciculture, apiculture, and other livelihood options to meet local needs. In a rural society, for example, villagers practice agriculture while also keeping cattle. The dung is used as manure in agricultural farms. Other animal products including dairy products, leather, etc. are used by the local as supplementary income. However, it is critical to examine local conditions and develop targetted integrated farming models. It is recommended that the GPLC supported by IRLC examine local capacities for agricultural alternatives at the outset, and then offer tailored choices at the panchayat level. Livestock-Fish Integrated Farming, Livestock-Honeybee Integrated Farming, Poultry-Fish Integrated Farming, and so on are some of the conceivable integrated farming combinations (Fig. 8.14).

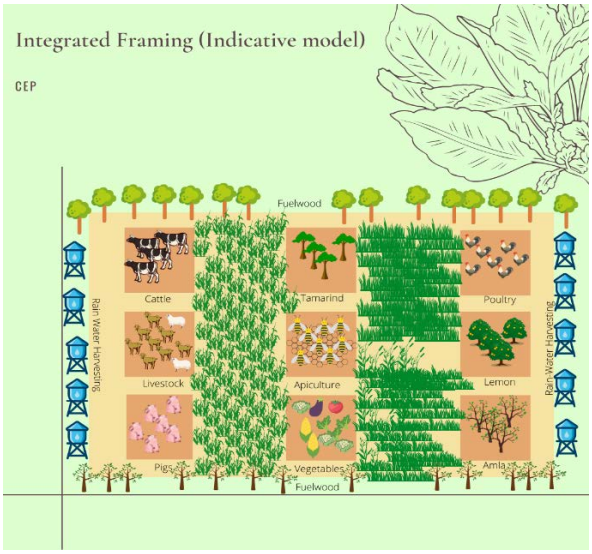


Figure 8.14. Indicative Integrated Farming System (options can be picked based on local interests and suitability)

(iv) Apiculture: Over time, we have seen a boom in apiculture in India because of the growing demand for organic and pure honey. This demand of urban households can be fulfilled by the rural households in the landscape. For which we can look up to such initiatives as 'Bonphool'. Supported by the Sundarbans Biosphere Reserve (Directorate of Forest, Government of West Bengal) and WWF India, Bonphool aims to provide authentic products while ensuring local communities' welfare. Honey is harvested from the forest by local communities in GPL, mainly for domestic use and sometimes traded in the market. Due to lack of any protection and financial guidance, they don't earn a fair price. It is proposed that villagers can practice apiculture, and under the National Beekeeping and Honey Mission which was launched by the Ministry of Agriculture and Farmers Welfare, wherein the participating farmers will be able to receive development and financial assistance till the time they decide to continue with the business. Under the mission's guidelines, the farmers will be able to produce multifloral and unifloral honey (Ministry of Agriculture and Farmers Welfare, 2021). National Bee Board and other local organisations can be approached to sell the product. One possible way to do this is through the Self Help Groups (SHGs) and market the products through the Cooperatives.

(v) Horticulture: National Horticulture Board implements programmes as sub-scheme of Mission for Integrated Development of Horticulture (MIDH). Individuals, Group of farmer growers/consumers, Farmers Producer Organizations (FPOs,) Partnership/ Proprietary Firms, SHGs, NGOs, Cooperatives, etc. are eligible to get assistance under all the NHB schemes. Important schemes of NHB are Commercial Horticulture Scheme, Cold Storage Scheme, Technology Development Transfer Scheme, Market Information Service Scheme for Horticulture Crops and Horticulture Promotion Service. There are several other central government level schemes which might be referred. These schemes are PMKSY Scheme, MIDH Scheme, Rashtriya Krishi Vikas Yojana, NMMP, Weather Based Crop Insurance Scheme and Aatmanirbhar Bharat, among other. Additionally, and more importantly, some of the state-level horticulture scheme might be of great value. Some of the state-level horticulture schemes are: Phal Vistar Kshetra Yojana, Sabzi Kshetra Vistar Yojana, Sanrakshit Kheti and Udyaniki Bagwani Hetu Yantrikikaran ko badhawa Dene Ki Yojana. Under the Fruiting Tree Expansion Scheme, every farmer might be given fruit tree saplings in 0.25-4-hectare area. The vegetables grown can then be sold at proper set-up *panchayat mandis* or at tehsil level.

(vi) Improving Animal Husbandry Practices: The Ministry of Agriculture and Farmers' Welfare launched the National Livestock Mission in 2014-15. It aims to improve the long-term growth of the livestock sector. Under the Entrepreneurship Development and Employment

Generation (EDEG) part of the National Livestock Mission, NABARD is the subsidy channeling agency. This mission was developed with the aim of ensuring the livestock industry's long-term survival by increasing the availability of high-quality feed and fodder. Dairy Entrepreneurship Development Plan, Dairy Processing and Infrastructure Development Fund and Kisan Credit Cards (KCC) to Livestock Farmers are just a few of the NLM's schemes. Many of these schemes, are either not implemented or people are unaware of them in GPL and can be used as convergence mechanisms.

(vii) Dung-based Economy: Stray cattle are a common issue in the landscape, and their numbers have risen because of the government's cattle-slaughter ban. Dung harvesting from households can be achieved easily, which will also keep the villages clean. Community-based manure can be made and used in farmlands. If the village generates excess manure, the government may purchase it for use in their plantation programmes. Dung collection might be used for a variety of purposes, including biogas plants, village electricity generation, and so on (Gowane *et al.*, 2019; Narayanan, 2019)**.**

(viii) Local Entrepreneurship: Panchayats might consider obtaining seed grants either from their own fund or ask the state or central government for local entrepreneurship. This will encourage residents to come up with new proposals and push them further in the early stages.

(ix) Lantana Furniture Making: In few villages of GPL, villagers make their own lantana furniture and sell it in the local market. They do not, however, have any formalised funding, training, and support, and rely on informal means. ATREE, a Bengaluru-based organisation train villagers in furniture and craft making funded by the Department of Science and Technology. Similarly, the forest department with the help of local NGOs may identify such local skills, and give them training and assistance in selling the products, seeking assistance from the Tribal Cooperative Marketing Development Federation of India (TRIFED) (Kent and Dorward, 2015; Rangasamy *et al.,* 2019; Saxena *et al.,* 2020).

(x) Promoting Basket Making: Basket making is common among the Basor community in the landscape (bamboo-craft makers), though the industry is sluggish. These communities face difficulty in finding work due to the plastic boom. Many craftsmen also had to leave this profession due to lack of profitability in this craftsmanship. Such social groups might be identified, and such environment friendly goods could be marketed at the local level, similar to what Tamil Nadu Government has launched a programme to use cotton cloth bags (Meendum Manjalpai Campaign). These people may be assisted with raw materials and

vocational training to connect them with merchants who will help them market their goods locally and in cities.

(xi) Village Tourism: Village tourism can be launched in unique areas of the landscape (Lane, 2009; Bogdanov *et al.*, 2011; Ciolac *et al*., 2013). It is important to strategically locate certain villages/areas in the landscape, and each forest division can propose a list of villages/areas where village tourism may occur. If camping facilities/homestays are established, tourists would be able to mingle and learn from the villagers, the 'Living with Simplicity' model. Last Wilderness Foundation, a Mumbai-based organisation train villagers as Nature Guides. Their model of ‘Walk with the Pardhis’ and ‘Village Tourism’, both in Panna can be replicated in other villages in the landscape too. This interaction would also allow urban and rural dwellers to learn about sustainability from each other and enable tourists to experience the local culture, traditions and cuisines of the region. At the initial stage, we propose village tourism in a few villages like Lalar (Rajnagar, Chhatarpur), Udla-Pandavan, Kunjavan, Tara, Jaiswanthpura, Jaithpura (Panna), Hathibhar (Bahoriband, Katni), and Sarra (Tendukheda, Damoh) (Fig. 8.15). The journey to these villages is captivating and might attract tourists. Such villages are scenic and can help to relieve pressure on the tiger reserve. Chhatarpur district's Kishangarh area has a lot of potential for tourism growth. It is located outside of the Panna Tiger Reserve and there are multiple potential religious and forested sites for village tourism. By linking them with livelihood and tourism, this activity would also help preserve the unique culture and traditions of the landscape.

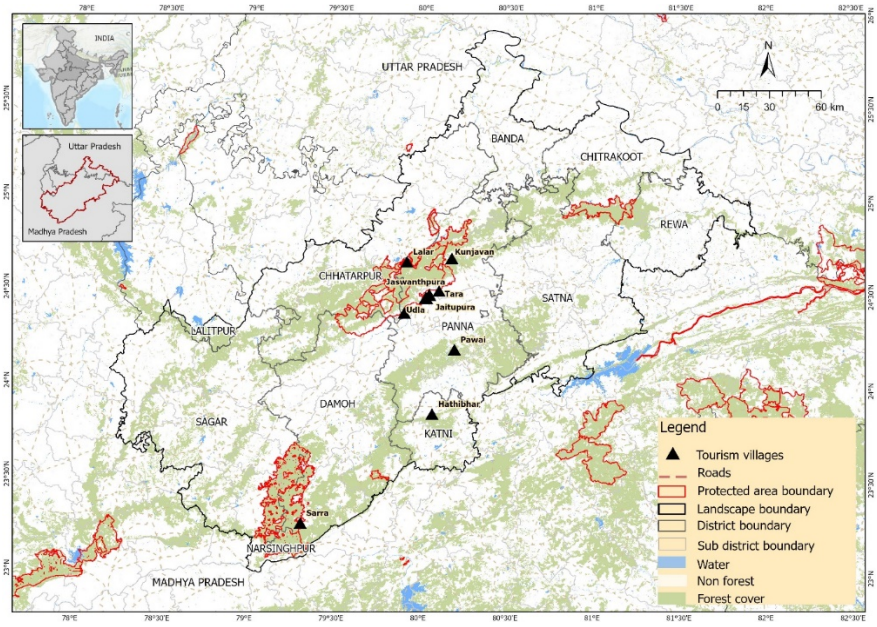


Figure 8.15. Map indicating villages with potential for tourism in GPL

8.3.8. Conserving Local/Traditional Knowledge: The following measures can be undertaken to conserve traditional knowledge on medicinal plants and (presently) uncultivated crop varieties and traditional livelihood activities:

(i) Citizen Portal for Medicinal Plants: The Government of India setup the National Medicinal Plants Board (NMPB) to coordinate all matters related to medicinal plants, as well as to support policies and programmes aimed at increasing trade, export, conservation, and cultivation The board is run by the Ministry of Ayurveda, Yoga and Naturopathy, Unani, Siddha, and Homeopathy (AYUSH). Under the Central Scheme, herbal gardens can be set up in villages and the types can be Home Herbal Gardens, School Herbal Gardens, Institutional/ Public Herbal Gardens, etc. The National Medicinal Plants Board (NMPB), in partnership with the Quality Council of India (QCI), has initiated a Voluntary Certification Scheme for Medicinal Plant Produce (VCSMPP) to promote Good Agricultural Practices (GAP) and Good Field Collection Practices (GFCP) in medicinal plants and to improve their quality and protection. At the village level, certain programmes could be promoted by the village panchayat and the forest department. At the panchayat level, a citizen portal can be maintained to list the medicinal plants in the area. This might attract investor and might provide a structure to the medicinal plants business (Vernooy *et al.*, 2020).

(ii) Community Seed Banks: Community Seed Banks (CSBs) are local level collective-actions that are regulated and run by the local communities, with the primary goal of preserving seeds for local use (Development Fund, 2011). A seed bank might be maintained at the panchayat level in GPL, this will be of great assistance to the area in times of severe droughts and will offer an alternate solution to water demanding crops like wheat and rice. The panchayat can also assist in the sale of the product to the market. Organic and uncommon food items are becoming popular in cities. Thus, these unique cultivars can be grown in the villages and marketed in cities.

(iii) Promoting Traditional Livelihood Options: Traditional livelihood generation activities like making handicraft using bamboo and cane by certain communities, should be encouraged to ensure the long-term utilization of natural capital in a sustainable manner.

8.3.9. Resolving Forest-related Issues

(i) Reducing Dependence on Forest for Fuelwood, Fodder and NTFP: The alternate livelihood strategies as discussed in the previous section (Section 8.3.7.) would help reduce dependence on NTFP as a source of income, reducing the pressure on PA. Direct measures

such as providing LPG, efficient stoves, bio-gas, solar cookers, solar powered pump sets etc. through EDCs and other existing schemes will help reduce fuelwood dependencies. Livestock grazing is one of the most significant occupations in the landscape, and pastures are especially crucial during the summer. We recommend adopting a landscape-level policy for pasture development that includes consultation with the civic society. The District Landscape Committee under GPLC must recognise local needs and give technical assistance and training to locals. It is recommended that public land (common property) or degraded land in and around each village should be converted to pastures. These areas must be maintained on a regular basis. Panchayati Raj Institutions should oversee the pastures, while the forest department and GPLC can provide direction and co-monitoring. The District Landscape Committee under GPLC must monitor stubble burning on agricultural farms and encourage the re-use of post-harvest residue as energy biomass for fuel (Tripathi *et al.*, 2019). Locally, fodder and fuelwood species should be promoted, and seed/germplasm banks should be established. Many of these plant-species are seasonal and may require storage. Storage facilities may be developed at the tehsil level, assisting farmers in obtaining fodder in extreme weather conditions. It is also suggested that nurseries be established at the village level, and panchayat can employ the local youth for running them. The GPLC can arrange for any necessary training in nursery setup and plant-based techniques. Alternate source of fuelwood and fodder can also be generated through social forestry and 'One Village One hectare' concepts discussed in detail within section 8.3.10.

(ii) Providing market access and fair price for NTFP: In case of communities that are allowed to collect NTFP, livelihood generation through NTFP selling can be improved by the following strategies:

(1) Scaling-up existing Amla Industry: The amla tree is a natural fit for Indian society. The tree bears edible fruit (Indian gooseberry). A tree can produce fruit for up to 70 years. The berry is high in pectin and vitamin C, and has unrivalled medicinal properties (Pandey, 2004; Sharma and Khandelwal, 2010; IGG, 2020; Sravyasree *et al.*, 2020; PIB, 2021). The district of Panna is known as the 'Amla district of Madhya Pradesh' and have been selected for Amla products under the 'One District One Product (ODOP)' scheme of the Ministry of Food Processing Industries of the Government of India. Locals were seen making amla murabba (dried gooseberries) in a few villages in the Panna district, which they sell locally. Such local businesses are sustainable and needs to be encouraged through the cooperatives.

(2) Market Access and Minimum Support Price (MSP) for NTFPs: Collection and marketing of NTFPs might be organised through Cooperatives or Growth Centres at local level, allowing for the development of social relationships as well as access to markets. MSPs should be negotiated and agreed in public meetings with local villagers. This will protect the vulnerable communities while also assisting in the formalisation of the local NTFP economy. The formalisation of NTFP economy might take time because it requires the quantification of natural resources and, with that data, the required steps to improve those livelihood choices might be taken. These efforts can be ensured under the Ministry of Tribal Affairs' initiative "Mechanism for Marketing of Minor Forest Produce (MFP) by Minimum Support Price (MSP) and Creation of Value Chain for MFP" that was adopted in 2013 as a measure to provide social protection to MFP gatherers.

(3) Community Cooperatives and Growth Centres: Several villages have been identified for developing forest resource-based cooperatives and growth centre in the landscape (Fig. 8.16-8.19). In the first phase, based on ODOP initiative, the NTFP can be chosen by the districts for setting up the cooperatives. The functioning of cooperatives requires access to raw resources, interests of the communities and motivation for protecting their interest. Factors of success for a cooperative include NGO formed cooperatives rather than forest department initiated, community formed rules and regulations, easy access to market, less external influences, among others (Dash and Behera, 2015). Several case studies for cooperative societies exist in India like Lijjat papad cooperative society, tendu leaf cooperatives in Madhya Pradesh, NTFP gatherers in Odisha supported by Tribal Cooperative Marketing Development Federation of India and Narendra Devi Farmer Producer Organisation among many others (Lele *et al.*, 2015; Bhamra, 2017; Bada Business, 2020; Barik, 2021). Some are based on several women coming together to form a cooperative while others are formed on communities having similar culture and traditions, all growing through the phase of *hand holding* to become self-sufficient. In PTR, few villages also have amla cooperatives out of which Dhalan Chauki village in Panna has the oldest and most successful Amla selling self-help group, *Maa Durga*. Based on the successful case studies, expert consultations and field surveys, community cooperatives and its structures are proposed as below:

- The communities, either from the same village or multiple villages should be prompted to form small or medium sized forest cooperatives based on sharing of ethnicity and interests. The structure will be part of the existing panchayat structure and the forest department could be an integral part of the governance mechanism.

- Based on the group formation, office bearers should be decided through a secret ballot system of voting- head, sub-head and 1-2 secretaries/treasurers (male and/or female). These office bearers should be involved in producing the final output and responsible for monitoring the implementation of the rules (decided by the communities themselves).
- Processors and value chain adders should be two or more personnel depending on the number of people in the formed group and the voting procedure conducted. They should be responsible for connecting with different markets for selling of products, acquiring processing material and helping in processing of the product made (for e.g., Amla murabba packaging) as well as value chain addition depending on supply and demand. The market links can be decided by the communities themselves, but the primary seller should be the forest department, so that the income generated can serve both the communities and the forest.
- The procurers should be three or more, depending on the number of people in the formed group and involved with producing the final output.
- External agencies like district officials, state federations, NGOs, companies and enterprises should be involved in the primary phase of setting up the cooperatives and act as market links so that they can evolve to become self-sufficient.

Table 8.3. Proposed cooperative structure

Members	Number	Responsibility
Office bearers (Head, Sub-head)	1	Producing the final output and responsible for monitoring the process and smooth functioning
Secretaries/treasurers	1-2	Responsible for handling all the finances
Processors and value chain adders	2 or more	Responsible for connecting with different markets for selling of products, acquiring processing

		material and helping in processing of the product made as well as value chain addition depending on supply and demand
Procurers	3 or more	Responsible for procuring raw material
Market links	External agencies	Government departments, State MFP Federations, NGOs, enterprises, tourists, others

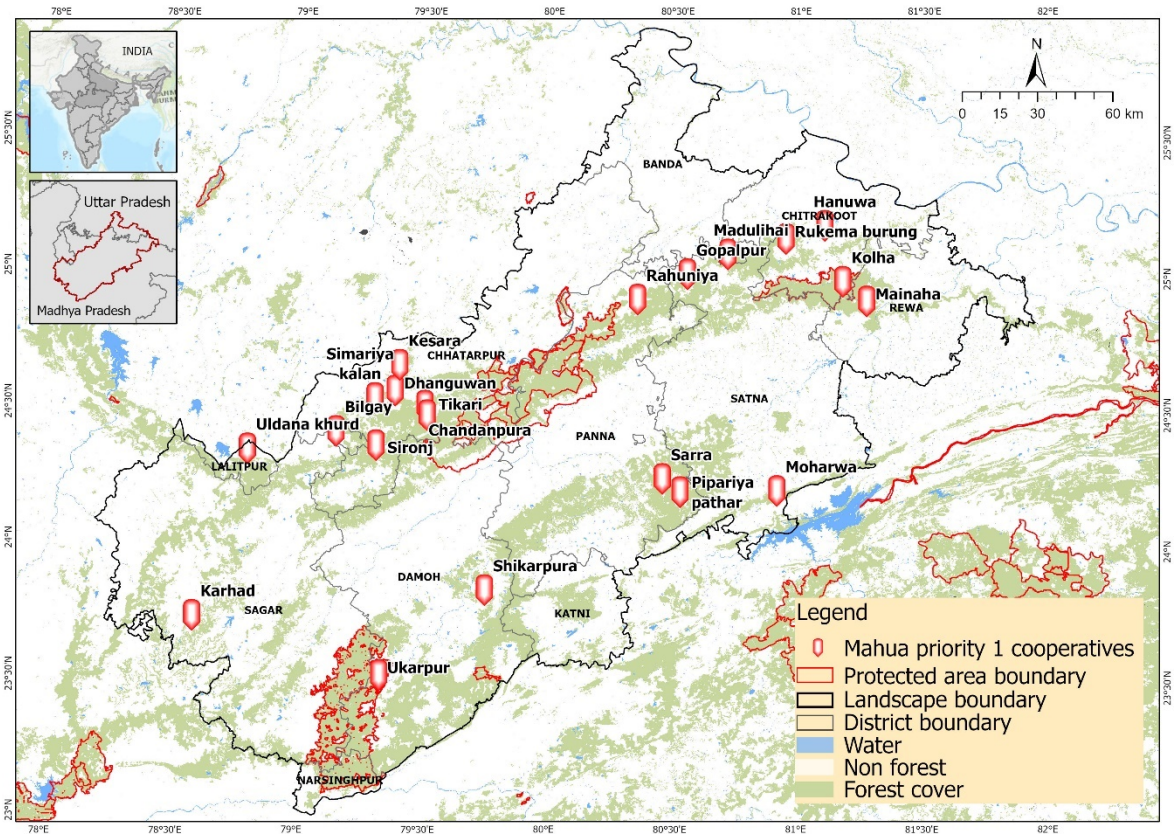


Figure 8.16. Map showing the priority villages for setting up Mahua cooperatives

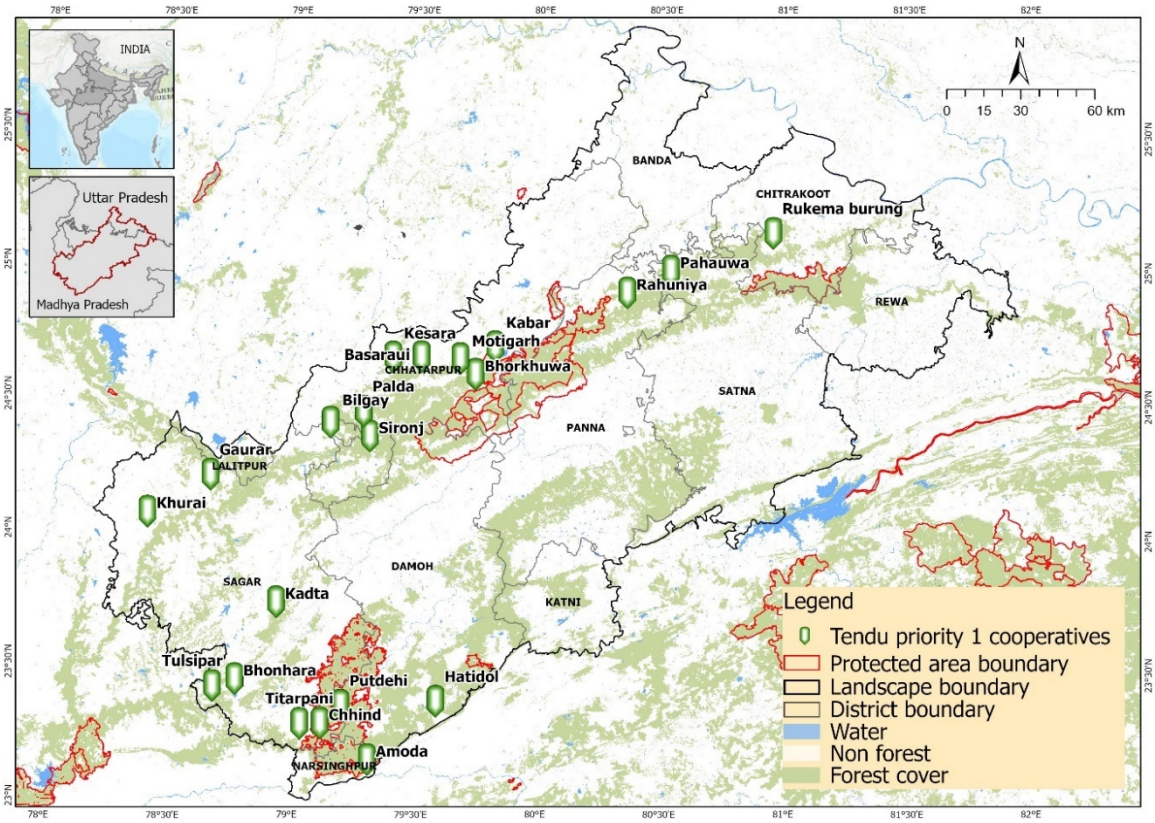


Figure 8.17. Map showing the priority villages for setting up Tendu cooperatives

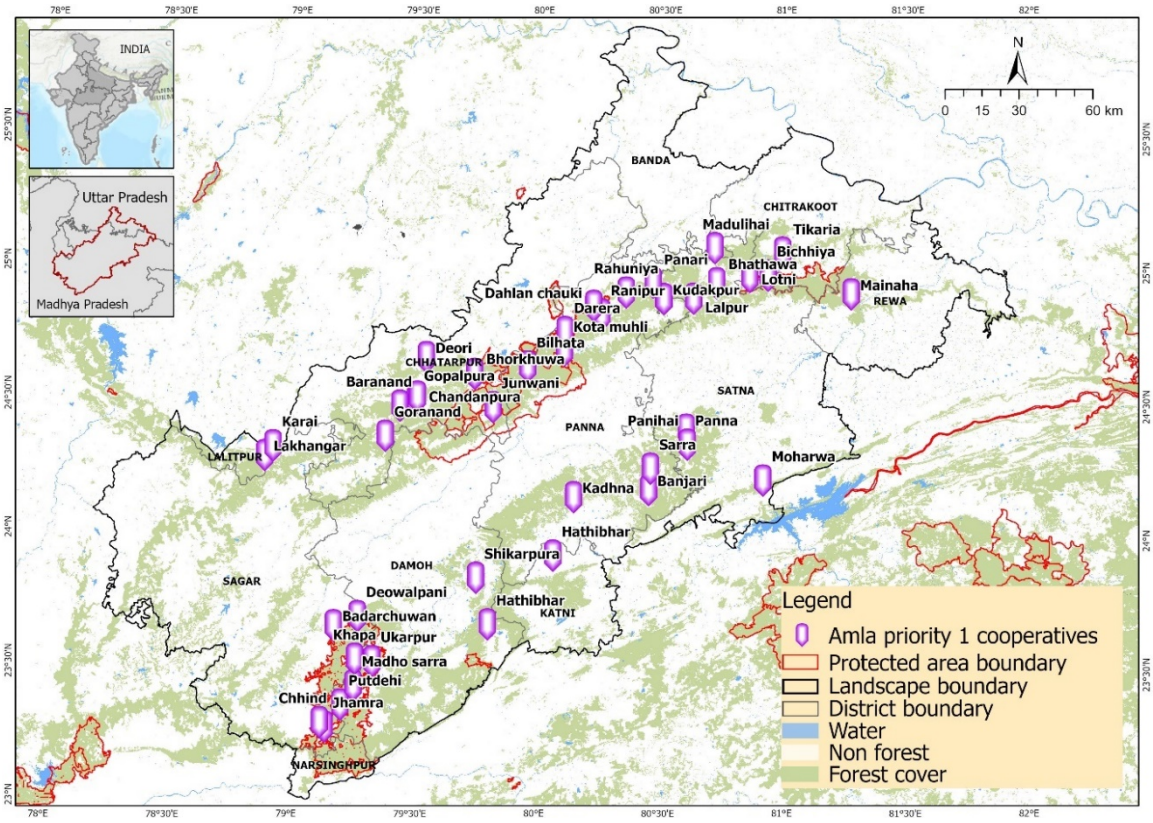


Figure 8.18. Map showing the priority villages for setting up Amla cooperatives

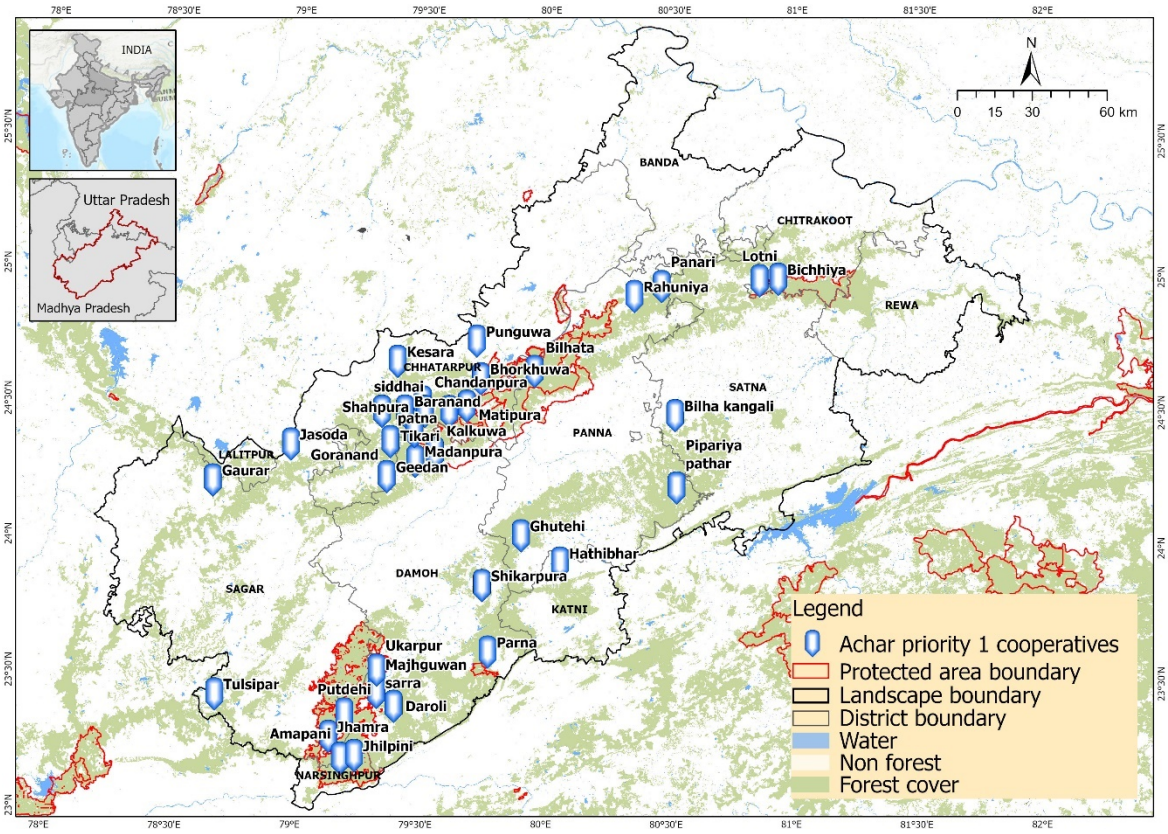


Figure 8.19. Map showing the priority villages for setting up Achar cooperatives

(iii) Resolution of People-Government Conflicts: The conflict especially those regarding land rights between local communities and forest management/government should be amicably settled. It is essential to take professional help while attempting any such conflicting issues. Surveyors from the forest and revenue departments can work together to resolve boundary related matters.

(iv) Revival/Rejuvenation of Ecodevelopment Committees: The EDCs that have been established in the landscape require detailed review and identification of the bottlenecks and gaps to become fully effective. Periyar Tiger Reserve is the most popular model of EDC development and functioning that has helped in increasing tourism, promoting tribal development, livelihood opportunities for many and reduce illegal poaching (Thampi, 2005; Kutty and Nair, 2005). Following the Periyar model, certain factors should be considered when deciding upon the structure and function of EDCs existing or proposed in the landscape:

- EDCs shall include representatives from diverse ethnicity, culture, locality, interests, and professional backgrounds.

- Each EDC shall decide its own method of revenue generation that can be approved by the Tiger Reserve authorities. In case a method is not feasible, new inputs can be given by different departments, NGOs and other stakeholders for revenue generation for each EDC formed.
- Each EDC shall also be involved in awareness campaigns, capacity building, imparting skill based training and upholding meetings to mediate conflicts and issues on a frequent basis.

We propose Theme-based EDCs to be created in the landscape, which can be formed after having discussions with local villagers in order to make sustainable use of locally available resources. Local villagers can develop these themes based on their needs. We propose these Theme-Based EDCs under the existing Panchayat System. Based on our data and field experience, we have identified some themes for the landscape (Table 8.3), however based on the issues/needs of the villages, the village EDC may decide on their own theme(s). It is important to recognise that villages in forested areas vary from villages in non-forested areas, and that they are subject to various legal obligations. As a result, it's important to discuss the proposed framework of EDCs with key stakeholders in the early stages of the plan's implementation, reach a consensus on co-management, and finalise roles and responsibilities. Based on the forest dependence and local availability of NTFP resources, certain villages have been identified for developing Theme-Based EDCs in the landscape.

Table 8.3: Proposed Theme-Based EDCs under different categories and proposed cooperatives

EDC Themes	**Proposed Cooperatives/Focus Areas**	**Rationale**
Forest Resources/NTFPs	Identified villages (Fig. 8.16-8.19)	Forest dependence based on sampled villages
Livestock Grazing/Fodder	Entire Landscape at Panchayat Level (Fig. 8.20)	Number of livestock in the landscape from primary and secondary sources

Conflict/Coexistence	Villages reporting high incidence of conflict	Negative human wildlife interaction in the landscape
Ecotourism	Needs to be identified by forest divisions in consultation with communities	Identification of potential sites for tourism
Water Conservation	Need to be identified by district administration	Water availability and crisis situations
Traditional Knowledge/Culture	Entire Landscape at Panchayat level	Local knowledge system about natural resources and their sustainable use

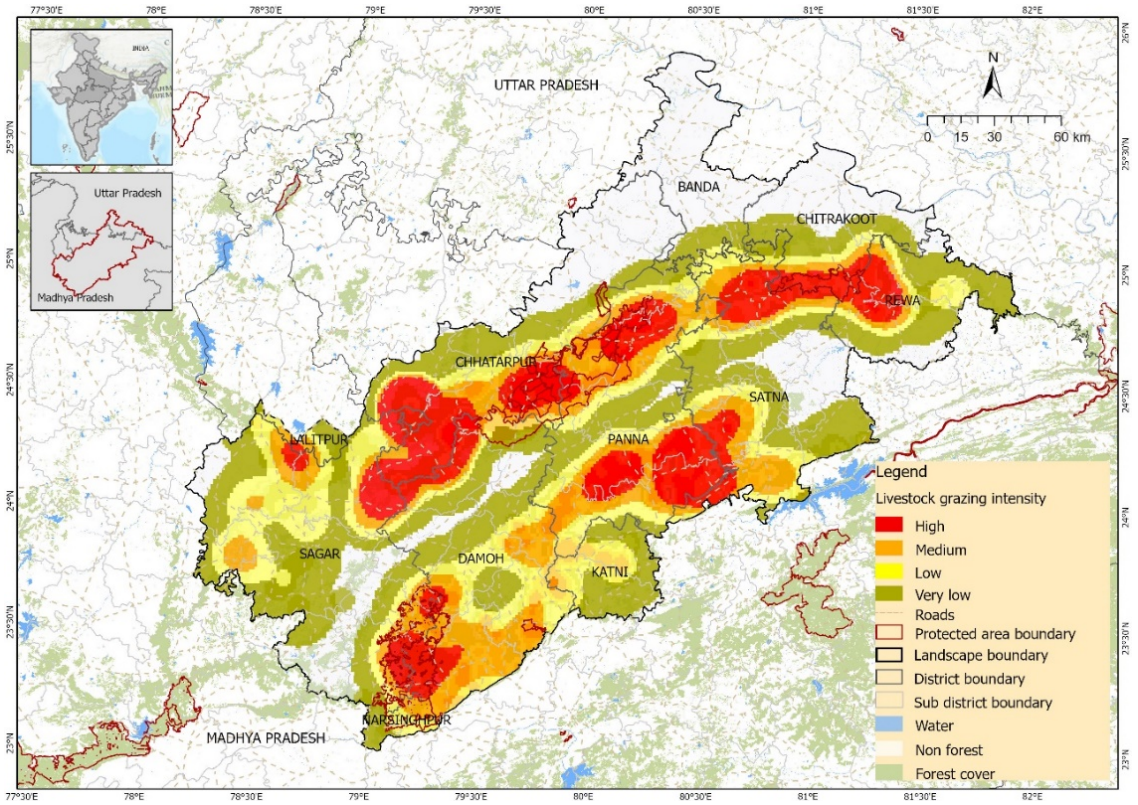


Figure 8.20. Map showing livestock grazing intensity in Greater Panna Landscape

8.3.10. Community Engagement in Biodiversity Conservation: Engaging local communities into decision making and key matters of biodiversity will ensure transparency, trust as well as improvement in the overall quality of life. Community engagement would be necessary for several measures suggested within the plan like establishment of intelligence and social fence network for tiger protection (Section 4.2.1), establishment of Community Reserve within revenue patches in PTR (Section 4.2.4), developing community reserve for vulture conservation and establishing a Network of Vulture Champions (NVC) (Section 5.2.1), community engagement in Gharial Conservation (Section 6.2.4.), grassland development under the umbrella of Joint Forest Management/ Ecodevelopment or Social Forestry / Agroforestry/ MGNREGA schemes (Section 7.2.1.), and Social forestry and Integrated farming activities suggested within River Conservation Zone (Section 7.2.2). Along with these community-based conservation strategies for tiger, vulture, gharial and biodiversity, some proposed strategies that should be explored for involving communities in conserving biodiversity within GPL are:

(1) Outreach and Awareness through Deployment of Ecological/Social Mobiliser: A person trained under GSDP or another qualified local person(s), should be hired as ecological and social mobiliser by each gram panchayat within the landscape based on priority actions. Such a person shall be responsible for informing people about existing government welfare and skill development schemes and helping them is accessing these schemes/application processes. He/she shall also be responsible for liaising with forest department to implement all the panchayat level strategies like theme-based EDCs and cooperatives/growth centres, as well as pasture and fuelwood development through integrated farming and social forestry, in their respective gram panchayat. The ecological mobiliser shall also be responsible for carrying out conservation awareness and outreach activities within their respective panchayat. 'Community Nominees' (well respected members within communities that can help dissolve conflict situation) can also be brought into the fold to implement various community engagement activities.

(2) Revival/Rejuvenation of Biodiversity Management Committees: All local bodies are mandated by Biological Diversity Act (2002) section 41(1) to establish Biodiversity Management Committees (BMCs). BMCs ensure conservation of biodiversity at local level through involvement of local people. Management of biological resources through BMCs at local level helps to establish principles of equity in conservation and sustainable use. BMCs are present in several panchayats within the landscape. It is important to provide innovative ideas and formulate mechanism of feedback and monitoring for effective functionality of such

committees. Focus of BMCs can be areas identified for restoration based on spatial prioritisation and those with high potential of biodiversity as identified through surrogate biodiversity mapping (Fig. 7.12; 7.24). Training can be provided to BMC members for the same.

(3) Development of Carbon Credit System and Green Economy: The scope of green economy and sustainability in rural areas has a rising potential. The concepts cover modernizing ecological instruments so that the additional cost-benefits of the developing systems can be accounted for sustainable development. The vital components include trading markets, technologies, and nature-based solutions to transform natural capital and monetise ecosystem services (McAfee, 2016). One such mechanism that is proposed in the villages of Panna landscape is the carbon credit system. The structure and functions are portrayed in Fig. 8.21. The revenue generated can be used for EDCs for forest protection and community-based conservation. This system can be set up by developers such as external consultancies.

Apart from trading mechanisms, GPLC and companies can partner to encourage CSR activities in forest and its fringe villages in GPL. By doing this, the triple bottom line of the three "Ps" gets considered by the businesses – People, Planet and Profits (Lahiri and Puri, 2018). The focus can be on capacity building programmes for adopting sustainable land management practises and nature-based solutions like identifying and conserving sacred groves as well as promoting green products and value chains. For examples, Mercedes- Benz and Shashwat Trust initiating a conservation plan for community conserved forest areas (sacred groves) in Ambegaon Taluka (Mercedes-Benz, 2021). These activities will contribute to increased carbon sequestration in the landscape aiding in achieving carbon neutrality for villages.

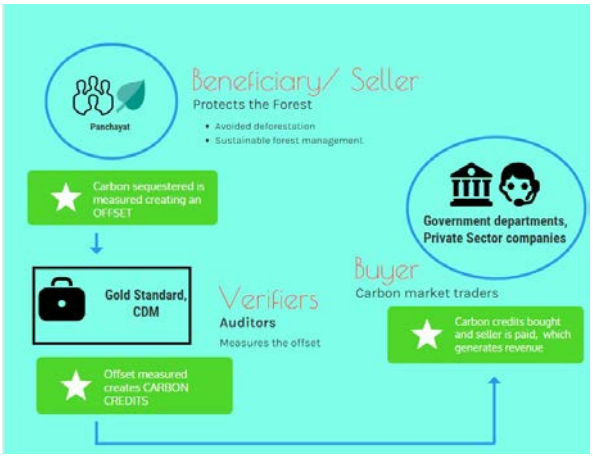


Figure 8.21. Proposed structure for carbon credit system within the landscape (Source: Native Energy, 2021; Plan Vivo Foundation, 2011)

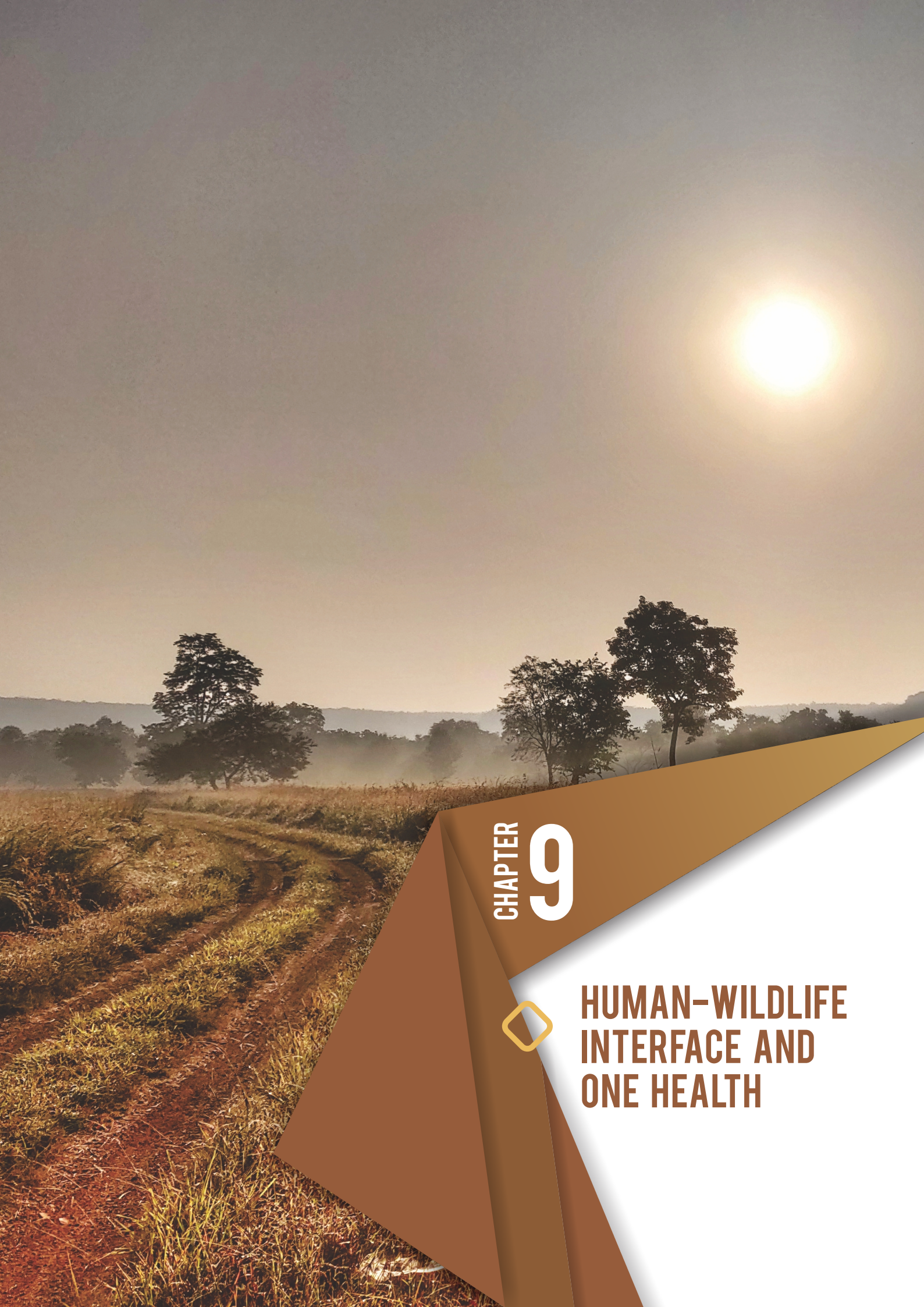
(4) Social Forestry: The National Commission on Agriculture, Government of India, coined the phrase "social forestry" in 1976. The purpose was to reduce burden on forests and utilise barren lands. In the landscape, there is a lot of common land available for such purposes. In the first phase, we propose “social-forestry” in the riparian zones along the Ken River and in the identified priority corridor areas where required. The objective should be to reduce pressure on protected areas in the landscape and fulfill fuel and fodder demand of the locals, while providing connectivity to dispersing animals and conserving biodiversity.

(5) One Village One Hectare Concept: Each village falling in the critical conservation area requiring restoration, villages with green economy focus and the command area of KBLP should be mandated to develop one hectare (or more depending on the size of the village) forest in village common land. The restoration activities be aligned with existing water bodies (ponds, streams and river channels), road-side areas and temple premises. These can be fuelwood plantations interspersed with sacred grooves like *Ficus* sp. and other keystone tree species, as well as other local tree species that provide multiple ecosystem services like *Azadirachta indica*. The idea is to not only divert fuelwood dependence of local communities on forests but also carbon sequestration, ground water recharge and biodiversity conservation at village level. Village panchayat shall be responsible for implementation of social forestry activities which can be combined with ‘one village one hectare’, with the help of ecological/social mobiliser and forest department, overseen by district administration. This strategy will enhance the ecosystem services and can be taken up for Payment for Ecosystem Services (PES) to enable sustainable management support for the communities. Agro-forestry scope may be included (National Agro-forestry Policy, 12014) given the current focus by Government of India (GoI) on agro-forestry programmes. The GoI in the budget for 2022-23 has used "Agro-Forestry and Farm Forestry" as an instrument to achieve carbon neutral economy.

8.4. Synthesis and Conclusions:

The degree of reliance by the rural and indigenous communities on forests and access to its resources influence their living conditions in the landscape. To promote the holistic development of both wildlife and communities, it is integral to look at the faced socio-economic and forest dependency challenges. Promoting water conservation techniques, provision of alternate livelihood practices, access to skill development and educational facilities, supporting the overall well-being through health centres, and creating alternate sources of fuelwood and fodder through integrated farming, social forestry and one village-one

hectare concepts, and reviving EDCs through proper fund flow, would resolve their social and forest-based issues paving a roadmap for uplifting their standard of life. Most importantly providing institutional support to communities' dependent on forest resources by means of forest resource based cooperatives will ensure the socio-economic development of these marginal communities. Encouraging the collaboration between different stakeholders and local communities through BMCs and green economy, will facilitate a participatory approach to biodiversity conservation within the Greater Panna Landscape.



CHAPTER 9

HUMAN-WILDLIFE INTERFACE AND ONE HEALTH

Chapter 9: Human-Wildlife Interface and One Health

9.1. Situation Analyses

9.1.1. Introduction: The relationship between human and wildlife has always been a complicated one. But never in our history, have we caused more damage to this relationship than in the 21st century. Nature has paid a huge price in the development of modern human society. We have triggered the sixth mass extinction of species, also called Holocene extinction (Turvey, 2009). This has resulted in the loss of 68% of wildlife since 1970s, and we are set to lose one million species of plants and animals within decades (Brondizio *et al.*, 2019; Almond *et al.*, 2020). We have converted half of the world's habitable land to agriculture (Ellis *et al.*, 2010) and food security is still a distant dream. Meanwhile we continue to lose 10 million ha of forest land per year (FAO and UNEP, 2020). Populous countries like India with increasing demands of land and at the same time increased focus on wildlife conservation, face the biggest challenge, that of balancing conservation and development. This struggle for land has made 'coexistence' the biggest conservation challenge that we face today. As the habitats shrink, wildlife is forced to utilise human dominated landscapes, leading to frequent interactions which often, turn into conflict. Moreover, there is growing evidence that zoonotic and other emerging diseases of humans have a close relationship with biodiversity conservation and the integrity of the natural environment, and that any changes to the same can result in detrimental effects on the health and well-being of humans and animals (Jones *et al.*, 2013). Hence, the concept of one health, the linkages of environment health, animal health and public health, is gaining prominence.

Human-Wildlife Conflict (HWC) is defined as 'when the needs and behaviour of wildlife impact negatively on the goals of humans or when the goals of humans negatively impact the needs of wildlife' (World Parks Congress, Recommendation 5.20, 2003) (IUCN, 2005). Studies in India have found that almost the entire country is facing HWC and almost 88 species across different orders and genera are involved in some kind of negative interaction with human (Anand and Radhakrishna, 2017). HWC has resulted in decline of many wildlife populations worldwide (Woodroffe and Ginsberg, 1998; Babrgir *et al.*, 2017). It has a far-reaching impact on not only the survival of wildlife species that is involved in the conflict but the social and economic well-being of the people facing wildlife related losses. Moreover, conflict erodes support for conservation (Gadd, 2005). In Panna landscape, there have been very few studies

on human-wildlife interaction/conflict, those too only in and around Panna Tiger Reserve (PTR) (Yoganand *et al.*, 2005; Kolipaka *et al.*, 2015; Kolipaka *et al.*, 2017). A few studies done in the past on sloth bear-human conflict in entire Madhya Pradesh, includes some of the districts of the landscape but provide very little information that can be turned into management inputs (Rajpurohit and Krausman, 2000). Therefore, even the basic status of HWC in the landscape is absent. Stretching between two states, comprising 11 districts within which lie approx. 11,500 villages, the landscape is human dominated with only three PAs and few reserve forests. However, these PAs and reserve forests are rich in biodiversity, and with the recent impetus on conservation of wildlife, notably that of tigers in PTR, wildlife numbers have increased. Tigers are spilling out of PTR into the landscape, however, their status once outside the reserve is not known. PTR has become a great 'source' but because it is surrounded by sink habitat, tigers dispersing out of PTR are prone to both poaching and causing conflict. HWC is one of the biggest challenges faced by the park management because it directly affects the people-park relationship, which must be amicable in order to achieve lasting conservation goals (Allendorf, 2010).

9.1.2. People-Park Relationship in PTR: During the workshop with representatives of 101 villages, in and around PTR, most village representatives termed their relationship with forest department as good or amicable (58.42%), however, many felt that their relationship was bad and there is animosity (17.82%). To a lesser degree people felt that the relationship was mixed (n=9), some aspects are good and some bad, others felt that their relationship was mostly good, but sometimes turn sour (n=4) when they are restricted from accessing forest resources. Some felt that their relationship was neither good nor bad, and there hardly was any relationship (n=5). People who felt that their relationship with forest department was bad, blamed it on restrictions on and sometimes arrests for collecting forest resources. Therefore, *prima facie* it seems that in case of PTR, relationship between park and people are generally not bad but need some work, especially in the manner that cases of harvesting of forest resources, especially by women, are dealt with.

9.1.3. People-Wildlife Relationship in PTR: During the workshop, it was found that 46.53% village representatives felt that wildlife is beneficial, however, 51.49% felt that there was no benefit from wildlife. 86.14% of village representatives perceived wildlife as harmful, only 12.87% did not see wildlife as harmful. However, more importantly, 86.14% of village representatives felt that wildlife should be conserved. People who saw wildlife as beneficial, gave such reasons as 'wildlife are important for conserving forest', 'wildlife attracts tourists',

'wild carnivores control wild pig/crop raiding animal populations', 'wild animals eat dead domestic livestock thus cleaning the environment' and the most oft repeated reason was that 'they are beautiful and we like to see them'. Almost all the people who perceived wildlife as harmful, said that it was because they cause economic losses especially crop loss.

Thus, forest dwelling communities around PTR do recognise the benefits of wildlife and are proconservation but the biggest challenge in engaging communities for wildlife conservation is human-wildlife conflict.

9.1.4. Status of Human-Wildlife Conflict in PTR:

(1) Wildlife Attack on Humans: People interviewed in and around PTR reported that most frequent number of attacks on human were by sloth bear, followed by wild pig and then leopard. Many respondents (65.90%) perceived the frequency of wildlife attacks to be high. Among the village representatives (n=101) interviewed during the workshop, 50.50% reported instances of wildlife attack on humans in their village. Most of the attacks were again attributed to sloth bear (42.57%), distantly followed by jackal (14.85%), leopard (12.87%), wild pig (8.91%), tiger (5.94%) and very few to wolf and nilgai (1.98% each). According to compensation data obtained from forest department, a total of 269 wildlife attack on humans has been reported from PTR in the ten-year period between 2010-2019, of which four died due to the attack. Most number of attacks were due to jackal (n=151), sloth bear (n=55), and wild pig (n=35), and occasionally by rhesus macaque (n=8), leopard (n=7), nilgai (n=4), tiger (n=2), crocodile (n=9), wolf (n=1), porcupine (n=1) and peacock (n=1).

Jackal was thus, responsible for most of the attacks on humans in PTR but people perceive sloth bear to be most frequently attacking human. This could be due to the severity of attack by sloth bear, and an artifact of 'fear' that a bear attack invokes in human, as compared to attack by a small carnivore, like jackal (Kaltenborn *et al.*, 2006; Ratnayeke *et al.* 2014).

Frequency of attack by major conflict causing species are further discussed below.

Jackal: Of the 151 jackal attacks on human, one proved to be fatal for an adult male. More attacks were on men (n=113) as compared to women (n=34).

Sloth bear: Of the 55 sloth bear attacks on human, one proved to be fatal for an adult male. More attacks were on men (n=48) as compared to women (n=7).

Wild pig: Of the 35 wild pig attacks on human, one proved to be fatal for an adult male. Again, more attacks were on men (n=25) as compared to women (n=10).

Thus, men are more vulnerable to wildlife related attacks as compared to women, which could reflect gender specific human-forest interactions, where men (going to collect NTFP or grazing livestock) may be venturing deeper into the forest, as compared to, women (going to collect water or fuelwood). Men and women also perceive risk differently, women being more fearful of wildlife; thus, women may be wary of venturing into the forest unaccompanied (Kaltenborn *et al.*, 2006; Gore and Kahler, 2012).

(i) Spatial Pattern of Wildlife Attack on Humans: As indicated by compensation data, average annual rate of wildlife attacks on humans was highest for Kishangarh buffer (10.67 attacks/year) and lowest for Gahrighat (only one incident recorded in 10 years) (Table 9.1). No case of attack on humans was recorded from Madla Range. As expected, in general, buffer ranges with multiple use forests, were facing more wildlife related attacks, as compared to core ranges with very less human presence (Table 9.1). Among core ranges, Chandranagar core has the highest average annual rate of attacks on humans (3.3 attacks/year) (Table 9.1). Among beats, Chadranagar buffer (Chadranagar Buffer) recorded the highest number of wildlife attacks at humans, at an average rate of 7.3 attacks/year, followed by Akona Beat (KGS) at 2.3 attacks/year (Fig. 9.1). Spatial patterns of attack by major conflict causing species are further discussed below.

Table 9.1: Range wise summary of average annual rate of wildlife attacks on humans in PTR

Range	Period	Total Attacks	Average Rate (No./Year)
Chandranagar Core	2010-2019	33	3.30
Gahrighat	2010-2019	1	0.10
Hinauta	2010-2019	6	0.60
Kishangarh Core	2010-2019	5	0.50

Panna Core	2010-2019	17	1.70
Madla	2010-2019	0	0
Gangau	2010-2019	16	1.60
Ken Gharial Sanctuary	2010-2019	31	3.10
Chandranagar Buffer	2014-2019	45	7.50
Kishangarh Buffer	2014-2019	64	10.70
Panna Buffer	2014-2019	15	2.50
Amanganj Buffer	2015-2019	32	6.40
Madiyadoh Buffer	2016-2019	4	1

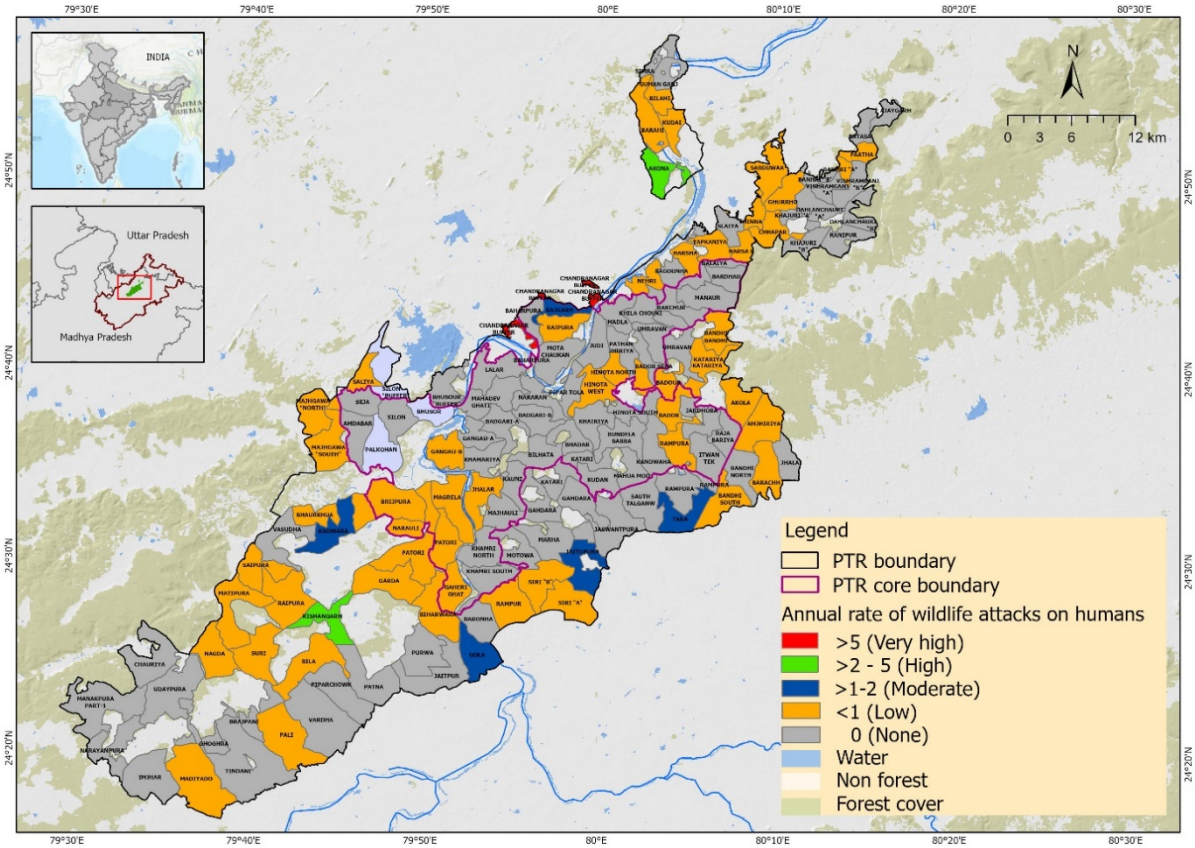


Figure 9.1. Thematic map depicting frequency of wildlife attacks on humans within forest beats of PTR

Jackal: Average annual rate of attack on humans by jackal, was highest for Chadranagar buffer (6.83 attacks/year), closely followed by Kishangarh buffer (6.17 attacks/year) and lowest for Panna buffer (0.17 attacks/year) (Table 9.2). Gahrighat, Kishangarh core and Madiyadoh Ranges reported no jackal attacks. Among core ranges, Chandranagar core has the highest

annual rate of jackal attacks on humans (2.4 attacks/year) (Table 9.2). Among beats, Chadranagar buffer (Chadranagar Buffer) recorded the highest number of jackal attacks at human, at an average rate of 6.70 attacks/year, followed by Akona beat (KGS) at 2.10 attacks/year (Fig. 9.2). Therefore, it seems that jackal was the species because of which these beats were reporting the highest rate of wildlife attacks.

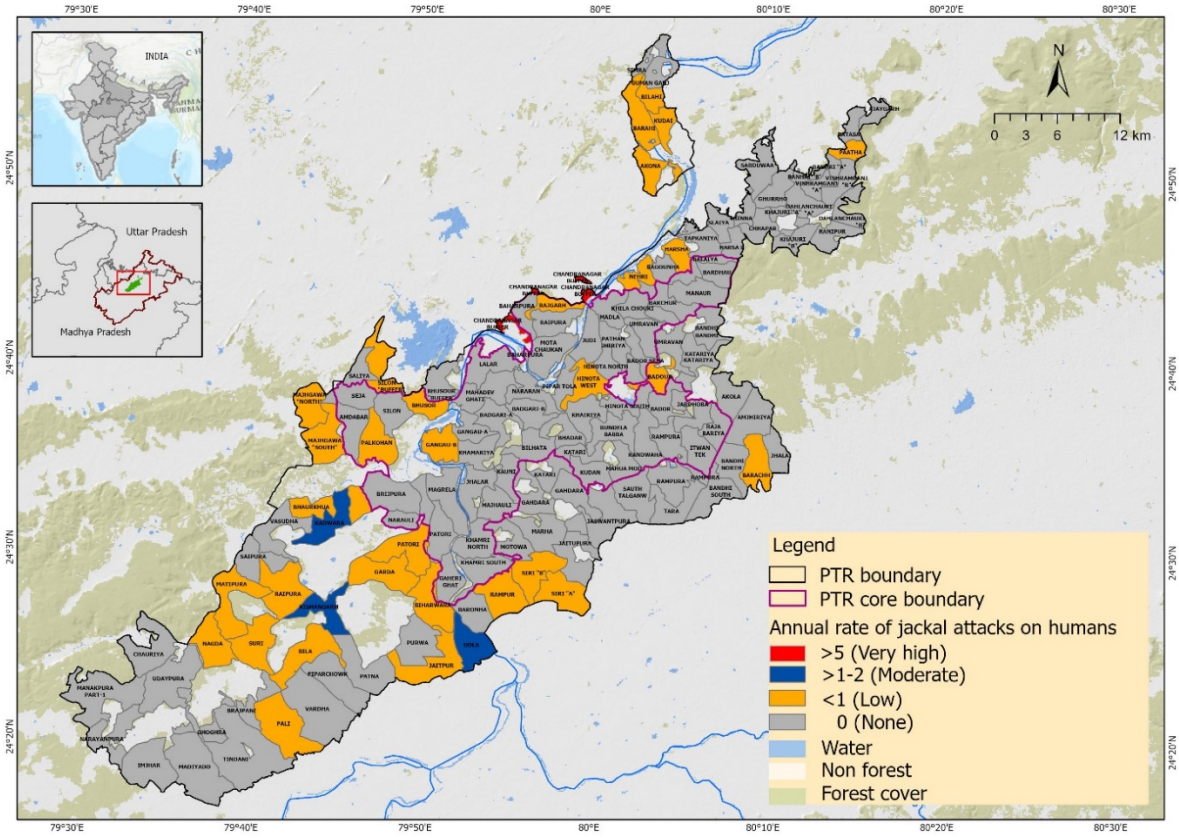


Figure 9.2. Thematic map depicting frequency of jackal attacks on humans within forest beats of PTR

Table 9.2: Range wise summary of average annual rate of jackal attack on humans in PTR

Range	Period	Total Attacks	Average Rate (No./Year)
Chandranagar Core	2010-2019	24	2.40
Gahrighat	2010-2019	0	0
Hinauta	2010-2019	2	0.20
Kishangarh Core	2010-2019	0	0
Panna Core	2010-2019	4	0.40
Madla	2010-2019	0	0

Gangau	2010-2019	3	0.30
Ken Gharial Sanctuary	2010-2019	28	2.80
Chandranagar Buffer	2014-2019	41	6.83
Kishangarh Buffer	2014-2019	37	6.17
Panna Buffer	2014-2019	1	0.17
Amanganj Buffer	2015-2019	11	2.20
Madiyado Buffer	2016-2019	0	0

Sloth Bear: Average annual rate of attack on human by sloth bear, was highest for Kishangarh buffer (2.33 attacks/year), closely followed by Panna buffer (2.0 attacks/year) and lowest for Hinauta (0.20 attacks/year) (Table 9.3). Gahrighat, Madiyadoh and KGS reported no sloth bear attacks. Among core ranges, Panna core has the highest annual rate of sloth bear attacks on human (0.60 attacks/year) (Table 9.3). Among beats, Sabduaa Beat (Panna Buffer) and Kishangarh Beat (Kishangarh Buffer) recorded the highest number of wildlife attacks on human, at an average rate of 0.50 attacks/year (Fig. 9.3).

Table 9.3: Range wise summary of average annual rate of sloth bear attack on humans in PTR

Range	Period	Total Attacks	Average Rate (No./Year)
Chandranagar Core	2010-2019	4	0.40
Gahrighat	2010-2019	0	0
Hinauta	2010-2019	2	0.20
Kishangarh Core	2010-2019	5	0.50
Panna Core	2010-2019	6	0.60
Madla	2010-2019	0	0
Gangau	2010-2019	8	0.80
Ken Gharial Sanctuary	2010-2019	0	0
Chandranagar Buffer	2014-2019	2	0.33
Kishangarh Buffer	2014-2019	14	2.33
Panna Buffer	2014-2019	12	2.00
Amanganj Buffer	2015-2019	2	0.40
Madiyado Buffer	2016-2019	0	0

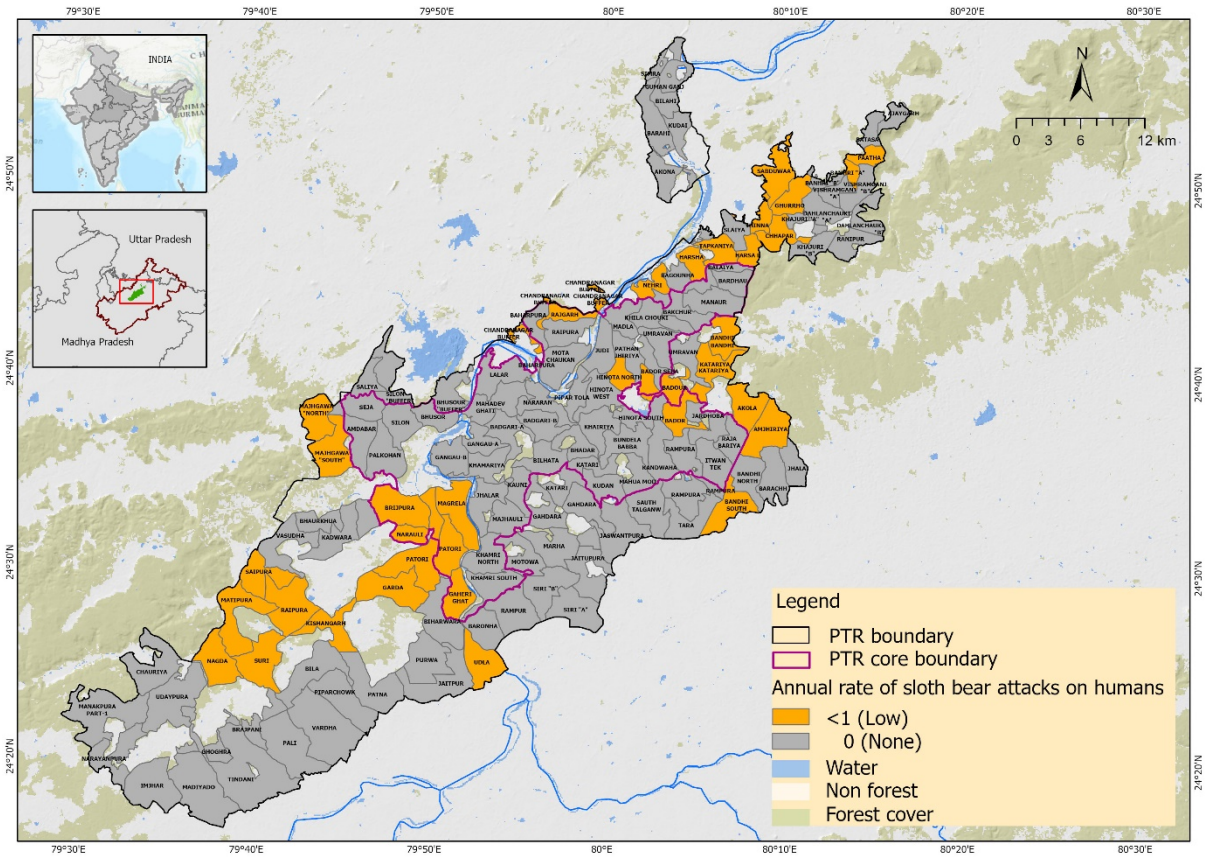


Figure 9.3. Thematic map depicting frequency of sloth bear attacks on humans within forest beats of PTR

Wild Pig: Average annual rate of attack on human by jackal, was highest for Amanganj buffer (2.0 attacks/year), followed by Kishangarh buffer (1.17 attacks/year) and lowest for Gahrighat (0.10 attacks/year) (Table 9.4). Hinauta, Kishangarh Core, KGS and Chandranagar Buffer reported no wild pig related attacks. Among core ranges, Panna core has the highest average annual rate of wild pig attacks on humans (0.50 attacks/year) (Table 9.4). Among beats, Tara and Udla Beats of Amanganj Buffer recorded the highest number of wild pig attacks at human, at a rate of 0.80 attacks/year (Fig. 9.4).

Table 9.4: Range wise summary of average annual rate of wild pig attack on humans in PTR

Range	Period	Total Attacks	Average Rate (No./Year)
Chandranagar Core	2010-2019	4	0.40
Gahrighat	2010-2019	1	0.10

Hinauta	2010-2019	0	0
Kishangarh Core	2010-2019	0	0
Panna Core	2010-2019	5	0.50
Madla	2010-2019	0	0
Gangau	2010-2019	3	0.30
Ken Gharial Sanctuary	2010-2019	0	0
Chandranagar Buffer	2014-2019	0	0
Kishangarh Buffer	2014-2019	7	1.17
Panna Buffer	2014-2019	2	0.33
Amanganj Buffer	2015-2019	10	2
Madiyado Buffer	2016-2019	3	0.75

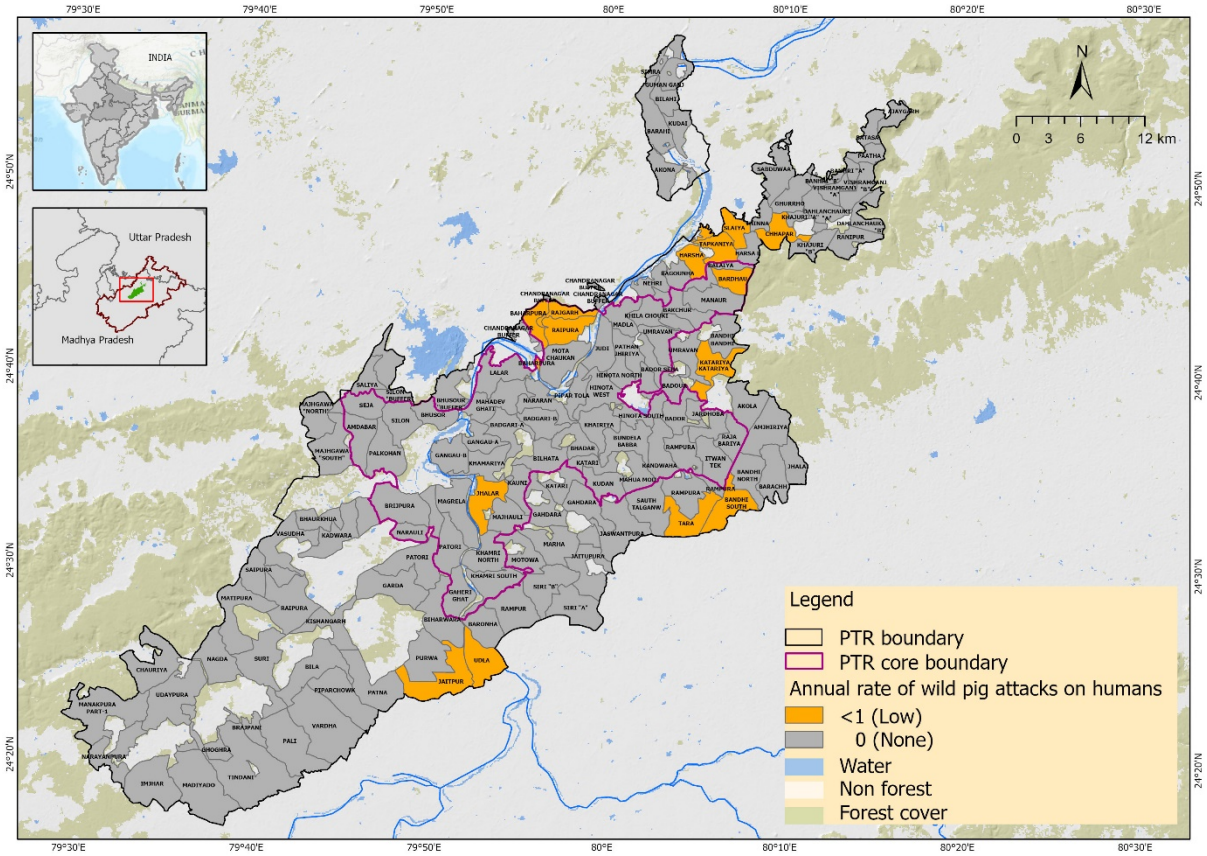


Figure 9.4. Thematic map depicting frequency of wild pig attacks on humans within forest beats of PTR

Snake: Data on snakebites were obtained from the Health Management Information Systems (HMIS) reports, which captures sub-district wise information on various health states (Table 9.5 and 9.6). Data reporting on in-patient services for snake bites at any of the primary, secondary or tertiary government health centres, has been included since 2017. Additionally, the district Chief Medical Health Officer (CMHO) of Panna was contacted and information regarding snake bite treatments and mortalities, reported in the Community Health Centres (CHC) and District Hospital was procured for the year 2021 (Table 9.7).

Table 9.5: No. of cases of snakebite at tehsil level for Panna district

Tehsil Name	2021-2022 (provisional)	2020-2021 (provisional)	2019-2020	2018-2019	2017-2018
Ajaygarh	3	24	2	2	12
Amanganj	-	-	0	0	0
Devendranagar	-	-	47	32	36
Gunnor	0	0			
Panna	1	41			
Pawai	1	43	30	16	15
Raipura	-	-			
Shahnagar	0	4	3	11	8
Simariya	-	-			

Source: HMIS reports

Table 9.6: Number of cases of snakebite at tehsil level for Chhatarpur District

Tehsil Name	2021-2022	2020-2021	2019-2020	2018-2019	2017-2018
Bijawar	0	9	9	3	0
Chhatarpur	NA	223	9	141	12
Rajnagar	NA	0	0	0	0

**Only tehsils bordering PTR and housing the district headquarters has been included for Chhatarpur district (Source: HMIS reports)*

Table 9.7: Number of cases and deaths on snakebite reported in Panna during 2021

Up to October-2021	Panna District Hospital	CHC Ajaigarh	CHC Amanganj-Gunnor	CHC Devendranagar	CHC Pawai	CHC Shahnagar
Reported cases	58	25	4	15	42	18
Reported deaths	6	0	0	0	1	3

Source: CMHO-Panna

(ii) Temporal Patterns of Wildlife Attacks on Humans: The highest number of wildlife attacks (for the 10-year period 2010-2019) were reported in the year 2015 (n=53), followed by 2016 (n=39). The highest number of wildlife attacks on human occurred in winter (n=126), followed by summer (n=80) and then monsoon (n=60). Temporal pattern of attack by major conflict causing species are further discussed below.

Jackal: The highest number of jackal attacks (for the period 2010-2019) were reported in the year 2015 (n=34), followed by 2016 (n=21). The highest number of jackal attacks on human occurred in winter (n=71), followed by summer (n=51) and then monsoon (n=26).

Sloth Bear: The highest number of sloth bear attacks (for the period 2010-2019) were reported in the year 2015 and 2018 (n=12). The highest number of sloth bear attacks on human occurred in winter (n=24), followed by monsoon (n=19) and then summer (n=12).

Wild pig: The highest number of wild pig attacks (for the 10-year period 2010-2019) were reported in the year 2016 (n=9), followed by 2018 (n=7). The highest number of wild pig attacks on human occurred in winter (n=23), followed by summer and monsoon, reporting six cases each.

(2) Wildlife Attack on Livestock: During the workshop with beat guards (n=143), 67.60% reported livestock depredation by wild animals in their beats. As for the species responsible for the loss, most (61.26%) beats reported livestock loss due to leopard, followed by tiger (42.25%), hyena (11.97%), wolf (9.15%) and jackal (8.45%). As for the village representatives interviewed during the workshop, 95.05% stated that their villages (n=101) face livestock loss due to wild animals, 42.57% of them termed the loss to be very high (>3 livestock/year/livestock owning household), but much fewer termed the loss to be high (2.97%) or moderate (5.94%), and many (11.88%) termed the loss to be low (~1 livestock/year/

livestock owning household). As for the species responsible for the loss, most (81.19%) villages reported to be facing loss due to leopard, followed by 55.44% due to tiger, 30.69% due to wolf, 19.80% due to wild dog, 7.92% due to jackal and 1.98% due to fox. People interviewed in and around PTR also reported that most frequent number of livestock loss was caused by leopard, tiger and wolf. They perceive that on an average 9.79% of total animals kept by them were lost to wildlife, annually.

According to compensation data obtained from forest department, a total of 2331 livestock have been lost to wildlife attack in PTR in the ten-year period between 2010-2019. Of this again most were due to tiger (n=1112) and leopard (n=723), followed by crocodile (n=24), wolf (n=22), jackal (n=22), hyena (n=2), python (n=1) and wild pig (in a bizarre incident a wild boar killed 13 domestic pigs).

(i) Spatial Pattern of Wildlife Attacks on Livestock: Loss is unevenly distributed across ranges and beats, with some ranges facing very high losses and other facing almost none. Annual rate of livestock loss due to wildlife was highest for Chandranagar buffer (76.71 livestock/year) and lowest for Madiyadoh buffer (0.75 livestock/year) (Table 9.8). As expected, in general, buffer ranges with multiple use forests, were facing more wildlife related livestock loss as compared to core ranges with very fewer domestic livestock presence (Table 9.8). Among core ranges, Panna core has the highest annual rate of livestock loss (46.90 livestock/year) (Table 9.8). Among beats, Chadranagar buffer (Chadranagar Buffer) recorded the highest number of livestock loss due to wildlife, at a rate of 73.14 livestock/year, however, most of it is because in the year 2017 a total of 417 cases were filed, other than that particular year, the total number of cases filed were below 50 between 2013-19. Even if we don't consider that particular year, when calculating annual loss, Chadranagar buffer beat is still reporting the highest loss at 15.8 livestock/year, closely followed by Gahadara (Amanganj Buffer) at 15.50 livestock/year (Fig. 9.5). Spatial patterns of attack by major conflict causing species are further discussed below.

Table 9.8: Summary of average annual rate of livestock loss due to wildlife in PTR

Range	Period	Total Attacks	Average Rate (No./Year)
Chandranagar Core	2010-2019	169	16.90
Gahrighat	2010-2019	14	1.40

Hinauta	2010-2019	152	15.20
Kishangarh Core	2010-2019	10	1
Panna Core	2010-2019	469	46.90
Madla	2010-2019	179	17.90
Gangau Wildlife Sanctuary	2010-2019	332	33.20
Ken Gharial Wildlife Sanctuary	2010-2019	11	1.10
Chandranagar Buffer	2013-2019	537	76.71
Kishangarh Buffer	2014-2019	141	14.10
Panna Buffer	2014-2019	54	9
Amanganj Buffer	2016-2019	260	65
Madiyado Buffer	2016-2019	3	0.75

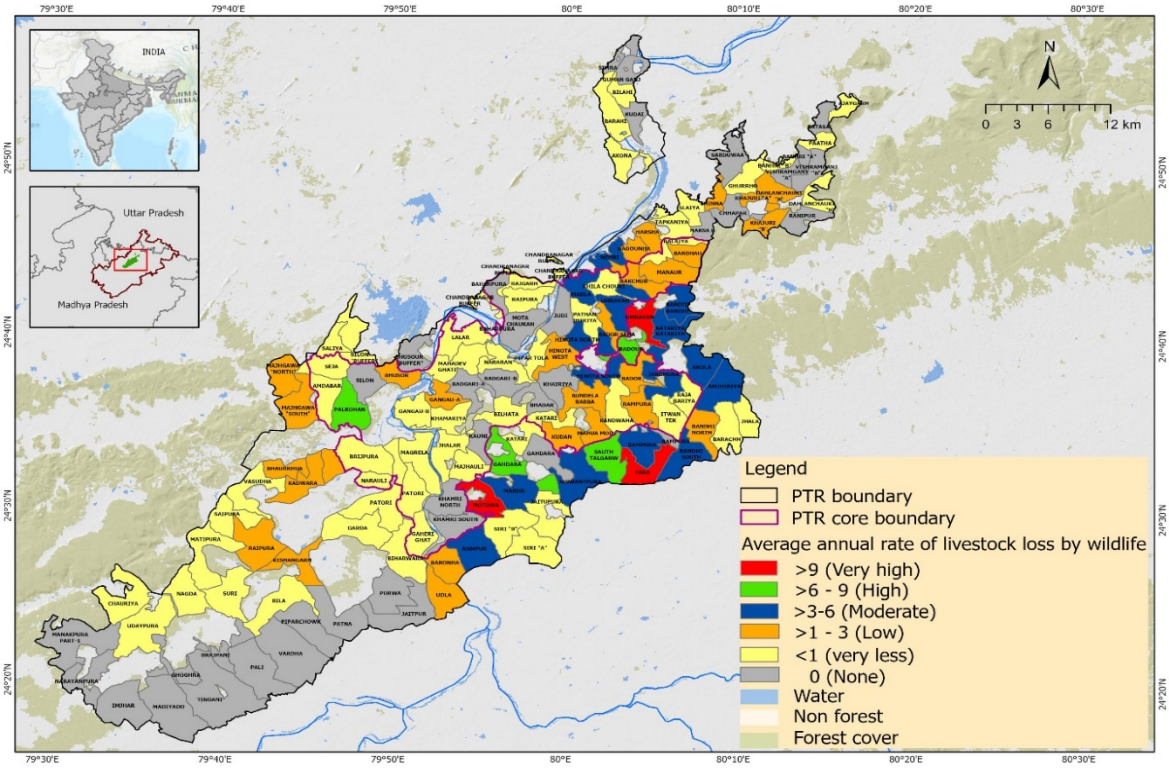


Figure 9.5. Thematic map depicting frequency of livestock loss by wildlife within forest beats of PTR

Frequency and spatial pattern of loss by major livestock depredating species is discussed in detail below.

Tiger: The most frequent livestock species lost to tiger was cow (n=551) closely followed by buffalo (n=512), and occasionally goat (n=44). As for the sex of the lost livestock, among cow,

slightly more females (n=286) were lost as compared to male/bullock (n=265). In case of buffalo many more females (n=443) were lost as compared to males (n=69). In case of goat also, more females (n=40) were lost as compared to males (n=4). As for the age of the lost livestock, among cow, most kill were of adults (n=533) and very few were of juveniles (n=16). In case of buffalo, again more adults (n=439) were predated as compared to juveniles (n=73). In case of goat also, many more adults (n=42) were predated as compared to juveniles (n=1). Annual rate of livestock loss due to tiger was highest for Amanganj Buffer (50.75 livestock/year) and lowest for Kishangarh Core (0.40 livestock/year) (Table 9.9). Madiyadoh Buffer and KGS did not report any loss due to tiger. Among core ranges, Panna core has the highest annual rate of livestock loss (36.50 livestock/year) (Table 9.9). Among beats, Gahadara (Amanganj Buffer) recorded the highest number of livestock loss due to tiger, at a rate of 15.25 livestock/year, followed by Chadranagar (Chadranagar Buffer) at 10.71 livestock/year (Fig. 9.6).

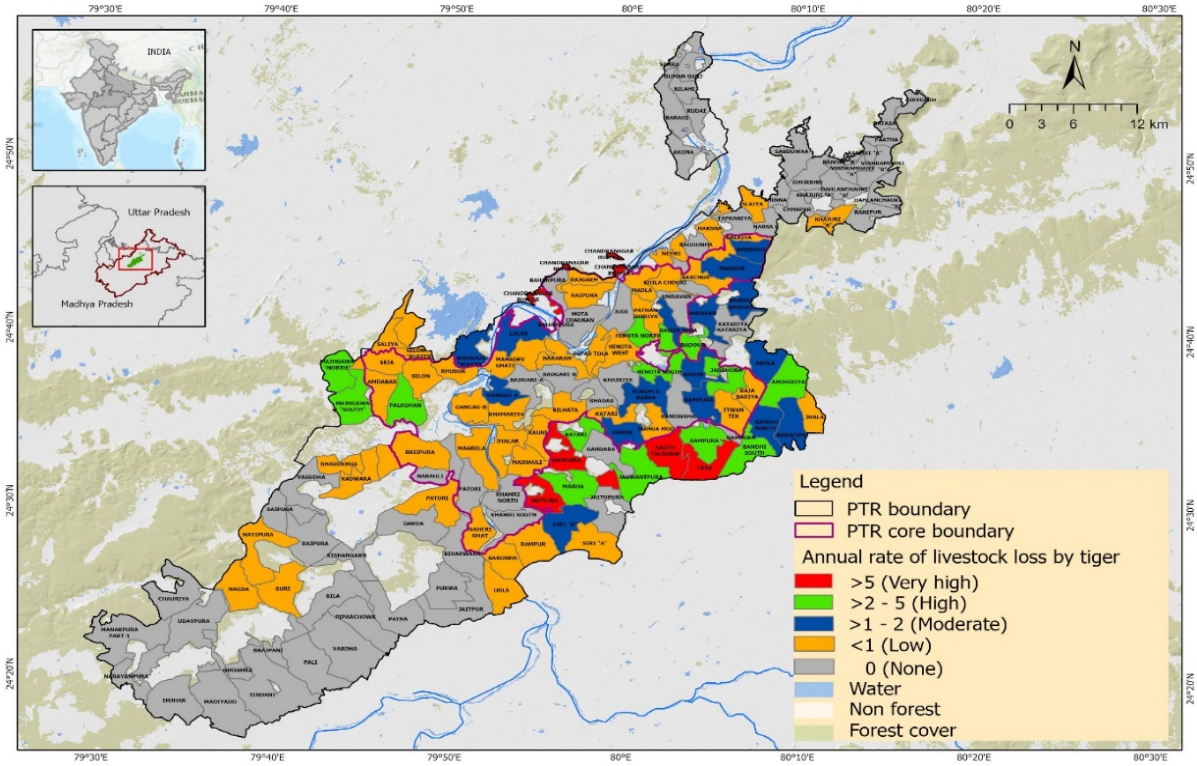


Figure 9.6. Thematic map depicting frequency of livestock loss by tiger within forest beats of PTR

Table 9.9: Range wise summary of average annual rate of livestock loss due to tiger in PTR

Range	Period	Total Attacks	Average Rate (No./Year)
Chandranagar Core	2010-2019	109	10.90
Gahrighat	2010-2019	9	0.90
Hinauta	2010-2019	99	9.90
Kishangarh Core	2010-2019	4	0.40
Panna Core	2010-2019	365	36.50
Madla	2010-2019	111	11.10
Gangau	2010-2019	86	8.60
Ken Gharial Sanctuary	2010-2019	0	0
Chandranagar Buffer	2013-2019	91	13.00
Kishangarh Buffer	2014-2019	32	5.33
Panna Buffer	2014-2019	3	0.50
Amanganj Buffer	2016-2019	203	50.75
Madiyado Buffer	2016-2019	0	0

Leopard: The most frequent livestock species lost to leopard was again cow (n=461) distantly followed by buffalo (n=137), and goat (n=116). As for the sex of the lost livestock, among cow, far more females (n=379) were lost as compared to male/bullock (n=82). In case of buffalo again, more females (n=108) were lost as compared to males (n=29). In case of goat also, more females (n=95) were lost as compared to males (n=21). As for the age of the lost livestock, among cow, again most kills were that of adults (n=390) and as compared, very few were of juveniles (n=71). In case of buffalo, again more adults (n=79) were predated as compared to juveniles (n=57). In case of goat also, many more adults (n=112) were predated as compared to juveniles (n=3). Annual rate of livestock loss due to leopard was highest for Gangau (23.50 livestock/year) and lowest for Gahrighat (0.50 livestock/year) (Table 9.10). KGS did not report any loss due to leopard. Among core ranges, Panna core has the highest annual rate of livestock loss (9.70 livestock/year) (Table 9.10). Among beats, Umravan (Gangau) recorded the highest number of livestock loss due to leopard, at a rate of 7.70 livestock/year, followed by Bador (again Gangau) at 6.10 livestock/year (Fig. 9.7).

Table 9.10: Range wise summary of average annual rate of livestock loss due to leopard in PTR

Range	Period	Total Attacks	Average Rate (No./Year)
Chandranagar Core	2010-2019	52	5.20
Gahrighat	2010-2019	5	0.50
Hinauta	2010-2019	51	5.10
Kishangarh Core	2010-2019	6	0.60
Panna Core	2010-2019	97	9.70
Madla	2010-2019	50	5
Gangau Wildlife Sanctuary	2010-2019	235	23.50
Ken Gharial Wildlife Sanctuary	2010-2019	0	0
Chandranagar Buffer	2013-2019	34	4.86
Kishangarh Buffer	2014-2019	96	16.00
Panna Buffer	2014-2019	48	8
Amanganj Buffer	2016-2019	46	11.50
Madiyado Buffer	2016-2019	3	0.75

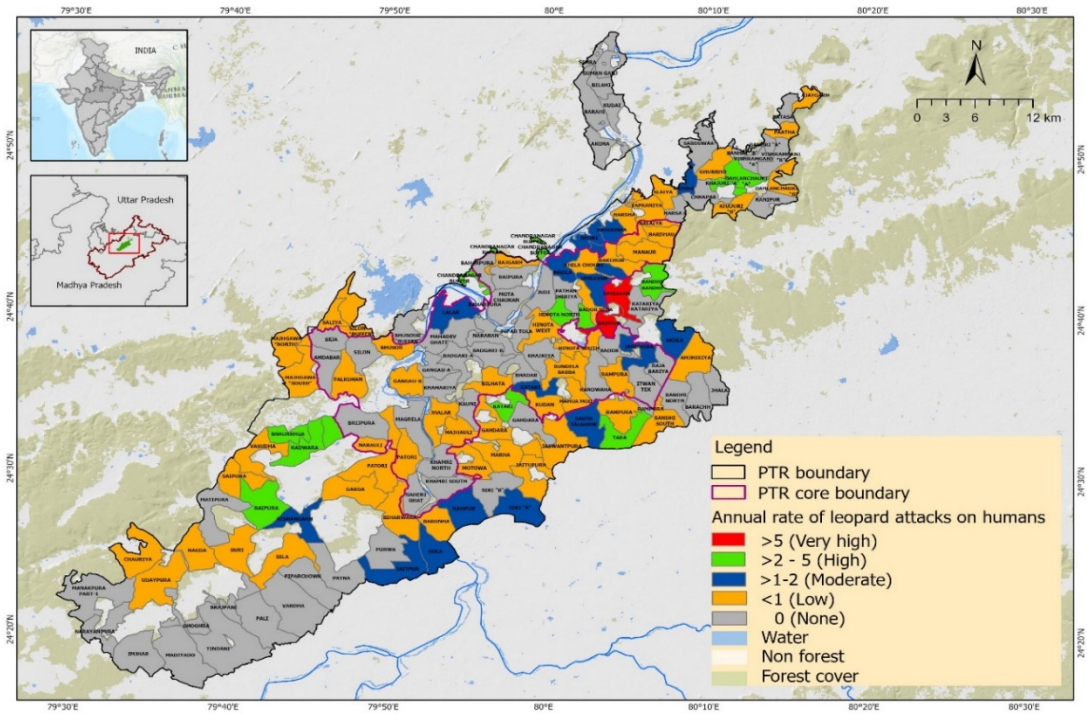


Figure 9.7. Thematic map depicting frequency of livestock loss by leopard within forest beats of PTR

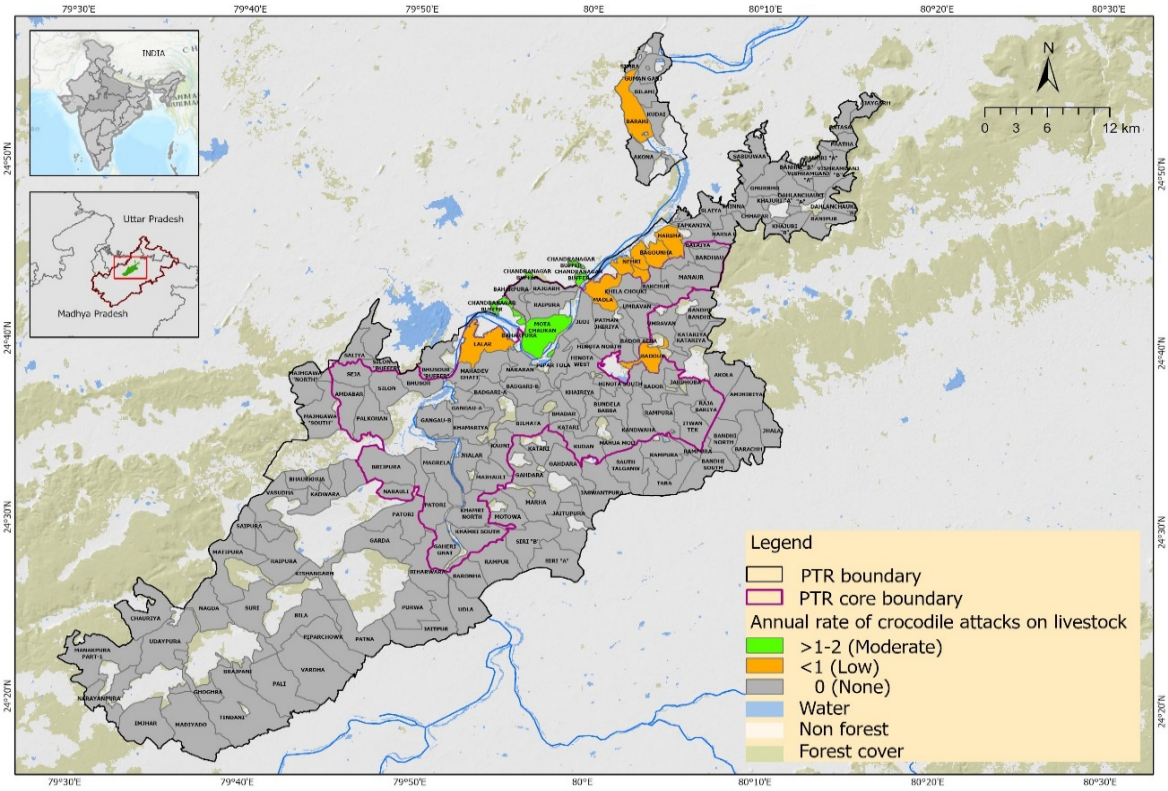


Figure 9.8. Thematic map depicting frequency of livestock loss by crocodile within forest beats of PTR

Crocodile: The most frequent livestock species lost to crocodile was buffalo (n=16) followed by goat (n=5), and cow (n=3). As for the sex of the lost livestock, among buffalo, far more females (n=14) were lost as compared to male (n=2). As for the age of the lost livestock, again most kills were that of adult buffaloes (n=11) as compared to juveniles (n=5). Losses due to crocodile were restricted to only Chandranagar, Gangau, KGS and Madla ranges. Among which only Gangau and Chandranagar buffer reported any substantial loss (1 livestock/year) (Table 9.11). Among beats, again Chandranagar (Chadranagar Buffer) recorded the highest number of livestock loss due to crocodile, at a rate of 1 livestock/year, followed by Katriya (Gangau) at 0.50 livestock/year (Fig. 9.8).

Table 9.11: Range wise summary of average annual rate of livestock loss due to crocodile in PTR

Range	Period	Total Attacks	Average Rate (No./Year)
Chandranagar Core	2010-2019	1	0.1
Gahrighat	2010-2019	0	0
Hinauta	2010-2019	0	0
Kishangarh Core	2010-2019	0	0
Panna Core	2010-2019	0	0
Madla	2010-2019	4	0.4
Gangau	2010-2019	11	1.1
Ken Gharial Sanctuary	2010-2019	1	0.1
Chandranagar Buffer	2013-2019	7	1
Kishangarh Buffer	2014-2019	0	0
Panna Buffer	2014-2019	0	0
Amanganj Buffer	2016-2019	0	0
Madiyado Buffer	2016-2019	0	0

Females of the livestock species seem to be more vulnerable to wildlife attack, which can be an artifact of people in general owning more female livestock for the purpose of milk production as compared to males and hence, increasing the chance that the depredated livestock would be female. It could also be a function of their smaller body size as compared to males, making them easier to predate upon.

Spatially, it is Chandranagar buffer where most of wildlife related attacks on livestock were occurring in PTR. However, spatial patterns differed with wildlife species. In case of tiger, depredation rate was highest in Amanganj Buffer, while in case of leopard, it was highest for Gangau Sanctuary.

(ii) Temporal Pattern of Wildlife Attacks on Livestock: The highest number of wildlife attacks on livestock (for the 10-year period 2010-2019) were reported in the year 2017 (n=629), which was almost double the second highest year 2018 (n=346). This was, as mentioned before, due to one beat, the Chandranagar buffer which suddenly reported 417 cases in 2017. The

highest number of wildlife attacks occurred in winter (n=895), followed by summer (n=542) and then monsoon (n=430). Temporal patterns of livestock loss by major conflict causing species are further discussed below.

Tiger: The highest number of tiger attacks on livestock (for the period 2010-2019) were reported in the year 2018 (n=229), followed by 2016 (n=183). The highest number of tiger attacks on livestock occurred in winter (n=577), followed by summer (n=266) and monsoon (n=245).

Leopard: The highest number of leopard attacks on livestock (for the period 2010-2019) were reported in the year 2015 (n=123), followed by 2014 (n=103). The highest number of leopard attacks on livestock occurred in winter (n=289), followed by summer (n=254) and monsoon (n=167).

Crocodile: The highest number of crocodile attacks on livestock (for the period 2010-2019) were reported in the year 2013 (n=6), followed by 2014 (n=5). The highest number of crocodile attacks on livestock occurred in summer (n=11), followed by monsoon (n=9) and winter (n=4).

(3) Crop Damage/Loss by Wildlife: During the workshop with beat guards (n=142), 81.69% reported that wild animals raid crop in villages around their beat, 16.20% termed the loss to be very high (>30%), 20.40% high (>20-30%), 28.17% moderate (>10-20%), and 19.72% low (>0-10%). All of them reported that villages were facing crop loss due to wild pig (81.69%) and nilgai (80.98%), distantly followed by chital (29.60%) and sambar (21.83%). All the village representatives interviewed during the workshop, stated that their villages (n=101) face crop loss, 68% of them termed the loss to be very high (>30%), 12.87% high (>20-30%), 13.86% moderate (>10-20%), and 4.95% low (>0-10%). All the villages (100%) reported to be facing crop loss due to wild pig, 97% reported facing crop loss due to nilgai, 31.68% to chital, 26.73% to macaque, and 21.78% to sambar. During interview with people also, wild pig, nilgai and cheetal were most frequently reported as crop raiding species.

Almost all village representatives from various tehsils perceive crop loss to be very high (>30%), but to a varying degree. 84% of representatives (n=13) in Rajnagar tehsil (adjacent to Chandranagar Range) perceive crop loss to be very high (>30%), followed by 80% in Amanganj (4 out of 5 villages), 73.90% in Panna (17 out of 23 villages), 70% in Ajaygarh (7 out of 10 villages), 67.70% in Bijawar (21 out of 31 villages) and 50% in Hatta (8 out of 16 villages). Only one village from Halda tehsil was represented and they perceived crop loss to be low (>0-10%) in their tehsil. As for the forest guards, many beats within Amanganj Buffer

(46.15% of beats) reported crop loss to be very high (>30%), followed by Panna core (35.29% of beats) (Table 9.12; Fig. 9.9). Further study to record the crops that are most often raided may help understand seasonality of loss, if any.

Table 9.12: Percentage of beats under each crop loss severity category, for all the ranges of PTR, based on perception of loss by forest guards

Range	No loss	Low (>0-10%)	Moderate (>10-20%)	High (>20-30%)	Very high (>30%)
Panna Core	0	17.65	11.76	23.53	35.29
Madla	64.29	7.14	7.14	7.14	14.29
Panna Buffer	5.26	15.79	42.11	31.58	5.26
Madhiyado Buffer	0	27.27	36.36	36.36	0
Kishangarh Core	0	20	0	20	0
Kishangarh Buffer	5.56	27.78	27.78	27.78	11.11
Ken Gharial Sanctuary	0	0	50	0	33.33
Amanganj Buffer	0	7.69	38.46	7.69	46.15
Gahrighat	0	60	20	0	0
Hinauta	27.27	9.09	36.36	18.18	0
Gangau	0	12.50	62.50	12.50	12.50
Chandranagar Core	0	33.33	22.22	22.22	22.22
Chandranagar Buffer	0	75	0	25	0

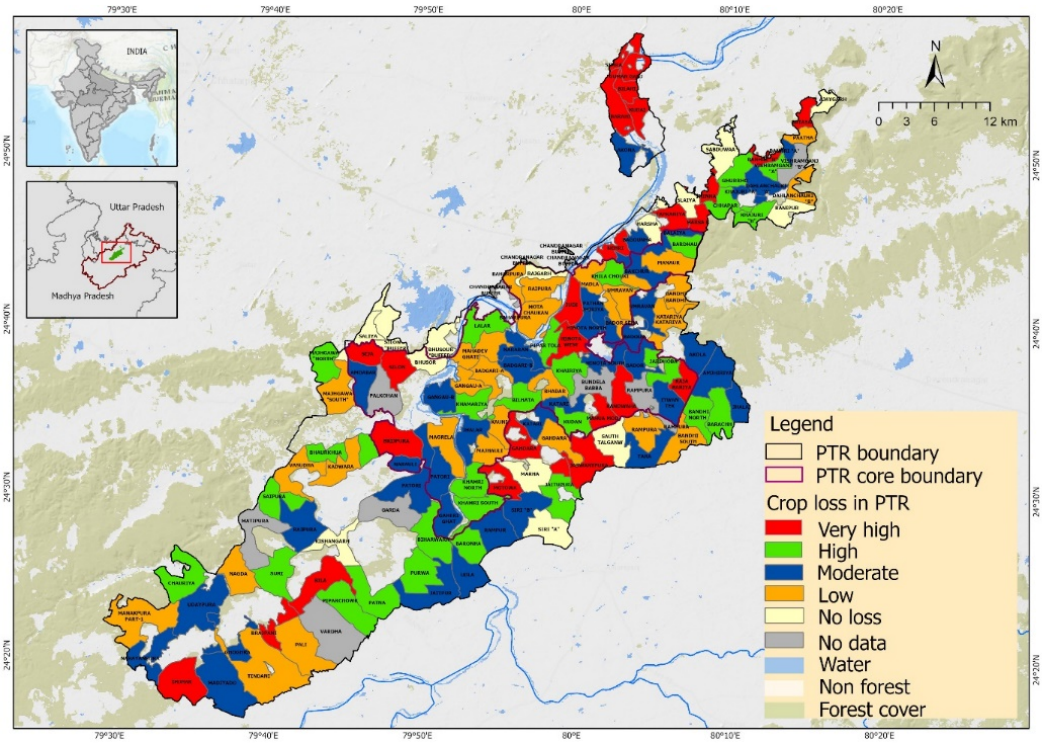


Figure 9.9. Thematic map depicting perceived crop loss around beats in PTR

9.1.5. Status of Human-Wildlife Conflict in the Greater Panna Landscape: Only 5% (n=135) of the sampled households in the landscape reported attack on humans by wildlife. Although, people reported that they are mostly afraid of tigers (n=2015) and sloth bear (n=799), however, it was snake (n=42) and jackal (n=37) that were responsible for most of the attacks on humans. Other notable species of which people reported to be afraid of, were, leopard (n=277), snake (n=220), wild pig (n=167), jackal (n=36) and wolf (n=14). Other species reported to have attacked humans were sloth bear (n=31), wild pig (n=16), tiger (n=3), leopard (n=3), two cases each of wild dog and rhesus macaque, and one case each of hyena, nilgai, chital, monitor lizard and scorpion.

12.87% (n=347) of the sampled households reported livestock loss due to wildlife. Leopard (n=115) and wolf (n=125) were reported to be causing highest number of domestic livestock loss, followed by tiger (n=61), jackal (n=26), wild dog (n=24), wild pig (n=4) and very few (n=2) by hyena, crocodile and python. 65.54% (n=1767) of the sampled households reported crop raiding by wild herbivores. Most households reported crop raiding by wild pig (n=1545) and nilgai (n=1136), distantly followed by chital (n=285), rhesus macaque (n=254) and sambar (n=200), and a few reported losses due to jackal (n=41), porcupine (n=32), chinkara (n=22) and black buck (n=13). Some people also reported crop loss due to parakeets, peacock, hare and mice. In some villages the crop loss is reportedly so severe that many people have stopped farming.

9.1.6. Current Status of Human Wildlife Conflict Management: Recently, the Standing Committee of the National Board of Wildlife (SC-NBWL) approved the advisory for Human-Wildlife Conflict (HWC) management in the country. The advisory seeks expedited inter-departmental coordinated and practical actions. The advisory envisages empowering gram panchayats in dealing with the problematic wild animals as per section 11 (1) (b) of the Wildlife (Protection) Act, 1972, utilizing add-on coverage under the Pradhan Mantri Fasal Bima Yojna for crop compensation against crop damage due to HWC, and augmenting fodder and water sources within the forest areas. Payment of a portion of ex-gratia as interim relief within 24 hours of the incident to the victim/family is also mentioned. The advisory also envisages prescribing inter-departmental committees at the local/state level, adoption of early warning systems, creation of barriers, dedicated circle wise Control Rooms with toll-free hotline numbers which could be operated on 24X7 basis, identification of hotspots and formulation and implementation of special plans for improved stall-fed farm animal, etc. The following sections describes the current measures to deal with HWC.

(i) Compensation for Wildlife-related Losses: The questionnaire survey conducted during the study, revealed that in the landscape only 312 households applied and received compensation for wildlife related losses. In PTR also, it was found that most of the households never claimed compensation for wildlife related losses (Fig. 9.10). The most oft repeated reason for not claiming compensation was low success (9.10%, N=44), unawareness about schemes, negative attitude towards government, time consuming, and corruption. During the workshop also, only 56.40% of village (n=110) representatives said that they receive compensation for livestock loss from forest department. Most of these representatives felt that the process was too complicated with lots of paperwork. Many felt that the process was time taking. Some blamed corruption and inability to produce post-mortem report for failure in claiming compensation. Even among the forest guards interviewed during the workshop only 69.01% reported that people claim compensation for livestock loss. And almost everyone said the biggest issue in claiming/issuing compensation was getting post-mortem report from a veterinarian. It is to be noted that forest department only compensates human and livestock attacks/losses by wildlife, not crop loss. Compensation for crop loss due to all natural disasters including wildlife is handled by the revenue department/collectorate.

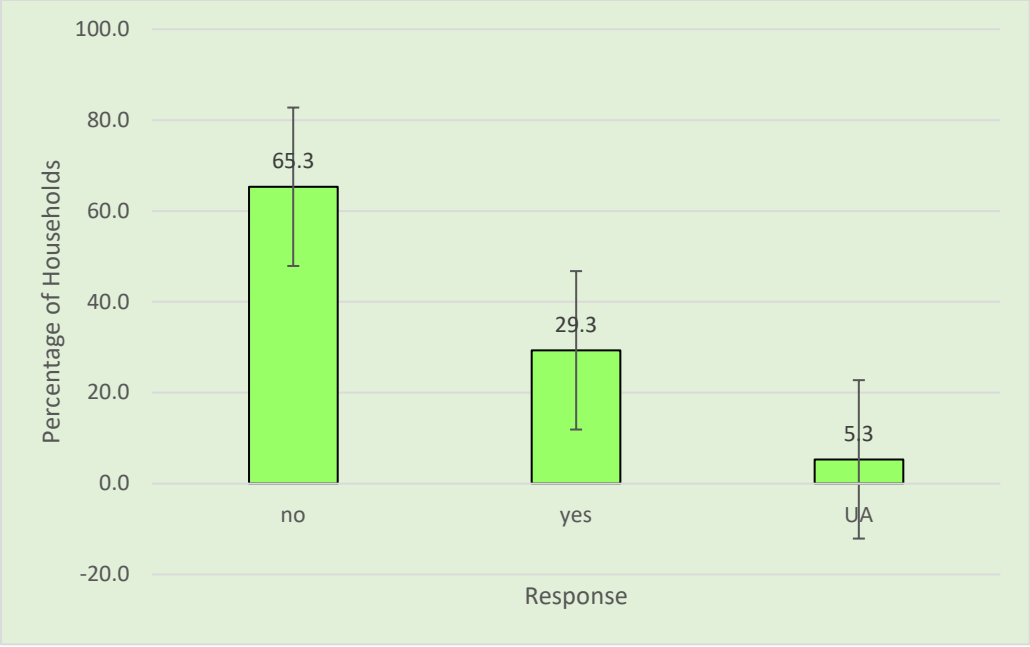


Figure 9.10. Households claiming compensation for livestock loss in PTR

(ii) Capture and Translocation of Problem Animals: To avoid conflict of dispersing or exploring tigers with human, the PTR management on several occasions resort to active management by pushing the tigers back inside using elephants. In case, that is not successful,

the team may also tranquilize the tiger and translocate it within its home range or in an area with low tiger density.

(iii) Community Engagement: PTR administration have organised series of meetings and events with local communities from adjoining villages under the banner of "Jan samarthan se bagh sanrakshan" (Tiger conservation through people's support). The aim of these meetings has been to create goodwill for tigers, especially for the dispersing ones, that may sometime venture into the villages and to overall improve people-park relationship. Nature camps are also organised for school children from Panna to inculcate conservation values in them.

During the landscape survey, local communities most frequently suggested that in order to prevent wildlife related losses specially to check crop raiding, chain link fencing should be done (n=752), followed mainly by compensation should be given (n=624), boundary walls should be erected around forest (n=548) and conflict causing species should be culled (n=510). However, many respondents said that they could not afford agricultural fencing and were entirely dependent on forest for fencing material. They suggested that if government could provide fencing material to them at concessional prices, then this could really minimize their losses. This is indicative of the gaps in the human-wildlife conflict management and since its coming from communities addressing these aspects will bring more effectiveness.

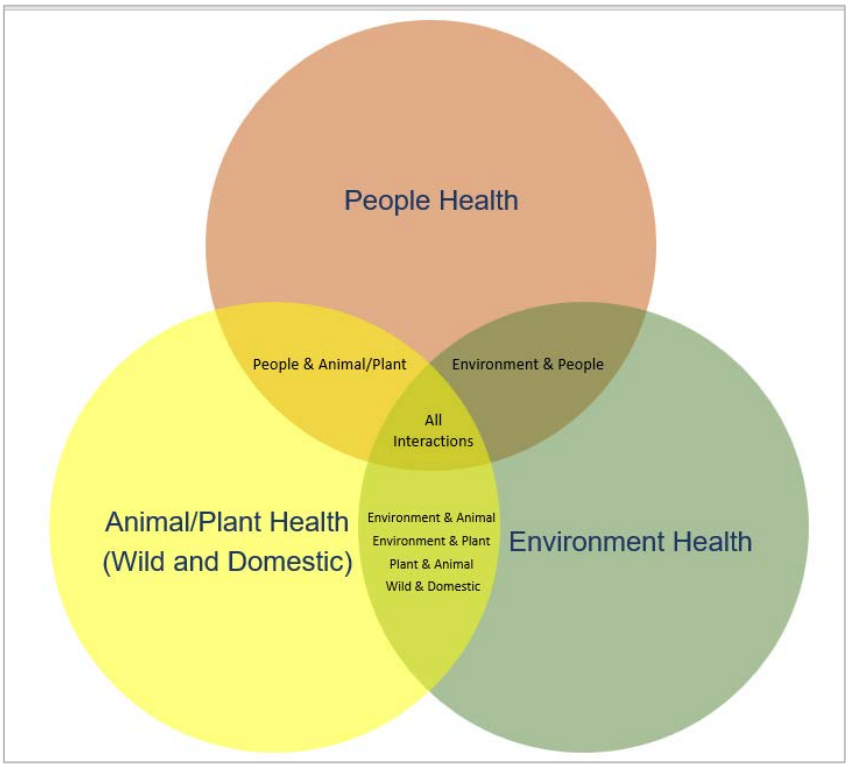


Figure 9.11. Schematic Diagram of One Health Concept

9.1.11. One Health Aspects: According to One Health High Level Expert Panel (OHHLEP), "*One Health is an integrated, unifying approach that aims to sustainably balance and optimize the health of people, animals, and ecosystems. It recognizes the health of humans, domestic and wild animals, plants, and the wider environment (including ecosystems) are closely linked and inter-dependent. The approach mobilizes multiple sectors, disciplines and communities at varying levels of society to work together to foster well-being and tackle threats to health and ecosystems, while addressing the collective need for clean water, energy and air, safe and nutritious food, taking action on climate change, and contributing to sustainable development*" (WHO, 2021). It essentially focusses on the linkages between environment health, animal/plant (wild and domestic) health and people health (Fig. 9.11). The approach involves the collaboration of experts from across different areas including physicians, veterinarians, environmentalists, epidemiologists, biologists, diagnosticians, microbiologists, immunologists, agriculturists, and sociologists, to improve the health and well-being of people and animals, including pets, livestock, and wildlife.

(i) Zoonotic Diseases in the Context of India: While the concept of One Health has mostly been applied in the context of human health and well-being, it is of great significance in the context of wildlife and nature conservation. Zoonoses are defined as those diseases and infections naturally transmitted between people and vertebrate animals (WHO, 2014). These include diseases caused by infectious agents (bacteria, viruses), parasites (helminths, protozoa, hemoparasites), diseases spread through contact or aerosol, soil-borne diseases, water-borne diseases, food-borne diseases, vector–borne diseases (VBD) and, more recently anti-microbial resistance (AMR). There are three classes of zoonotic diseases (WHO, 2014) and these are (1) endemic zoonoses which are present in many places and affect many people and animals. These include tuberculosis, rabies, anthrax, Kyasannur forest disease; (2) epidemic zoonoses which are sporadic in temporal and spatial distribution. These include Salmonellosis, Leptospirosis, Leishmaniosis, tick-borne encephalitis; and (3) emerging and re-emerging zoonoses which are newly appearing in a population or have existed previously but are rapidly increasing in incidence or geographical range. These include Nipah virus, Crimean Congo Haemorrhagic Fever, Pandemic influenza (H1N1), Avian Influenza (H5N1), SARS-CoV-1, MERS-CoV and most recently, SARS-CoV-2 (or Covid-19 disease). The main zoonotic diseases of public health importance in India include: Rabies, Leishmaniasis, Plague, Leptospirosis, Echinococcosis, Rickettsial diseases, Toxoplasmosis, Taeniasis, Cysticercosis, Brucellosis, Anthrax, Listeriosis, Arboviral infections (including Dengue, Chikungunya, Japanese

Encephalitis (JE), Tick-borne encephalitis (TBE), Kyasannur Forest Disease (KFD), Crimean-Congo Haemorrhagic Fever (CCHF)) and, Zika virus disease (NCDC, 2016; CBHI, 2019). Other zoonotic diseases that are of regional context include Nipah virus, pandemic influenza (H1N1), Avian influenza (H5N1), Salmonellosis, Schistosomiasis.

(ii) Zoonotic Diseases in the Context of PTR and Landscape: Although there have been no studies to investigate the occurrence or prevalence of zoonotic diseases in the Panna landscape, there have been sporadic reports of cases from humans and sometimes, in animals. According to information provided by the Office of Chief Medical Officer, Panna District, four cases of scrub typhus were reported in 2020, from two districts, Amanganj and Ajaygarh in Panna landscape. One laboratory-confirmed case of Leptospirosis was also reported from Pawai. Filariasis is endemic in the district, especially in urban areas, identified based on laboratory diagnosis of suspected cases. It is believed that there might be many more unreported or undiagnosed cases due to lack of awareness and facilities in most of these regions. Rabies is not commonly reported although there are several reported cases of dog-bites. Tuberculosis highly prevalent, but there is no information on whether there is mixed infection with *M. bovis*. Meanwhile, there is little information on the prevalence of zoonotic diseases in livestock and wildlife from the region as no limited surveillance activities or monitoring programmes have been undertaken for the same. However, the large interface between wildlife, livestock and humans in the region, the rapid urbanization in the smaller towns, encroachment into forest lands by humans and livestock, unsupervised grazing by livestock within forest land, large feral cattle population in the region and the fragmented nature of the forested areas, leading to dispersal of wildlife outside the PAs, all indicate a high level of risk for occurrence and transmission of zoonotic diseases. Additionally, there is a major reliance on livestock by the communities in the PTR region, for livelihood as well as for subsistence. Of the 386 and 303 households surveyed in different villages across Panna and Chhatarpur districts, 80% (n= 307 and n= 241) of the households in both districts, held livestock.

There is no systematic information available on the zoonotic diseases affecting people and animals in the PTR or landscape. However, a list of potentially important zoonotic diseases especially in terms of public health has been prioritized and compiled based on the cases reported, likelihood of occurrence based on national level data, previous historical data and risk of spread from adjacent areas known to be affected by the diseases (Singh *et al.*, 2010; Asokan *et al.*, 2011; Singh and Gajadhar 2014; NCDC 2016; Chaubey *et al.*, 2017; Dhiman

and Tiwari, 2018; Sharma *et al.*, 2019; Patel *et al.*, 2020). A list of diseases with zoonotic potential in PTR and the landscape is given in Table 9.13.

Table 9.13: Potential zoonotic diseases affecting wildlife, livestock and humans in PTR and landscape

Viral Zoonotic Diseases 1. Rabies 2. Highly Pathogenic Avian Influenza 3. Zika virus disease 4. Nipah virus disease 5. Japanese encephalitis	
Bacterial Zoonotic Diseases 1. Bovine tuberculosis 2. Anthrax 3. Brucellosis 4. Scrub typhus 5. Paratuberculosis (Johne's disease) 6. Plague 7. Q-fever	8. Leptospirosis 9. Other Rickettsial disease (Murine typhus, Spotted fever) 10. Food and water- borne illnesses (Listeriosis, Salmonellosis, *E. coli* infections, Campylobacteriosis, Shigellosis)
Parasitic Zoonotic Diseases 1. Cryptosporidiosis 2. Toxoplasmosis 3. Schistosomiasis 4. Echinococcosis 5. Taeniasis/ Cysticercosis	6. Visceral Leishmaniasis 7. Dirofilariasis 8. Filarial diseases 9. Food and water- borne illnesses (Trichinellosis, Giardiasis)

According to information from the Wildlife Veterinary Officer and the Panna Animal Husbandry Department, the epizootic diseases listed in Table 9.14 have been observed in wild, domestic and feral animal populations in the core and buffer regions of PTR. Some of these pose a conservation threat to endangered species, while others pose a threat to food security and economic stability of the rural communities in PTR.

Table 9.14: Epizootic diseases that have been reported in livestock, domestic or wildlife in PTR

Disease	Pathogen/ Agent	Species Affected	Mode of Transmission	Risk Factors
Canine Distemper	*Canine distemper virus*	Domestic (dog, cat) and wild carnivores, mustelids, macaques	Aerosol infection (Oro-nasal route)	Increased interface between

				domestic and wild carnivores
Canine Parvovirus Enteritis	*Canine parvo virus*	Domestic (dog, cat) and wild carnivores	Aerosol infection (Oro-nasal route)	Increased interface between domestic and wild carnivores
Hemorrhagic Septicemia	*Pasteurella multocida*	Cattle and buffalo, and wild ungulates (deer, antelope)	Aerosol infection (Oro-nasal route)	Free-roaming herds, congested and unsanitary housing conditions
Black Quarter	*Clostridium chauvoei*	Cattle, sheep, goat, pig	Contaminated feed or soil (Feco-oral route)	congested and unsanitary housing conditions
Foot and Mouth Disease	*Foot and Mouth disease virus (Apthovirus)*	Cattle, swine, goats and cloven-hoofed ruminants	Aerosol infection (Oro-nasal route)	Increased interface between livestock, congested and unsanitary housing
Colibacillosis	*Avian Pathogenic Escherichia coli*	Poultry (chicken, turkey, duck)	Contaminated feed and water (Feco-oral/ Oro-nasal route)	Contaminated water, congested and unsanitary housing

(iii) One Health Interfaces at Play in PTR: In Panna, the core area is free from any human habitation thanks to the rehabilitation efforts by the forest department over the past two decades. However, grazing by unauthorized livestock (owned or feral) is quite common with a risk for the spread of zoonotic and other animal diseases. Livestock and other domestic animals (including pigs, dogs and cats) that are not vaccinated against, and/ or, potentially infected with, agents of zoonotic diseases can be a source of infection to the wildlife inside the reserve. Feral dogs from urbanised areas are also a major source of many infectious agents, which they pick up from their environment. They also tend to range very large distances, often foraying into the forest fringes and interacting with wild meso-carnivores and small mammals like jackals, foxes, civets, rodents. Thus, they could be an important link in the transmission of zoonotic diseases between domestic and wild animals. Wild carnivores, especially the big cats are particularly susceptible to the diseases carried by the feral/ free-ranging canine populations

in PTR (Beineke *et al.*, 2015). This has been evidenced in the case of Canine Distemper Virus (CDV), Canine Parvo Virus (CPV) and Canine Adeno Virus (CAV). Free ranging dog populations in the buffer region of PTR act as the reservoirs of these infections and their increasing population densities creates an environment for highly virulent strains to emerge. Additionally, tigers have also been shown to be prone to the SARS-CoV-2 virus that causes Covid-19 (McAloose *et al.*, 2020). These findings reiterate the importance of one health approaches in the arena of wildlife conservation as well. These infections, potentially threaten the decades of conservation efforts that have been put in to revive the population of the big cats in PTR.

The National Tiger Conservation Authority (NTCA) has already issued guidelines and preventive measures for CD viral infections and Covid-19. According to the information provided from the Wildlife Veterinary Officer of PTR, CD virus has been confirmed to be the cause of death in 1 tiger and 2 leopards in the reserve since 2015. Following this, a sero-surveillance study was conducted in both wild carnivores as well, for the feral dog and cat populations in the buffer regions of PTR between 2016-2018 (Nayak *et al.*, 2020). The results of the same reveal that there was a high risk of spill over of viral infections from feral dog populations to wild carnivores in the reserve (Table 9.15).

Table 9.15: Observed sero-prevalance of CPV, CDV and CAV in big cats and feral dogs in PTR

Animal Tested	**Samples Tested (n)**	**CPV**	**CDV**	**CAV**
Dogs	112 (Phase 1)	89.2% (n=100)	91.9% (n=103)	42.8% (n=48)
	47 (Phase 2)	89.4% (n=42)	80.9% (n=38)	36.2% (n=17)
Big Cats* (Tiger, Leopard)	4 (Phase 1)	100% (n=4)	75% (n=3)	Not observed
	3 (Phase 2)	100% (n=3)	33.3% (n=1)	Not observed

*Also included carcasses of 1 tiger and 3 leopards. All remaining were tiger serum samples.

Small scale poultry farming is carried out by communities along the borders of buffer zone of PTR. As per the revised guidelines in the 2021 National Action Plan for Prevention, Control

and Containment of Avian Influenza (Department of Animal Husbandry, Dairying & Fisheries (DADF), 2021), surveillance strategies should include identifying areas inhabited by wild and migratory birds that are in the vicinity of commercial poultry farms. For Panna district, the actual figure on the number of functioning poultry farms is currently unavailable, with only 12 farms having been registered with the animal husbandry department in the district. Lack of benefits and incentives seem to be the main reason for lack of interest from the poultry farmers for not having their farms registered. The housing and functioning of poultry farms around PTR were also observed to be sporadic. Information from farmers belonging to Kunjvan village (bordering PTR) where 10 of the registered farms exist revealed that close to 250 farms were earlier functional around the region. Currently, most of the farms were non-functional or closed permanently due to the economic losses incurred because of the Covid-19 lockdowns. In the farms that functioned, history of *E. coli* outbreaks was reported. Outbreaks of avian influenza was not reported in any of the farms, which was also confirmed at the district animal husbandry department. However, their proximity to PTR, which is visited by a number of winter migrants and the presence of a large water body close to the farms in Kunjvan village increases the risk for spread of Avian influenza from wild birds to domestic poultry. Having identified this risk, an occupancy survey was also carried out at the water body to identify the presence of wild and migratory birds. The Animal Husbandry department for the state of Madhya Pradesh currently has two subsidy schemes in place to promote rural/ tribal farmers to set up backyard poultry units. This also includes the supply of the disease resistant 'Kadaknath' chicken which is an indigenous breed (Verma *et al.*, 2020). With backyard poultry set to play a key role in the upcoming decade, for providing supplementary income to marginalised communities in the landscape, it becomes imperative to safeguard the health of poultry and other livestock through targeted surveillance of wild birds for AIV, in critical areas. Such surveillances will act as a warning signal and aid the incumbent department officials in taking timely preventive actions for safeguarding animal and human health.

(iv) Public Health Concern in PTR: Villages in the core and buffer region of PTR experience a dual burden, of both communicable and non-communicable diseases (NCD). Conditions that have or are suspected to have a significant burden on the health and well-being of the communities in PTR include childhood diseases and malnutrition, (Panna and adjoining districts of PTR had one of the highest neonatal, infant and under 5 child mortality rates among all districts in Madhya Pradesh and contribute significantly to the national child mortality burden (Dandona *et al.*, 2020)), snakebite envenoming and silicosis.

(v) Current Health Management Interventions and Strategies: Given the increasing acceptance of the threat from zoonoses to public and animal health, and the need for a One Health approach to address the same, the Government of India had created a National Standing Committee on Zoonoses (Aggarwal and Ramachandran, 2020). Already there are specific control programmes for certain endemic zoonoses such as Rabies, Brucellosis, Visceral Leishmaniasis (Kala Azar), Japanese Encephalitis, Filariasis, Plague, Leptospirosis and Tuberculosis including Bovine tuberculosis mixed infections. More recently, there is a Covid-19 control programme nationally and globally. MP state has initiated monitoring and surveillance programme for Leptospirosis, scrub typhus and Filariasis. All human health data in the district is managed through the Health Management Information System of the National Health Mission, Government of India. However, there is no active sero-surveillance for any diseases. Diagnostic facilities at the district level are basic, or non-existent. On the animal front, the State Animal Husbandry Department has initiated control programmes for Rabies, Brucellosis and tuberculosis. The information on all zoonotic and infectious diseases is managed through the National Animal Disease Monitoring and Surveillance System (ADMAS) and the National Animal Disease Reporting System (NADRS). However, there is no active sero-surveillance for any of these diseases and diagnostic facilities at the district level are basic, or non-existent. There are no existing monitoring, surveillance, or management activities undertaken for zoonotic diseases in wildlife in the region.

(vi) Gaps in Knowledge and Skillsets: There is very little information available on the biology and distribution of the invertebrate and vertebrate hosts of many zoonotic diseases, especially from peri-urban, rural or forest areas. This is especially true for the Panna TR and landscape. Yet, there are several vector controls programmes that are undertaken by both the public health and animal husbandry departments at the national and state level. However, there is little to no coordination between the same. There are no systematic monitoring strategies built into these programmes. There is need for a feedback mechanism, based on field evidence of efficacy of the scheme, for the efficient utilisation and prioritisation of resources under such control programmes. While individual officers of the Public Health and Animal Husbandry Department are aware of the zoonotic diseases and threats to health from the same, there is a need for building capacity in management and treatment of zoonotic diseases. There is need for development of a strategic zoonotic disease monitoring and surveillance plan by the various stakeholder departments. Relevant laboratories, diagnostic agencies, surveillance and monitoring wings and data analysis wings need to be developed at regional level to coordinate

and manage the plan. Currently, there is insufficient training and capacity for individual departments to plan, mobilise and implement a strategic action plan on zoonoses control. There is an immediate and urgent need to educate the public about the potential zoonoses in their area, sources and modes of transmission, cultural and social practices that may influence spread and control of these diseases, and prevention and control options available for the same.

9.2. Recommendations and Prescriptions

The approach to managing HWC in PTR and the larger Panna Landscape must be people-forest participation. To anchor which it is envisaged to involve Ecodevelopment Committees. However, the structure and function of these communities needs to be reimagined. It is proposed that all forest-based activities will be linked with both protection/conservation of wildlife/forest and income generation through skill development and opportunity creation for the local communities. To do so instead of having one EDC in each village, theme-based EDCs would be developed at range level. One of the key themes would be 'HWC management'. It is also proposed to create a temporary post of 'ecological mobiliser' who will be employed by forest department but shall be deployed at each gram panchayat to act as a bridge between forest department and the panchayat. The following mitigation tools are proposed to be implemented.

9.2.1. Physical Tools:

(i) Establishment of Deterrent Fencing: Fencing are widespread and effective conflict mitigation tools (Lindsey *et al.*, 2012). The type of fence depends on the conflict causing species and locally available material (Distefano, 2005). Building net or stonewall fencing by reserve management is not only costly but often ineffective in the long term due to lack of maintenance and manpower to do so. We have thus discussed three types of fencing that we believe may work best for PTR:

(a) Bio-fencing: Biofencing has been erected to tackle the problem of crop raiding by elephant (using lemongrass (*Cymbopogon cintratus*)) and wild pig (using agave (*Agave americana*)) elsewhere in the country, with some success (Financial Express, 2019). In the same line for PTR, we propose dual biofencing using bamboo species as first line of fencing followed by a second line of fencing with *Euphorbia nivulia*, that are thorny and may serve as a local substitute for agave. The biofence should be temporarily supported with chain link fence with a stone foundation, till it is established.

High conflict areas as identified by us (like certain beats of Chandranagar and Amanganj buffer, facing both crop and livestock related losses (Fig. 9.1, 9.5, 9.9) can be fenced with the help of local communities. As mentioned above, the HWC theme EDC shall be responsible for the maintenance of the fence, which would also generate economic benefits for people by providing bamboo which can be utilised for furniture and basket making, fencing, and house building. Fencing may lead to habitat fragmentation and loss in connectivity (Osipova *et al.*

2018), hence we propose that only areas with sharp human-agricultural interface and no known connectivity be fenced in this manner. In fact, this exercise would help in channelising the movement of dispersing wildlife (Ausband *et al.*, 2013) especially, tiger towards corridors thus decreasing conflict due to dispersing tigers. However, the impact of fencing on other non-target species (like herpetofauna) also needs to be taken into account (Distefano, 2005). Thus, instead of fencing the park, fencing the afflicted fields may be more ecologically acceptable, this idea has been explored below.

(b) Solar-fencing: Electric fencing has been effectively utilised to reduce human-wildlife conflict especially crop damage (Sapkota *et al.*, 2014). Using Solar Power Fencing Technology can help the landscape because there are no megaherbivores like elephants, gaur, or rhinoceros. The electric shock is a non-lethal method and functions as a psychological barrier for humans and animals. A NABARD report presents five different models, in which the cost for 1-acre farmland is Rs. 1,61907/-. The report concludes that this is not viable in growing food-grains; rather it can be feasible for cash crops like vegetables and fruit crops. State Government may form a committee to study the feasibility of Solar Power Fencing in the State for crop protection. State Government may examine setting up solar power fencing units on a pilot basis as demonstration units at few places to determine its effectiveness and utility for crop protection and measures to replicate the same. However, in India it has been observed that electric fences are only effective in the long term if they are managed by the communities. This has been done on experimental basis in Tadoba Andheri and Sariska Tiger Reserves (Bhardwaj, 2017; Purohit, 2018). In these reserves, instead of fencing the park, agricultural fields are fenced, and the fences are maintained by the communities instead of the forest department. Therefore, as an immediate alternate to biofencing (because large scale plantations may take time to establish and grow), especially in areas with severe crop loss by wild pig and nilgai, solar electric fencing may also be explored. We suggest that instead of bearing the cost of this fencing the forest department only does hand holding of gram panchayat by providing guidance through the 'ecological mobilizer'. This would ensure that communities feel a sense of ownership towards the fencing and take charge of its smooth functioning.

(c) Wall-Fencing: Although bio-fencing and solar fencing should be the first choice for fencing, but given that bio-fencing will take time to establish, and solar fencing may not be effective where regular maintenance is lacking, as an alternate, stone wall fencing may be put up in such areas around high interface villages. Strategic areas may be identified through surveys, keeping in mind movement pattern of tigers and other wildlife.

(d) Social Fencing: Social fencing as discussed in detail earlier (Section 4.2.1.) is an attempt to engage local communities through EDC or Support Institutions (SI) under Panchayat Administration to reduce the pressure of constant surveillance from forest staff, to protect pre-identified sensitive areas (in terms of poaching, illicit felling or unauthorized cattle-grazing or resource extraction) of tiger reserves or fragile ecosystems as well as building up long term trust between forest department and local people while generating income for the local people and build knowledge on settlements of communities' rights of access on forest resources, in an institutionalized way. The social fencing would also help manage conflict through engagement of people in both awareness activities as well as self-regulating their dependence on forest and movement within the PA, resulting in reduced conflict incidence. Social Fencing Network (SFN) will have to be established in each of the villages in and around PTR, and this would require investments related to awareness, capacity building and incentives for the communities. In PTR, Last Wilderness Foundation with support of forest department and Astral Foundation is running a project called "Gram Rakshak", wherein community representatives after initial training act as guardians of both village and wildlife, reporting fire incidents, illegal activities, and imparting conservation awareness. SFN shall be integrated with these existing activities and upscaled.

(ii) Early Warning System: Early Warning System (EWS) has been found to be affective in mitigating conflict with crop raiding species (Sitati and Walpole, 2006; Branco *et al.*, 2020). In PTR, early warning system using radio telemetry, UAV or camera trapping may be continued to avoid conflict with dispersing tiger or crop raiding wild pig and nilgai. Making HWC theme EDC responsible for communicating movement details of conflict causing wildlife to vulnerable villages.

(iii) Special Performance Unit (SPU): As discussed earlier (Section 4.2.1), the three SPU, under the direct control of Deputy Director/Field Director PTR, to exclusively look after eastern zone, central zone and western zone, would deal with protection as direct measure and managing human-large carnivore conflicts as indirect measure including community mobilization where required for awareness and consultations. These units, consisting of five-member team with fixed tenure system, drawn from Deputy Ranger/Forest Guards from concerned Ranges, will be equipped with all logistics including sophisticated vehicle with necessary tools including UAV and monitor. However, any legal procedure and compensation payment would be dealt by the concerned forest guard of the beat where the conflict incident is recorded, to ensure consistency and accountability.

(iv) Conflict Task Force/Rapid Response Team: It is suggested that a Conflict Task Force/Rapid Response Team should be made in each division of GPL with an exclusive helpline number. Training should be provided to forest staff to deal with crisis situation – People management/Crowd management, as well as, capture and translocation of animals involved in the conflict situation. The team shall respond to conflict situations involving all kind of taxa including carnivores like tiger, leopard, etc., herbivores like nilgai, wild pig etc., omnivores like sloth bear, primates like rhesus macaque, reptiles like snake, crocodile etc., and hence should be trained to handle all the different kinds of animals and should be provided necessary equipment and facilities for the same.

(v) Capture and Translocation of Herbivores: Managing herbivore species which are involved in crop-raiding in human-dominated landscape is important to mitigate human-wildlife conflict and could be used as an indirect approach to manage carnivore population as well. In buffer zone of PTR, local translocation of herbivores from high density areas to low density areas is recommended as immediate measure based on due capture protocol. To do this, first based on encounter rate of herbivores obtained from line transect data, beats have been identified and can be periodically updated where problem wild ungulates are high or low in occurrence (Fig. 9.12, 9.13).

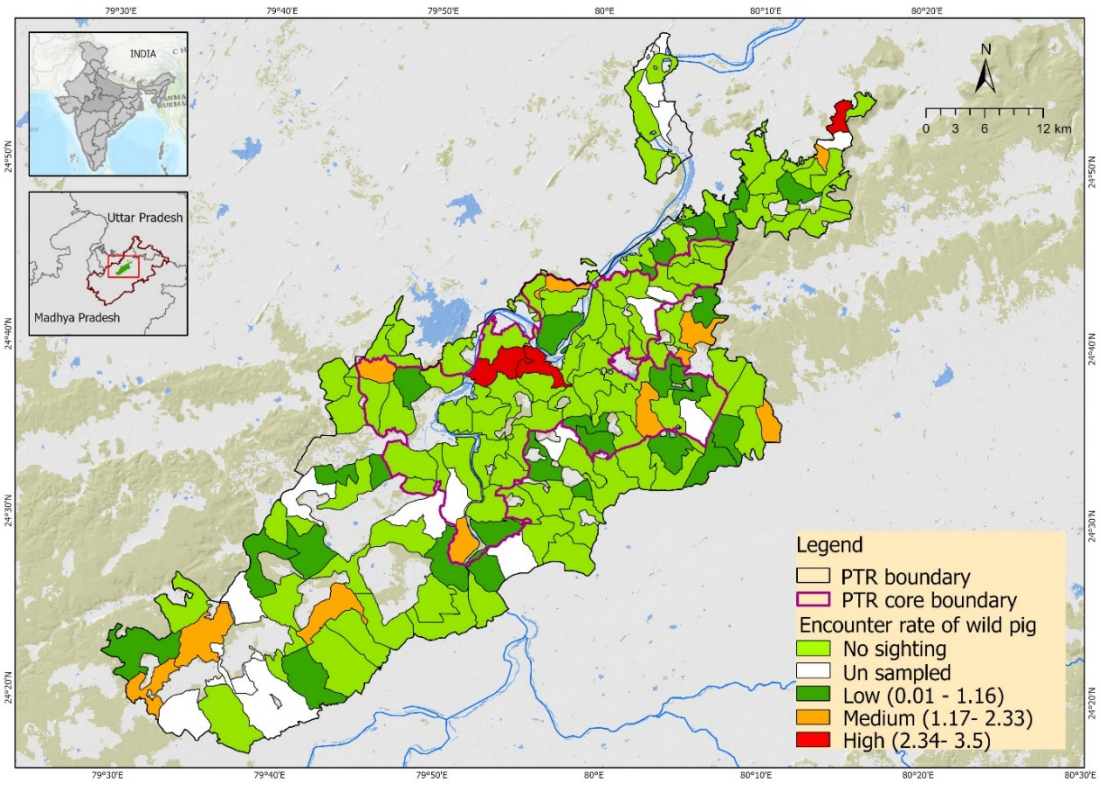


Figure 9.12. Map showing encounter rate of wild pig in PTR across forest beats

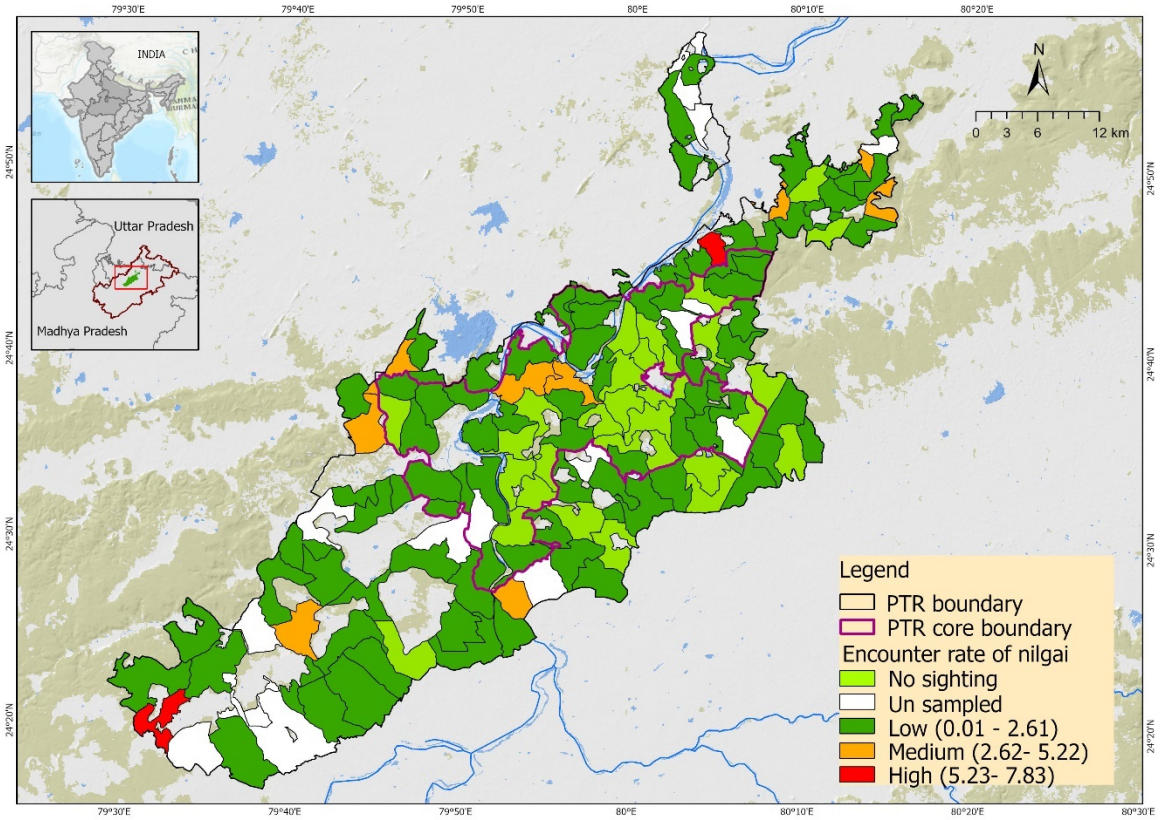


Figure 9.13. Map showing encounter rate of nilgai in PTR across forest beats

The salient features of this local translocation are as follows:

- Firstly, periodic (twice in a year) population density monitoring need be carried out in all beats of buffer zone through line transects (which is currently practiced once in a year). Line transects need to be laid into the vacant areas to fill the gap and effectively represent as much forest area as possible. Identification of target areas need to be done based on encounter rate of wild herbivores and compared year-wise.
- After identification, mass capture of wild ungulates (especially nilgai and wild pig), can be carried out in those areas. To do so, herbivore capture facility (Boma structure) would have to be placed preferably in open forest areas. The whole process needs to be monitored, and the success/failure measured. In case of logistics and feasibility, other capture methods could also be explored including chemical immobilization.
- The releasing site of captured herbivores would be not only the low occurrence of wild ungulates areas but will also away from human settlements and in areas with occurrences of tigers and other predators. If a beat holds low density of herbivores, but

also situated in the close proximity of villages, it would be avoided to release the captured animals, as it could potentially increase the conflict scenarios.

- It would be implemented as a periodic operation in all the ranges in buffer zone. A separate team of beat guards and chowkidars would be required to form at each range and the concerned Range Officer would be entrusted to implement the whole process.
- The effectiveness of this method would be monitored through the regular monitoring of population status of herbivores through line transect method as mentioned above in the capture site (beat) and released site, and also involving camera traps, telemetry and drone techniques.

For mass capturing of herbivores, the use of boma structure has been applied successfully elsewhere (Bandhavgarh Tiger Reserve to Sanjay Dubri Tiger Reserve) in Madhya Pradesh to augment the prey population. However, all these operations have been carried out in core zone of Tiger Reserves and it would be challenging to implement this in buffer. Hence, firstly, it is recommended to implement this procedure in buffer zone on trial basis. Periodic capture and translocation of herbivores in buffer zone would be especially useful to the staff working in buffer zone who generally do not get exposure to the handling of wild animals. This would facilitate to develop the capacity building among the staff regarding capture and translocation of wild animals in the context of wildlife population management and human-wildlife conflict. Mass capture and translocation of wild ungulates would be also beneficial for the people who are facing severe crop-damage due to nilgai and wild pig. Buffer zone of PTR holds substantial population density of nilgai, and wild pig, and occurrence of these species are high in some beats. Translocation of these species could possibly reduce the incidents of crop damage. However, careful selection of release site and post-translocation monitoring are key to the success of such programmes and thus, should be given due attention.

(vi) Capture and Translocation of Carnivores: Local translocation of conflict causing carnivores can be done as an immediate measure to alleviate conflict, especially of individuals attacking humans. Tigers can be translocated from high density areas to low density areas based on habitat suitability as described in earlier section. If deemed necessary/feasible, they may also be transferred to the Controlled Population Management Facility as indicated earlier (Fig. 4.13). Similar habitat suitability and occupancy study should be done for other carnivores and sloth bear to understand their habitat use and availability. Based on which local translocations can be carried out for other species as well.

(vii) Rescue and Rehabilitation Facility: Based on the evaluation of the supervising veterinarian or specialists, the captured conflict animals may be taken to a Rescue and Rehabilitation Facility (or Temporary Holding Facility), where they can be examined and if necessary, treated by trained veterinarians, before releasing them back into the wild. Each division in the landscape must have such rescue and rehabilitation facilities. Such facilities should be designed keeping in mind all the animal welfare guidelines and with the intention to cause least amount of stress and injury to the animals.

9.2.2. Financial Tools: Intensity of HWC often relates to financial implications to the people, depending on which the broader response or resentment may be seen among the communities not about the species of concern but also of overall wildlife values. Therefore, financial tools become an important instrument to combat the HWC in the immediate and long-term. The following measures linked to financial tools are suggested:

(i) Insurance: In PTR, it was found that very few people in villages around the reserve insure their crop with schemes like Pradhan Mantri Fasal Bima Yojna (PMFBY). As mentioned earlier, recently wildlife related losses have also been brought under the fold of PMFBY (Pinjarkar, 2020) although farmers will have to pay the premium to claim the compensation. Similarly, insurance of domestic livestock should also be promoted. We propose that it would be the role of 'ecological mobiliser' to decimate such information to local communities and oversee implementation of this and other environment related schemes within their respective gram panchayats. Life insurance of local people involved in risky activities need to be taken up through EDCs or based on other available mechanism including community-based industries and corporate support.

(2) Compensation: The existing compensation scheme is riddled with problems, however, changing a few things may help in making the compensation process easier and simpler. First is to ensure the availability of a veterinary officer to make Post-mortem report, so that the applicant does not have to run pillar to post to find a veterinarian. Another because application process with its numerous paperwork seems overwhelming to the uneducated or less educated people, the aforementioned 'ecological mobiliser' in each Panchayat shall assist people with filing the application. Additionally, compensation for livestock loss should be increased to at least 50% of the market value and this needs to be discussed with all stakeholders before taking decision to ensure sustainability. Forest staff should also be sensitised about how to deal with wildlife loss related complaints. States like Odisha are making good use of a mobile app

Anukampa for compassionate payment, field visit, application processing, mapping and monitoring on real time basis. this reduces the process complications in a sizable way. The same may be implemented for the landscape.

9.2.3. Outreach, Awareness and Trust Building: In several situations it is not possible to erect fences, as is the case with most carnivore related conflict in PTR, wherein it is not the wildlife that is moving outside and causing conflict, but the people who are venturing in their habitat. In such a situation the only solution is to educate people about wildlife and their habits, so that they can change their habits and behaviour to protect themselves and their livestock. Educating people about wildlife also reduces negative perception arising out of wildlife related losses, making them more positive towards conservation (Consorte-McCrea *et al.*, 2017). Based on our interaction (as discussed above), we have found that local communities in PTR are mostly proconservation. The PTR management, as discussed already has a mandate of tiger conservation with people's participation and organises interactions with villagers and nature camp for children. We propose expanding these community engagement strategies to include conservation education. Education programmes can be designed for different gender and age groups to accommodate all sections of the society. Additionally, species specific awareness campaigns with respect to forest appropriate behaviour (to avoid wildlife attack), also needs to be designed and decimated during winter months, when livestock attack by most species have been recorded to be highest. People should also be informed about the activities that are restricted in the reserve forest, and laws under which they can be penalised, if they are involved in any such activity. The aforementioned 'ecological mobilizers' in villages/Panchayats would play a key role in organising such activities. Local NGOs and members of civil society can also be engaged to utilise their expertise in designing these programs and arranging qualified educators for this purpose. Most importantly relationship and trust building exercises must be carried out by forest department to ensure proactive management of people-people conflict.

9.2.4. Management of Species Attacking Human

(i) Jackal: Although jackals are small carnivores with a varied omnivorous diet that thrive in human dominated forest-agro ecosystems (Chaurasia *et al.*, 2012; Negi, 2014; Chaurasia, 2015), they have been found to have a propensity to bite people when and where there is high overlap in human activities and jackal feeding requirements (Akhtar and Chauhan, 2009). And although these attacks are rarely severe or life threatening as we have observed in PTR, attacks on humans by jackal could lead to creation/promotion of negative sentiments towards not only

the species but also wildlife and park, in general. Additionally, it also has implications for rabies management in the reserve (Loveridge and Macdonald, 2001). In case of PTR, (although further study is needed to confirm this), the high rate of jackal attack may be linked to fruiting of *ber* (*Ziziphus mauritiana*) tree/shrub during winter, and *jamun* (*Syzygium cumini*) during summer, that are utilised by both human and jackal. *Ziziphus* and *Syzygium* trees as also common in agricultural fields and villages, which may attract jackals. High incidence of jackal bite in and around agricultural fields may also be linked to open defecation. High conflict beats like Chandranagar buffer and Akona can be monitored for overlap of human and jackal resources (feeding and denning sites) and awareness campaign for avoiding such sites specially during winter months can be organised in villages falling around these beats. The village panchayat should make efforts in making these villages ODF (Open Defecation-Free). Additionally, since jackal are also known to raid crops and are attracted by the presence of rodents in agricultural fields (Chaurasia, 2015); biofencing of forest boundary and or solar fencing of agricultural field can also reduce the chances of human-jackal habitat overlap. Optionally, the ecological role of jackals in managing rodent population or pest control can be highlighted when carrying out conservation education programs, and by doing so, not only combat negative perceptions towards the species but gain support for jackal conservation in agro ecosystems.

(ii) Sloth Bear: Earlier studies done on human-bear conflict in PTR and elsewhere in Madhya Pradesh, have linked it to intensity of human use of forest (NTFP collection), day time activity of bear and use of Lantana patch and caves by bears for resting during the day (Rajpurohit and Krausman, 2000; Yoganand *et al.*, 2005; Seidensticker *et al.* 2011). Most of the attacks occurred when people were either herding their cattle near a Lantana patch or collecting NTFP (sloth bear exhibit high preference for tendu (*Diospyros melanoxylon*) and ber (*Ziziphus mauritiana*) fruits in PTR) and passing by an area with dense vegetation cover or escarpment habitat with caves (Yoganand *et al.*, 2005; Singh *et al.*, 2018). Since most attacks due to sloth bear occur inside the forest, the only and major tool for preventing human-sloth bear conflict in PTR, is to create awareness among people utilizing buffer forests of Kishangarh and Panna, as has been done in other parts of the country with high human-sloth bear conflict (Singh *et al.*, 2018). Sabduaa beat in Panna buffer and Kishangarh beat in Kishangarh buffer, should be monitored for human-sloth bear habitat use overlap. Awareness should be created among local communities utilizing these ranges/beats to avoid areas with dense vegetation cover, especially, that of Lantana and or fruiting tendu and ber trees, as well as, going near caves in escarpment

habitat. Additionally, since most of the attacks occurred due to sudden encounters, it is wise to create sound or noise when passing through bear habitat (Singh *et al.*, 2018).

9.2.5. Management of Species Attacking Livestock

(i) Tiger: The growing tiger population has also led to an increase in livestock loss around the reserve, especially in multiple use buffer forests (Kolipaka *et al.*, 2017). However, since most of the livestock attacks by tiger in PTR occur within the reserve boundary, it is only the human-behaviour which can be modified to prevent livestock loss. It is suggested that when imparting conservation education, the livelihood strategies or husbandry practices that makes people more vulnerable to loss shall also be discussed and alternate strategies identified with community participation, to decrease chances of livestock depredation. As an immediate management measure, in beats where conflict is high like Gahadara in Amanganj Buffer, early warning systems should be put in place and or livestock pressure reduced by promoting stall feeding in Gahadara village.

(ii) Leopard: In areas with high tiger density, leopards have been observed to occupy fringe habitats, where they may be more prone to conflict (Malviya and Ramesh, 2015). In PTR, since high rate of livestock depredation by leopard have been reported from Umravan and Bador Beats of Gangau, biofencing can be explored to reduce leopard-livestock overlap. However, in case that is not feasible, the conservation education and seasonal awareness programmes, along with early warning system and reduced livestock pressure, as indicated for tigers above, can be explored.

9.2.6. Management of Species Causing Crop Damage

All across India wild pig and nilgai are considered as the most crop damaging species (Chauhan and Singh, 1990; Chauhan *et al.*, 2009). Apart from solar fencing, some low cost traditional methods like putting metal cow bells and shining tapes on the fences and deploying fireworks has also proven successful in preventing crop damage by wild pig in other parts of the Indian subcontinent (Tshering, 2019; Senthilkumar *et al.*, 2020). In case of damage, insurance/compensation claims can help manage losses. Within PTR, focus should be on Amanganj and Chandranagar buffer where most beats/villages reported severe crop damage.

9.2.7. Management of One-Health Aspects

(i) Coordination Committee: While a National One Health Policy is still in the wings, it should not deter states or districts from undertaking their own One Health strategies for managing zoonotic diseases. For the Panna landscape, we recommend the creation of a

Regional One-Health Coordination Committee, under the leadership of district administration (on rotational basis) and involvement of Forest Department, Animal Husbandry Department, Public Health Department and Pollution Control Board. It should also include technical advisory experts from local universities, research organisations and NGOs working in the region. The committee should be headquartered at Panna, given that it is the headquarter of the PTR, and a central district for the landscape. In the beginning, the committee should meet to formalise the committee and decide the terms of reference for the same. At the same time a budget should be developed for planned activities under the new committee. Under regular circumstances, the committee should meet biannually to evaluate the status of zoonotic diseases in the region and to strategise action plan for future surveillance and monitoring. In case of outbreaks, or suspected cases of zoonoses, the committee may meet on an emergency basis to coordinate the action plan for handling the zoonoses at the level of human, livestock and wildlife, as the case may be.

(ii) One Health Action Plan: The Regional Coordination Committee should mandate each of the district to prepare a One Health Action Plan with focus on local as well as regions issues. The local level management would consist of (1) zonation of interface areas, (2) mapping of interface intensity, (3) identification of indicators, (4) surveillance and quantification of transmission, (5) fixing of the threshold or standards, (6) monitoring of the indicators, (7) stake-holder engagements and (8) counter or remedial actions. These steps or actions require baseline assessment, short-term and long-term research, series of consultation workshops, monitoring and adaptive management. The Long-term Research and Learning Centre to be established in Panna Tiger Reserve will have to facilitate the process through dedicated manpower and support system.

(iii) Community Engagement: Education and awareness programme are the most important link in the control and management strategies for zoonotic diseases. It is important to educate local communities about the zoonotic diseases prevalent in the areas, threats to health and livelihoods and develop ways to include local participation, especially of women and children, in zoonotic disease management and control programmes. Incorporating elements of local culture and tradition (evidence-based) for health promotion and health literacy should be considered. A strategy for ensuring transportation accessibility for pregnant mothers to public health facilities to promote institutional births should be developed through inter-departmental collaborations (*e.g.* Forest department providing transportation facilities for pregnant mothers living in remote buffer villages).

(iv) 3A Framework for Addressing Snakebites: The 3A framework (Awareness, Accessibility and Availability) involves creating Awareness about prevention and management of snake bites, improving Accessibility of health services and Availability of antidotes for treatment of snake bites. Awareness campaigns and resource materials, in addition to focusing on prevention of snakebites and correct management of snakebites in both humans and animals, should be region-specific, inform on the free costs of Anti-Snake Venom (ASV) and to be made available in the closest health facility. Opportunities to add snakebite prevention along with prevention of important diseases to their existing curriculum should be explored. Sustenance of awareness and education campaigns should be ensured by 'health facilitators. Since traditional healers are the first point of contact for treatment of snake bites in many tribal communities, opportunities for collaborating with the healers (since such practices have deep traditional and cultural roots) to function as 'health facilitators' in referring the public to health facilities for snake bites and other diseases should be explored. In addition, the aforementioned 'health-facilitators' can be trained to aid with seeking the available compensation for snake-bite victims and for improving financial literacy among households. Availability and use of motor-bike ambulances for snake bite emergencies provide addition options.

(v) Mental Health Management: Plan for mental health should explore technology driven health solutions and appraise the use of tele-medicine in bringing mental health care services to the people in remote communities. Additionally, capacity strengthening of all community health workers including doctors on mental health disorders should be ensured before implementation of any mental health interventions. Interventions for stigma reduction should be disease-specific and be tailored based on scientific understanding of social factors in play. In addition to infectious diseases, these interventions should particularly focus on stigma reduction against people with mental illness.

(vi) Habitat Management of Zoonotic Diseases: Most zoonotic diseases, especially of animal origin, arise from changes in the forest cover, land use changes, and/ or changes in climate resulting in changes to the distribution and abundance of pathogens and their vectors and hosts. Therefore, it is important for an effective to also manage habitat and consider socioeconomics of the community that may affect land and natural resource use.

(vii) Solid Waste Disposal Management: This is one of the most important aspects for maintenance of hygiene, sanitation, reducing proliferation of invertebrate vectors and vertebrate hosts of diseases, pathogens that spread through foods and water contaminated with

sewage and waste, etc. All the districts must thus, work towards a comprehensive solid waste management plan that can tap into the resources provided by already operational National Programmes such as Swatchh Bharat Abhiyaan, Zero Open Defecation Program, etc.

(viii) Sanitation and Hygiene: This aspect ties in with the previous theme of proper disposal of waste and maintaining a clean and hygienic environment. It also includes educating the local communities on practicing hygiene such as use of toilets with proper water supply, drainage and sewage system, washing of hands with soap and water, provisions of clean drinking water, maintaining separate areas for domestic animals and humans, etc.

(ix) Management of Water Bodies and Wetlands: Most water bodies have become open drains due to dumping of untreated sewage and waste, as well as garbage into the same. Many have been overrun by weeds and algae and need to be 'detoxified' to ensure proper circulation of water and oxygen. Many wetlands have been converted into agricultural lands promoting the growth and spread of pathogens and vectors that thrive in these environments. Wetlands and waterbodies are often used by both humans and their livestock thus, increasing the chances of exposure to pathogens and diseases between them. Therefore, it is important to maintain and manage wetlands and water bodies and ensure that the levels of pathogenic microorganisms are kept below infectious thresholds, through routine water quality monitoring. In addition, all waterbodies/wetlands that are near poultry and other large livestock farms need to be surveyed for migratory birds and a database needs to be developed for aiding research and targeted surveillance strategies for monitoring diseases (avian influenza) in wetlands of the landscape.

(x) Management of Grasslands/Pastures and Open Lands: Most people consider grasslands and open lands (areas not covered by trees) as wastelands and use them either as dumping grounds or for development, such as agriculture or housing. This exposes humans and their livestock to the pathogens and vectors that thrive in these environments. It also causes the outward spread of pathogens and vectors from these areas to other areas, thus, contributing to spread of diseases. Therefore, it is important to incorporate a programme for management of such areas, based on scientific studies on their productivity, biodiversity, especially in terms of microbes, invertebrates, and small mammals, such that they are left as inviolate and continue to act as sinks for pathogenic microorganisms.

(xi) Proper Carcass Disposal: There should be proper plans for the disposal of carcasses in designated areas which, while being open to scavenging birds, should be inaccessible to domestic and wild scavengers, which can act as carriers of disease-causing pathogens, from the

dumping grounds to the human habitations as well as to scavenging birds. Setting up of properly managed 'vulture feeding' points as suggested in the plan can aid in managing carcass disposal and curb the potential transmission and spread of diseases through facultative scavengers. In such a case, One Health Plan should also include routine monitoring and surveillance of the feeding sites for disease outbreaks among the birds as well as for safeguarding the birds from possible drug/ chemical contaminations.

(xii) Integrated Zoonotic Disease Surveillance and Monitoring System (IZDSMS): As mentioned above, integration of all information systems and databases will help identify the patterns and processes involved in the occurrence and spread of zoonotic diseases in the various groups. There should be a dedicated groups or cell, composed of skilled and trained personnel, to analyse all the data to develop epidemiological models, diseases risk maps and early warning systems for prevention and management of zoonotic diseases in the landscape. These should be shared with all concerned agencies to further boost integrated management and control efforts for One Health. Clear and practical indicators should be identified to evaluate the effectiveness of the response and management actions, as well as to map the progress of the program over fixed timeframes.

9.3. Synthesis and Conclusions

The human-wildlife interface is high in GPL because of high density of human population and presence of several wildlife habitats. Human-wildlife conflict is one of the biggest conservation challenges in such human-dominated landscapes. It was found that both in PTR and the landscape the highest number of wildlife attacks on humans was caused by snakes followed by jackal and sloth bear, the highest number of livestock loss in and around PTR was caused by tiger and leopard, while in the landscape it was wolf and leopard, and highest crop loss in both PTR and landscape was caused by wild pig and nilgai. It is recommended that multiprong approach should be adopted for the management of human-wildlife conflict in PTR involving fencing (biofencing, solar fencing, stone walls and social fencing), early warning system, creation of Conflict Task Force for dealing with conflict situations including capture and translocation of conflict causing animals, Rescue and Rehabilitation Facility for captured and injured conflict animals, financial tools like compensation and insurance, and, conservation education and awareness. For species causing highest loss different combination of these measures have been proposed, which can be applied in high conflict areas identified within the plan, with the help and cooperation of local communities. If found effective these strategies

should be emulated in the larger landscape. One Health Concept will enable appreciable linkages and effectiveness in the long-term for dealing with human-wildlife interface issues. Developing a One Health Action plan by setting up of a regional One health co-ordination committee has been proposed for effective prevention and management of spread of zoonotic infections. Public education and awareness, proper sanitation and hygiene, effective management of habitats and wetlands, environmental pollution control and integrated disease surveillance strategies are recommended in order to holistically ensure the health and safety of humans, livestock and wildlife in PTR and GPL.



CHAPTER 10

INTEGRATED LANDSCAPE MANAGEMENT

Chapter 10: Integrated Landscape Management

10.1. Background

Integrated Landscape Management (ILM) is the (combined or complementary) management of production systems and natural resources in an area large enough to produce vital ecosystem services and small enough to be managed by the people using the land and producing those services (FAO, 2013). The Greater Panna Landscape (GPL) covering an area of 47621 sq. km., in 11 districts (08 in Madhya Pradesh and 03 in Uttar Pradesh) including key protected areas is a haven for a plethora of flora and fauna, and diverse traditions. The species assemblage includes several landscape-depended species and prominent among them are tiger, vulture, gharial, and mahseer and is a hotspot for conservation priority. Because of its high biodiversity and natural resources, GPL serves as a critical habitat for both its animals and humans. Over one crore people share this landscape with the wildlife, with around 75% of this population engaged in farming and agricultural activities. The people are culturally diverse, comprising tribal communities, primarily the Gonds, alongside many other ethnic groups, making it also an anthropological hotspot. However, almost all districts in the landscape have a low socio-economic and literacy status, which is below the national average. The situation has further been compounded by high seasonal fluctuations in weather, with the landscape experiencing severe water scarcities during the summers, and inundations during the monsoons. Further, the ever-expanding human presence and shrinking natural habitats has rendered the landscape vulnerable to many issues. Lately anthropogenic land use-changes have severely, in many cases, irreversibly impacted the natural resources and wildlife in the landscape, leading to biodiversity loss, increased human-wildlife conflicts, and emergence of infectious diseases. Recent development in the form of Ken-Betwa Link Project (KBLP) will cause submergence, affect connectivity and alter natural flow. It is imperative now, more than ever, to holistically address these impediments, to preserve and safeguard this fragile landscape and its components. Previous sections have highlighted key thematic issues concerning the biodiversity and social values in the landscape, while this section brings convergence of these thematic focus and executive strategy for integrated management of the landscape.

10.2. Description of the Landscape Components

10.2.1. Land Use Land Cover: The land use land cover (LULC) reflects historic and contemporary interplay of various interacting elements including anthropogenic impacts. In GPL, following twelve LULC classes (Fig. 10.1) have been identified by National Remote Sensing Centre (NRSC), Hyderabad.

i. **Built up:** The area of human habitation developed due to non-agricultural use and that has a cover of buildings, transport and communication, utilities in association with water, vegetation, and vacant lands.

ii. **Kharif crop:** Lands which are cropped during August- November months.

iii. **Rabi crop:** Lands which are cropped during January/February-March months.

iv. **Zaid crop:** Lands which are cropped during April- May months.

v. **Double/Triple crop:** Lands which are cropped during or more than two seasons.

vi. **Current fallow:** Lands which are taken up for cultivation but are temporarily allowed to rest, un-cropped for one or more season, but not less than one year.

vii. **Plantation:** These are the areas under agricultural tree crops planted, adopting agricultural management techniques. Depending on the location, they exhibit a dispersed or contiguous pattern.

viii. **Deciduous forest:** The term forest is used to refer to the land with a tree canopy cover of more than 10 percent and area of more than 0.5 ha. The trees should be able to reach a minimum height of 5 m (MOEF&CC, 2020). Deciduous forest types that are predominantly composed of species, which shed their leaves once a year, especially during summer.

ix. **Degraded / Scrub-forest:** These are the forest areas which are generally seen at the fringes of dense forest cover and settlements, where there is biotic and abiotic interference.

x. **Wasteland:** The degraded lands which can be brought under vegetative cover with reasonable effort and is currently underutilised, which is deteriorating for lack of appropriate water and soil management or on account of natural causes.

xi. **Water bodies maximum:** Maximum area covered by waterbody during a year.

xii. **Water bodies minimum:** Minimum area covered by waterbody during the dry season.

GPL is mainly dominated by agriculture (Double/Triple and Kharif crop). However, a lot of area also comes under deciduous and scrub forests (Table 10.1).

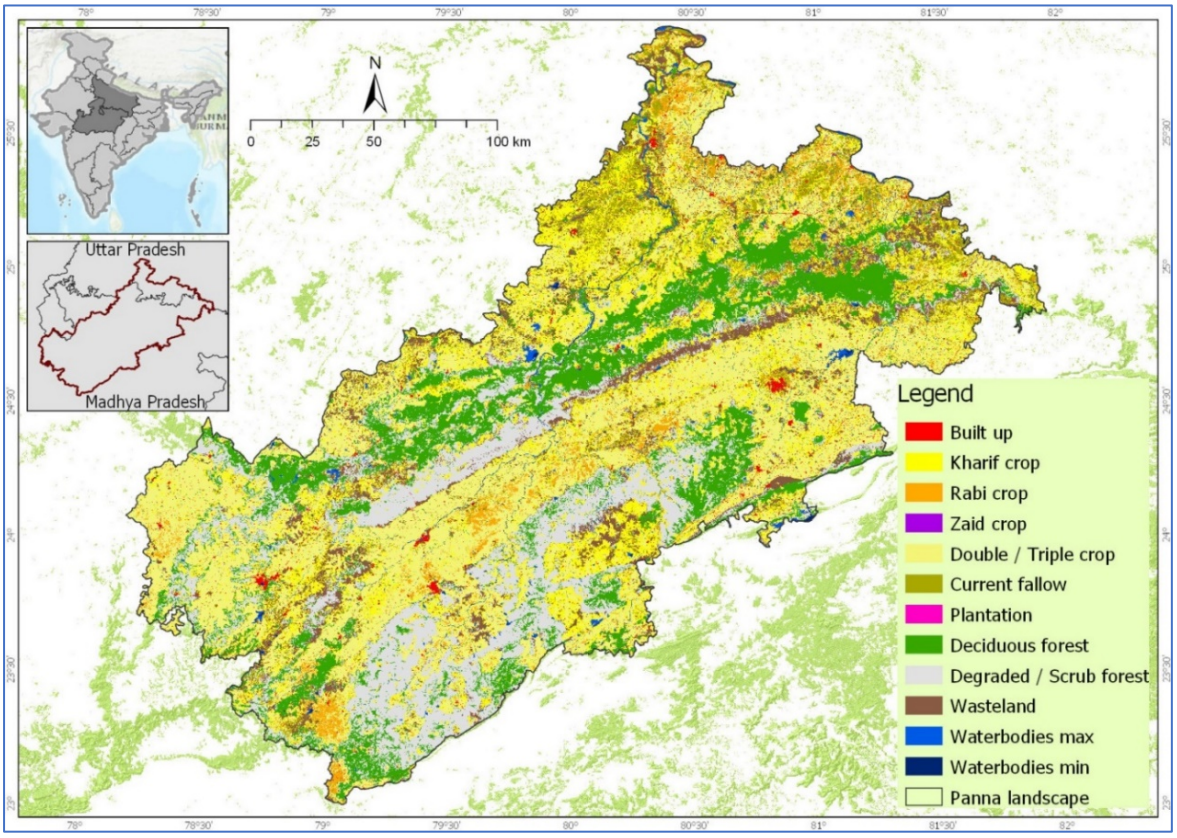


Figure 10.1. LULC map of Greater Panna landscape (Source: NRSC)

Table 10.1: Area distribution of LULC

S. No.	LULC Class	Area (km^2)
1	Built up	640.06
2	Kharif crop	7899.32
3	Rabi crop	1730.36
4	Zaid crop	0.50
5	Double / Triple crop	15467.6
6	Current fallow	2968.93
7	Plantation	20.44
8	Deciduous forest	7580.73
9	Degraded / Scrub-forest	8411.58
10	Wasteland	3912.53
11	Water bodies maximum	776.86
12	Water bodies minimum	96.40
	Total	**49505.34***

*Area is more than actual due to the inclusion of entire pixels falling on the periphery of the landscape boundary (some of the pixels fall outside the defined boundary)

10.2.2. Configuration: Spatial pattern analyses of GPL using Fragstats software revealed that double and triple crop class occupies the largest proportion (PLAND = 31.25%) and Zaid crop class forms the smallest patch size (AREA_MN = 0.51 hectare). The largest contiguous patch is formed by the degraded and scrub forest (LPI = 6.54%) and the aggregation index is highest for the deciduous forest (AI = 90.90%) followed by degraded and scrub forest (AI = 90.28), indicating that the patches of these classes are well compacted, wherever these occur. The most fragmented class within the landscape is wasteland (NP = 731540), followed by current fallow (NP = 169988), as these are scattered around crop fields and built-up areas. A separate moving window analysis of forest and non-forest classes provided a clear understanding of Largest Patch Index (LPI) (Fig. 10.2) and Edge Density (ED) (Fig. 10.3) as given below.

i. **Largest Patch Index:** LPI for the forest class shows that the forested landscapes are occupied by largest patches which are mosaics of dense and degraded forest class. Further, the largest patch of the dense forest classes is mainly distributed inside or nearby protected areas while areas outside the protected areas are occupied by the largest patch formed by the degraded forests. However, the degraded forest class have lower LPI values than dense forest class.

ii. **Edge Density:** ED is the simple measure of fragmentation within the class. Accordingly, the forested class shows lowest ED in the protected areas and within the forest divisions situated in the southern part of the landscape, representing these forest patches as least fragmented. Degraded forests had high ED all around the landscape making this class highly fragmented.

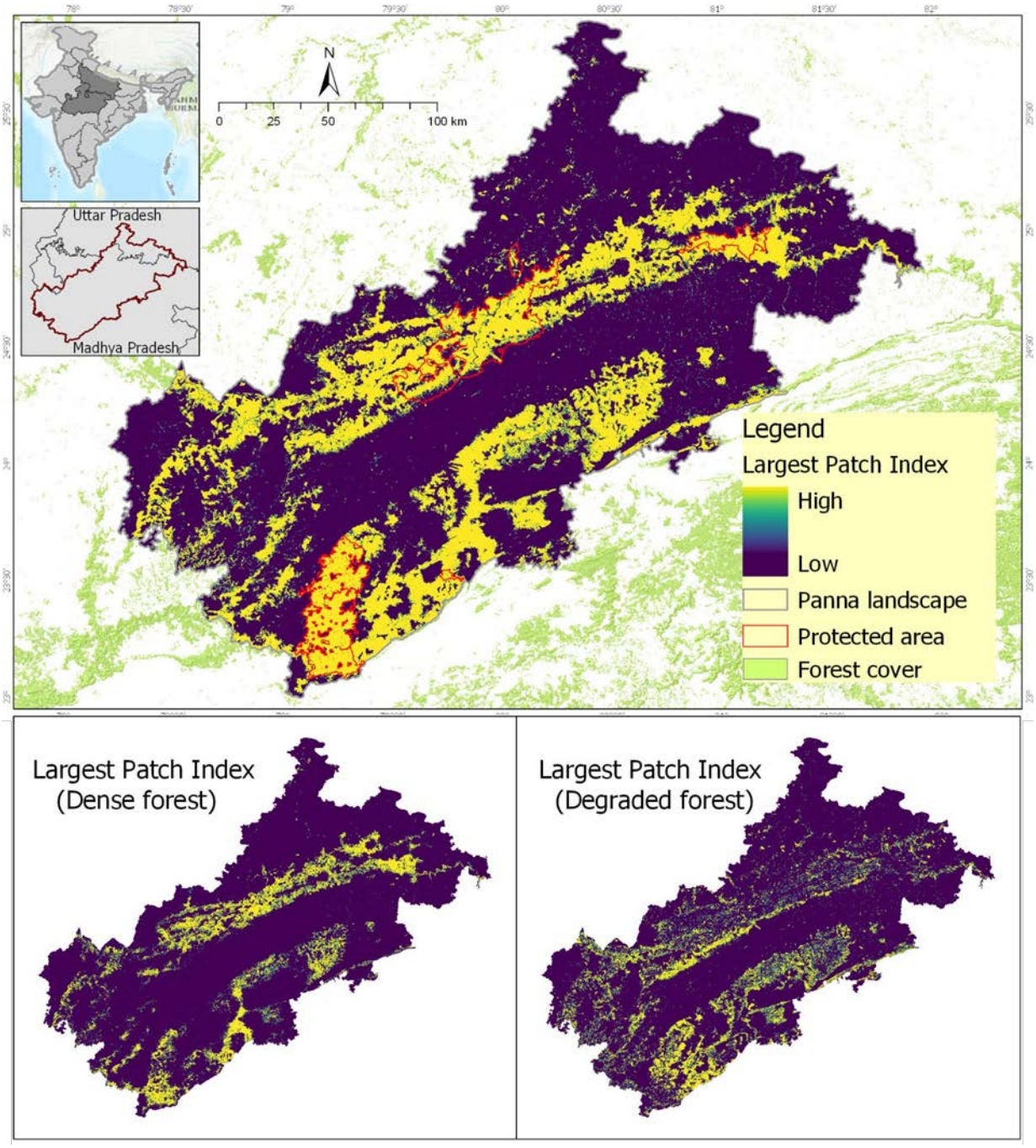


Figure 10.2. Largest patch index of forest cover in Greater Panna Landscape

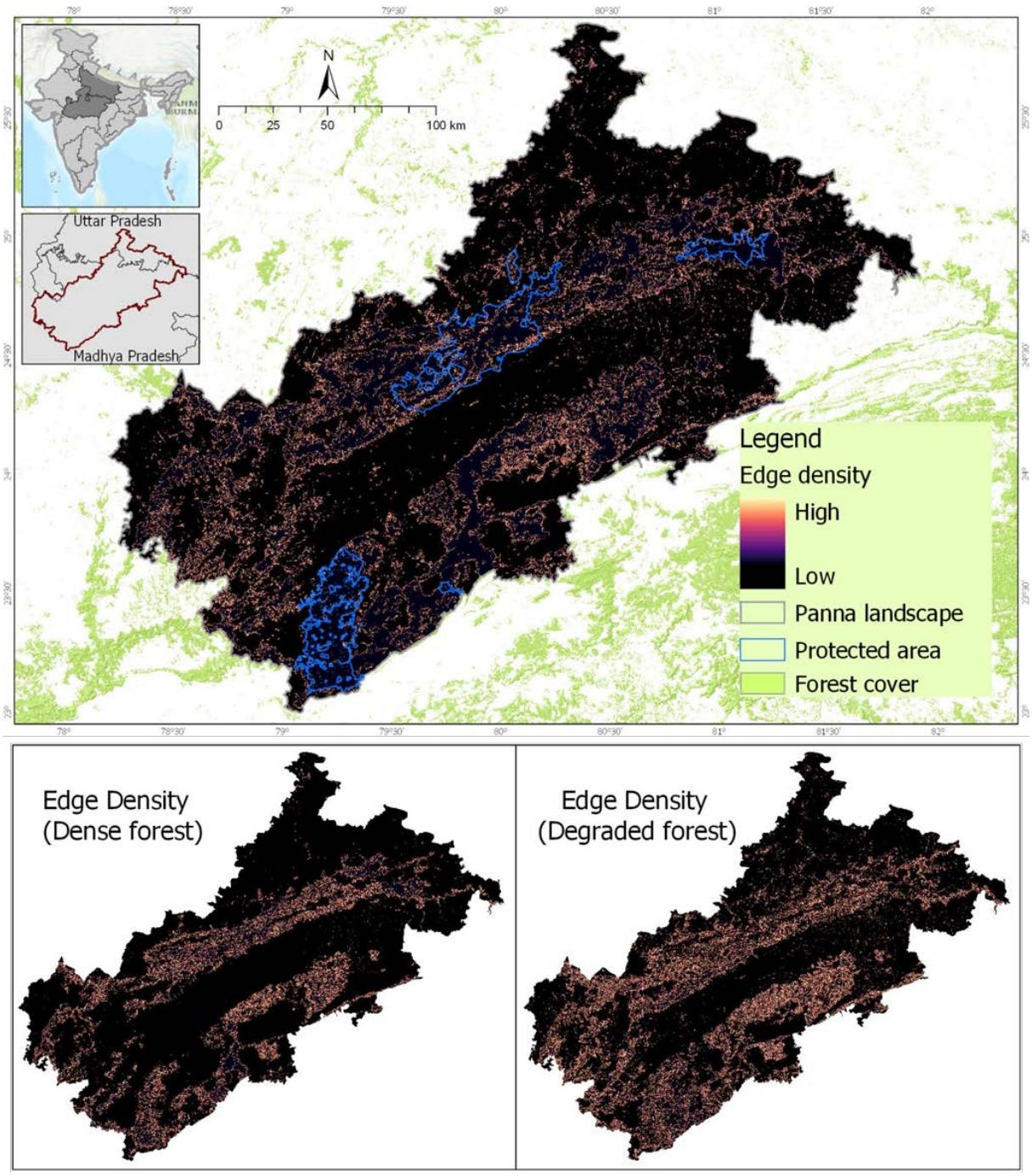


Figure 10.3. Edge density of forest cover in Greater Panna Landscape

10.2.3. Alteration and Restoration Opportunity: Categorisation of land parcels based on altered states is key to landscape level planning (GTF, 2021). An estimated 25% of the global land surface is being degraded in one way or another, and about 15% of these is considered appropriate for the forest landscape restoration (Stanturf *et al.*, 2015). Forest restoration can contribute to economic growth, reducing the vulnerability of forest-dependent communities, food security, climate resilience and biodiversity conservation (Jamnadass *et al.*, 2015). And socially acceptable successful restoration stories can be built if prepared and designed with

adequate participation of relevant stakeholders given the fact that landscapes cannot be simplified as “forest” and “non-forest” as these are biophysical as well as social mosaics of land use and land cover and more variables (Lindenmayer *et al.*, 2008). In case of GPL, landscape alteration appears to be positive with more forest than before, while there are still substantial areas available for restoration opportunities (Fig. 10.4, Table 10.3).

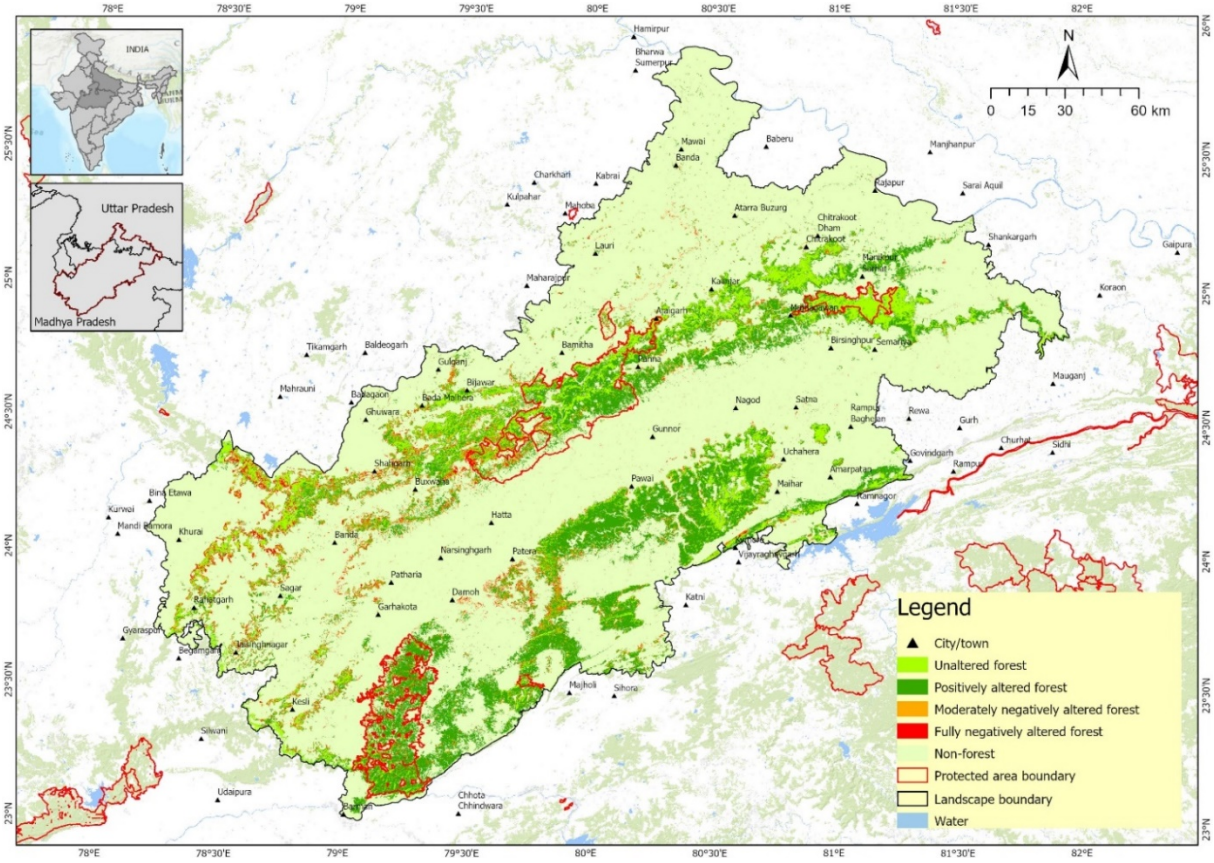


Figure 10.4. Map of altered and unaltered forest areas in Greater Panna Landscape

Table 10.3: Area-wise description of different forest and non-forest classes

Class	Area (Km^2)	Area (%)
Unaltered forest	2790.64	5.84
Positively altered forest	7744.3	16.22
Moderately negatively altered forest	979.35	2.05
Fully negatively altered forest	842.87	1.76
Non-forest	3540.13	74.12

The forests of central Indian highlands are a part of larger human dominated landscape where forests can be found mainly on the undulating terrains. And these forests have been major sources of livelihood to the surrounding communities for decades leading the forest towards degradation. Although the forest cover has been showing an increasing trend in GPL, but simultaneously the edges around the large patches and small linear forest patches which are important for connectivity have been showing decreasing trend. Thus, restoration strategies are needed for this landscape which not only takes into account of ecological integrity at local level, but also emphasizes on human wellbeing at landscape scale.

10.2.4. Key Ecosystem Services: Ecosystem services (ESs) are those critical benefits that people receive from natural ecosystems and help to sustain and support human well-being (MA, 2005). Sustaining and enhancing human well-being requires a balance of all our assets - individual people, society, the built economy, and ecosystems. This reframing of the way we look at ‘‘nature’’ is essential to solving the problem of how to build a sustainable and desirable future for humanity (Costanza *et al.*, 2014). GPL is home to over one crore of human population and has an incredible biodiversity. Mapping of ecosystem services is essential step for policy making and can be used as an important tool for the stakeholders and decision makers responsible for land use planning as maps are able to geo-locate the ecosystems of high value services. Three of the following ecosystem services, the key services relevant to GPL, have been quantified and mapped as baseline for future management strategies.

(i) Carbon Stock: Terrestrial based carbon storage is most widely recognised ecosystem service (IPCC, 2006). The social value of a sequestered ton of carbon is equal to the social damage avoided by not releasing the tonne of carbon into the atmosphere (Tol, 2005; Stern, 2007). The information on where carbon is stored is fundamental step to manage the landscapes for carbon storage and sequestration. Figure 10.5 shows the total carbon stock distribution in the forested landscape, which store more carbon than the degraded forest areas and can be used for guiding restoration process linked to climate change mitigation and carbon economy.

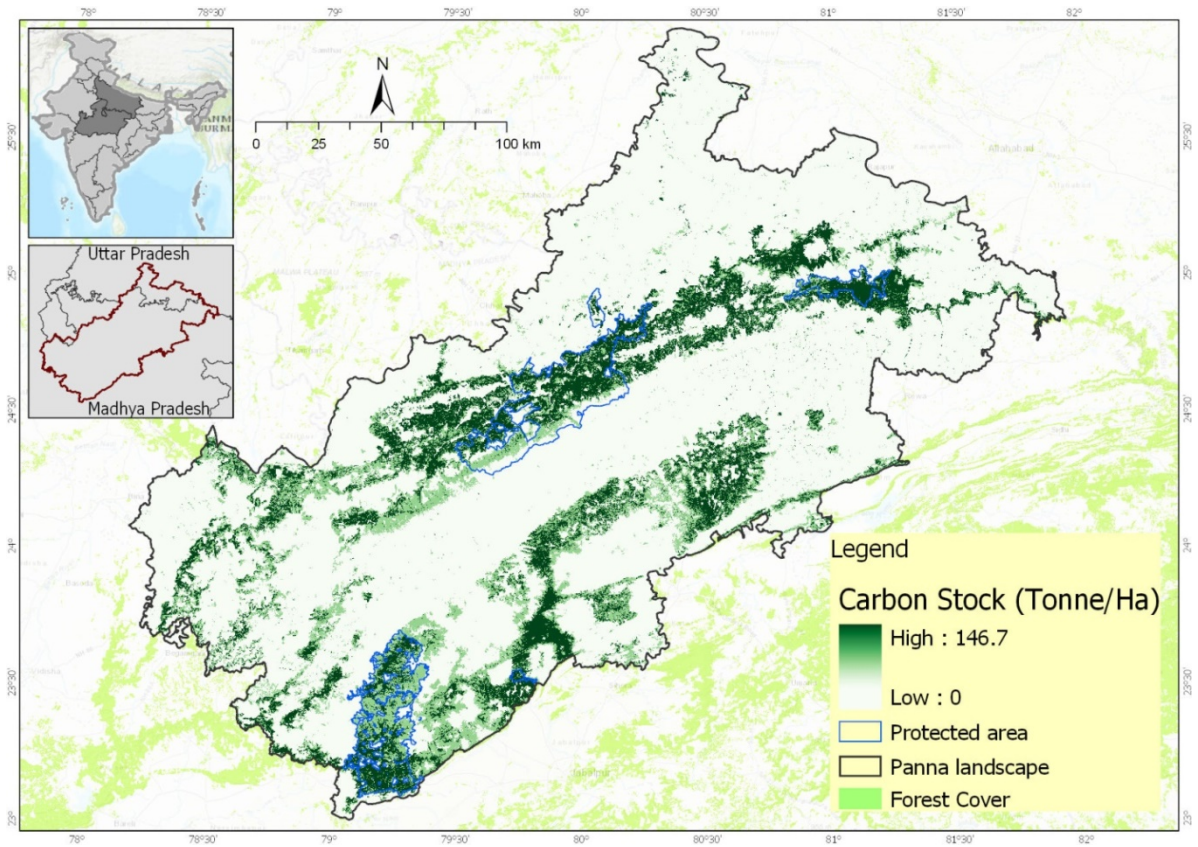


Figure 10.5. Carbon stock map of Greater Panna Landscape

(ii) Sediment Retention: Soil erosion is a natural process responsible for shaping the physical landscape but when accelerated due to anthropogenic activities can lead towards loss of natural soil functions (Panagos *et al.*, 2014). Erosion prevention is a safeguard process to protect the ecological environment and the ability of soils to contribute to the ecosystem functioning (Wu *et al.*, 2020). Soil erosion by water has become one of the greatest global threat to the environment (Navarro *et al.*, 2016) and is best addressed by sediment retention capacity offered by the natural vegetative cover. Figure 10.6 shows the soil retention/conservation from water within GPL. It is clearly reflected that forest cover along the variety of complex topography and varying levels of erosion susceptibility shows higher values of sediment retention when located on steep slopes while the agricultural areas around the landscape have low sediment retention values. As expected, forest cover holds the highest value in sediment retention and it can guide the decision making process of where to preserve the forest cover or where to manage the agricultural lands to maximise sediment retention.

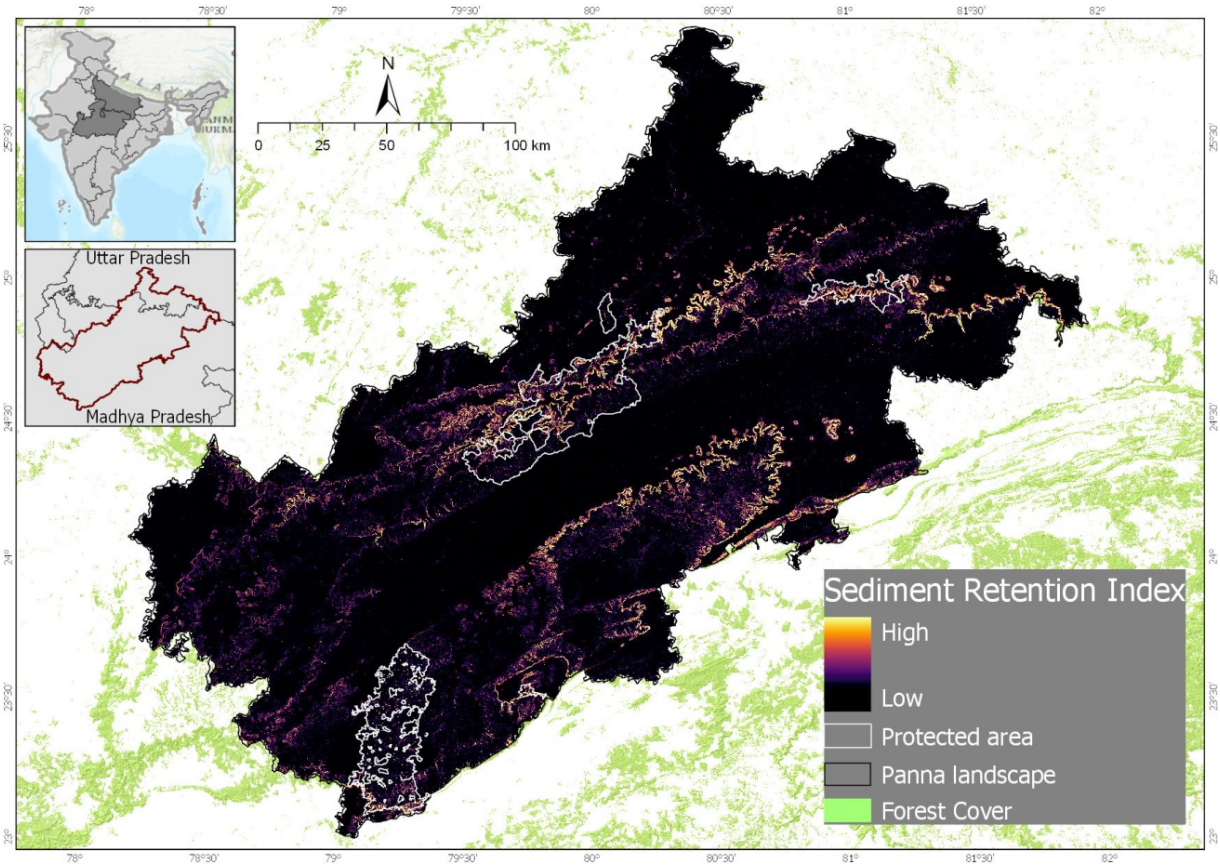


Figure 10.6. Sediment retention index for Greater Panna Landscape

(iii) Water Provision: Water is a crucial natural resource, and it is essential for sustaining human life. The overexploitation of water resources by humans along with the uneven spatial and temporal distribution causes scarcity of water (Mekonnen and Hoekstra, 2011). Water yield is the maintenance of water by ecosystems within a certain period (Xu *et al.*, 2016) and it is known to be influenced by several biophysical factors. Mapping of water yield (m^3) in the sub-watersheds of GPL (Fig. 10.7), indicates that there is considerable variation in annual water yield which can be related to the precipitation patterns at local scale or to the land use land cover type. By 2050, the freshwater demand is expected to increase by 20-30% globally (UNESCO, 2019) and thus management of watersheds will be required for sustainable water resource management.

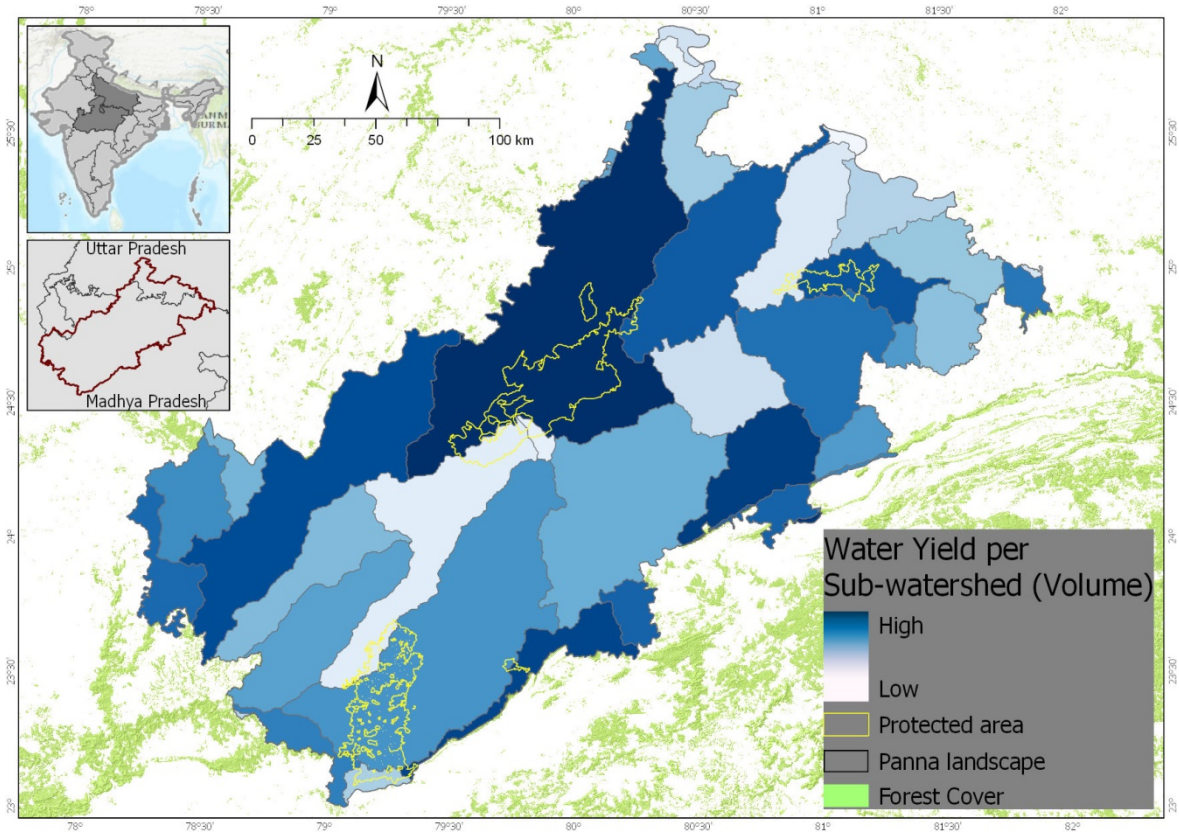


Figure 10.7. Volume of water yield per sub-basin in Greater Panna Landscape (the values shown is an averaged value for the entire sub-basin and does not reflect local spatial context)

10.2.5. Resilience Capacity: The distribution of water resources in GPL is scarce and uneven. A major part of the landscape falls under Bundelkhand region which is a drought prone area in Indian context. These droughts have affected the livelihood of the rural population as agriculture is the prime source of employment and have negative impact on the ecosystem functioning. Under the climate change regime, the situation can get more frequent thus it becomes essential to understand the drought resilience of land use land cover types in GPL. Resilience can be defined as the ability of an ecosystem to recover to the similar functionality after a disturbance (Holling, 1996; Spasojevic *et al.*, 2016). For drought events, the recovery of any ecosystem especially in the tropical dry forest is highly dependent on water availability (Paz *et al.*, 2018). Thus, water use efficiency (WUE) was used to investigate the resilience of GPL. WUE is the ratio of the productivity, biomass, or yield against the available moisture, typically in the form of evapotranspiration (Hatfield *et al.*, 2001; Xue *et al.*, 2015). The increased WUE improves drought tolerance (Ruggiero *et al.*, 2017). The results of Standard Precipitation Index (SPI) calculated for 64 data points across GPL revealed the year 2009 to be the driest year over the study period as shown in the Figure 10.8, representing the SPI6 for 15th data point. Table 10.4 and Figure 10.9. shows the area distribution of resilient and non-resilient

classes across the landscape. Table 10.5 and Figures 10.10 and 10.11 present the area distribution of resilient classes for croplands and forest respectively.

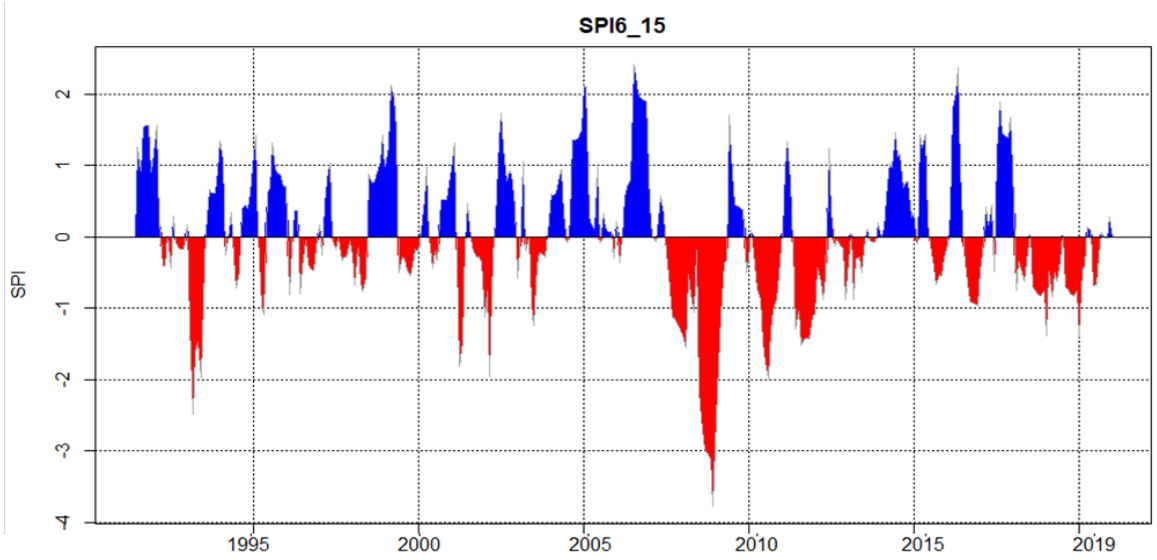


Figure 10.8. Standard Precipitation Index

Table 10.4: Area distribution of resilience classes in Greater Panna Landscape

Resilience Class	Area (km^2)	Area (%)
Severely non-resilient	484.25	0.99
Moderately non-resilient	3489.75	7.13
Slightly non-resilient	12380.75	25.31
Resilient	32556.55	66.56
Total	48911.3	100

*Area is more than actual due to the inclusion of entire pixels falling on the periphery of the landscape boundary (some of the pixels fall outside the defined boundary)

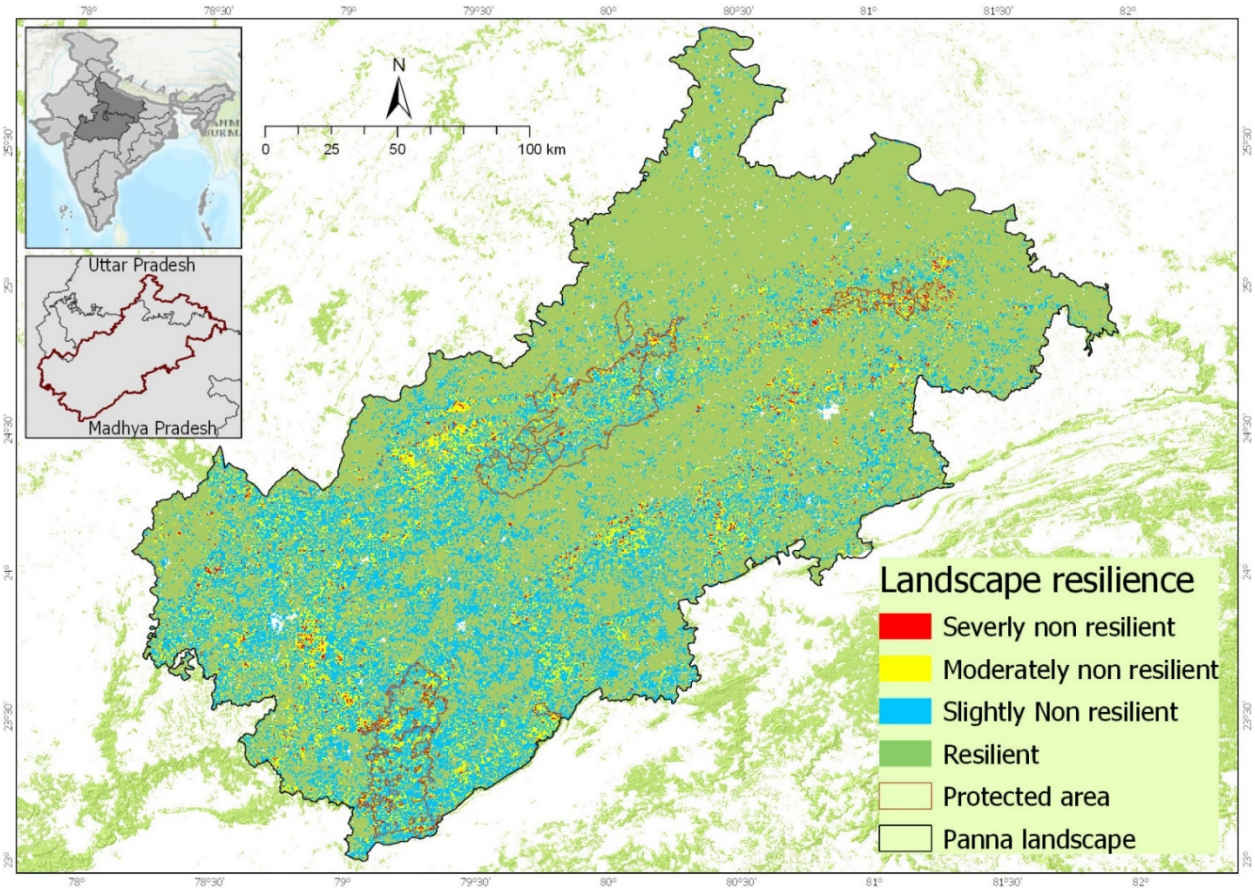


Figure 10.9. Drought resilience of Greater Panna Landscape

Table 10.5: Area distribution of resilience classes for cropland and forest in Greater Panna Landscape

Resilience class	Severely non-resilient	Moderately non-resilient	Slightly non-resilient	Resilient	Total
Area of cropland class (km^2)	205	1433	6577.75	24807.8	33023.55
Percentage	0.62	4.33	19.91	75.12	100
Area of forest class (km^2)	238.25	1610	3669.25	4229.5	9747
Percentage	2.44	16.51	37.64	43.39	100

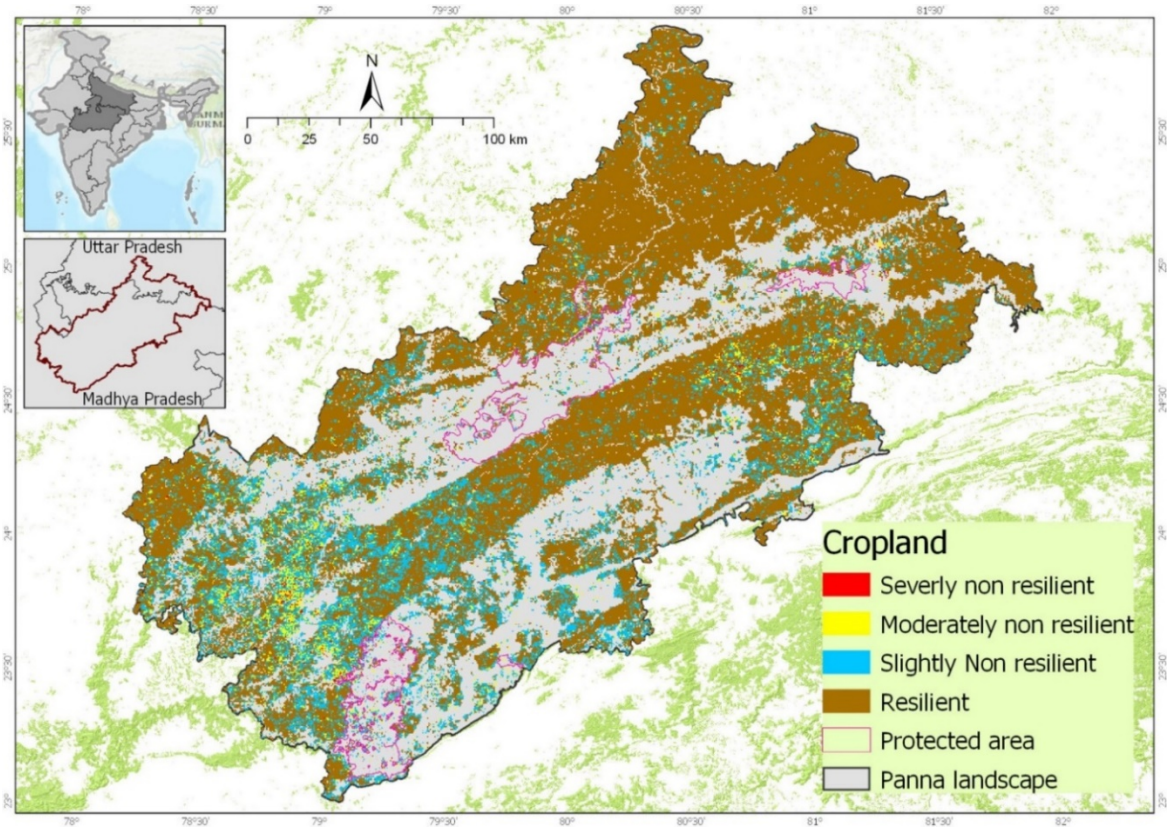


Figure 10.10. Drought resilience of croplands in Greater Panna Landscape

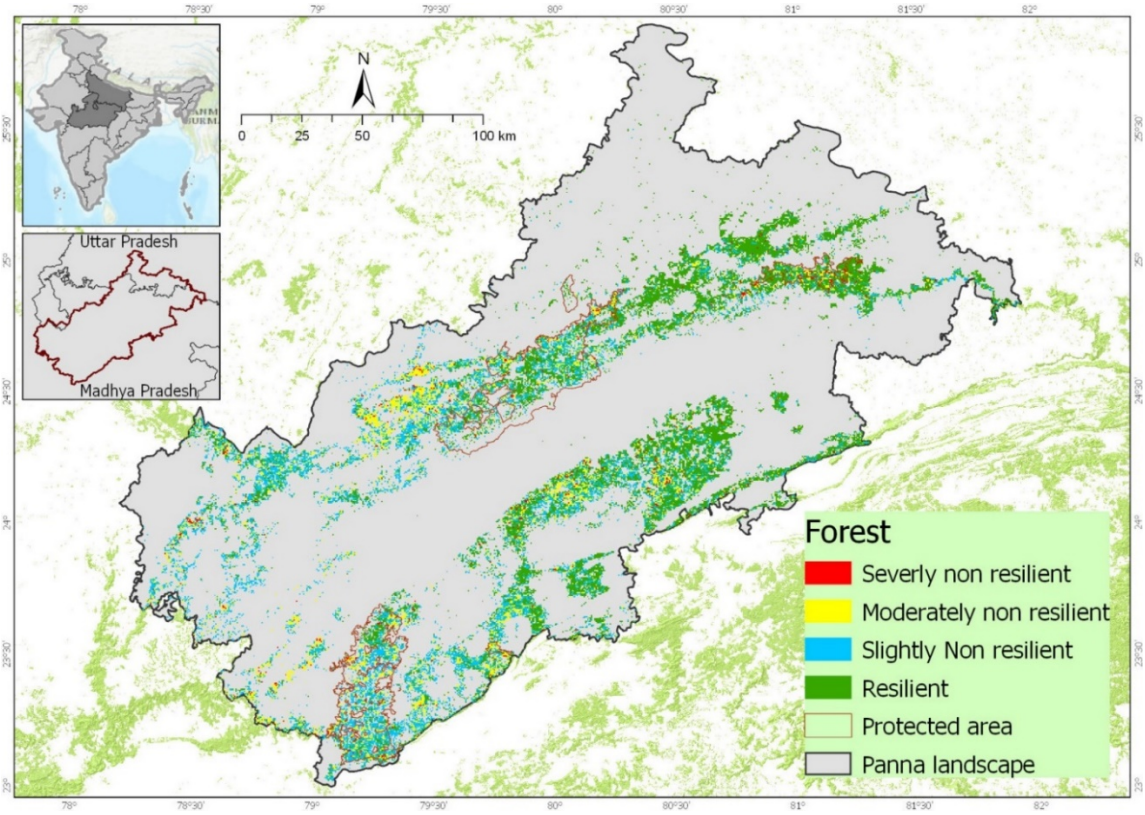


Figure 10.11. Drought resilience of forest in Greater Panna Landscape

The results of landscape resilience analysis show that slightly non resilient classes are dominant across the landscape and when results are extracted for forest and cropland separately, forest classes are more non-resilient in the whole study area while the other land use classes show resilience to drought. The possible reason associated with this trend can be the availability of artificial water resources in the agricultural lands and globally it has been reported that dry forest has lower WUE than agriculture land (Sharma and Goyal, 2017). The northern part of the landscape under Banda and Chitrakoot districts of Uttar Pradesh shows a significant resilience, falls under the Gangetic plains and have different controlling hydro climatic regime than rest of the landscape. It was also observed that moving towards the western part of the landscape the non-resilient classes are increasing (Fig. 10.9). To explore this further the data was extracted for Bundelkhand region (with the defined landscape boundary), which is already a water deficit area and the map represents more concentration of non-resilient classes within this region especially in the far western parts (Fig. 10.12).

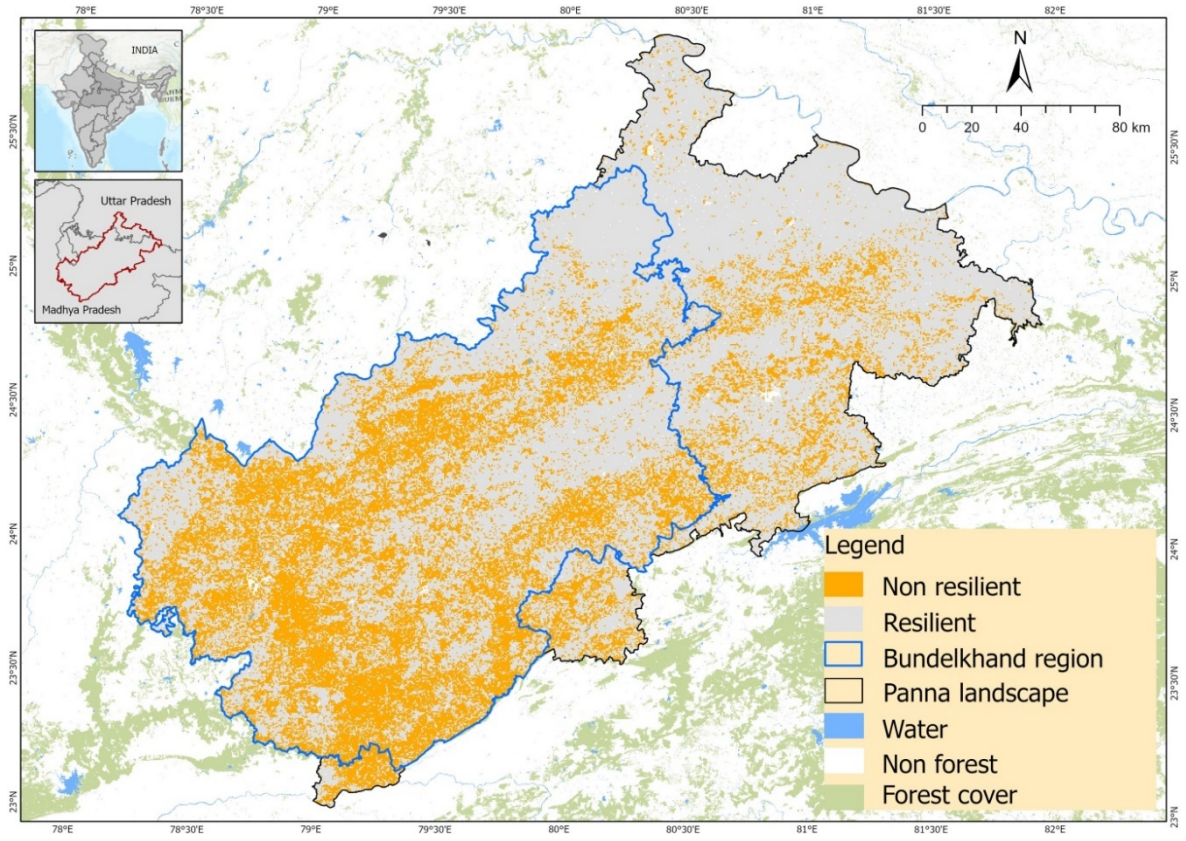


Figure 10.12. Distribution of resilient and non-resilient classes across GPL

Although within the landscape, in non-resilient classes, the slightly non-resilient class is dominating, but it is still a matter of concern as GPL falls under the tropical dry deciduous forest system with lower WUE making them more vulnerable to drought events. The analysis

also reflects, that the western part of the landscape has less and fragmented forest cover mostly falling under the non-resilient classes and the agriculture lands here are also classified as non-resilient thus further analysis is required to investigate the relationship between forest cover and the resilience while also acknowledging the hydro climatic regime.

10.2.6. Focal Species Group: While the landscape harbours wide variety of wildlife species, some of these acts as umbrella species with large home ranges and wide habitat niche. These are often referred as landscape species or landscape-dependent species and provide single-window option to address various conservation and human-interface issues. There are three such key landscape species or species group in GPL which covers terrestrial, arboreal and aquatic systems and these are tiger, vulture and gharial. Therefore, specific emphasis has been made and described in details in the earlier sections, while accounting for other biodiversity elements (both based on field quantification and surrogate approach) to present a comprehensive understanding of the issues in GPL. An overview of these taxa or species group is presented below.

(i) Tiger: The tiger population in GPL is centred around PTR as a major source population. As of December 2021, there were 60 tigers (including known cubs) in PTR, with 63% distribution in the core area. The tiger population of the reserve showed a remarkable recovery following the reintroduction, with a high rate of 61% during early phase and overall growth rate of ~27% across the years with average annual growth rate of 31%, indicating a healthy population model. Carrying capacity of tigers in PTR was predicted to be between maximum of 70 and 140 individuals by different models. However, based on the suitability of available habitat, healthy growth rate and necessary management interventions including removal of biotic disturbances, the tiger population can be increased by 20 to 30% and perhaps can further be increased to over 100 individuals. As for GPL, between 2013 and 2021, 37 adults/sub-adults have dispersed in the landscape. Two of these dispersing tigers became conservation concern due to conflict or electrocution risk and were captured. One was translocated to Sanjay-Dubri Tiger Reserve and another to Satpura Tiger Reserve within Madhya Pradesh. There was a report of tiger reaching Bandhavgarh Tiger Reserve, while some have dispersed to Ranipur Wildlife Sanctuary, Uttar Pradesh, and rest are believed to be in the landscape, although complete evidence is not available, despite efforts. Future of tiger in PTR needs to focus on human-tiger interface issues and landscape-level management including satellite cores and connectivity.

(ii) Vultures: Seven out of nine vulture species found in India are present in PTR and the landscape. Of the total number of 2905 individuals recorded during 2018/2019 (winter) survey, PTR alone accounted for 34% and Nauradehi Wildlife Sanctuary accounted for another 10%. Among the territorial forest divisions, North Panna and Chhatarpur adjoining PTR (18%) and South Panna, South Sagar and Damoh including Veerangana Durgawati Wildlife Sanctuary contiguous with Nauradehi Wildlife Sanctuary (25%) together contribute to the maximum percentage of the population in the landscape. It appears that while the entire landscape provides scope for the vultures in terms of foraging opportunity, the protected areas serve as crucial refuges. In terms of population viability, any catastrophe (poisoning, disease, and habitat loss/destruction) coupled with low survival and high mortality will likely force the population to decline and lead to probable extinction from the area. The best conservation strategy to facilitate the long-term survival of these species would be to consolidate the existing population by way of protection, ensuring food security, and supporting population growth to their carrying capacity. The survival of vultures not only depends on the nesting and roosting habitats, but also on foraging grounds which are both inside and outside forest areas in the landscape.

(iii) Gharial: The population of Gharial has drastically declined over the last 60 years (Choudhury *et al.*, 2007) owing to reasons such as over-hunting for skins and trophies, egg collection for consumption, killing for indigenous medicine, and opportunistic killing by fishermen when caught in fishing nets. However, the past status of Gharial in Ken River is not known and even with translocation from Chambal is not showing desired results. Despite a large number of gharials (about 170) released since 1983, only one adult female gharial is seen for many years and the population status can safely be stated as precarious, requiring a comprehensive recovery effort, not just reintroduction. It appears that regular flood during monsoon and absence of proper flow during lean period have affected favourable condition for Gharials. The Gangau Dam in PTR and Bariarpur Wier on the upstream of KGS also relate to these disrupted flow patterns to some extent. Downstream of KGS also suffers from large scale sand mining activities which deprives of gharials with nesting and refuge opportunities.

10.2.7. Biodiversity Richness: There is another perspective that multiple species are likely to serve as better “umbrellas” than individual taxa (Lambeck, 1997). The concept of multispecies conservation or biodiversity has recognized the ecological role of each species in maintaining the viability of the trophic structure and functionality of a particular ecosystem. Also, the multispecies conservation approach promotes integrated management of multi-habitats utilised

by different taxa including flora and fauna. Other than tigers, vultures and gharials, PTR is also home to a host of other floral and faunal species.

(i) Vegetation and Flora: There are eight distinct types of vegetation (Teak Forest, Teak-mixed Forest, Mixed Forest, Bamboo-mixed Forest, Kardhai - *Annogessius pendula* Forest, Riverine Forest, Scrub Forest and Grassland), harbouring 363 species belonging to 109 families.

(ii) Mammal: A total of 30 mammal species were recorded in PTR, represented by 18 carnivores, seven herbivores, two primates and three rodents. As for GPL, a total of 33 mammalian species were recorded including large representation of carnivores with 17 species although carnivore concentrations are mostly around protected habitats of PTR. Eleven species of herbivores were recorded across the landscape, with higher concentration of herbivores in northern part of the landscape.

(iii) Bird: Of the bird species, there were 90 species in grasslands, 35 species in water bodies and 108 species in woodlands.

(iv) Herpetofauna: In PTR, thirteen species of amphibians belonging to nine genera and four families were recorded. Forty-two species of reptiles belonging to 32 genera and 17 families were also recorded, including new records of *Fejervarya orissaensis, Hoplobatrachus crassus* and *Cyrtopodion cf aravallensis* were found in Madhya Pradesh state. *Eublepharis satpuraensis, Hemidactylus sahgali, Pangshura tecta* and *Pangshura tentoria* for the region.

(v) Fish: A total of 64 fish species belonging to 8 orders, 18 families, and 40 genera were recorded in the river Ken in PTR. Peak spawning, however, follows the outbreak of monsoons. In the case of PTR, pre-monsoon breeding is recorded only in small stretches towards the southern boundary. However, post-monsoon breeding occurs in almost the entire river stretch passing through PTR and up to KGS.

(vi) Spatial Pattern of Biodiversity Richness Potential: Spatial patterns of various physical and biological attributes, analysed at 1x1km grid cells, reflected the composite value of biodiversity richness potential, represented by low (0) to high (1) index values. Accordingly, PTR is largely represented by 0.15 to 0.69 biodiversity index reflecting mostly low to moderate biodiversity areas, while high biodiversity grids are highly scattered and are in restricted pockets. In GPL, the biodiversity richness potential in the landscape largely varied from low to moderate, and high only in certain areas. The estimated values ranged from 0.1 to 0.54 with

a mean score of 0.26. Most of the rich areas are found in the districts of Panna, Satna and Chhatarpur Divisions, while the poorest biodiversity areas are in Banda, Rewa and Chitrakoot districts. There are significant areas that are rich in biodiversity, located outside this protected area network. The spatial patterns of the biodiversity richness potential reflect overall habitat quality and provide options for recovery strategies.

Highly invasive species such as *Lantana camara,* in addition to other weed species, is a major threat to the native vegetation and the dependent biodiversity, due to their competitive and aggressive nature of growth and spread. In addition to the destruction of native flora, they also influence the composition of birds and animals in the region. Furthermore, this invasive nature poses a huge challenge for vegetation management activities aimed at restoring the native plants and desired species. Uncontrolled forest fires during the summers in PTR, which in most cases are not natural and human-induced, are ruinous to the floral and faunal species. Anthropogenic disturbances and habitat destruction from tree-lopping and cutting activities, uncontrolled livestock grazing and unorganised NTFP collection, pose high threats to biodiversity conservation in PTR and the landscape. Riverbank agricultural practices, rock mining, sand mining, presence of brick kilns and unregulated solid and industrial waste disposal into rivers, are all major threats to riparian habitats and the ecosystem services provided by these habitats. Associated riparian biodiversity is also severely under threat due to destruction of the riparian zones, as seen in the case of conservation of endangered Mahseer in GPL.

In addition to degradation of riparian habitats, lack of awareness and widened knowledge gaps of the associated biodiversity, especially about distribution, population, and migration of species like the Mahseer are crucial in overcoming and mitigating some of the threats and challenges. Additionally, wildlife disease outbreaks are also particularly relevant due to the increased domestic/livestock and human interactions with wildlife, in PTR and across the landscape.

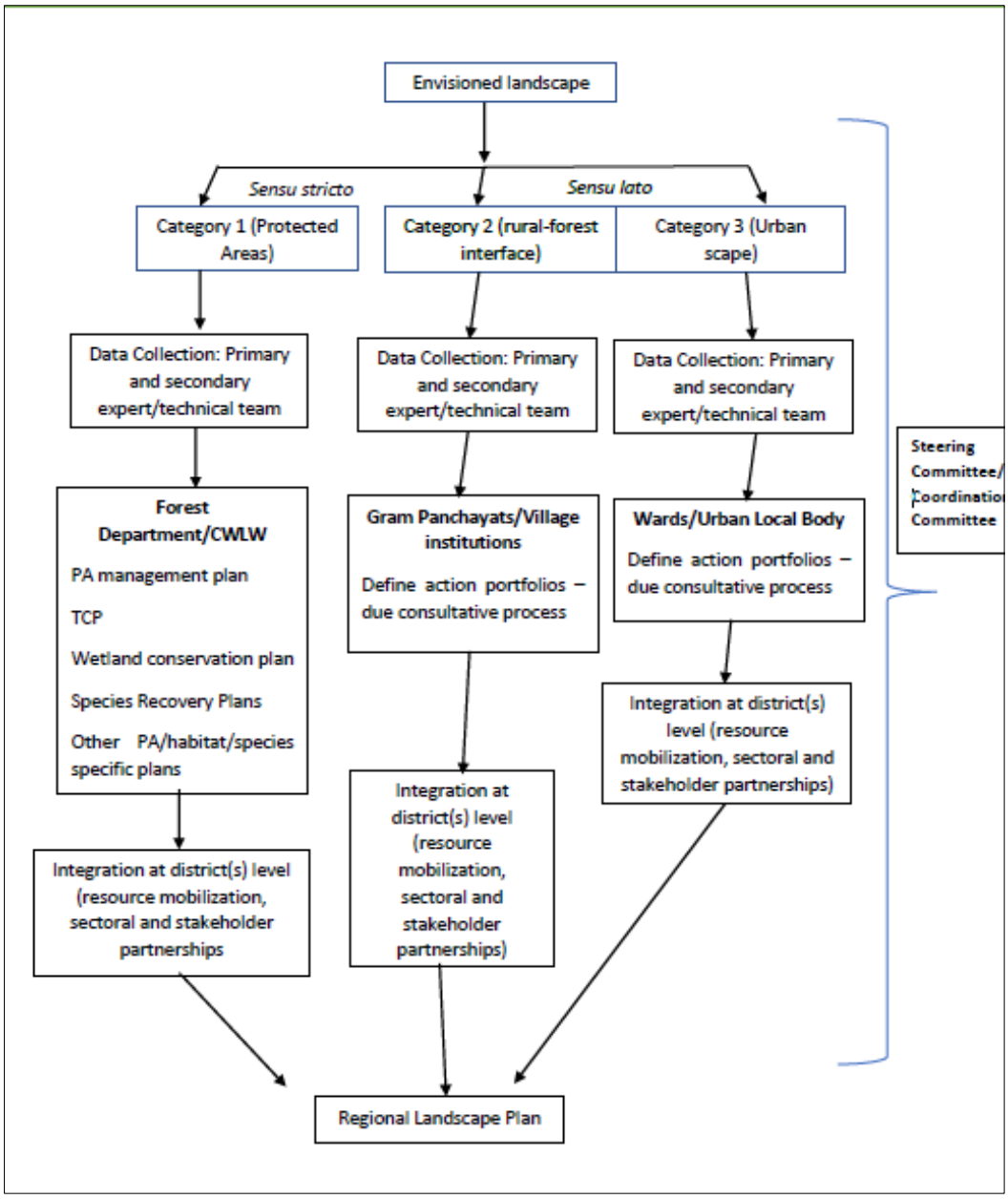
10.2.8. Forest-People Relationship: As described in the earlier sections, the landscape is highly interspersed with human population not only in terms of spatial configuration but also in terms of the interaction for livelihood and development. The human population in the landscape is one of the least developed with high poverty, malnutrition and infant mortalities, and source of livelihood comes from multiple sources, the major being agriculture-based and forest-based economies. Therefore, the conservation management of the landscape is closely linked to the human interface, and thus, the landscape management plan is aimed at thematic

focus of conservation and operational focus of existing administrative framework. In addition to the resource dependency, the forest people relationship needs special focus on the human-wildlife conflict management and one health management strategies.

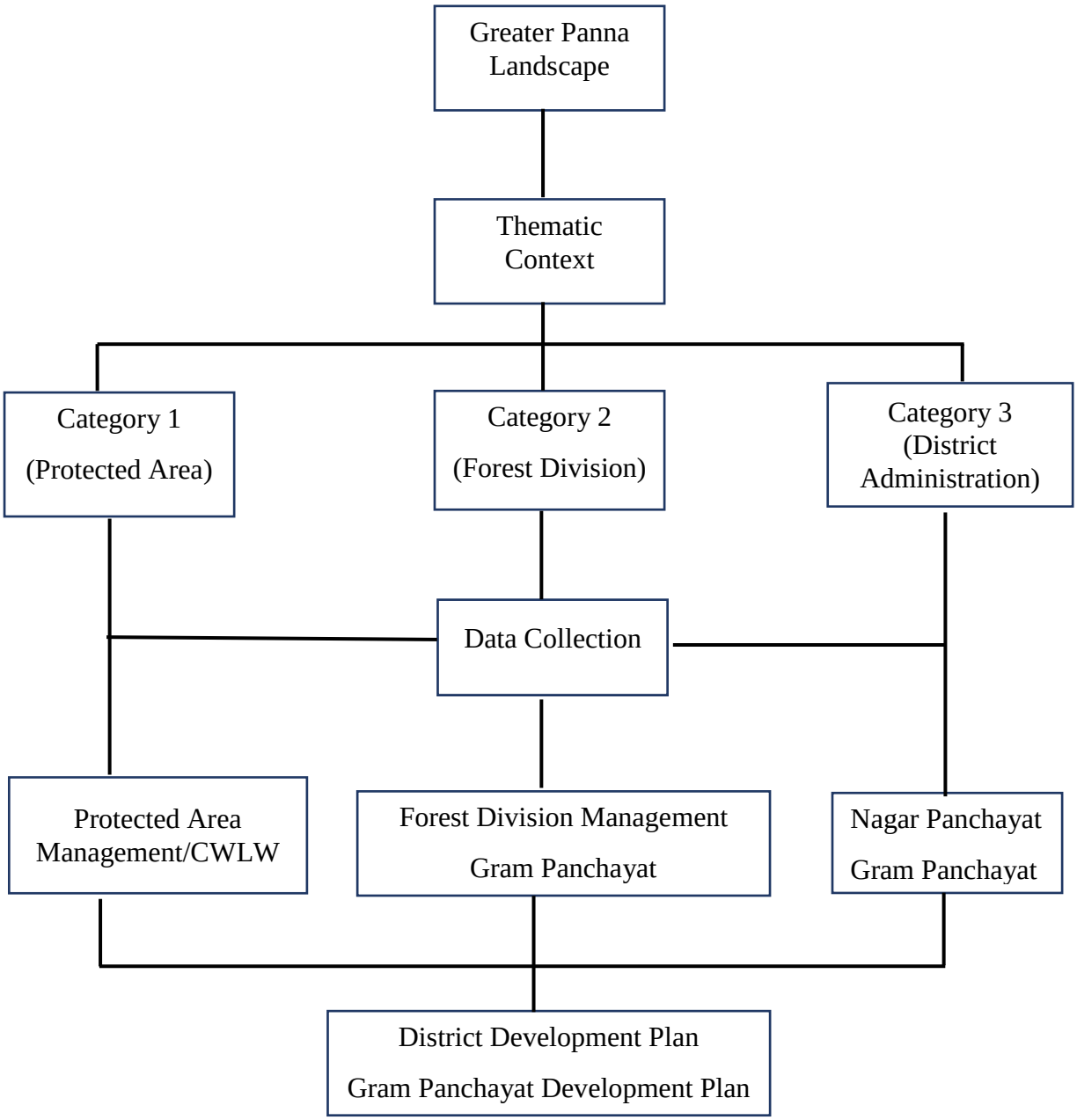
10.2.9. Agroforestry and Conservation: Panna landscape falls broadly under the central highlands agro-ecological region categorised as hot, sub-humid region with medium and deep black soil (NBSSLUP). The total area of agriculture land involved with different agriculture patterns shows that double/triple cropping pattern is practiced mostly followed by kharif and rabi crops respectively. Agroforestry System is prominent in the region. Silvi-pasture system refers to rehabilitation of non-arable lands by planting grasses and forest trees together. Such trees could be fodder or timber trees. Nutan, Ber, Babul, Bamboo and alongside forage grasses have been found very successful in region. They have shown potential of yielding up to 10t/ha/year biomass as against less than 1t/ha/year biomass production without any intervention. Other Agroforestry systems may include fish + aquatic plants + trees on surroundings. These Agroforestry systems are key to sustainability of farming enterprise in drought prone Bundelkhand Region as they ensure food, fodder, fuel and timber. Minor forest produce from these plants are source of nutrition. They support alternate livelihood system (gum and raisin, honey, basket, mat broom making industry) and offer employment.

10.2.10. Convergence with Other Landscape Models

Landscape approach to conservation is increasingly being advocated across the country as a solution to balance conservation and societal goals. Various models of landscape approach have been adopted in several places such as Chilika Lake, Attappady Hill Area, Gulf of Mannar Biosphere Reserve etc. However, when developing a management plan for a new landscape, there are operational issues in following these models, because they are context and landscape specific. Global Tiger Forum (GTF) in collaboration with UNDP and MoEF&CC has proposed a guideline for landscape level participatory management (GTF, 2021). In the draft guideline, three major categories/landscape parcels with different levels of transformation/alteration have been identified *viz*. Protected Area, Rural-Forest Interface and Urbanscape as given below in the box.



But because of its comprehensive and overarching nature, meant for wider application, this guideline is largely generic, with all categorizations mainly based on 'state of forest' within the landscape. Therefore, while drafting the landscape plan for GPL, instead of following the guideline literatim, we have augmented the plan based on these guiding principles, with focus on wider conservation themes, beyond the forest cover. Accordingly, we have identified major themes based on the conservation focus of GPL (which corresponds to theme plans) and have identified three main categories (which corresponds to zone plan) towards operational strategy as given below in the box.



Further the recommendations provided within the plan are also suggested to be integrated with the district planning process, ensuring convergence with existing schemes and programs. For the purpose of which, during the implementation phase, a district level booklet will be generated in both English and Hindi to offer guidance for field practitioners. These district level booklets will have all the recommendations specific to the districts, that can be integrated with the district development plan (DDP) and Gram Panchayat Development Plans (GPDP). The overall implementation strategy would include a Steering Committee which in this case would be the Greater Panna Landscape Council (GPLC) as a part of the Special Purpose

Vehicle. GPLC will be supported by Greater Panna Technical Advisory Committee (GPTAC), which will be placed as a part of the Integrated Research and Learning Centre (IRLC). At the ground level, District Landscape Committee (DLC) will coordinate the field implementation and would explore the opportunities for convergence and scaling up within the districts.

10.3. Thematic Contexts of the Landscape Management

10.3.1. Protection: Protection of existing biodiversity in GPL with special reference to three key species i.e., tiger, vulture and gharial is an imperative measure to ensure its long-term sustainability. Local extinction and subsequent recovery of tigers and its growing numbers in human-dominated landscape warrant further attention in terms of protection. Similarly, ever-increasing anthropogenic activities also threaten the localized populations of vultures and gharials. Hence, to consolidate the current and/or growing population of these three species, enhancement of the existing protection regime has been proposed.

(i) Tiger: For tiger conservation, the following specific actions are required under the integrated landscape management with focus on PTR and other relevant spatial units.

1. Deployment of zone-specific special performance unit (SPU) constituting of a team of five members along with vehicles and sophisticated gears.
2. A crime deduction and alert system (CDAS), either exclusively or as a part of enterprise resource planning (ERP), to manage specific response requirements.
3. Year-round monitoring of tigers and other wildlife through camera traps or continuous camera trap monitoring system (CCMS) should be extended to the buffer zone of PTR, apart from core zone.
4. Strengthening of staff infrastructure and logistics as well as developing a strong intelligence network would be essential to motivate the existing manpower and reduce forest and wildlife related offences.
5. Technological integration to enhance protection further such as application of unmanned aerial vehicles (UAVs) can also be used for various purposes namely surveillance, patrolling, tracking of animals (especially tigers), wildlife population monitoring etc.
6. To tackle wildlife-human interface with special reference to tiger, fencing of predetermined boundaries of PTR through wireless sensor network and communication tool (WSNCT) could be a technologically advanced and effective option.
7. Creation of social fence network through developing sense of collective responsibilities towards protection of forest through communities' participation, would be an effective means of enhancing protection.
8. Protection of denning site is a serious management concern in terms of protection of newly born cubs, which is necessary to maintain a viable population within the PA.

Regular monitoring of the active denning sites and intervention in tourism, by means of restricted movement near the den site, can be practised if required. Restriction should be implemented at least for 4-5 months once the pregnant tiger is settled in the den or during the active den periods. Simultaneously, restriction in movement of humans and cattle must be implemented and strongly monitored near the den sites.

(ii) Vultures: Conservation of vultures warrants three different aspects of protection namely (i) protection of population (from poaching, breeding loss, and diseases), (ii) protection of habitat (from destruction and anthropogenic disturbances, fire incidents) and (iii) protection of forage (from non-targeted poisoning and feral dogs). Establishment of electronic surveillance systems (ESSs) with thermal cameras and/or web-enabled system in addition to ground-based monitoring would be effective for monitoring and protection of vultures. Strategic fencing of carcass dump sites (around villages and gaushalas) or elevated platforms needs to be carried out to restrict the movement of feral dogs and reduce the spread of zoonotic diseases. A separate gaushala coordination committee (GCC) should also be formed to ensure the foraging safety for vultures. To protect the roosting and nesting sites of vultures from anthropogenic disturbance, installation of wireless camera trap networks (GSM-based) would be effective. Application of UAVs would be suitable for monitoring of fire incidents and device appropriate response strategy. Since communities' awareness and participation are key mandate for conservation, creation of Network of Vulture Champions (NVC) consisting of school/college students as members and dedicated personnel as facilitators, would be an effective approach.

(iii) Gharial: Gharials (and mugger) are mostly affected by the dynamite and gill-net fishing, sand mining on an industrial scale, riverbank agriculture and livestock herding. To enhance the protection of gharials and other crocodiles, crocodile priority and restricted zones would be formed in certain preidentified parts of Ken River inside PTR and KGS. Interventions related to habitat quality assessment, its management and protection in coordination with local communities should be taken up in these zones apart from regular patrolling. Restriction and regulation of fishing activities should be ensured inside and outside of PTR boundary (towards KGS) respectively. Similarly, ban or strategic regulation of sand/boulder mining should also be imposed alongside some preidentified stretches of Ken River, in coordination with different stakeholders (local communities and district administration). Creation of buffer zones of varied length alongside the banks of Ken River should be carried out to mitigate the human-crocodile conflict, enhance the protection of riparian habitats and taking up management activities. Lastly, deployment of SPUs equipped with sophisticated UAVs will have to be done to monitor

the inaccessible areas of Ken River, especially during monsoon and ensuring the protection of crocodilians.

10.3.2. Habitat Consolidation: The existing habitat both within and outside the PA needs to be consolidated. Such areas have been identified for the key species and conservation strategies have been suggested.

(i) Tiger: For habitat consolidation within PTR, it is suggested that landownership of Compensatory Village Area identified by NWDA be transferred to forest department. Similarly, landownership of Revenue Open Areas within PTR (five patches) should also be transferred to forest department, and in case of community concerns, these five patches together as a cluster can be declared as Conservation Reserve under the unified control of Field Director, PTR, and possibly a dedicated officer at SDO level to manage this area. With KBLP causing submergence, the connectivity in the upstream would be affected. Therefore, it is proposed that structural connectivity is ensured by construction of over-bridges/over-passes across Ken River in three places: (1) Chaukan Rapta, (2) along with dam in the downstream and (3) one above Gahrighat. Moreover, to ensure movement of wildlife is not restricted due to linear infrastructure such as roads, it is suggested that night traffic should be stopped between Amanganj and Panna (SH49) between 6 PM and 6 AM with option to divert through Gunaur. The eight-kilometre stretch between Panna and Madla can be made as elevated road or alternative route can go from Bamitha to Panna Buffer or through other alternate options. Similarly, the Amanganj to Bijawar road passing through PTR buffer in Kishangarh and Chandranagar Ranges either need to be diverted to alternate road or underpasses or over passes should be established in the sensitive wildlife crossing areas along this road. In case of landscape, several areas have been identified based on tiger movement and habitat suitability, that can be consolidated for ensuring tiger conservation in a metapopulation framework. In the GPL, 28 habitat cores have been identified, of these, 9 habitat patches can act as satellite cores, 5 habitat patches can act as stepping stones and 5 can serve as both sattelite core and stepping stone. Additionally, 57 potential corridor links (nine priority I, nine priority II, nine priority III, seventeen priority IV, and thirteen priority V), between the delineated habitat cores have been identified. The identified satellite cores and stepping stones hold promise of facilitating future colonization and dispersal events, thus being crucial to the long-term persistence of tigers in the landscape. Under-passes and Over-passes should be suggested where major roads cut through these corridors. Based on field survey and existing knowledge, specific habitat consolidation strategies have been proposed like establishment of Interstate Tiger Reserve

(Ranipur-Satna Tiger Reserve), establishment of Kalda Conservation Reserve, expansion of Veerangna Durgawati Wildlife Sanctuary, and protection and restoration of River Corridor Zone.

(ii) Vultures: There are several falls and river escarpments in the landscape that serve as potential nesting/roosting sites for vultures. The potential sites for conservation priority areas for vultures in the landscape outside the Protected Areas are Pawai Range in South Panna Division, Purwa Fall in Rewa Division, Rahatgarh fort in South Sagar and Baghdari Fall in Damoh Division. It is recommended that these, as well as any other newly found vulture nesting sites be protected by declaring them as Community Reserve or Conservation Reserve depending on the respective land use, its ownership and use of resources by the local communities.

(iii) Gharial: Currently, gharial is restricted only to KGS and even in KGS, it has limited habitat with little opportunity available, while upstream area in PTR has habitat for gharial. Therefore, reintroduction measures should have enhanced scope beyond KGS and the opportunity available in PTR needs to be utilised. Thus, the conservation measures such as release, and habitat management have been proposed within PTR as well. The most effective habitat restoration and management strategy would be to maintain viable flow around the year, including the option of artificial flow based on pumping of water from downstream to upstream habitats.

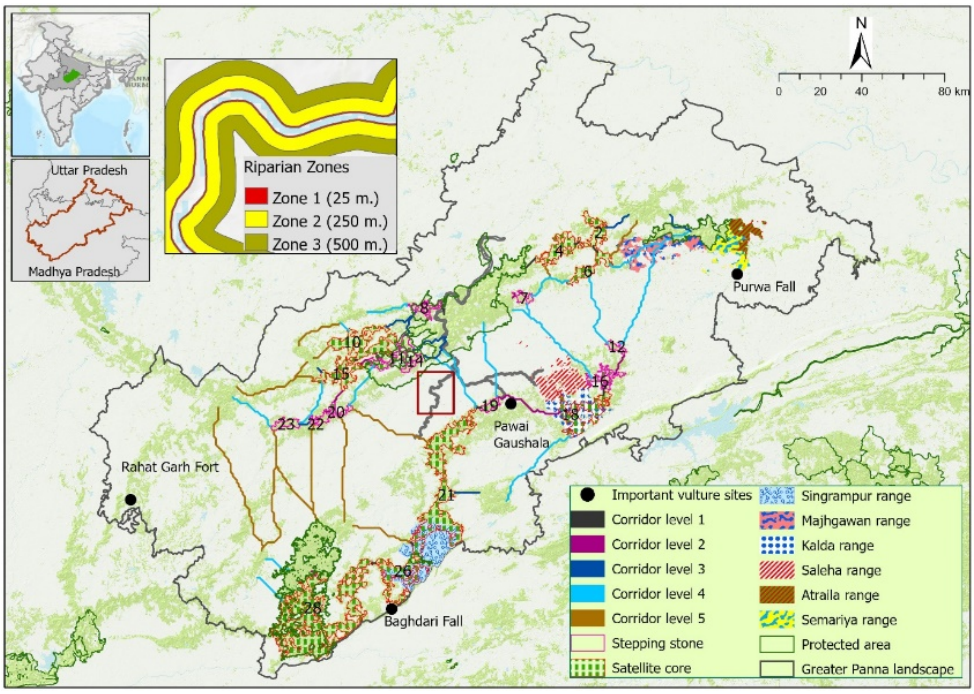


Figure 10.13. Area (terrestrial and riparian habitat) proposed for landscape consolidation.

If all these measures are followed, then an area of approximately 4377.38 sq. km shall be protected, such that along with existing protected area in the landscape (3002.78 sq. km), the total protected area thus would become 7380.16 sq. km. It will bring about consolidation of 60.86% of the forest area in the landscape or 15.50% of the total landscape (Fig. 10.13).

10.3.3. Restoration and Prioritisation: In addition to consolidation of existing habitats, it is necessary to restore degraded habitats and augment biodiversity conservation potential of the landscape. Following strategies are suggested:

(i) Restoration of Negatively Altered Forest Areas: The distribution of forests within the GPL is limited to the undulating terrains where soil depth is also shallow and not suitable for the other land use practices. Although the green cover has been increased during the past decades especially inside the protected areas, but the edges of the forested lands has been degraded or deforested. The shrinking edges of the forest land is directly related to the requirements of human population around the landscape and if no measures are taken immediately the soil quality will degrade, and erosion will take place making these lands wasteland. Within the altered forest identified by our change detection analyses, the negatively altered forests are of great concern as this class covers 3.81% (1822.22 km^2) of total area of the landscape. The current situation of the negatively altered forest is a risk to the landscape integrity, ecosystem functioning, human wellbeing and can also lead towards the rise in human-forest conflicts. To manage the current situation, it is proposed to restore the forests within these lands by reforestation or afforestation activities while making the community as a part of this practice to ensure the safeguarding of such initiatives. Within the positively altered forest, it is also essential to keep track of which tree species are coming back and whether it is native or invasive and required measures should be followed to protect the natural forest composition and prevent the spread of the weeds and invasives. The restoration of the negatively altered forest will not only add to the green cover of the landscape, but will also increase the flow of ecosystem services and human wellbeing altogether when planned in manner that takes into account the forest and people as well.

(ii) Spatial Prioritisation: GPL offers opportunity to conserve the biodiversity beyond exiting protected areas. These areas are vulnerable to various anthropogenic threats and need immediate response. Through spatial conservation prioritization we can conserve these areas to meet the sustainable development goals. Based on cost and biodiversity richness, sites have been prioritized into six classes: (1) Priority 1 (Tiger and high biodiversity richness); (2) Priority

2 (Tiger and moderate and high biodiversity richness); (3) Priority 3 (Only tiger; tiger and low biodiversity richness); (4) Priority 4 (Only moderate biodiversity richness); and Priority 5 (only low biodiversity richness) (Fig. 10.14). Based on the area falling under prioritized and non-prioritized classes, districts within the landscape can be focussed for conservation and restoration activities (Table 10.10).

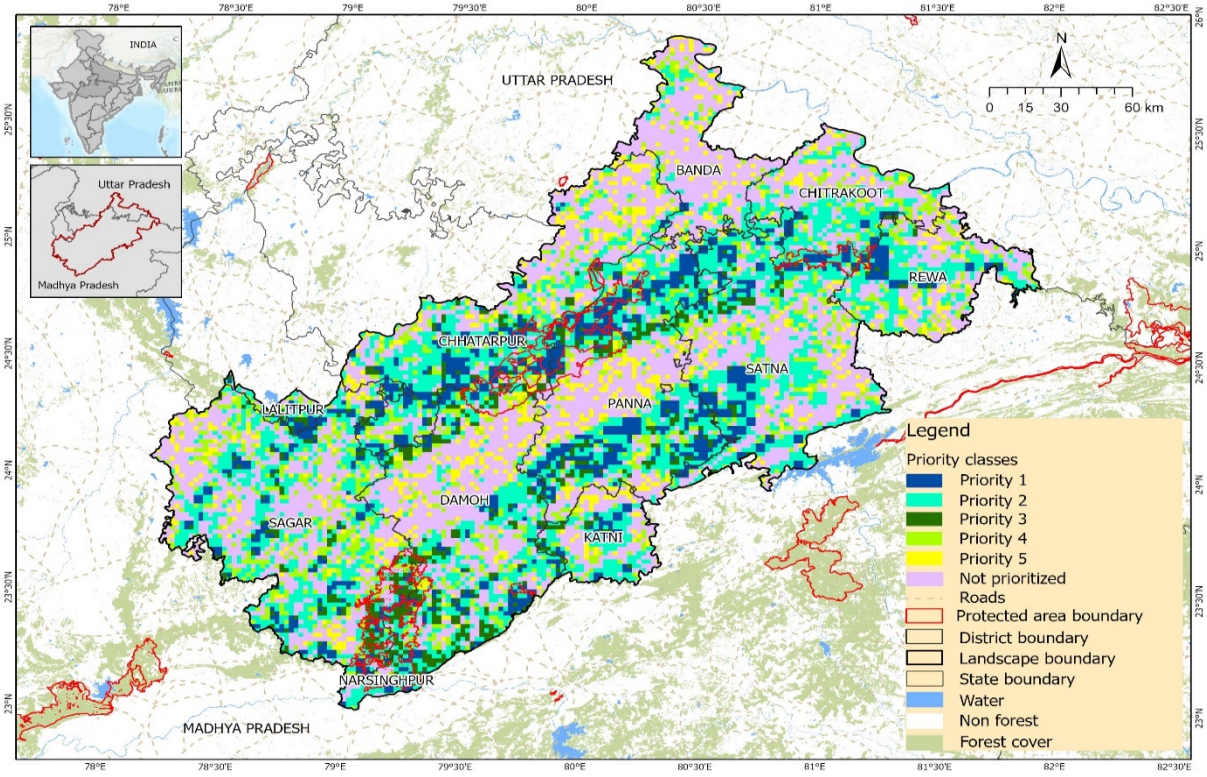


Figure 10.14. Spatial conservation prioritization in Panna Landscape

Table 10.10: Area prioritized for conservation of biodiversity richness in each district

District	Not prioritized (area in sq. km)	Prioritized (area in sq. km)
Madhya Pradesh		
Panna	2474.01	4334.74
Chhatarpur	2475.12	3963.63
Damoh	3438.45	3582.86
Katni	664.10	936.66
Narsinghpur	137.36	355.03
Rewa	1170.46	1797.45

Sagar	3907.22	5260.33
Satna	2657.92	4005.63
Uttar Pradesh		
Banda	2010.29	1021.65
Chitrakoot	1264.11	1806.40
Lalitpur	106.75	250.18

Habitat restoration efforts (as indicated in 10.3.3. (i)) should initially be focussed on negatively altered forests falling within the priority I class of spatial prioritization (Fig.10.15), and then on priority II, and so on.

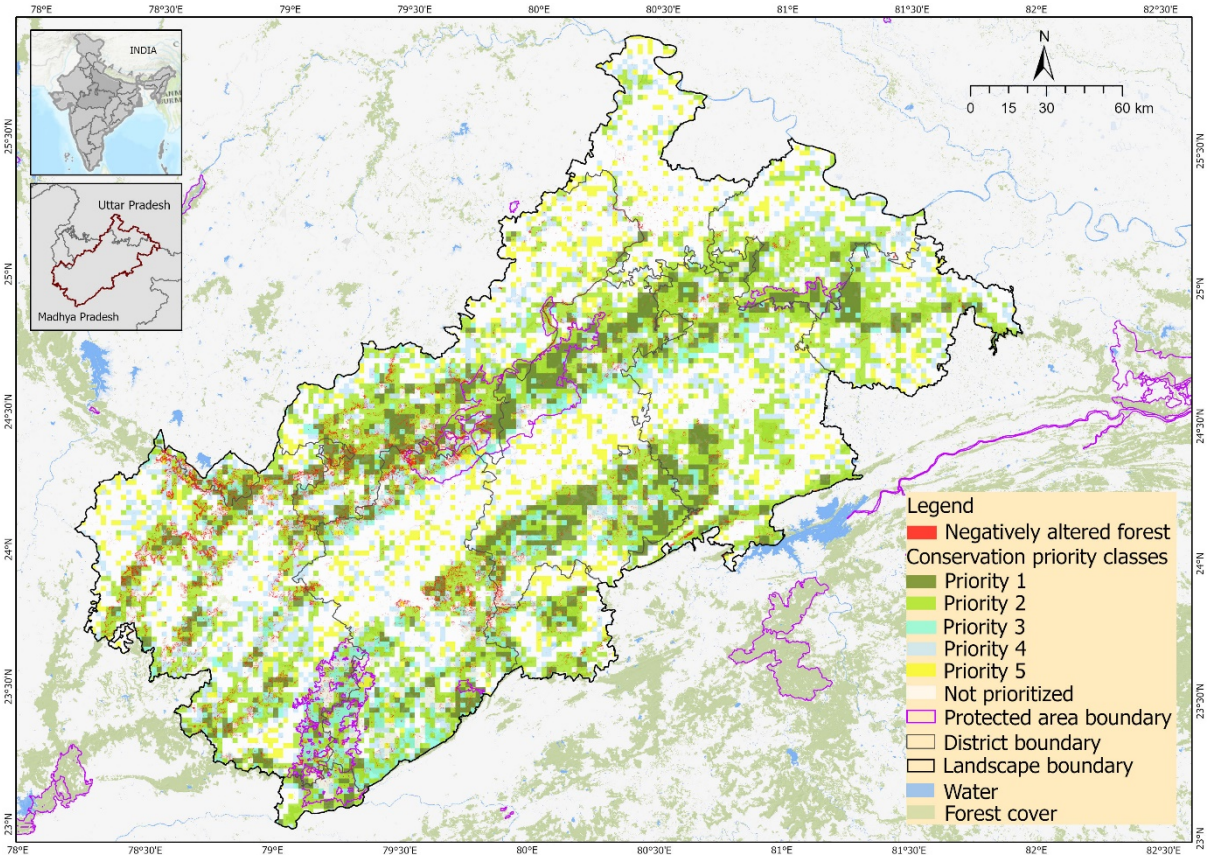


Figure 10.15. Map showing negatively altered landscape overlaid on priority areas of conservation within Greater Panna Landscape

(iii) Convergence for Consolidation and Restoration: As indicated above, Fig. 10.16 provides the combined value for PTR, these identified targets should be the focus for habitat consolidation, protection and restoration.

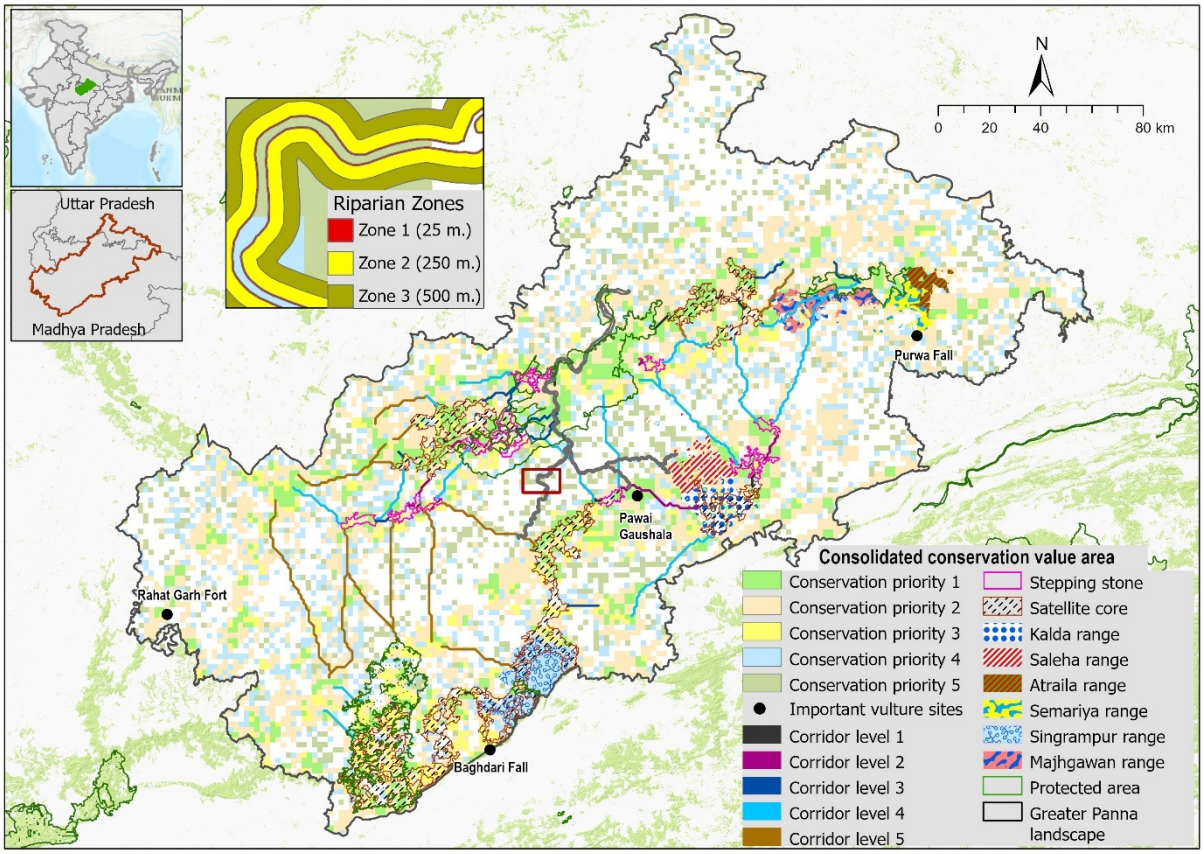


Figure 10.16. Map showing all the areas to be protected and restored (satellite cores, stepping stones, corridors, proposed conservation reserve, priority sites for biodiversity conservation) within Greater Panna Landscape

10.3.4. One Health Management: The linkages between environmental, animal (wild and domestic) and public health is a long-accepted knowledge but only recently the One Health Concept is beginning to dominate global discourse. However, the way forward to implement the one health concept has root in landscape approach where in the tangible and intangible interface at local and global scale among these three factors can be understood and acted upon. To take this forward under the integrated landscape management, it is proposed to establish (a) One Health Coordination Committee and to develop (2) Regional One Health Plan, with enhanced focus on interface areas and this would require a Detailed Project Report (DPR) with dedicated technical and funding mechanism.

10.3.5. Conservation Education and Ecotourism: Presence of Panna Tiger Reserve and other national parks in the landscape provides scope for creation and expansion of ecotourism initiatives for tourists to responsibly explore and enjoy the wilderness of the region, such that it promotes conservation, disseminates knowledge and at the same time provides livelihood opportunities and economic development for local communities.

(i) Tiger Tourism: Tourism in PTR at Hinauta and Madla plateau is currently conditional (vehicle movement within a defined zone, twice a day), and heavily focussed on tigers. Establishing a controlled population facility for managing high-quality individuals in areas with no connectivity value in Panna district, has great tourism potential and would serve as an added boost to the existing setup. Construction of overpasses/bridges especially in Chokan Rapta Area connecting Madla and Chandranagar ranges, would also enhance tourism benefits. Establishment of Nature Interpretation and Tourism Promotion Centre in Panna is also proposed. It can attract the local crowds as well as the tourists visiting the town and can attract and enhance their understanding of the nature and efficient reserve management. Furthermore, establishment of Conservation Reserve in Kalda and Saleha ranges has good scope for community-based tourism and religious tourism. All these, however needs to be done in a regulated manner.

(ii) Vulture Tourism: While the focus of tiger-based tourism will continue to be the major attraction, promoting the same for vultures can provide options to expand the scope of current tourism and community-based economies in the landscape. For this, we recommend establishing vulture viewing points. One of these can be developed in Udla Beat, where a watch tower and an interpretation centre can be set-up, at least 2-3 km away from the vulture nesting sites along the ledges of the escarpment. A feeding point can be developed in KGS, where an observation centre for the tourists can be set up at a sufficient distance from the feeding point. Nature-trails can also be developed along the Ken River in Udla Beat and in KGS to attract tourists. The already existing nature trail in KGS needs to be complemented with proper bird-watching instruments and relevant signboards. The observation points should also be equipped with multiple spotting-scopes. Vulture identification leaflets should be provided to the tourists, who should be accompanied by trained guides to create awareness about vultures and appropriate behaviour. Vulture observation point in Dhundhwa needs to be shifted to `Chhota Dhundwa', which is a better option, as the observation point will be at least 300m away from the nesting and roosting site. The observation point can also have a live-transmission video network so that viewers will have a better experience.

(iii) Nature Tourism: The knowledgebase on the natural areas and wildlife richness in the landscape was limited, but with recent baseline on various taxonomic groups, the tourism potential is manifold and this needs to be effectively utilised. This would also be a great service to nature conservation by reducing pressure from few species including pressure on the department and private service providers. Therefore, several local sites within and outside PTR and in the landscape can be promoted for wildlife tourism with focus on flora, birds, herpetofauna, etc. Wildlife camping sites and aerial walkways can be developed across the landscape to promote tourism and local livelihood opportunities.

(iv) Village Tourism: In addition to wildlife tourism, village tourism can be launched in unique areas of the landscape. Strategically located villages are important for this purpose and each forest division can propose a list of villages/areas where village tourism may potentially occur. Based on the field experience a few villages like Lalar (Rajnagar, Chhatarpur), Udla-Pandavan, Kunjavan, Tara, Jaiswanthpura, Jaithpura (Panna), Hathibhar (Bahoriband, Katni), and Sarra (Tendukheda, Damoh) have been proposed for village tourism. The journey to these villages is captivating and might attract tourists. Such villages are scenic and can help to relieve pressure on the tiger reserve. The facilitators could use the 'Living with Simplicity' and ‘Clean Village and Green Economy’ models. Furthermore, companies providing online marketplace for homestay rentals and tourism activities like AirBnB (a community built on sharing space and experience) can be approached for collaboration.

10.3.6. Community Engagement: In line with the Convention to Biological Diversity and other global goals, connecting biodiversity with the local perspectives serves the purpose of interdisciplinary science of conservation. For this reason, stakeholder mapping and prioritization should form the backbone of all the multilateral recommendations proposed in the plan. The engagement of internal and external stakeholders will form partnerships and promote collaborations making the entire procedure participatory. Integrating partnerships, the suggested prescriptions will focus on the bridging the gaps of socio-economic and forest dependency issues via priority actions and access and benefit sharing. For socio-economic improvement within the landscape, the priorities should be on water security, health management, educational development, waste disposal, poverty alleviation and increasing employment options. Another important aspect would be on the land-sparing situation where in the villages that are vacated for conservation, the communities need to be engaged with capacity development for finance literacy, skill building, alternative livelihood options, etc.

Villagers should be actively engaged in management of forests, agriculture, grazing areas, integrated farming, dung collection, setting up of enterprises and tourism. This can be done through collaborative consultations, skill development, capacity building, job creation, technology, and knowledge generation, and theme-based committees. Community involvement in vulture conservation shall be done by forming Network of Vulture Champions (NVC) which can function as a link between forest department and communities. For growth of the agricultural sector in the landscape, informing people about the schemes, distribution of soil health cards and incorporating integrated farming practices should help. The practices can range from Livestock-Fish Integrated Farming, Livestock-Honeybee Integrated Farming to keeping Poultry-Fish together. Through utilization of existing government schemes and missions, combining harvesting and marketing multifloral and unifloral honey through apiculture, growing vegetables and selling at *panchayat mandis* or tehsil level and increasing the availability of high-quality feed and fodder for keeping different livestock should be incorporated. Utilizing the dung from domestic and stray cattle for harvesting in biogas plants, electricity generation and even marketing for plantation programmes can also be supplemented. Most importantly, setting up forest resource-based cooperatives and growth centres shall go a long way in improving livelihood options of the committee.

10.3.7. Policy and Legislation: Land is a finite resource, and the management of land resources is essential for India being a developing country, which shares 17% of world's population on 2.40% of the total geographical area of the earth. With the growing population of the country, the per capita land availability will further reduce, simultaneously the forest and agriculture areas have increased in the last few decades including in GPL while the lands under 'other areas' has decreased dramatically, posing the risk on forest and agriculture lands for future land demands. The Constitution of India, in the entry no. 18 of the Seventh Schedule states, "Land" being a State subject, falls under the legislative and administrative competence of the States. Land use planning, therefore, falls under the responsibility of the State Governments. Similar to this, Article 243ZD (1) of the Constitution states, "There shall be constituted in every State at the district level a District Planning Committee to consolidate the plans prepared by the Panchayats and the Municipalities in the district and to prepare a draft development plan for the district as a whole".

Government of India has brought various policies to deal with issues related to specific sectors. These policies include (i) National Water Policy 1987, (ii) National Land Use Policy Outlines 1988, (iii) National Forest Policy 1988, (iv) National Livestock Policy Perspective 1996, (v)

National Agricultural Policy 2000, (vi) National Population Policy 2000, (vii) National Policy for Farmers 2007, (viii) National Food Security Act 2013, (ix) National Land Reforms Policy 2013, (x) National Land Utilization Policy 2013, (xi) National Nutrition Strategy 2014 and (xii) National Agroforestry Policy 2014. Accordingly, several mission-mode programmes and special programmes have been initiated. The "National Land Use Policy Guideline and Action Points" (1988) under the chairmanship of Prime minister of India have been circulated throughout the country for adoption after suitable consideration by states, however it is still to be realized. Currently in the field of Land use planning, no single approach is being followed country wide. As per the draft National Land Utilization Policy, various sectors at central level such as urban, rural, mining etc. follow their own approaches. For instance, in rural sector since majority of the population is agriculture dependent, the sectors only lay focus on reforms on land acquisition, resettlement and modernisation of land records, and there is no approach yet in place for planning and management of land resources in rural areas. However, it is increasingly becoming necessary to implement certain policy instruments to safeguard the landscape integrity and, in this context, the Greater Panna Landscape Management Plan may serve as basis for implementing such a policy at regional level across the country.

10.4. Zonal Context of the Landscape Management

The thematic context of the conservation requirements provides a basis for appropriate management strategies. While the actions to be followed has been described in the earlier chapters and also in the thematic context section of this chapter, the management actions would follow existing administrative framework such as Tiger Reserve, Wildlife Sanctuary, Forest Divisions and District Administrations. Panna Tiger Reserve (PTR) is already operating on a legally mandated Tiger Conservation Plan (TCP) and thus, the measures proposed here may be integrated as part of TCP, while the finance support should be made available from the Greater Panna Landscape Council (GPLC) under the Special Purpose Vehicle being formed by the Government of India. Similarly, the Management Plans in Wildlife Sanctuaries and Working Plans in Forest Divisions should consider the conservation measures proposed for the key species and other biodiversity components with specific fund flow that can be managed under the ILMP. These three administrative units (Tiger Reserve, Wildlife Sanctuary and Forest Division) are already codified with appropriate legal backing and likewise, the proposed Conservation Reserve and Community Reserve or Eco-Sensitive Zone (ESZ) will again draw legal strength from Wildlife Protection Act and Environment Protection Act. To align these and the areas outside these already established conservation units, the ILMP will be focus on

District Administration to bring convergence of inputs and resources in the long-term and enable the forest-public administrations to implement effective measures benefitting wildlife and people. Accordingly, some of the measures relevant to conservation of the thematic focus under the ILMP is proposed district wise.

10.4.1. Category I: Protected Areas

(1) Panna Tiger Reserve (including Gangau & Ken Gharial Sanctuaries)

1. **Transfer of landownership** of the five patches of revenue land within PTR to forest department should be done and these can be added to buffer or made as Conservation Reserve or Community Reserve based on consultative process (Fig. 10. 17).
2. **Restoration of the consolidated village areas** (that have been vacated in the past and those that are proposed to be relocated by NWDA (Fig. 10. 18) to develop grasslands.
3. **Protection of vultures and biodiversity priority sites** (level 1 & 2) from anthropogenic disturbance, especially where they are falling along the boundary/edges (Fig. 10.19; 10.20).
4. **Restoration of significantly negatively altered area** (mostly falling within the buffer and some parts of KGS) through reforestation or afforestation activities involving local communities where possible (Fig. 10.21). The first step should be removal of weeds and invasives, and protecting the area from overgrazing. If the area being restored was a grassland, then *Sehima-Dichanthium* grass composition should be promoted in areas occupied by weeds and *Chrysopogon fulvus* can be promoted in rocky degraded areas. If the area was earlier forested, then native tree species of both fast and slow growing species with good regeneration capacity should be planted. In areas where tree plantations may not be successful, Bamboo can be planted. Within the positively altered forest, it is also essential to keep track of which tree species are coming back and whether it is native or invasive and required measures should be followed to protect the natural forest composition. Habitat restoration efforts should initially be focussed on negatively altered forests falling within the priority I class of spatial prioritization, and then on priority II, and so on (Fig. 10.22).
5. **Convergence for Consolidation and Restoration:** As indicated above, Fig. 10.23 provides the combined value for PTR, these identified targets should be the focus for habitat consolidation, protection and restoration.

6. **Integrated Research and Learning Centre** is to be set-up for monitoring of various ecological and socioeconomic activities and to provide technical support and skill development in the region.

7. **State-of-the-art Conservation and Tourism Management** facilities in the form of (a) Controlled Population Management Facility for Tiger (Fig. 4.13) and (b) Nature Interpretation and Tourism Promotion Centre should be developed under PTR administration in Panna District.

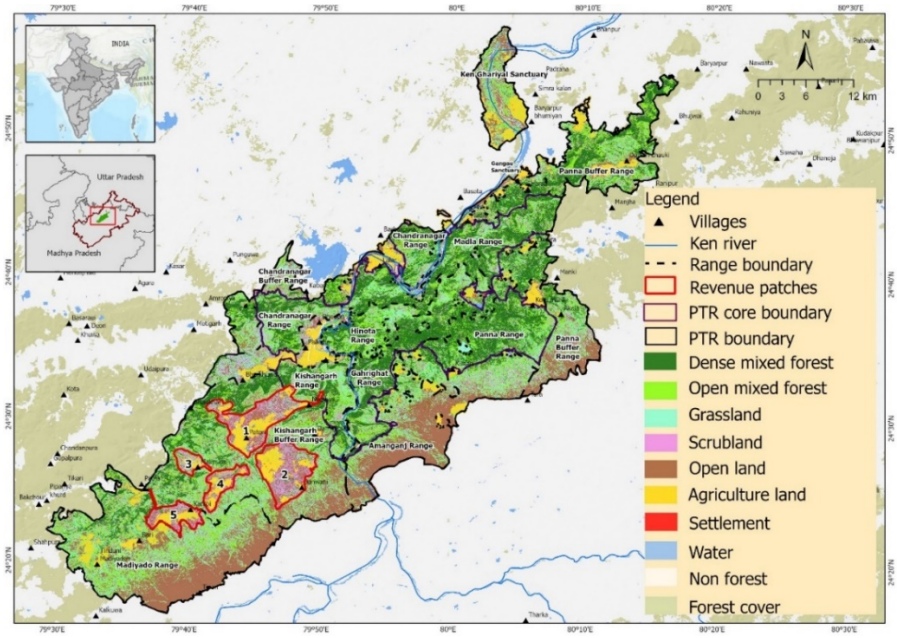


Figure 10.17. Location and extent of revenue areas within buffer of PTR

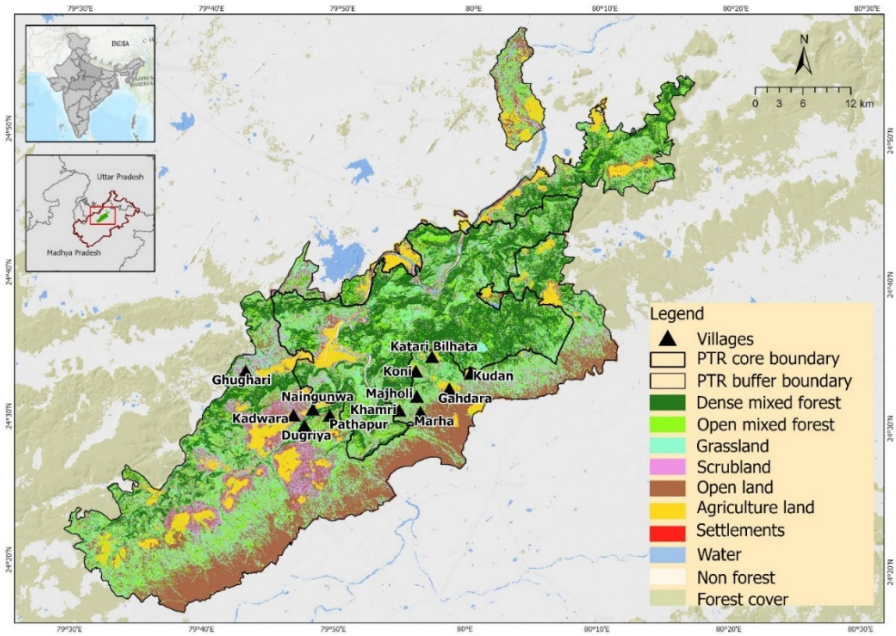


Figure 10.18. Location of villages identified for compensatory area by NWDA

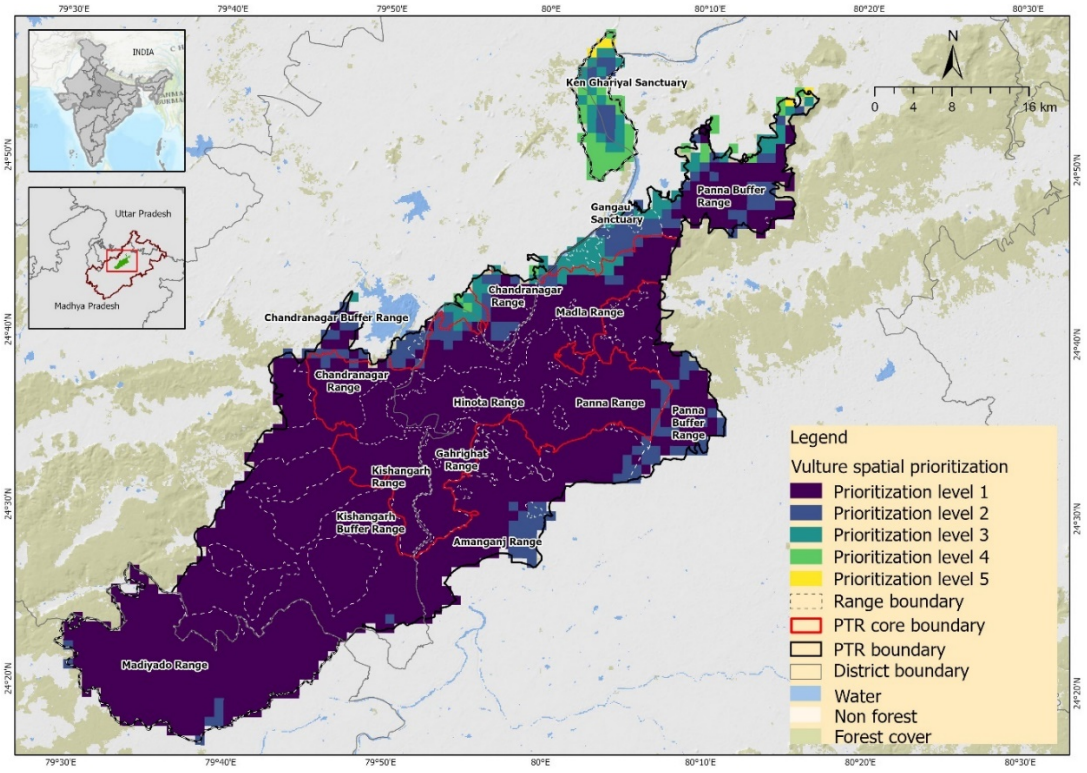


Figure 10.19. Map showing vulture conservation priority areas within Panna Tiger Reserve and Ken Gharial Sanctuary

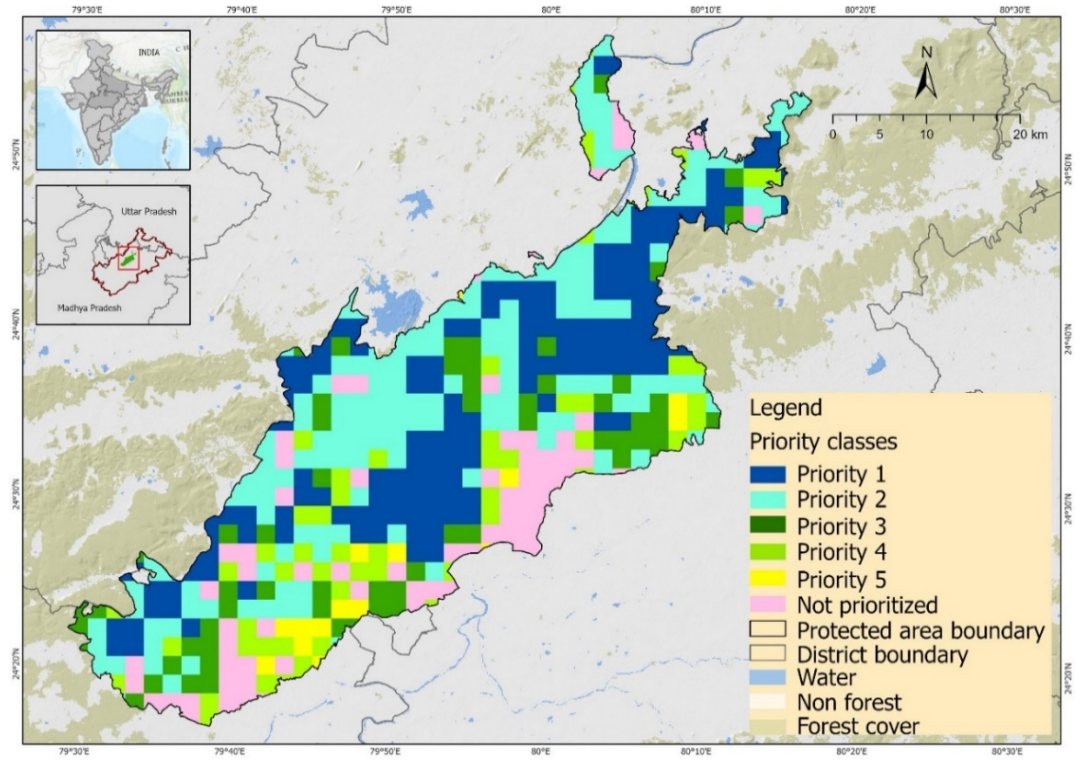


Figure 10.20. Priority areas for conservation in Panna Tiger Reserve and Ken Gharial Sanctuary

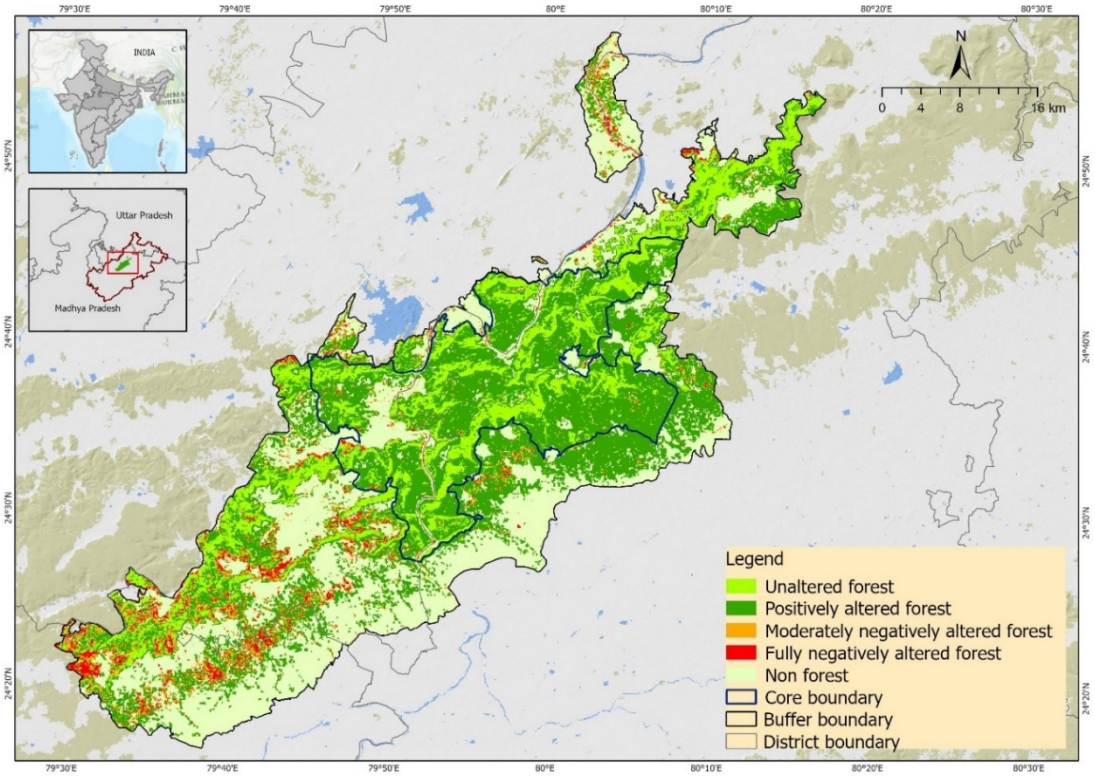


Figure 10.21. Map showing altered-unaltered landscape within Panna Tiger Reserve and Ken Gharial Sanctuary

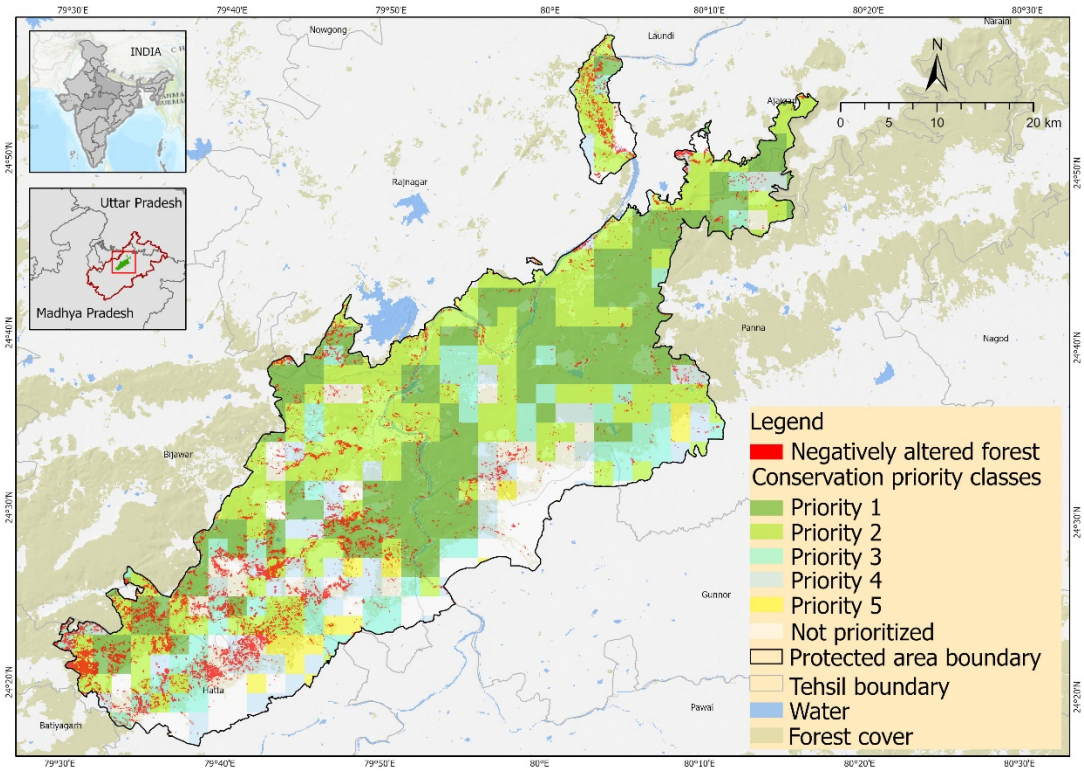


Figure 10.22. Map showing negatively altered landscape overlaid on priority areas of conservation within Panna Tiger Reserve and Ken Gharial Sanctuary

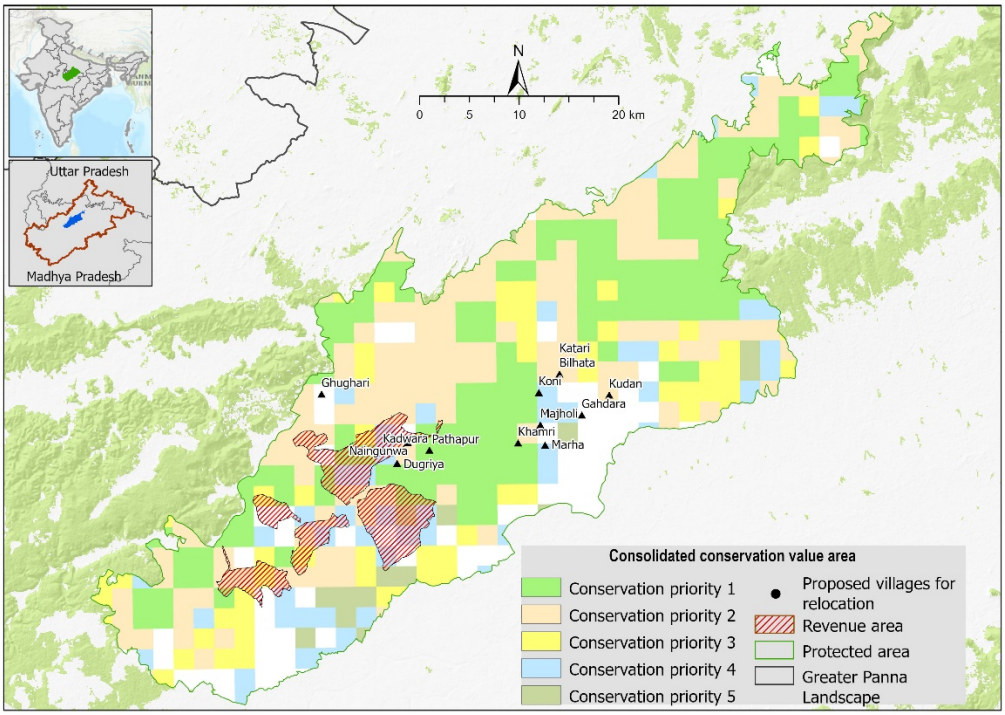


Figure 10.23. Map showing all the areas to be protected and restored (revenue patches, relocated village sites, priority sites for biodiversity conservation) within the Panna Tiger Reserve and Ken Gharial Sanctuary

(2) Nauradehi Wildlife Sanctuary

1. Establishment of Nauradehi-Durgawati Tiger Reserve will enhance conservation support for tiger in the long-term. The state of Madhya Pradesh has already proposed the tiger reserve, including areas from adjoining Veerangana Durgawati Wildlife Sanctuary and reserve forests.

2. Protection of vultures and biodiversity priority sites (level 1 & 2) from anthropogenic disturbance, especially where they are falling along the boundary/edges (Fig. 10.24; 10.25).

3. Restoration of significantly negatively altered area through reforestation or afforestation activities (Fig. 10.26). The first step should be removal of weeds and invasives, and protecting the area from overgrazing. If the area being restored was a grassland, then *Sehima-Dichanthium* grass composition should be promoted in areas occupied by weeds and *Chrysopogon fulvus* can be promoted in rocky degraded areas. Based on local soil conditions other palatable grass species listed in this plan can also be planted. If the area was earlier forested then native tree species of both fast and slow growing species with good regeneration capacity should be planted. In areas where tree plantations may not be successful, Bamboo can be planted. Within the positively altered forest, it is also essential to keep track of which tree species are coming back and whether it is native or invasive and required measures should be followed to protect

the natural forest composition. Habitat restoration efforts should initially be focussed on negatively altered forests falling within the priority I class of spatial prioritization, and then on priority II, and so on (Fig. 10.27).

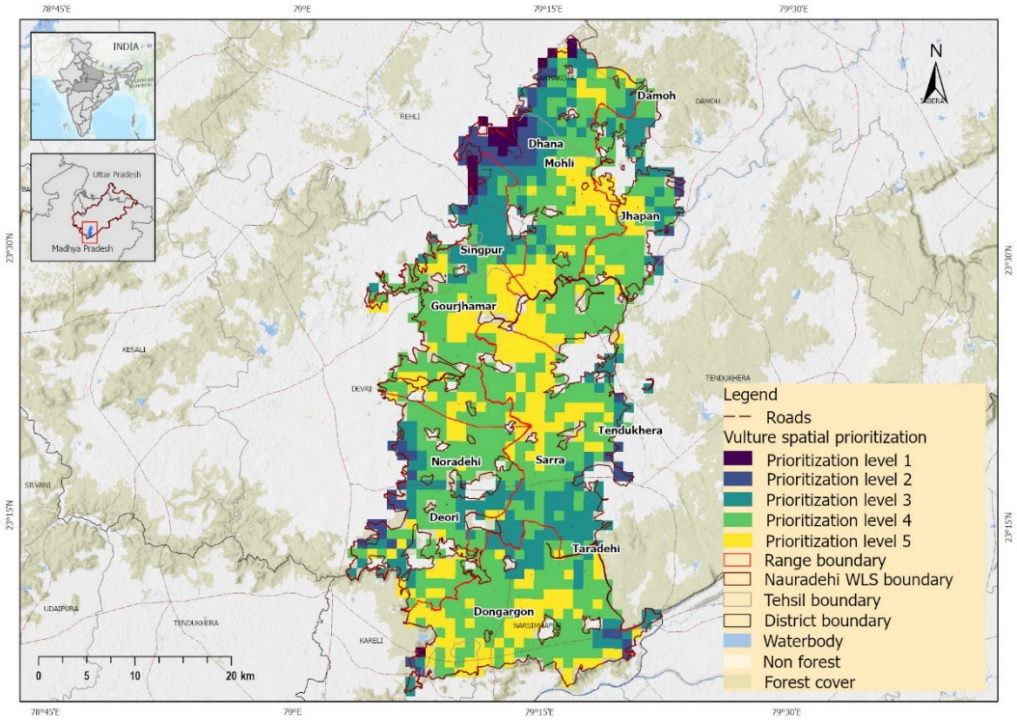


Figure 10.24. Map showing vulture conservation priority areas within Nauradehi Wildlife Sanctuary

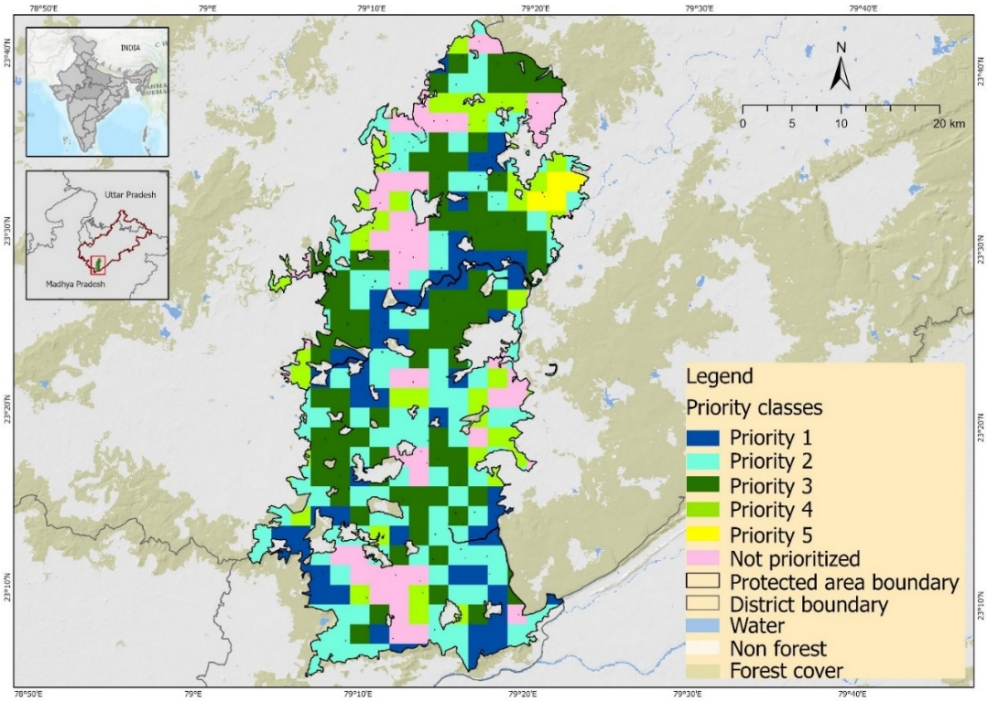


Figure 10.25. Priority areas for conservation in Nauradehi Wildlife Sanctuary

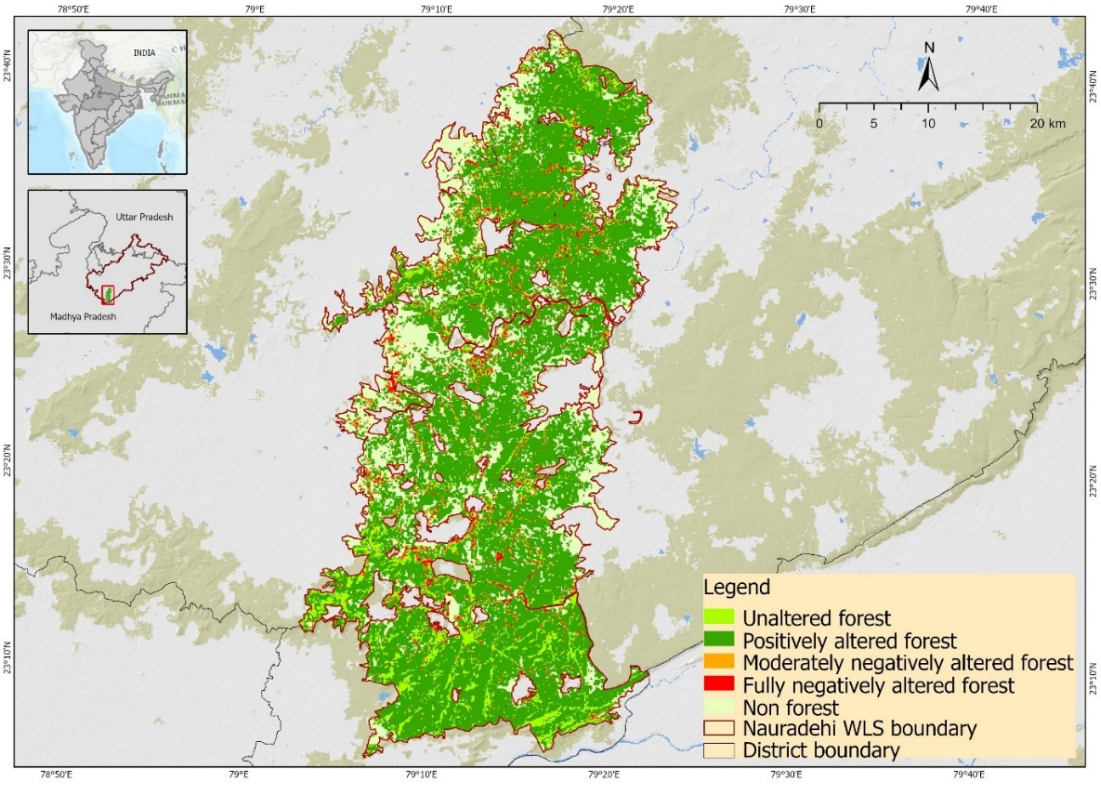


Figure 10.26. Map showing altered-unaltered landscape within Nauradehi Wildlife Sanctuary

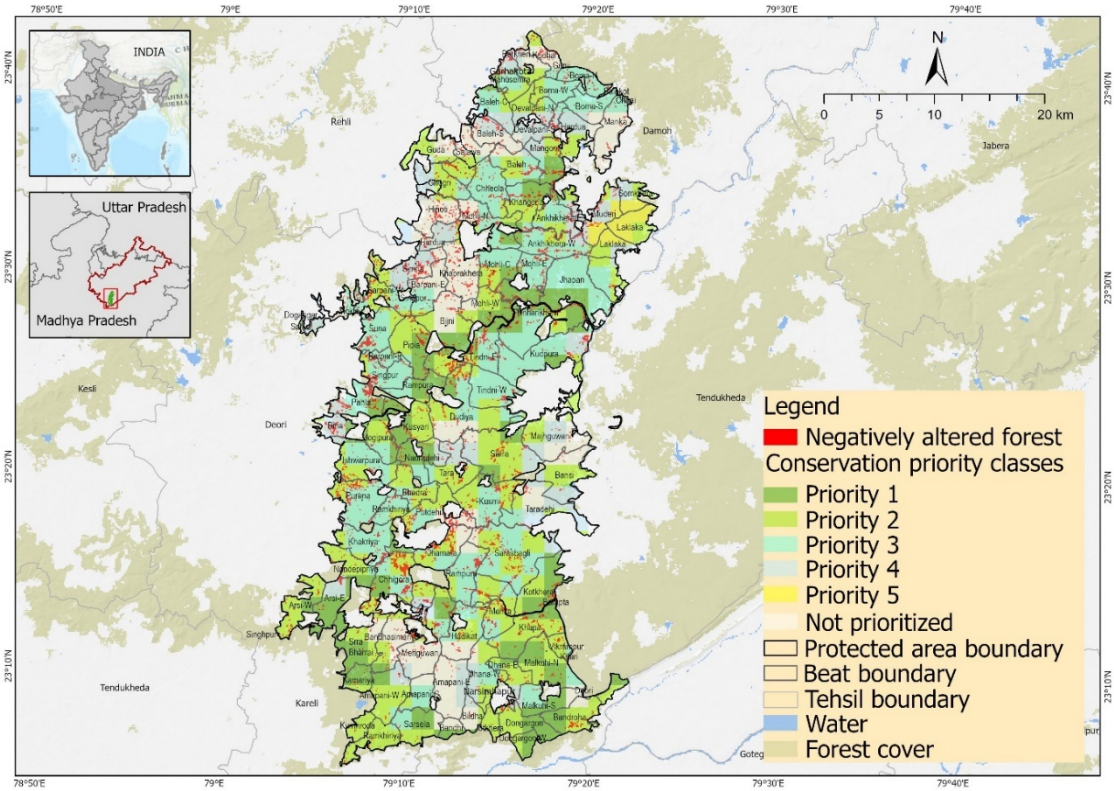


Figure 10.27. Map showing negatively altered landscape overlaid on priority areas of conservation within Nauradehi Wildlife Sanctuary

(3) Ranipur Wildlife Sanctuary

1. **Ranipur Wildlife Sanctuary should be developed into an Interstate Tiger Reserve (Ranipur-Majhgawan Tiger Reserve)** wherein Ranipur Wildlife Sanctuary (Uttar Pradesh) will constitute the Core area, while some parts of reserve forests in Uttar Pradesh and Majhgawan, Semariya, Atraila Ranges of Satna and Rewa Forest Divisions of Madhya Pradesh can constitute the buffer area (Fig. 10.28). Operationally, it will be feasible following the Standard Operating Procedure for Interstate Coordination issued by NTCA and through the Integrated Landscape Management Plan under the Special Purpose Vehicle of KBLP.
2. **Protection of vultures and biodiversity priority sites** (level 1 & 2) from anthropogenic disturbance, especially where they are falling along the boundary/edges (Fig. 10.29; 10.30).
3. **Restoration of significantly negatively altered area** through reforestation or afforestation activities (Fig 10.31). The first step should be removal of weeds and invasives, and protecting the area from overgrazing. If the area being restored was a grassland, then *Sehima-Dichanthium* grass composition should be promoted in areas occupied by weeds and *Chrysopogon fulvus* can be promoted in rocky degraded areas. Based on local soil conditions other palatable grass species listed in this plan can also be planted. If the area was earlier forested, then native tree species of both fast and slow growing species with good regeneration capacity should be planted. In areas where tree plantations may not be successful, Bamboo can be planted. Within the positively altered forest, it is also essential to keep track of which tree species are coming back and whether it is native or invasive and required measures should be followed to protect the natural forest composition. Habitat restoration efforts should initially be focussed on negatively altered forests falling within the priority I class of spatial prioritization, and then on priority II, and so on (Fig. 10.32).

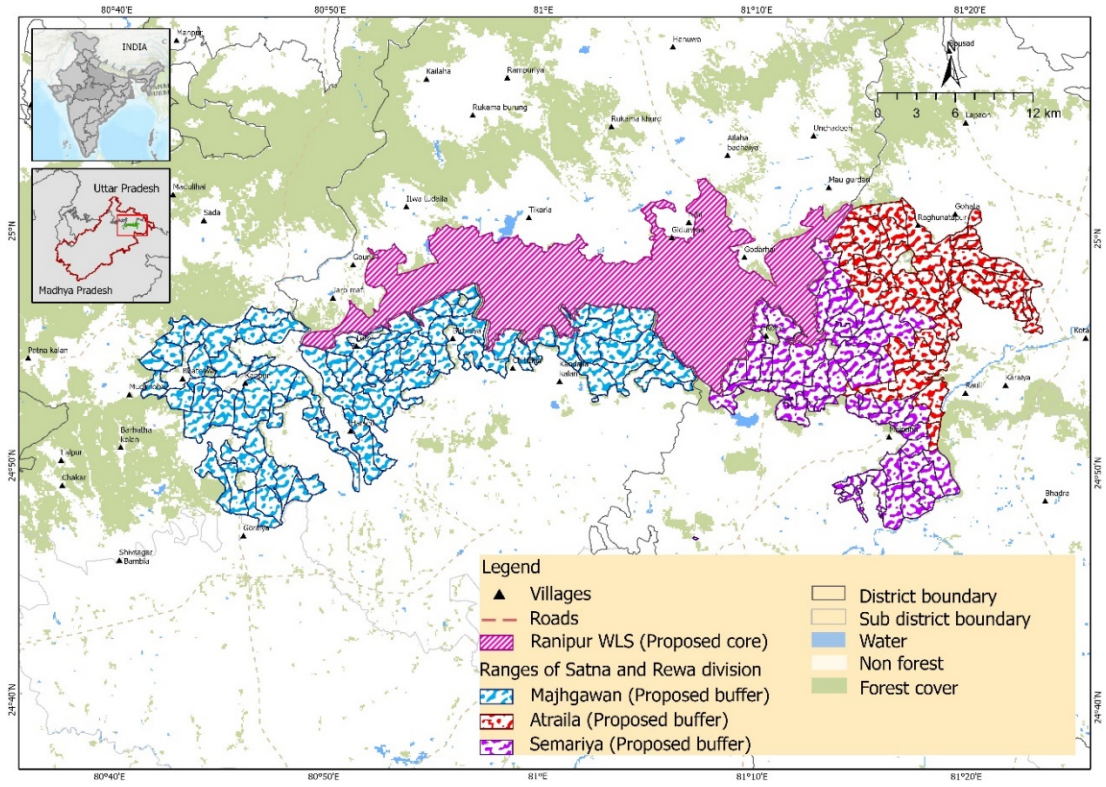


Figure 10.28. Map of proposed Interstate Tiger Reserve

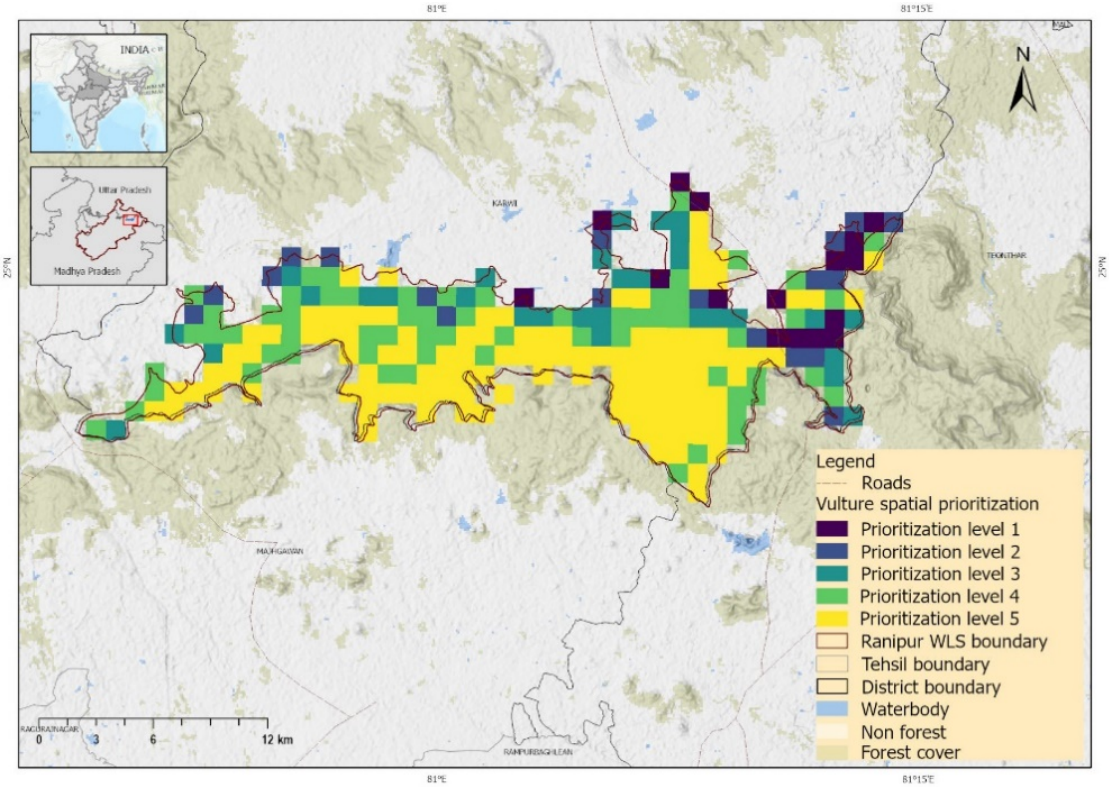


Figure 10.29. Map showing vulture conservation priority areas within Ranipur Wildlife Sanctuary

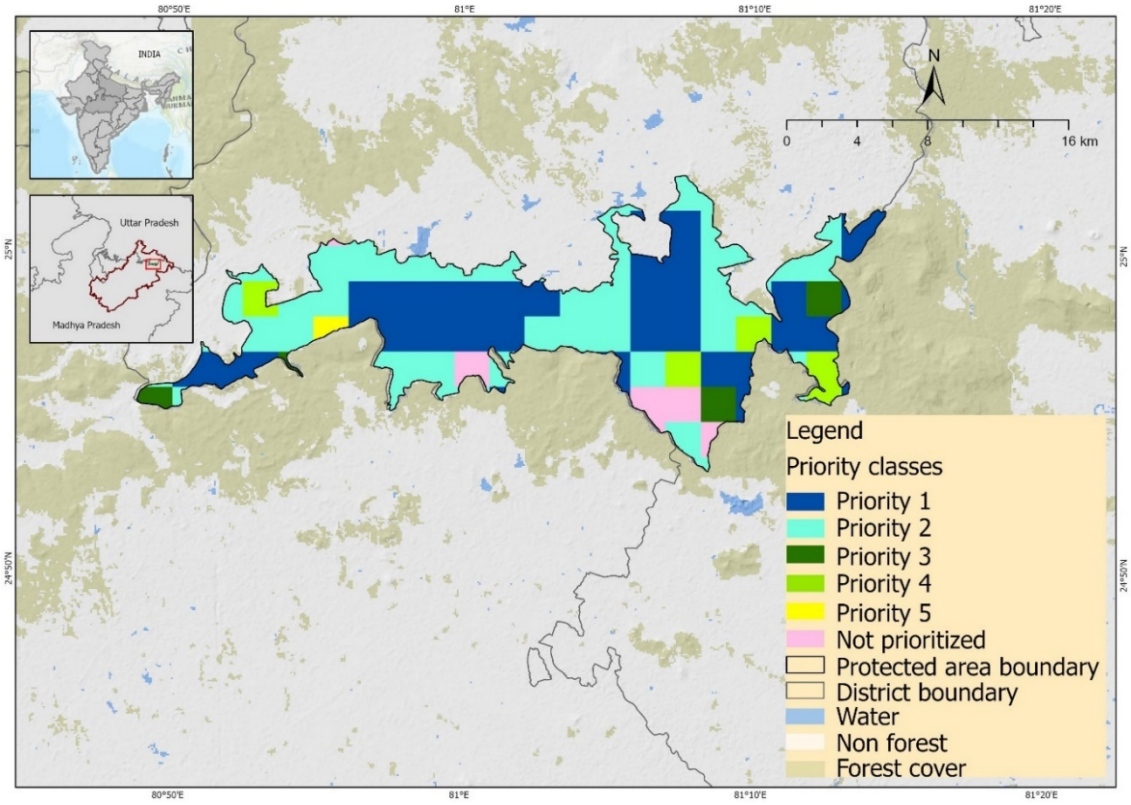


Figure 10.30. Priority areas for conservation in Ranipur Wildlife Sanctuary

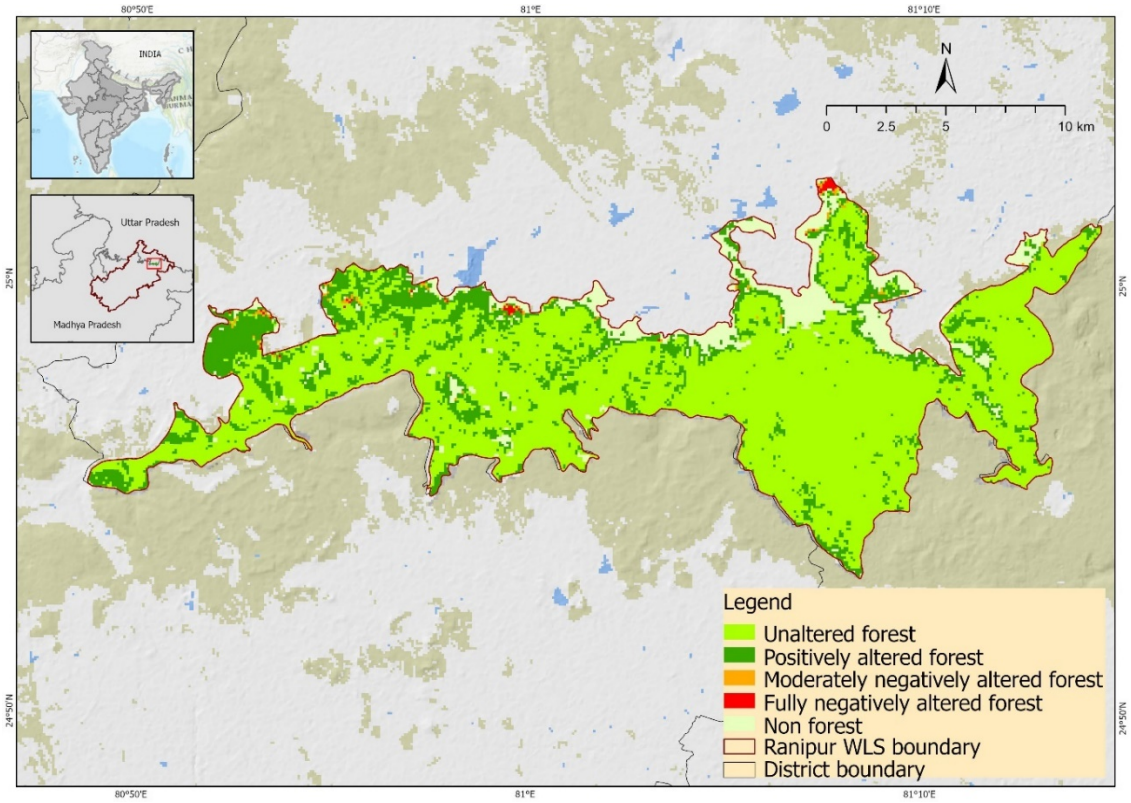


Figure 10.31. Map showing altered-unaltered landscape within Ranipur Wildlife Sanctuary

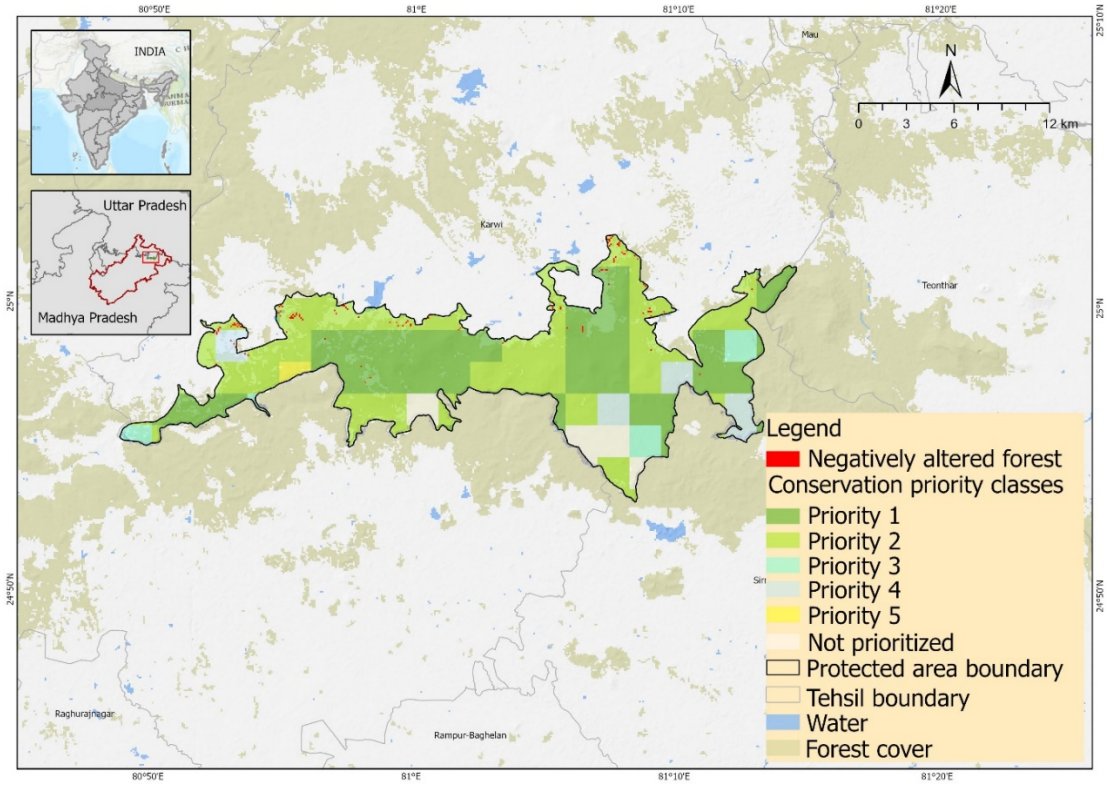


Figure 10.32. Map showing negatively altered landscape overlaid on priority areas of conservation within Ranipur Wildlife Sanctuary

(4) Veerangna Durgawati Wildlife Sanctuary

1. **Expansion of Veerangana Durgawati Wildlife Sanctuary** is necessary to ensure viability of the sanctuary for wildlife and people, and this can be done by adding Singrampur Range of Damoh Forest Division (Fig. 10.33). This proposal has already been taken by the state of Madhya Pradesh, and taking it forward, it has been proposed as Tiger Reserve along with Nauradehi Wildlife Sanctuary. This is necessary for long-term viability of tiger, vultures and other wildlife species.
2. **Protection of vultures and biodiversity priority sites** (level 1 & 2) from anthropogenic disturbance, especially where they are falling along the boundary/edges (Fig. 10.34; 10.35).
3. **Restoration of significantly negatively altered area** through reforestation or afforestation activities (Fig. 10.36). The first step should be removal of weeds and invasives, and protecting the area from overgrazing. If the area being restored was a grassland, then *Sehima-Dichanthium* grass composition should be promoted in areas occupied by weeds and *Chrysopogon fulvus* can be promoted in rocky degraded areas. Based on local soil conditions other palatable grass species listed in this plan can also

be planted. If the area was earlier forested, then native tree species of both fast and slow growing species with good regeneration capacity should be planted. In areas where tree plantations may not be successful, Bamboo can be planted. Within the positively altered forest, it is also essential to keep track of which tree species are coming back and whether it is native or invasive and required measures should be followed to protect the natural forest composition. Habitat restoration efforts should initially be focussed on negatively altered forests falling within the priority I class of spatial prioritization, and then on priority II, and so on (Fig. 10.37).

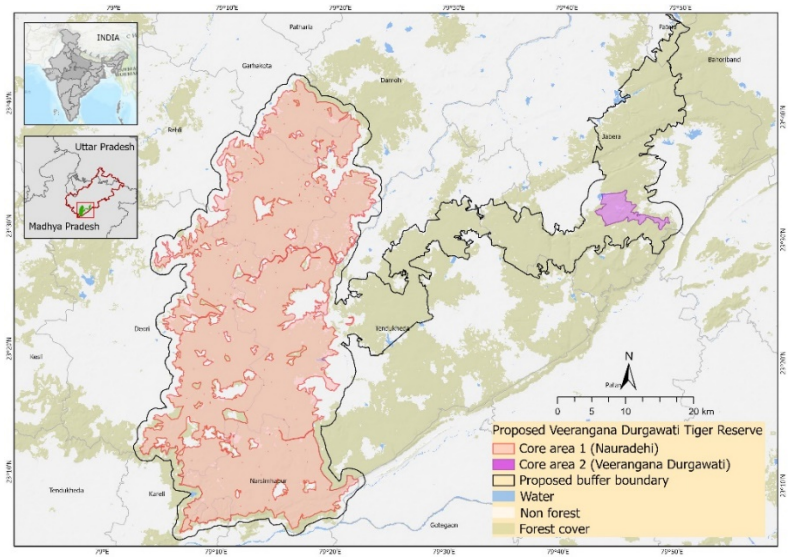


Figure 10.33. Proposed expansion of Veerangna Durgawati Wildlife Sanctuary

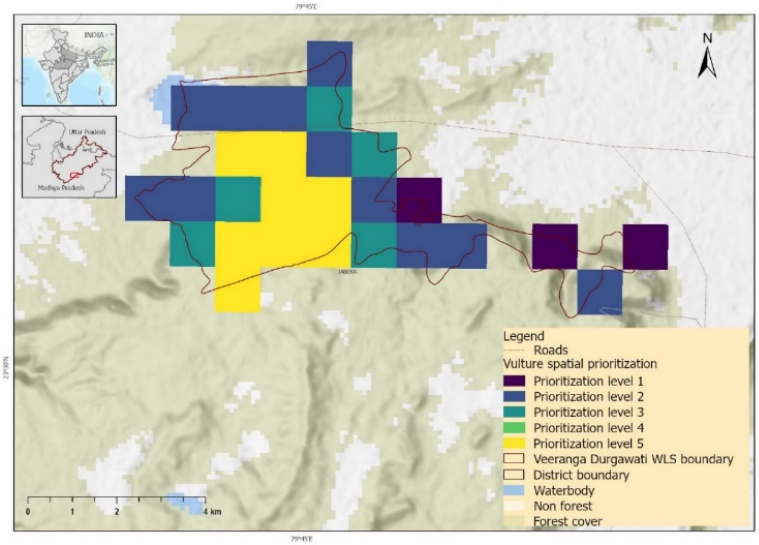


Figure 10.34. Map showing vulture conservation priority areas within Veerangna Durgawati Wildlife Sanctuary

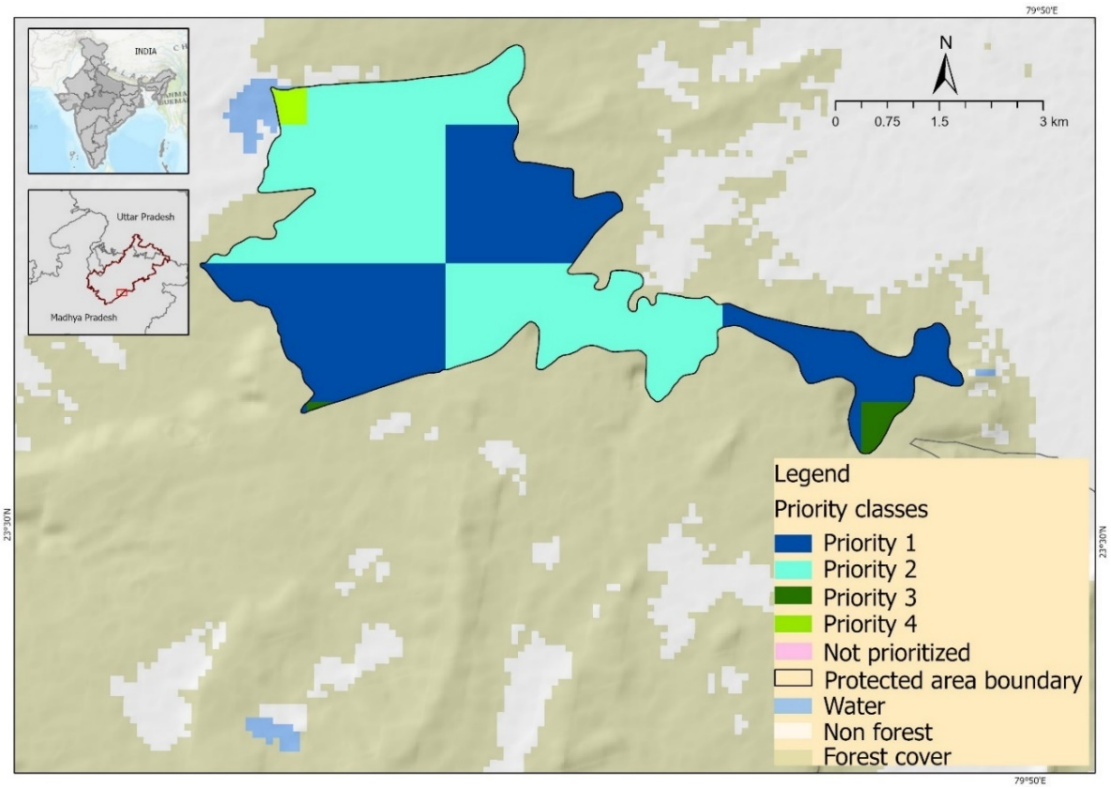


Figure 10.35. Priority areas for conservation in Veerangna Durgawati Wildlife Sanctuary

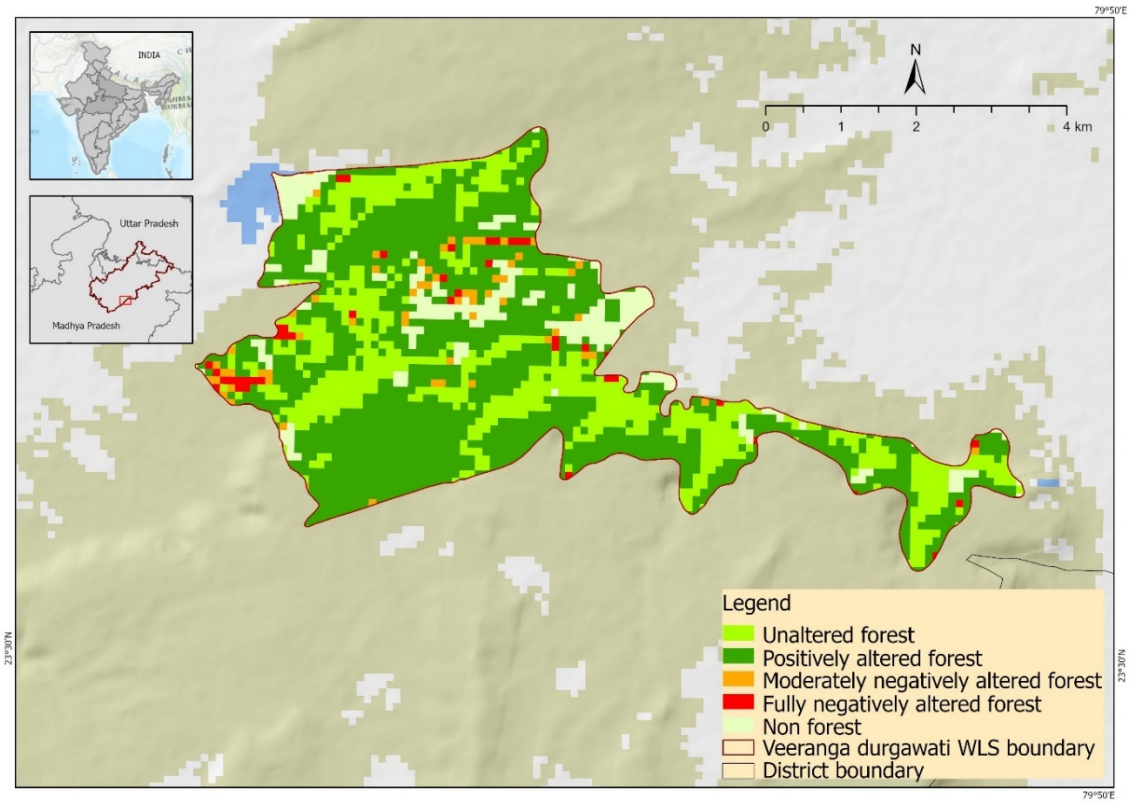


Figure 10.36. Map showing altered-unaltered landscape within Veerangna Durgawati Wildlife Sanctuary

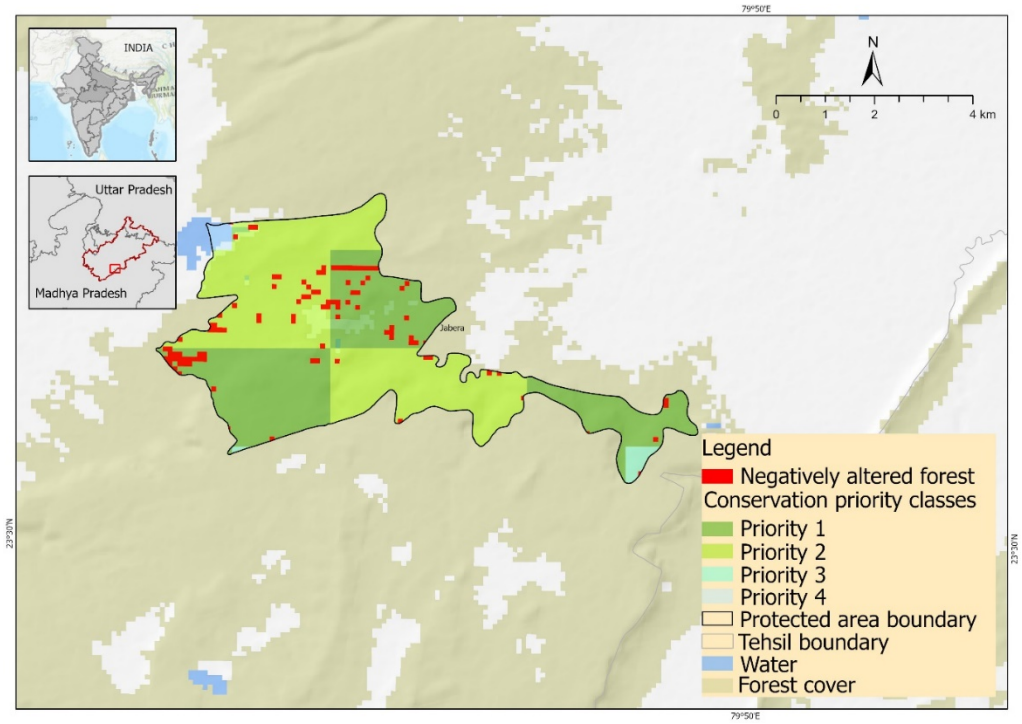


Figure 10.37. Map showing negatively altered landscape overlaid on priority areas of conservation within Veerangna Durgawati Wildlife Sanctuary

10.4.2. Category II: Forest Division/Rural-Forest Interface

(1) Damoh Forest Division

1. **Habitat Protection** is required for the five satellite cores, three stepping stones, two satellite core/stepping stone and 15 corridors (three priority I, three priority II, one priority III, two priority IV, and six priority V) identified in this division (Fig. 10.38) and this needs to be protected from community dependency and development activities including mining.

2. **Structural Interventions** (overpass and underpass) should be made at points where major roads are cutting through the proposed corridors (Fig. 10.39).

3. **Singrampur Range of Damoh Forest Division should be added to Veerangna Durgawati Wildlife Sanctuary**, for better protection of this valuable tiger habitat (Fig. 10.38).

4. **Biodiversity Management Committee** should be activated to monitor and conserve the highest conservation priority areas for vultures and biodiversity (Fig. 10.40; 10.41). The Baghdari Falls in Damoh Forest Division should be brought under enhanced conservation focus, as Important Vulture Area (IVA) (Fig. 10.40). Based on the

information collected, access and benefit sharing should be made a part of Gram Panchayat Development Plan.

4. **One Village One Hectare** concept for restoration of areas that have been significantly negatively altered, where forest cover has declined drastically, should be considered (Fig. 10.42). This intervention can involve social forestry, integrated farming, ecosystem service trade-off and carbon economy, and can be subjected to payment for ecosystem service (PES) model at state and national level. Restoration efforts should initially be focussed on negatively altered forests falling within the priority I class of spatial prioritization, and then on priority II, and so on (Fig. 10.43).

5. **Convergence for Consolidation and Restoration:** As indicated above, Fig. 10.44 provides the combined value for PTR, these identified targets should be the focus for habitat consolidation, protection and restoration.

6. **Green Economy Cooperatives and Growth Centres** should be established in selected Panchayat/Village for Amla (Shikarpura, Hathibhar, Ukarpur, Khapa, Madho and Sarra), for Mahua (Shikarpura and Ukarpur), for Tendu (Hatidol) and for Achar (Shikarpura, Ukarpur, Majhguwan, Sarra, Daroli, Parna, Geedan, Madanpura, Kalkuwa and Shahpura).

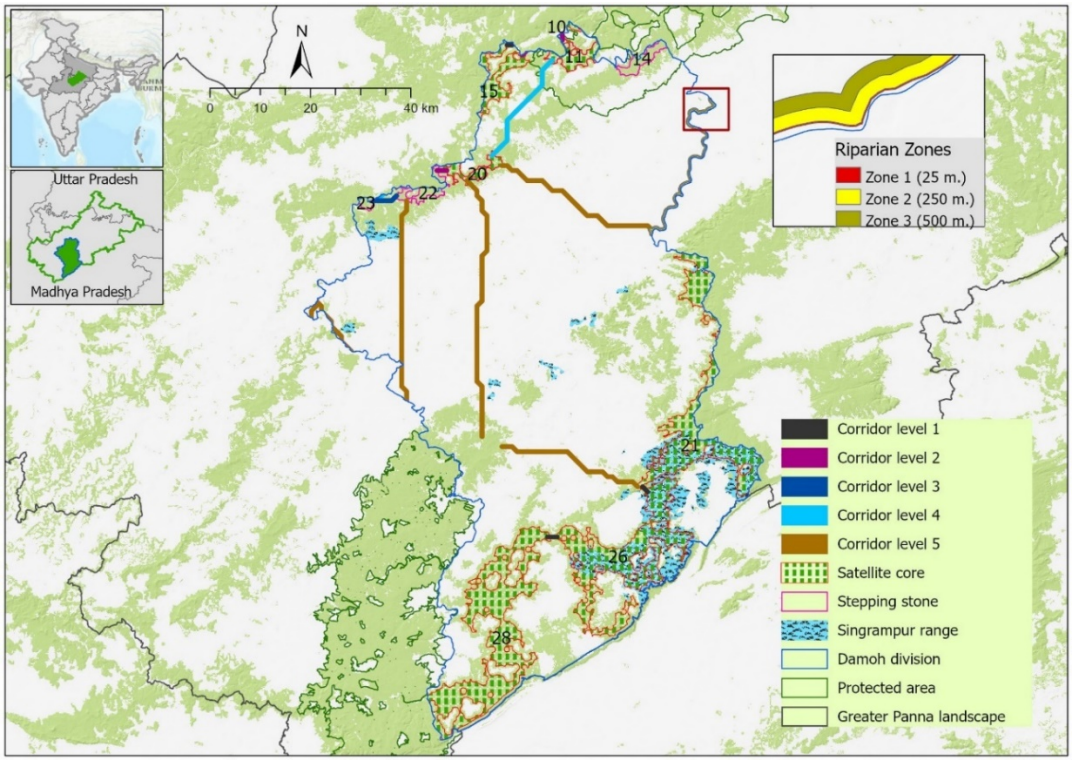


Figure 10.38. Map showing areas to be consolidated (satellite cores, stepping stones, corridors and Singrampur Range) within Damoh Forest Division

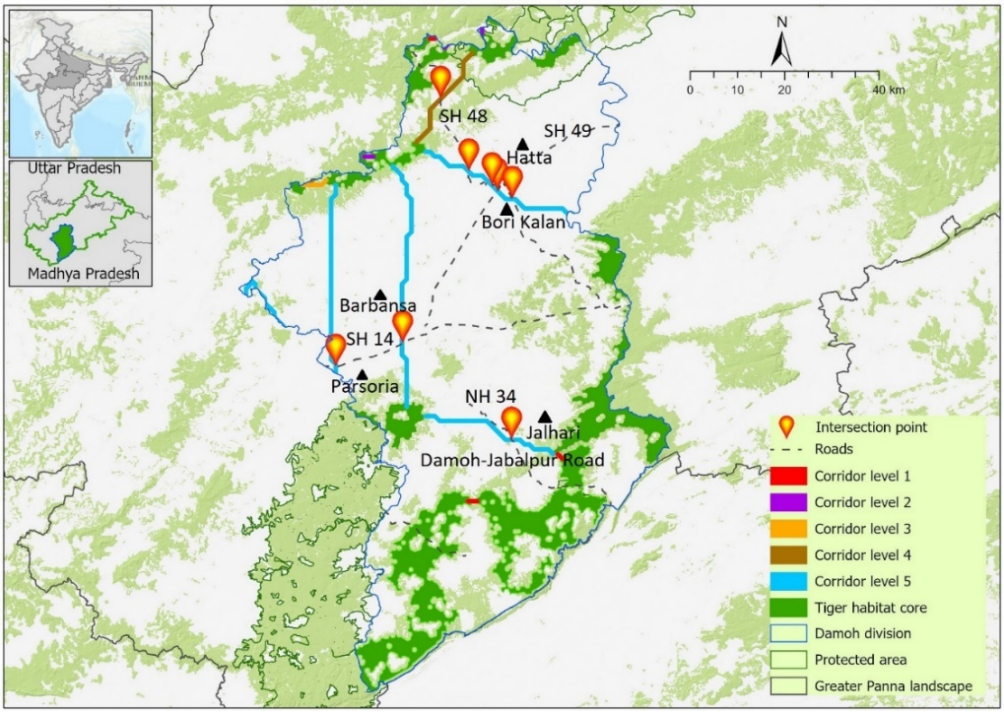


Figure 10.39. Map showing points where major roads are intersecting with proposed corridors in Damoh Forest Division for structural interventions

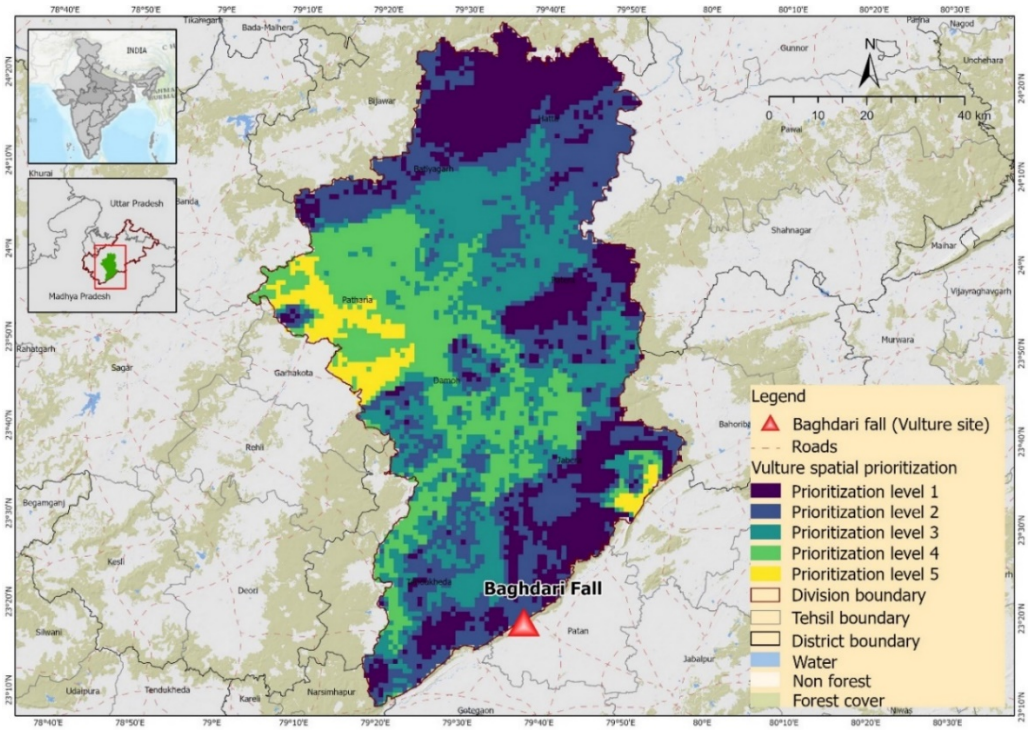


Figure 10.40. Map showing vulture conservation priority areas within Damoh Forest Division

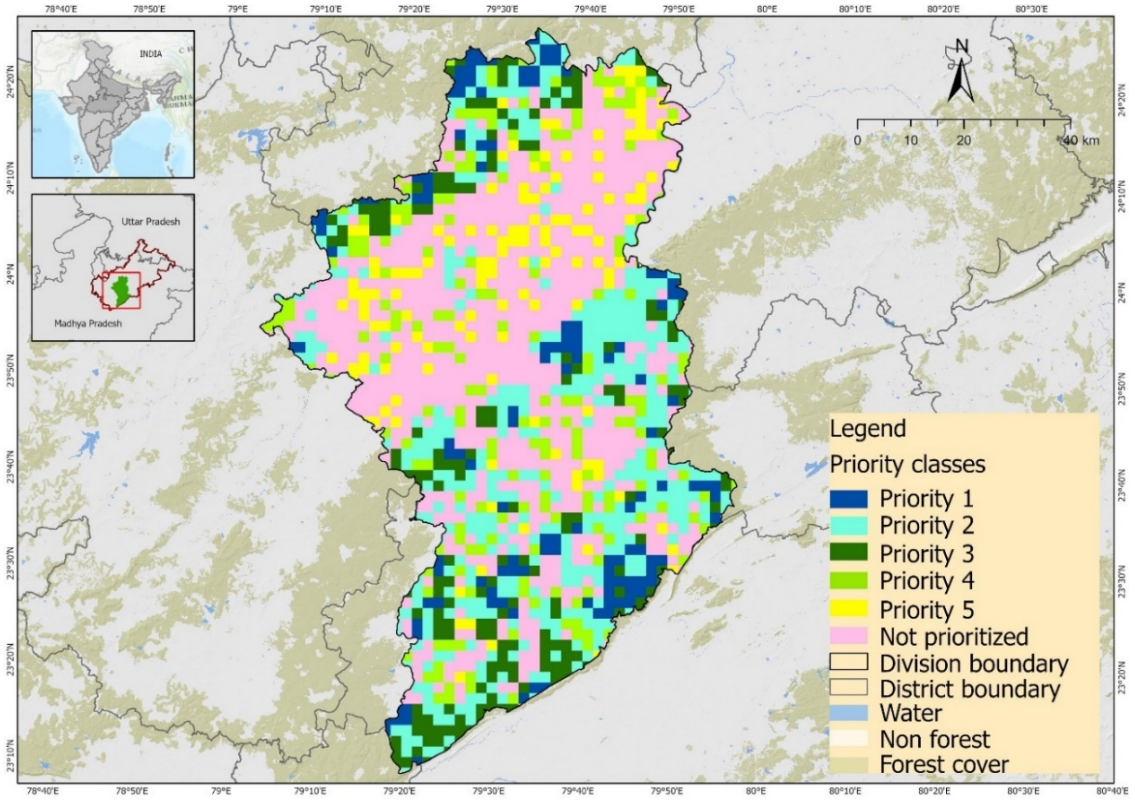


Figure 10.41. Priority areas for conservation in Damoh Forest Division

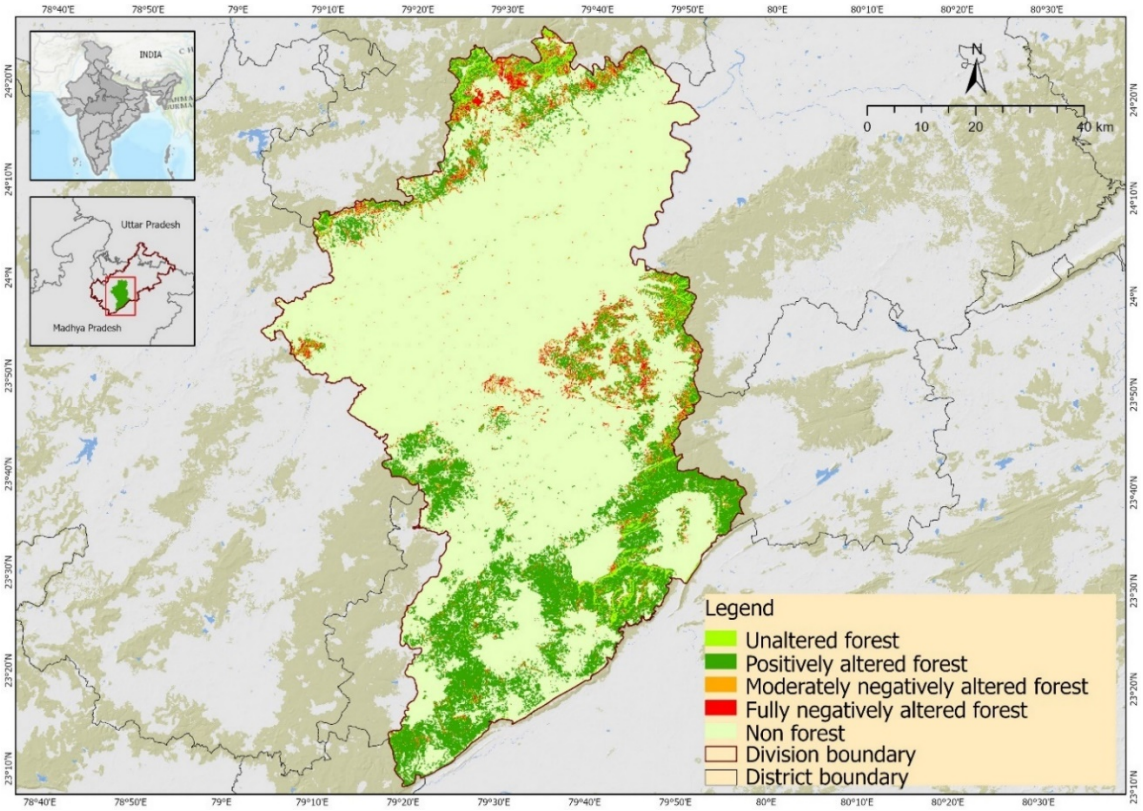


Figure 10.42. Map showing altered-unaltered landscape within Damoh Forest Division

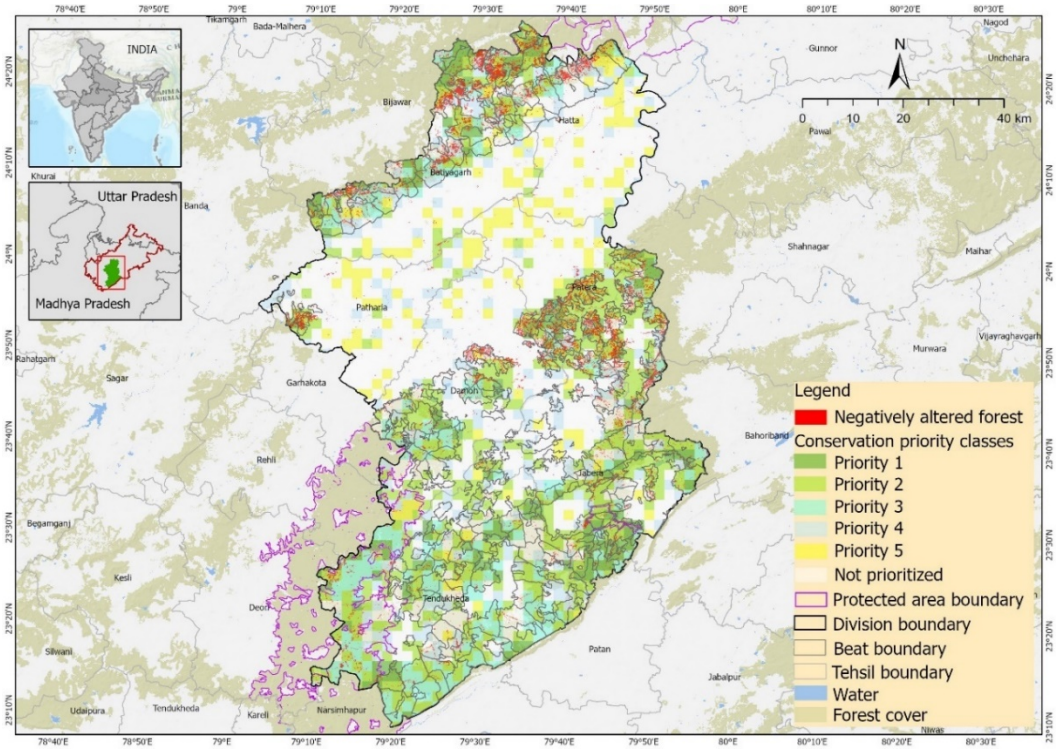


Figure 10.43. Map showing negatively altered landscape overlaid on priority areas of conservation within Damoh Forest Division

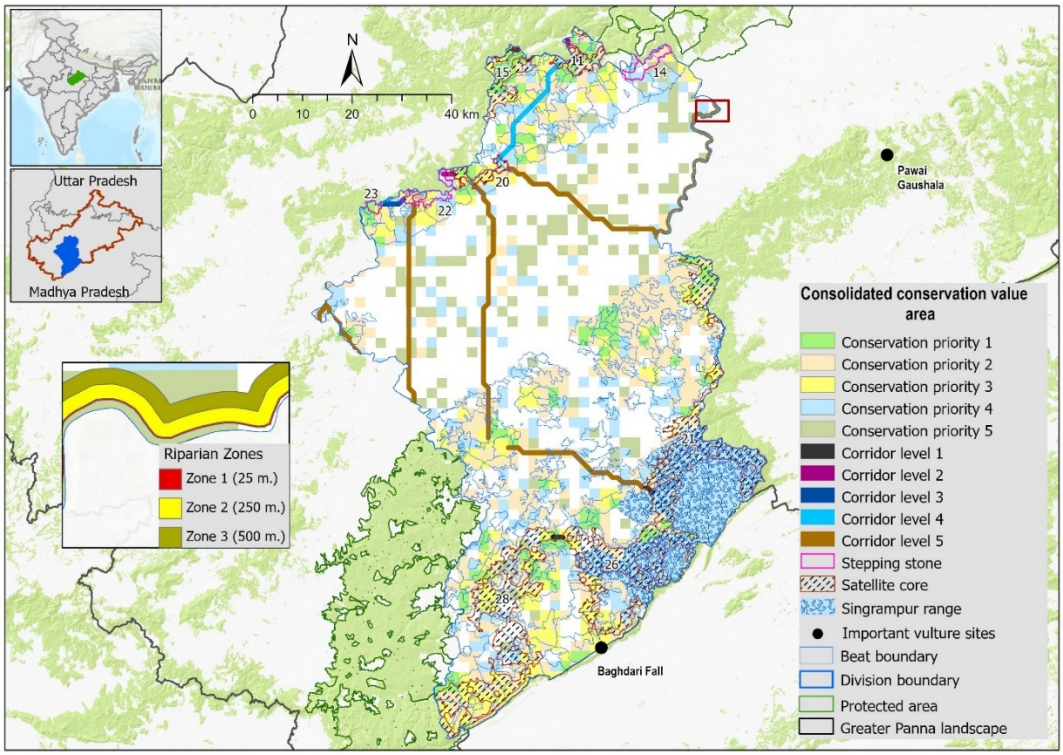


Figure 10.44. Map showing all the areas to be protected and restored (satellite cores, stepping stones, corridors, proposed tiger and community reserve, priority sites for biodiversity conservation) within the Damoh Forest Division

(2) Satna Forest Division

1. **Habitat Protection** is required for the four satellite cores, one steppingstone, one satellite core/steppingstone and 13 corridors (three priority I, one priority II, one priority III, seven priority IV, and one priority V) identified in this division (Fig. 10.45) and this needs to be protected from community dependency and development activities including mining.
2. **Inter-state Tiger Reserve** is required to constituted comprising of Ranipur Wildlife Sanctuary of Uttar Pradesh as Core and part of the Satna (Majhgawan Range) and Rewa (Semariya and Atraila Ranges) Forest Divisions of Madhya Pradesh as buffer (Fig. 10.45). This is critical for ensuring survival of dispersing tigers from PTR and to enable another source population in the eastern part of the landscape.
3. **Structural Interventions** (overpass and underpass) should be made at points where major roads are cutting through the proposed corridors (Fig. 10.46).
4. **Biodiversity Management Committee** should be activated to monitor and conserve the highest conservation priority areas for vultures and biodiversity (Fig. 10.47; 10.48). Based on the information collected, access and benefit sharing should be made a part of Gram Panchayat Development Plan.
5. **One Village One Hectare** concept for restoration of areas that have been significantly negatively altered, where forest cover has declined drastically, should be considered (Fig. 10.49). This intervention can involve social forestry, integrated farming, ecosystem service trade-off and carbon economy, and can be subjected to payment for ecosystem service (PES) model at state and national level. Restoration efforts should initially be focussed on negatively altered forests falling within the priority I class of spatial prioritization, and then on priority II, and so on (Fig. 10.50).
6. **Convergence for Consolidation and Restoration:** As indicated above, Fig. 10.51 provides the combined value for PTR, these identified targets should be the focus for habitat consolidation, protection and restoration.
7. **Green Economy Cooperatives and Growth Centres** should be established in selected Panchayat/Village for Amla (Bichhiya, Madulihai, Bhathawa, Lotni, Lalpur, Panna, Panihai and Moharwa), for Mahua (Pahauwa), for Tendu (Hatidol) and for Achar (Bichhiya, Lotni and Bilha Kangali).

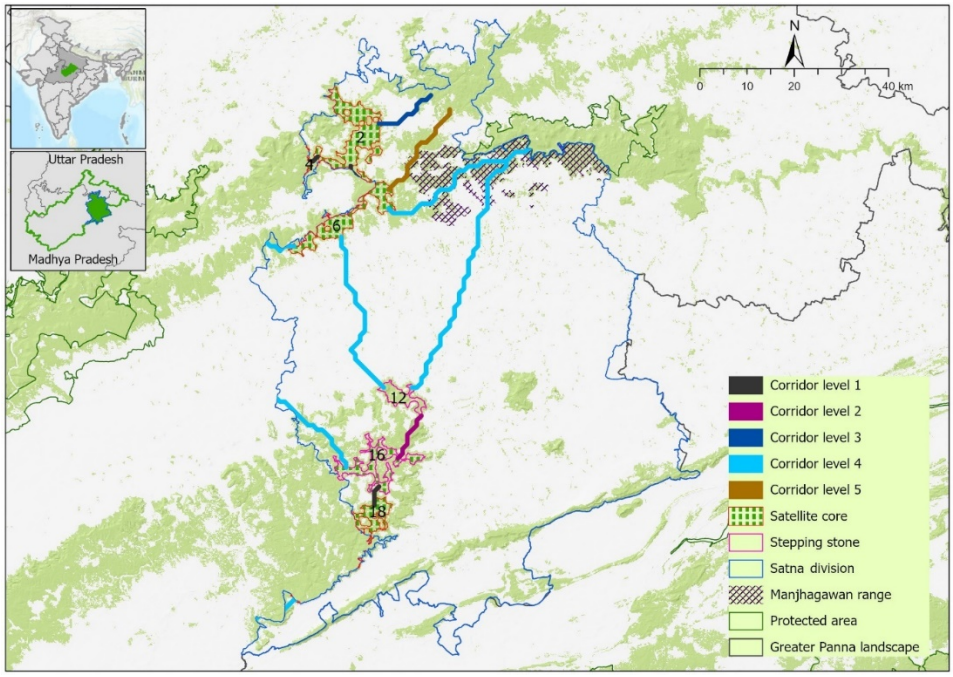


Figure 10.45. Map showing areas to be consolidated (satellite cores, stepping stones, corridors and Majhgawan Range) in Satna Forest Division

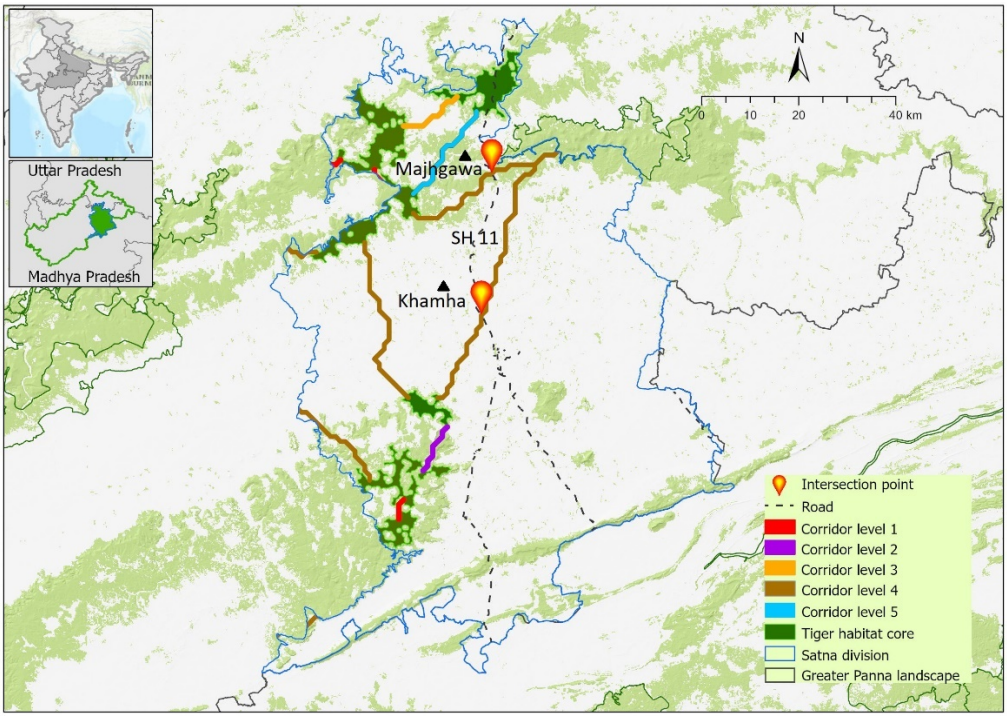


Figure 10.46. Map showing points where major roads are intersecting with proposed corridors in Satna Forest Division for structural interventions

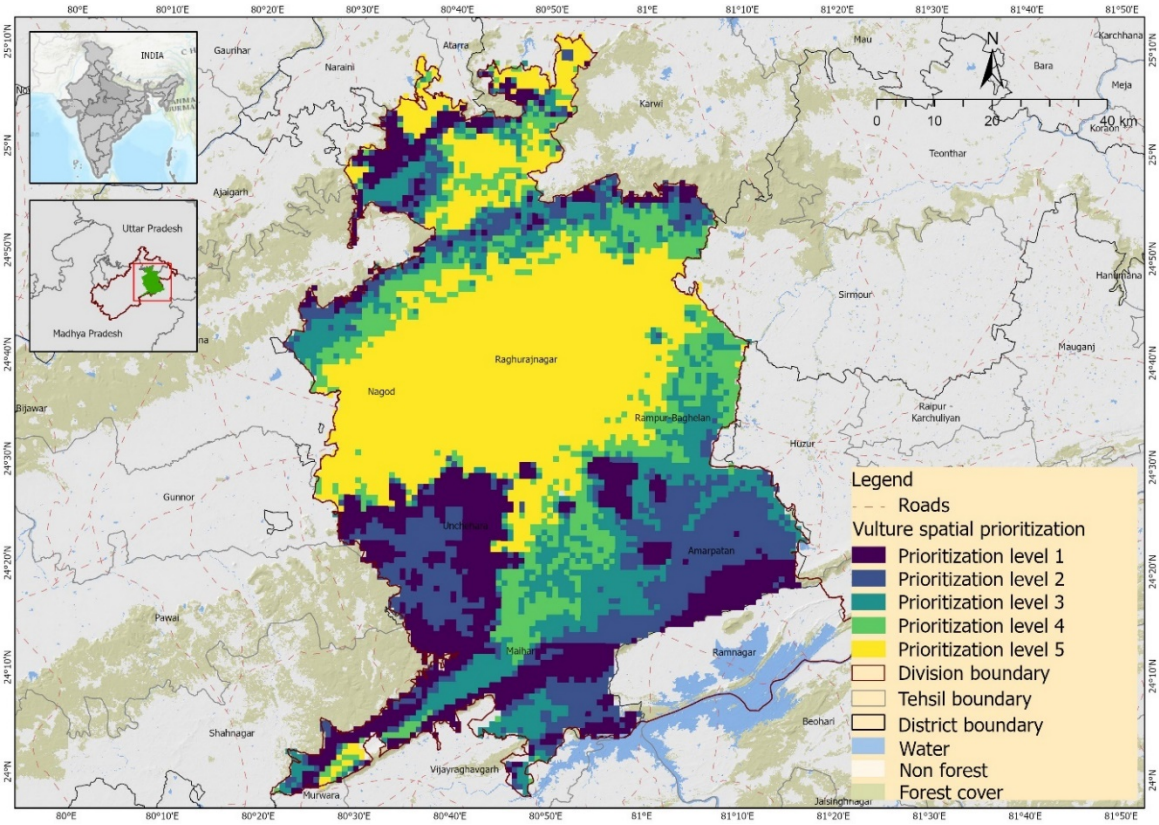


Figure 10.47. Map showing vulture conservation priority areas within Satna Forest Division

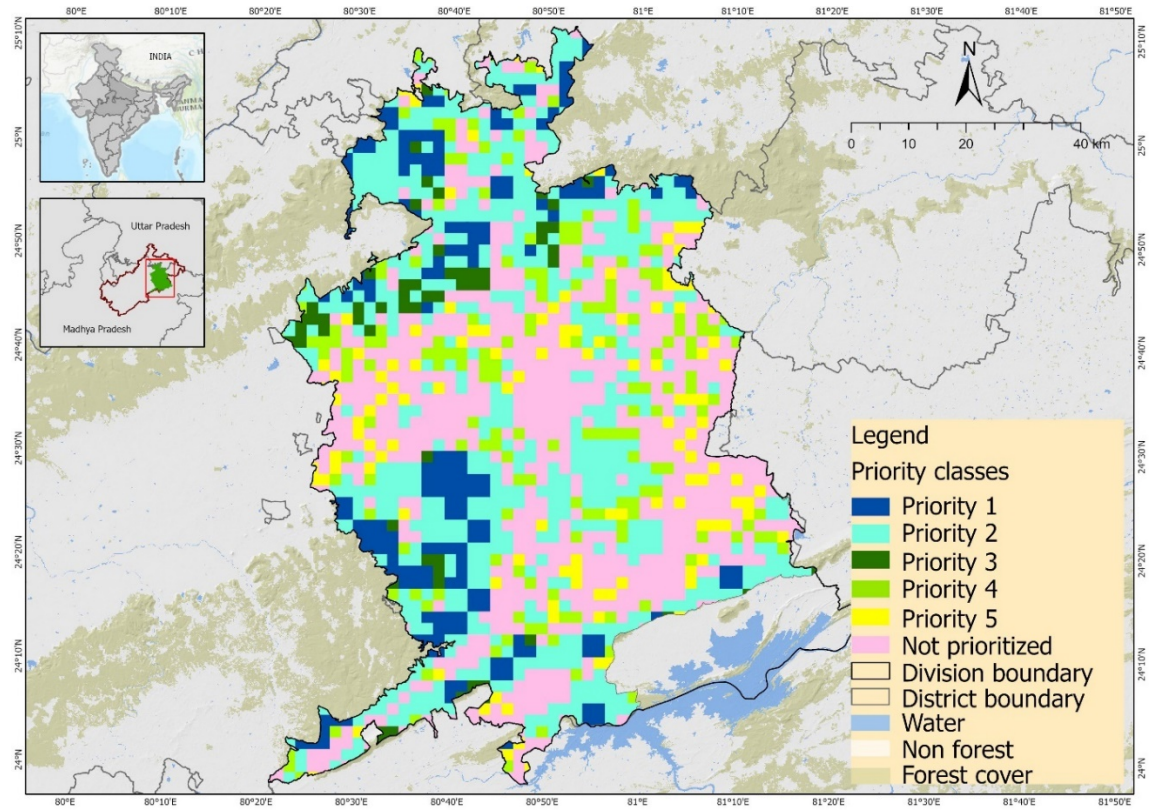


Figure 10.48. Priority areas for conservation in Satna Forest Division

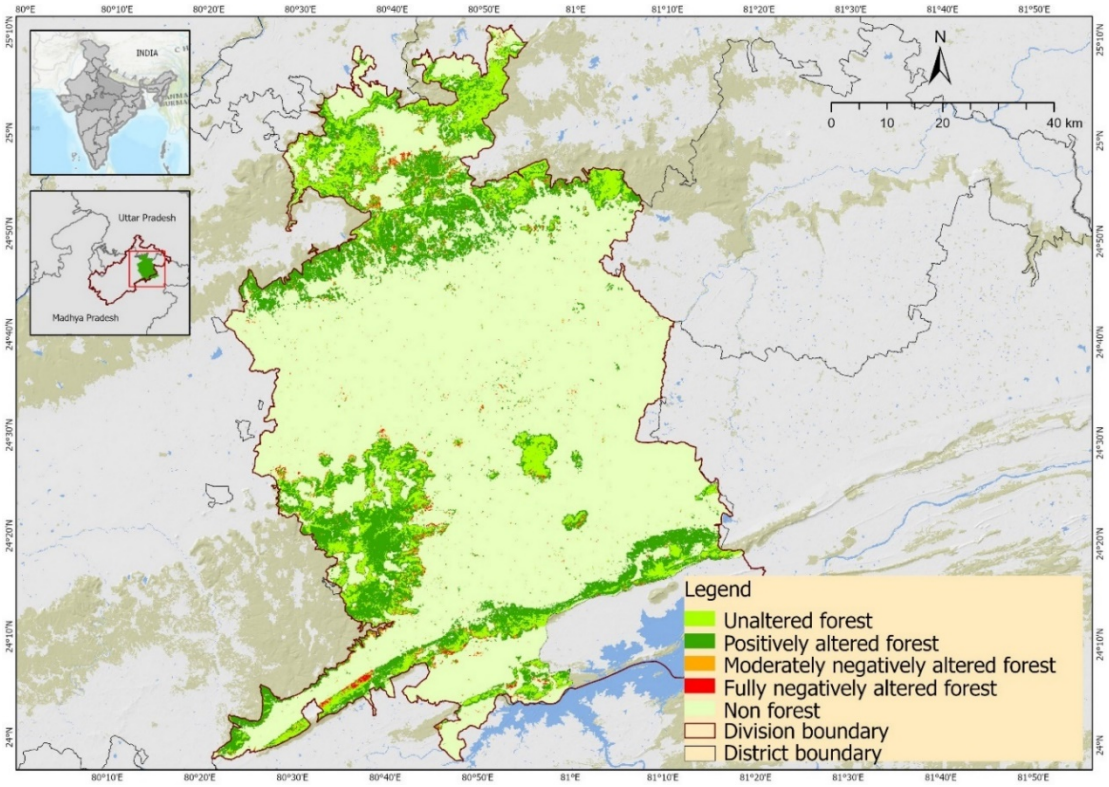


Figure 10.49. Map showing altered-unaltered landscape within Satna Forest Division

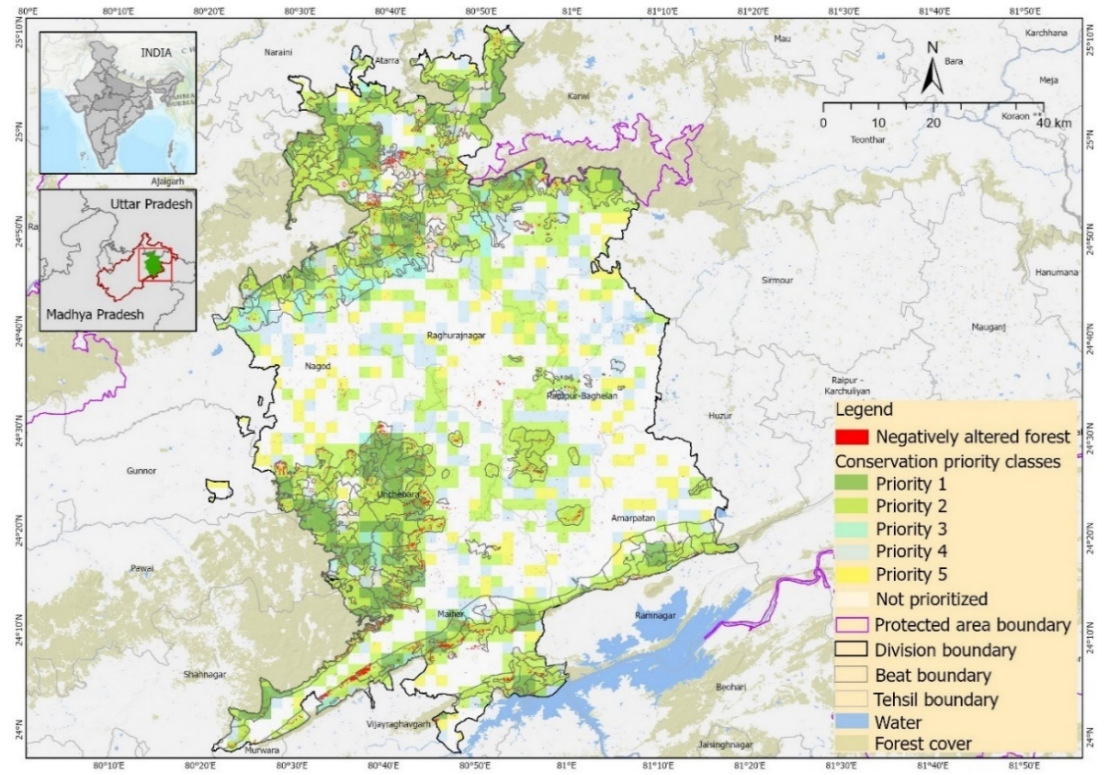


Figure 10.50. Map showing negatively altered landscape overlaid on priority areas of conservation within Satna Forest Division

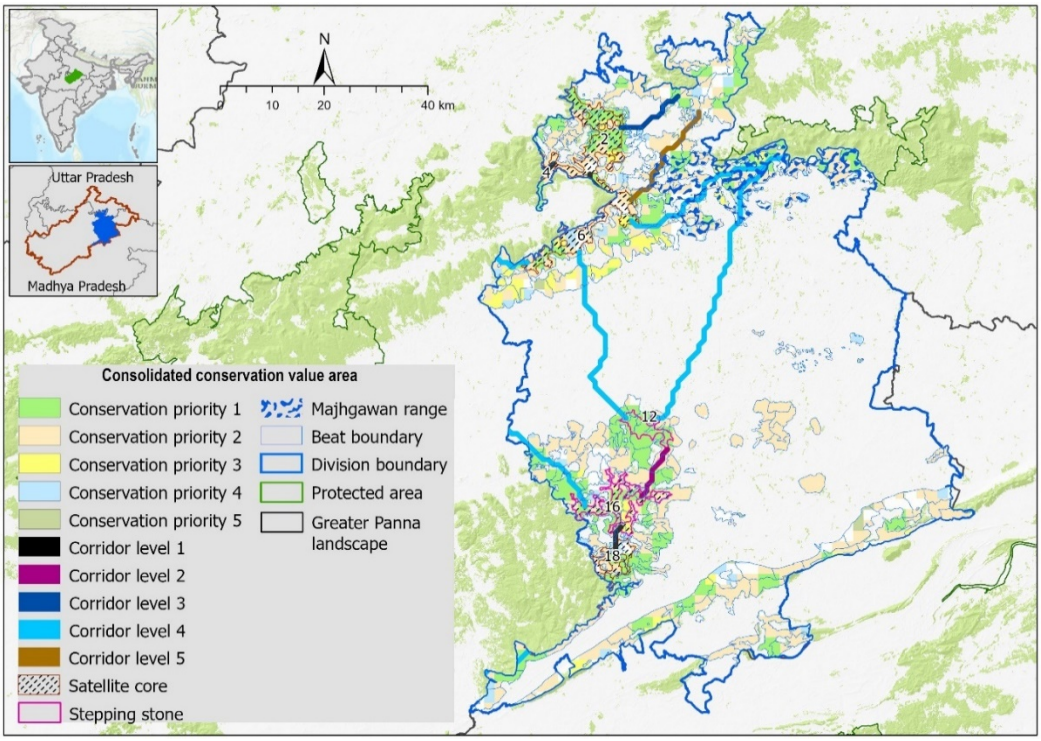


Figure 10.51. Map showing all the areas to be protected and restored (satellite cores, stepping stones, corridors, proposed tiger, reserve, priority sites for biodiversity conservation) within the Satna Forest Division

(3) Chhatarpur Forest Division

1. **Habitat Protection** is required for the two satellite cores, three stepping stones, three steppingstone/ satellite core and 21 corridors (two priority I, four priority II, six priority III, five priority IV, and four priority V) identified in this division (Fig. 10.52) and this needs to be protected from community dependency and development activities including mining.
2. **River Conservation Zone** (1km width) around part of Ken River (Fig. 10.52) should be conserved through community-based conservation and restoration methods. There are tourism industries, fishing activities and agriculture practices along the downstream of the Ken River from PTR to KGS, and these stakeholders can be brought under co-management approach to ensure river zone integrity.
3. **Structural Interventions** (overpass and underpass) should be made at points where major roads are cutting through the proposed corridors (Fig. 10.53).
4. **Biodiversity Management Committee** should be activated to monitor and conserve the highest conservation priority areas for vultures and biodiversity (Fig. 10.54; 10.55).

Based on the information collected, access and benefit sharing should be made a part of Gram Panchayat Development Plan.

5. **One Village One Hectare** concept for restoration of areas that have been significantly negatively altered, where forest cover has declined drastically, should be considered (Fig. 10.56). This intervention can involve social forestry, integrated farming, ecosystem service trade-off and carbon economy, and can be subjected to payment for ecosystem service (PES) model at state and national level. Restoration efforts should initially be focussed on negatively altered forests falling within the priority I class of spatial prioritization, and then on priority II, and so on (Fig. 10.57).

6. **Convergence for Consolidation and Restoration:** As indicated above, Fig. 10.58 provides the combined value for PTR, these identified targets should be the focus for habitat consolidation, protection and restoration.

7. **Green Economy Cooperatives and Growth Centres** should be established in selected Panchayat/Village for Amla (Deori, Bhorkuwa, Chandanpura, Baranand, Gopalpura, and Goranand), for Mahua (Kesara, Simariya kalan, Dhanguwan, Chandanpura, Tikari and Sironj), for Tendu (Kesara, Basaraui, Kabar, Motigarh and Bhorkhuwa) and for Achar (Kesara, Punguwa, Bhorkuwa, Patna, Chandanpura, Siddhai, Baranand, Tikari and Goranand).

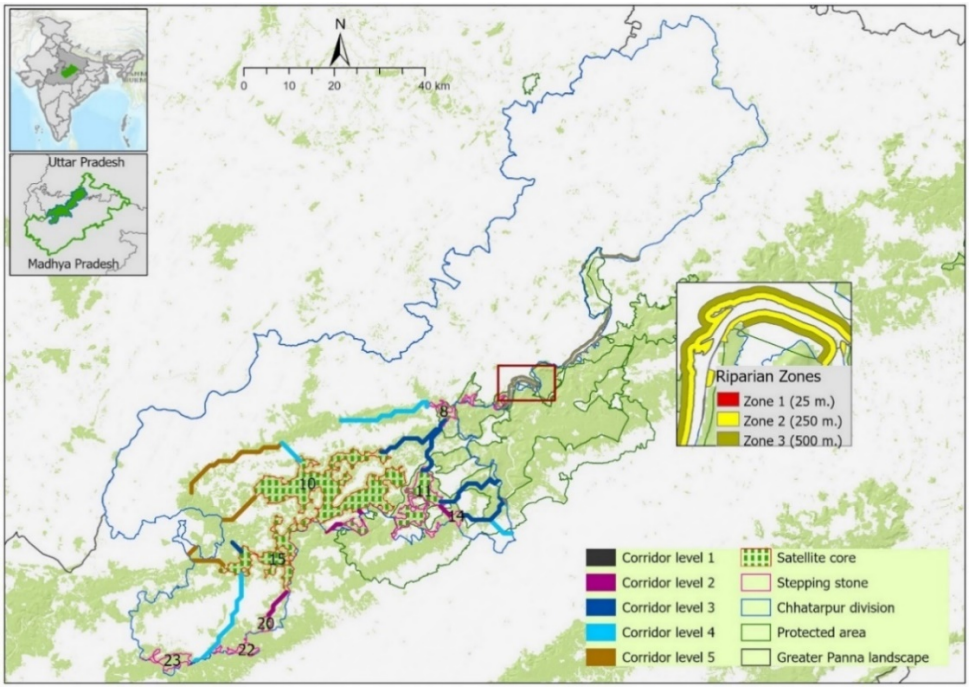


Figure 10.52. Map showing areas to be consolidated (satellite cores, stepping stones, corridors and river conservation zone) in Chhatarpur Forest Division

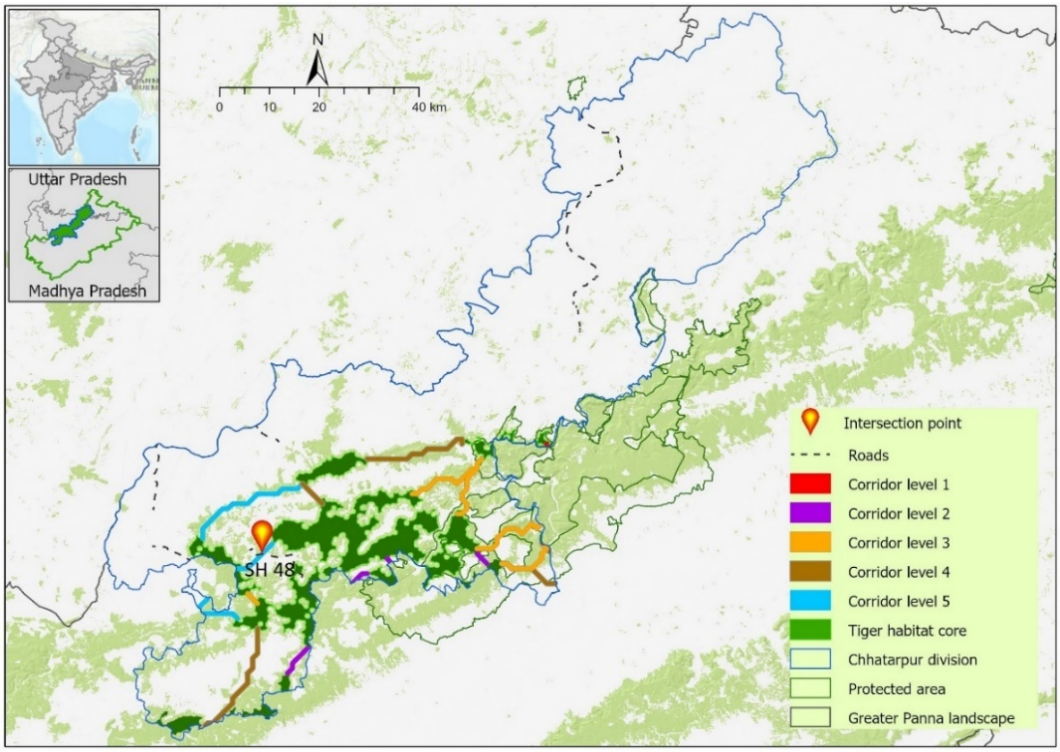


Figure 10.53. Map showing points where major roads are intersecting with proposed corridors in Chhatarpur Forest Division for structural interventions

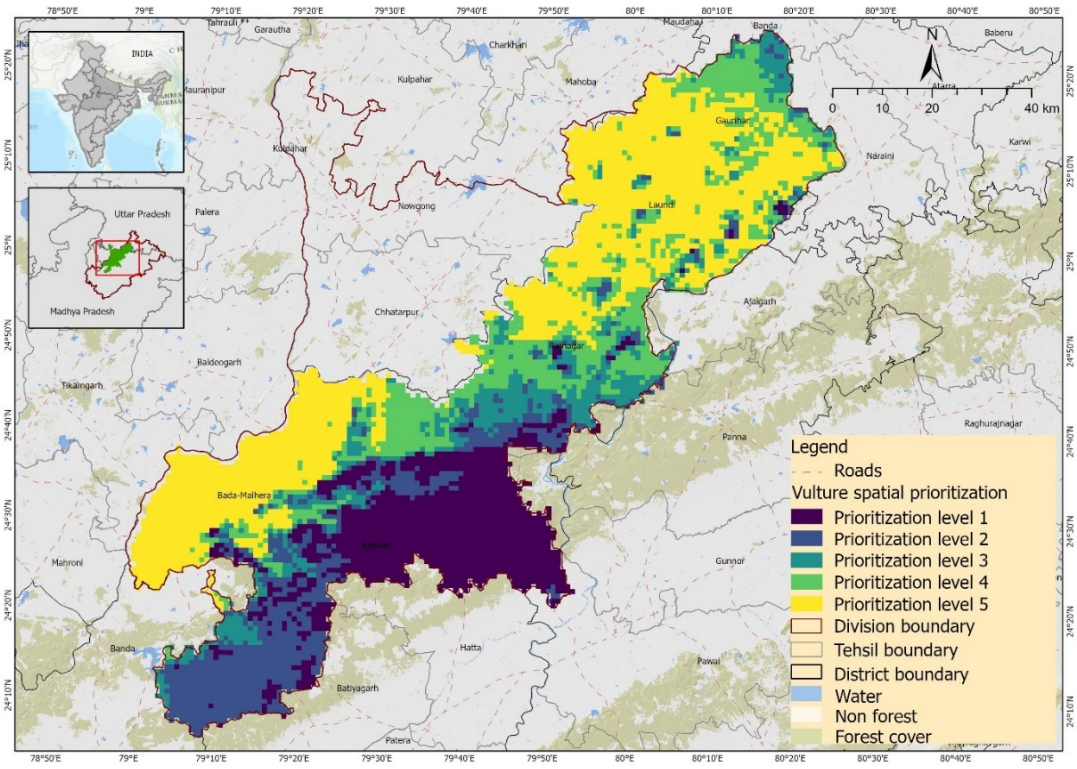


Figure 10.54. Map showing vulture conservation priority areas within Chhatarpur Forest Division

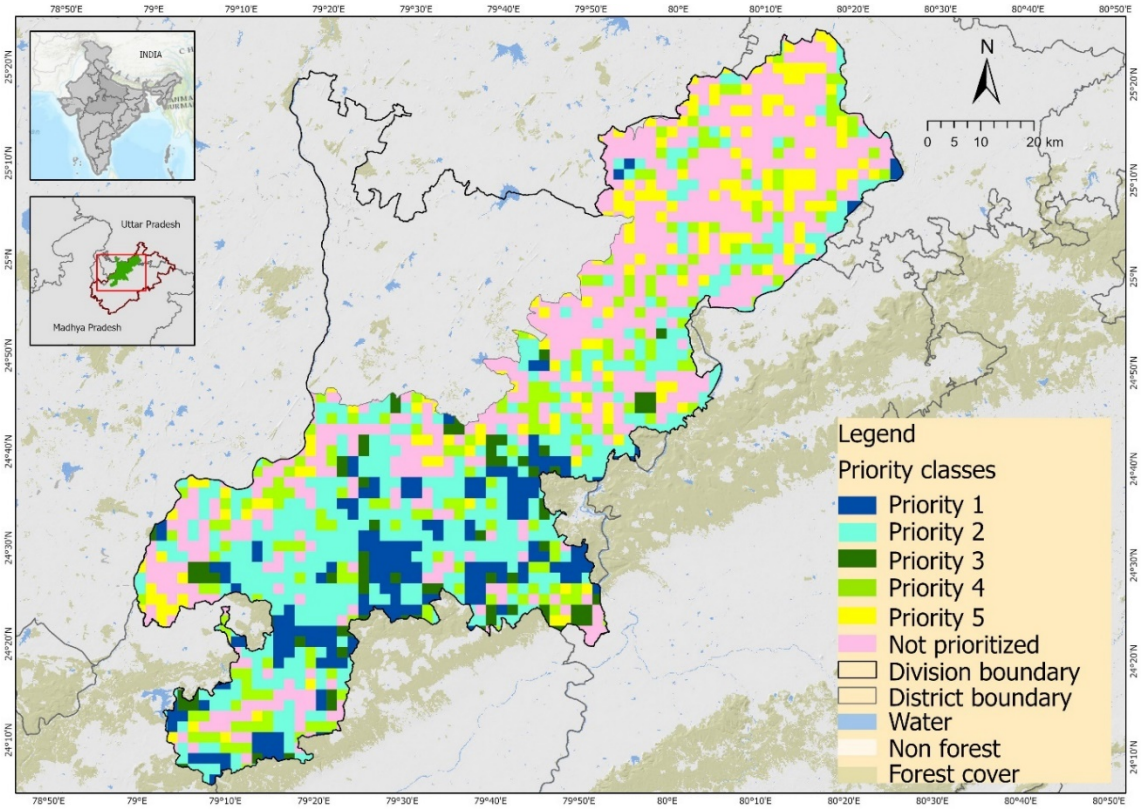


Figure 10.55. Priority areas for conservation in Chhatarpur Forest Division

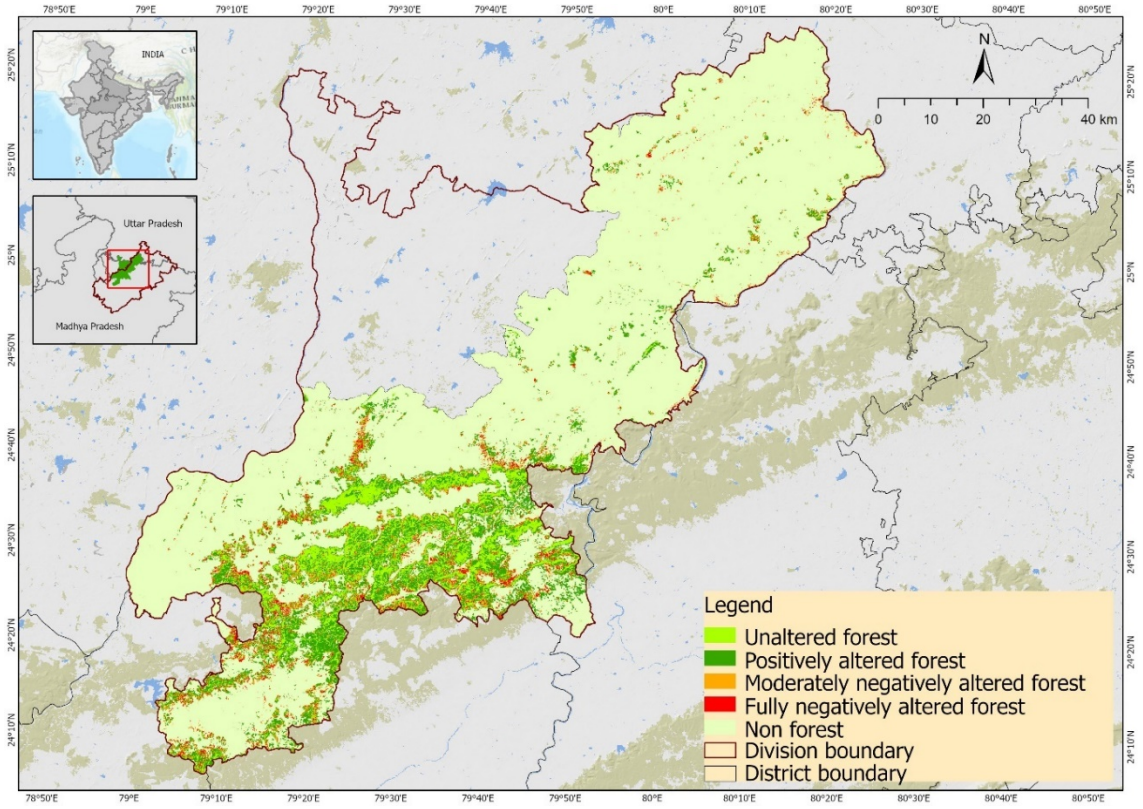


Figure 10.56. Map showing altered-unaltered landscape within Chhatarpur Forest Division

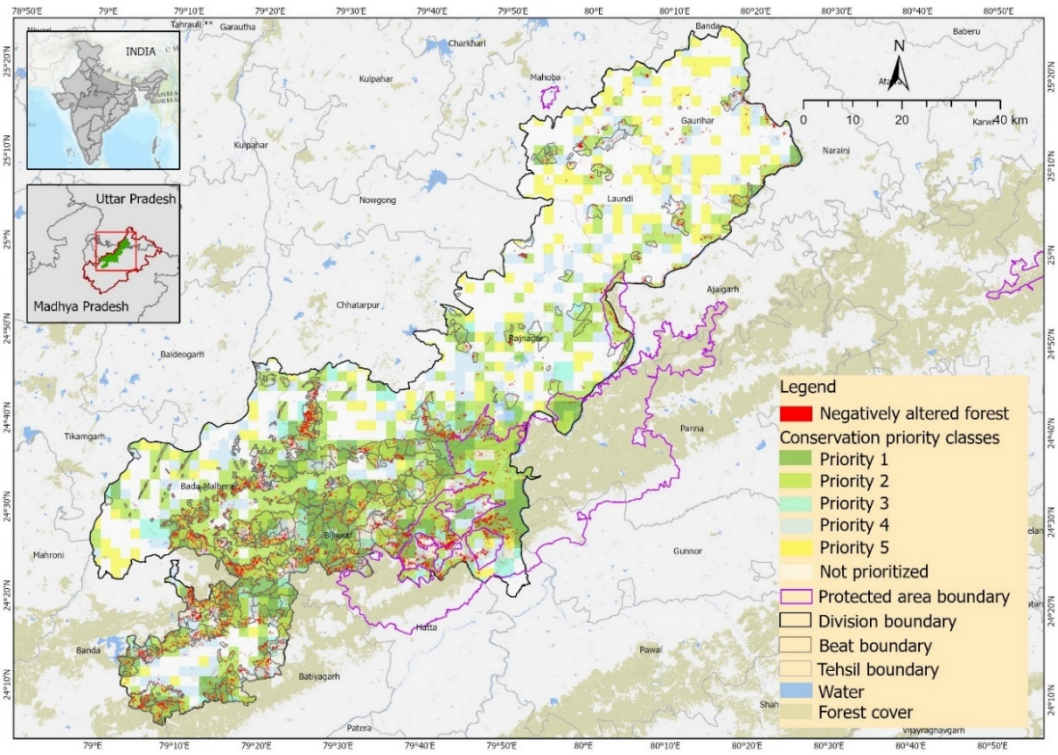


Figure 10.57. Map showing negatively altered landscape overlaid on priority areas of conservation within Chhatarpur Forest Division

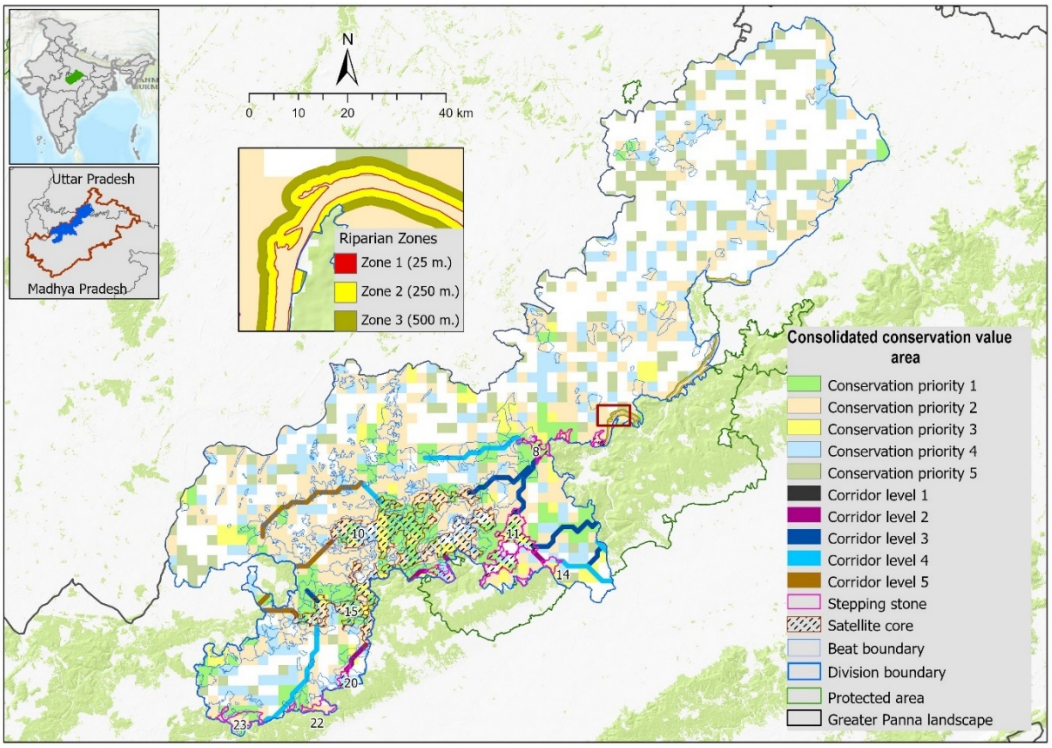


Figure 10.58. Map showing all the areas to be protected and restored (satellite cores, stepping stones, corridors, proposed community reserve, priority sites for biodiversity conservation) within the Chhatarpur Forest Division

(4) South Panna Forest Division

1. **Habitat Protection** is required for the two satellite cores, two satellite core/steppingstone, and eight corridors (one priority I, one priority II, five priority IV, and one priority V) identified in this division (Fig. 10.59) and this needs to be protected from community dependency and development activities including mining.
2. **Structural Interventions** (overpass and underpass) should be made at points where major roads are cutting through the proposed corridors (Fig. 10.60).
3. **River Conservation Zone** (1km width) around part of Ken, Patne and Bearma Rivers, which connects South Panna Forest Division and PTR should be declared as Community Reserve or Eco-sensitive Zone (Fig. 10.59). This intervention would involve social forestry, integrated farming, ecosystem service trade-off and carbon economy including the option to implement One Village One Hectare green cover development program.
4. **Conservation Reserves** should be established consisting of Kalda and Saleha Ranges (Fig. 10.59) with focus on tiger and Pawai Range with focus on vultures (Fig. 10.61).
5. **Biodiversity Management Committee** should be activated to monitor and conserve the highest conservation priority areas for vultures and biodiversity (Fig. 10.61; 10.62). Based on the information collected, access and benefit sharing should be made a part of Gram Panchayat Development Plan.
6. **One Village One Hectare** concept for restoration of areas that have been significantly negatively altered, where forest cover has declined drastically, should be considered (Fig. 10.63). This intervention can involve social forestry, integrated farming, ecosystem service trade-off and carbon economy, and can be subjected to payment for ecosystem service (PES) model at state and national level. Restoration efforts should initially be focussed on negatively altered forests falling within the priority I class of spatial prioritization, and then on priority II, and so on (Fig. 10.64).
7. **Convergence for Consolidation and Restoration:** As indicated above, Fig. 10.65 provides the combined value for PTR, these identified targets should be the focus for habitat consolidation, protection and restoration.

8. **Green Economy Cooperatives and Growth Centres** should be established in selected Panchayat/Village for Amla (Kadhna, Sarra and Banjari), for Mahua (Piparia Pathar and Sarra), and for Achar (Pipariya Pathar and Ghutehi).

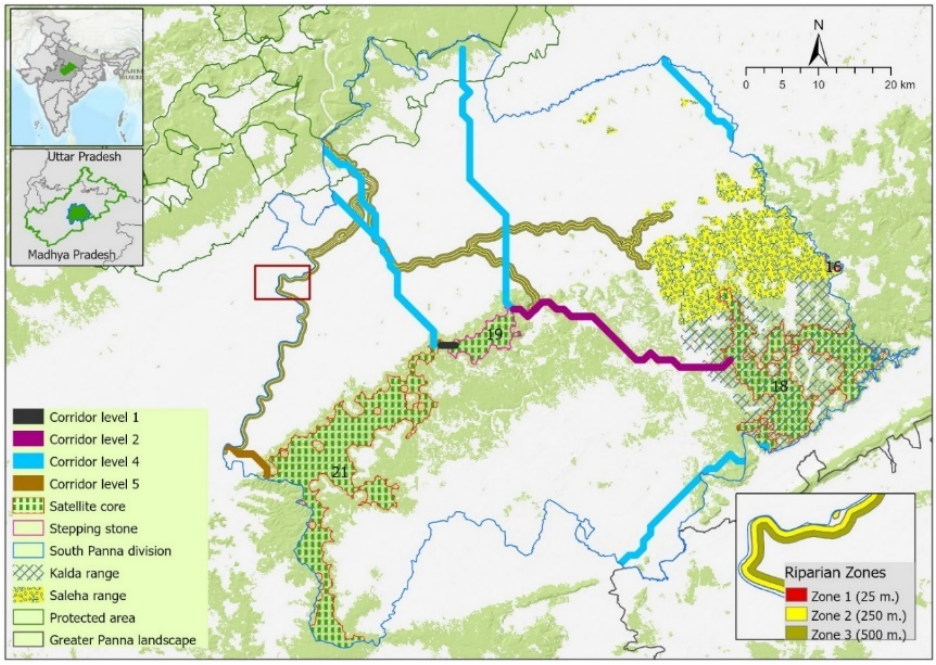


Figure 10.59. Map showing areas to be consolidated (satellite cores, stepping stones, corridors, river conservation zone, and Kalda & Saleha Ranges) in South Panna Forest Division

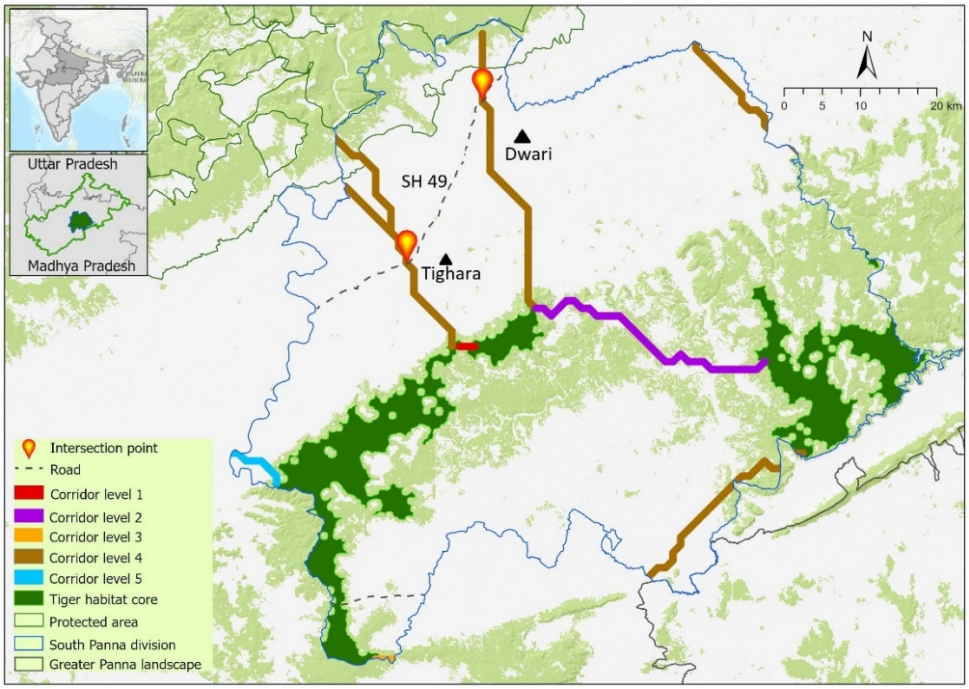


Figure 10.60. Map showing points where major roads are intersecting with proposed corridors in South Panna Forest Division for structural interventions

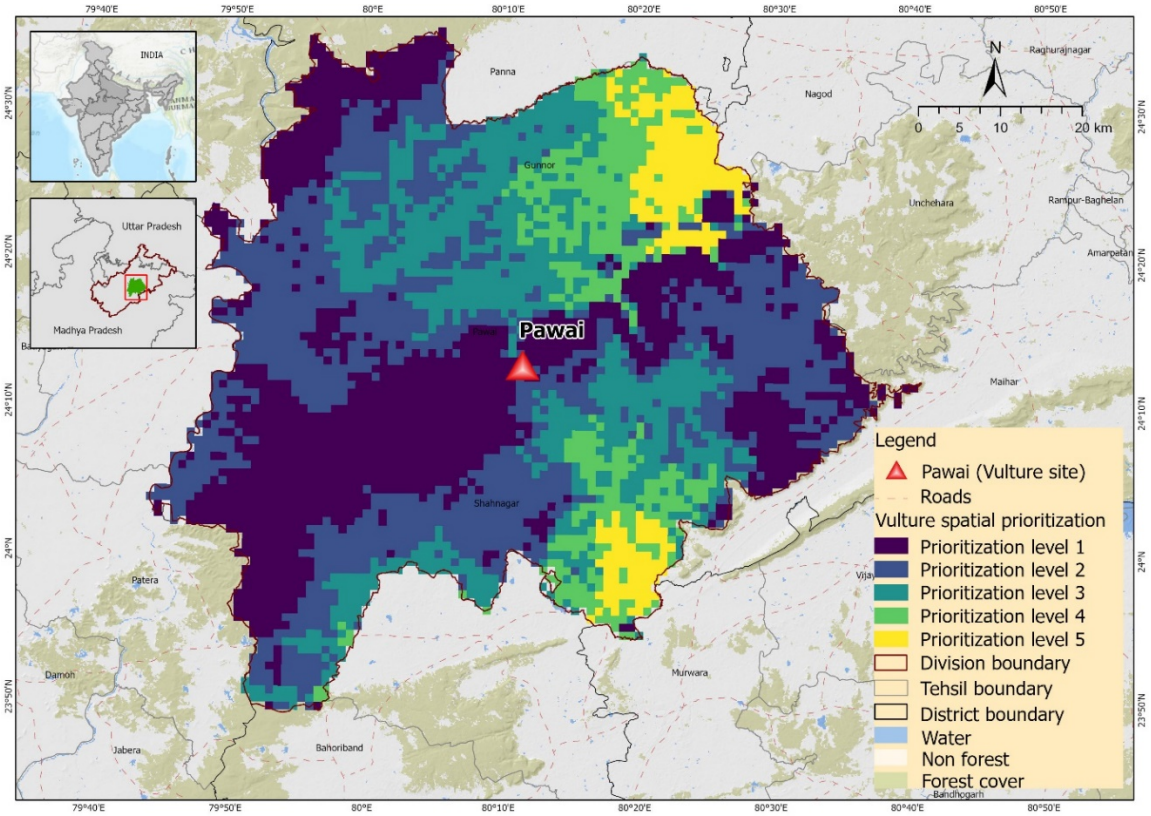


Figure 10.61. Map showing vulture conservation priority areas within South Panna Forest Division

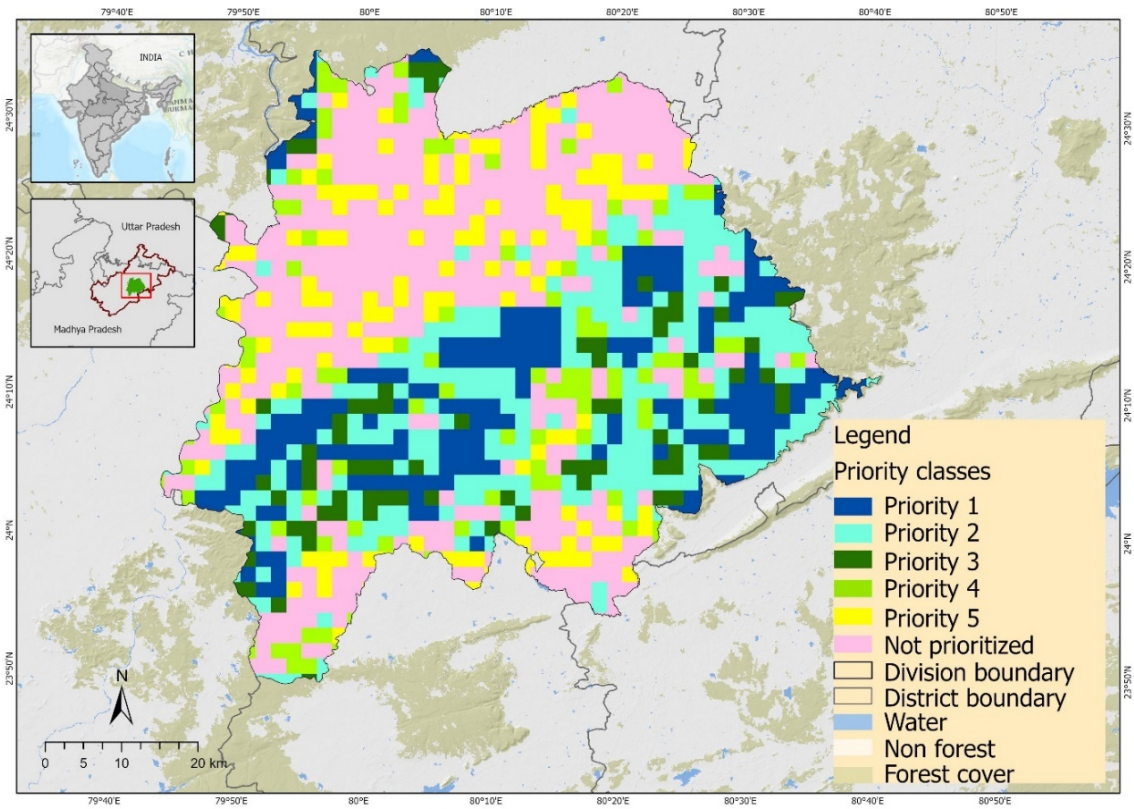


Figure 10.62. Priority areas for conservation in South Panna Forest Division

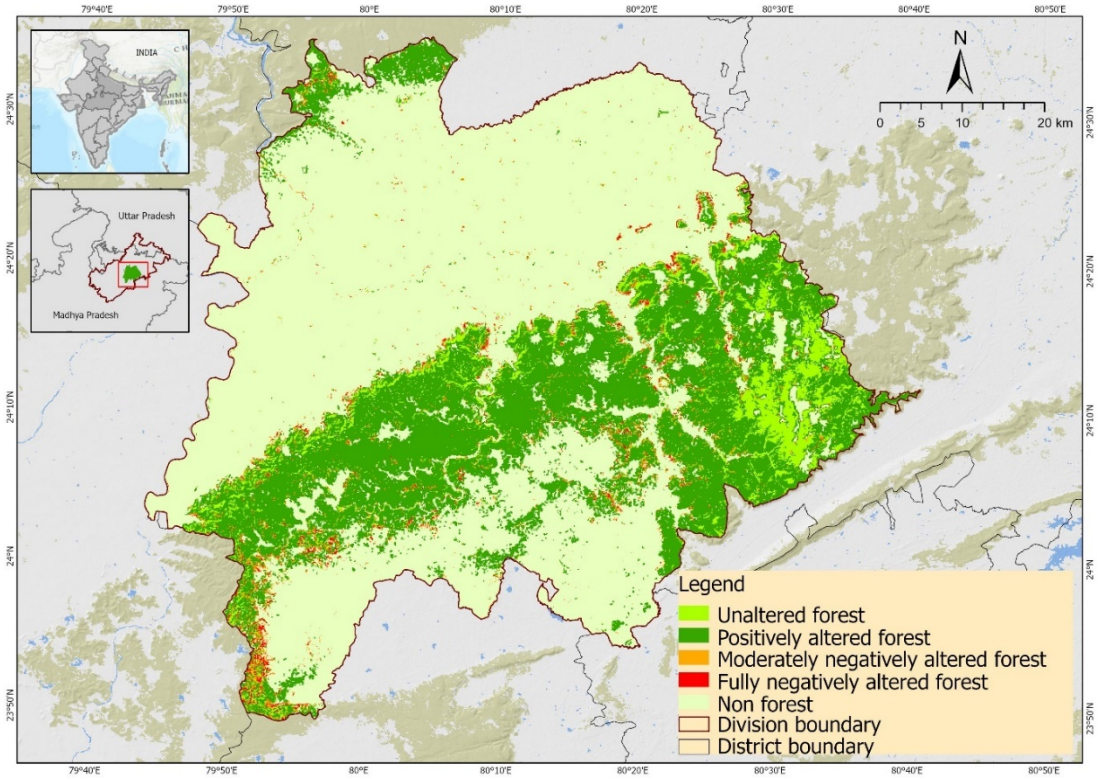


Figure 10.63. Map showing altered-unaltered landscape within South Panna Forest Division

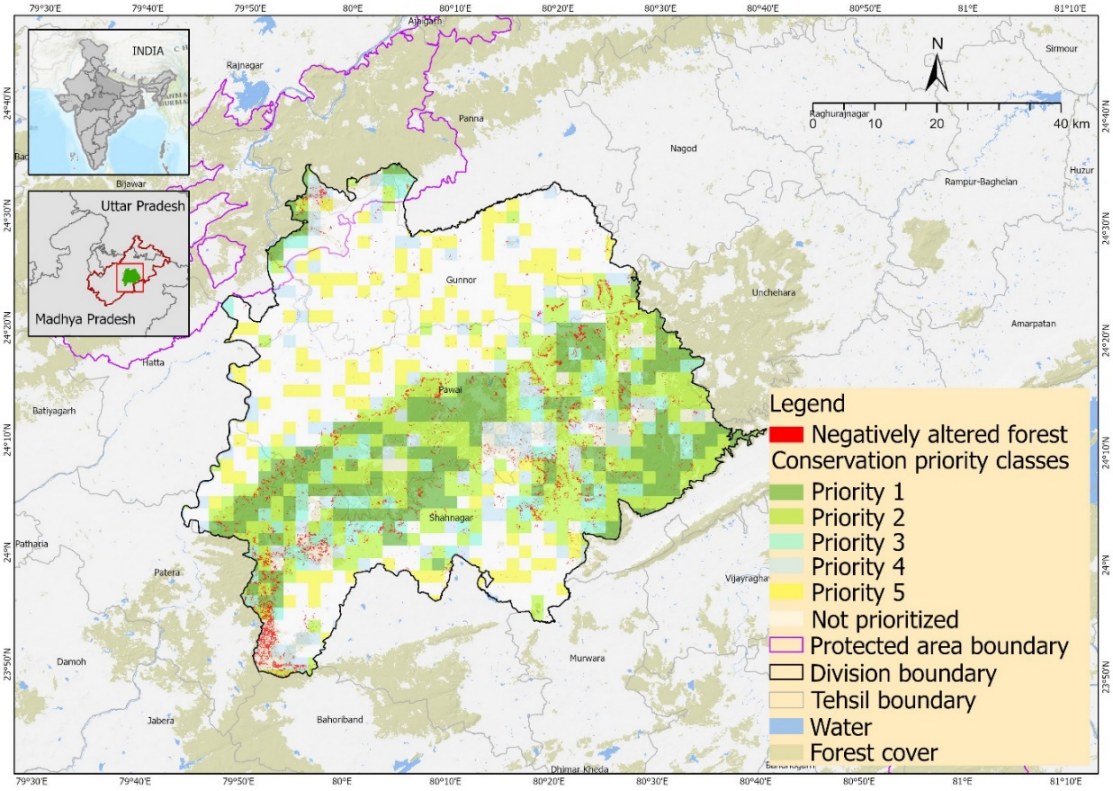


Figure 10.64. Map showing negatively altered landscape overlaid on priority areas of conservation within South Panna Forest Division

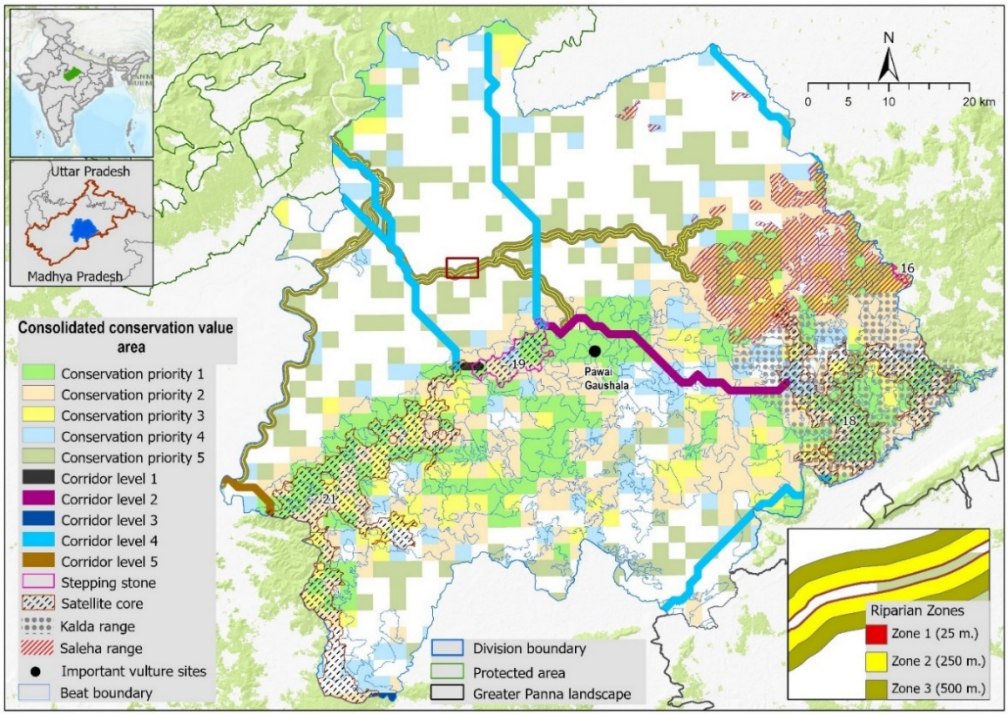


Figure 10.65. Map showing all the areas to be protected and restored (satellite cores, stepping stones, corridors, proposed conservation and community reserves, priority sites for biodiversity conservation) within the South Panna Forest Division

(5) South Sagar Forest Division

1. **Habitat Protection** is required for six corridors (Two priority IV and four priority V) identified in this division (Fig. 10.66) and this needs to be protected from community dependency and development activities including mining.

2. **Structural Interventions** (overpass and underpass) should be made at points where major roads are cutting through the proposed corridors (Fig. 10.67).

3. **Biodiversity Management Committee** should be activated to monitor and conserve the highest conservation priority areas for vultures and biodiversity (Fig. 10.68; 10.69). The Rahatgarh Fort in South Sagar Forest Division should be brought under enhanced conservation focus, as Important Vulture Area (IVA) (Fig. 10.68). Based on the information collected, access and benefit sharing should be made a part of Gram Panchayat Development Plan.

4. **One Village One Hectare** concept for restoration of areas that have been significantly negatively altered, where forest cover has declined drastically, should be considered (Fig. 10.70). This intervention can involve social forestry, integrated farming,

ecosystem service trade-off and carbon economy, and can be subjected to payment for ecosystem service (PES) model at state and national level. Restoration efforts should initially be focussed on negatively altered forests falling within the priority I class of spatial prioritization, and then on priority II, and so on (Fig. 10.71).

5. **Convergence for Consolidation and Restoration:** As indicated above, Fig. 10.72 provides the combined value for PTR, these identified targets should be the focus for habitat consolidation, protection and restoration.

6. **Green Economy Cooperatives and Growth Centres** should be established in selected Panchayat/Village for Mahua (Karhad), for Tendu (Kadta, Bhonhara, Tulsipar, and Titarpani) and for Achar (Tulsipar).

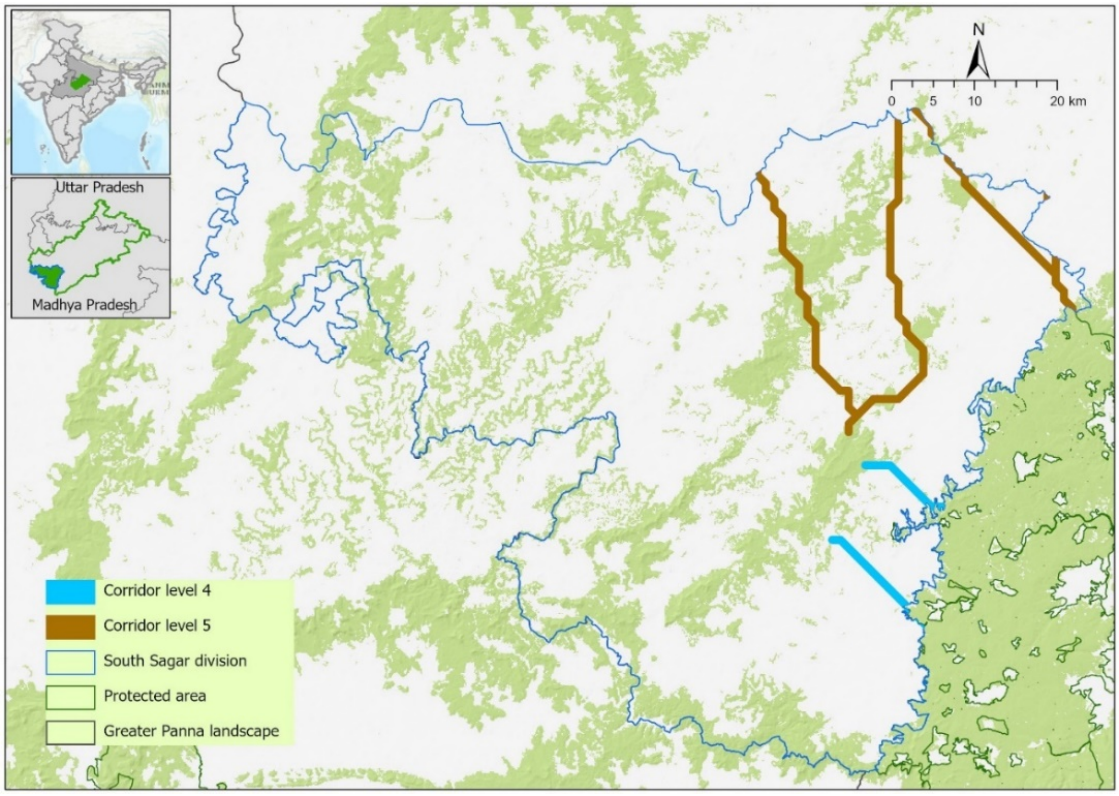


Figure 10.66. Map showing areas to be consolidated (satellite cores, stepping stones and corridors) in South Sagar Forest Division

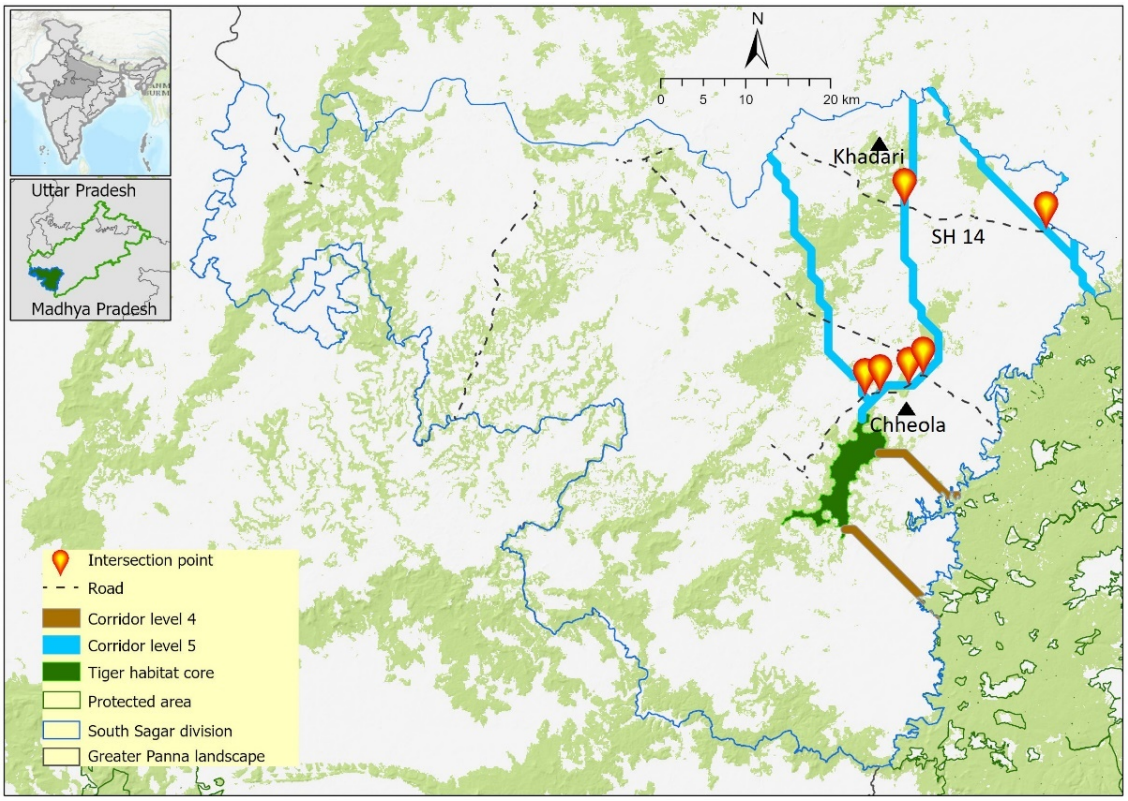


Figure 10.67. Map showing points where major roads are intersecting with proposed corridors in South Sagar Forest Division for structural interventions

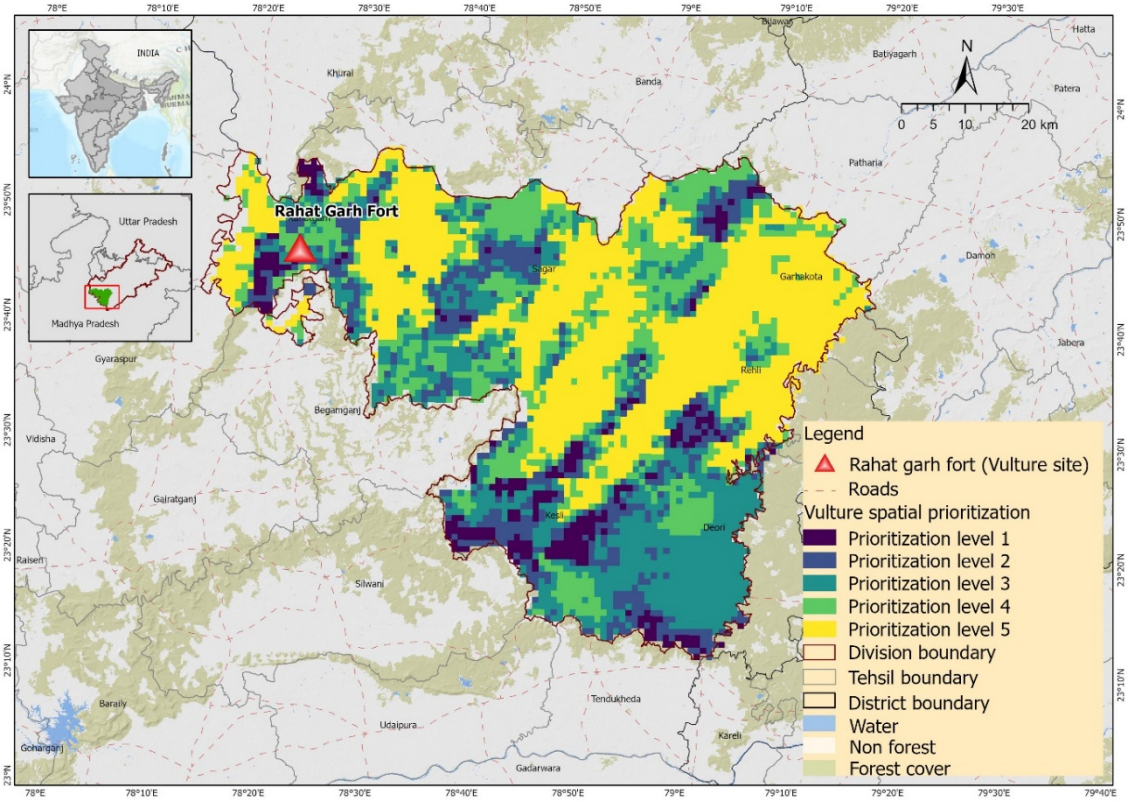


Figure 10.68. Map showing vulture conservation priority areas within South Sagar Forest Division

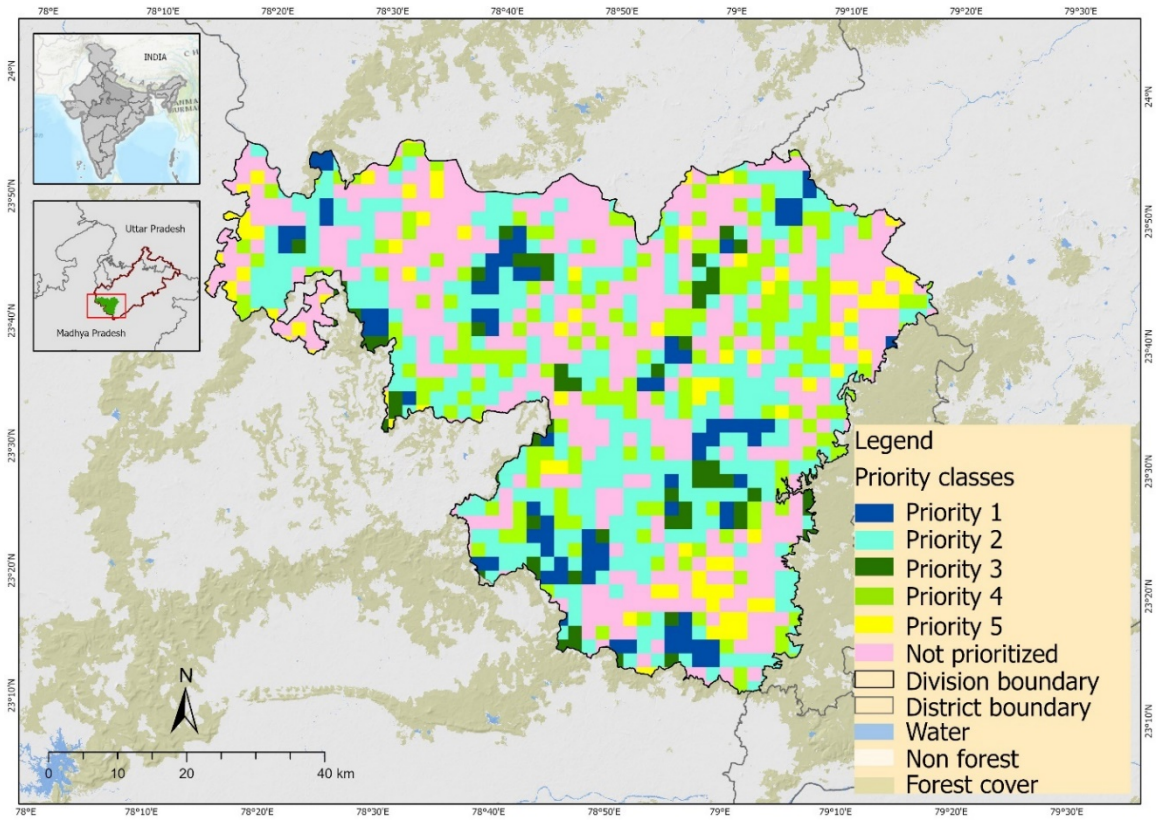


Figure 10.69. Priority areas for conservation in South Sagar Forest Division

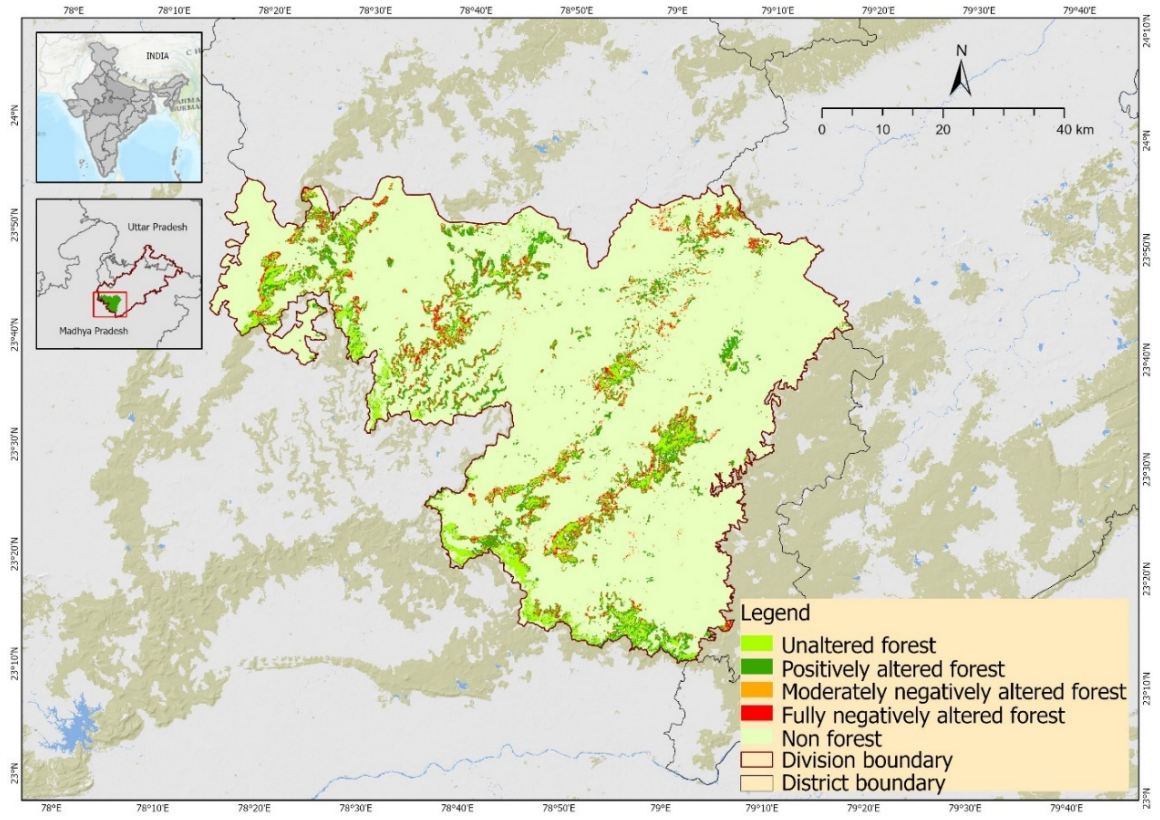


Figure 10.70. Map showing altered-unaltered landscape within South Sagar Forest Division

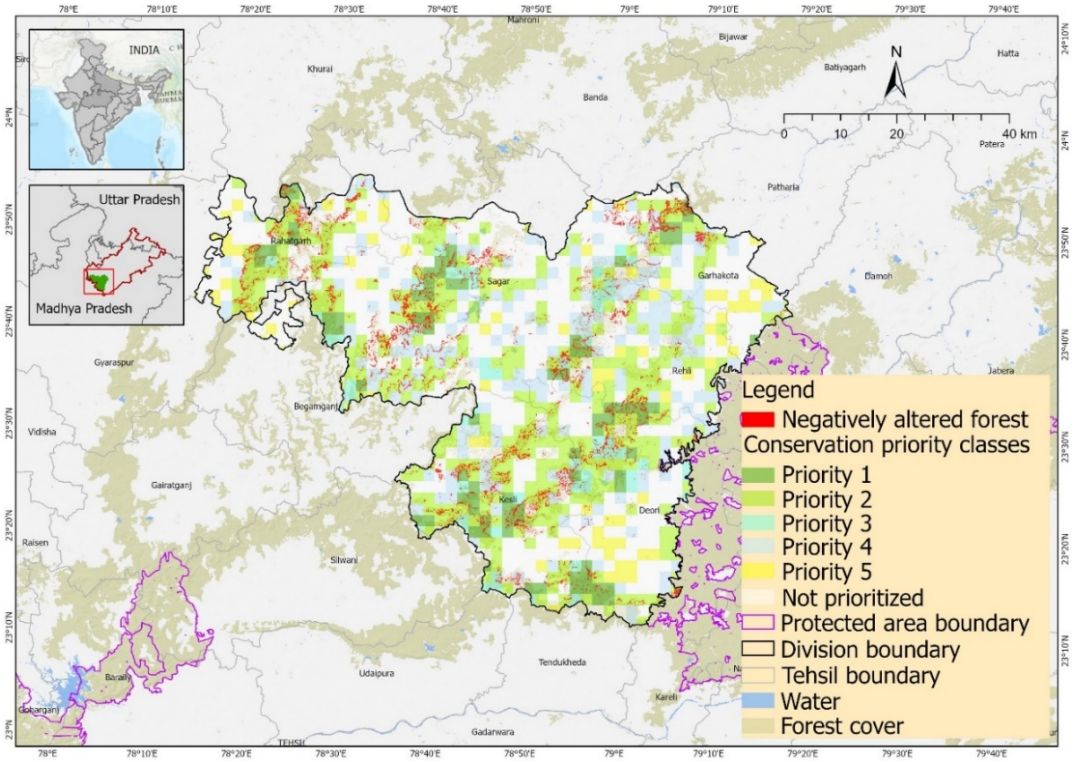


Figure 10.71. Map showing negatively altered landscape overlaid on priority areas of conservation within South Sagar Forest Division

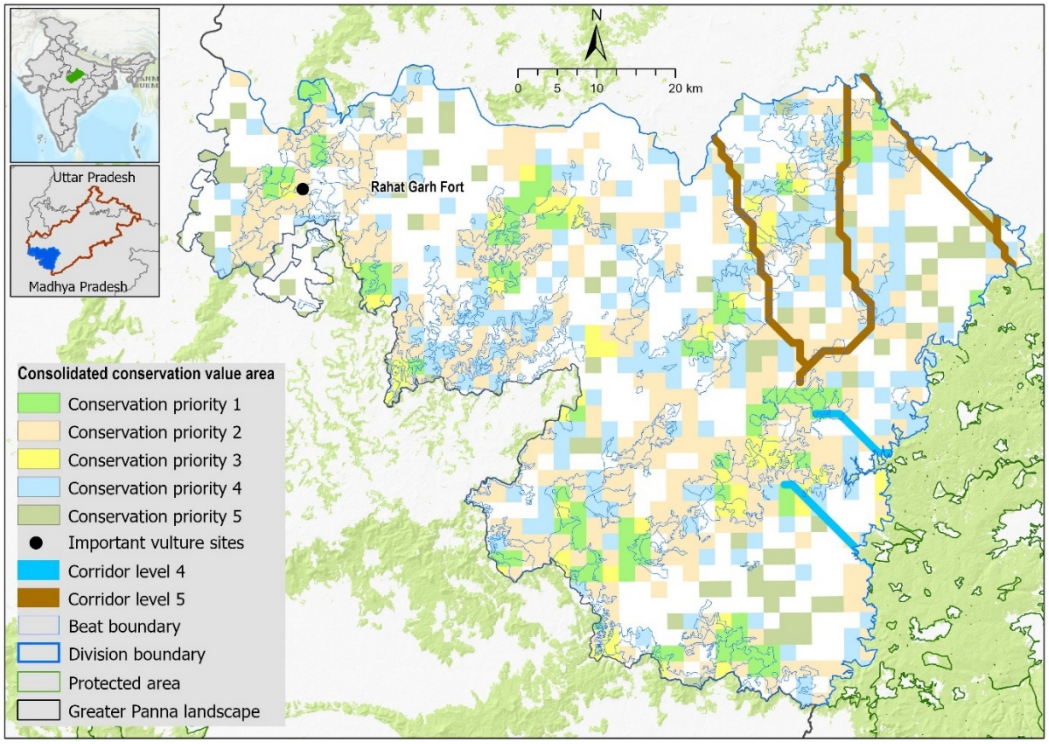


Figure 10.72. Map showing all the areas to be protected and restored (corridors, proposed community reserve, priority sites for biodiversity conservation) within the South Sagar Forest Division

(6) North Sagar Forest Division

1. **Habitat Protection** is required for one steppingstone and six corridors (One priority IV and five priority V) identified in this division (Fig. 10.73) and this needs to be protected from community dependency and development activities including mining.
2. **Structural Interventions** (overpass and underpass) should be made at points where major roads are cutting through the proposed corridors (Fig. 10.74).
3. **Biodiversity Management Committee** should be activated to monitor and conserve the highest conservation priority areas for vultures and biodiversity (Fig. 10.75; 10.76). Based on the information collected, access and benefit sharing should be made a part of Gram Panchayat Development Plan.
4. **One Village One Hectare** concept for restoration of areas that have been significantly negatively altered, where forest cover has declined drastically, should be considered (Fig. 10.77). This intervention can involve social forestry, integrated farming, ecosystem service trade-off and carbon economy, and can be subjected to payment for ecosystem service (PES) model at state and national level. Restoration efforts should initially be focussed on negatively altered forests falling within the priority I class of spatial prioritization, and then on priority II, and so on (Fig. 10.78).
5. **Convergence for Consolidation and Restoration:** As indicated above, Fig. 10.79 provides the combined value for PTR, these identified targets should be the focus for habitat consolidation, protection and restoration.
6. **Green Economy Cooperatives and Growth Centres** should be established in selected Panchayat/Village for Amla (Karai), for Mahua (Bilgay), for Tendu (Gaurar, Khurai, and Bilgay) and for Achar (Jasoda, and Gaurar).

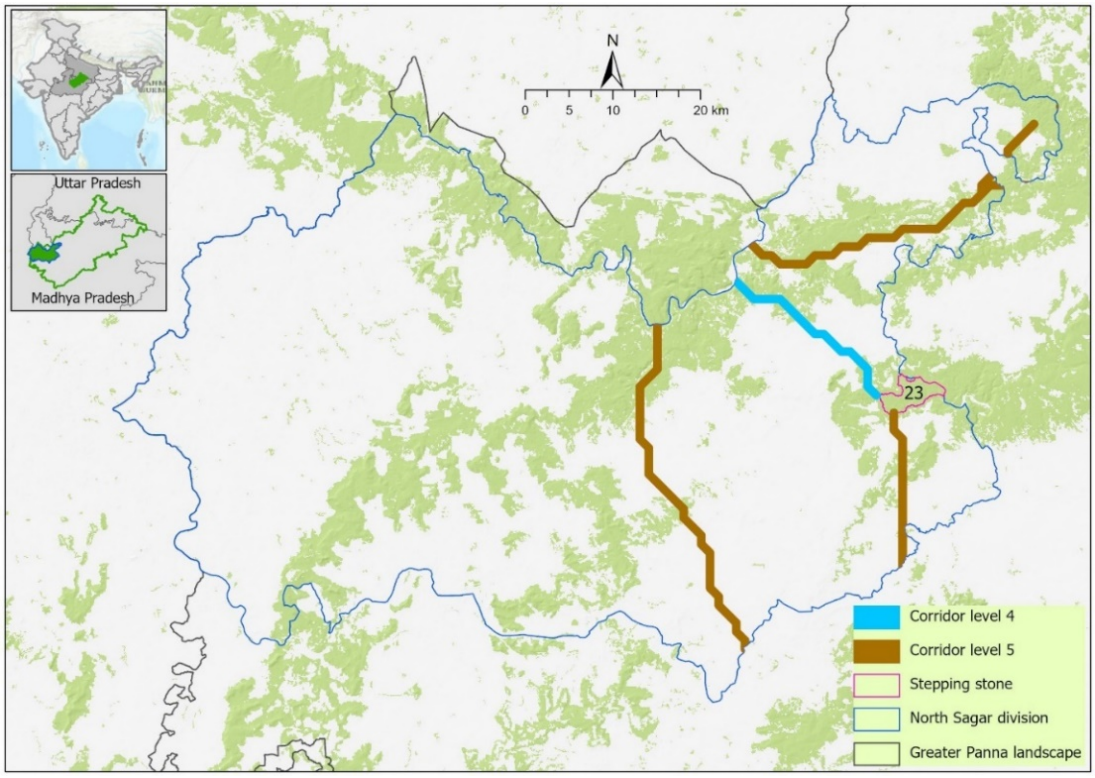


Figure 10.73. Map showing areas to be consolidated (satellite cores, stepping stones and corridors) in North Sagar Forest Division

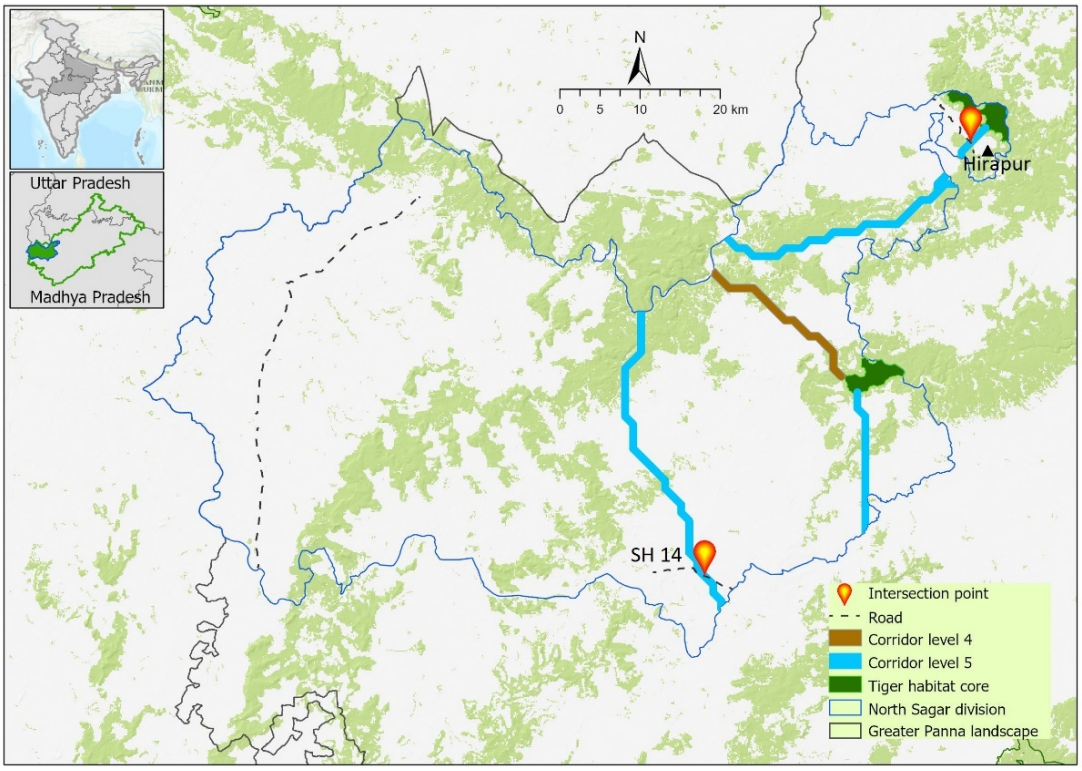


Figure 10.74. Map showing points where major roads are intersecting with proposed corridors in North Sagar Forest Division for structural interventions

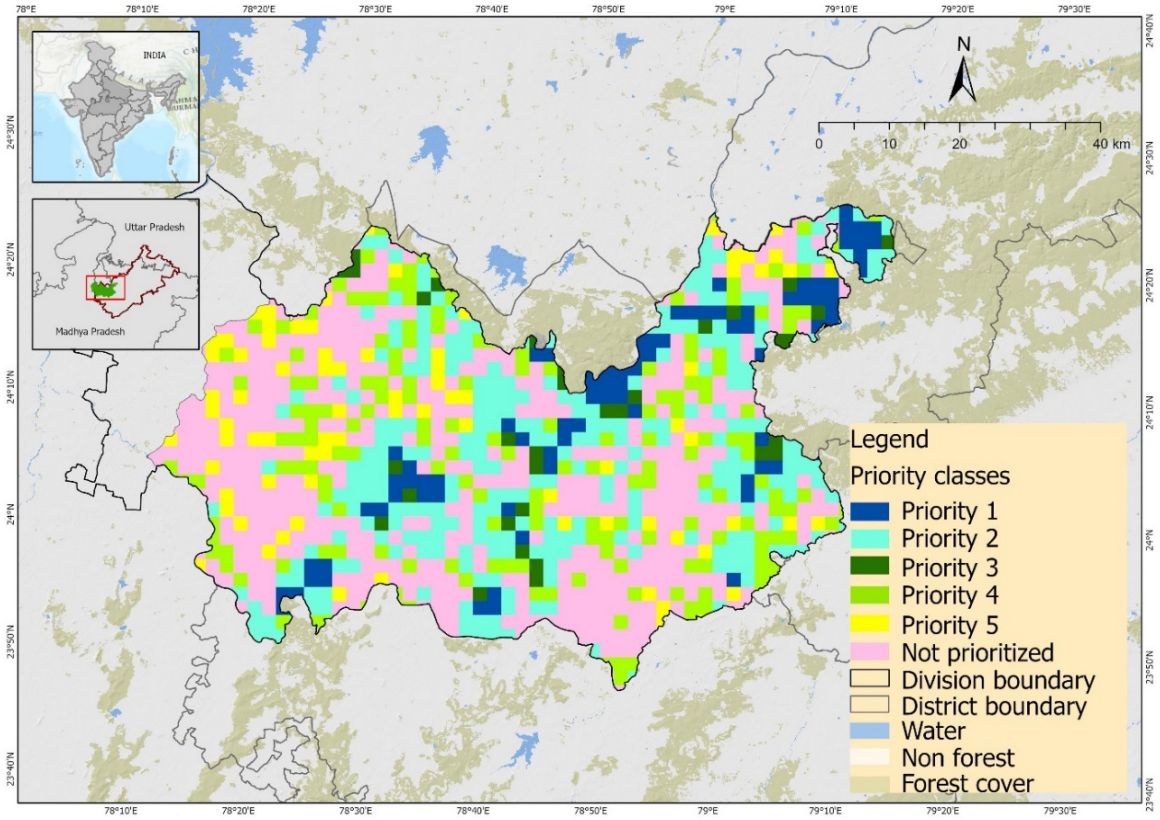


Figure 10.75. Priority areas for conservation in North Sagar Forest Division

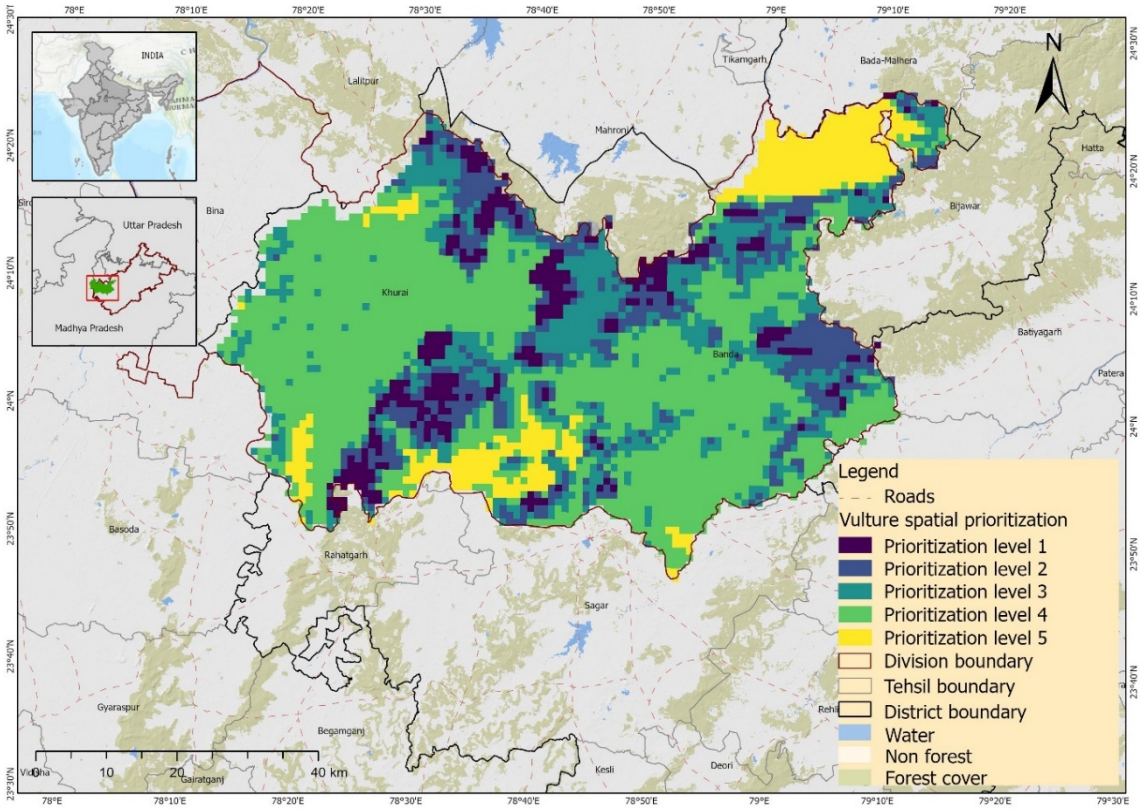


Figure 10.76. Map showing vulture conservation priority areas within North Sagar Forest Division

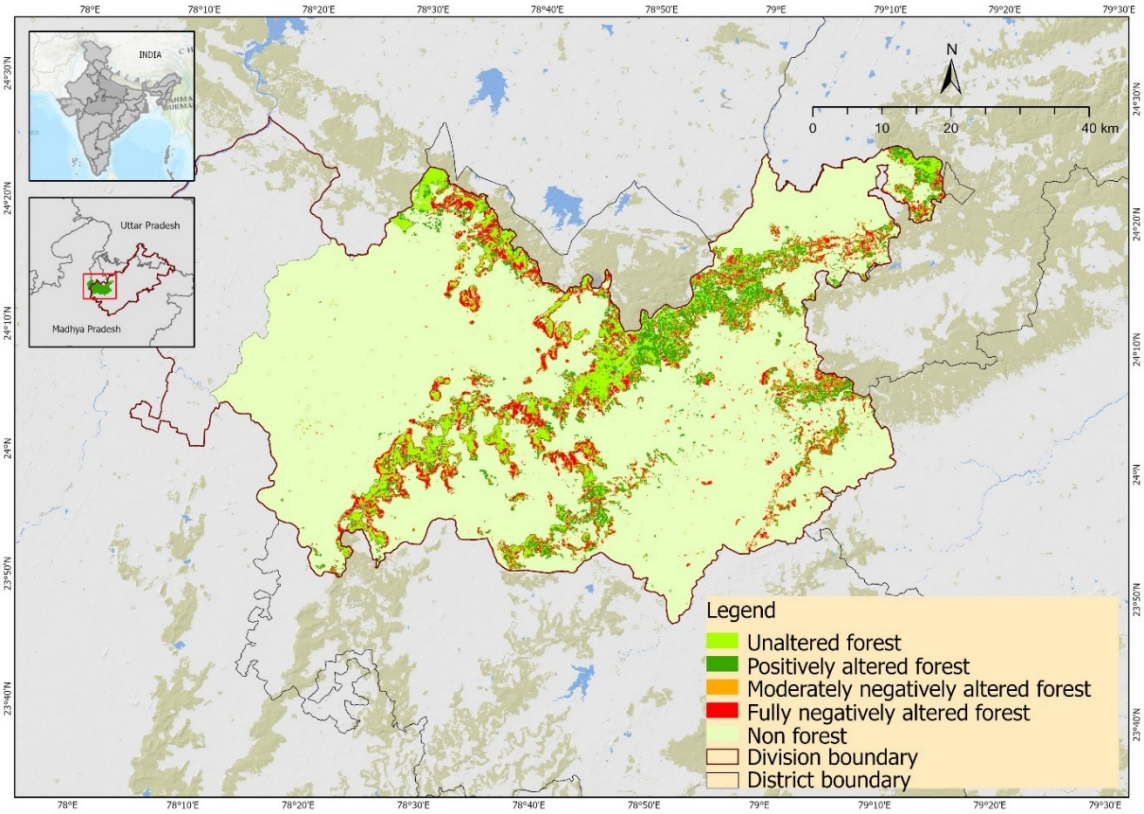


Figure 10.77. Map showing altered-unaltered landscape within North Sagar Forest Division

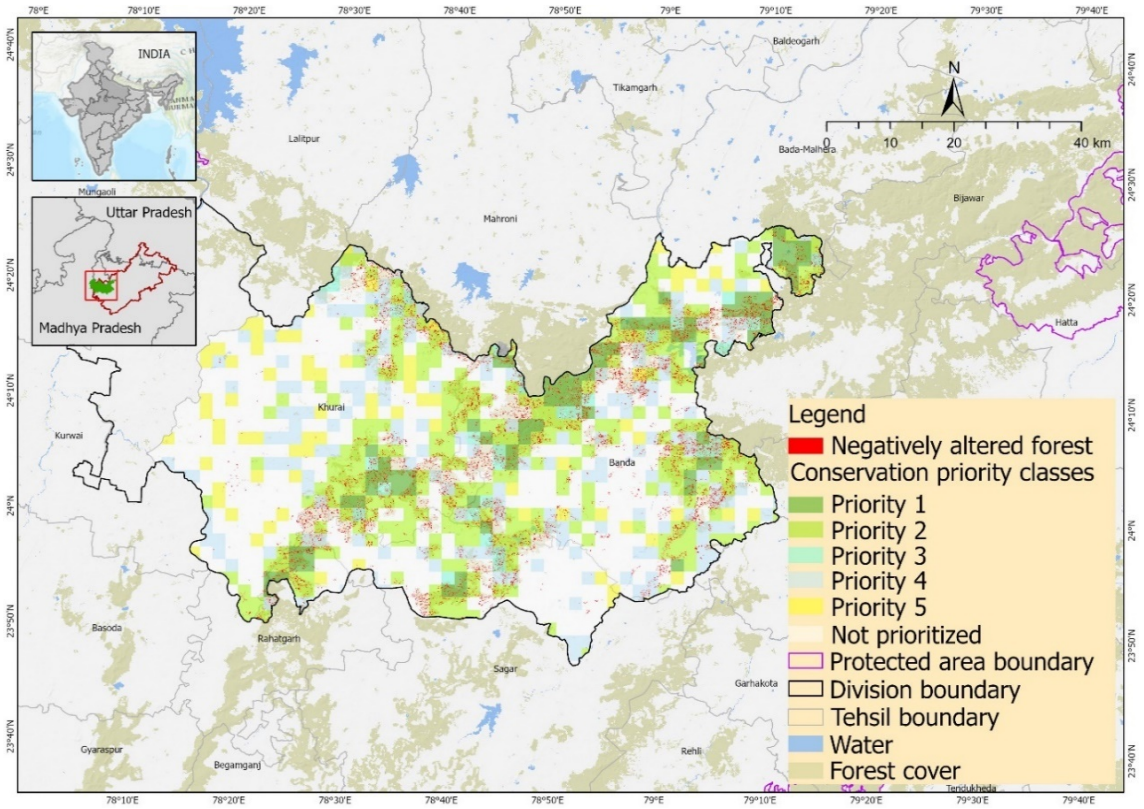


Figure 10.78. Map showing negatively altered landscape overlaid on priority areas of conservation within North Sagar Forest Division

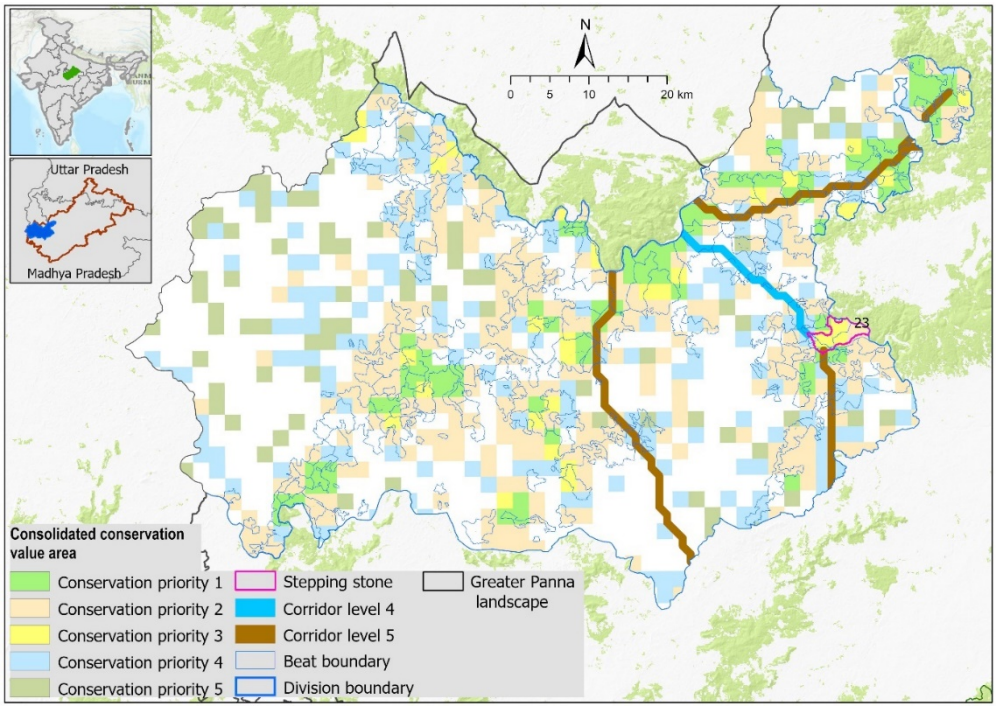


Figure 10.79. Map showing all the areas to be protected and restored (stepping stones, corridors, proposed tiger, priority sites for biodiversity conservation) within the North Sagar Forest Division

(7) North Panna Forest Division

1. **Habitat Protection** is required for the three satellite cores, one steppingstone, and eight corridors (three priority I, one priority II, three priority IV, and one priority V) identified in this District (Fig. 10.80) and this needs to be protected from community dependency and development activities including mining.

2. **River Conservation Zone** (1km width) around part of Ken River, which connects KGS and PTR should be declared as Community Reserve or Eco-sensitive Zone (Fig. 10.80). This intervention would involve social forestry, integrated farming, ecosystem service trade-off and carbon economy including the option to implement One Village One Hectare green cover development program.

3. **Biodiversity Management Committee** should be activated to monitor and conserve the highest conservation priority areas for vultures and biodiversity (Fig. 10.81; 10.82). Based on the information collected, access and benefit sharing should be made a part of Gram Panchayat Development Plan.

4. **One Village One Hectare** concept for restoration of areas that have been significantly negatively altered, where forest cover has declined drastically, should be considered (Fig. 10.83). This intervention can involve social forestry, integrated farming, ecosystem service trade-off and carbon economy, and can be subjected to payment for ecosystem service (PES) model at state and national level. Restoration efforts should initially be focussed on negatively altered forests falling within the priority I class of spatial prioritization, and then on priority II, and so on (Fig. 10.84).

5. **Convergence for Consolidation and Restoration:** As indicated above, Fig. 10.85 provides the combined value for PTR, these identified targets should be the focus for habitat consolidation, protection and restoration.

6. **Green Economy Cooperatives and Growth Centres** should be established in selected Panchayat/Village for Amla (Dahlan chowki, Ranipur, Darela, Kota Muhli, Panari, Rahuniya, and Kudakpur), for Mahua (Rahuniya), for Tendu (Rahuniya) and for Achar (Panari, and Rahuniya).

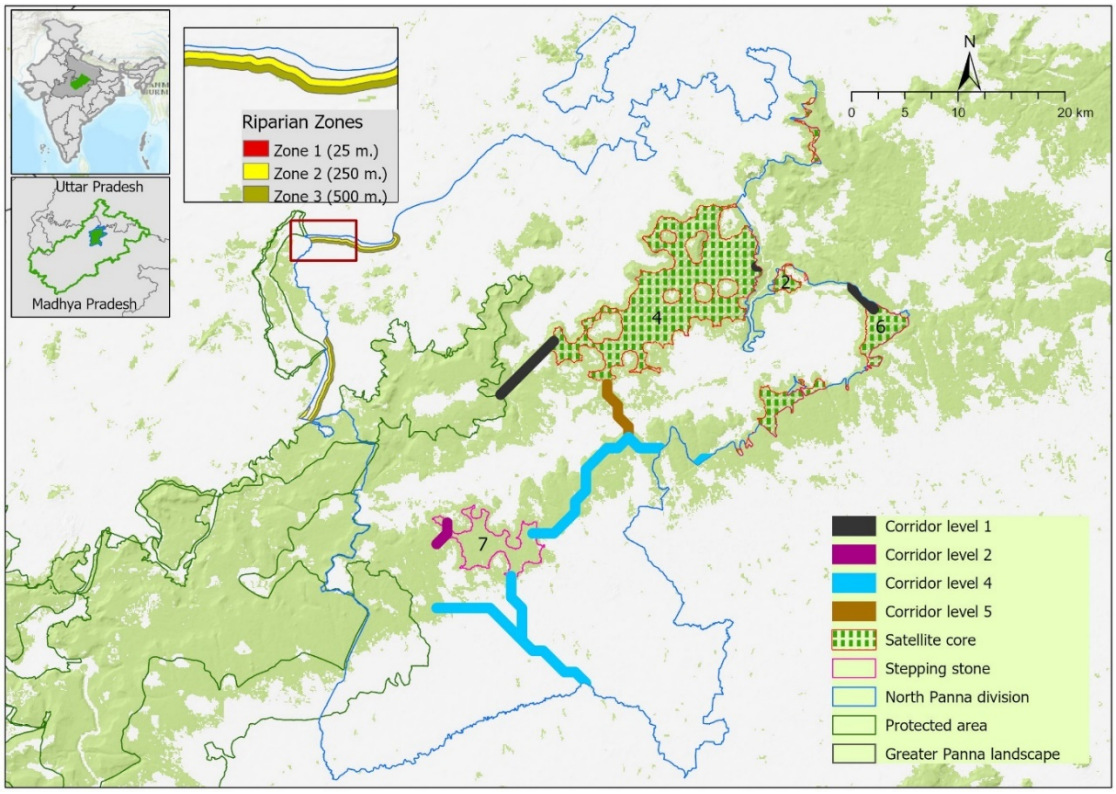


Figure 10.80. Map showing areas to be consolidated (satellite cores, stepping stones and corridors) in North Panna Forest Division

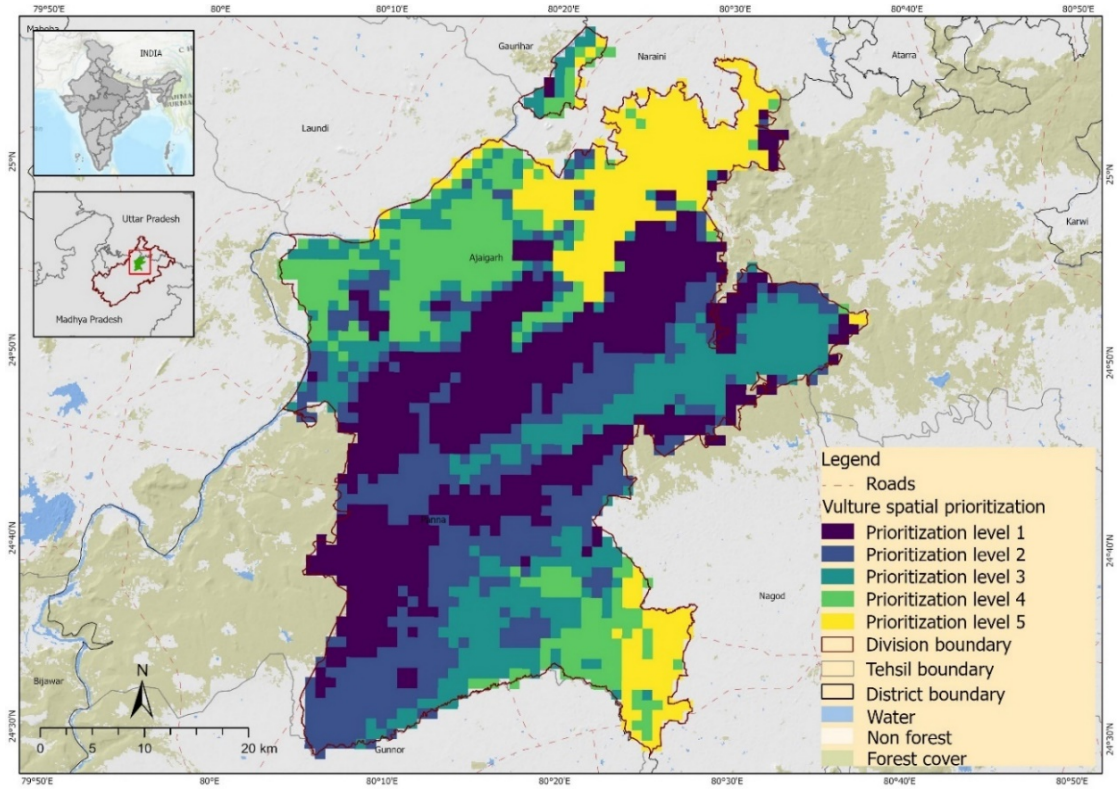


Figure 10.81. Map showing vulture conservation priority areas within North Panna Forest Division

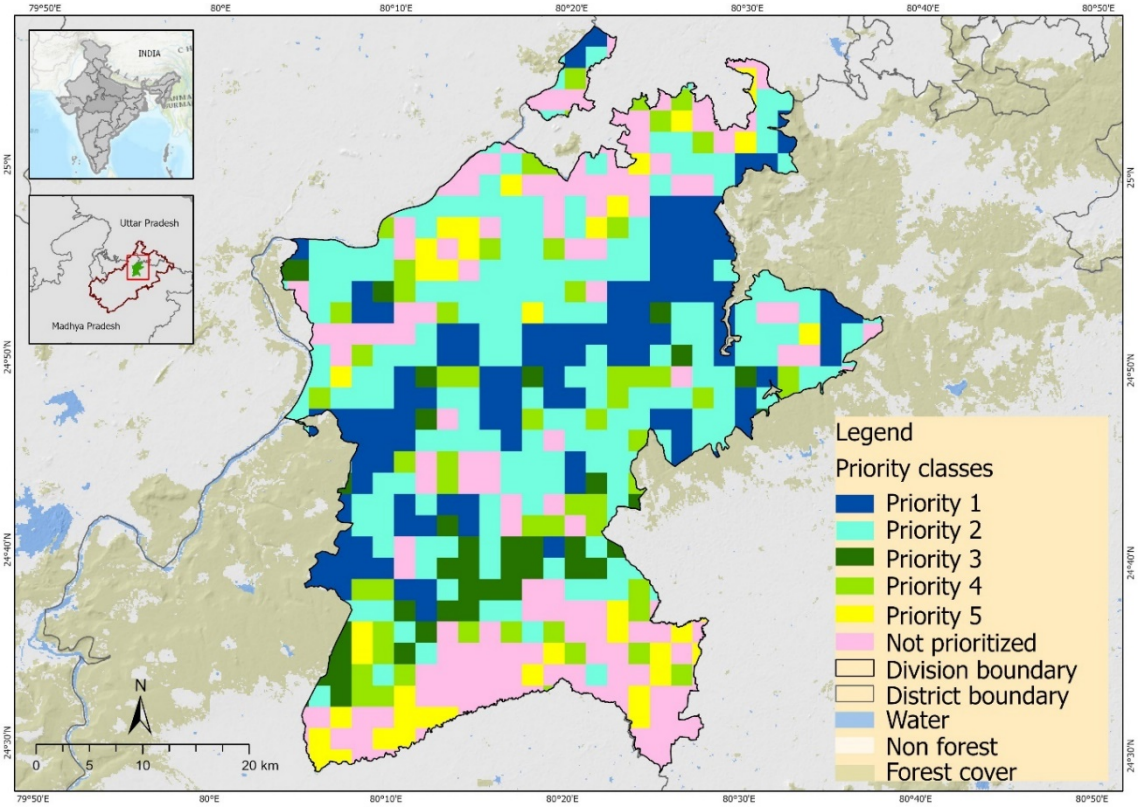


Figure 10.82. Priority areas for conservation in North Panna Forest Division

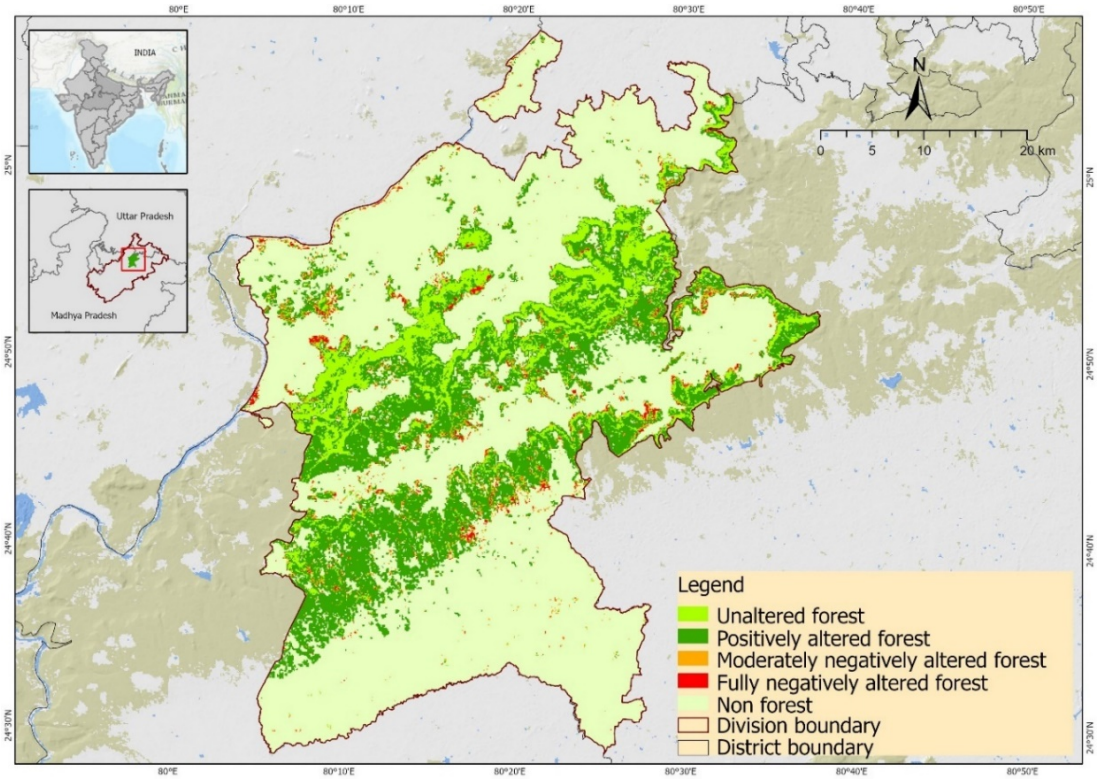


Figure 10.83. Map showing altered-unaltered landscape within North Panna Forest Division

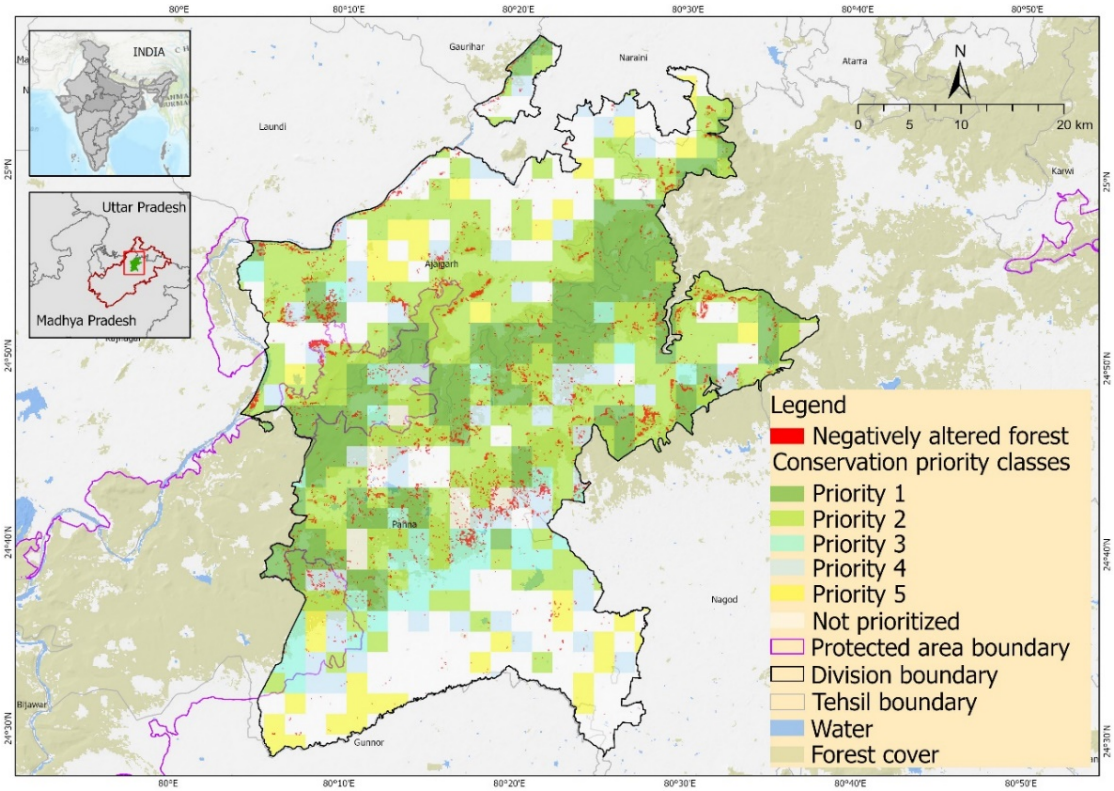


Figure 10.84. Map showing negatively altered landscape overlaid on priority areas of conservation within North Panna Forest Division

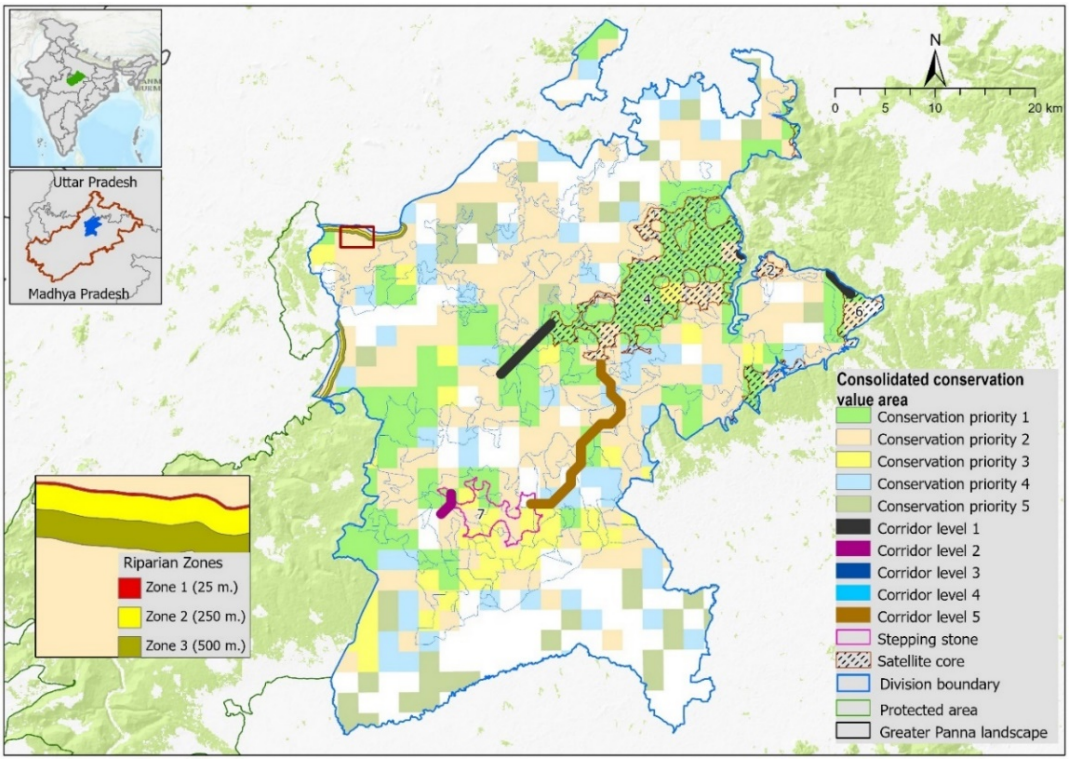


Figure 10.85. Map showing all the areas to be protected and restored (satellite cores, stepping stones, corridors, proposed community reserve, priority sites for biodiversity conservation) within the North Panna Forest Division

(8) Rewa Forest Division

1. **Inter-state Tiger Reserve**, proposed to be constituted with Ranipur Wildlife Sanctuary as core area is required, is to be supported with Semariya and Atraila Ranges of Rewa Forest Division as buffer (Fig. 10.86). This is critical for consolidating habitat and ensuring long-term survival of tigers in this recovering core area.

1. **Biodiversity Management Committee** should be activated to monitor and conserve the highest conservation priority areas for vultures and biodiversity (Fig. 10.87; 10.88). The Purwa Falls in Rewa Forest Division should be brought under enhanced conservation focus, as Important Vulture Area (IVA) (Fig. 10.87). Based on the information collected, access and benefit sharing should be made a part of Gram Panchayat Development Plan.

2. **One Village One Hectare** concept for restoration of areas that have been significantly negatively altered, where forest cover has declined drastically, should be considered (Fig. 10.89). This intervention can involve social forestry, integrated farming, ecosystem service trade-off and carbon economy, and can be subjected to payment for

ecosystem service (PES) model at state and national level. Restoration efforts should initially be focussed on negatively altered forests falling within the priority I class of spatial prioritization, and then on priority II, and so on (Fig. 10.90).

3. **Convergence for Consolidation and Restoration:** As indicated above, Fig. 10.91 provides the combined value for PTR, these identified targets should be the focus for habitat consolidation, protection and restoration.

4. **Green Economy Cooperatives and Growth Centres** should be established in selected Panchayat/Village for Amla (Mainaha) and for Mahua (Mainaha and Kolha) (these villages fall within Semariya range which may become buffer of Interstate Tiger Reserve).

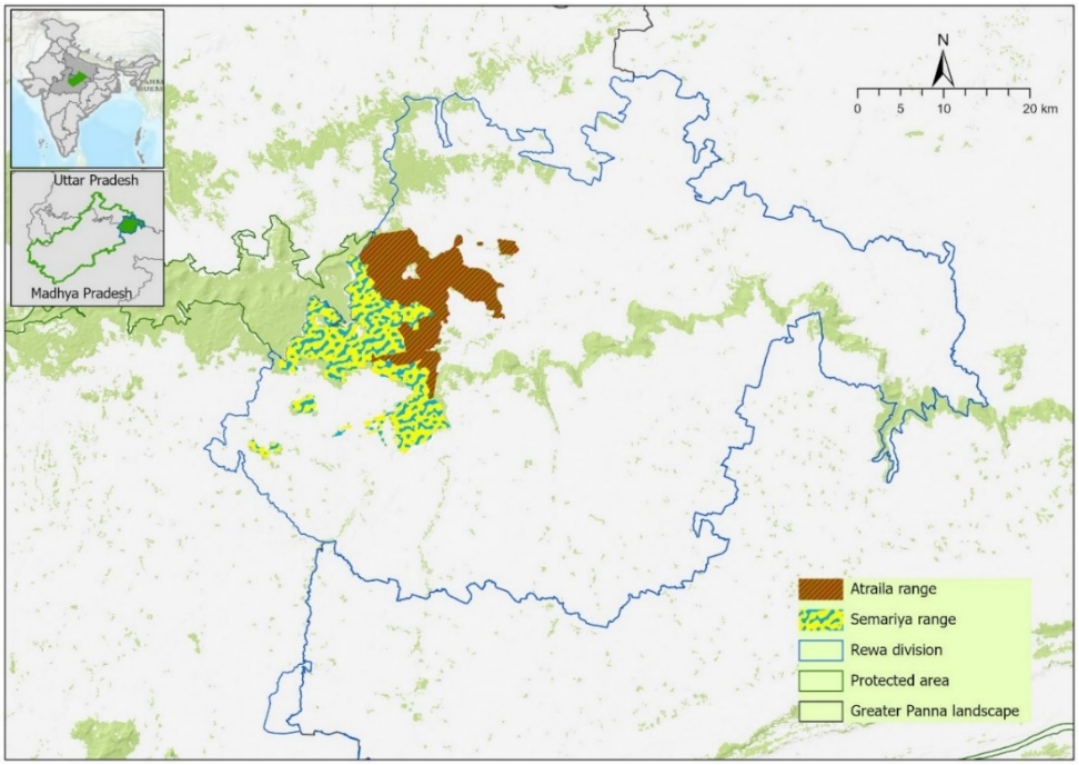


Figure 10.86. Map showing areas to be consolidated under Interstate Tiger Reserve in Rewa Forest Division

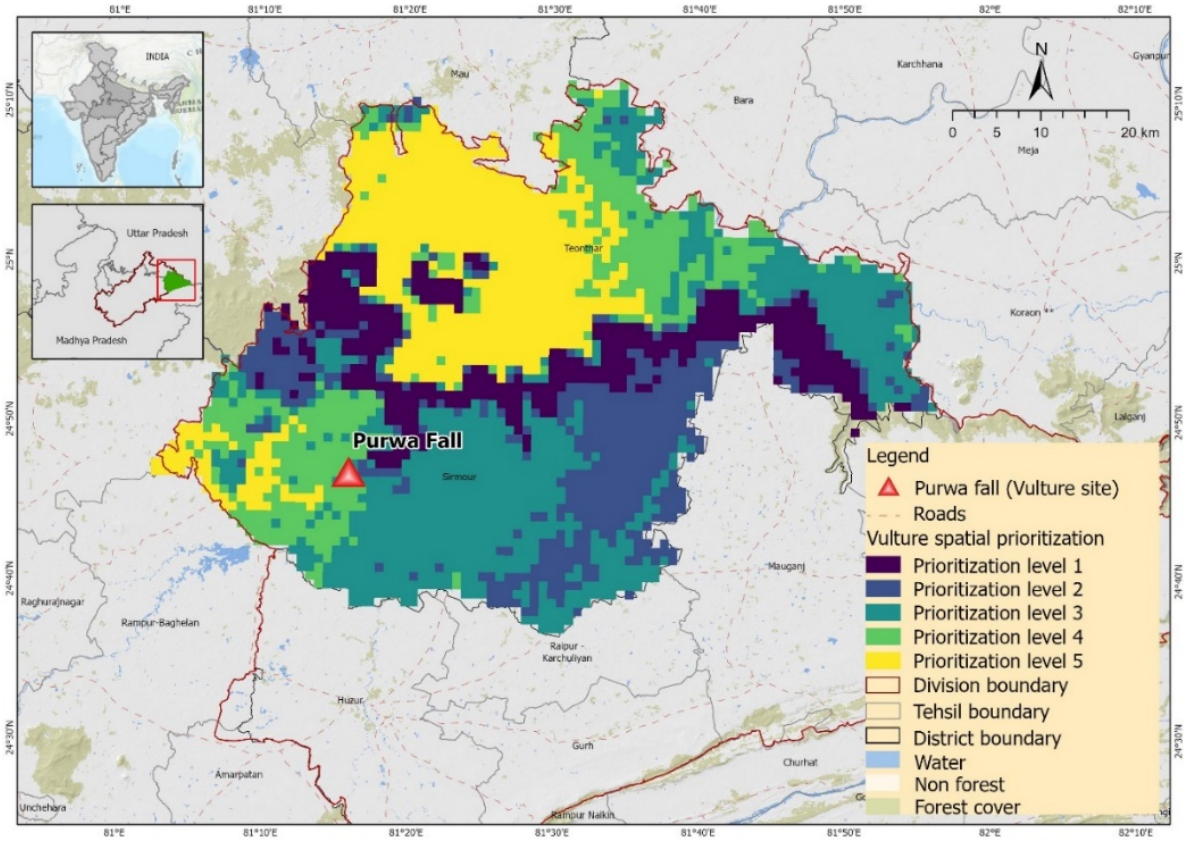


Figure 10.87. Map showing vulture conservation priority areas within Rewa Forest Division

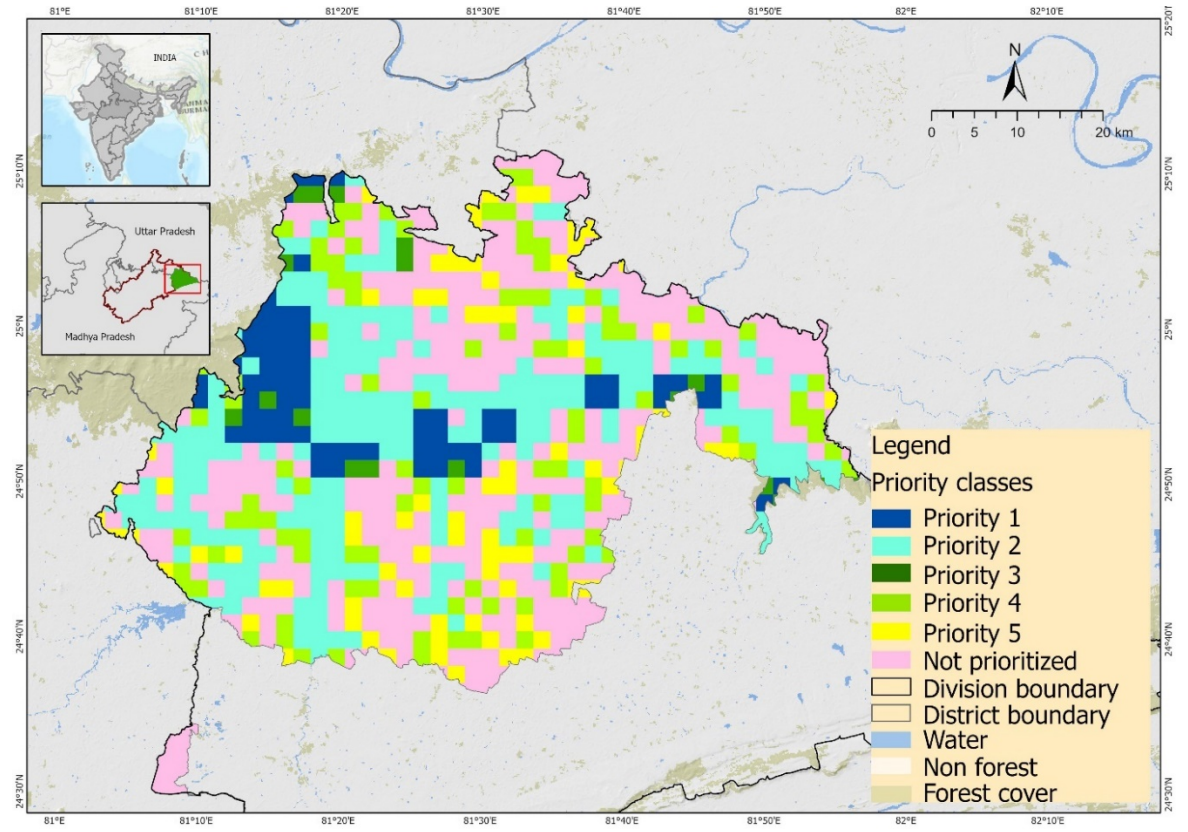


Figure 10.88. Priority areas for conservation in Rewa Forest Division

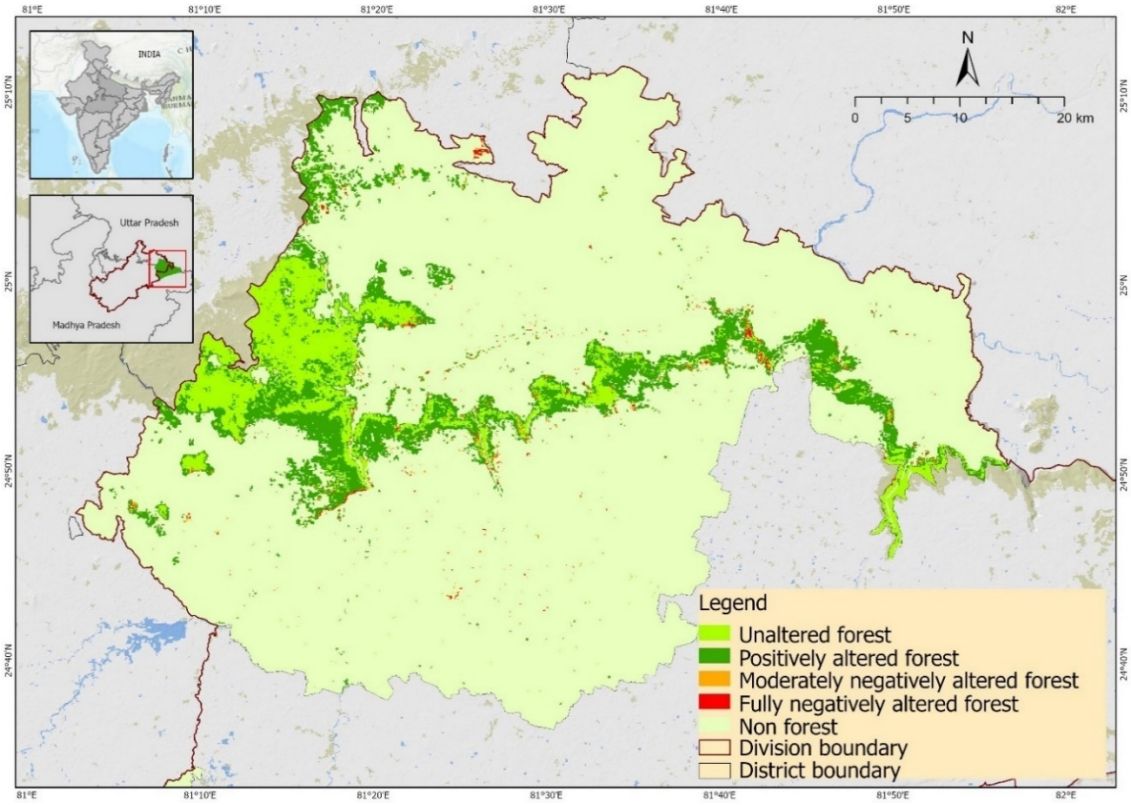


Figure 10.89. Map showing altered-unaltered landscape within Rewa Forest Division

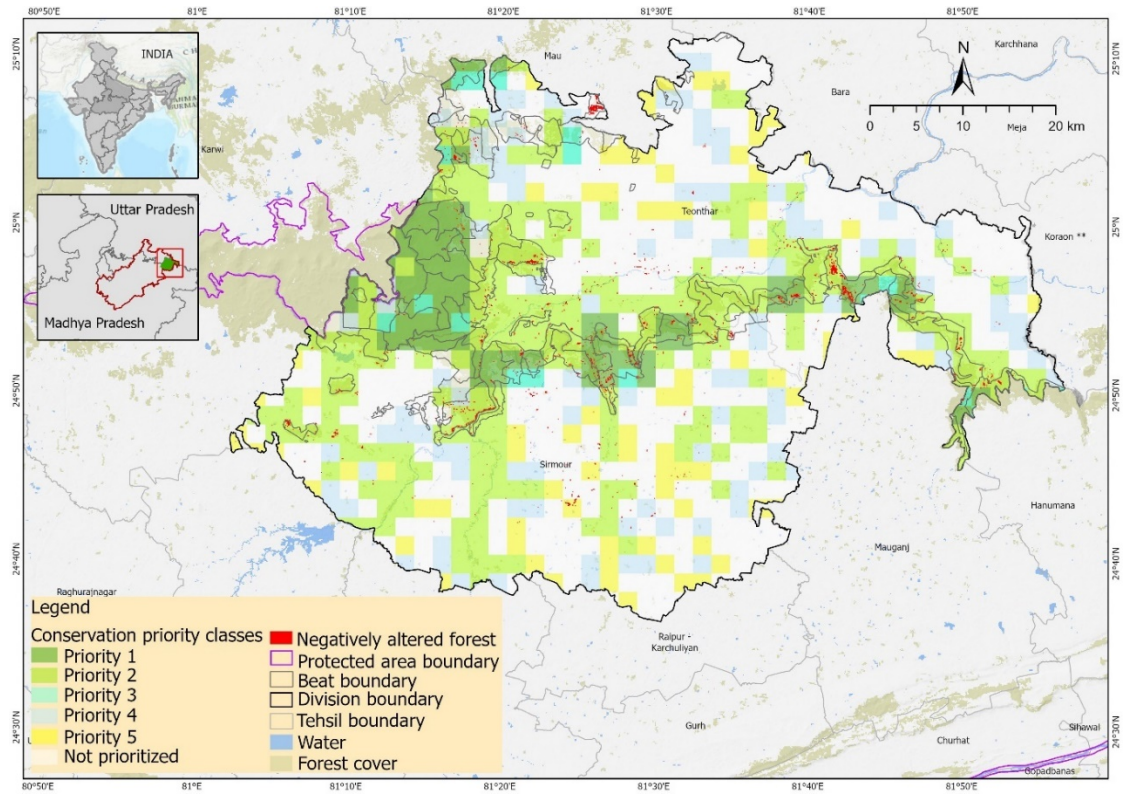


Figure 10.90. Map showing negatively altered landscape overlaid on priority areas of conservation within Rewa Forest Division

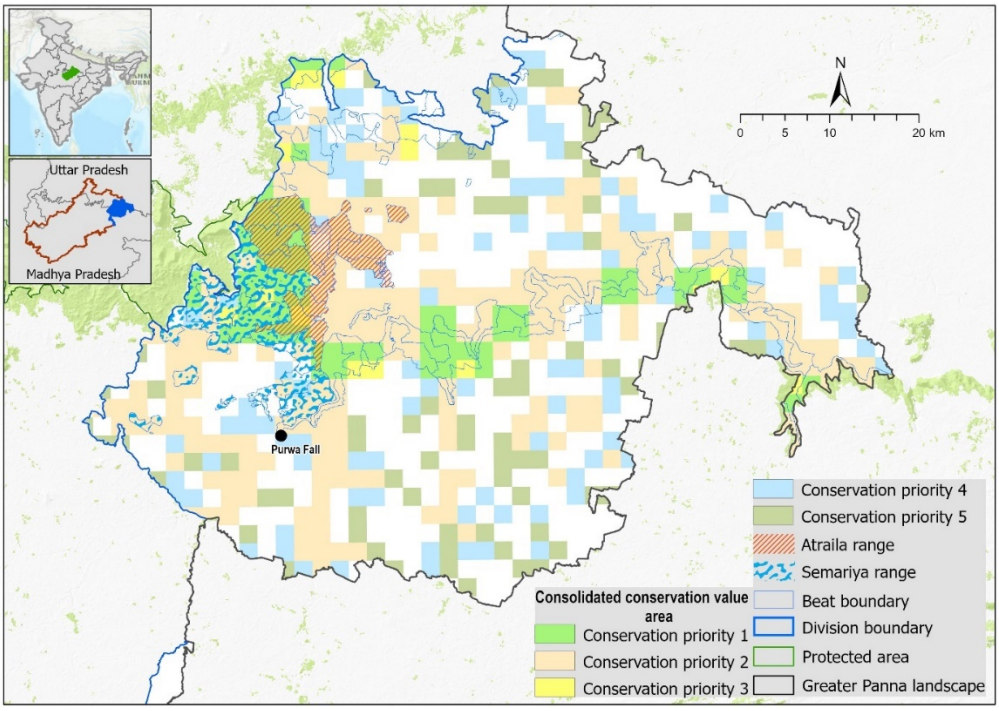


Figure 10.91. Map showing all the areas to be protected and restored (proposed tiger and conservation reserves, priority sites for biodiversity conservation) within the Rewa Forest Division

(9) Katni Forest Division

1. **Habitat Protection** is required for one satellite core and two corridors (One priority III and one priority IV) identified in this division (Fig. 10.92) and this needs to be protected from community dependency and development activities including mining.
2. **Structural Interventions** (overpass and underpass) should be made at points where major roads are cutting through the proposed corridors (Fig. 10.93).
3. **Biodiversity Management Committee** should be activated to monitor and conserve the highest conservation priority areas for vultures and biodiversity (Fig. 10.94; 10.95). Based on the information collected, access and benefit sharing should be made a part of Gram Panchayat Development Plan.
4. **One Village One Hectare** concept for restoration of areas that have been significantly negatively altered, where forest cover has declined drastically, should be considered (Fig. 10.96). This intervention can involve social forestry, integrated farming, ecosystem service trade-off and carbon economy, and can be subjected to payment for ecosystem service (PES) model at state and national level. Restoration efforts should

initially be focussed on negatively altered forests falling within the priority I class of spatial prioritization, and then on priority II, and so on (Fig. 10.97).

5. **Convergence for Consolidation and Restoration:** As indicated above, Fig. 10.98 provides the combined value for PTR, these identified targets should be the focus for habitat consolidation, protection and restoration.
6. **Green Economy Cooperatives and Growth Centres** should be established in Hathibhar Village for Amla and Achar.

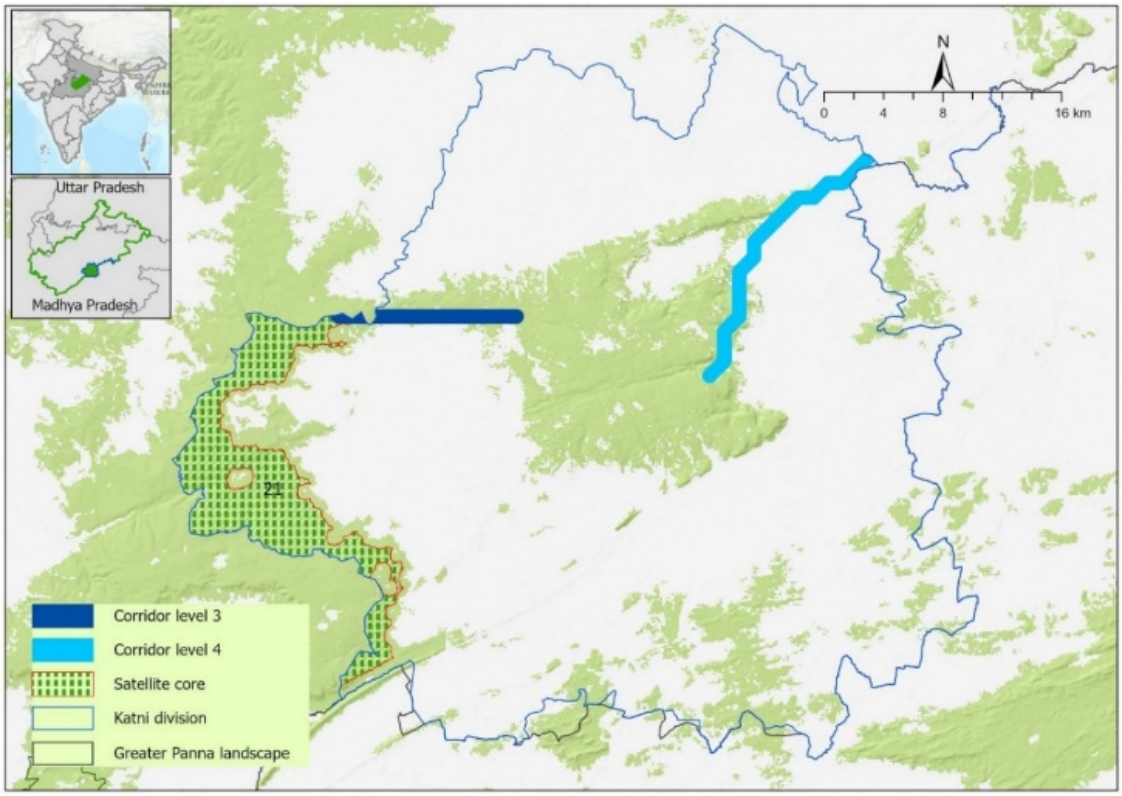


Figure 10.92. Map showing areas to be consolidated (satellite cores, stepping stones and corridors) in Katni Forest Division

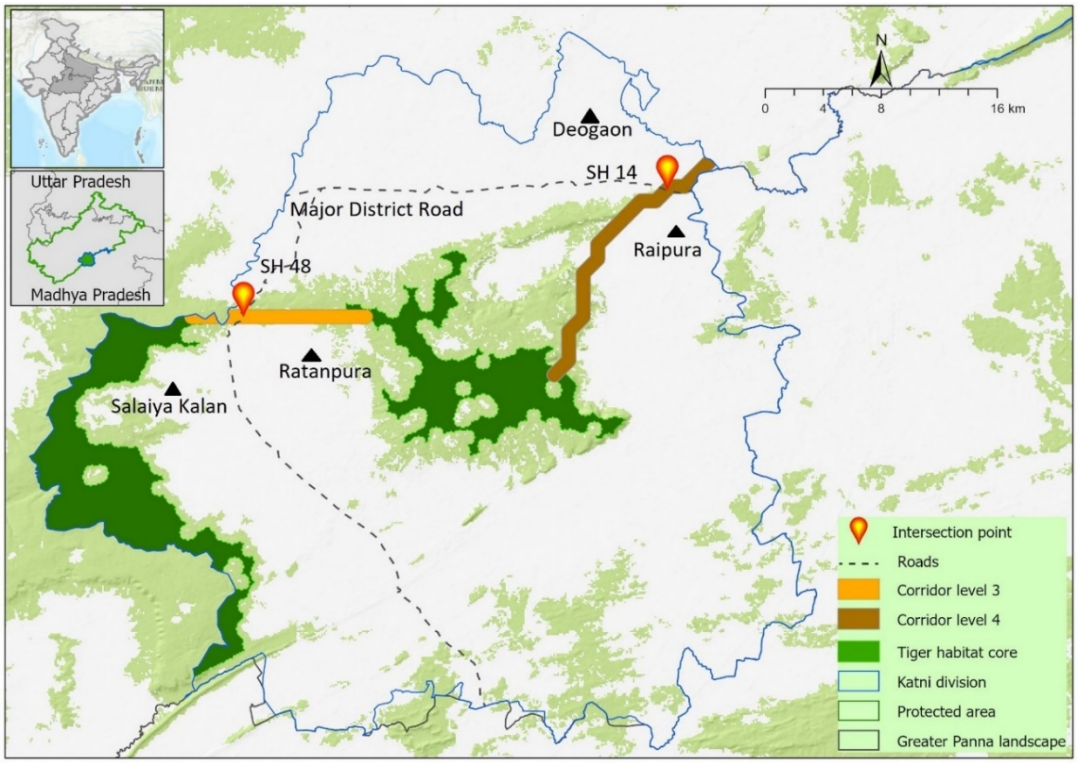


Figure 10.93. Map showing points where major roads are intersecting with proposed corridors in Katni Forest Division for structural interventions

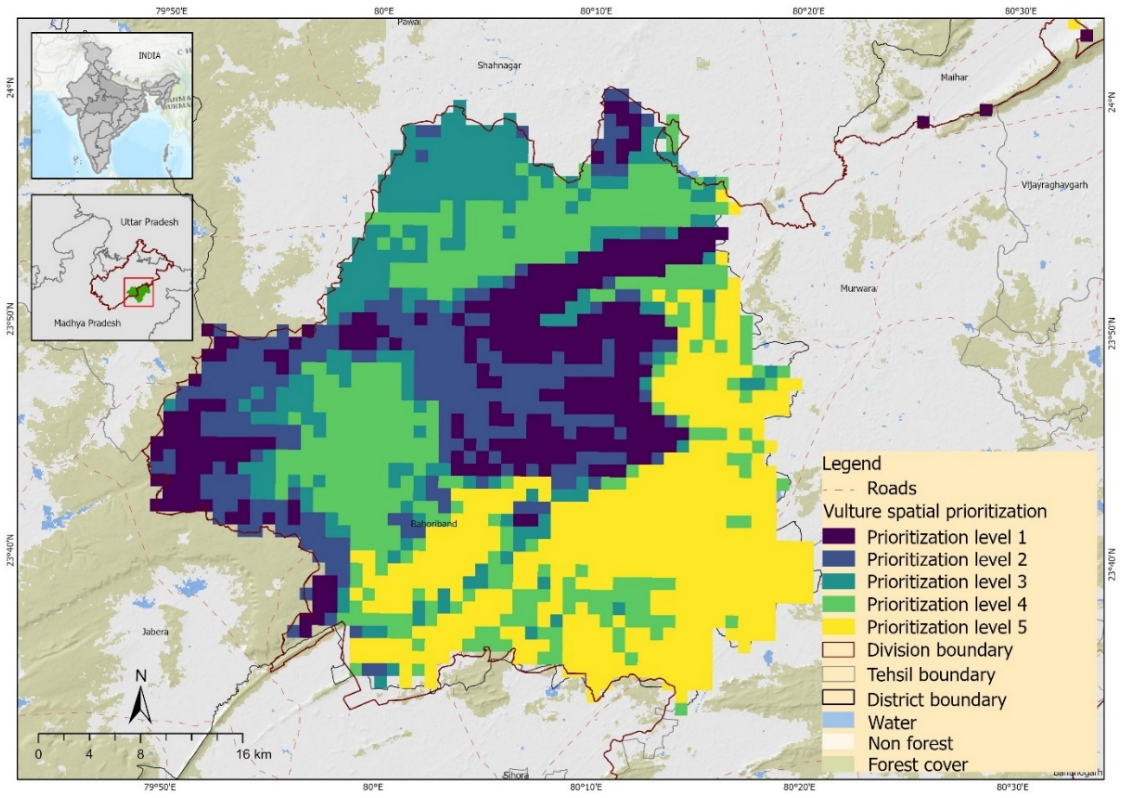


Figure 10.94. Map showing vulture conservation priority areas within Katni Forest Division

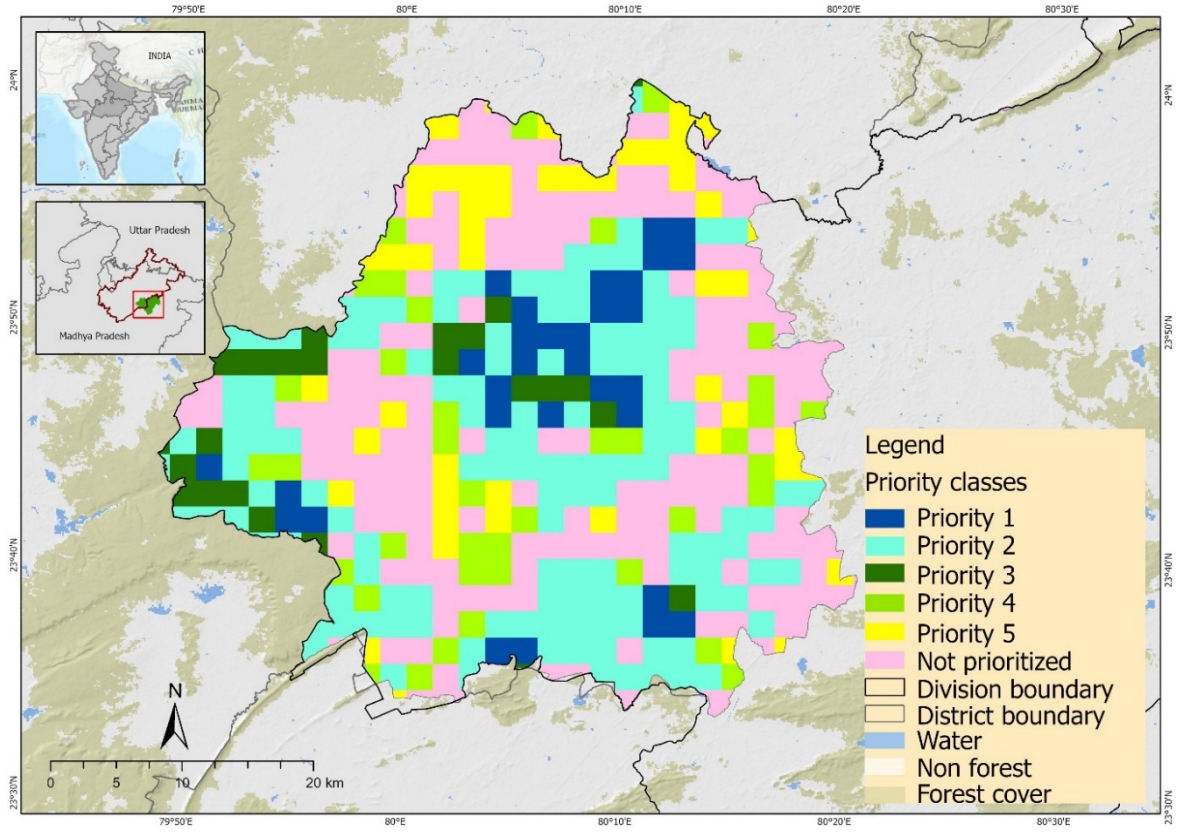


Figure 10.95. Priority areas for conservation in Katni Forest Division

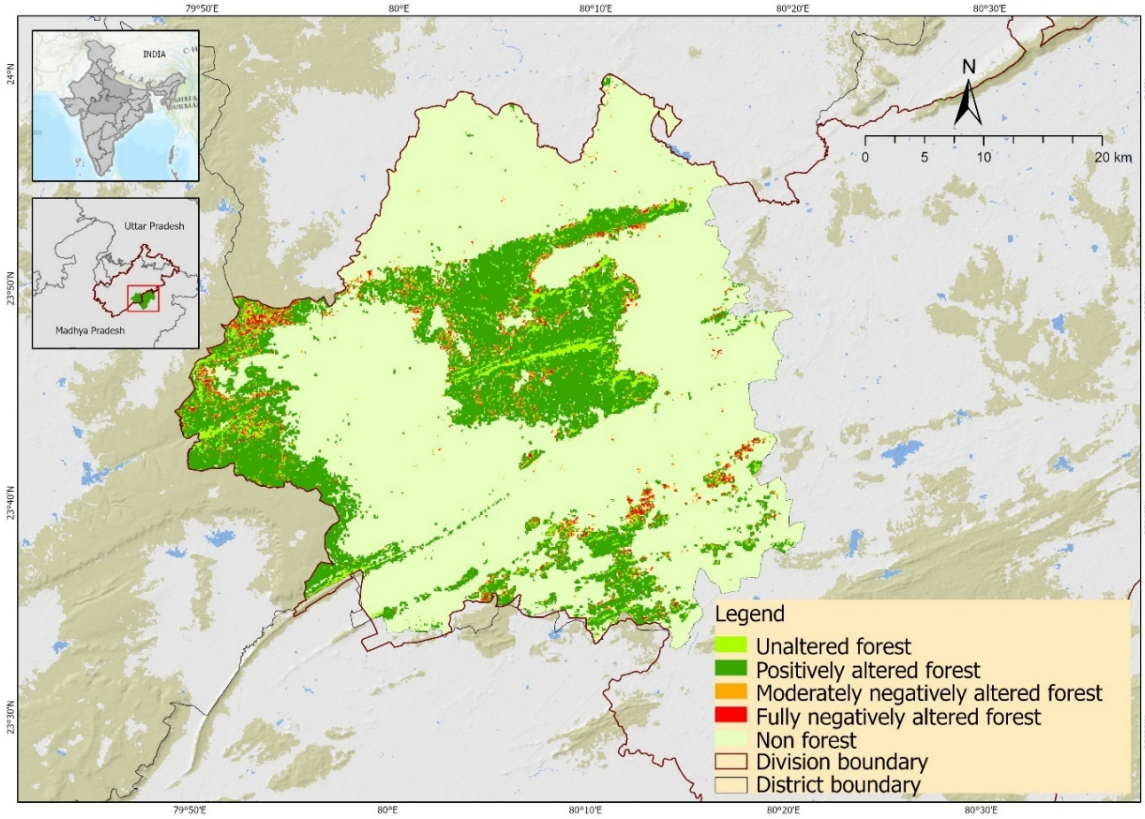


Figure 10.96. Map showing altered-unaltered landscape within Katni Forest Division

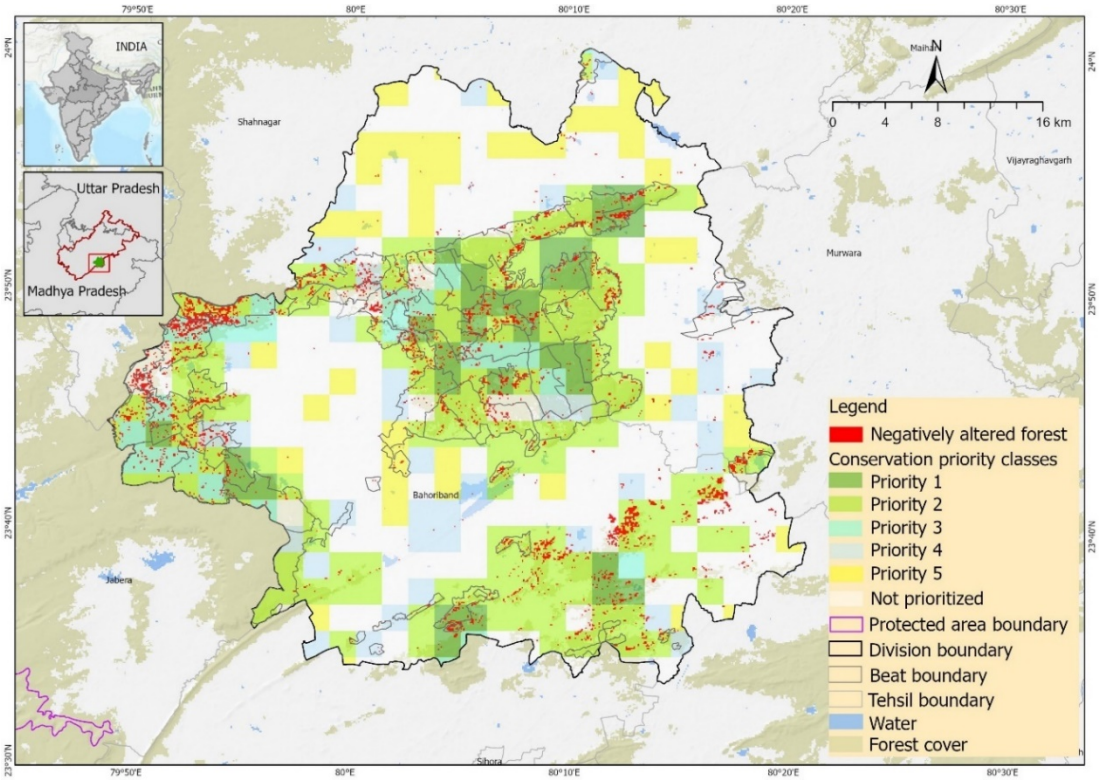


Figure 10.97. Map showing negatively altered landscape overlaid on priority areas of conservation within Katni Forest Division

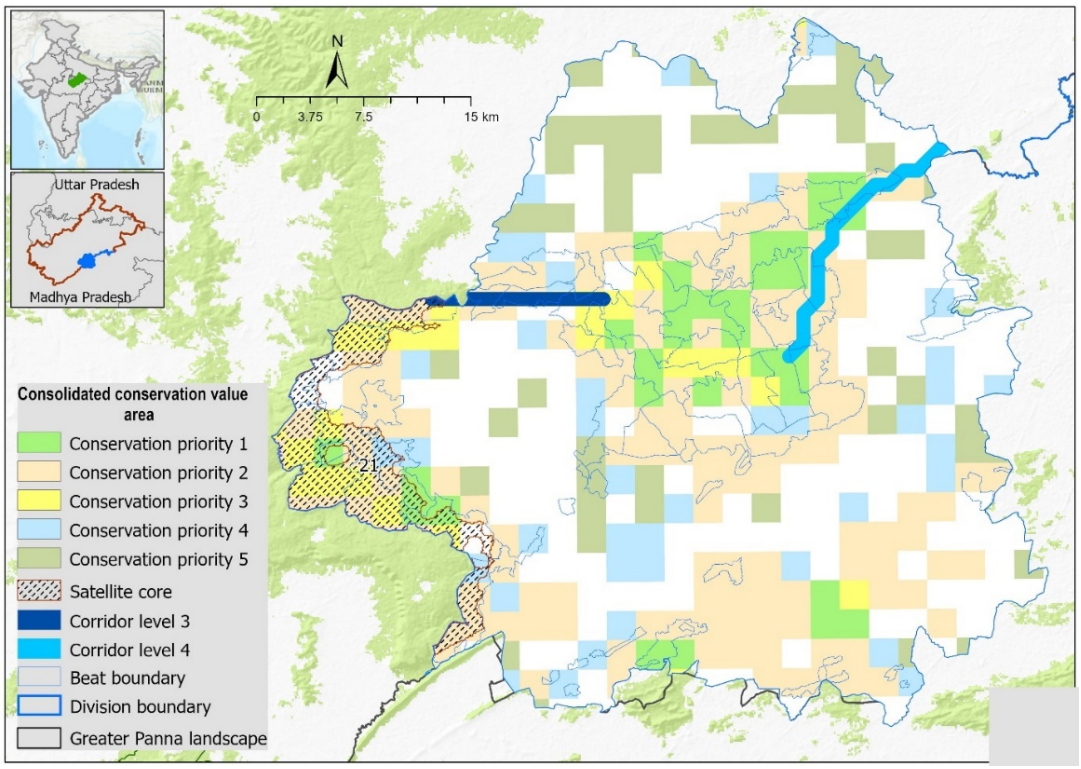


Figure 10.98. Map showing all the areas to be protected and restored (satellite cores, corridors, priority sites for biodiversity conservation) within the Katni Forest Division

(10) Chitrakoot Forest Division

1. **Habitat Protection** is required for two corridors (One priority III and one priority IV) identified in this division (Fig. 10.99) and this needs to be protected from community dependency and development activities including mining.
2. **Biodiversity Management Committee** should be activated to monitor and conserve the highest conservation priority areas for vultures (Fig. 10.100) and biodiversity (Fig. 10.101). Based on the information collected, access and benefit sharing should be made a part of Gram Panchayat Development Plan.
3. **One Village One Hectare** concept for restoration of areas that have been significantly negatively altered, where forest cover has declined drastically, should be considered (Fig. 10.102). This intervention can involve social forestry, integrated farming, ecosystem service trade-off and carbon economy, and can be subjected to payment for ecosystem service (PES) model at state and national level. Restoration efforts should initially be focussed on negatively altered forests falling within the priority I class of spatial prioritization for biodiversity conservation, and then on priority II, and so on (Fig. 10.103).
4. **Convergence for Consolidation and Restoration:** As indicated above, Fig. 10.104 provides the combined value for PTR, these identified targets should be the focus for habitat consolidation, protection and restoration.
5. **Green Economy Cooperatives and Growth Centres** should be established in Hathibhar Village for Amla (Tikaria), for Mahua (Hanuwa and Rukema Burung) and for Tenud (Rukema Burung) (Appendix 10.24-10.26).

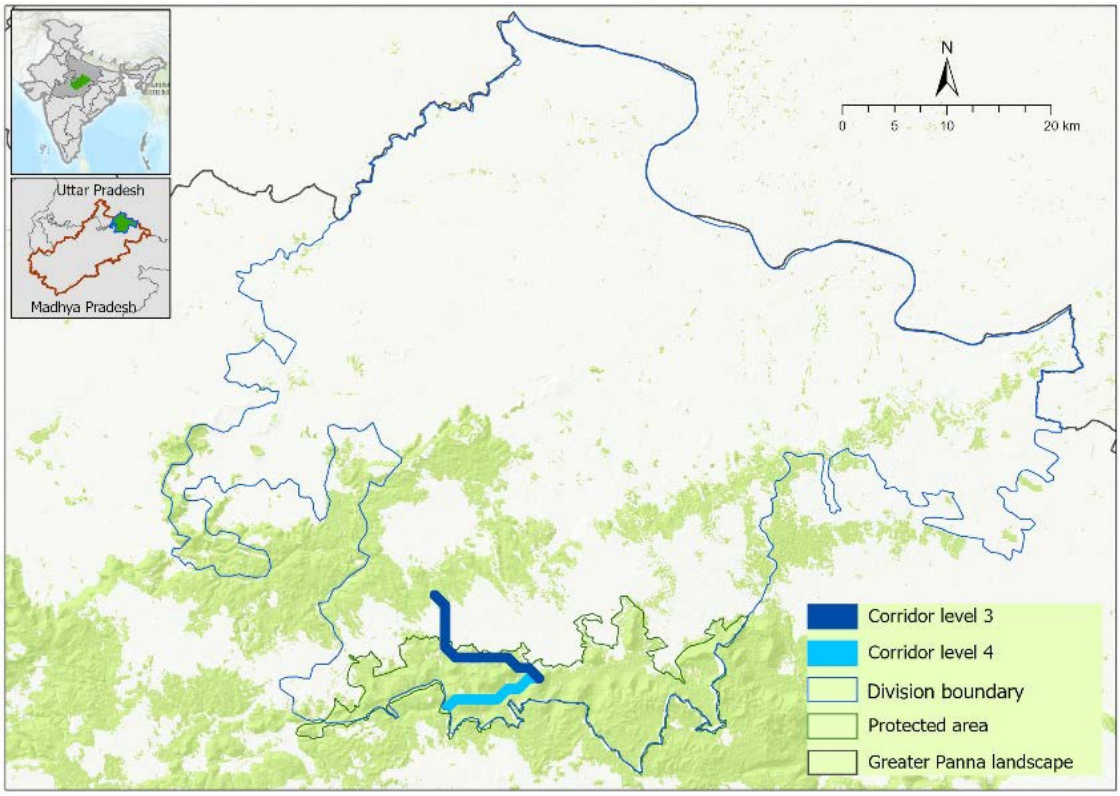


Figure 10.99. Map showing areas to be consolidated (satellite cores and corridors) in Chitrakoot Forest Division

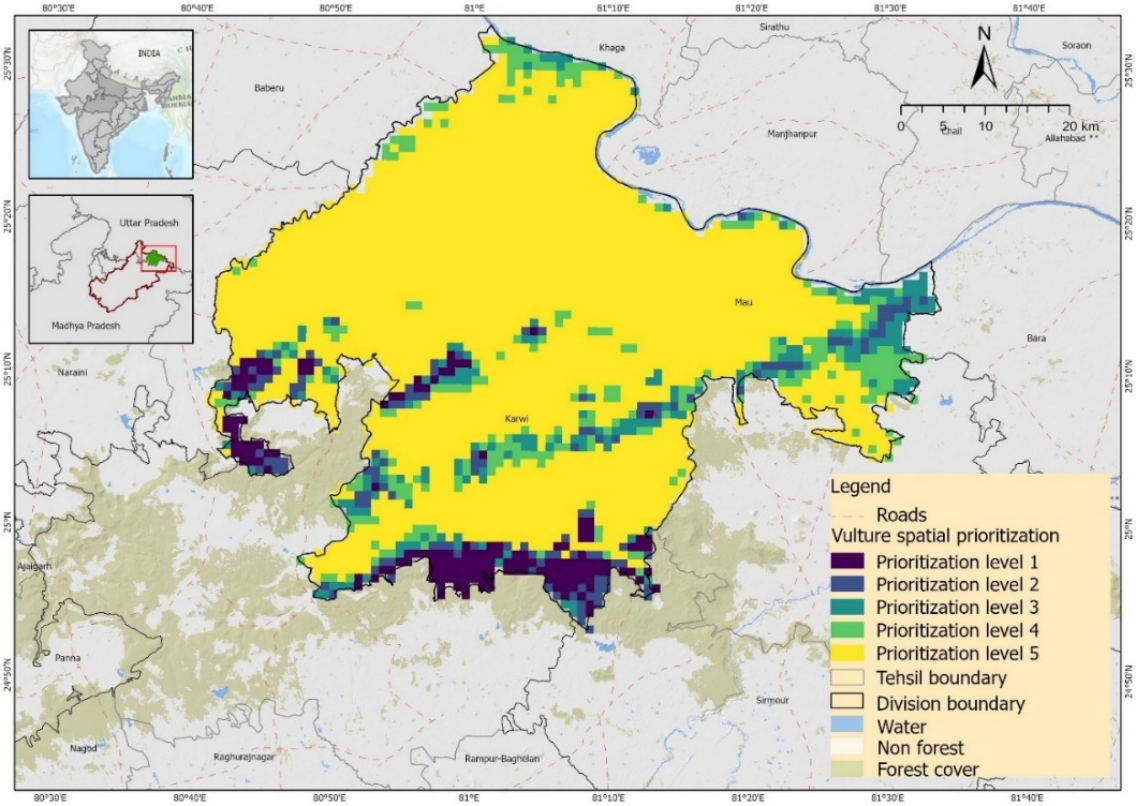


Figure 10.100. Map showing vulture conservation priority areas within Chitrakoot Forest Division

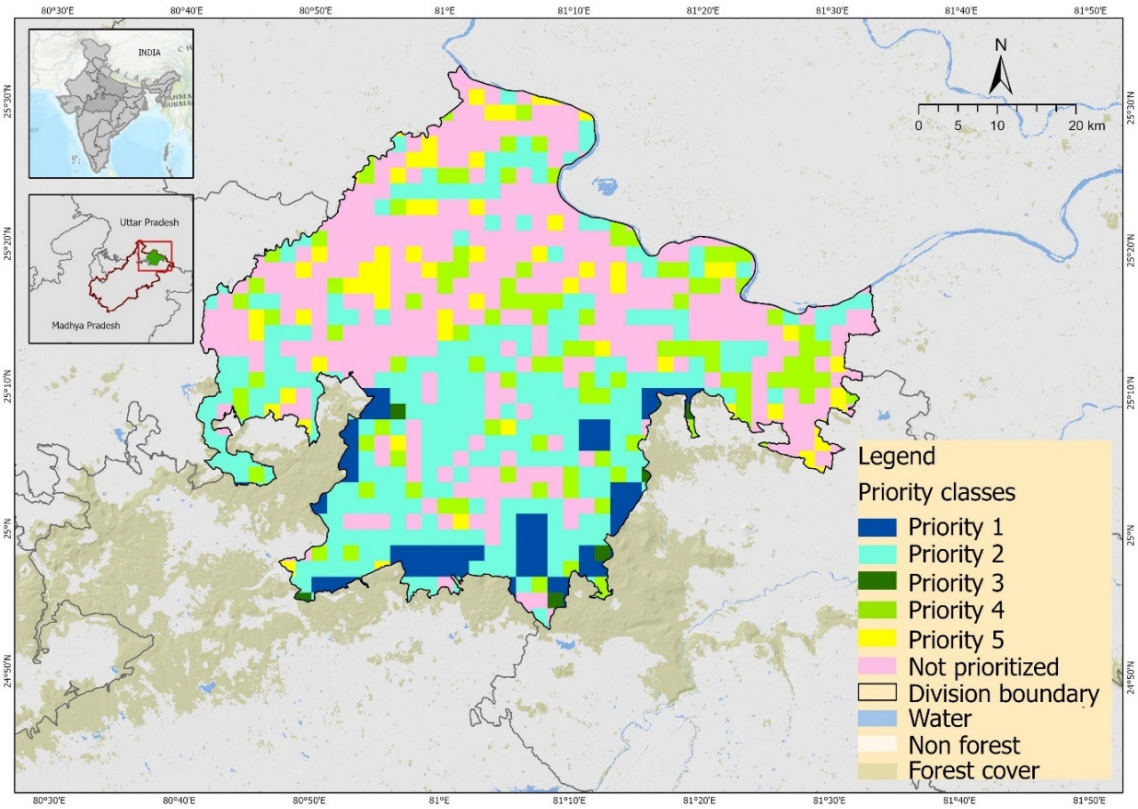


Figure 10.101. Priority areas for conservation within Chitrakoot Forest Division

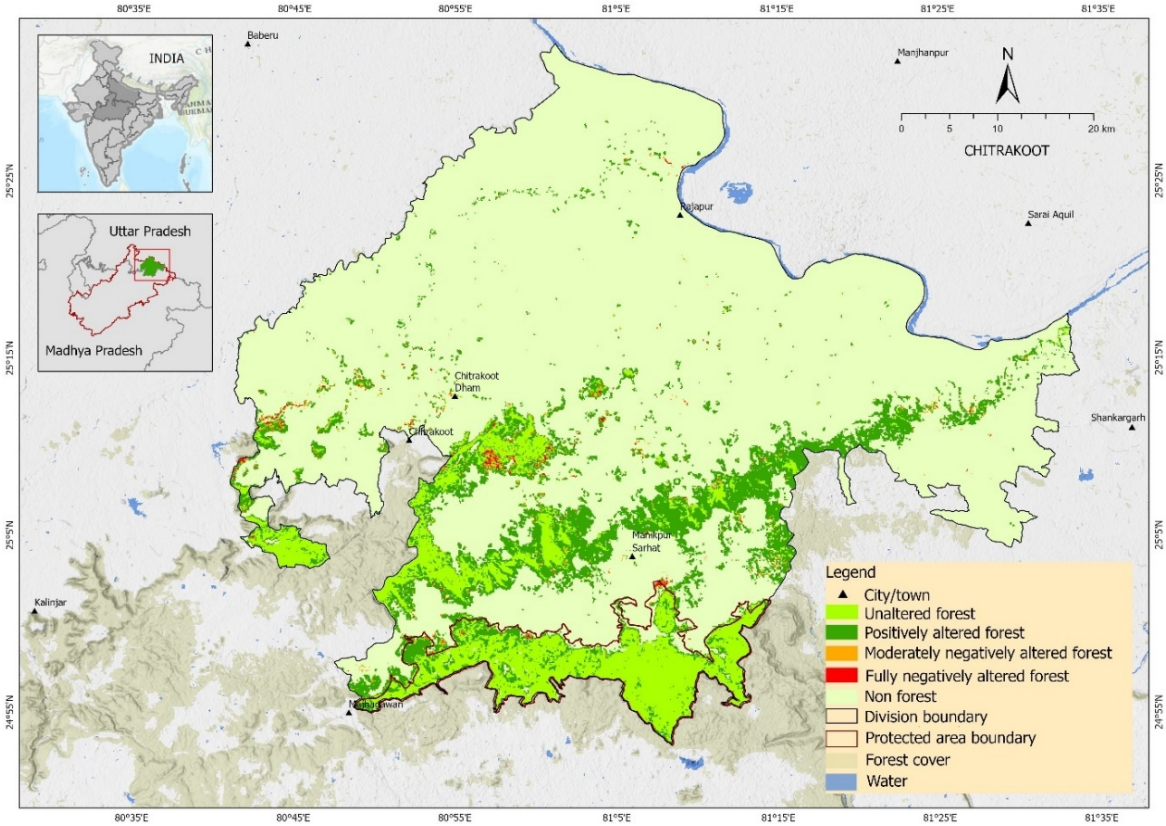


Figure 10.102. Map showing altered-unaltered landscape within Chitrakoot Forest Division

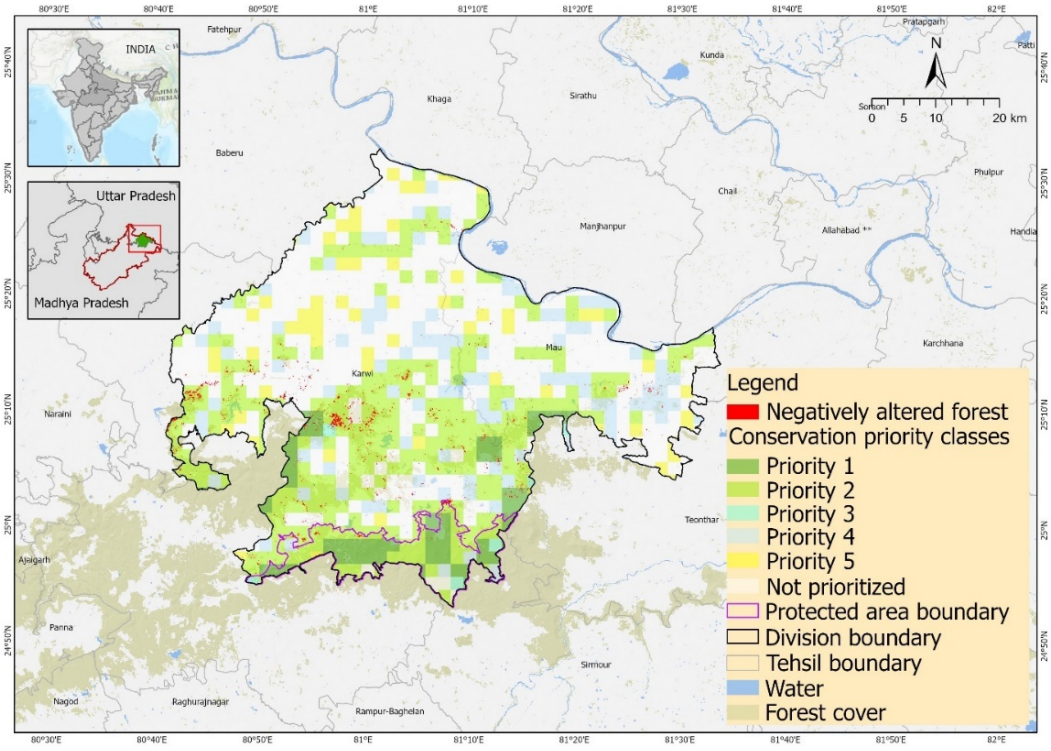


Figure 10.103. Map showing negatively altered landscape overlaid on priority areas of conservation within Chitrakoot Forest Division

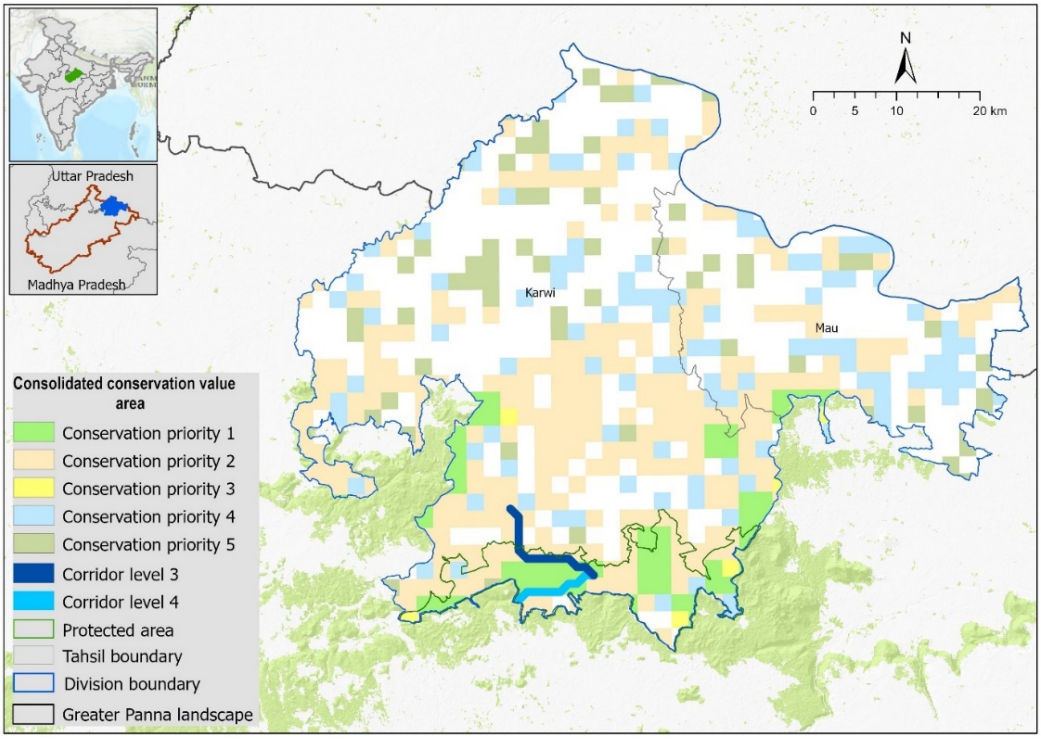


Figure 10.104. Map showing all the areas to be protected and restored (corridors, proposed tiger reserve, priority sites for biodiversity conservation) within the Chitrakoot Forest Division

(11) Lalitpur Forest Division

1. **Habitat Protection** is required for three corridors (One priority IV and two priority V) identified in this division (Fig. 10.105) and this needs to be protected from community dependency and development activities including mining.
2. **Biodiversity Management Committee** should be activated to monitor and conserve the highest conservation priority areas for vultures (Fig. 10.106) and biodiversity (Fig. 10.107). Based on the information collected, access and benefit sharing should be made a part of Gram Panchayat Development Plan.
3. **One Village One Hectare** concept for restoration of areas that have been significantly negatively altered, where forest cover has declined drastically, should be considered (Fig. 10.108). This intervention can involve social forestry, integrated farming, ecosystem service trade-off and carbon economy, and can be subjected to payment for ecosystem service (PES) model at state and national level. Restoration efforts should initially be focussed on negatively altered forests falling within the priority I class of spatial prioritization for biodiversity conservation, and then on priority II, and so on (Fig. 10.109).
4. **Convergence for Consolidation and Restoration:** As indicated above, Fig. 10.110 provides the combined value for PTR, these identified targets should be the focus for habitat consolidation, protection and restoration.
5. **Green Economy Cooperatives and Growth Centres** should be established in Lakhangar Village for Amla, and Uldana Khurd for Mahua (Appendix 10.27-10.28).

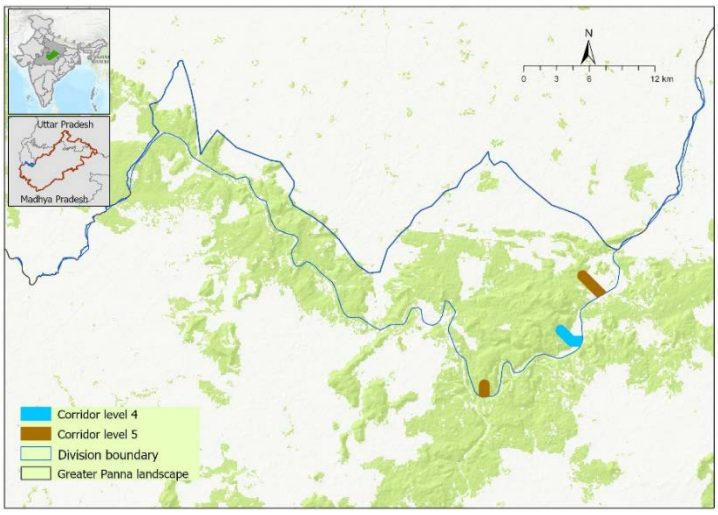


Figure 10.105. Map showing areas to be consolidated (corridors) in Lalitpur Forest Division

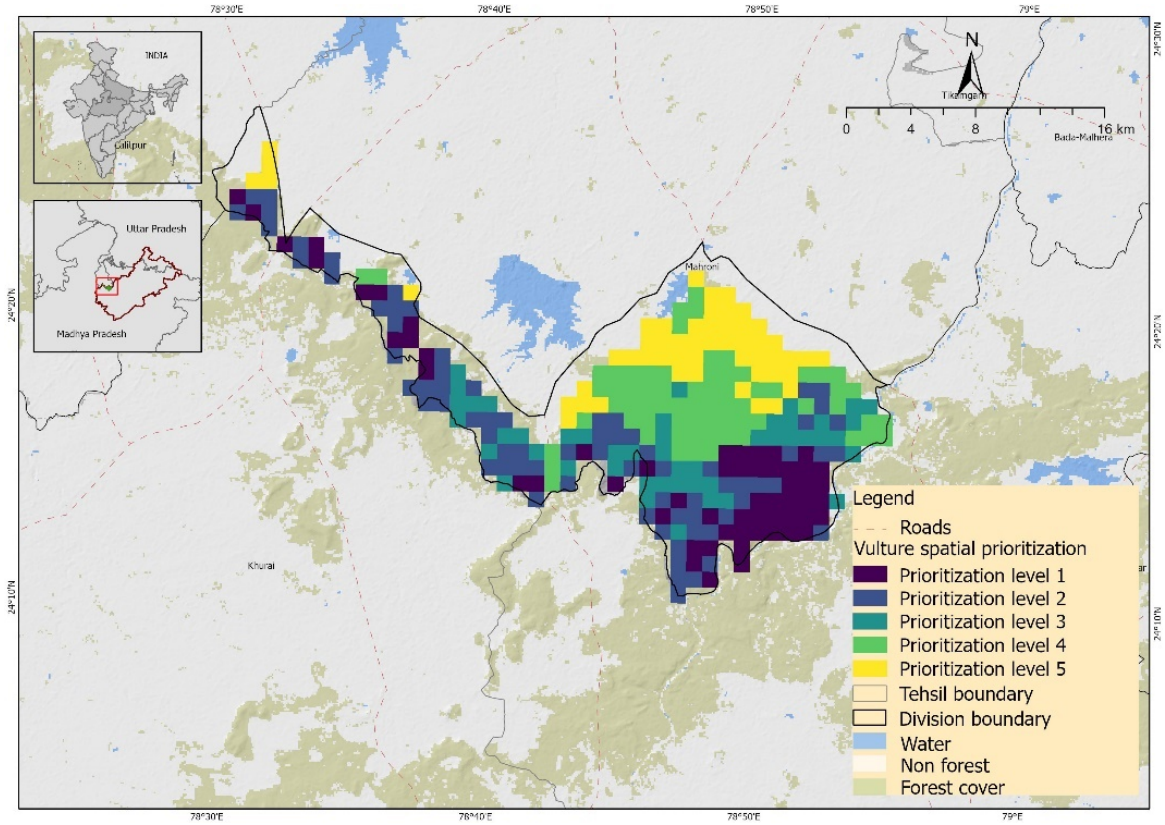


Figure 10.106. Map showing vulture conservation priority areas within Lalitpur Forest Division

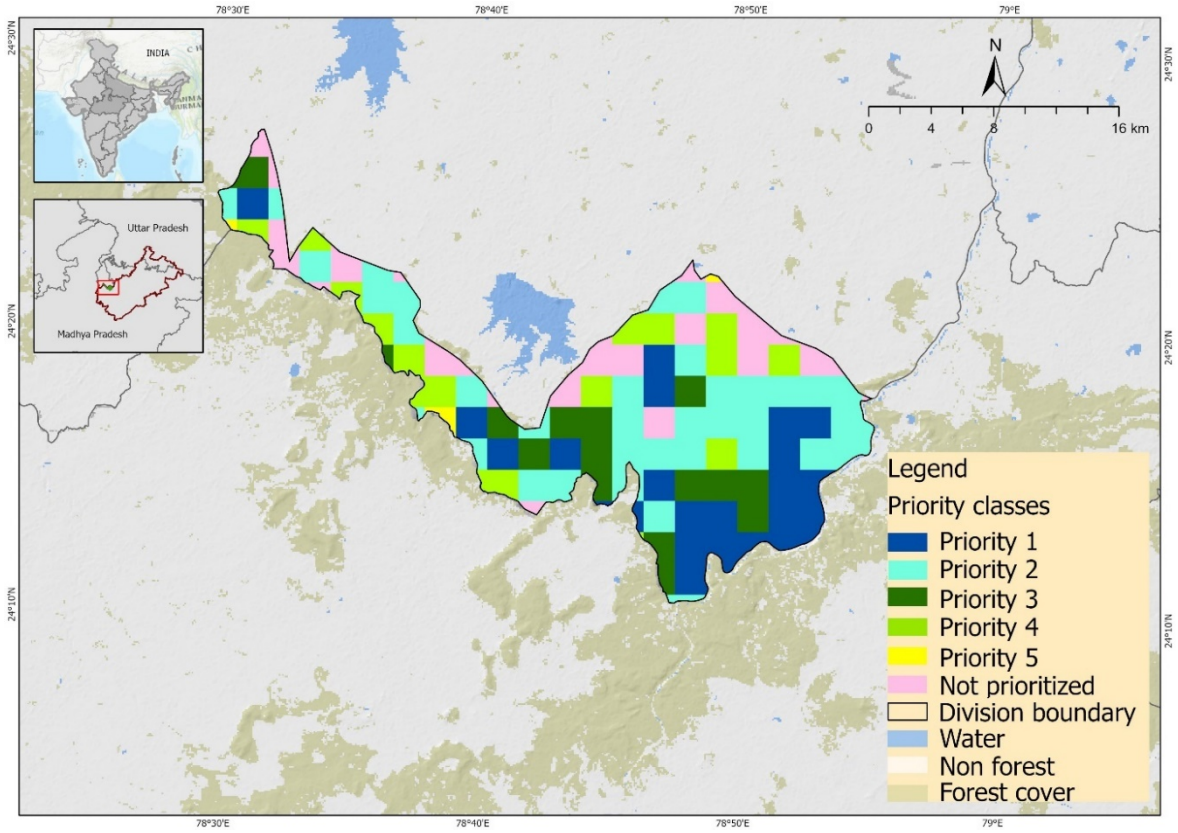


Figure 10.107. Priority areas for conservation within Lalitpur Forest Division

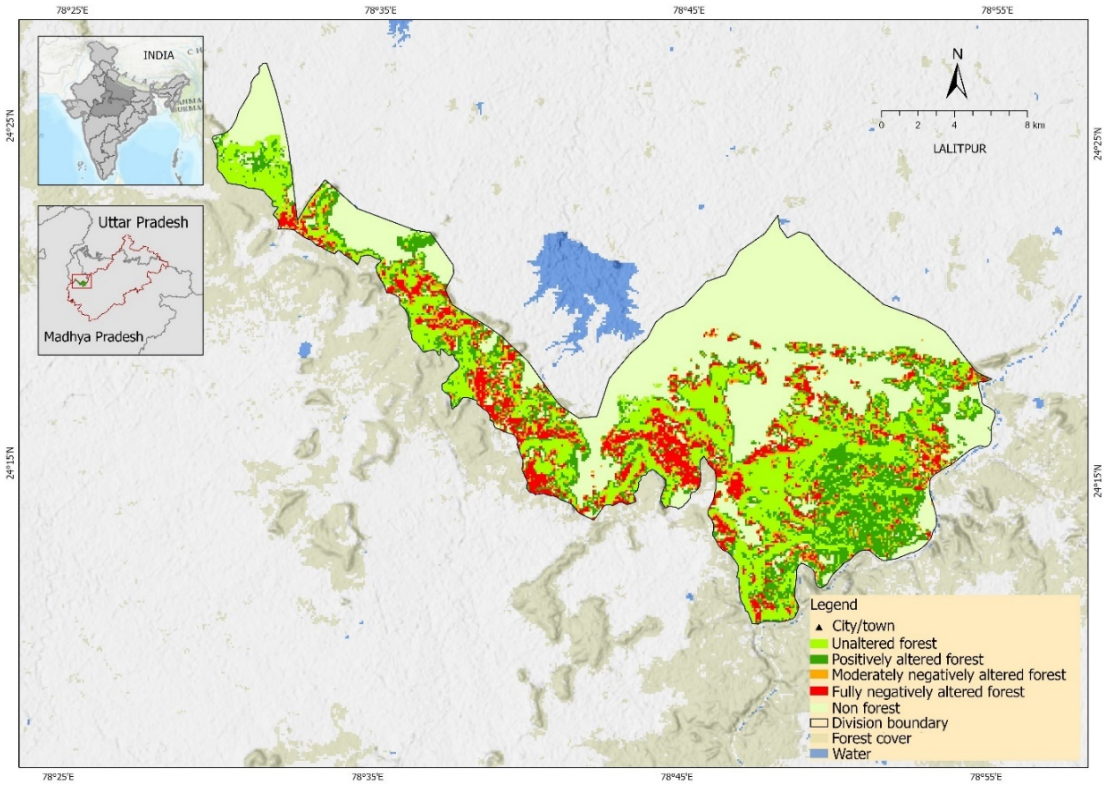


Figure 10.108. Map showing altered-unaltered landscape within Lalitpur Forest Division

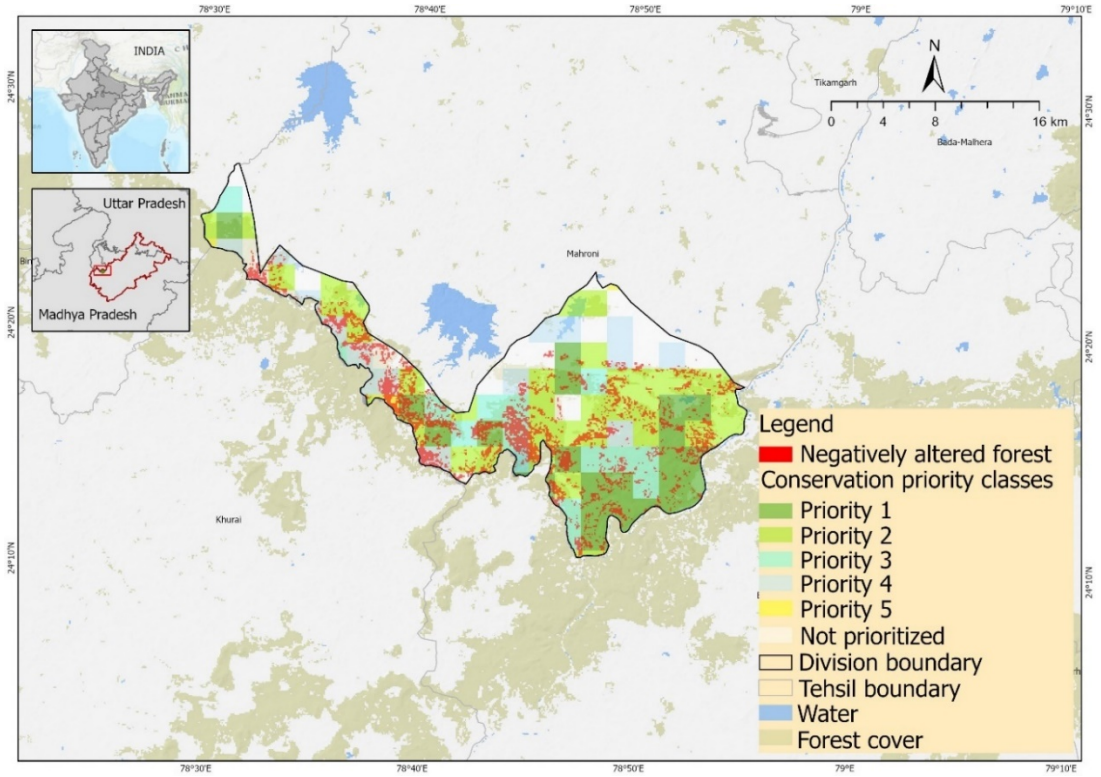


Figure 10.109. Map showing negatively altered landscape overlaid on priority areas of conservation within Lalitpur Forest Division

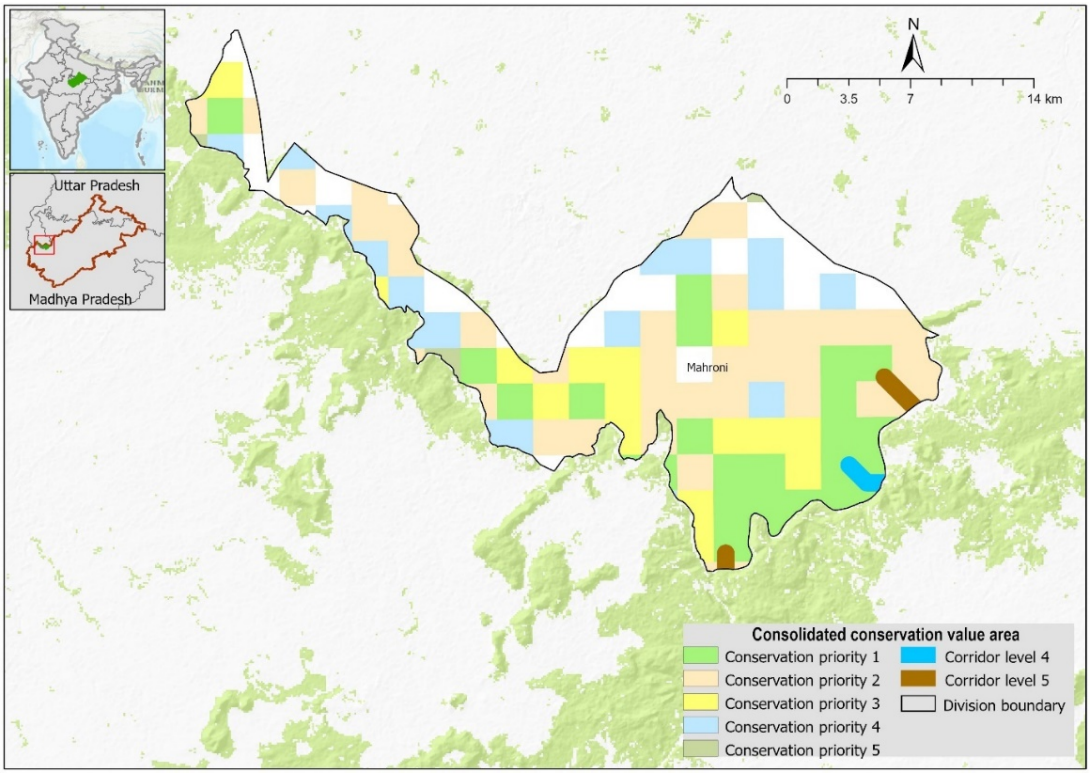


Figure 10.110. Map showing all the areas to be protected and restored (corridors, priority sites for biodiversity conservation) within the Lalitpur Forest Division

(12) Banda Forest Division

1. **Biodiversity Management Committee** should be activated to monitor and conserve the highest conservation priority areas for vultures (Fig. 10.111) and biodiversity (Fig. 10.112). Based on the information collected, access and benefit sharing should be made a part of Gram Panchayat Development Plan.

2. **One Village One Hectare** concept for restoration of areas that have been significantly negatively altered, where forest cover has declined drastically, should be considered (Fig. 10.113). This intervention can involve social forestry, integrated farming, ecosystem service trade-off and carbon economy, and can be subjected to payment for ecosystem service (PES) model at state and national level. Restoration efforts should initially be focussed on negatively altered forests falling within the priority I class of spatial prioritization for biodiversity conservation, and then on priority II, and so on (Fig. 10.114).

3. **Convergence for Consolidation and Restoration:** As indicated above, Fig. 10.114 provides the combined value for PTR, these identified targets should be the focus for habitat consolidation, protection and restoration.

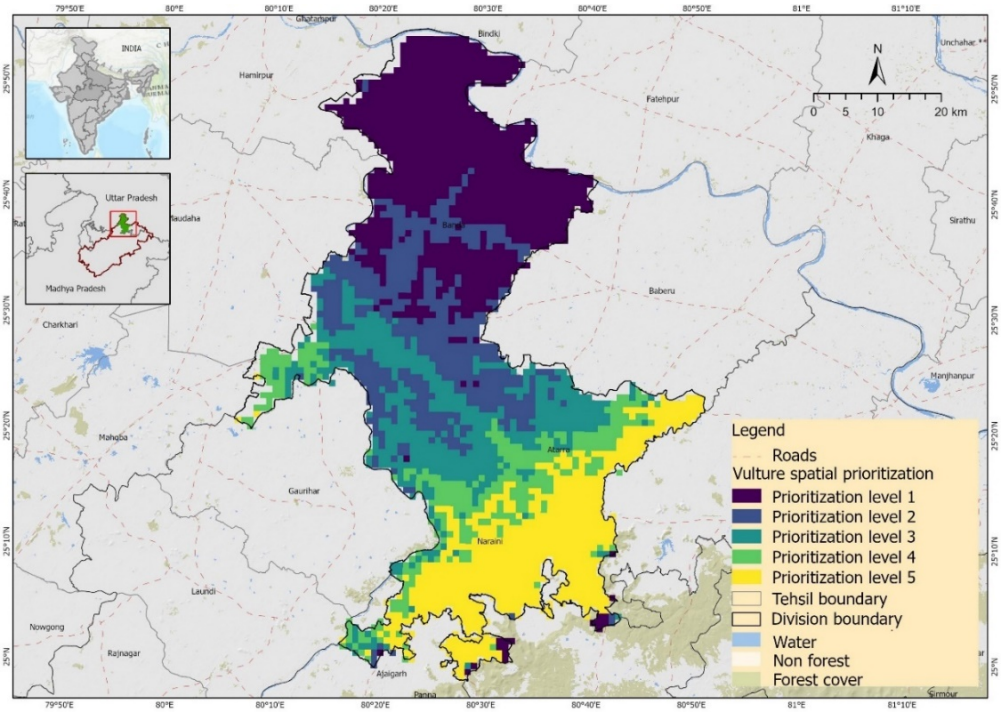


Figure 10.111. Map showing vulture conservation priority areas within Banda Forest Division

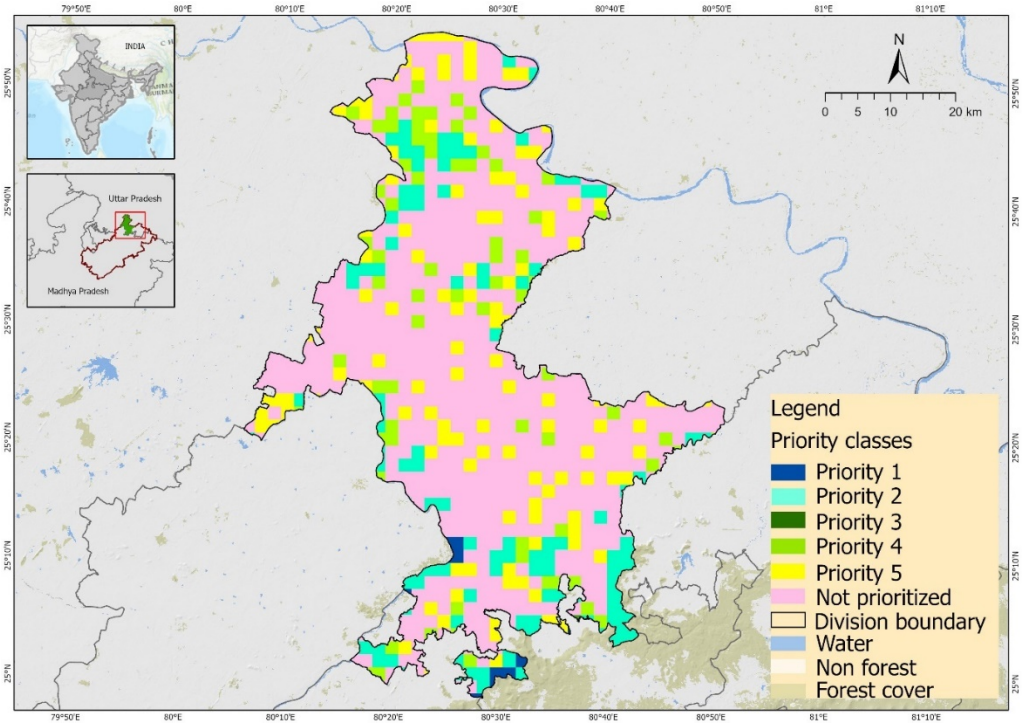


Figure 10.112. Priority areas for conservation within Banda Forest Division

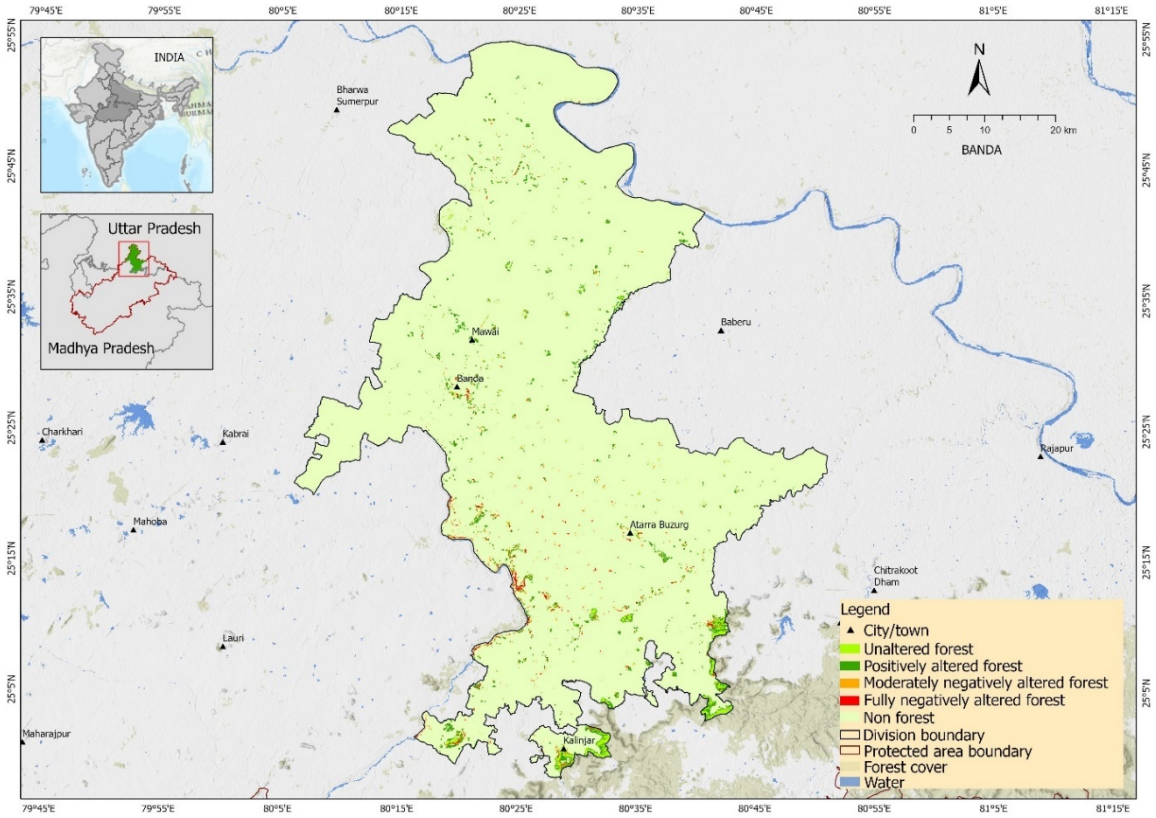


Figure 10.113. Map showing altered-unaltered landscape within Banda Forest Division

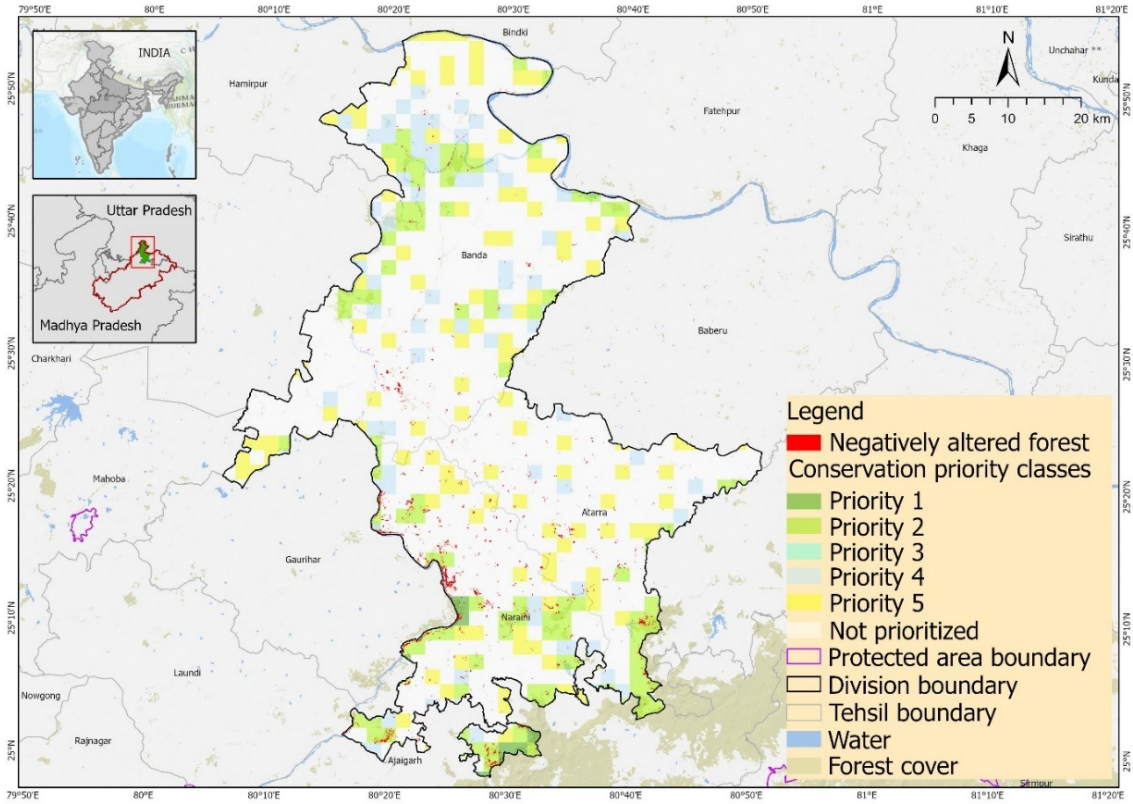


Figure 10.114. Map showing negatively altered landscape overlaid on priority areas of conservation within Banda Forest Division

10.4.3. Category III: Civil Administration/Urbanscape

The recommendations provided below should be made part of district planning process (as emphasized in the guideline developed by GTF for landscape level participatory management (GTF, 2021)), ensuring convergence with existing schemes and programs.

(1) Panna District

1. **Habitat Protection** is required for the five satellite cores, one steppingstone, two satellite core/steppingstone and 19 corridors (five priority I, two priority II, three priority III, seven priority IV, and two priority V) identified in this District (Fig. 10.115) and this needs to be protected from community dependency and development activities including mining.
2. **Structural Interventions** (overpass and underpass) should be made at points where major roads are cutting through the proposed corridors (Fig. 10.116).
3. **River Conservation Zone** (1km width) around part of Ken and Bearma Rivers, which connects South Panna Forest Division and PTR should be declared as Community Reserve or Eco-sensitive Zone (Fig. 10.115). This intervention would involve social forestry, integrated farming, ecosystem service trade-off and carbon economy including the option to implement One Village One Hectare green cover development program.
4. **Conservation Reserves** should be established consisting of Kalda and Saleha Ranges (Fig. 10.115) with focus on tiger and Pawai Range with focus on vultures (Fig. 10.117).
5. **Joint Forest Management** of high biodiversity conservation priority areas (Fig. 10.118) should be considered under the focus of Joint Forest Management and Biodiversity Management Committees. Based on the information collected, access and benefit sharing should be made a part of Gram Panchayat Development Plan.
7. **One Village One Hectare** concept for restoration of areas that have been significantly negatively altered, where forest cover has declined drastically should be considered (Fig. 10.119). This can be also subjected to payment for ecosystem service (PES) model at state and national level. Restoration efforts should initially be focussed on negatively altered forests falling within the priority I class of spatial prioritization for biodiversity conservation, and then on priority II, and so on (Fig.10.120).

6. **Convergence for Consolidation and Restoration:** As indicated above, Fig. 10.121 provides the combined value for PTR, these identified targets should be the focus for habitat consolidation, protection and restoration.

7. **Green Economy Cooperatives and Growth Centres** should be established in selected Panchayat/Village for Amla (Dahlan chowki, Ranipur, Darela, Kota Muhli, Panari, Rahuniya, Kudakpur, Sarra, Kadhna and Banjari), for Mahua (Piparia Pathar and Rahuniya), for Tendu (Rahuniya) and for Achar (Panari, Rahuniya, Pipariya Pathar and Ghutehi) (Appendix 10.1-10.4).

8. **Integrated Research and Learning Centre** is to be set-up for monitoring of various ecological and socioeconomic activities and to provide technical support and skill development in the region.

9. **State-of-the-art Conservation and Tourism Management** facilities in the form of (a) Controlled Population Management Facility for Tiger (Fig. 4.13) and (b) Nature Interpretation and Tourism Promotion Centre should be developed in the district.

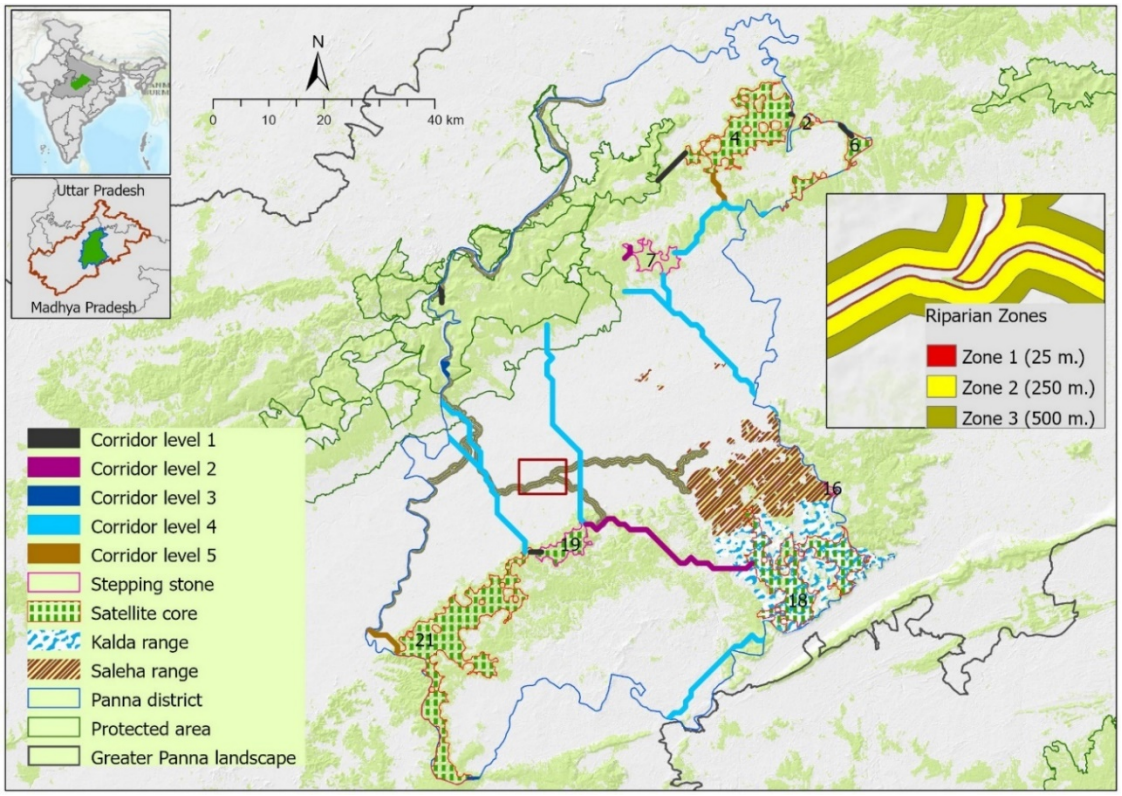


Figure 10.115. Map showing areas to be consolidated (satellite cores, stepping stones and corridors, Kalda & Saleha Ranges and river conservation zone) in Panna District

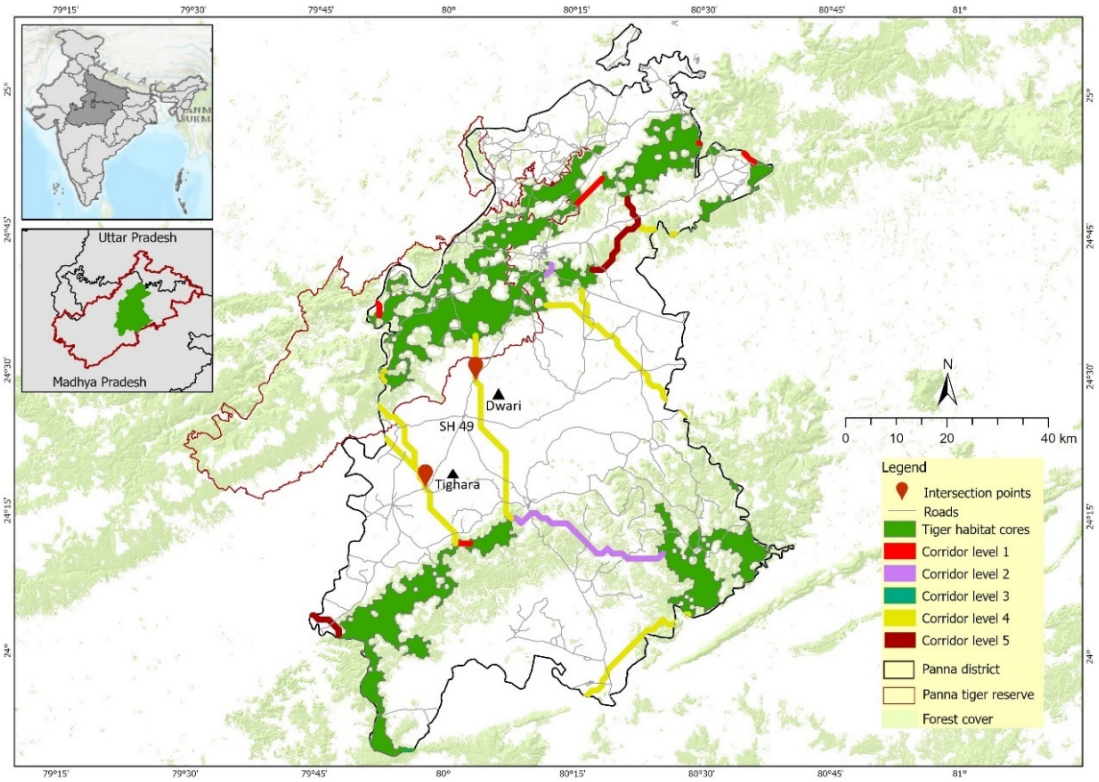


Figure 10.116. Map showing points where major roads are intersecting with proposed corridors in Panna District for structural interventions

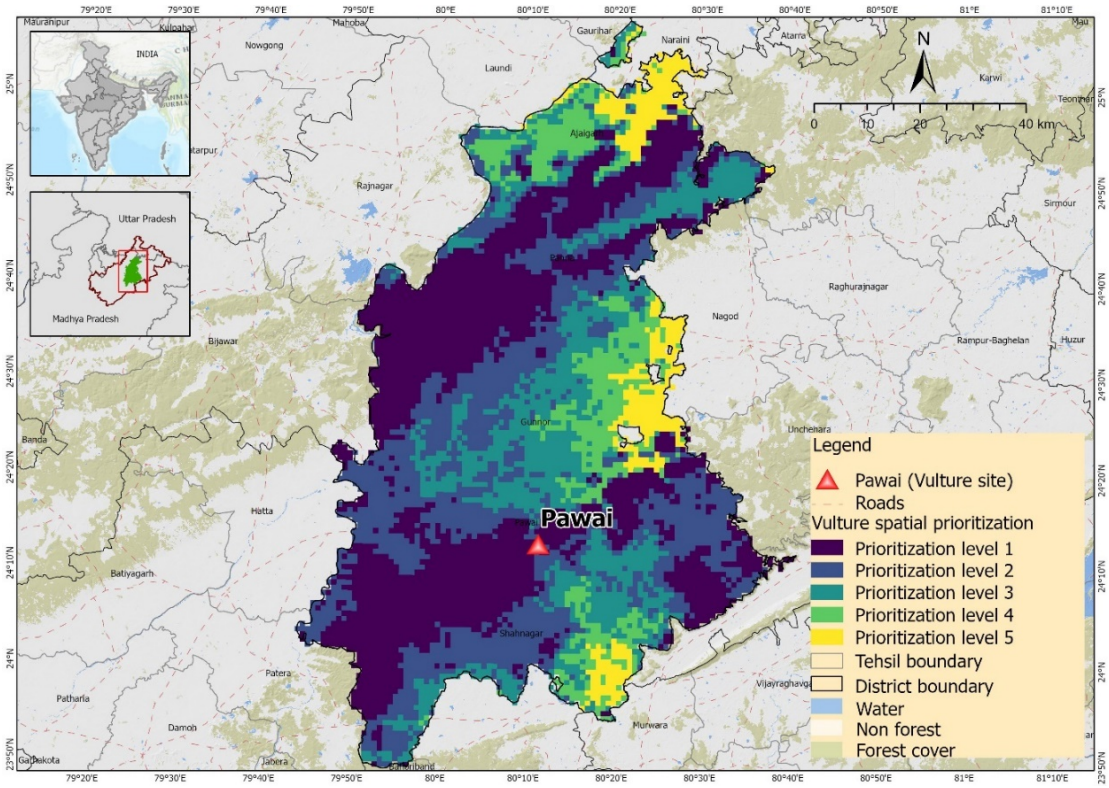


Figure 10.117. Map showing vulture conservation priority areas within Panna District (the red placemark is Pawai, which should be declared as Conservation Reserve)

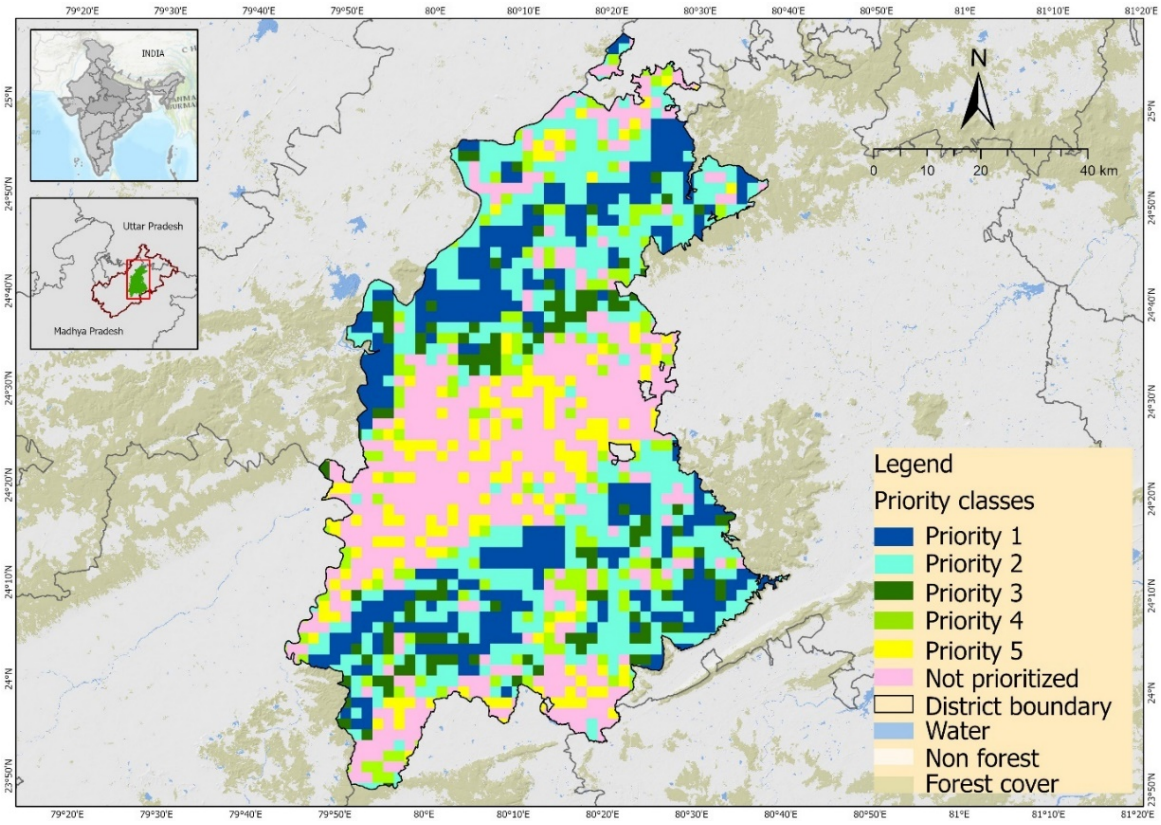


Figure 10.118. Priority areas for conservation in Panna District

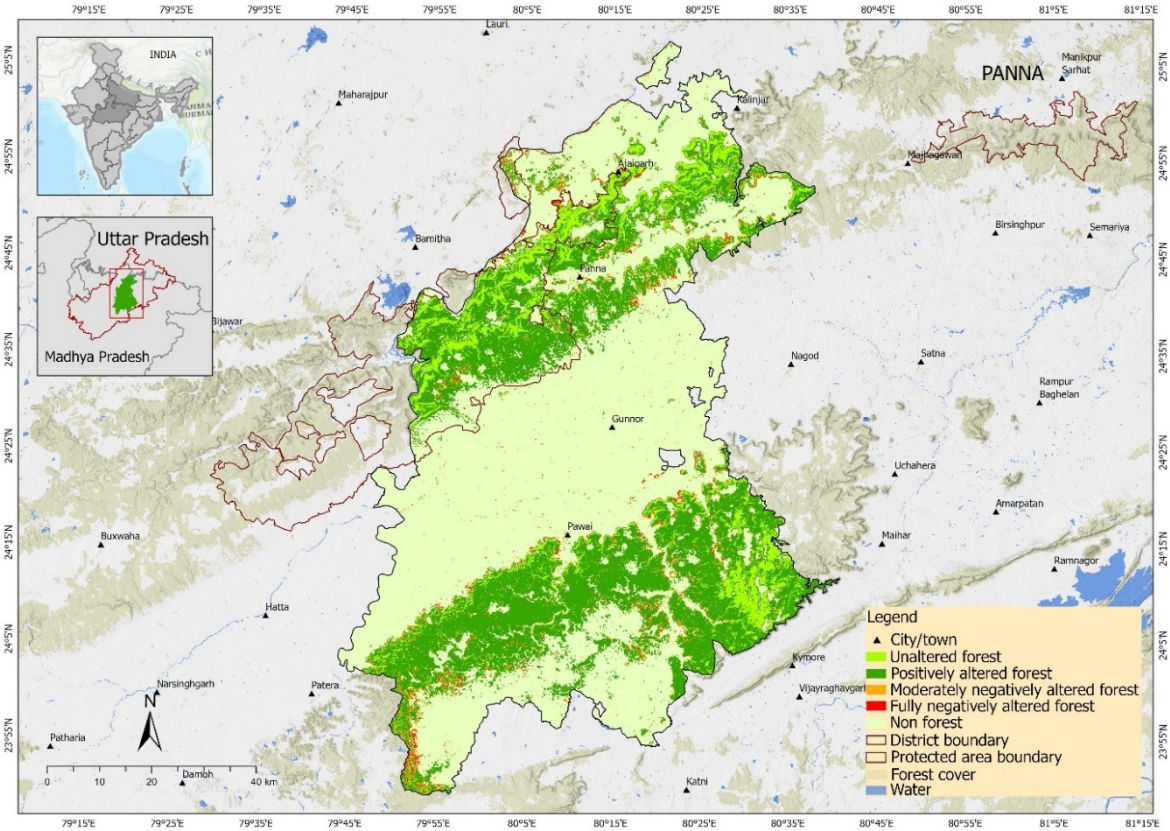


Figure 10.119. Map showing altered-unaltered landscape within Panna District

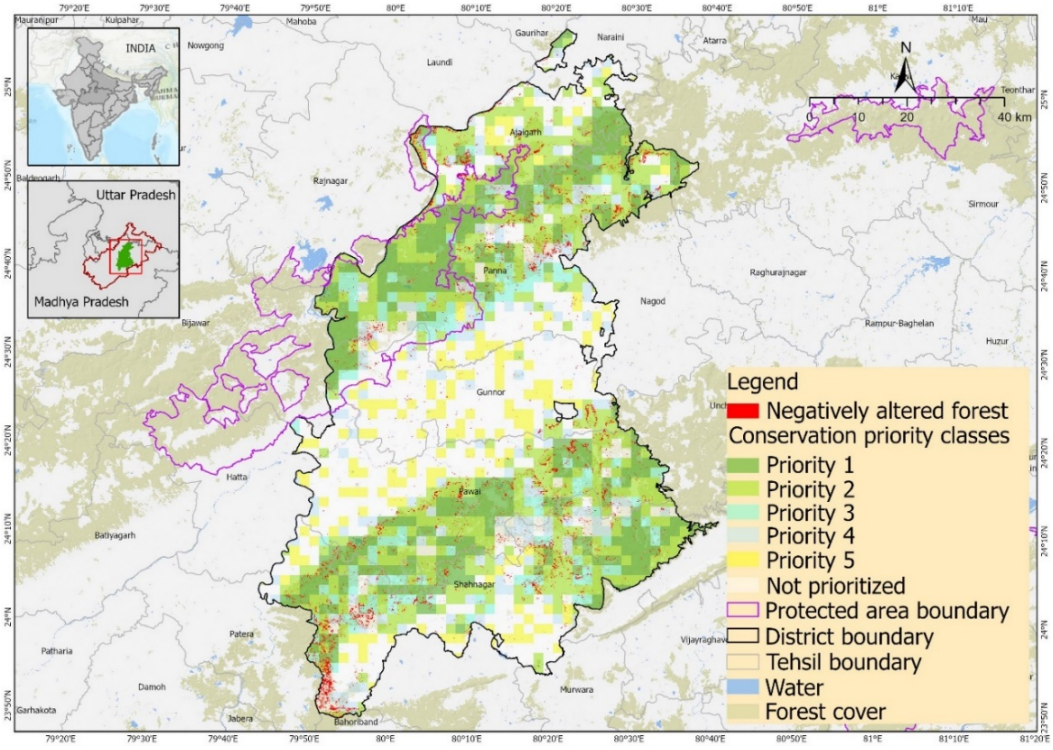


Figure 10.120. Map showing negatively altered landscape overlaid on priority areas of conservation within Panna District

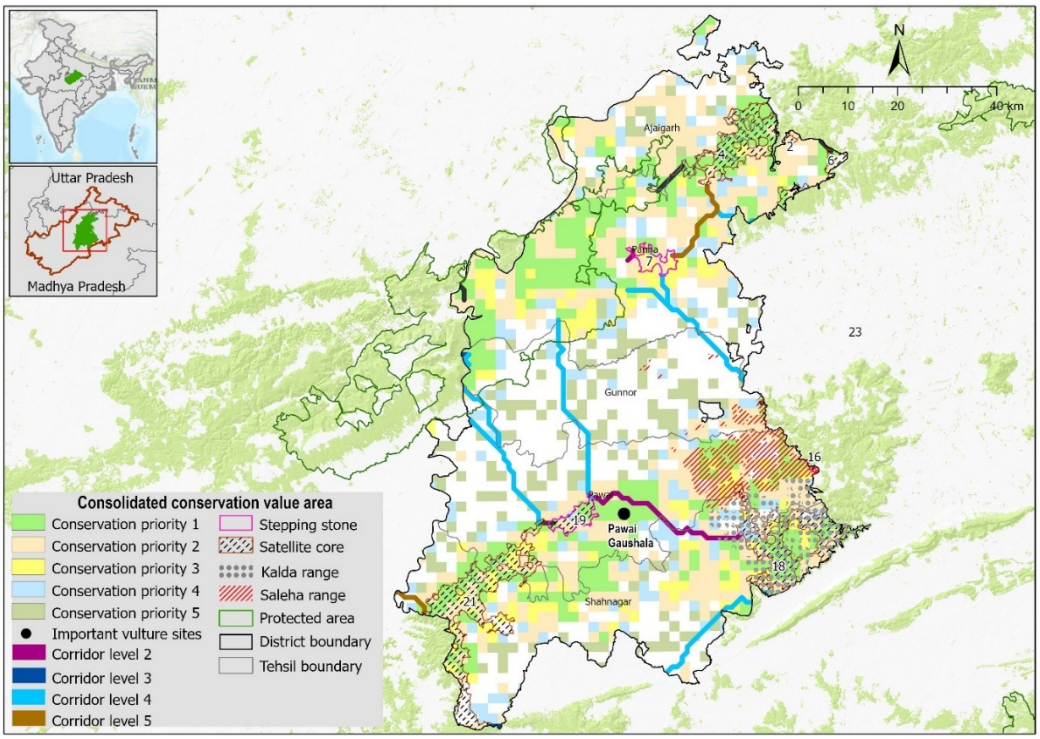


Figure 10.121. Map showing all the areas to be protected and restored (satellite cores, stepping stones, corridors, proposed conservation and community reserves, priority sites for biodiversity conservation) within the Panna District

(2) Chhatarpur District

1. **Habitat Protection** is required for the two satellite cores, three stepping stones, three satellite core/steppingstone and 21 corridors (two priority I, four priority II, six priority III, five priority IV, and four priority V) identified in this District (Fig. 10.122) and this needs to be protected from community dependency and development activities including mining.
2. **Transfer of Landownership** of the five patches of revenue land within PTR to forest department should be done and these can be added to buffer or made as Conservation Reserve or Community Reserve based on consultative process.
3. **Structural Interventions** (overpass and underpass) should be made at points where major roads are cutting through the proposed corridors (Fig. 10.123).
4. **River Conservation Zone** (1km width) around part of Ken River (Fig. 10.122) falling in the district, should be conserved through community-based conservation and restoration methods. There are tourism industries, fishing activities and agriculture practices along the downstream of the Ken River from PTR to KGS, and these stakeholders can be brought under co-management approach to ensure river zone integrity.
5. **Biodiversity Management Committee** should be activated to monitor and conserve the highest conservation priority areas for vultures (Fig. 10.124) and biodiversity (Fig. 10.125). Based on the information collected, access and benefit sharing should be made a part of Gram Panchayat Development Plan.
6. **One Village One Hectare** concept for restoration of areas that have been significantly negatively altered, where forest cover has declined drastically, should be considered (Fig. 10.126). This intervention can involve social forestry, integrated farming, ecosystem service trade-off and carbon economy, and can be subjected to payment for ecosystem service (PES) model at state and national level. Restoration efforts should initially be focussed on negatively altered forests falling within the priority I class of spatial prioritization for biodiversity conservation, and then on priority II, and so on (Fig. 10.127).
7. **Convergence for Consolidation and Restoration:** As indicated above, Fig. 10.128 provides the combined value for PTR, these identified targets should be the focus for habitat consolidation, protection and restoration.

8. **Green Economy Cooperatives and Growth Centres** should be established in selected Panchayat/Village for Amla (Deori, Bhorkuwa, Chandanpura, Baranand, Gopalpura, and Goranand), for Mahua (Kesara, Simariya kalan, Dhanguwan, Chandanpura, Tikari and Sironj), for Tendu (Kesara, Basaraui, Kabar, Motigarh and Bhorkhuwa) and for Achar (Kesara, Punguwa, Bhorkuwa, Patna, Chandanpura, Siddhai, Baranand, Tikari and Goranand) (Appendix 10.5-10.8).

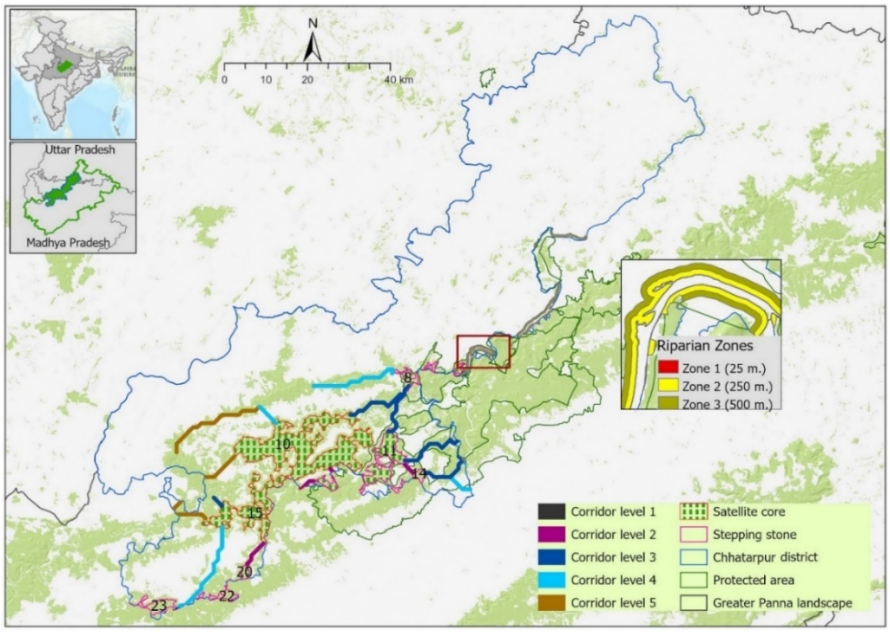


Figure 10.122. Map showing areas to be consolidated (satellite cores, stepping stones, corridors, and river conservation zone) in Chhatarpur District

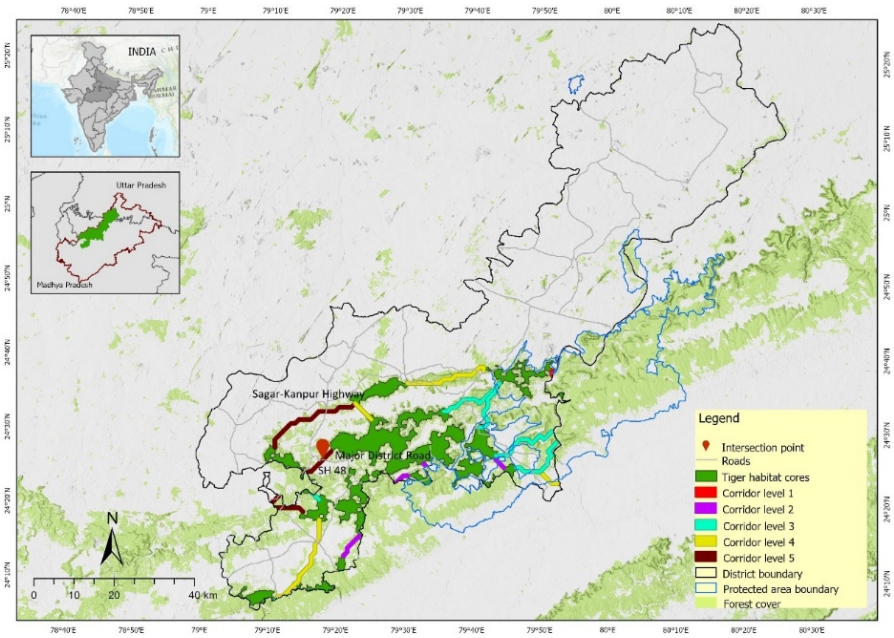


Figure 10.123. Map showing points where major roads are intersecting with proposed corridors in Chhatarpur District for structural interventions

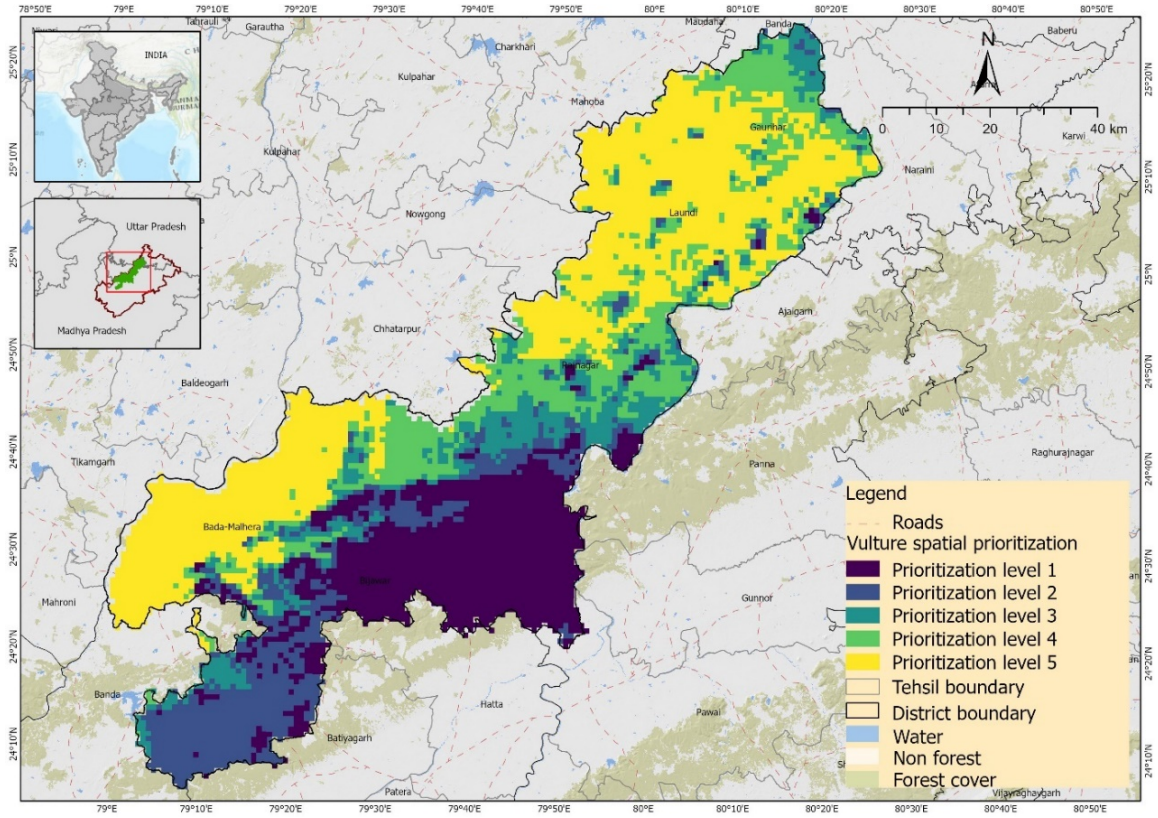


Figure 10.124. Map showing vulture conservation priority areas within Chhatarpur District

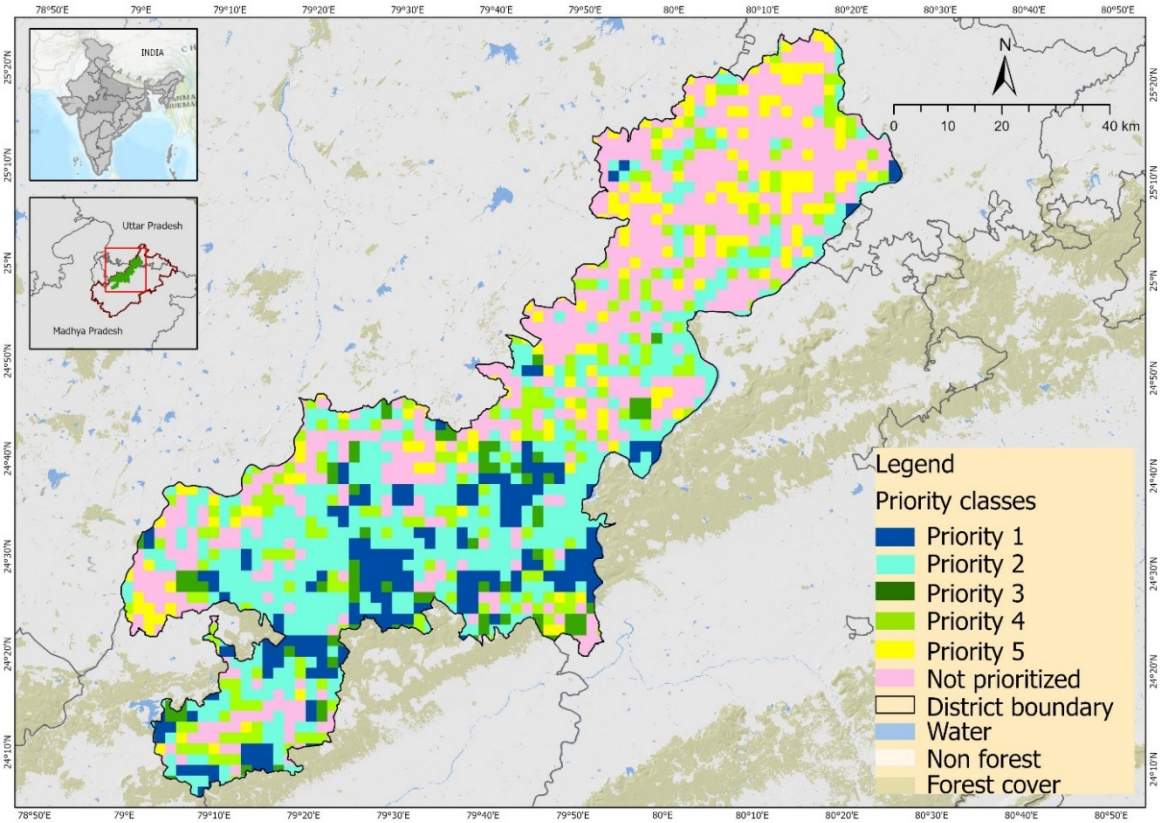


Figure 10.125. Priority areas for conservation in Chhatarpur District

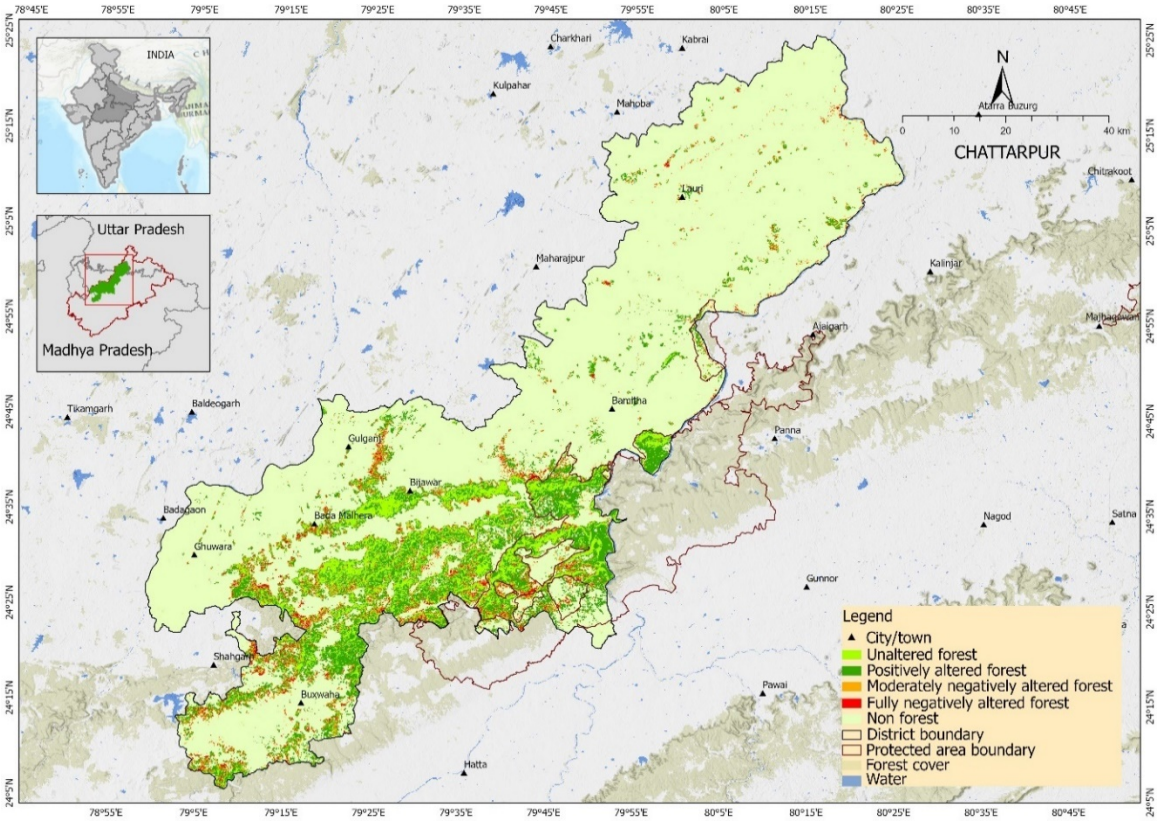


Figure 10.126. Map showing altered-unaltered landscape within Chhatarpur District

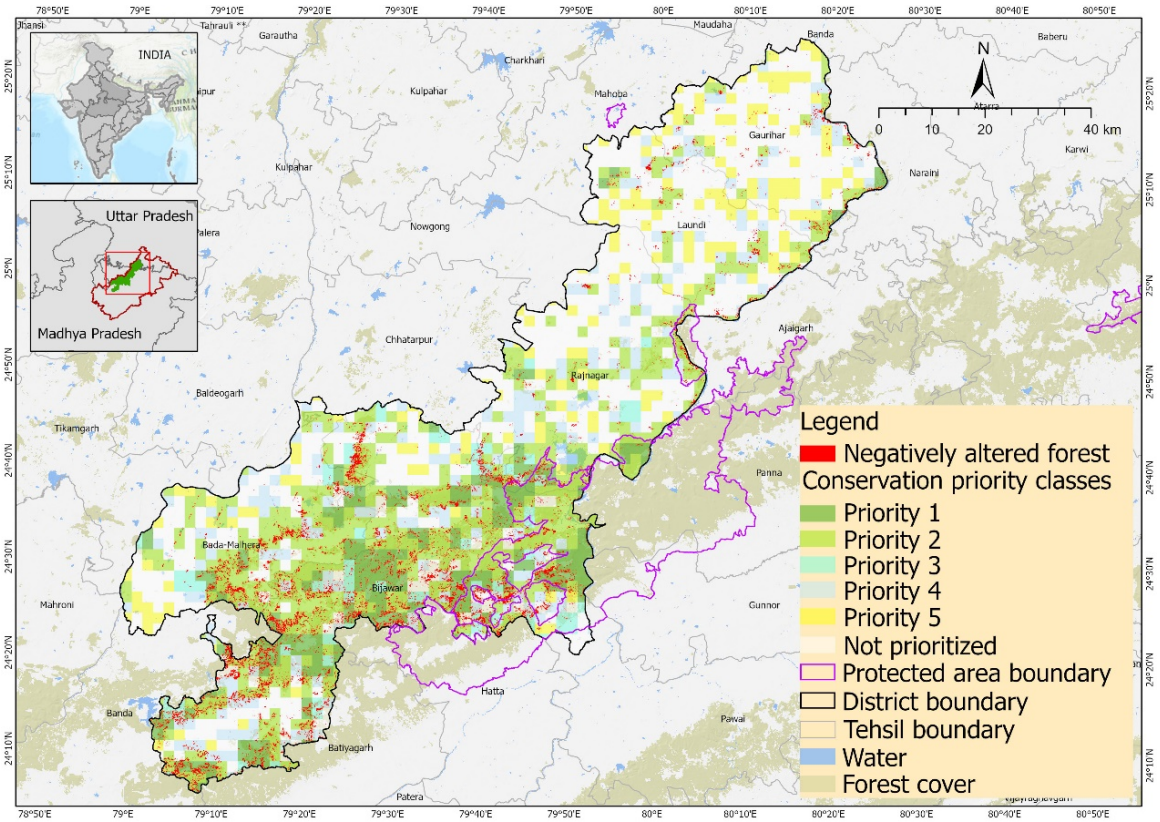


Figure 10.127. Map showing negatively altered landscape overlaid on priority areas of conservation within Chhatarpur District

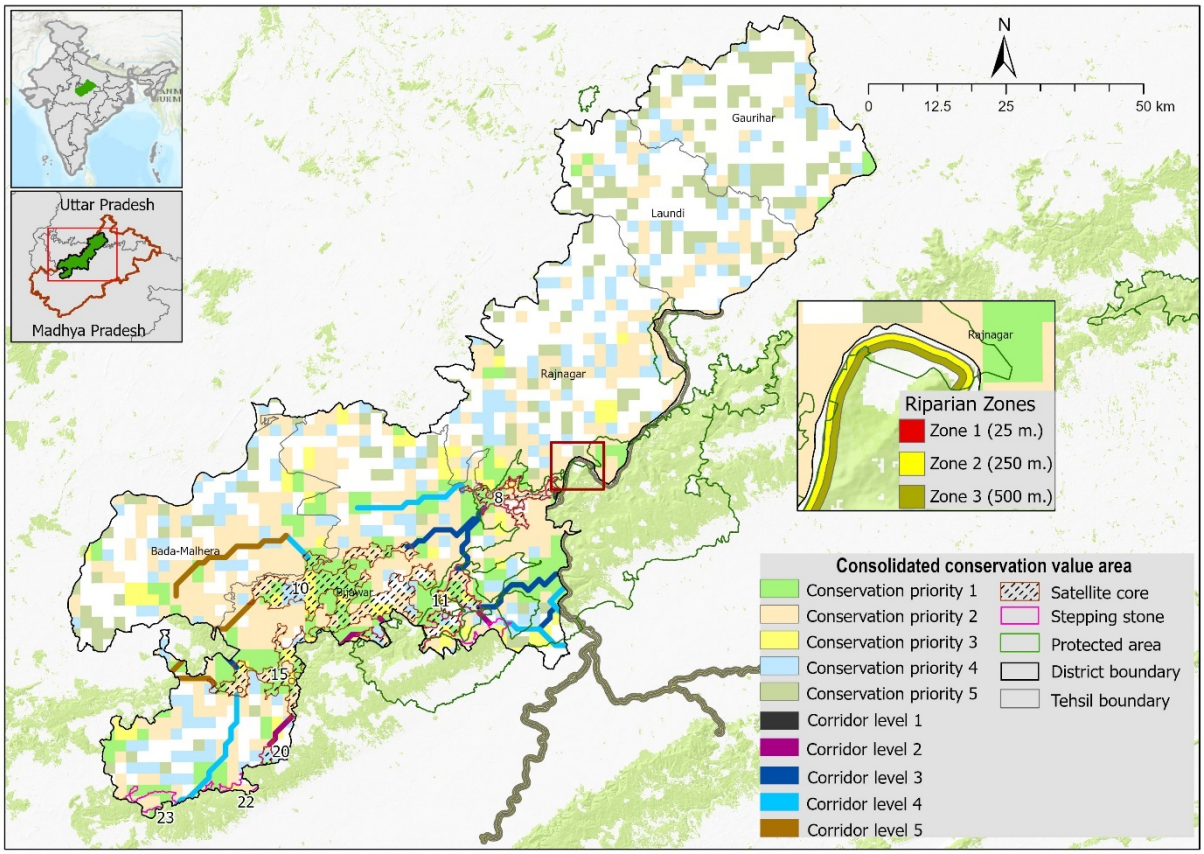


Figure 10.128. Map showing all the areas to be protected and restored (satellite cores, stepping stones, corridors, proposed community reserve, priority sites for biodiversity conservation) within the Chhatarpur District

(3) Damoh District

1. **Habitat Protection** is required for the five satellite cores, three stepping stones, two satellite core/steppingstone and 15 corridors (three priority I, three priority II, one priority III, two priority IV, and six priority V) identified in this District (Fig. 10.129) and this needs to be protected from community dependency and development activities including mining.
2. **Expansion of Veerangana Durgawati Wildlife Sanctuary** is necessary to ensure viability of the sanctuary for wildlife and people, and this can be done by adding Singrampur Range of Damoh Forest Division (Fig. 10.129). This would have to be integrated with the proposed Nauradehi Tiger Reserve.
3. **Structural Interventions** (overpass and underpass) should be made at points where major roads are cutting through the proposed corridors (Fig. 10.130).
4. **Biodiversity Management Committee** should be activated to monitor and conserve the highest conservation priority areas for vultures (Fig. 10.131) and

biodiversity (Fig. 10.132). The Baghdari Falls in Damoh Forest Division should be brought under enhanced conservation focus, as Important Vulture Area (IVA) (Fig. 10.131). Based on the information collected, access and benefit sharing should be made a part of Gram Panchayat Development Plan.

5. **One Village One Hectare** concept for restoration of areas that have been significantly negatively altered, where forest cover has declined drastically, should be considered (Fig. 10.133). This intervention can involve social forestry, integrated farming, ecosystem service trade-off and carbon economy, and can be subjected to payment for ecosystem service (PES) model at state and national level. Restoration efforts should initially be focussed on negatively altered forests falling within the priority I class of spatial prioritization for biodiversity conservation, and then on priority II, and so on (Fig. 10.134).
6. **Convergence for Consolidation and Restoration:** As indicated above, Fig. 10.135 provides the combined value for PTR, these identified targets should be the focus for habitat consolidation, protection and restoration.
7. **Green Economy Cooperatives and Growth Centres** should be established in selected Panchayat/Village for Amla (Shikarpura, Hathibhar, Ukarpur, Khapa, Madho and Sarra), for Mahua (Shikarpura and Ukarpur), for Tendu (Hatidol) and for Achar (Shikarpura, Ukarpur, Majhguwan, Sarra, Daroli, Parna, Geedan, Madanpura, Kalkuwa and Shahpura) (Appendix 10.9-10.12).

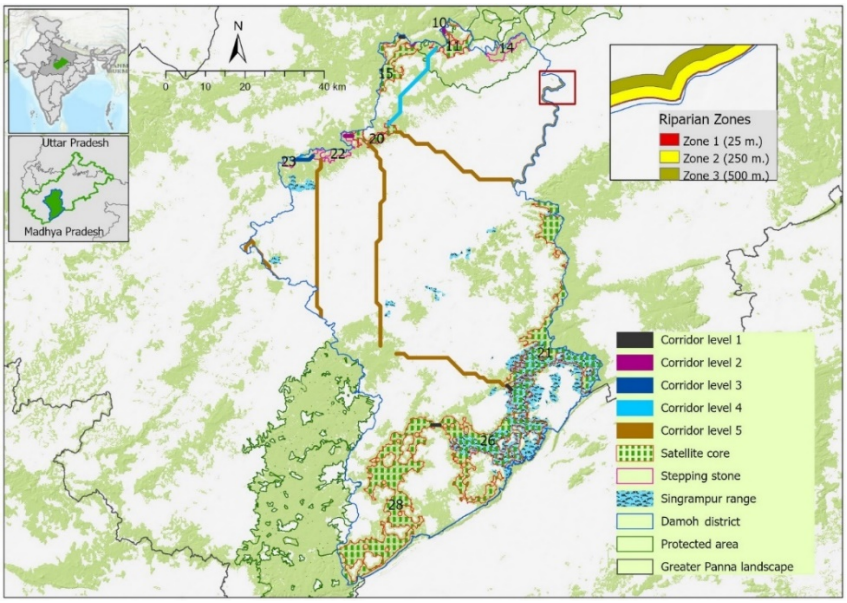


Figure 10.129. Map showing areas to be consolidated (satellite cores, stepping stones, corridors and Singrampur Range) within Damoh District

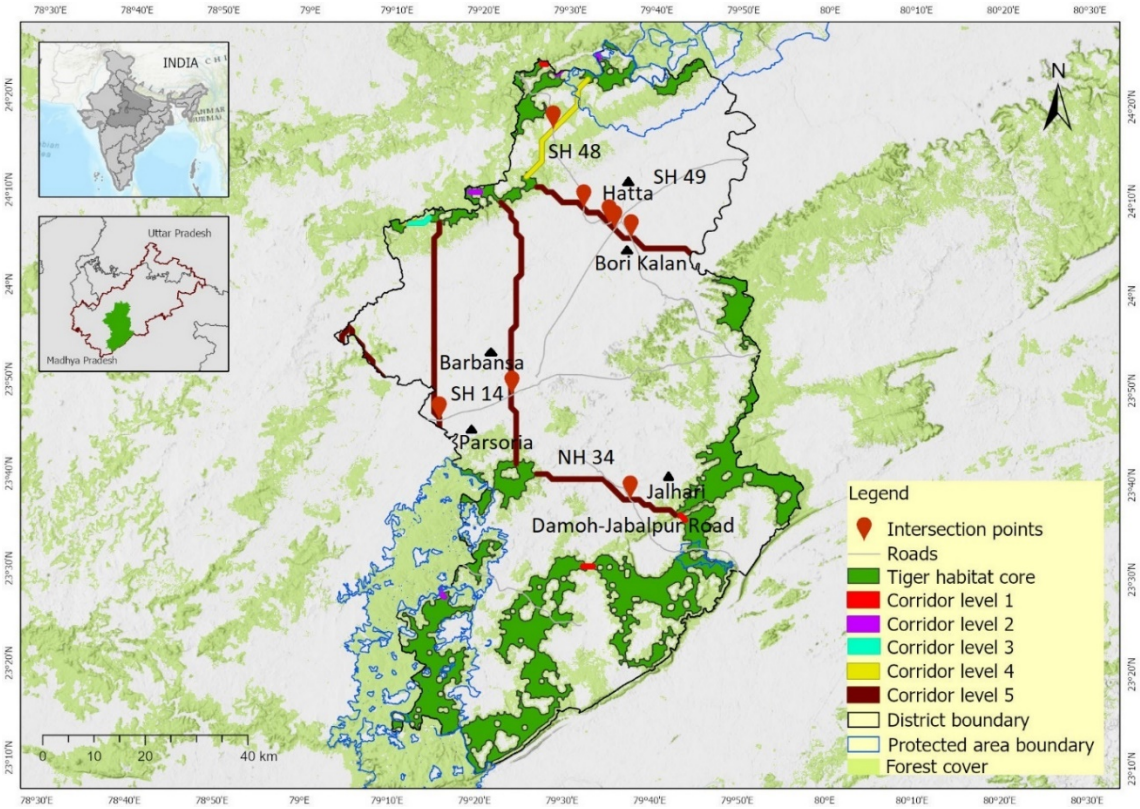


Figure 10.130. Map showing points where major roads are intersecting with proposed corridors in Damoh District for structural interventions

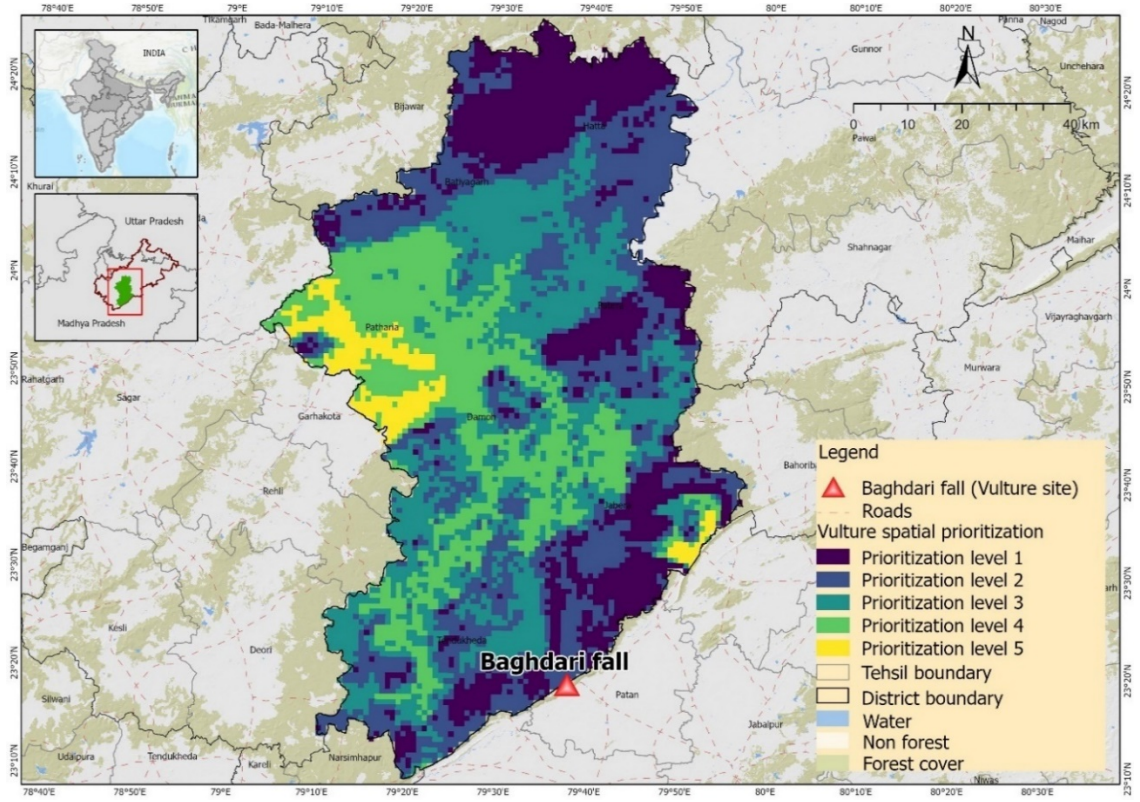


Figure 10.131. Map showing vulture conservation priority areas within Damoh District

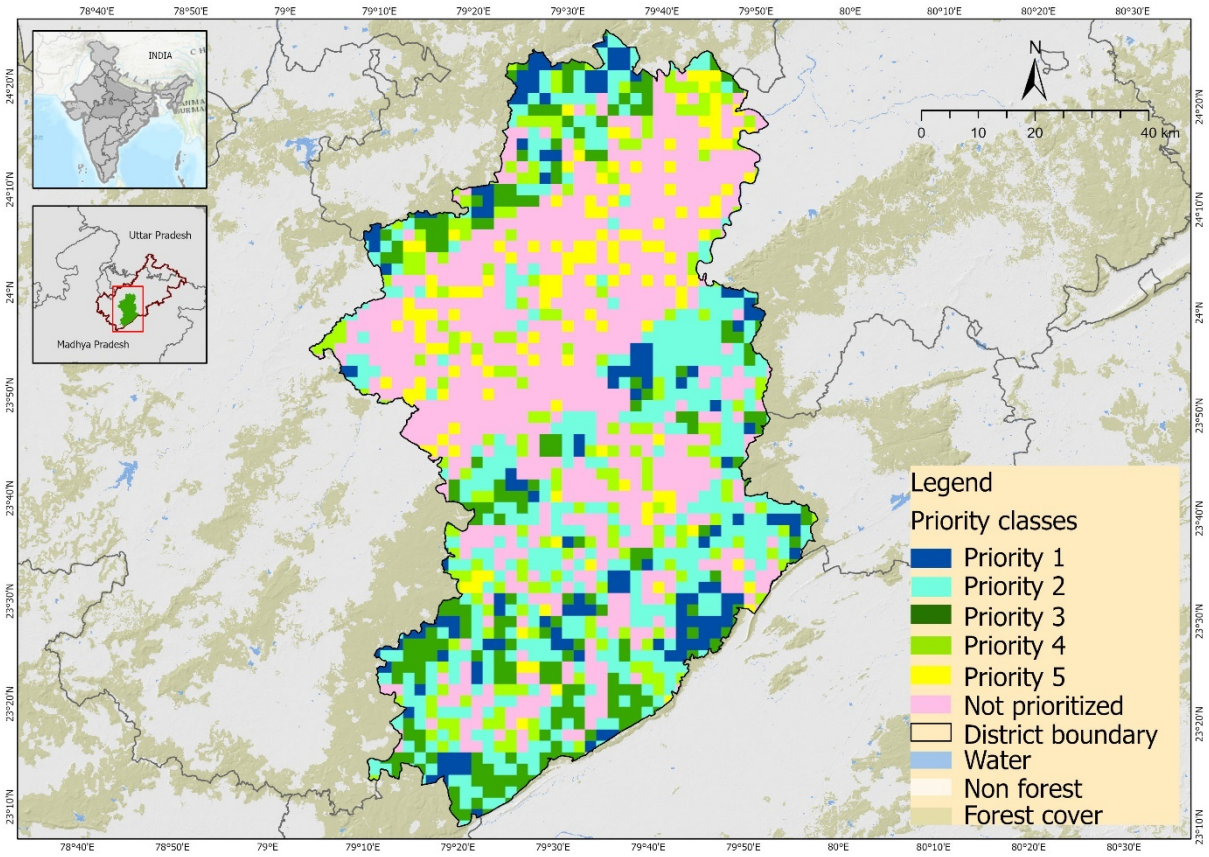


Figure 10.132. Priority areas for conservation in Damoh District

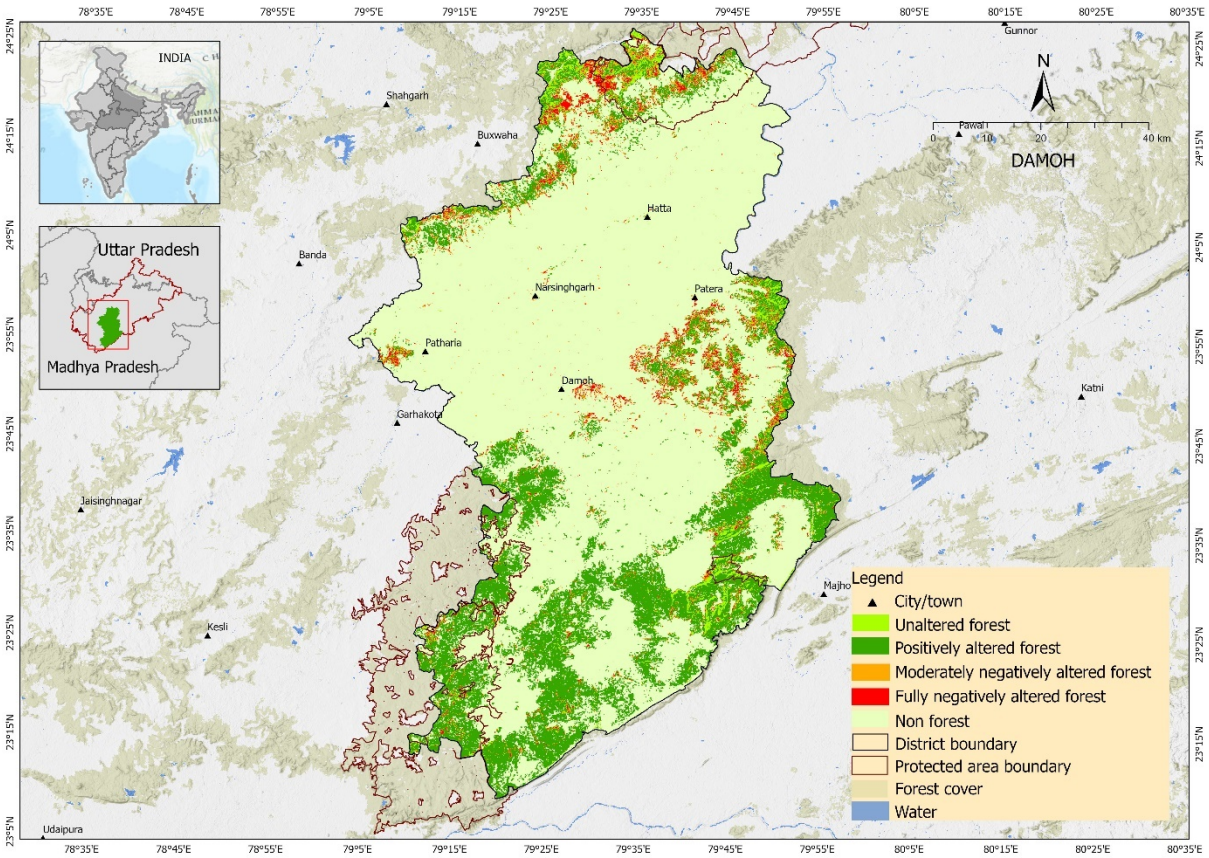


Figure 10.133. Map showing altered-unaltered landscape within Damoh District

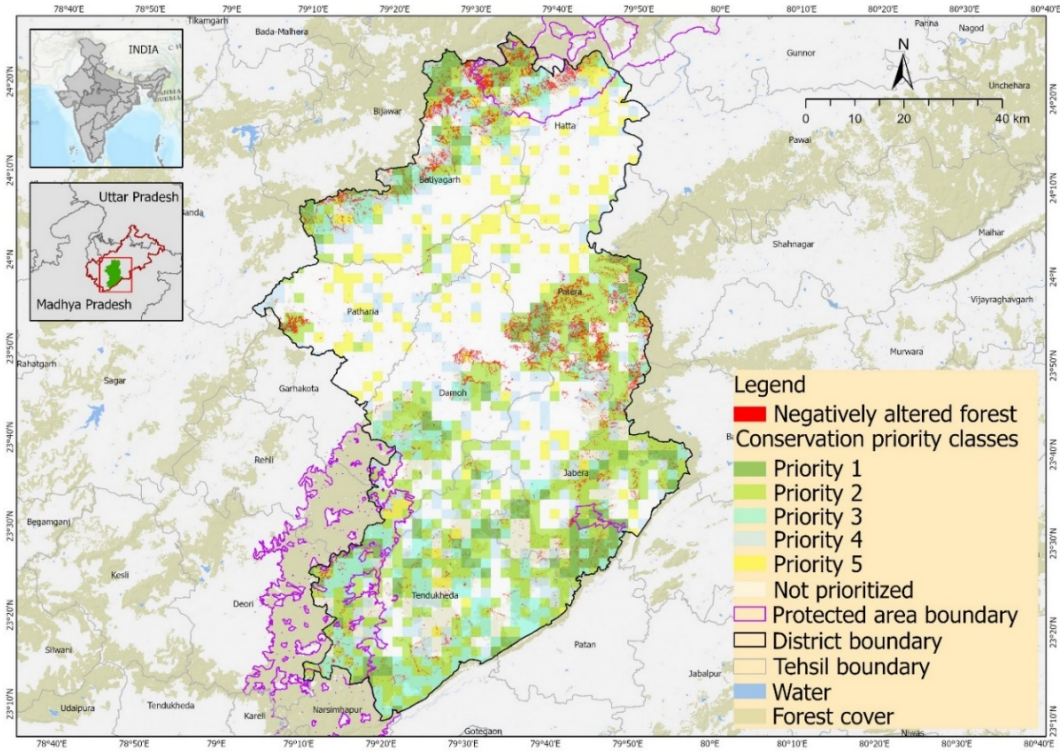


Figure 10.134. Map showing negatively altered landscape overlaid on priority areas of conservation within Damoh District

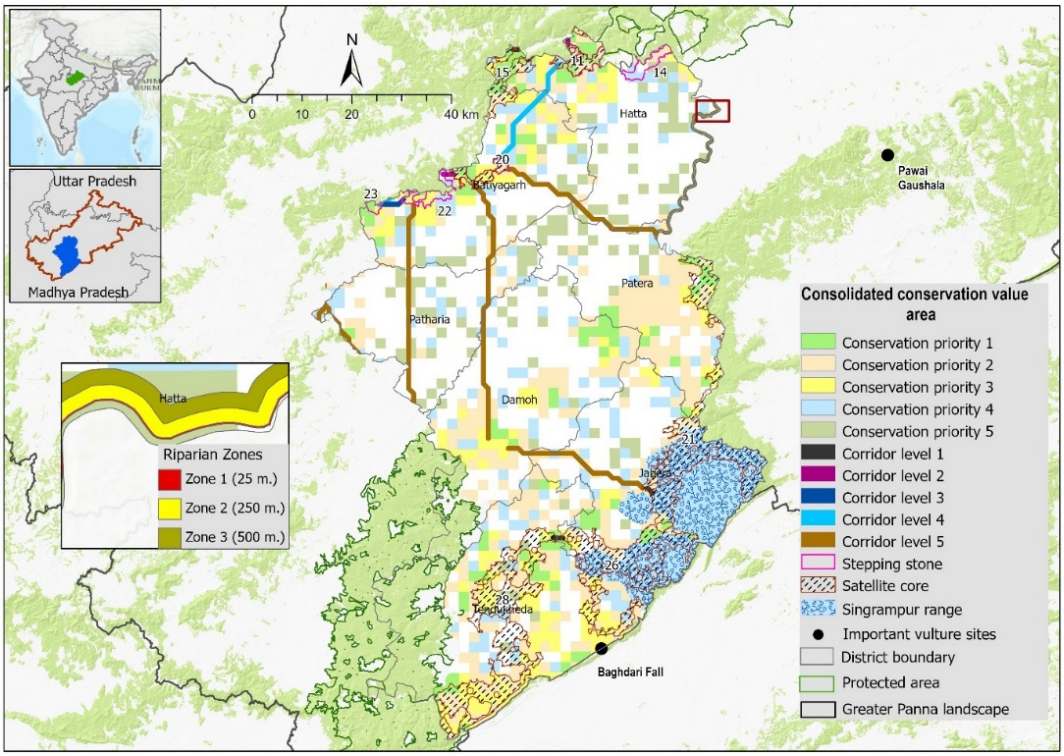


Figure 10.135. Map showing all the areas to be protected and restored (satellite cores, stepping stones, corridors, proposed tiger and community reserves, priority sites for biodiversity conservation) within the Damoh District

(4) Satna District

1. **Habitat Protection** is required for the four satellite cores, one steppingstone, one satellite core/steppingstone and 13 corridors (three priority I, one priority II, one priority III, seven priority IV, and one priority V) identified in this District (Fig. 10.136) and this needs to be protected from community dependency and development activities including mining.
2. **Inter-state Tiger Reserve**, proposed to be constituted with Ranipur Wildlife Sanctuary as core area is required to be supported with Majhgawan Range of Satna Forest Division as buffer (Fig. 10.137). This is critical for consolidating habitat and ensuring long-term survival of tigers in this recovering core area.
3. **Structural Interventions** (overpass and underpass) should be made at points where major roads are cutting through the proposed corridors (Fig. 10.138).
4. **Biodiversity Management Committee** should be activated to monitor and conserve the highest conservation priority areas for vultures (Fig. 10.139) and biodiversity (Fig. 10.140). Based on the information collected, access and benefit sharing should be made a part of Gram Panchayat Development Plan.
5. **One Village One Hectare** concept for restoration of areas that have been significantly negatively altered, where forest cover has declined drastically, should be considered (Fig. 10.141). This intervention can involve social forestry, integrated farming, ecosystem service trade-off and carbon economy, and can be subjected to payment for ecosystem service (PES) model at state and national level. Restoration efforts should initially be focussed on negatively altered forests falling within the priority I class of spatial prioritization for biodiversity conservation, and then on priority II, and so on (Fig. 10.142).
6. **Convergence for Consolidation and Restoration:** As indicated above, Fig. 10.143 provides the combined value for PTR, these identified targets should be the focus for habitat consolidation, protection and restoration.
7. **Green Economy Cooperatives and Growth Centres** should be established in selected Panchayat/Village for Amla (Bichhiya, Madulihai, Bhathawa, Lotni, Lalpur, Panna, Panihai and Moharwa), for Mahua (Pahauwa), for Tendu (Hatidol) and for Achar (Bichhiya, Lotni and Bilha Kangali) (Appendix 10.13-10.16).

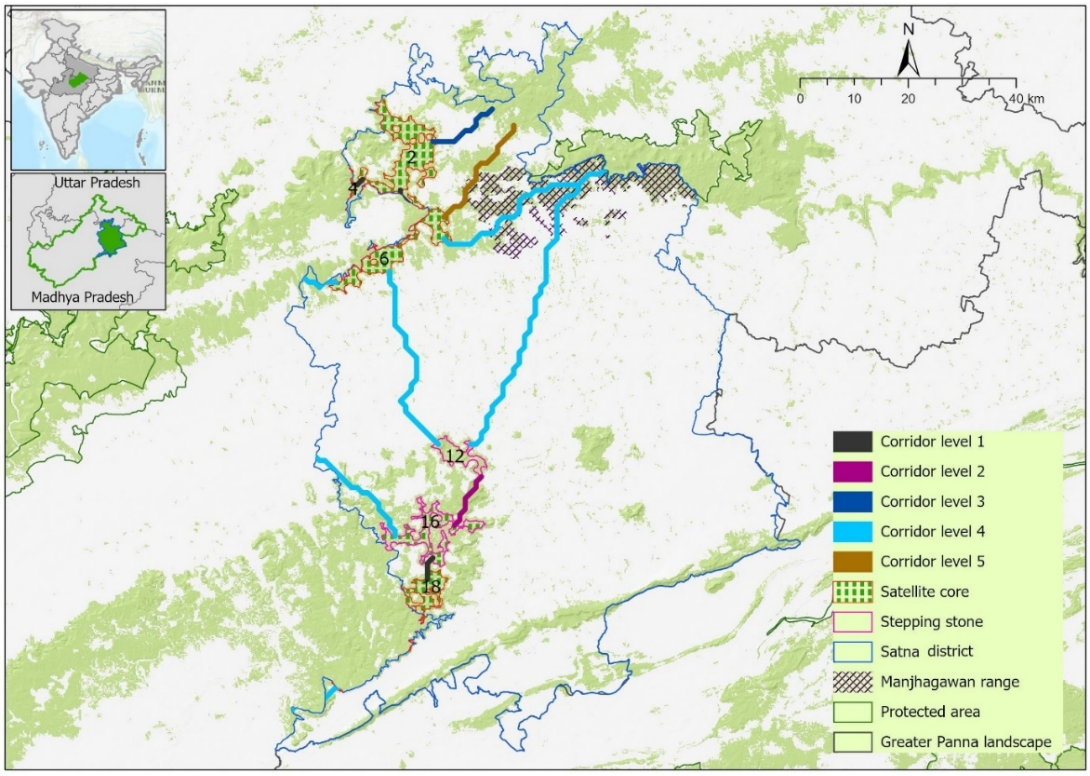


Figure 10.136. Map showing areas to be consolidated (satellite cores, stepping stones and corridors) in Satna District

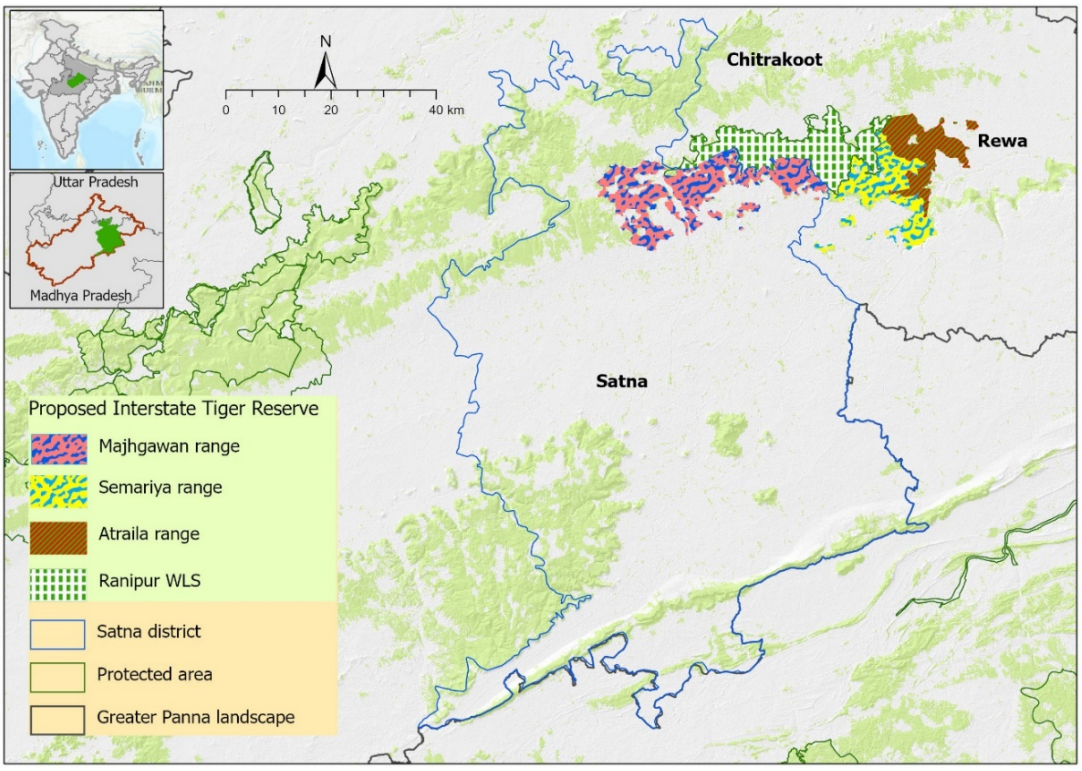


Figure 10.137. Map showing areas to be consolidated under Interstate Tiger Reserve in Satna District

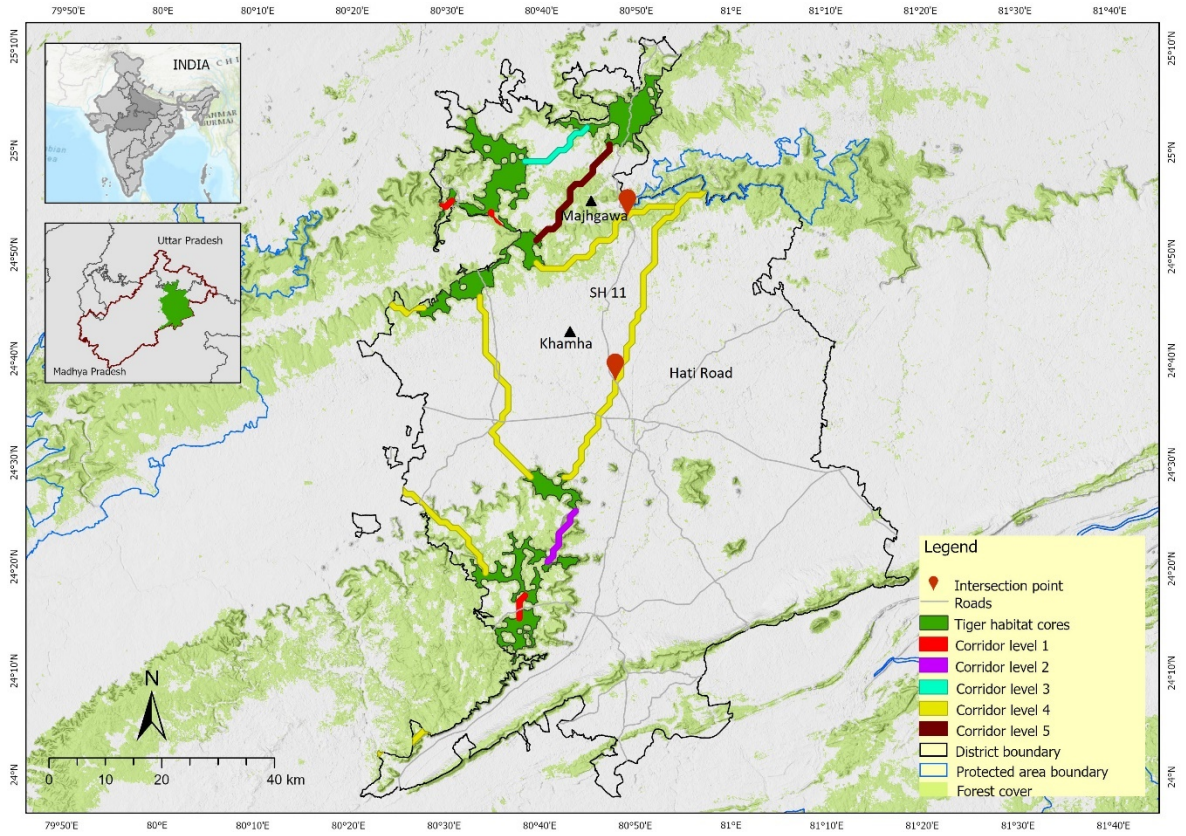


Figure 10.138. Map showing points where major roads are intersecting with proposed corridors in Satna District for structural interventions

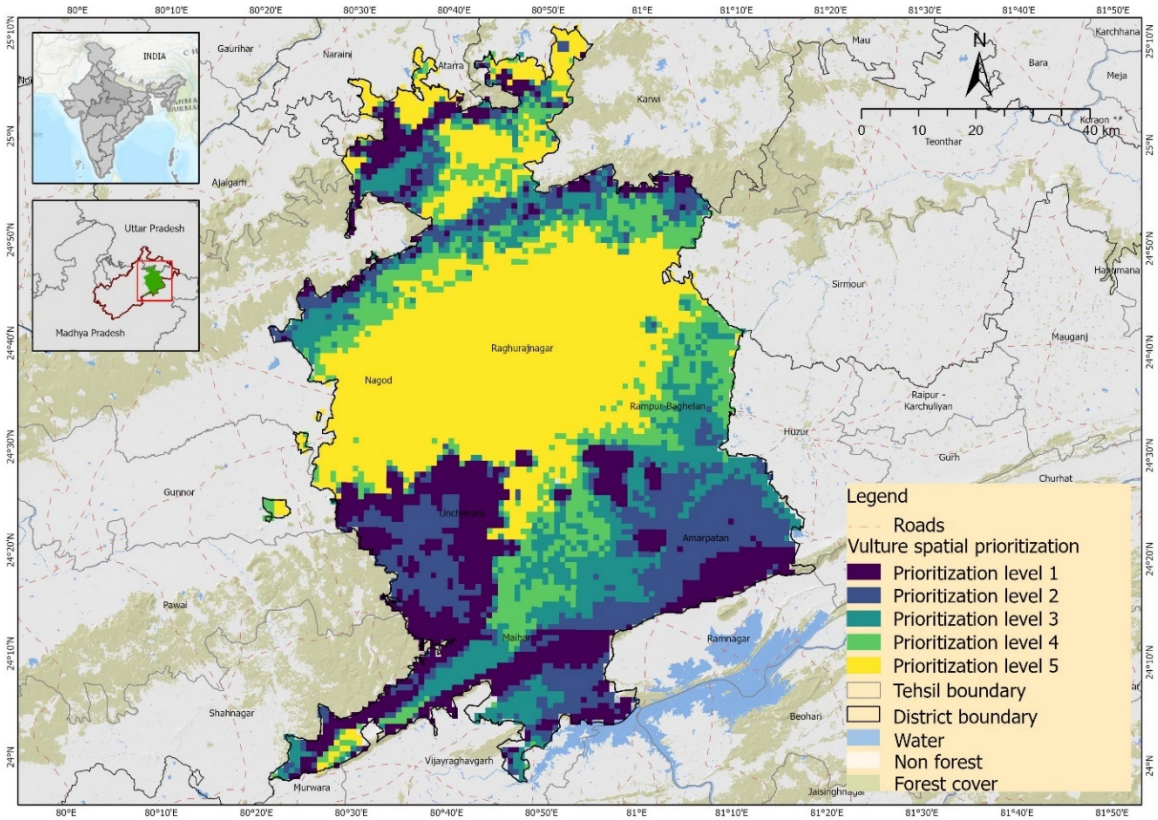


Figure 10.139. Map showing vulture conservation priority areas within Satna District

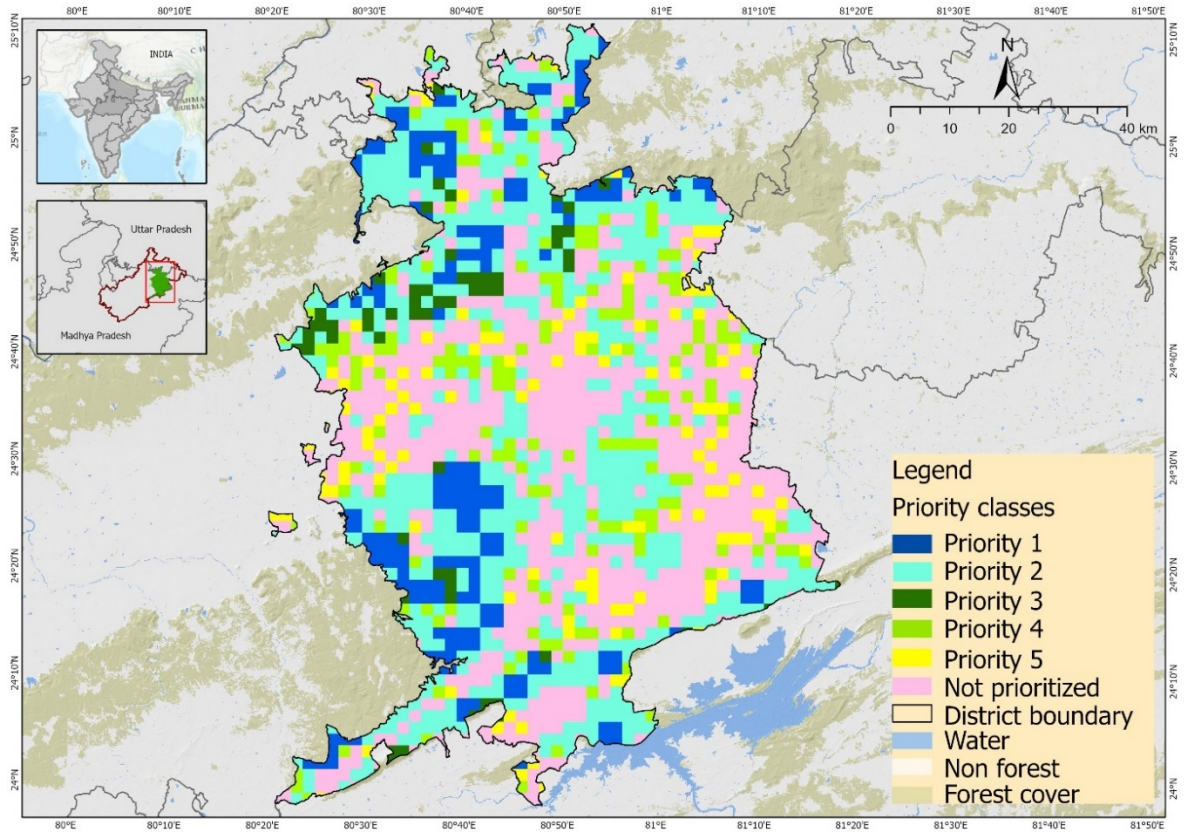


Figure 10.140. Priority areas for conservation within Satna District

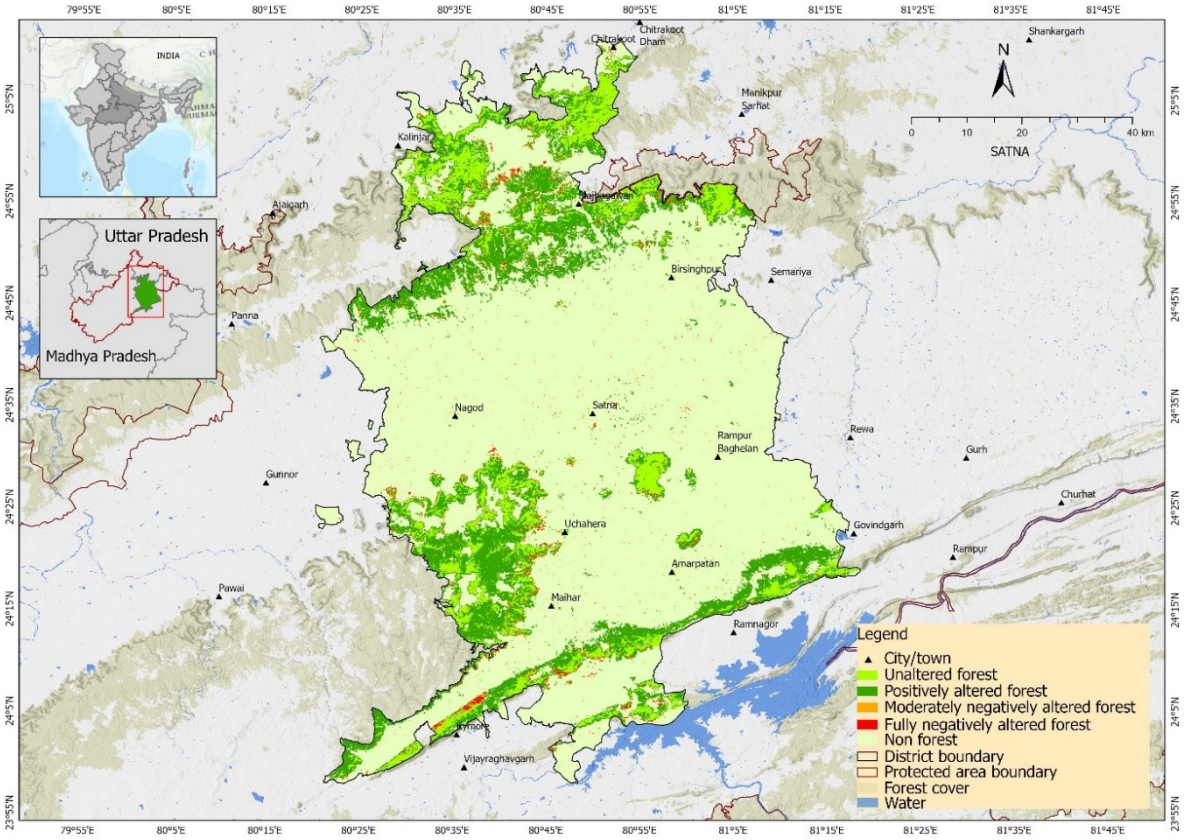


Figure 10.141. Map showing altered-unaltered landscape within Satna District

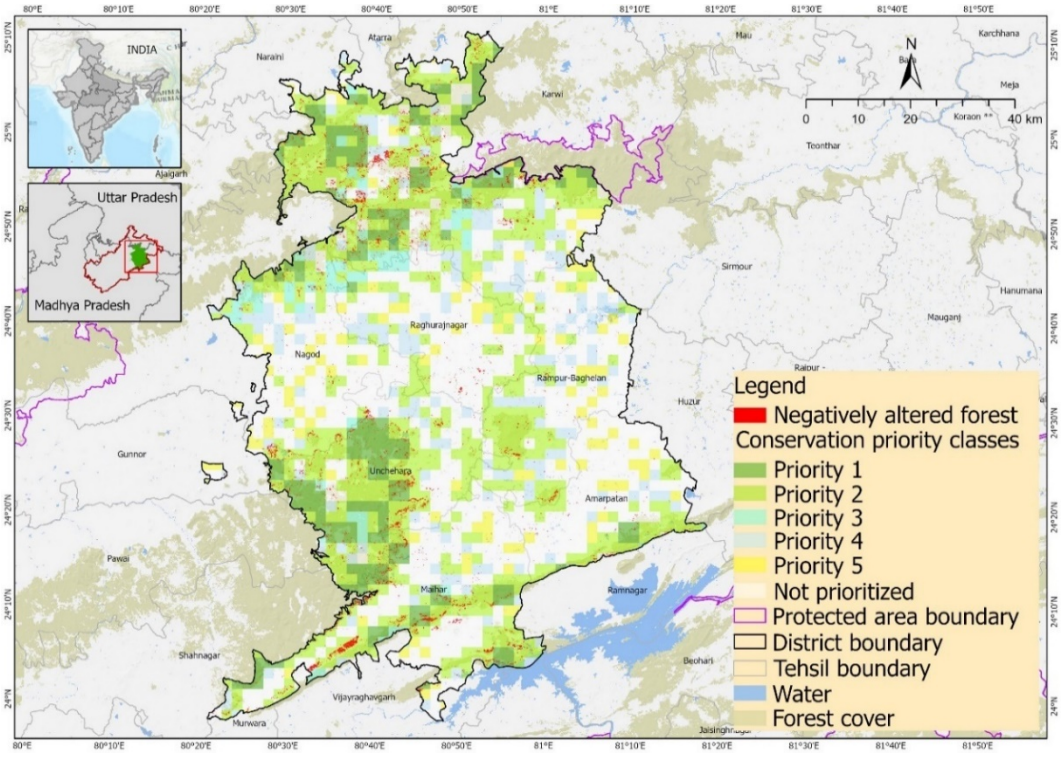


Figure 10.142. Map showing negatively altered landscape overlaid on priority areas of conservation within Satna District

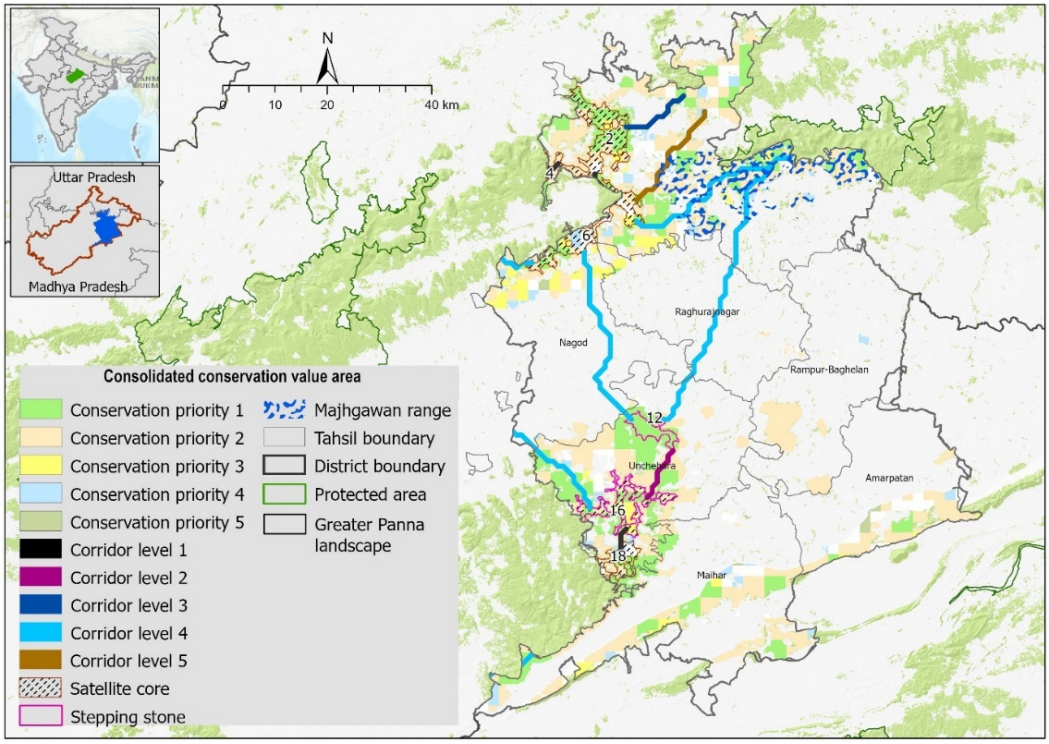


Figure 10.143. Map showing all the areas to be protected and restored (satellite cores, stepping stones, corridors, proposed tiger reserve, priority sites for biodiversity conservation) within the Satna District

(5) Rewa District

1. **Inter-state Tiger Reserve**, proposed to be constituted with Ranipur Wildlife Sanctuary as core area is required to be supported with Semariya and Atraila Ranges of Rewa Forest Divisions as buffer (Fig. 10.144). This is critical for consolidating habitat and ensuring long-term survival of tigers in this recovering core area.
2. **Biodiversity Management Committee** should be activated to monitor and conserve the highest conservation priority areas for vultures (Fig. 10.145) and biodiversity (Fig. 10.146). The Purwa Falls in Rewa Forest Division should be brought under enhanced conservation focus, as Important Vulture Area (IVA) (Fig. 10.145). Based on the information collected, access and benefit sharing should be made a part of Gram Panchayat Development Plan.
3. **One Village One Hectare** concept for restoration of areas that have been significantly negatively altered, where forest cover has declined drastically, should be considered (Fig. 10.147). This intervention can involve social forestry, integrated farming, ecosystem service trade-off and carbon economy, and can be subjected to payment for ecosystem service (PES) model at state and national level. Restoration efforts should initially be focussed on negatively altered forests falling within the priority I class of spatial prioritization for biodiversity conservation, and then on priority II, and so on (Fig. 10.148).
4. **Convergence for Consolidation and Restoration:** As indicated above, Fig. 10.149 provides the combined value for PTR, these identified targets should be the focus for habitat consolidation, protection and restoration.
5. **Green Economy Cooperatives and Growth Centres** should be established in selected Panchayat/Village for Amla (Mainaha) and for Mahua (Mainaha and Kolha) (these villages fall within Semariya range which may become buffer of Interstate Tiger Reserve) (Appendix 10.17-10.18).

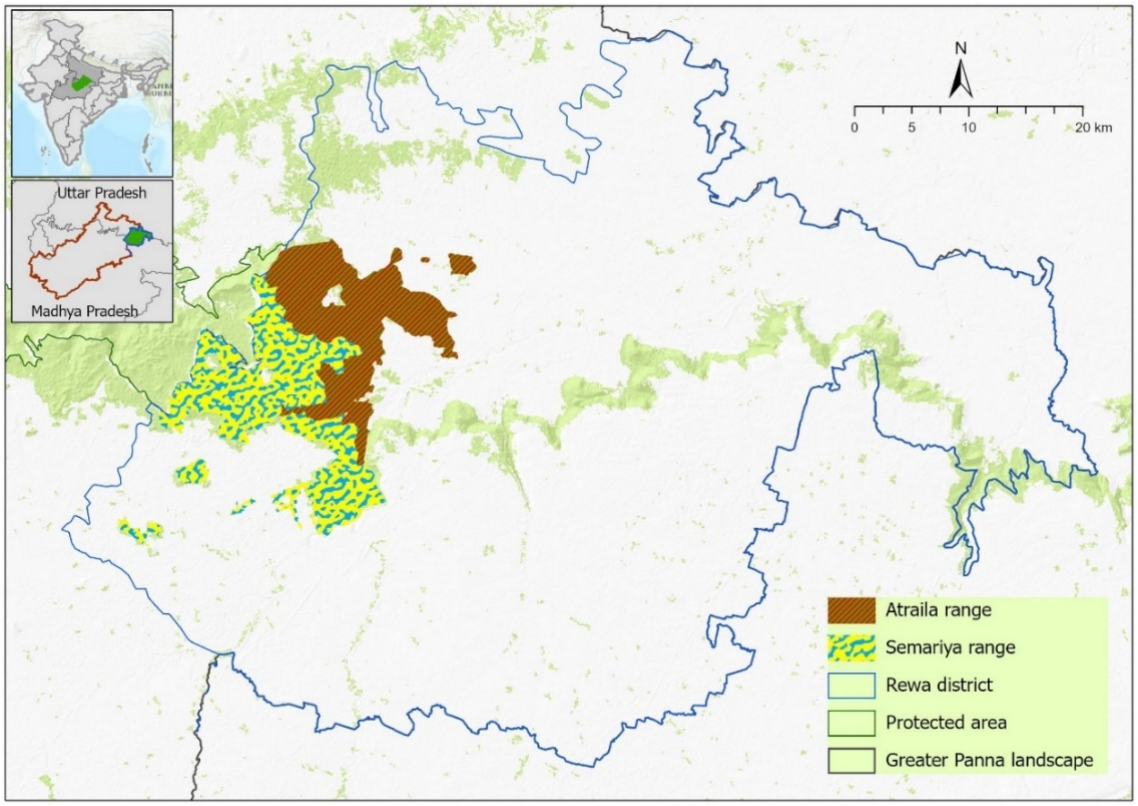


Figure 10.144. Map showing areas to be consolidated under Interstate Tiger Reserve in Rewa District

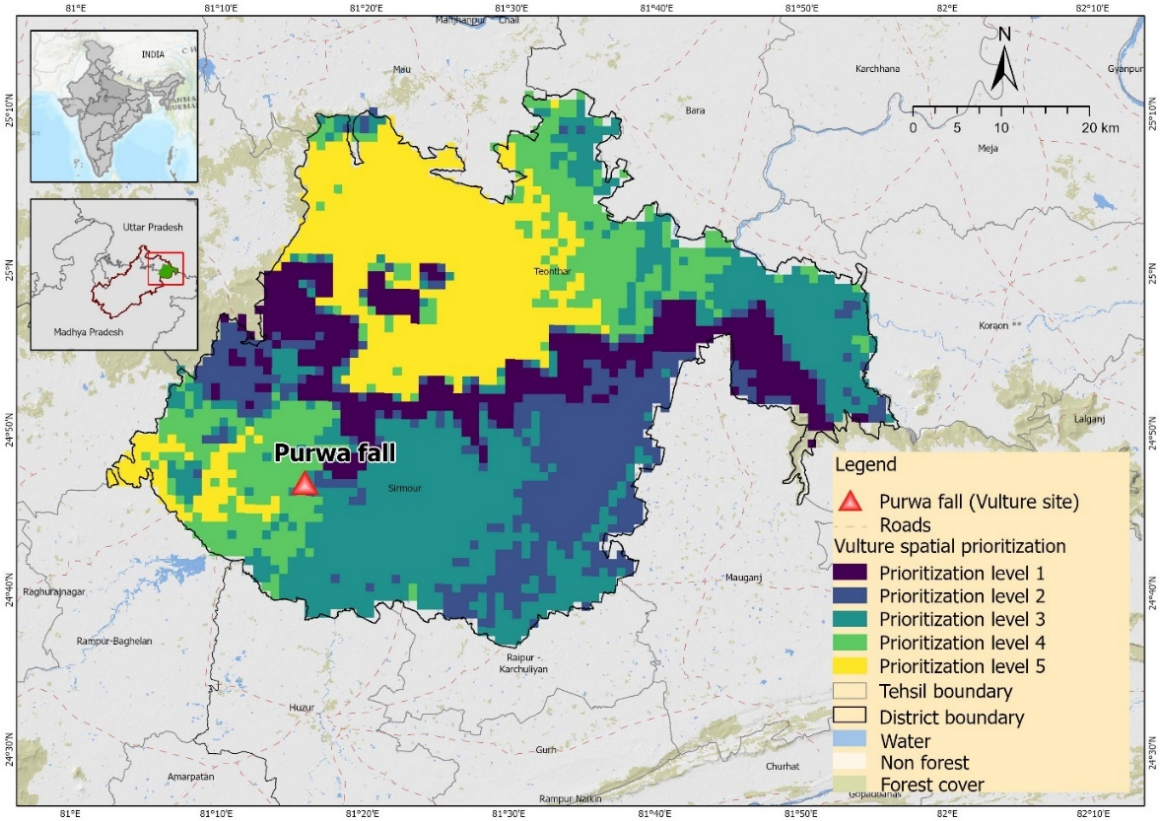


Figure 10.145. Map showing vulture conservation priority areas within Rewa District

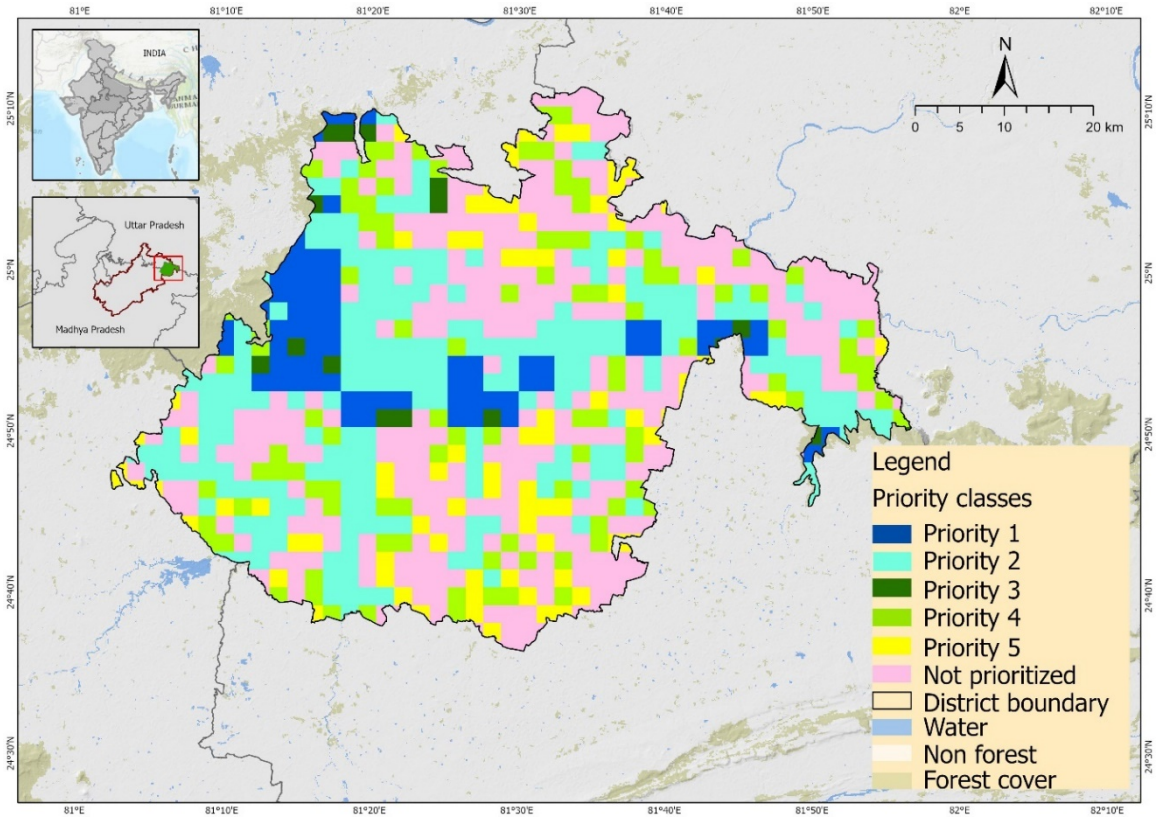


Figure 10.146. Priority areas for conservation within Rewa District

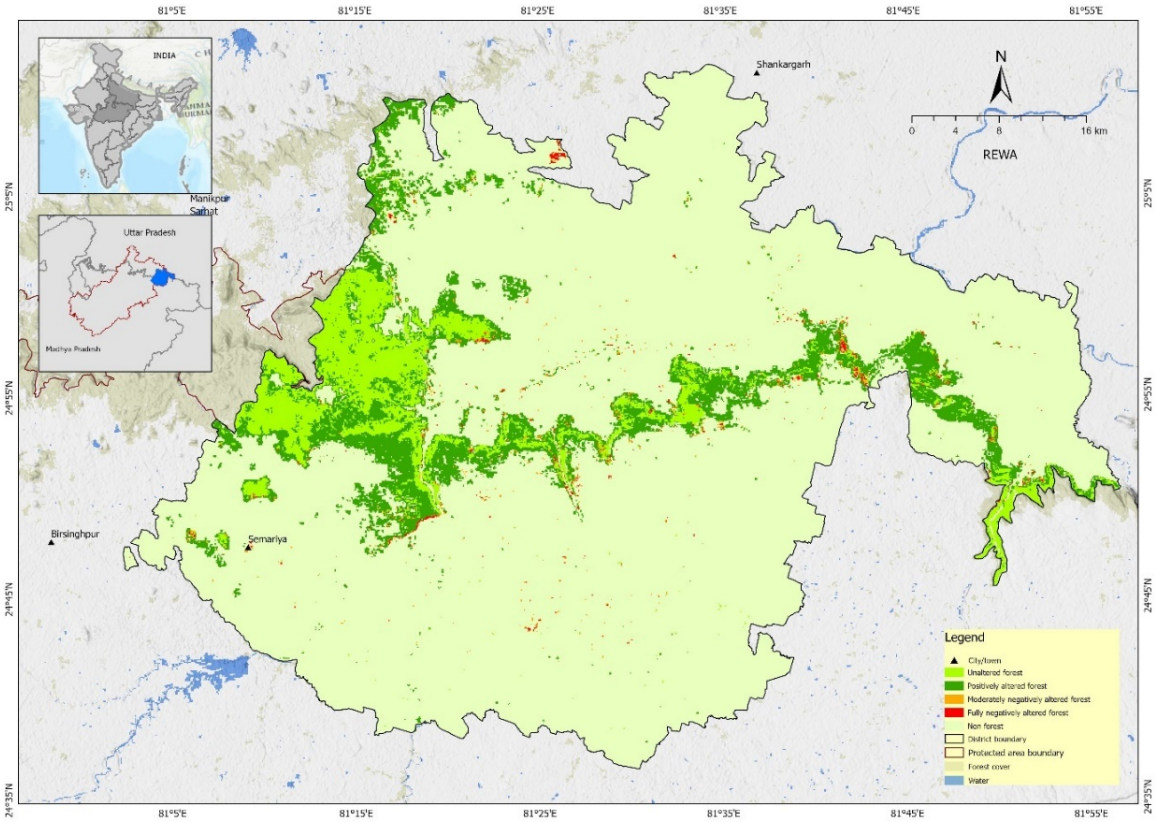


Figure 10.147. Map showing altered-unaltered landscape within Rewa District

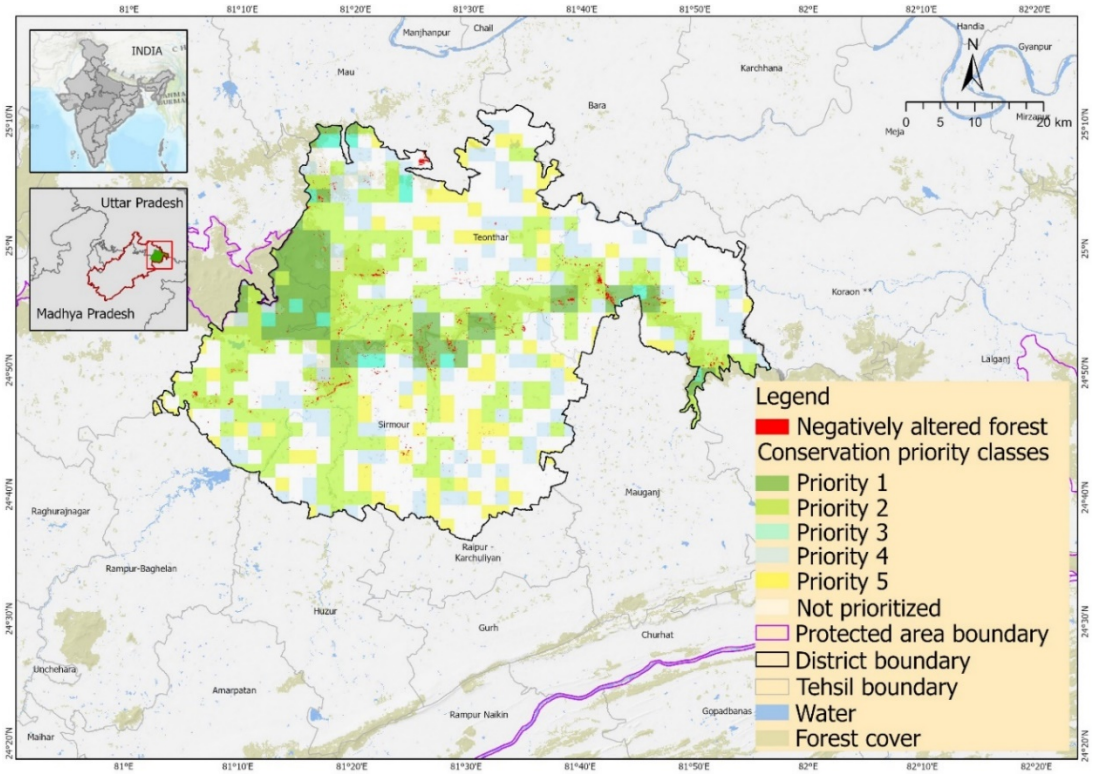


Figure 10.148. Map showing negatively altered landscape overlaid on priority areas of conservation within Rewa District

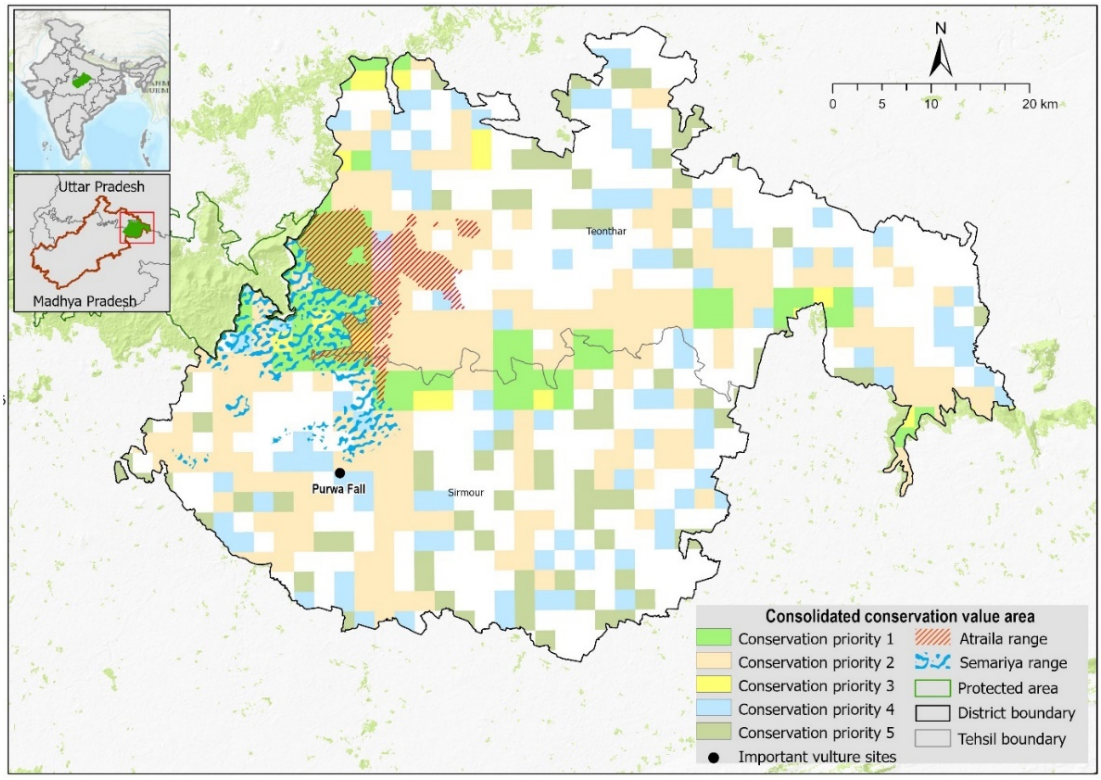


Figure 10.149. Map showing all the areas to be protected and restored (proposed tiger and conservation reserves, priority sites for biodiversity conservation) within the Rewa District

(6) Sagar District

1. **Habitat Protection** is required for one steppingstone and nine corridors (One priority II, three priority IV and five priority V) identified in this District (Fig. 10.150) and this needs to be protected from community dependency and development activities including mining.
2. **Structural Interventions** (overpass and underpass) should be made at points where major roads are cutting through the proposed corridors (Fig. 10.151).
3. **Biodiversity Management Committee** should be activated to monitor and conserve the highest conservation priority areas for vultures (Fig. 10.152) and biodiversity (Fig. 10.153). The Rahatgarh Fort in South Sagar Forest Division should be brought under enhanced conservation focus, as Important Vulture Area (IVA) (Fig. 10.152). Based on the information collected, access and benefit sharing should be made a part of Gram Panchayat Development Plan.
4. **One Village One Hectare** concept for restoration of areas that have been significantly negatively altered, where forest cover has declined drastically, should be considered (Fig. 10.154). This intervention can involve social forestry, integrated farming, ecosystem service trade-off and carbon economy, and can be subjected to payment for ecosystem service (PES) model at state and national level. Restoration efforts should initially be focussed on negatively altered forests falling within the priority I class of spatial prioritization for biodiversity conservation, and then on priority II, and so on (Fig.10.155).
5. **Convergence for Consolidation and Restoration:** As indicated above, Fig. 10.156 provides the combined value for PTR, these identified targets should be the focus for habitat consolidation, protection and restoration.
6. **Green Economy Cooperatives and Growth Centres** should be established in selected Panchayat/Village for Amla (Karai), for Mahua (Bilgay and Karhad), for Tendu (Bilgay, Gaurar, Khurai, Kadta, Bhonhara, Tulsipar, and Titarpani) and for Achar (Jasoda, Gaurar, and Tulsipar) (Appendix 10.19-10.22).

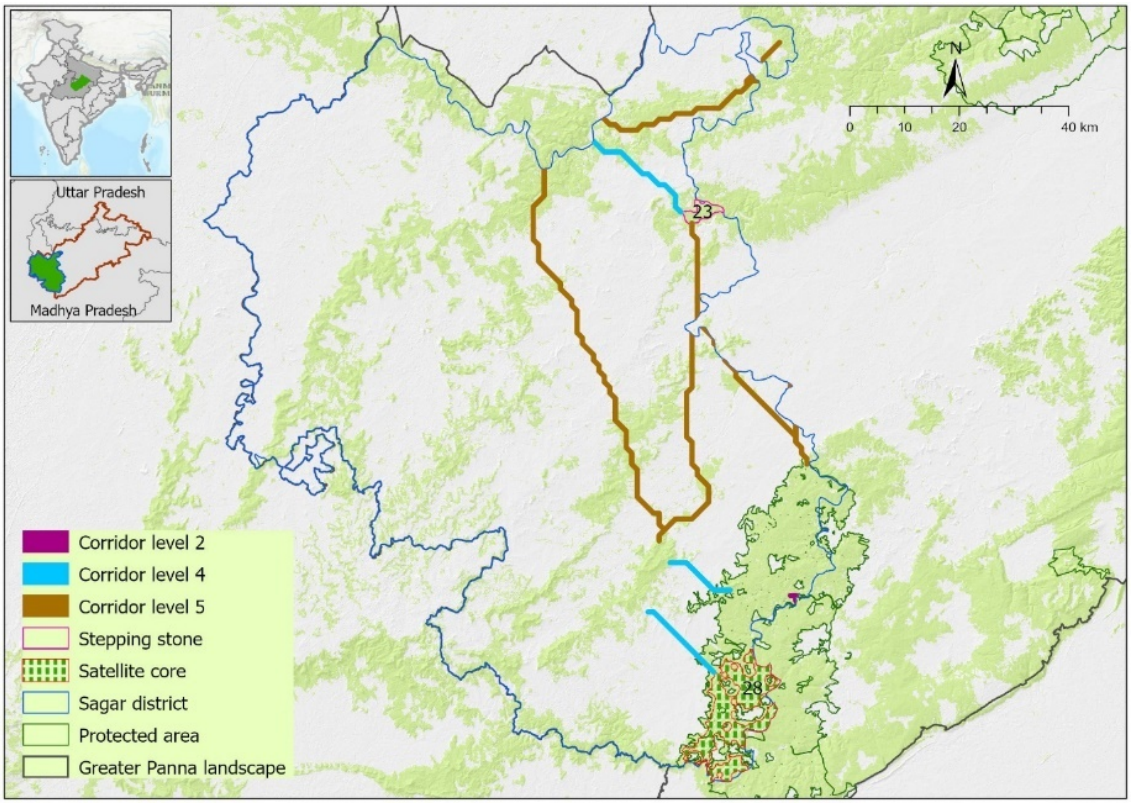


Figure 10.150. Map showing areas to be consolidated (steppingstone and corridors) in Sagar district

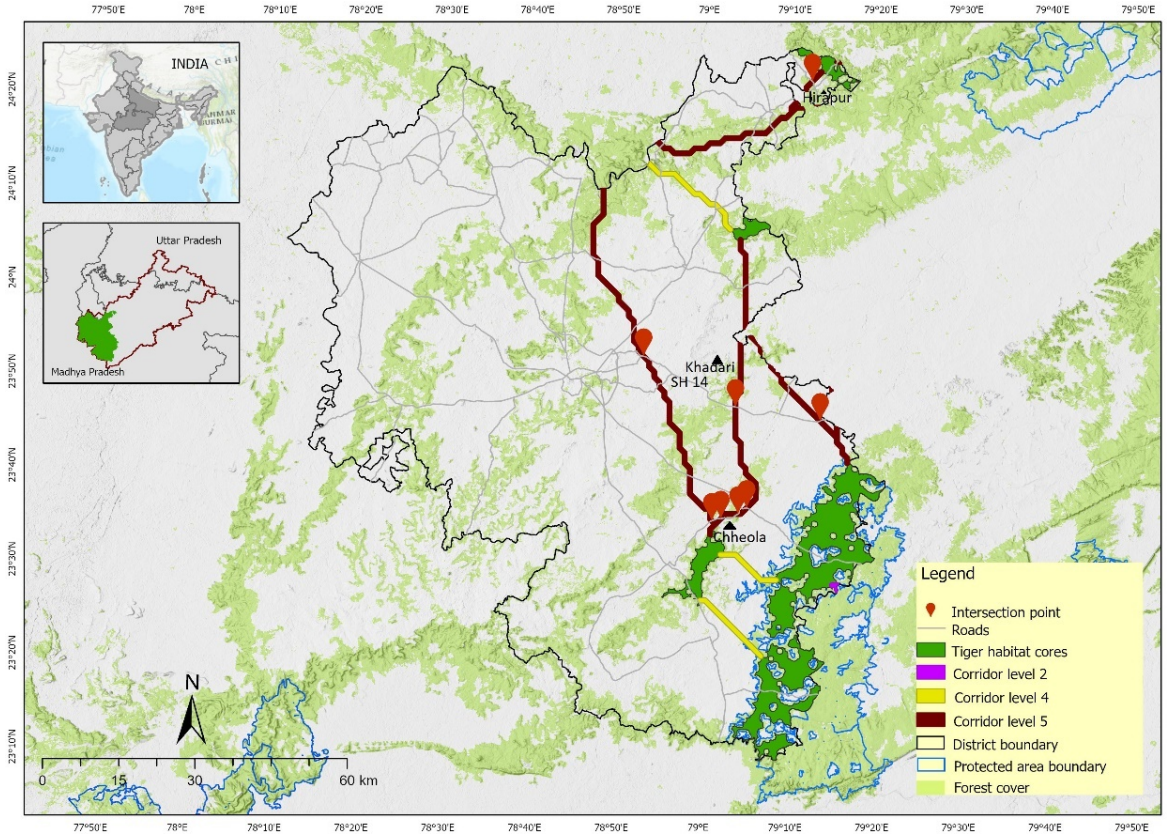


Figure 10.151. Map showing points where major roads are intersecting with proposed corridors in Sagar District for structural interventions

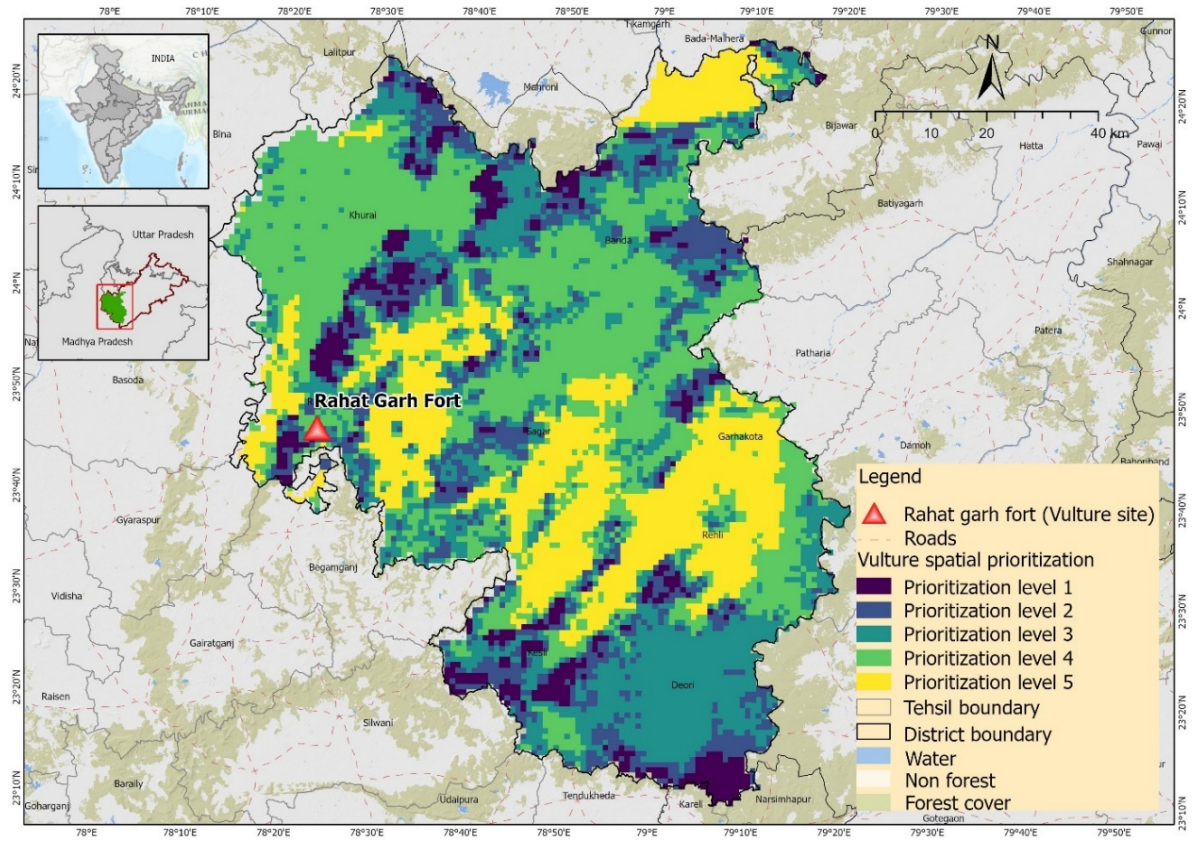


Figure 10.152. Map showing vulture conservation priority areas within Sagar District

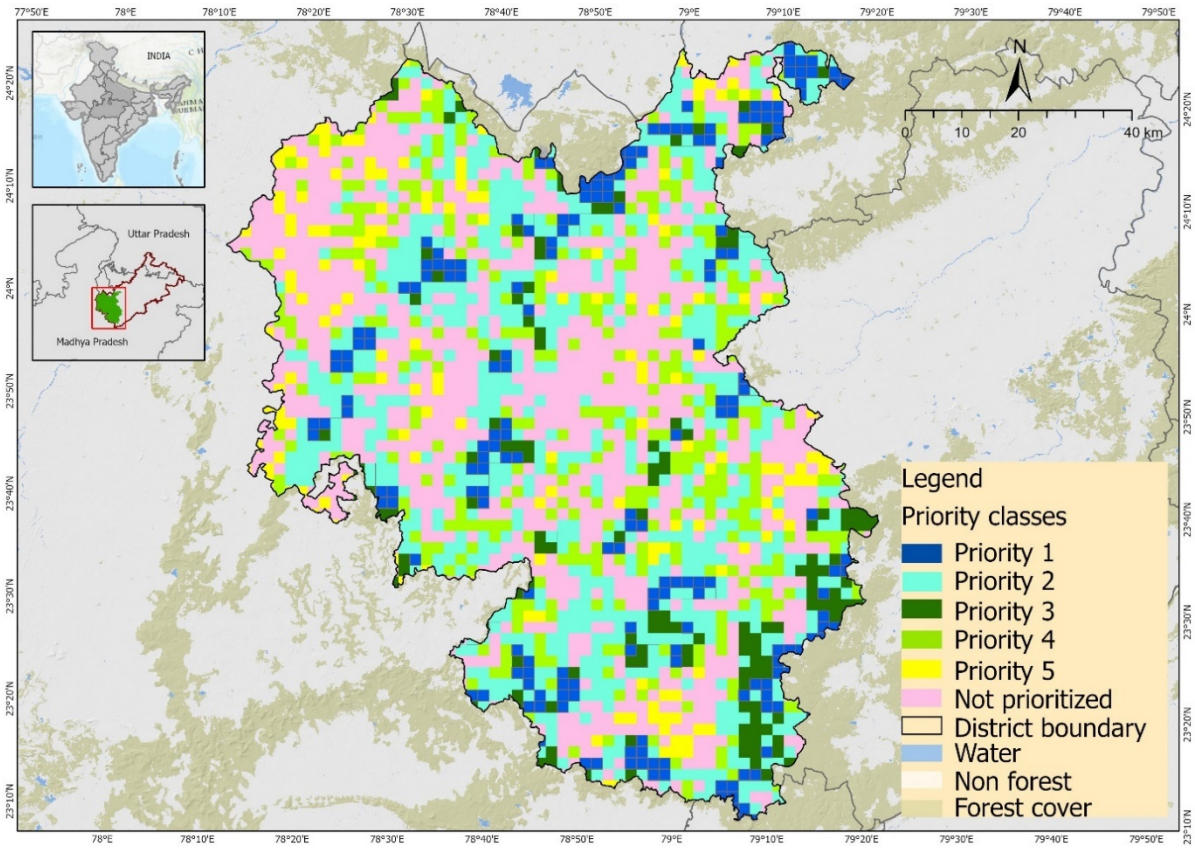


Figure 10.153. Priority areas for conservation within Sagar District

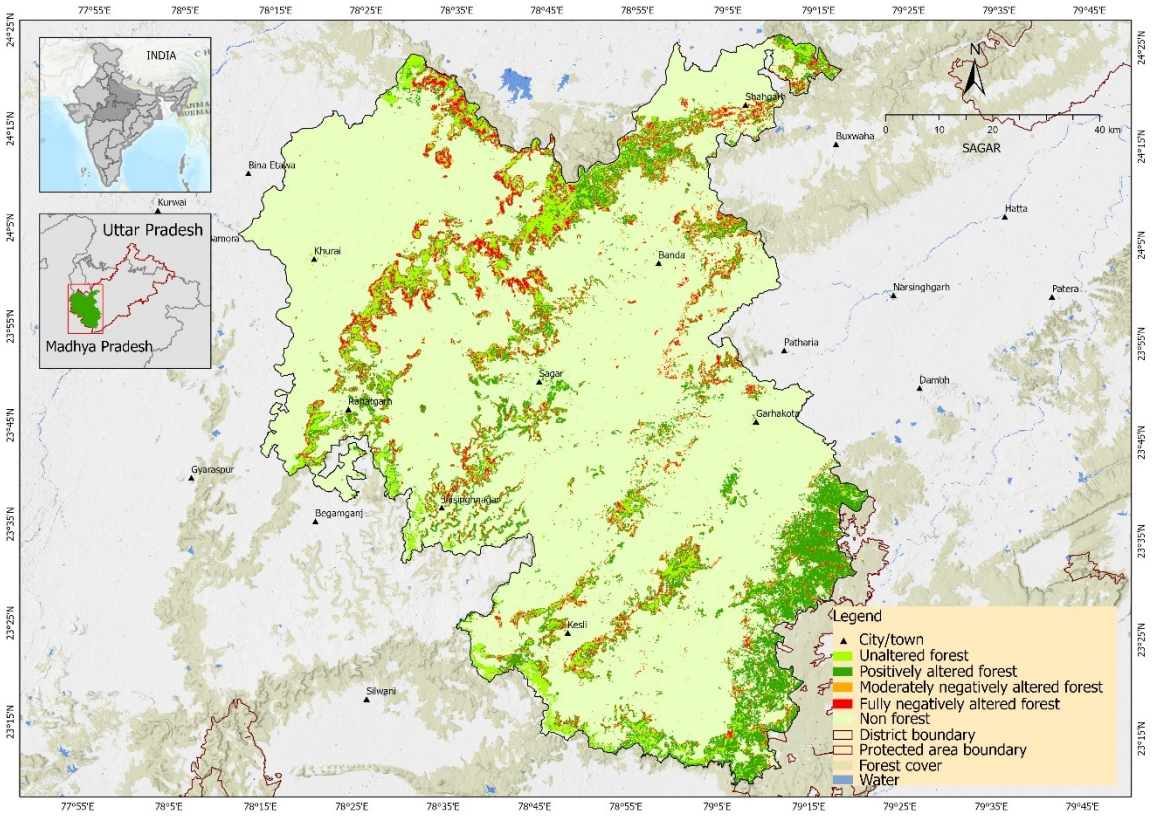


Figure 10.154. Map showing altered-unaltered landscape within Sagar District

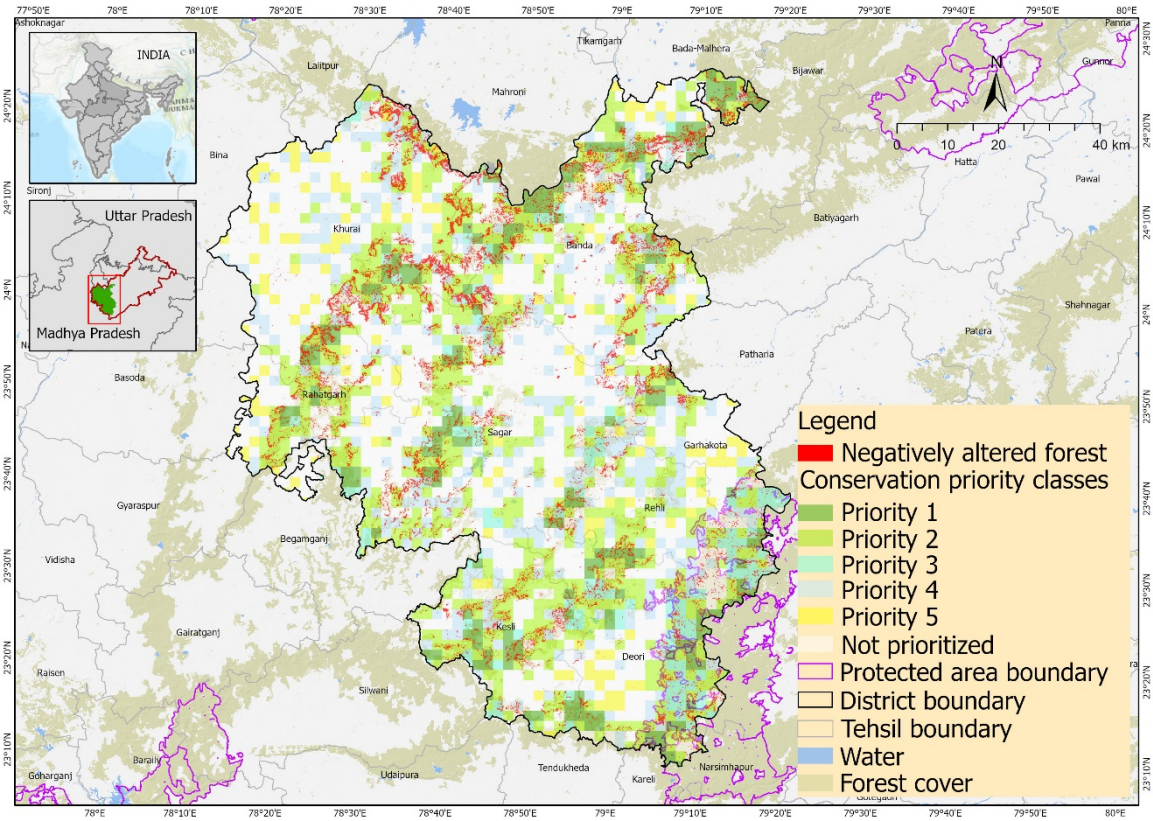


Figure 10.155. Map showing negatively altered landscape overlaid on priority areas of conservation within Sagar District

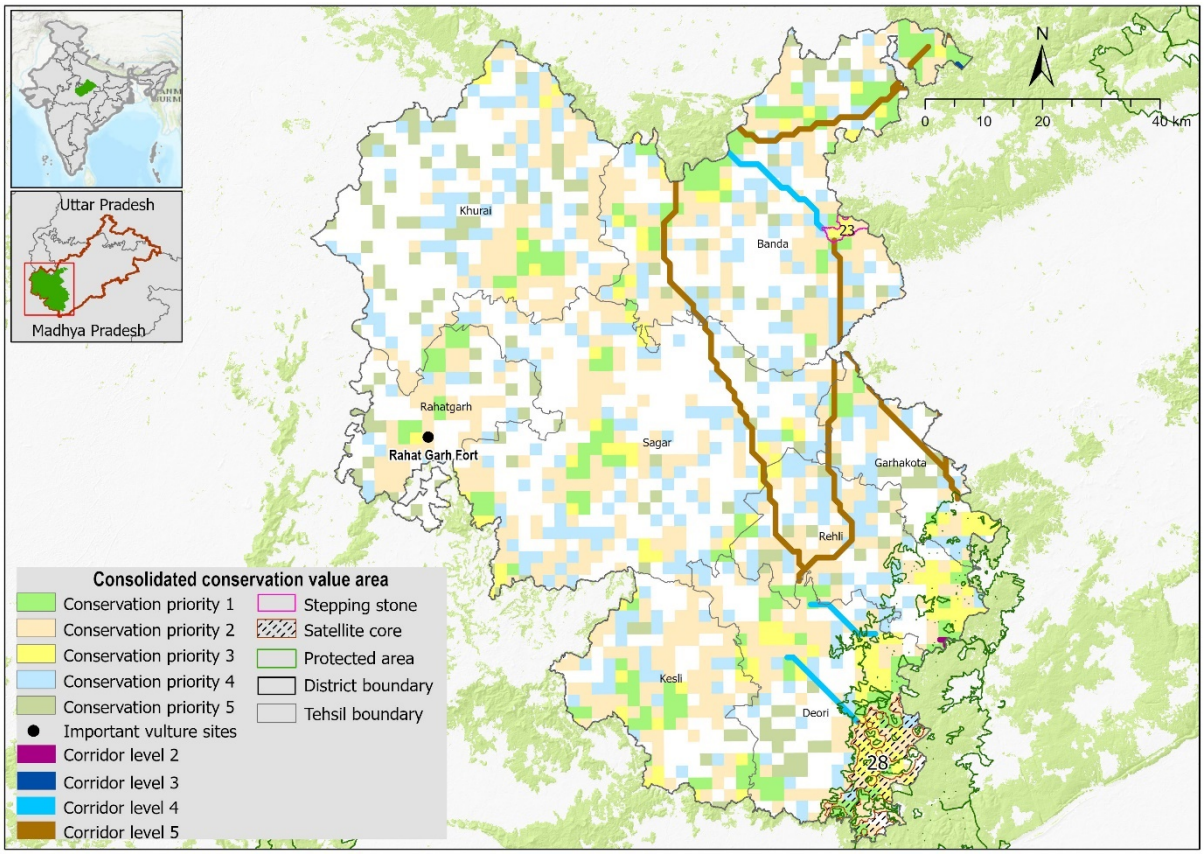


Figure 10.156. Map showing all the areas to be protected and restored (stepping stone, corridors, priority sites for biodiversity conservation) within the Sagar District

(7) Katni District

1. **Habitat Protection** is required for one satellite core and two corridors (One priority III and one priority IV) identified in this District (Fig. 10.157) and this needs to be protected from community dependency and development activities including mining.
2. **Structural Interventions** (overpass and underpass) should be made at points where major roads are cutting through the proposed corridors (Fig. 10.158).
3. **Biodiversity Management Committee** should be activated to monitor and conserve the highest conservation priority areas for vultures (Fig. 10.159) and biodiversity (Fig. 10.160). Based on the information collected, access and benefit sharing should be made a part of Gram Panchayat Development Plan.
4. **One Village One Hectare** concept for restoration of areas that have been significantly negatively altered, where forest cover has declined drastically, should be considered (Fig. 10.161). This intervention can involve social forestry, integrated farming, ecosystem service trade-off and carbon economy, and can be subjected to payment for

ecosystem service (PES) model at state and national level. Restoration efforts should initially be focussed on negatively altered forests falling within the priority I class of spatial prioritization for biodiversity conservation, and then on priority II, and so on (Fig. 10.162).

5. **Convergence for Consolidation and Restoration:** As indicated above, Fig. 10.163 provides the combined value for PTR, these identified targets should be the focus for habitat consolidation, protection and restoration.

6. **Green Economy Cooperatives and Growth Centres** should be established in Hathibhar Village for Amla and Achar (Appendix 10.23).

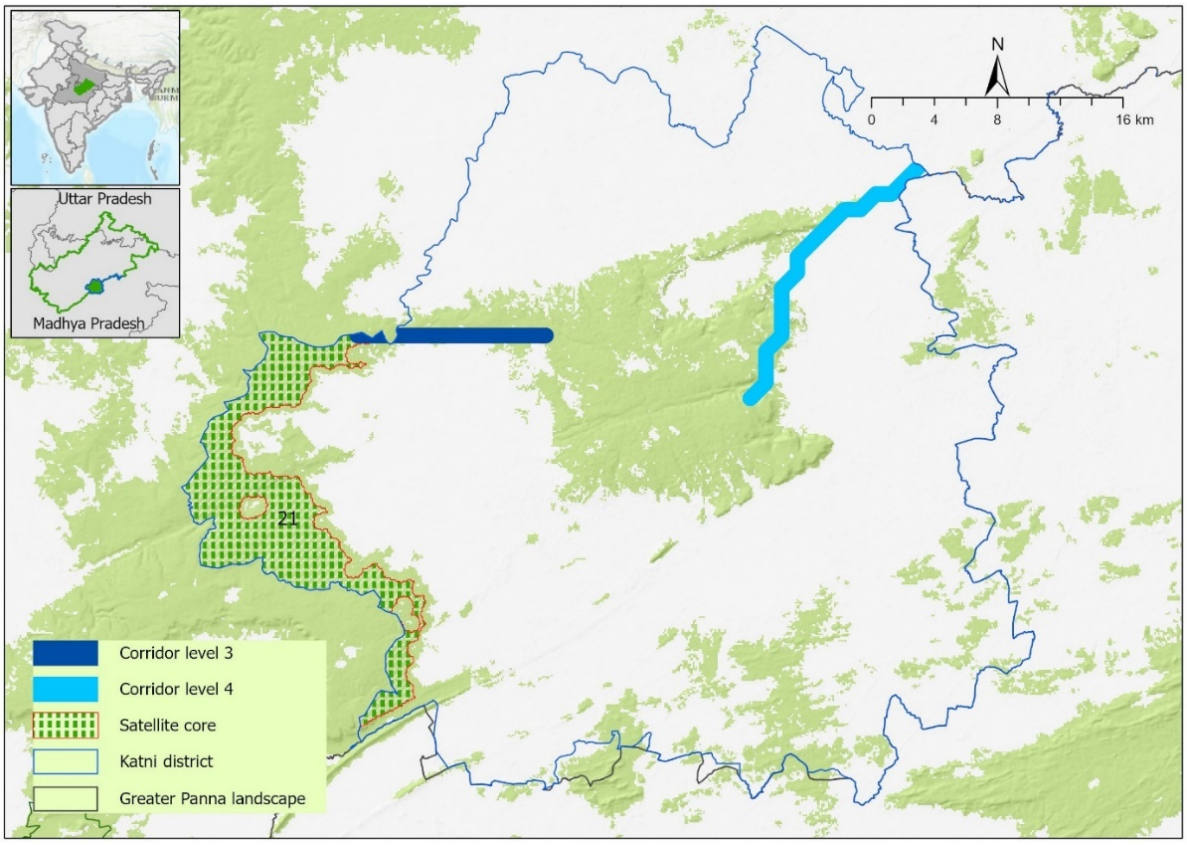


Figure 10.157. Map showing areas to be consolidated (satellite cores, stepping stones and corridors) in Katni District

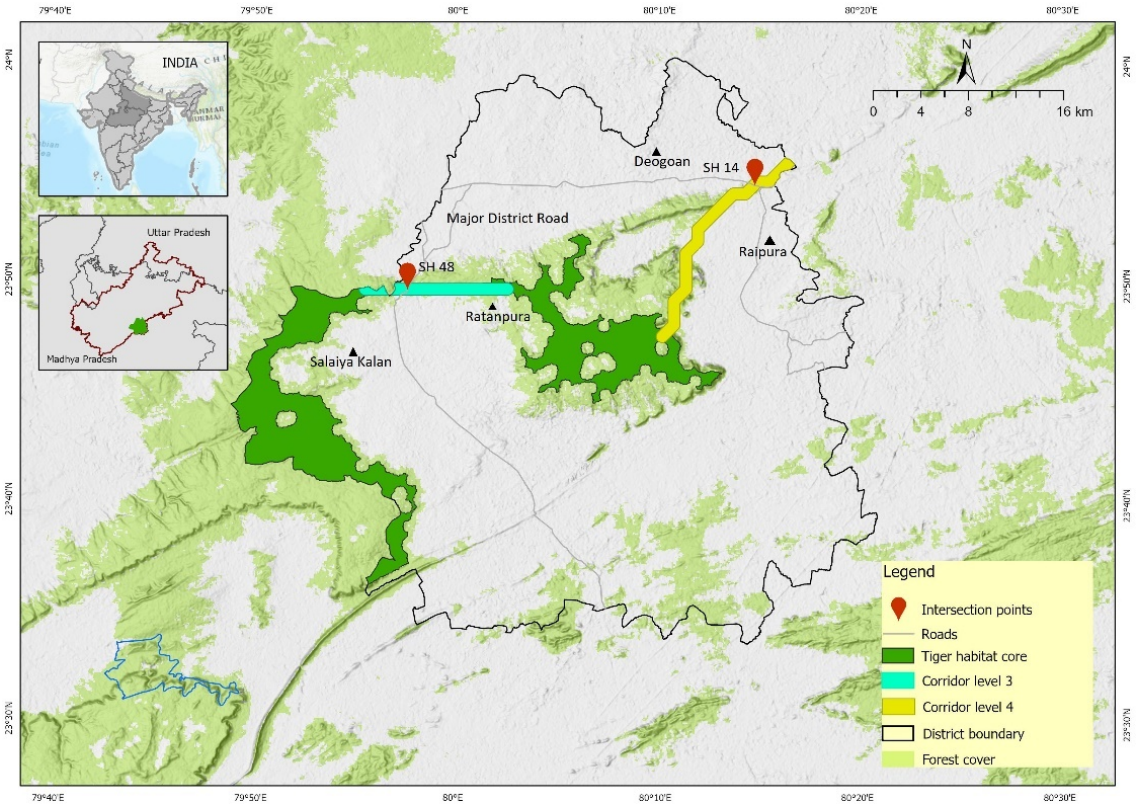


Figure 10.158. Map showing points where major roads are intersecting with proposed corridors in Katni District for structural interventions

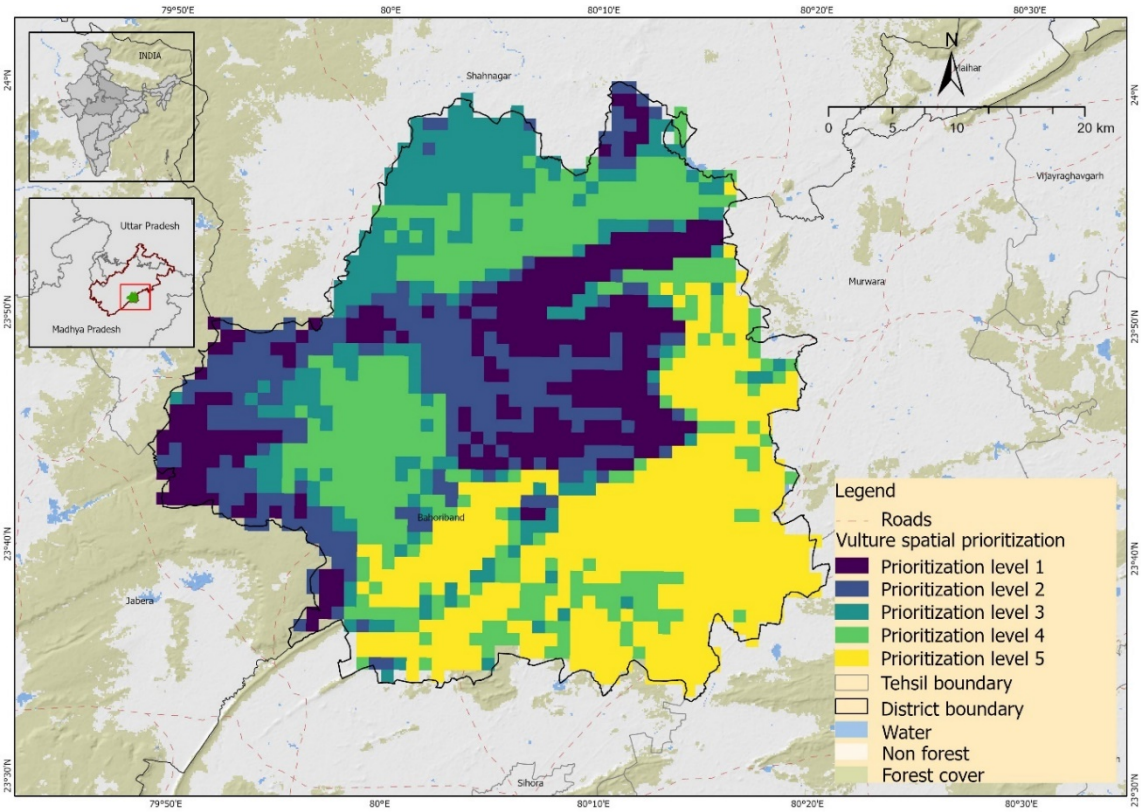


Figure 10.159. Map showing vulture conservation priority areas within Katni District

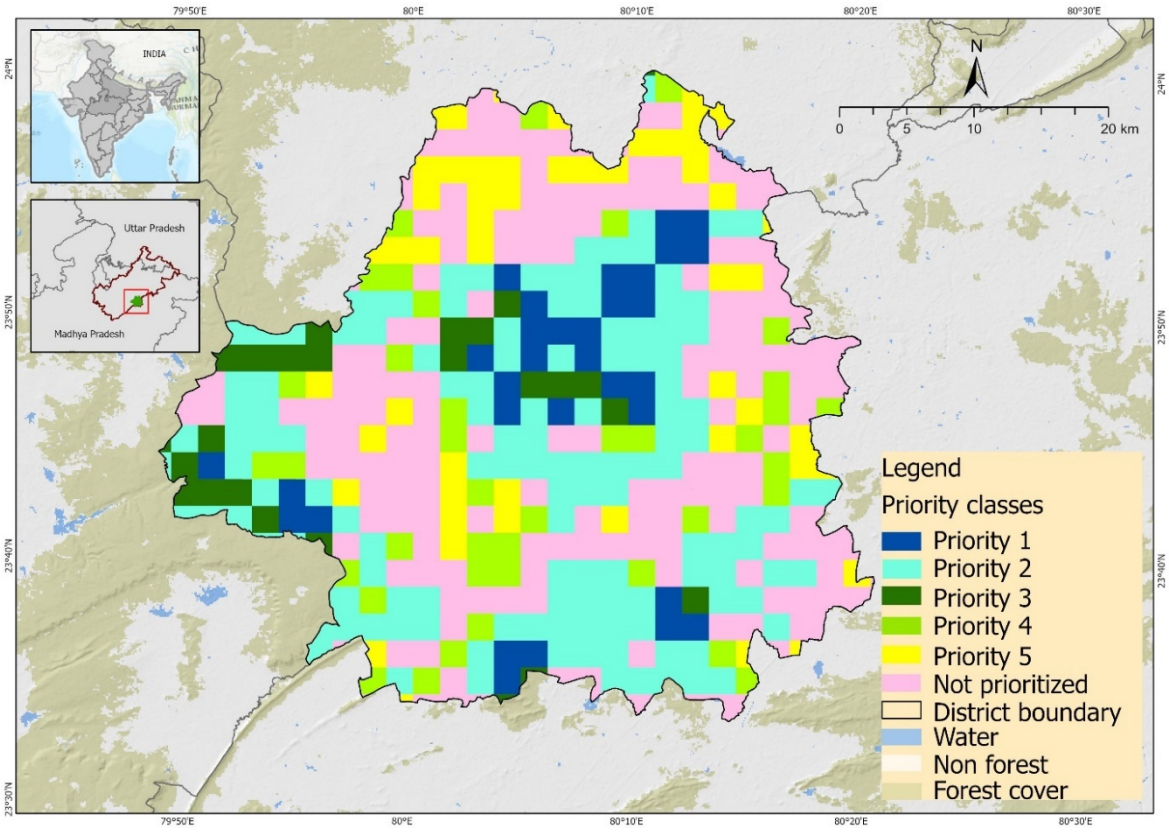


Figure 10.160. Priority areas for conservation within Katni District

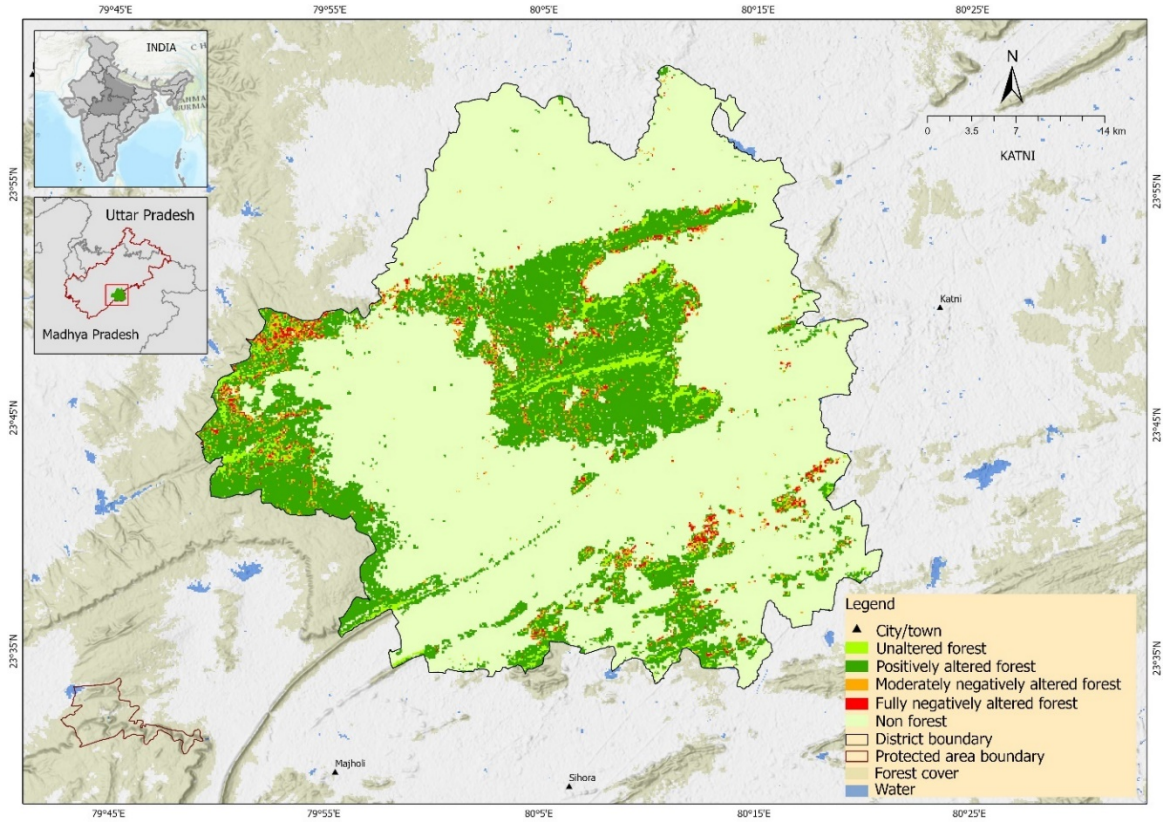


Figure 10.161. Map showing altered-unaltered landscape within Katni District

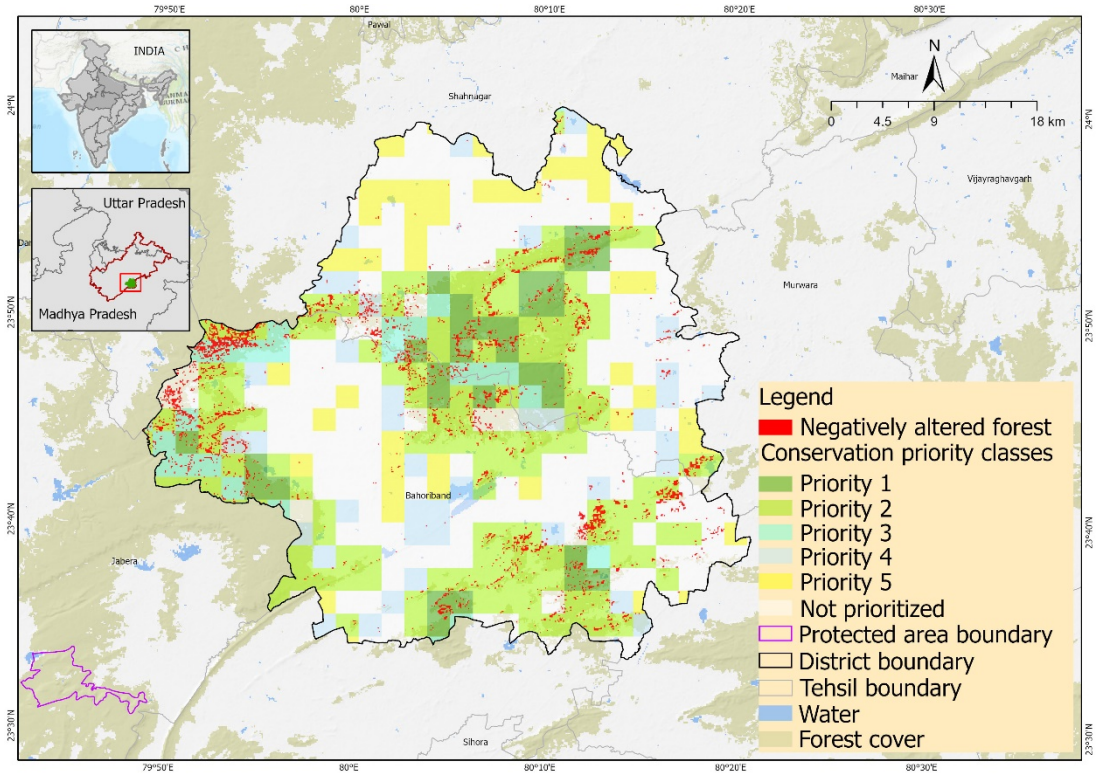


Figure 10.162. Map showing negatively altered landscape overlaid on priority areas of conservation within Katni District

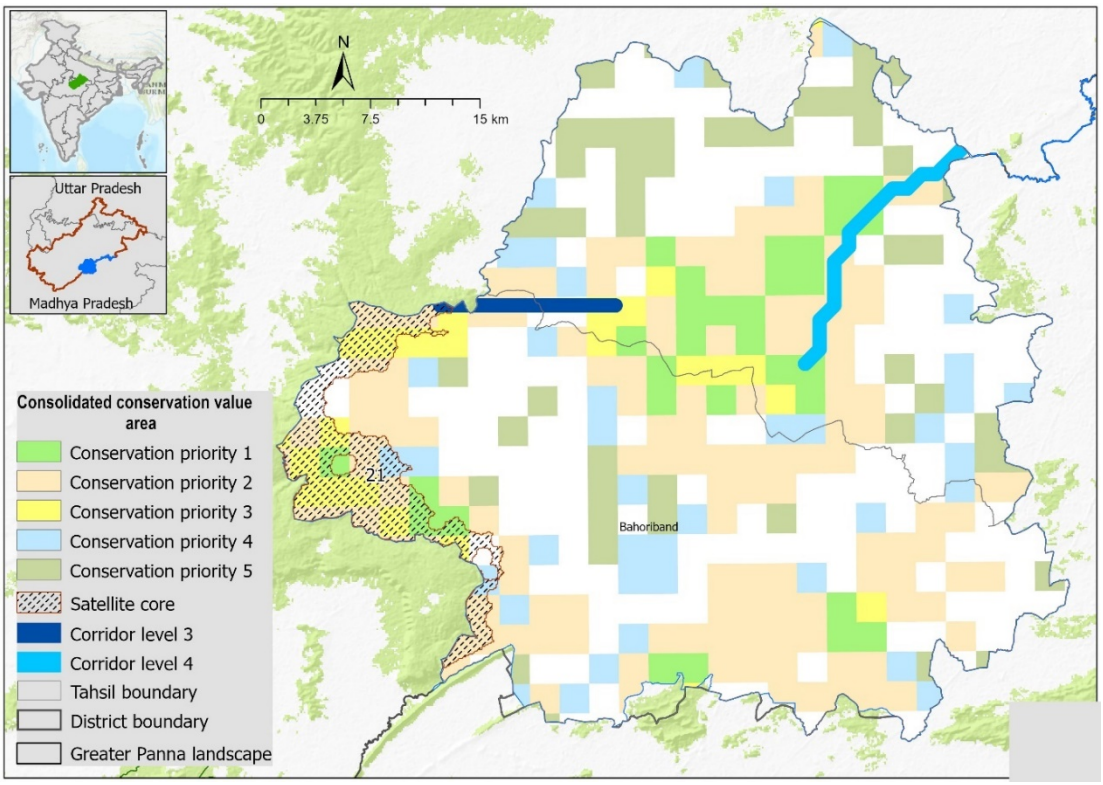


Figure 10.163. Map showing all the areas to be protected and restored (satellite cores, corridors, priority sites for biodiversity conservation) within the Katni District

(8) Chitrakoot District

1. **Habitat Protection** is required for two corridors (One priority III and one priority IV) identified in this District (Fig. 10.164) and this needs to be protected from community dependency and development activities including mining.
2. **Ranipur Wildlife Sanctuary in Chitrakoot District should be developed into an Interstate Tiger Reserve (Ranipur-Majhagawan Tiger Reserve)** wherein Ranipur Wildlife Sanctuary (Uttar Pradesh) will constitute Core area while Manjhgawan, Semariya, Atraila Ranges of Satna and Rewa Forest Divisions (Madhya Pradesh) will constitute Buffer area.
3. **Biodiversity Management Committee** should be activated to monitor and conserve the highest conservation priority areas for vultures (Fig. 10.165) and biodiversity (Fig. 10.166). Based on the information collected, access and benefit sharing should be made a part of Gram Panchayat Development Plan.
4. **One Village One Hectare** concept for restoration of areas that have been significantly negatively altered, where forest cover has declined drastically, should be considered (Fig. 10.167). This intervention can involve social forestry, integrated farming, ecosystem service trade-off and carbon economy, and can be subjected to payment for ecosystem service (PES) model at state and national level. Restoration efforts should initially be focussed on negatively altered forests falling within the priority I class of spatial prioritization for biodiversity conservation, and then on priority II, and so on (Fig. 10.168).
5. **Convergence for Consolidation and Restoration:** As indicated above, Fig. 10.169 provides the combined value for PTR, these identified targets should be the focus for habitat consolidation, protection and restoration.
6. **Green Economy Cooperatives and Growth Centres** should be established in Hathibhar Village for Amla (Tikaria), for Mahua (Hanuwa and Rukema Burung) and for Tenud (Rukema Burung) (Appendix 10.24-10.26).

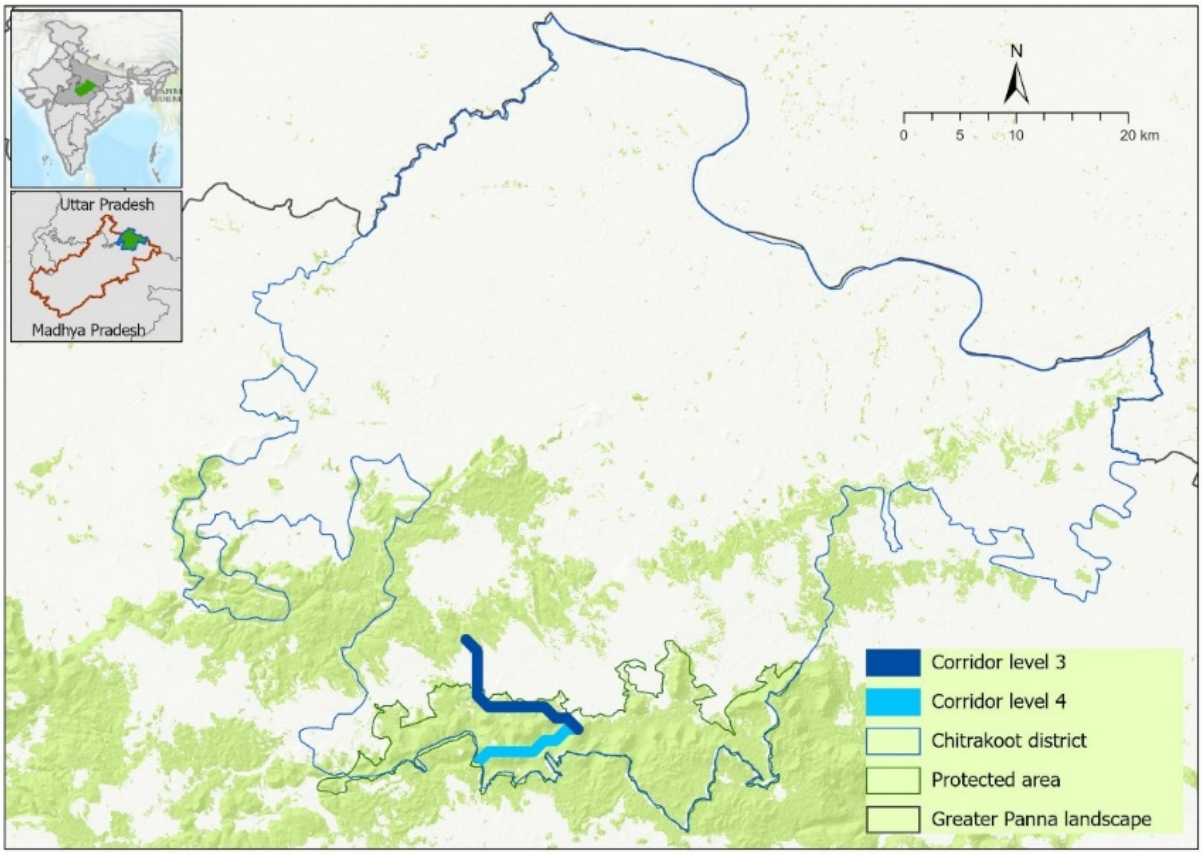


Figure 10.164. Map showing areas to be consolidated (corridors) in Chitrakoot District

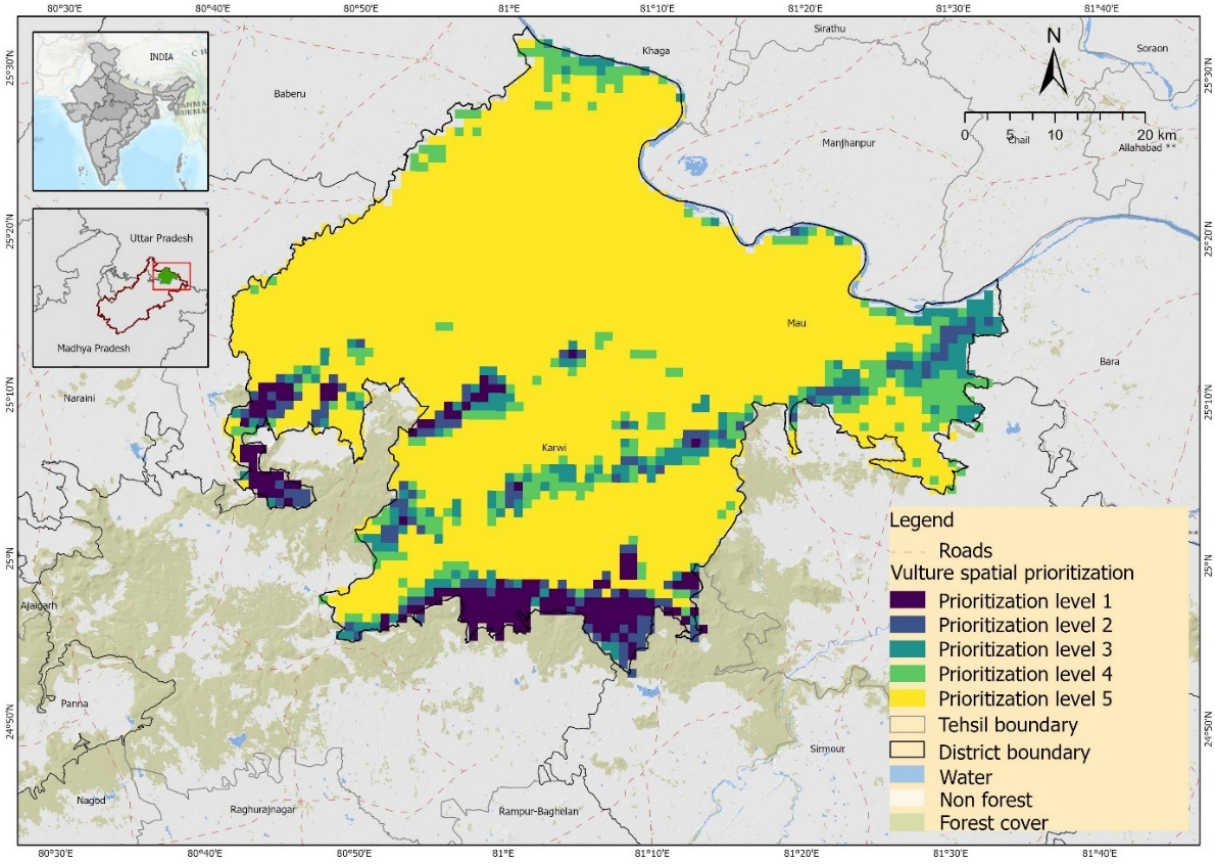


Figure 10.165. Map showing vulture conservation priority areas within Chitrakoot District

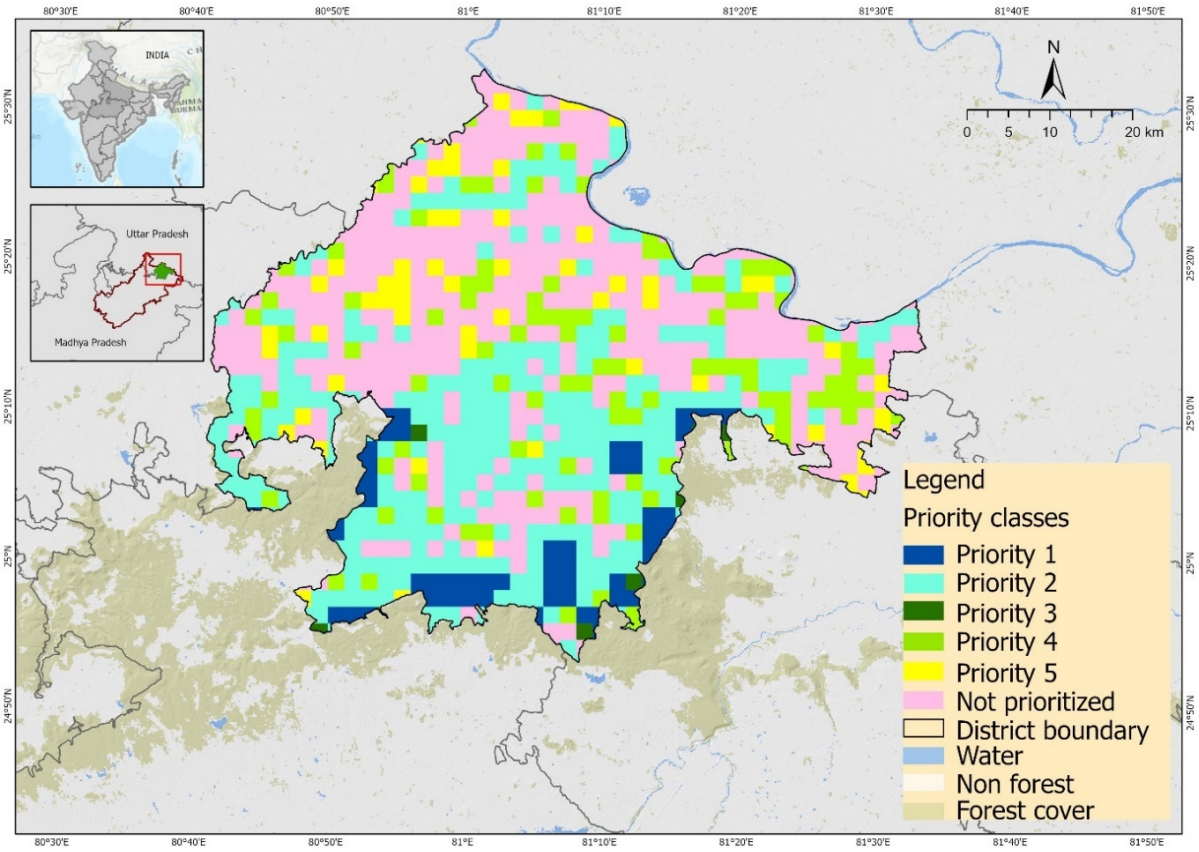


Figure 10.166. Priority areas for conservation within Chitrakoot District

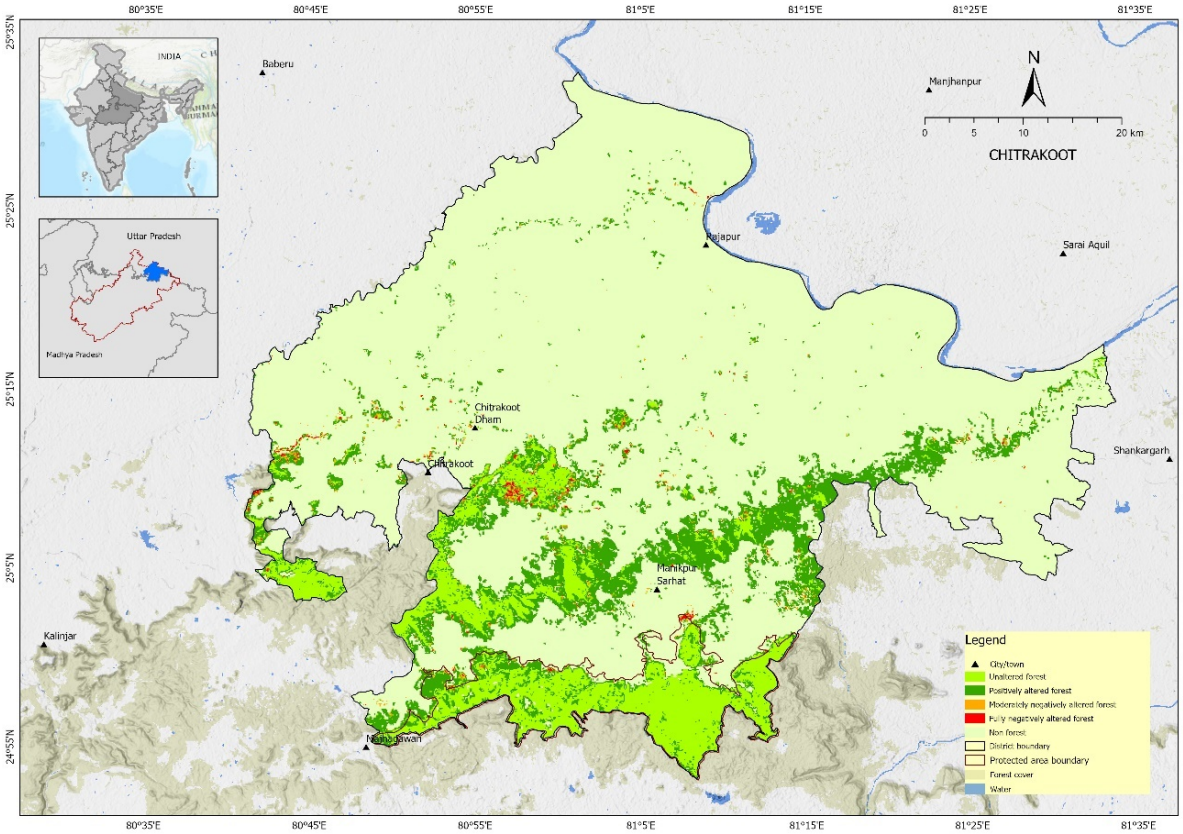


Figure 10.167. Map showing altered-unaltered landscape within Chitrakoot District

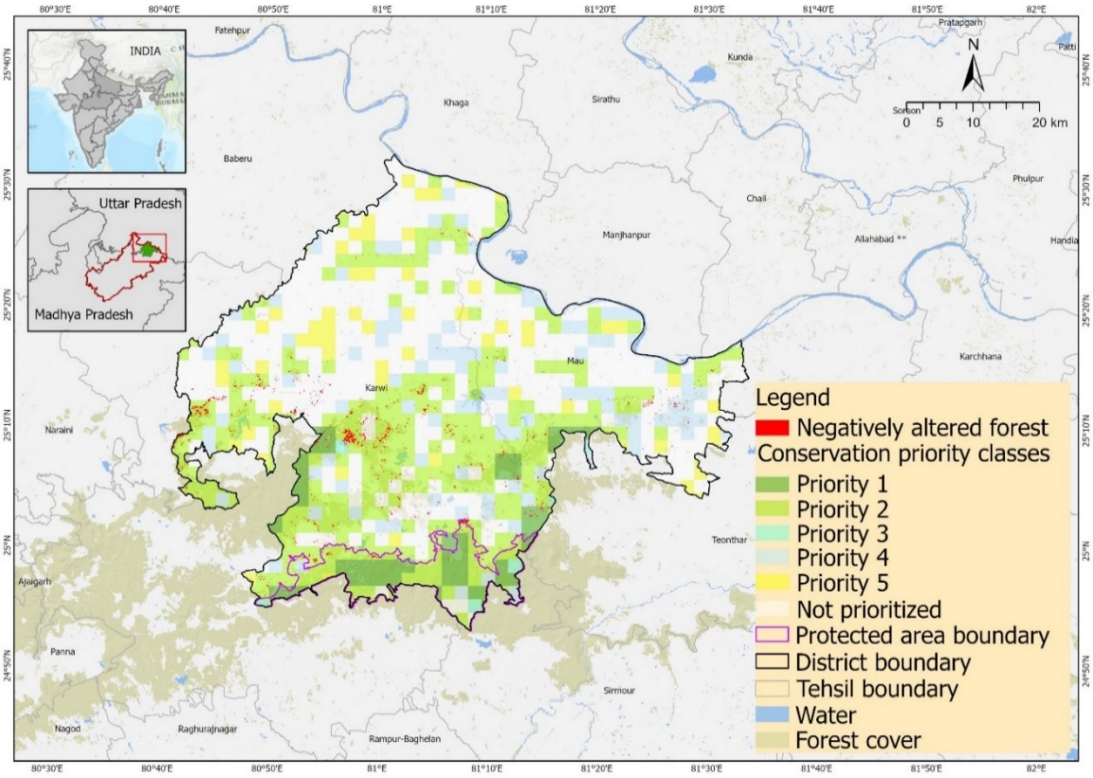


Figure 10.168. Map showing negatively altered landscape overlaid on priority areas of conservation within Chitrakoot District

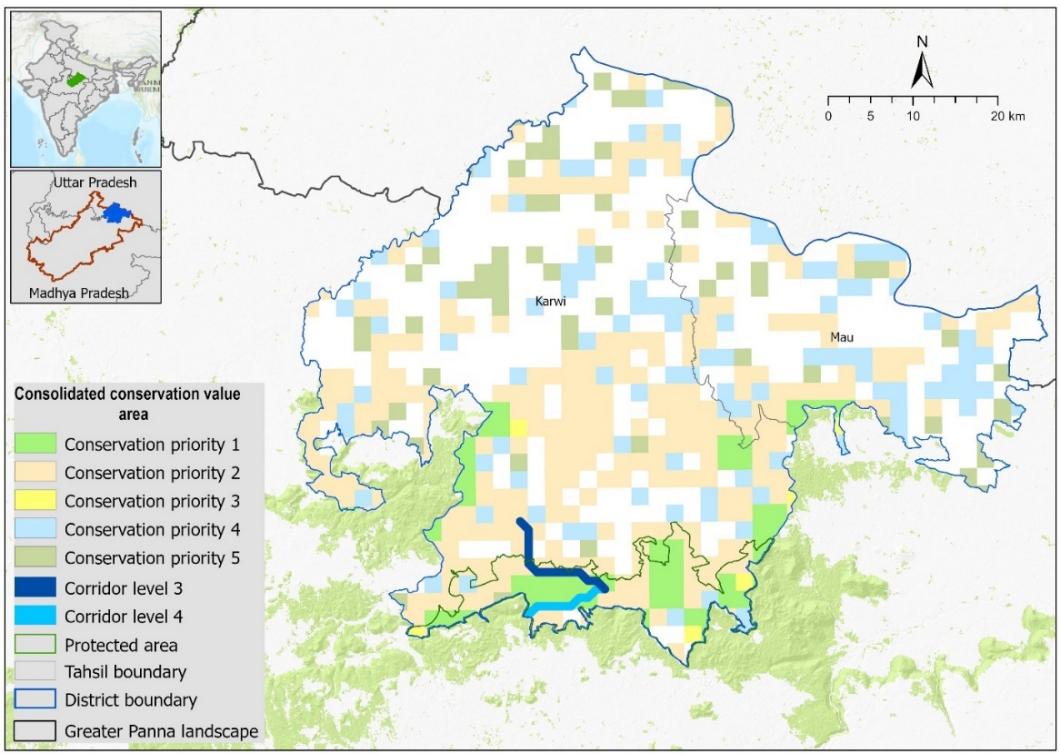


Figure 10.169. Map showing all the areas to be protected and restored (corridors, proposed tiger reserve, priority sites for biodiversity conservation) within the Chitrakoot District

(9) Lalitpur District

1. **Habitat Protection** is required for three corridors (One priority IV and two priority V) identified in this District (Fig. 10.170) and this needs to be protected from community dependency and development activities including mining.
2. **Biodiversity Management Committee** should be activated to monitor and conserve the highest conservation priority areas for vultures (Fig. 10.171) and biodiversity (Fig. 10.172). Based on the information collected, access and benefit sharing should be made a part of Gram Panchayat Development Plan.
3. **One Village One Hectare** concept for restoration of areas that have been significantly negatively altered, where forest cover has declined drastically, should be considered (Fig. 10.173). This intervention can involve social forestry, integrated farming, ecosystem service trade-off and carbon economy, and can be subjected to payment for ecosystem service (PES) model at state and national level. Restoration efforts should initially be focussed on negatively altered forests falling within the priority I class of spatial prioritization for biodiversity conservation, and then on priority II, and so on (Fig. 10.174).
4. **Convergence for Consolidation and Restoration:** As indicated above, Fig. 10.175 provides the combined value for PTR, these identified targets should be the focus for habitat consolidation, protection and restoration.
5. **Green Economy Cooperatives and Growth Centres** should be established in Lakhangar Village for Amla, and Uldana Khurd for Mahua (Appendix 10.27-10.28).

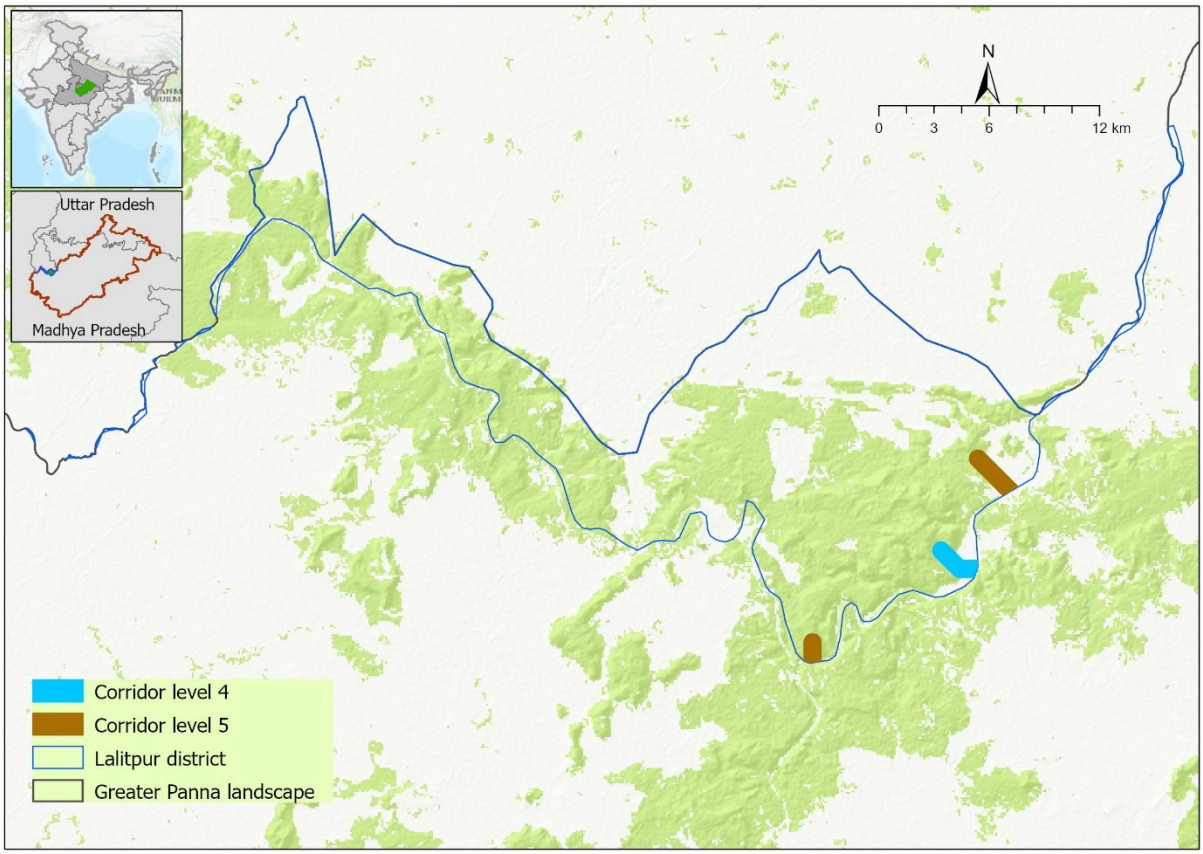


Figure 10.170. Map showing areas to be consolidated (corridors) in Lalitpur District

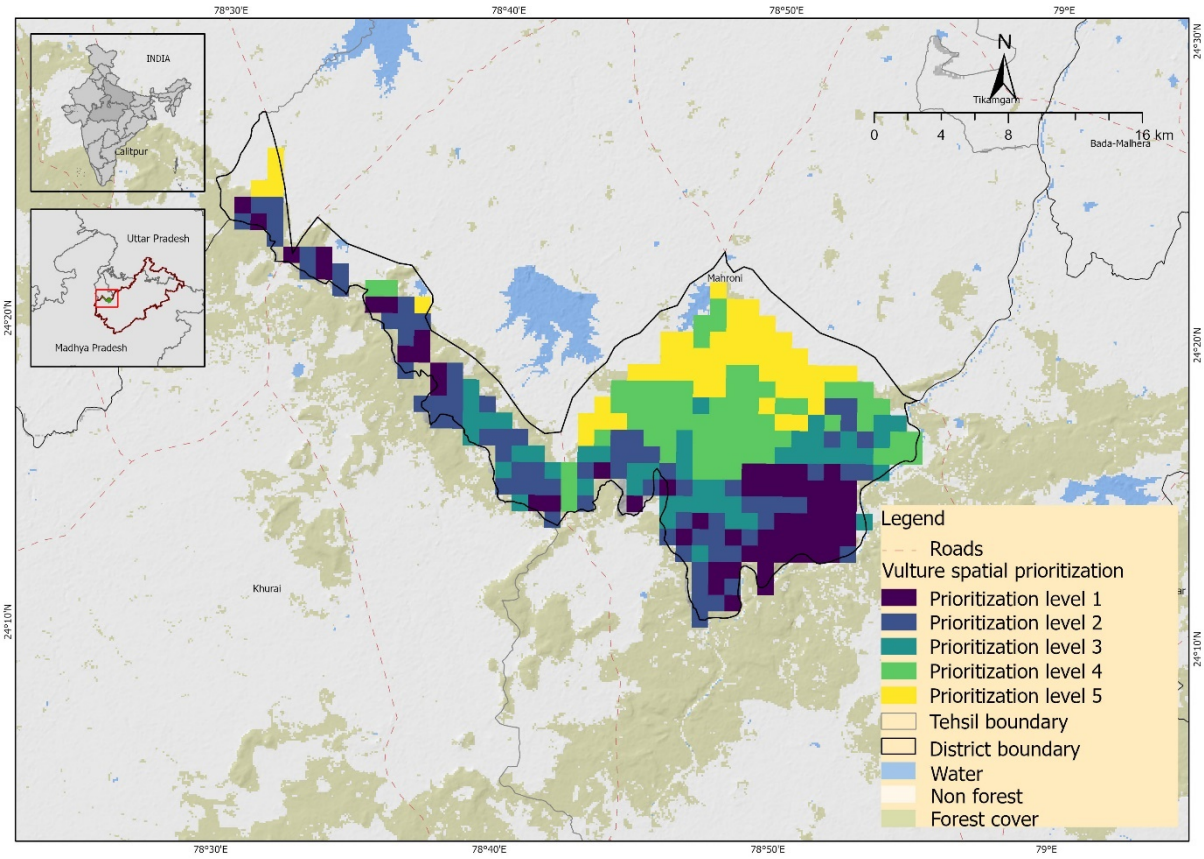


Figure 10.171. Map showing vulture conservation priority areas within Lalitpur District

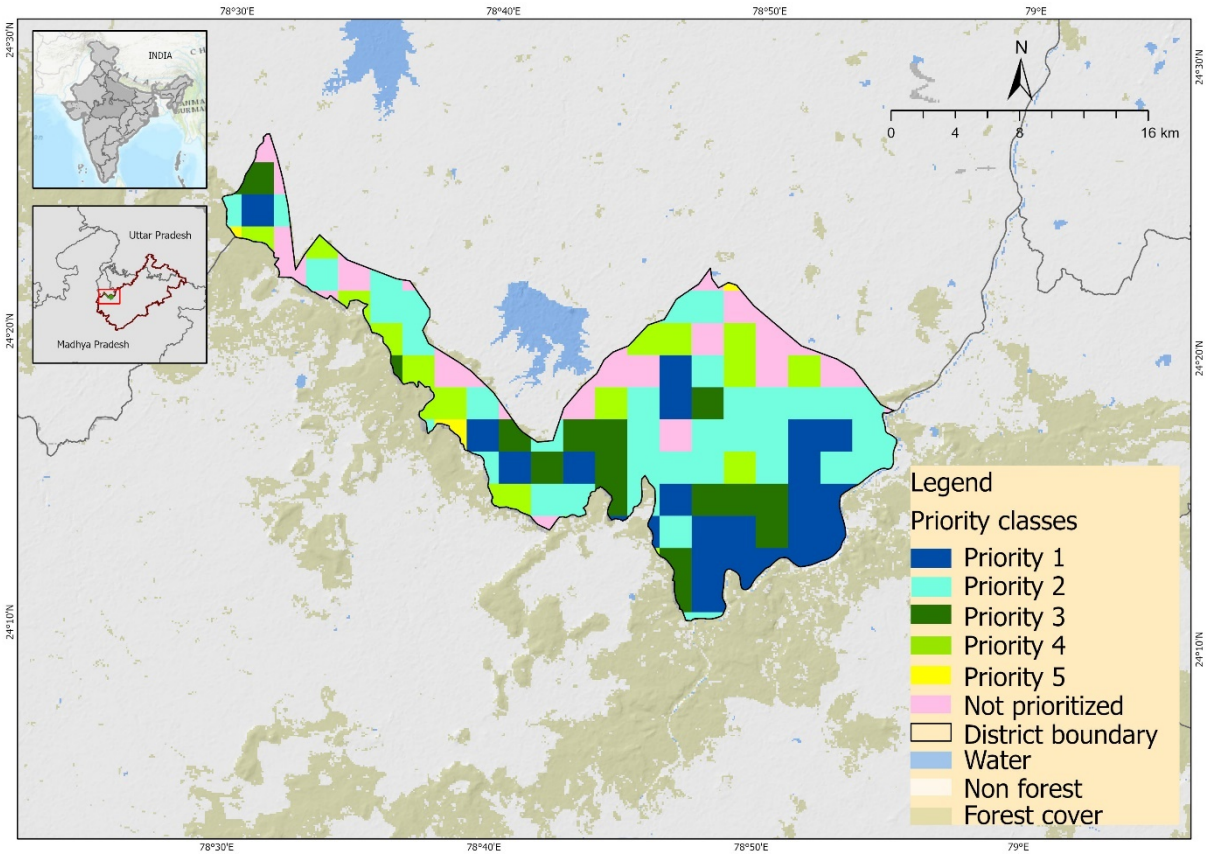


Figure 10.172. Priority areas for conservation within Lalitpur District

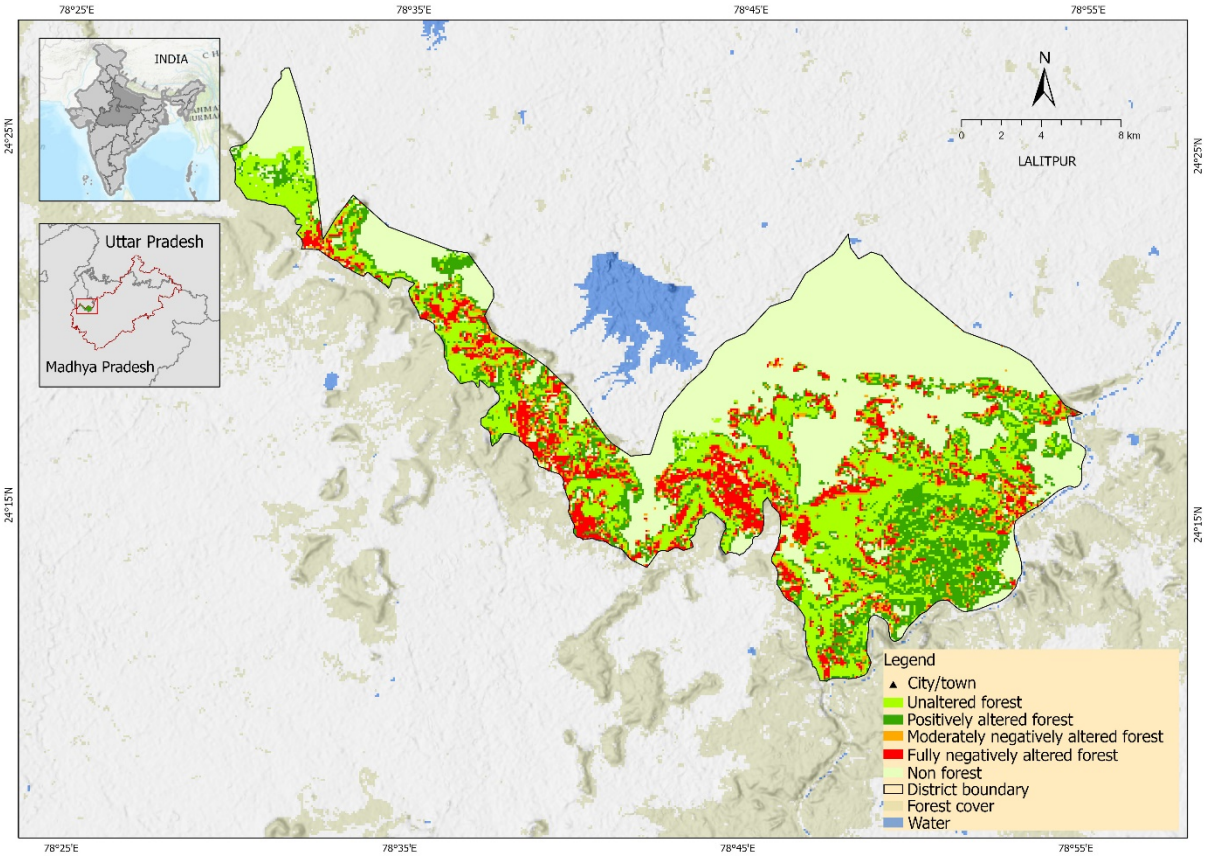


Figure 10.173. Map showing altered-unaltered landscape within Lalitpur District

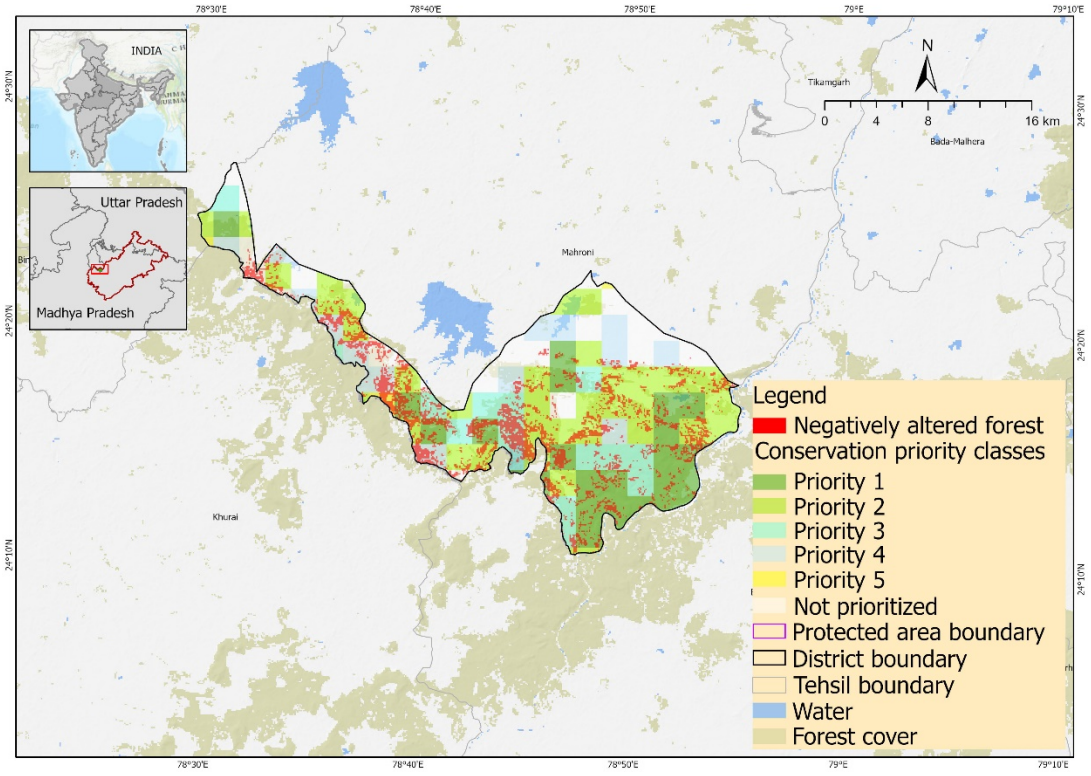


Figure 10.174. Map showing negatively altered landscape overlaid on priority areas of conservation within Lalitpur District

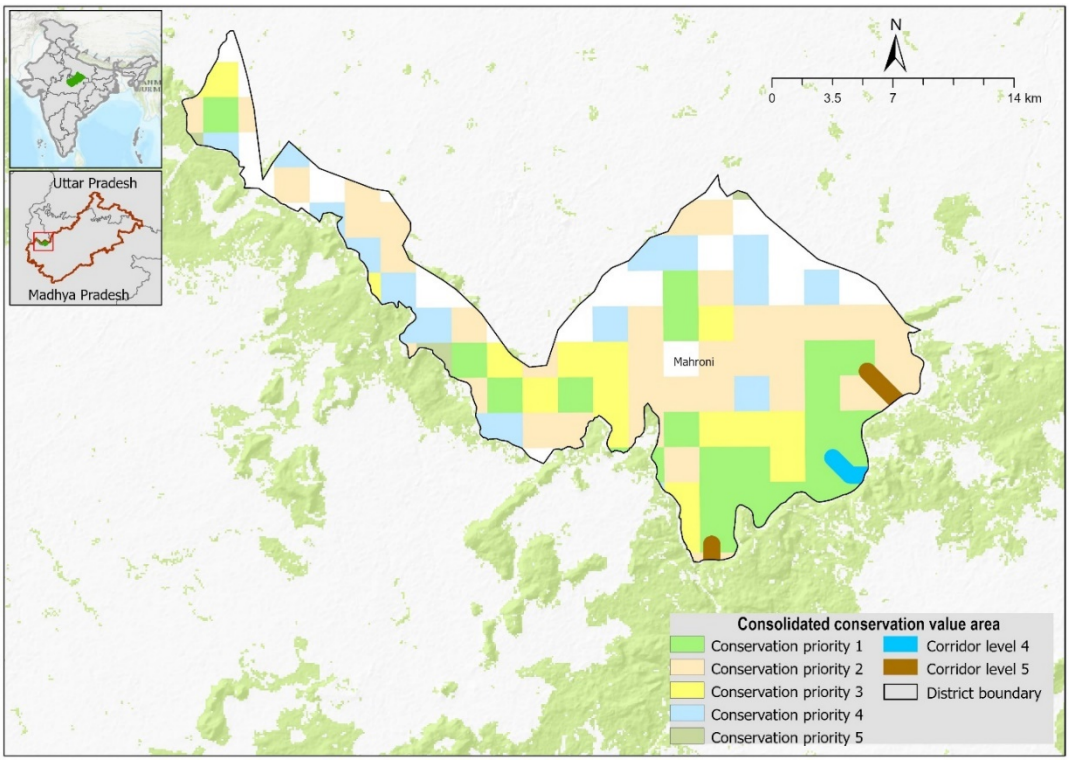


Figure 10.175. Map showing all the areas to be protected and restored (corridors, priority sites for biodiversity conservation) within the Lalitpur District

(10) Narsinghpur District

1. **Biodiversity Management Committee** should be activated to monitor and conserve the highest conservation priority areas for vultures (Fig. 10.176) and biodiversity (Fig. 10.177). Based on the information collected, access and benefit sharing should be made a part of Gram Panchayat Development Plan.
2. **One Village One Hectare** concept for restoration of areas that have been significantly negatively altered, where forest cover has declined drastically, should be considered (Fig. 10.178). This intervention can involve social forestry, integrated farming, ecosystem service trade-off and carbon economy, and can be subjected to payment for ecosystem service (PES) model at state and national level. Restoration efforts should initially be focussed on negatively altered forests falling within the priority I class of spatial prioritization for biodiversity conservation, and then on priority II, and so on (Fig. 10.179).
3. **Convergence for Consolidation and Restoration:** As indicated above, Fig. 10.179 provides the combined value for PTR, these identified targets should be the focus for habitat consolidation, protection and restoration.
4. **Green Economy Cooperatives and Growth Centres** should be established in Amapani and Jhilipani Villages for Achar and Amoda Villlage for Tendu (Appendix 10.29-10.30).

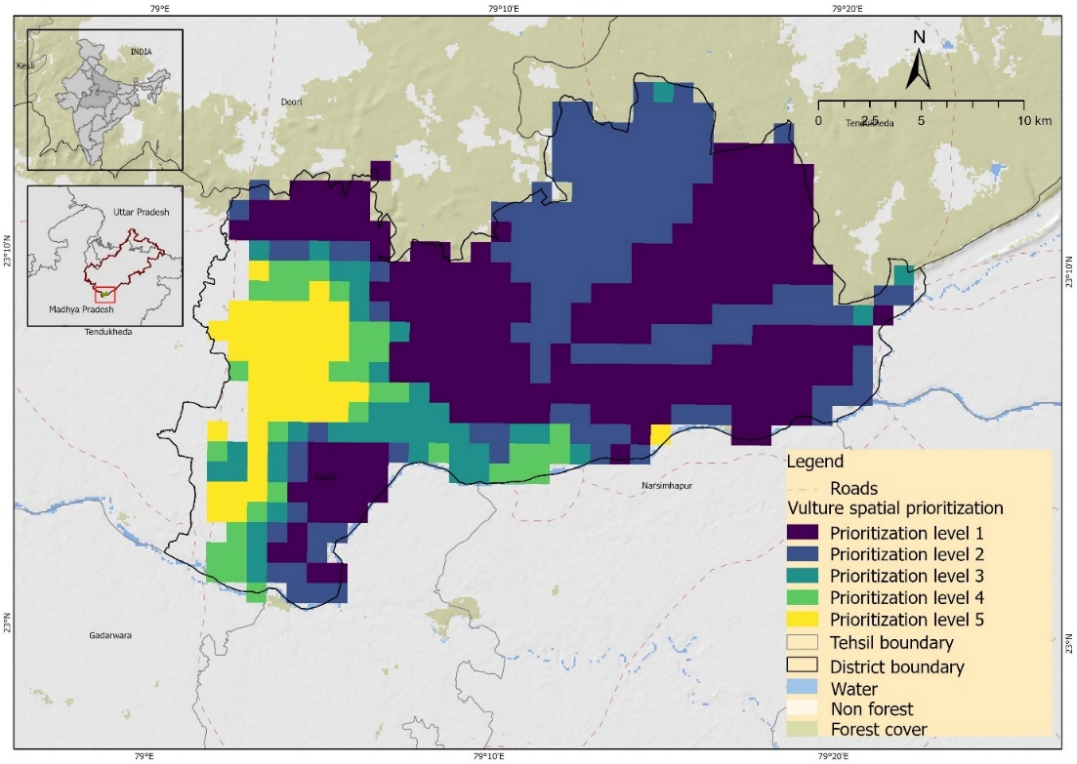


Figure 10.176. Map showing vulture conservation priority areas within Narsinghpur District

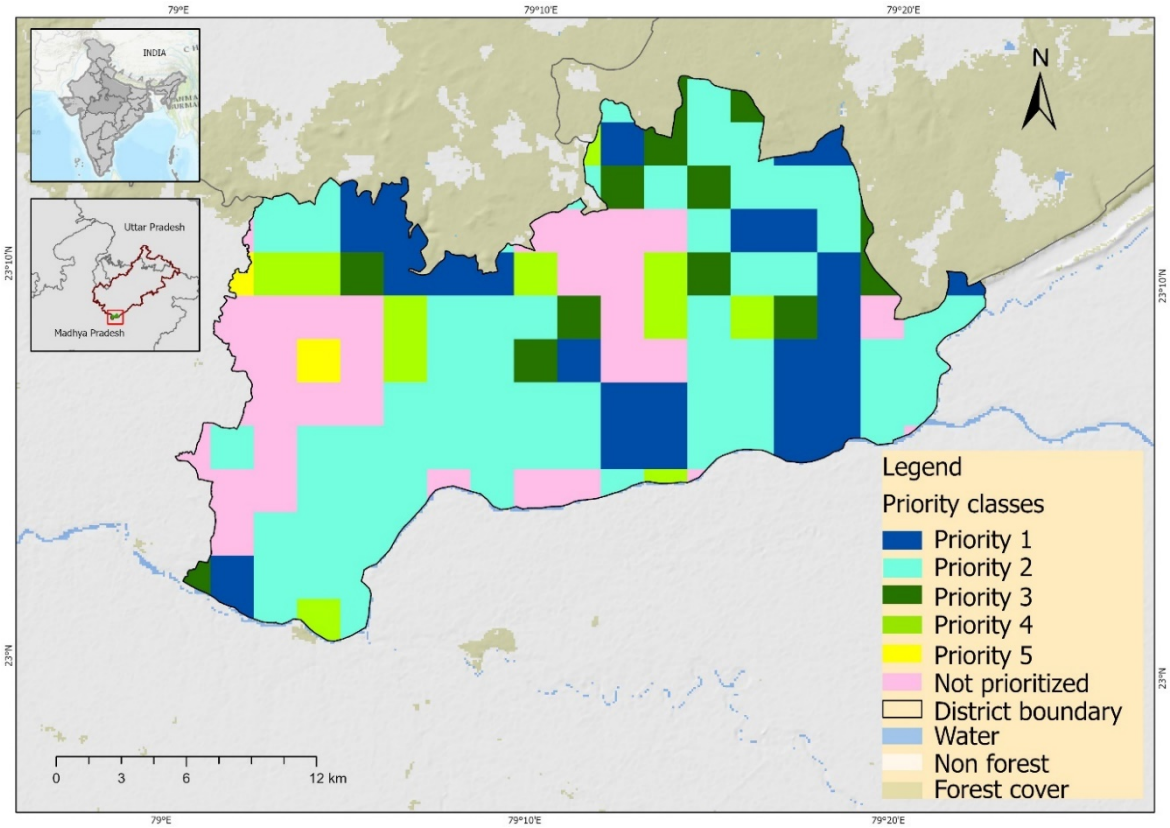


Figure 10.177. Priority areas for conservation within Narsinghpur District

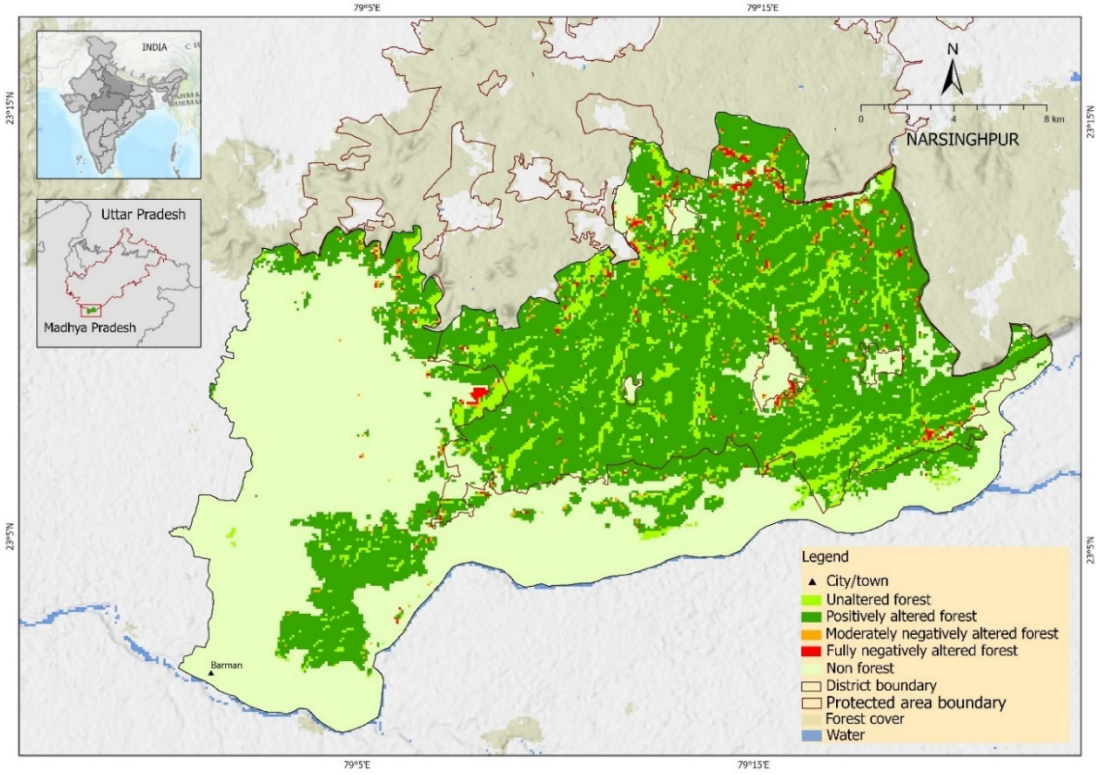


Figure 10.178. Map showing altered-unaltered landscape within Narsinghpur District

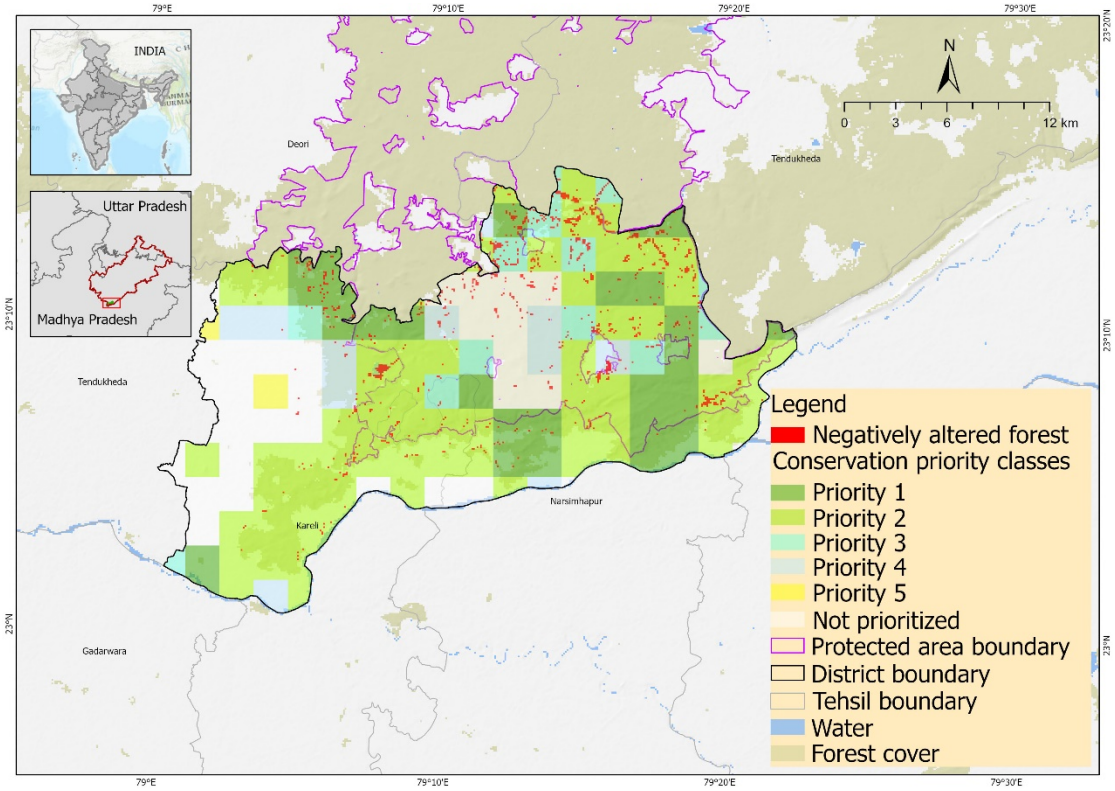


Figure 10.179. Map showing negatively altered landscape overlaid on priority areas of conservation within Narsinghpur District

(11) Banda District

1. **Biodiversity Management Committee** should be activated to monitor and conserve the highest conservation priority areas for vultures (Fig. 10.180) and biodiversity (Fig. 10.181). Based on the information collected, access and benefit sharing should be made a part of Gram Panchayat Development Plan.

2. **One Village One Hectare** concept for restoration of areas that have been significantly negatively altered, where forest cover has declined drastically, should be considered (Fig. 10.182). This intervention can involve social forestry, integrated farming, ecosystem service trade-off and carbon economy, and can be subjected to payment for ecosystem service (PES) model at state and national level. Restoration efforts should initially be focussed on negatively altered forests falling within the priority I class of spatial prioritization for biodiversity conservation, and then on priority II, and so on (Fig. 10.183).

3. **Convergence for Consolidation and Restoration:** As indicated above, Fig. 10.183 provides the combined value for PTR, these identified targets should be the focus for habitat consolidation, protection and restoration.

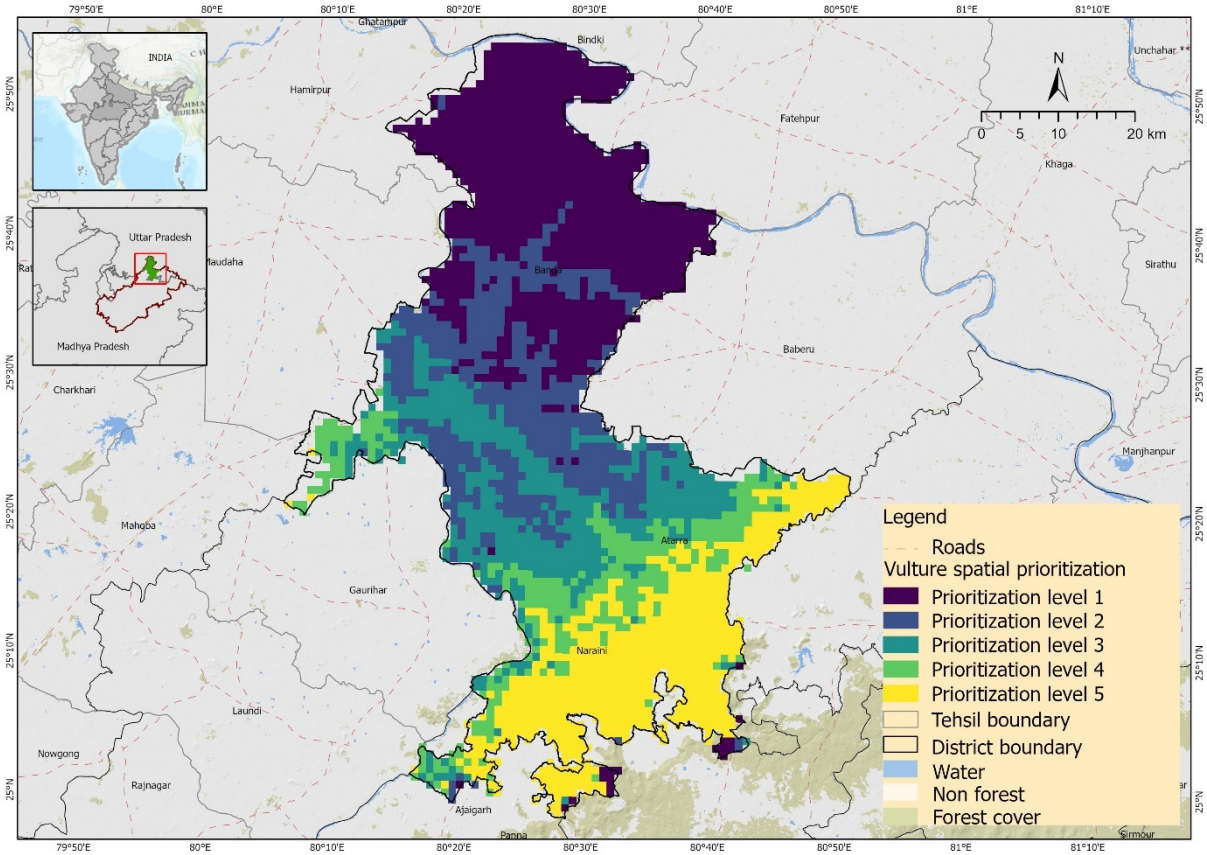


Figure 10.180. Map showing vulture conservation priority areas within Banda District

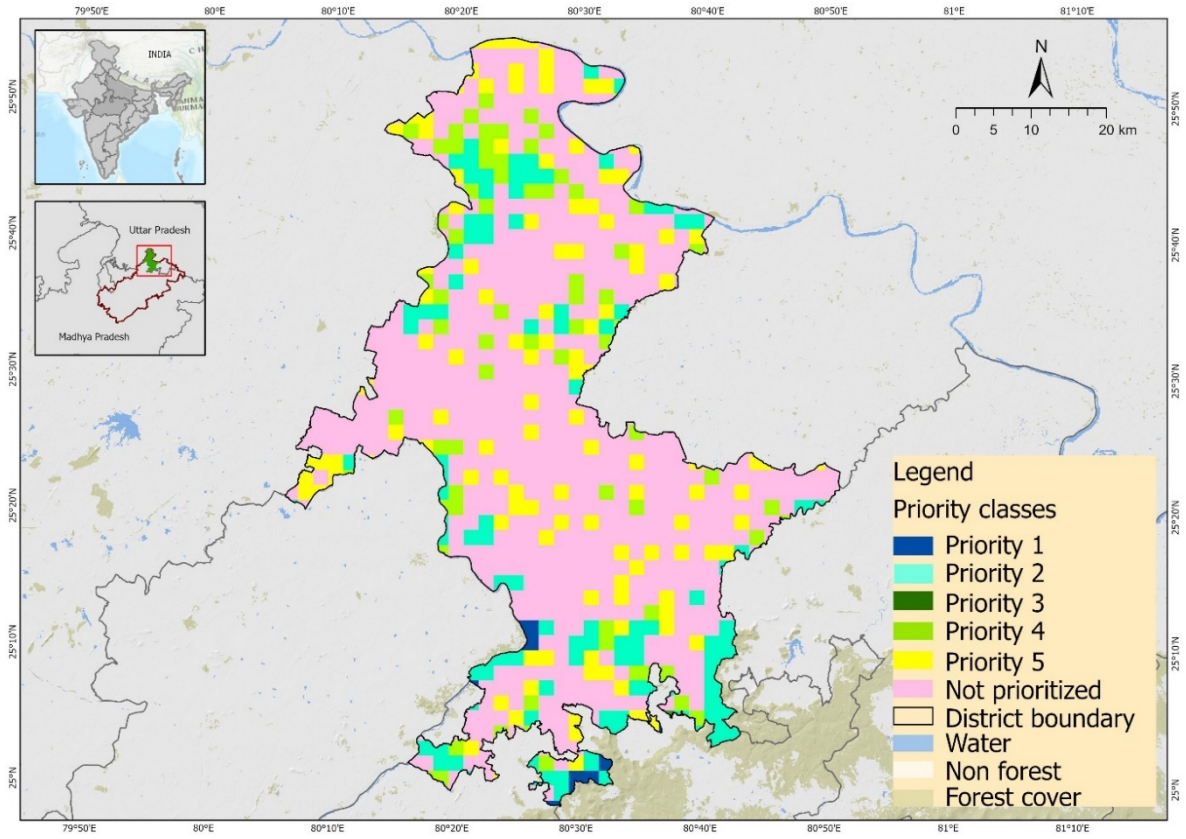


Figure 10.181. Priority areas for conservation within Banda District

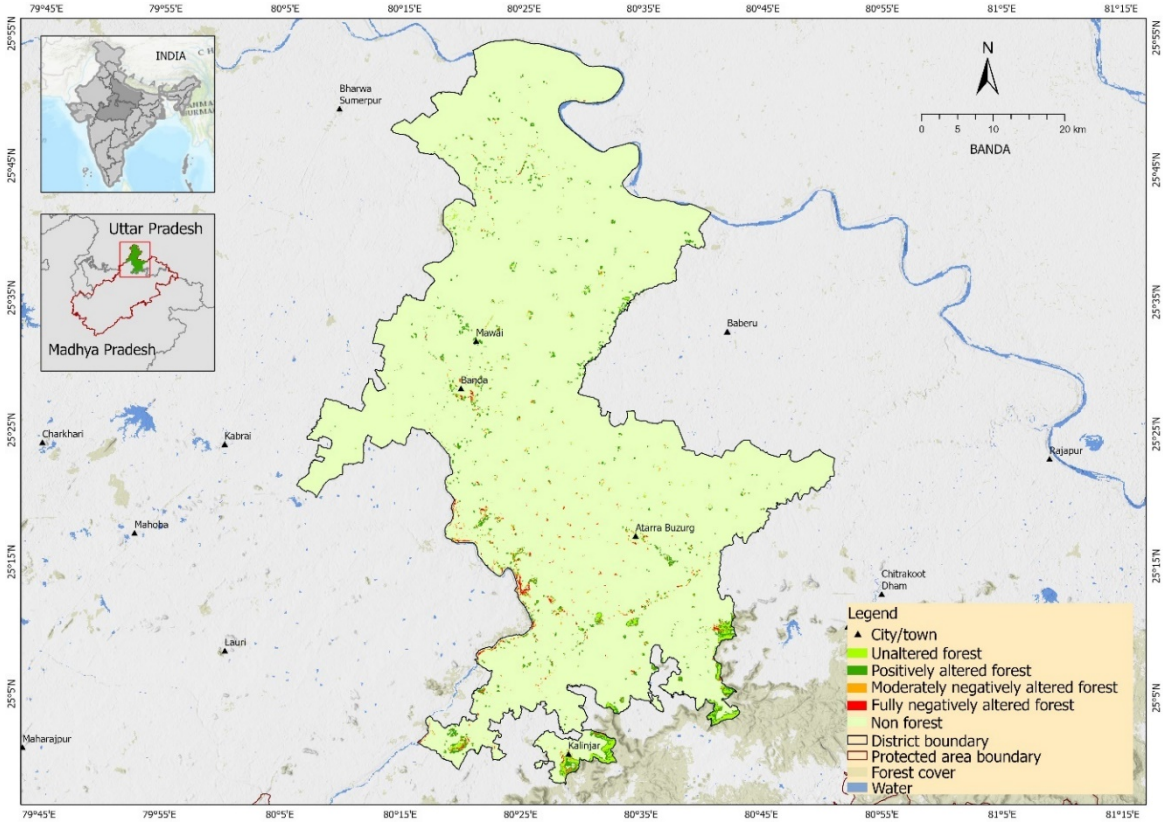


Figure 10.182. Map showing altered-unaltered landscape within Banda District

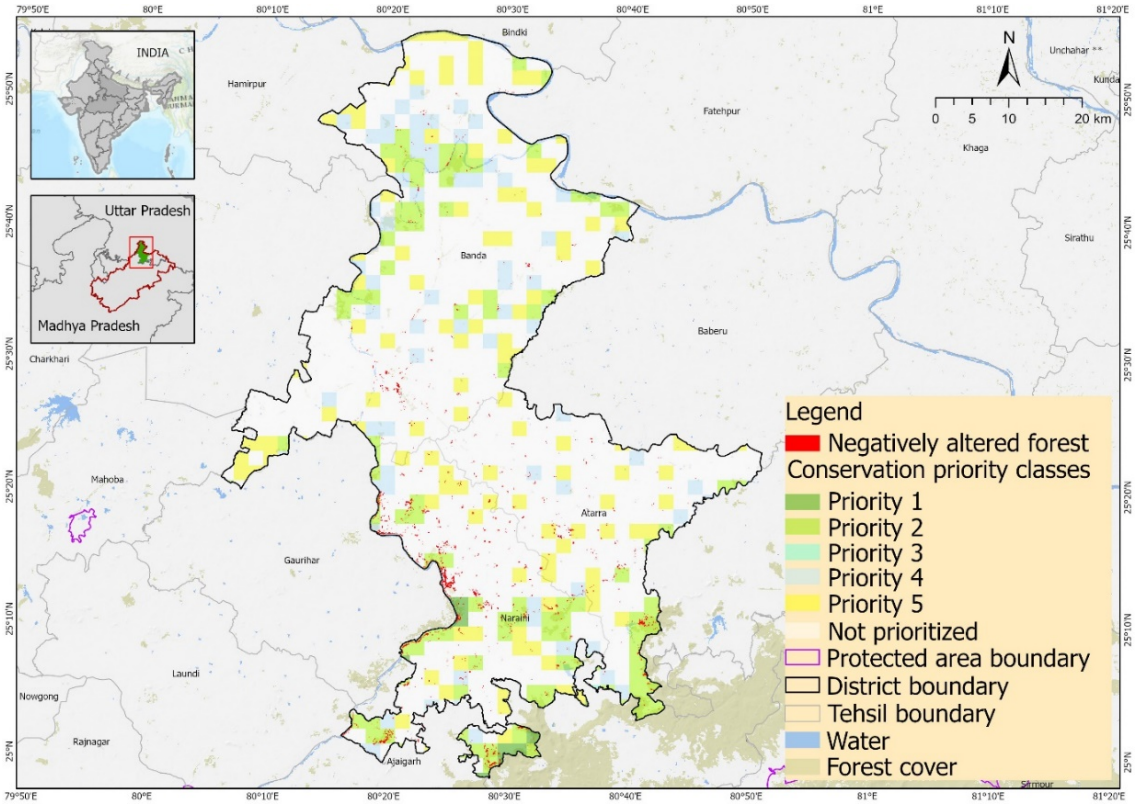


Figure 10.183. Map showing negatively altered landscape overlaid on priority areas of conservation within Banda District

10.4.4. Stakeholders and Line Agencies: The management actions need to consider the stakeholders and the line agencies that are mandated with certain responsibilities. Accordingly, some of the stakeholders and line agencies have been listed below. However, these can be finalized as per the interventions specified above for different categories of zones and can vary for different units/districts.

Stakeholders

1. Forest Department
2. Communities
3. Civil Administrations
4. NGOs/NGIs
5. Research/Education Institutions
6. Mines and Manufacturing Industries
7. Hospitality Industry
8. Tourism Industry
9. Pharmaceutical Industries
10. Gaushala Establishments

Line Agencies

1. Forest Department
2. Farmer Welfare and Agriculture Development Department
3. Department of Animal Husbandry
4. Panchayat and Rural Development Department
5. Ministry of Tribal Welfare
6. Public Works Department
7. National Highway Authority
8. Water Resources Department
9. Ministry of Health and Family Welfare
10. Mineral Resources Department
11. Energy Department
12. State Pollution Control Board
13. State Biodiversity Board
14. Ministry of Chemicals & Fertilizers

10.4.5. Knowledge Management and Capacity Building: One of the key drivers of effective management relates to how historical, contemporary and predicted data is managed, in terms of quality, storage, retrieval and sharing mechanism. Therefore, knowledge management which is fundamental to landscape management and its proper use, will serve as an effective decision support system. This particular action would be handled by the Integrated Research and Learning Centre (IRLC) to be set up in Panna by the Wildlife Institute of India for this purpose. This would have state-of-art technology, hardware/software, and necessary manpower to implement the knowledge management system, also involving remote sensing and GIS tools and web-based network service. Similarly, with knowledge, capacity development for regular and need-based activities is another important component that can ensure quality outcome. Therefore, the knowledge management and capacity development would focus on the above thematic and zonal components, and would be both in-house and field based, including some opportunities for learning from other best practices both within and outside country.

(i) Training on Technology and Monitoring Methods: In the context of PTR and a part of GPL, the capacity building activities for forest staff on Telemetry (VHF and Satellite-based), Monitoring of Tiger, Co-predator and Prey Species (Phase I and Phase IV of NTCA Protocol), use of Camera Traps, Unmanned Arial Vehicle (UAV) and M-STrIPES have been conducted over the last decades enhancing their ability to perform the tasks effectively. Similar activities should be strengthened and organised across the forest divisions of landscape.

(ii) Training on Anti-Poaching Activities: GPL is human-dominated and often the forest staff is likely to face the anti-social elements, individuals involved in poaching or snaring, or people engaged in unlawful activities. To have effective control, the staff must be equipped with modern arms and ammunitions and should know how to handle them. Thus, full course training to handle the arms and ammunition along with intelligence network for information gathering should be arranged for the field staff on regular basis. There should be special training for women staff and officers to deal with physical and psychological stress for effectively performing the duty.

(iii) Training on Forensic Investigation: Training on the basic skills to collect samples from carcasses, its storage and transfer to the nearest wildlife veterinary centres or forensic laboratories for detailed investigation is required for the forest staff. Similar to this, sensitising ground level staff (beat guards and chowkidars) on physical capture and chemical immobilisation of wild animals which enter inside the human settlements needs to be carried

out to monitor and prevention of infectious diseases and to mitigate human-wildlife conflict. Orientation courses on computer application and GIS also needs to be conducted for hassle-free day to day tasks.

(iv) Strengthening of Infrastructure: Strengthening of infrastructure is also required to motivate the forest staff as well as for their wellbeing. The basic facilities i.e., access to clean water, toilet, LPG for cooking and healthcare requires strengthening within forest staff camps. A mobile hospital shall also be established to make healthcare accessible to the forest staff.

(v) Skill-development of Communities: Capacity building of communities should be done through skill development programs focussed on computer applications and GIS technology, tailoring, enterprising, driving, marketing, training in vermicomposting or earthworm culture, horticulture, silviculture, apiculture, marketing, tourism management, wildlife monitoring, waste management, and other allied fields on need basis. These should be managed through IRLC with pilot programs in few households and informing the public about relevant schemes. Certain programs can be coordinated through Regional Institute of Rural Development (RIRD).

10.4.6. Research and Monitoring: Research and monitoring are two pillars of sustainable long-term management of thematic focus and would guide adaptive management strategies even if there is any gap or inadequacy in the planning and implementation process. Research based management is crucial to understand the ecology of respective species. The research priorities are focused on two major aspects - gaining knowledge on species ecology and subsequently conducting ‘problem solving studies’. Based on available knowledge, detailed monitoring protocol for each of the species/themes have been provided at the end of the plan. The same may be revised based on new research and further, the focus of research may be revised based on the feedback from monitoring.

The following is a list of research activities that require focus as a part of the landscape management plan implementation process, since these would provide adaptive management options.

Species-centric Studies

1. Develop coarse scale and fine scale population estimation and monitoring strategy for various taxonomic groups with appropriate sample size and effect size.
2. Investigation on population dynamics of RET species and other lesser-known species of both flora and fauna towards conservation and recovery strategies.
3. Study the distribution and population estimation of lesser-known species and explore restoration/augmentation strategies for these species and also the species that have shown recent population declines.
4. Vegetation studies looking to the phyto-sociological aspects, phenology, functional traits, carbon sequestration and permanent plot monitoring.
5. Study on bird species richness with focus on effects of habitat quality on the richness and abundance.
6. Study the population dynamics of raptors (diurnal and nocturnal) and ground-dwelling birds based on capture and recapture, and telemetry methods.
7. Study the movement, dispersal pattern, colonization and survival rate of tiger, vulture and gharial based on field survey, camera trapping, telemetry, and spatially explicit modelling as appropriate.
8. Intensive study on the effects of habitat quality and anthropogenic impacts on the demographic, genetic and physiological response by tiger, co-predators (including leopard, hyena, wild dog and wolf), sloth bear, prey species, vulture and gharial in the landscape.
9. Study the prey-predator relationship and develop carrying capacity for different areas and species long-term management of the landscape.
10. Spatial pattern and cause-effect relationship of human-wildlife conflict involving carnivores and herbivores based on community consultation, field assessment and technological involvement.

System-centric Studies

1. Spatially explicit mapping and monitoring of nutrient value of different vegetation types and its potential for determining carrying capacity of the system.
2. Undertake fine scale assessment and long-term monitoring of habitat quality and response of indicator species in different ecosystems with more emphasis on riparian and aquatic systems.
3. Monitoring of woodlands and grasslands based on experimental designs to maintain productivity and to enhance biodiversity values.
4. Investigation on hybridization and disease transmission between domestic and wild animals in the spatial contexts.
5. Study the effect of climate change and anthropogenic drivers on the various taxonomic groups (terrestrial and aquatic species) and interface dynamics.
6. Study the villages that have been vacated and also in the new settlements to understand anthropogenic response and provide solutions for management of these areas.
7. Study the socioeconomics and perception of the people across space and time to devise management strategies accordingly, including for financial literacy and convergence of various schemes.
8. Review and detailed investigation of efficiency of existing EDCs and BMCs.
9. Quantification of ecosystem services and economic valuation of GPL and inputs for restoration and carbon credit.
10. Investigate one health concept with focus on interface areas and investigate all for physical and mental health issues in the landscape.
11. Assessment of efficacy of different technologies including aerial survey by UAV and suggestions for cost effective deployment in the landscape specifically for population estimation, habitat mapping, fire detection and law enforcement.

10.4.7. Development of Research and Training Infrastructure: The Integrated Research and Learning Centre (IRLC) should be established in close vicinity of either Hinauta or Madla gate in PTR, within Panna District. The probable places could also be NMDC township area in Majhgawan or Panna. As per the land availability and nearness to the entry gate, places between Panna city and Hinauta gate could also be thought of. The IRLC would focus on conducting

research identified in the earlier section, supplementary chapters, and emerging requirements. Additionally, it would also carry out activities related to training and capacity building of forest department staff, as well as, local communities, as identified within the plan. It will also serve as a learning centre for students from school and colleges in the landscape, and other professionals that are involved in landscape level management. Apart from IRLC, one small field base camp would also be constructed at Kishangarh gate, most preferably at Kishangarh township area. This would facilitate conducting field works in distant parts of the PTR especially the two buffer ranges *viz*. Kishangarh and Madiadoh, as well as Kishangarh core, which would be otherwise not feasible from the main research station.

10.4.8. Development and Conservation Linkages: GPL with its diverse habitat, rich faunal assemblage and successful tiger recovery has high conservation value. However, the districts falling within the landscape perform poorly across most socioeconomic indicators because of which several developmental projects have been planned in the region. In GPL, the conservation agenda is likely to be impacted by three types of developmental projects: river-linking project, mining, and road/infrastructure development.

(i) River Linking Project: The implications of KBLP due to construction of Daudhan dam within PTR, as discussed earlier, are multifold. And although it is not possible to mitigate the impacts entirely that the project is going to have on the reserve, the conservation strategies indicated in LMP would certainly help enhance conservation outcome, offering win-win situation if implemented effectively. In addition to the compensatory areas to be made available, protection of satellite cores, steppingstone, and corridors identified in this plan, declaration of Ranipur Interstate Tiger Reserve and Kalda Conservation Reserve, protection of River Corridor Zone, expansion of Veerangna Durgawati Wildlife Sanctuary to be made as part of proposed Nauradehi (-Durgawati) Tiger Reserve and structural intervention to maintain connectivity within PTR, may address the concerns of KBLP's impact on tiger connectivity and habitat loss. The proposal to declare priority cliff nesting sites within GPL as community/conservation reserve for vultures and the support to be provided for protection of habitat specially feeding sites may address the concerns related to loss of vulture nesting sites due to submergence. Protection of river and riparian zone, identification of 'crocodile priority zones' and 'restricted zones', along with the proposal of gharial recovery as indicated within the plan shall also minimize the impact that KBLP would have on the aquatic fauna. More importantly the minimum flow to be maintained keeping in view the requirements for gharial

would also ensure the flow requirement for other species. All these prescribed conservation actions must be implemented to address the implications of KBLP.

(ii) Mining: The diamond mines run by NMDC within PTR, open cast mines, proposed diamond mining project in Buxwaha, several legal and illegal sand and boulder mining activities along the rivers in GPL are and would impact both the terrestrial and aquatic habitats. It is recommended that no mining projects be developed within any of the conservation priority sites (satellite cores, stepping stones and corridors) and other conservation zones/areas identified within the plan. And ongoing mining activities within the river corridor zone should be regulated and monitored for their impact on riparian habitat.

(iii) Road/Infrastructure Development: Presence of several state and national highways, expansion of railways and townships in the landscape is and are expected to negatively impact wildlife habitat and connectivity within GPL. It is recommended that underpasses and overpasses be constructed at the points where major roads intersect with corridors identified within this plan. Green-belt concept should be integrated as a part of any development project in the landscape. Additionally, community should be engaged in developing conservation priority sites outside PA network as community reserves and incentivized to develop one-hectare forest in each village in the command area of KBLP project. The future for the landscape must be green development, ensuring sustainable use of natural resources and conserving landscape dependent species such as tiger and vultures**.**

10.4.9. Implementation Principle: The ILMP is to be implemented on the NSL (Now-Soon-Late/long-term) principle and specific actionable points have already been described for each of thematic areas and zonal actions have also been specified. The Now-Soon-Later principle is proposed in the time scale from 2022/23 to 2023/24 (Now), from 2023/24 to 2026/27 (Soon) and from 2023/24 to 2031/32 (Later or long-term), and with what, when and whom strategy so that the implementation can be carried forward with better clarity.

(i) Tiger Conservation Strategies

S. No.	What	When	Whom*
1	Special Performance Unit (SPU)	Now	Panna Tiger Reserve
2	Continuous Camera-trap Monitoring System (CCMS)	Now	Panna Tiger Reserve, other Protected Areas, and Forest Division

3	Crime Deduction and Alert System (CDAS)	Soon	Panna Tiger Reserve, other Protected Areas, Forest Division, and Wildlife Crime Control Bureau
4	Intelligence Network and Incentives	Soon	Panna Tiger Reserve and other Protected Areas
5	Un-manned Aerial System (UAV) for monitoring and supply of essentials	Soon	Wildlife Institute of India and Panna Tiger Reserve
6	Strengthening Staff Infrastructure and Logistics	Soon and Later / Long-term	Panna Tiger Reserve, other Protected Areas, and Forest Division
7	Virtual Fence Network	Soon and Later / Long-term	Wildlife Institute of India and Panna Tiger Reserve
8	Social Fencing Network (SFN)	Soon and Later / Long-term	Panna Tiger Reserve, other Protected Areas, Forest Division, District Administration, Community Professionals, NGOs, and Gram Panchayat
9	Fine-scale Distribution Mapping and Monitoring	Soon and Later / Long-term	Wildlife Institute of India, State Forest Research Institute (SFRI), and Tiger Conservation Foundation
10	Spatially Explicit Population Estimation and Monitoring with Effect Size and Required Sample Size	Soon and Later / Long-term	Wildlife Institute of India, SFRI, and Tiger Conservation Foundation
11	Demographic Management	Soon and Later / Long-term	Panna Tiger Reserve, other Protected Areas, and Wildlife Institute of India
12	Genetic Management	Soon and Later / Long-term	Panna Tiger Reserve, other Protected Areas, Forest Division, and Wildlife Institute of India
13	Establishment of Controlled Population Management Facility	Soon and Later / Long-term	Panna Tiger Reserve
14	Transfer of Landownership of Compensatory Village Area	Now	National Water Development Agency, and, Panna and Chhatarpur District Administration
15	Transfer of Landownership of Revenue Areas and development of Conservation Reserve	Now	Chhatarpur District Administration and Government of Madhya Pradesh
16	Restoration of Consolidated Village Areas	Soon and Later / Long-term	Panna Tiger Reserve

17	Construction of Structural Connectivity across Ken River	Soon and Later / Long-term	National Water Development Agency
18	Diversion of Road Traffic Volume, Strategic Fencing and Alert System	Soon and Later / Long-term	Panna and Chhatarpur District Administrations
19	Retrofitting of Under Passes and Over Passes	Soon and Later / Long-term	District Administrations, National Highway Authority, and State Highway Department
20	Recognition and protection of important tiger habitats for satellite cores, stepping stones and corridors	Now, Soon and Later / Long-term	Panna Tiger Reserve, other Protected Areas, Forest Division, District Adiministration and Wildlife Institute of India
21	Research, monitoring and capacity building towards adaptive management	Now, Soon and Later / Long-term	Panna Tiger Reserve, Wildlife Institute of India, State Forest Research Institute, and other State and National Institutions, such as Sagar, Banda, Rewa, and Jabalpur Universities

*****Identified institutions are only tentative and may be added as per emerging requirements and expertise, including individual experts and NGOs to whom work can be outsourced.

(ii) Vulture Conservation Strategies

S. No.	What	When	Whom*
1	Establishment of Electronic Surveillance System	Soon and Later / Long-term	Forest Division with support of Institutions such as IIT Indore, IIT Kanpur, IIIT-Allahabad
2	Fencing of Carcass Dump Sites	Soon and Later / Long-term	Forest Division, District Administration, Gram Panchayat, and Gaushala Authority
3	Deployment of Alert System	Soon and Later / Long-term	Panna Tiger Reserve, other Protected Area, Forest Divisions with support of Institutions such as IIT Indore, IIT Kanpur, IIIT-Allahabad
4	Aerial Surveillance of Fire and Prevention	Soon and Later / Long-term	Panna Tiger Reserve, other Protected Areas, Forest Divisions and Wildlife Institute of India
5	Establishment of Network of Vulture Champions	Now	Panna Tiger Reserve, other Protected Areas, Forest Division, District

			Administration, Gram Panchayat, and NGOs
6	Gaushala Coordination Committee	Now	District Administration
7	Robust Population Estimation and Monitoring	Now, Soon and Later / Long-term	Wildlife Institute of India, Panna Tiger Reserve, other Protected Areas, Forest Division, SFRI, and Bhopal Vulture Centre
8	Demographic and Genetic Structure Profiling	Now and Soon	Wildlife Institute of India, State Veterinary Institute, and other institutions such as Sagar and Rewa Universities
9	Roosting Site and Nest-site Monitoring	Now, Soon and Later / Long-term	Panna Tiger Reserve, other Protected Areas, Forest Division, and Vulture Champions
10	Biochemical Analyses and Monitoring	Soon and Later / Long-term	State Veterinary Institute and Salim Ali Centre for Ornithology and Natural History (SACON)
11	Establishment of Vulture Rehabilitation Centres (VRC)	Now and Soon	Panna Tiger Reserve, other Protected Areas, Forest Division, and Bhopal Vulture Centre
12	Awareness and Engagement of People and Veterinary Professionals	Now and Soon	NGOs, individual experts/consultants, State Veterinary Institute, and Regional Institute for Rural Development
13	Implementation of Flyway Action Plan	Now and Soon	Wildlife Institute of India and Panna Tiger Reserve
14	Disease Surveillance and Monitoring	Now and Soon	State Veterinary Institute
15	Augmentation of Riparian Tree Species	Soon and Later / Long-term	Panna Tiger Reserve, other Protected Areas and Forest Division
16	Management of Dumping Site/ Feeding Point	Soon and Later / Long-term	District Administrations, Panchayat Administrations, and Gaushala Authority
17	Developing Community/ Conservation Reserve	Soon and Later / Long-term	District Administrations and State Governments of Madhya Pradesh and Uttar Pradesh
18	Vulture-based Tourism	Soon and Later / Long-term	Panna Tiger Reserve, other Protected Areas, Forest Division, District Administration, Tourism Department, and Local Hospitality/Tourism Industries

19	Research, monitoring and capacity building towards adaptive management	Now, Soon and Later / Long-term	Panna Tiger Reserve, other Protected Areas, Forest Division, District Administration, Wildlife Institute of India, State Forest Research Institute, IIFM-Bhopal, Sagar University, Banda University, Rewa University, IISER Bhopal, State Veterinary Research Institute, Nanaji Deshmukh Veterinary Science Institute

*****Identified institutions are only tentative and may be added as per emerging requirements and expertise, including individual experts and NGOs to whom work can be outsourced.

(iii) Crocodilians Conservation Strategies

S. No.	What	When	Whom*
1	Protection of Crocodile Priority and Restricted Zones	Now	Panna Tiger Reserve
2	Enforcement of Ban or Strategic Regulation on Fishing	Now, Soon and Later / Long-term	Panna Tiger Reserve
3	Protection and Co-Management of River Habitats (Zonation of Riparian habitat)	Now, Soon and Later / Long-term	Panna Tiger Reserve, District Administrations, and Local Stakeholders
4	Deployment of Unmanned Aerial System for Security-based Monitoring	Now, Soon and Later / Long-term	Wildlife Institute of India and Panna Tiger Reserve
5	Population Estimation and Monitoring	Now, Soon and Later / Long-term	Panna Tiger Reserve
6	Demographic and Genetic Management	Now and Soon	Panna Tiger Reserve and State Veterinary Institute
7	Coordinated Gharial Recovery Programme (re-introduction and *ex-situ*)	Now and Soon	Wildlife Institute of India, Panna Tiger Reserve, and other Professionals
8	Crocodile Rehabilitation Centre	Soon and Later / Long-term	Panna Tiger Reserve
9	Management of Environment Flow and Sediments	Soon and Later / Long-term	Panna Tiger Reserve and National Water Development Agency
10	Prey Population Management	Soon and Later / Long-term	Panna Tiger Reserve and Department of Fisheries
11	Management of Artificial Sandbanks	Soon and Later / Long-term	Panna Tiger Reserve and other Professionals
12	Alternative Livelihood Opportunities	Soon and Later / Long-term	Panna Tiger Reserve, NGOs, and other Professionals

13	Awareness, Training and Stakeholder Workshop	Now, Soon and Later / Long-term	Panna Tiger Reserve, NGOs, and other Professionals
14	Research, monitoring and capacity building towards adaptive management	Now, Soon and Later / Long-term	Panna Tiger Reserve, Wildlife Institute of India, State Forest Research Institute, and other State and National Institutions such as Madras Crocodile Bank, Snake Park Trust etc.

*****Identified institutions are only tentative and may be added as per emerging requirements and expertise, including individual experts and NGOs to whom work can be outsourced.

(iv) Biodiversity Conservation Strategies

S. No.	What	When	Whom*
1	Management of *Lantana camara* and *Hyptis suaveolens* (Van Tulsi) in PTR Core	Soon and Later / Long-term	Panna Tiger Reserve
2	Management of *Lantana camara* and *Hyptis suaveolens* (Van Tulsi) in the Landscape	Soon and Later / Long-term	Other Protected Areas and Forest Divisions
3	Grassland management in PTR in Core and Buffer: augmentation and experimental design in relocated villages	Soon and Later / Long-term	Panna Tiger Reserve
4	Management and augmentation of existing ponds/water bodies	Soon and Later / Long-term	Panna Tiger Reserve, other Protected Areas, Forest Divisions and District Administration
5	Augmentation/restoration of riparian habitat based on Riparian Vegetation Index (RVI) inside PTR	Soon and Later / Long-term	Panna Tiger Reserve
6	Establishment of Riparian Conservation Zone / Community Reserve	Now, Soon and Later / Long-term	Panna Tiger Reserve, Forest Divisions, District Administrations, NGOs, and other Professionals
7	Conservation measures for vegetation species: Assisted Natural Regeneration (ANR) of tree species, conservation measures for SCS (Species of Conservation Significance)	Soon and Later / Long-term	Panna Tiger Reserve, other Protected Areas, Forest Divisions, Wildlife Institute of India
8	Conservation measures for mammal species: conservation measures for SCS (endangered, indicator species)	Soon and Later / Long-term	Panna Tiger Reserve, other Protected Areas, Forest Divisions, and Wildlife Institute of India

9	Conservation measures for bird species: conservation measures for SCS (woodland, grassland, water and migratory birds)	Soon and Later / Long-term	Panna Tiger Reserve, other Protected Areas, Forest Divisions and Wildlife Institute of India
10	Conservation measures for herpetofauna species: conservation measures for SCS, creation of Micro-habitats	Soon and Later / Long-term	Panna Tiger Reserve, other Protected Areas, Forest Divisions and Wildlife Institute of India
11	Spatial delineation of freshwater fish safe zone	Now and Soon	Forest Divisions, District Administration and Wildlife Institute of India
12	Conservation awareness and species recovery plan for Mahseer	Now and Soon	Panna Tiger Reserve and Wildlife Institute of India
13	Research, monitoring and capacity building towards adaptive management	Now, Soon and Later / Long-term	Panna Tiger Reserve, other Protected Areas, Wildlife Institute of India, State Forest Research Institute and other State and National Institutions

*****Identified institutions are only tentative and may be added as per emerging requirements and expertise, including individual experts and NGOs to whom work can be outsourced.

(v) Community Engagement Strategies

S. No.	**What**	**When**	**Whom***
1	Water Security Measures	Soon and Later / Long-term	Panna Tiger Reserve, District Administrations, NGOs and individual experts/consultants
2	Health Improvement Measures	Soon and Later / Long-term	District Administrations
3	Education and Skill Development	Soon and Later / Long-term	District Administrations, NGOs and individual experts/consultants
4	Waste Management	Soon and Later / Long-term	District Administrations, NGOs and individual experts/consultants
5	Employment and Alternate Livelihood Options	Now, Soon and Later / Long-term	District Administrations, National Skill Development Corporation (NSDC), National Institute for Rural Development (NIRD) /State Institute for Rural Development (SIRD), MoEF&CC, NGOs and individual experts/consultants

6	One Health Management	Now, Soon and Later / Long-term	Panna Tiger Reserve, District Administrations, Wildlife Institute of India, State Veterinary Institute, Indian Institute of Public Health Gandhinagar, Kerala Veterinary and Animal Sciences University, District Administrations, Panna Tiger Reserve, NGOs and individual experts/consultants
7	Human Wildlife Conflict Management	Now, Soon and Later / Long-term	Panna Tiger Reserve, other Protected Areas, Forest Divisions, District Administrations, NGOs and individual experts/consultants

*****Identified institutions are only tentative and may be added as per emerging requirements and expertise, including individual experts and NGOs to whom work can be outsourced.

(vi) Integrated Landscape Management Strategies

S. No.	What	When	Whom*
1	Establishment and declaration of Interstate Tiger Reserve, Conservation Reserves, Community Reserves, Riverzone and Important Conservation Units including Satellite Cores, Steppingstones and Corridors	Now	Other Protected Areas, Forest Divisions, District Administrations, State Government of Madhya Pradesh and Uttar Pradesh, other Protected Areas, Forest Divisions, District Administrations, Global Tiger Forum, and Wildlife Institute of India
2	Structural Interventions	Soon and Later / Long-term	National Water Development Agency, National / State Highway Authorities and State Government of Madhya Pradesh and Uttar Pradesh
3	Restoration Programs based on One Village and One Hectare Concept	Soon and Later / Long-term	District Administrations, Forest Divisions and NGOs
4	Engagement of Biodiversity Monitoring Committee, Joint Forest Management Committee and Gaushala Coordination Committee	Now, Soon and Later / Long-term	District Administrations, Forest Divisions, Panna Tiger Reserve, Wildlife Institute of India, and Global Tiger Forum
5	Establishment of Green Economy Cooperatives and Growth Centre	Soon and Later / Long-term	District Administrations, Forest Divisions and Not-for-profit Companies

6	Establishment and functioning of Integrated Research and Learning Centre (IRLC)	Now and Soon	Wildlife Institute of India, Panna Tiger Reserve and Panna District Administration
7	Notification and functioning of Greater Panna Landscape Management Council under the Special Purpose Vehicle	Now and Soon	Ministry of Jal Shakti, MoEF&CC, Government of Madhya Pradesh and Government of Uttar Pradesh
8	Integrated research, monitoring, capacity building and feedback for adaptive management	Soon and Later / Long-term	Wildlife Institute of India, Panna Tiger Reserve, other Protected Area, Forest Division and Panna District Administration

*****Identified institutions are only tentative and may be added as per emerging requirements and expertise, including individual experts and NGOs to whom work can be outsourced.

10.4.8. Administration and Implementation Structure

Integrated Landscape Management Plan will have to be implemented by Greater Panna Landscape Council (GPLC) or Authority. The Special Purpose Vehicle (SPV)/ Ken Betwa Link Project Authority (which has already been established for which Gazette notification has also been issued) will have notify to integrate GPLC with dedicated team and mandates, technically supported by Integrated Research and Learning Centre (IRLC) to be set up in Panna District. Overall, the administrative and implementation structure will have (i) Greater Panna Landscape Council (GPLC) as a part of Special Purpose Vehicle, (ii) Greater Panna Technical Advisory Committee as a part of IRLC, and (iii) District Landscape Committee (DLC) as a part of District Administration. Following are the details of these proposed administrative mechanisms and coordination strategy for implementing the ILMP and long-term viability of conservation and development goals:

(i) Greater Panna Landscape Council: GPLC is proposed to be constituted under the Special Purpose Vehicle (SPV)/ Ken Betwa Link Project Authority to execute the ILMP. The constitution of the GPLC may be as under:

1. Chief Secretary, Government of Madhya Pradesh - Chairman
2. Principal Secretary Forest, Madhya Pradesh - Member
3. Principal Secretary Rural Development, Madhya Pradesh - Member
4. Principal Secretary Agriculture, Madhya Pradesh - Member
5. Principal Secretary Forest, Uttar Pradesh - Member
6. Joint Secretary, MoJS - Member
7. Member Secretary, NTCA, MoEF&CC - Member
8. Director, Wildlife Institute of India - Member

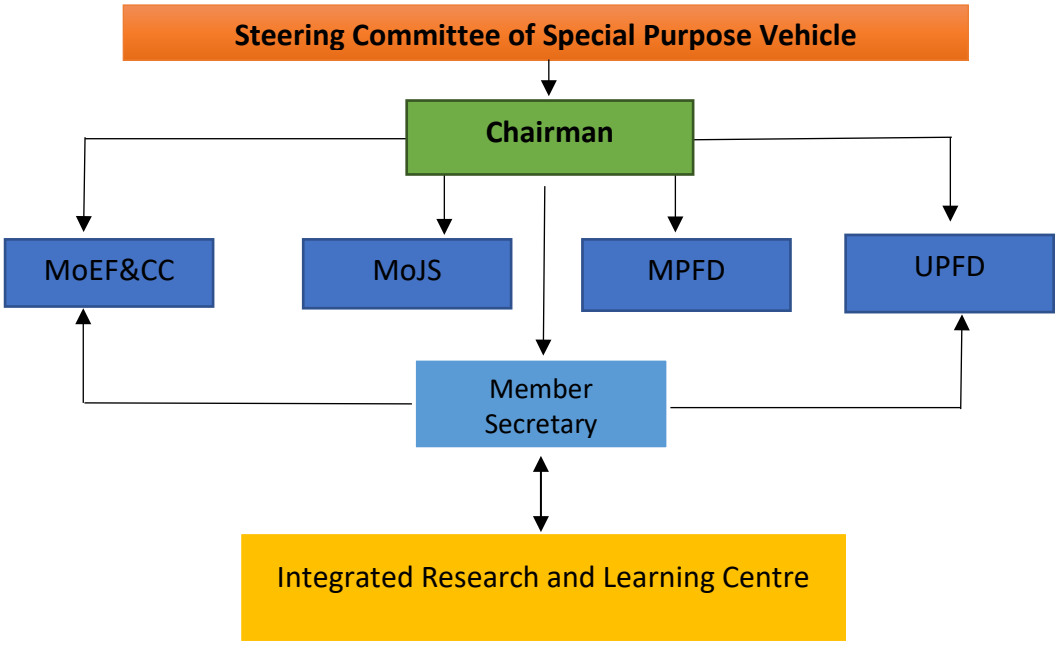
9. Inspector General of Forests (Wildlife), MoEF&CC - Member
10. Director General, NWDA, MoJS - Member
11. Principal Chief Conservator of Forests & HoFF, MP - Member
12. Chief Wildlife Warden, Madhya Pradesh - Member
13. Chief Wildlife Warden, Uttar Pradesh - Member
14. District Collector, Panna - Member
15. District Collector, Chhatarpur - Member
16. In-charge of IRLC - Member
17. Field Director, Panna Tiger Reserve - Member Secretary

The GPLC will oversee the implementation of the ILMP and will have approval of SPV based on progress and accomplishment as envisaged in the plan. The budget allocated for the ILMP would be placed with the Special Purpose Vehicle and in a separate bank account in the name of 'Greater Panna Landscape Management Plan' for direct disbursal based on the plan allocation and annual plan of operation. The entire budget envisioned for the ILMP should be transferred in the first year in the specific account and the interest accrued would be utilized for the inflation and unforeseen expenditure. The GPLC would have the following mandates;

(1) Implementation of the Integrated Landscape Management Plan.

(2) Overseeing and monitoring of the Environment Management Plan activities.

(3) Overseeing and monitoring of the CAMPA activities for which the fund has been transferred by NWDA, so that the fund flow is ensured for the GPL.



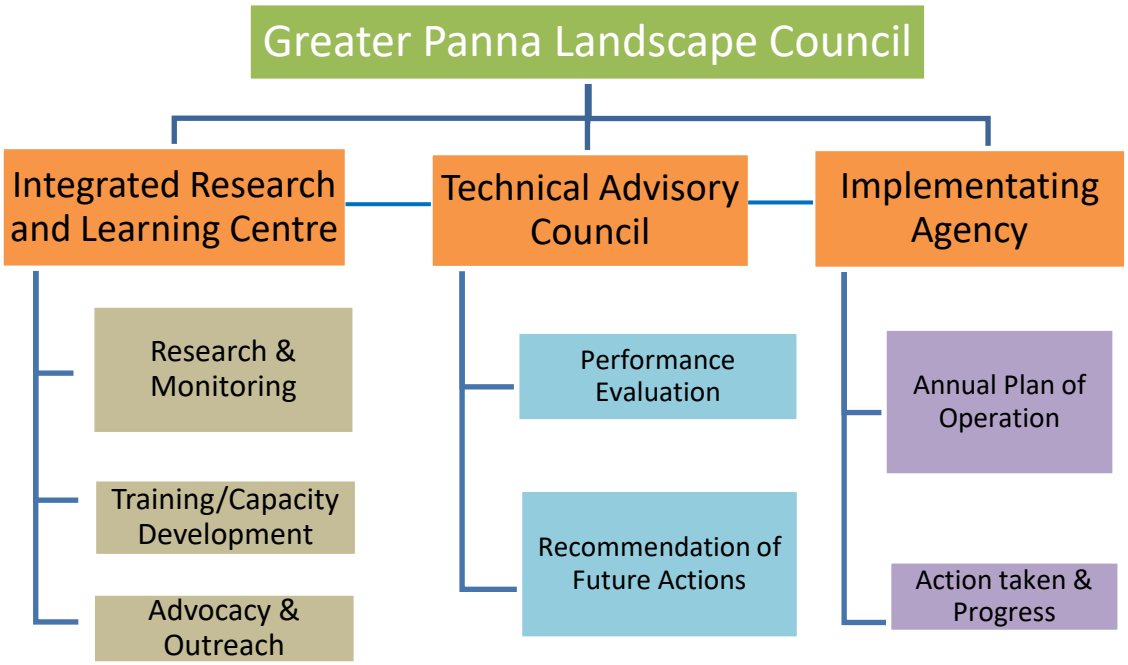
(ii) Greater Panna Technical Advisory Committee (GPTAC): The Integrated Research and Learning Centre (IRLC) will play an important role not only in implementing research, training and advisory within the GPL, but would also undertake independent monitoring of ILMP implementation and progress. Therefore, the Technical Advisory Committee (GPTAC) would be formed as a part of the IRLC, so that the activities and progress meaningfully analysed and synthesized for effective reporting to GPLC and follow-up directions. Given that IRLC has strong technical components, it will have to be established and supported by Wildlife Institute of India to ensure long-term sustainability even after the proposed ILMP period. GPTAC may be constituted as under;

1. Director/Dean, Wildlife Institute of India - Chairman
2. Member Secretary, State Biodiversity Board, MP - Member
3. Member Secretary, State Biodiversity Board, UP - Member
4. Additional PCCF (Wildlife), Madhya Pradesh - Member
5. Chief Engineer, NWDA, MoJS - Member
6. Deputy Inspector General of Forest (Wildlife), MoEF&CC - Member
7. Chief Conservator of Forests in GPL - Member
8. Director, State Forest Research Institute - Member
9. Director, Jabalpur Veterinary Science University - Member
10. Director, State Institute for Rural Development - Member
11. Director, Animal Husbandry, Madhya Pradesh - Member
12. Regional Director, Directorate of Health Services - Member
13. Field Director, Panna Tiger Reserve - Member
14. Nominated Expert in Life Science - Member
15. Nominated Expert in Social Science - Member
16. In-charge of IRLC - Member Secretary

IRLC will have dedicated manpower and support system from the budget provision available in the ILMP. While serving as Knowledge Management and Decision Support Centre, the IRLC will partly implement ILMP and monitor effectiveness of interventions and will provide updates to GPLC.

(iii) District Landscape Committee (DLC): Since much of the activities have to be carried forward with zonal strategy and with inputs/support of several stakeholders and line agencies, the DLC may be constituted for each of the district in the GPL as under with the mandate of coordinating and supporting different stakeholders and line agencies;

1. District Collector - Chairman
2. Divisional Forest Officer - Member
3. Head of other Line Agencies - Member
4. Stakeholders Representatives - Invited Member
5. Program Coordinator (hired for the ILPM) - Member Secretary



10.5. Budget Summary (for 10 Years)

Component A - Tiger Conservation Strategies								
S. No.	**Activities/Interventions**	**Unit Cost (INR Crore)**	**Total Cost (INR Crore)**	**Panna Tiger Reserve**	**Other Protected Areas**	**Forest Division**	**District Administration**	**GPLC/IRLC**
1.	Special performance unit (SPU)	10	100	100	-	-	-	-
2.	Continuous camera trap monitoring system (CCMS)	10	20	5	5	10	-	-
3.	Crime deduction and alert system (CDAS)	5	10	4	2	2	-	2
4.	Intelligence network and incentives	3	30	20	10	-	-	-
5.	Un-manned aerial system (UAV) for monitoring and supply of essentials	10	30	10	-	-	-	20
6.	Strengthening staff infrastructure and logistics	10	100	40	20	40	-	-
7.	Virtual fence network	5	15	5	-	-	-	10
8.	Social fencing network (SFN)	3	30	5	5	5	10	5
9.	Fine scale distribution mapping and monitoring	1	10	-	-	-	-	10
10.	Spatially explicit population estimation and monitoring	3	15	-	-	-	-	15
11.	Demographic management	2	20	12	5	-	-	3
12.	Genetic management	2	20	10	3	3	-	4
13.	Establishment of controlled population management facility	10	20	20	-	-	-	-
14.	Landownership-transfer of compensatory village area	0	0	-	-	-	-	-
15.	Landownership-transfer of revenue open areas and community reserve	0	0	-	-	-	-	-

16.	Restoration of consolidated village areas	30	90	90	-	-	-	-
17.	Construction of structural connectivity across Ken River	10	20	-	-	-	-	20
18.	Diversion of road traffic volume, strategic fencing and alert system	20	60	-	-	-	60	-
19.	Retrofitting of under passes and over passes	5	30*	-	-	-	15	15
20.	Recognition and protection of important tiger habitats for satellite cores, stepping stones and corridors	20	60*	5	10	20	20	5
21.	Research, monitoring and capacity building towards adaptive management	2	20	5	-	-	-	15
	Sub-total		**700**	**331**	**60**	**80**	**105**	**124**
	GST	**@18%**	**126**					
	Total		**826**					

Component B - Vulture Conservation Strategies

S. No.	Activities/Interventions	Unit Cost (INR Crore)	Total Cost (INR Crore)	Panna Tiger Reserve	Other Protected Areas	Forest Division	District Administration	GPLC/IRLC
1.	Establishment of E-Surveillance System	2	8	-	-	7	-	1
2.	Fencing of Carcass Dump Sites	10	60	-	-	20	20	20
3.	Deployment of Alert System	1	10	2	2	4	-	2
4.	Aerial Surveillance of Fire and Prevention	1	5	1	1	2	-	1
5.	Establishment of Network of Vulture Champions	3	30	1	2	2	20	5
6.	Gaushala Coordination Committee	2.8	28	-	-	-	28	-
7.	Robust Population Estimation and Monitoring	1	10	1	1	4	-	4

8.	Demographic and Genetic Structure Profiling	1	5	-	-	-	-	5
9.	Roosting Site and Nest-site Monitoring	1	5	1	1	2	-	1
10.	Biochemical Analyses and Monitoring	1	5	-	-	-	-	5
11.	Establishment of Vulture Rehabilitation Centres (VRC)	3	9	2	2	4	-	1
12.	Awareness and Engagement of People and Veterinary Professionals	2	20	-	-	-	-	20
13.	Implementation of Flyway Action Plan	1	5	2	0	-	-	3
14.	Disease Surveillance and Monitoring	2	20	-	-	-	-	20
15.	Augmentation of Nesting Tree Species	1	10	1	2	7	-	-
16.	Management of Dumping Site/ Feeding Point	2	20	-	-	-	10	10
17.	Developing Community/ Conservation Reserve	5	20	-	-	-	10	10
18.	Vulture-based Tourism	1	10	2	3	3	1	1
19.	Research, monitoring and capacity building towards adaptive management	2	20	4	2	2	2	10
	Sub-total		**300**	**17**	**16**	**57**	**91**	**119**
	GST	**@18%**	**54**					
	Total		**354**					
Component C - Crocodilian Conservation Strategies								
S. No.	**Activities/Interventions**	**Unit Cost (INR Crore)**	**Total Cost (INR Crore)**	**Panna Tiger Reserve**	**Other Protected Areas**	**Forest Division**	**District Administration**	**GPLC/IRLC**
1.	Protection of Crocodile Priority and Restricted Zones	2	20	20	-	-	-	-
2.	Enforcement of Ban or Strategic Regulation on Fishing	1	10	10	-	-	-	-

3.	Protection and Co-Management of River Habitats (Zonation of Riparian habitat)	1	10	8	-	-	2	-
4.	Deployment of Unmanned Aerial System for Security-based Monitoring	1	5	4	-	-	-	1
5.	Population Estimation and Monitoring	1	10	10	-	-	-	0
6.	Demographic and Genetic Management	1	10	5	-	-	-	5
7.	Coordinated Gharial Recovery Program (re-introduction and ex-situ)	5	50	30	-	-	-	20
8.	Crocodile Rehabilitation Centre	3	10	10	-	-	-	
9.	Management of Environment Flow and Sediments	2	20	5	-	-	-	15
10.	Prey Population Management	1	10	5	-	-	-	5
11.	Management of Artificial Sandbanks	1	10	8	-	-	-	2
12.	Alternative Livelihood Opportunities	2	15	5	-	-	-	10
13.	Awareness, Training and Stakeholder Workshop	1	10	2	-	-	-	8
14.	Research, monitoring and capacity building towards adaptive management	1	10	2	-	-	-	8
	Sub-total		**200**	**124**	**0**	**0**	**2**	**74**
	GST	**@18%**	**36**					
	Total		**236**					
Component D - Biodiversity Conservation Strategies								
S. No.	**Sub-components**	**Unit Cost (INR Crore)**	**Total Cost (INR Crore)**	**Panna Tiger Reserve**	**Other Protected Areas**	**Forest Division**	**District Administration**	**GPLC/IRLC**
1.	Management of Lantana camara and *Hyptis suaveolens* (Van Tulsi) in PTR	1	5	5	-	-	-	-
2.	Management of Lantana camara and *Hyptis suaveolens* (Van Tulsi) in the Landscape	5	25	-	20	5	-	-

3.	Grassland management in PTR in Core and Buffer: augmentation and experimental design in relocated villages	2	20	20	-	-	-	-
4.	Management and augmentation of existing ponds/water bodies	1	10	1	3	3	3	-
5.	Augmentation/restoration of riparian habitat based on Riparian Vegetation Index (RVI) inside PTR	1	10	10	-	-	-	-
6.	Establishment of Riparian Conservation Zone / Community Reserve	5	50	-	-	20	20	10
7.	Conservation measures for vegetation species: Assisted Natural Regeneration (ANR) of tree species, conservation measures for SCS (Species of Conservation Significance)	2	20	5	5	5	-	5
8.	Conservation measures for mammal species: conservation measures for SCS (endangered, indicator species)	4	40	10	10	10	-	10
9.	Conservation measures for bird species: conservation measures for SCS (woodland, grassland, water and migratory birds)	4	40	10	10	10	-	10
10.	Conservation measures for herpetofauna species: conservation measures for SCS, creation of Micro-habitats	4	40	10	10	10	-	10
11.	Spatial delineation of freshwater fish safe zone	1	10	-	-	5	2	3
12.	Conservation awareness and species recovery plan for Mahseer	2	20	10	-	-	-	10
13.	Research, monitoring and capacity building towards adaptive management	1	10	2	2	-	-	6
	Sub-total		**300**	**83**	**60**	**68**	**25**	**64**

	GST	**@18%**	**54**					
	Total		**354**					
Component E – Community Engagement Strategies								
S. No.	**Sub-components**	**Unit Cost (INR Crore)**	**Total Cost (INR Crore)**	**Panna Tiger Reserve**	**Other Protected Areas**	**Forest Division**	**District Administration**	**GPLC/IRLC**
1.	Water Security Measures	12	120	20	-	-	80	20
2.	Health Improvement Measures	5	50	-	-	-	50	-
3.	Education and Skill Development	5	50	-	-	-	20	30
4.	Waste Management	1	10	-	-	-	8	2
5.	Employment and Alternate Livelihood Options	25	250	-	-	-	200	50
6.	One Health Management	10	100	20	-	-	30	50
7.	Human Wildlife Conflict Management	12	120	40	20	30	20	10
	Sub-total		**700**	**80**	**20**	**30**	**408**	**162**
	GST	**@18%**	**126**					
	Total		**826**					
Component F - Integrated Landscape Management Strategies								
S. No.	**Sub-components**	**Unit Cost (INR Crore)**	**Total Cost (INR Crore)**	**Panna Tiger Reserve**	**Other Protected Areas**	**Forest Division**	**District Administration**	**GPLC/IRLC**
1.	Establishment and declaration of Interstate Tiger Reserve, Conservation Reserves, Community Reserves, Riverzone and Important Conservation Units including Satellite Cores, Steppingstones and Corridors	5	20	-	5	5	5	5
2.	Structural Interventions	0	0	-	-	-	-	-

3.	Restoration Programs based on One Village One Hectare Concept	10	100*	-	-	25	50	25
4.	Engagement of Biodiversity Monitoring Committee, Joint Forest Management Committee and Gaushala Coordination Committee	5	50	5	-	10	10	25
5.	Establishment of Green Economy Cooperatives and Growth Centre	3	30	-	-	10	10	10
6.	Establishment and functioning of Integrated Research and Learning Centre (IRLC)	30	150	5	-	-	25	120
7.	Integrated Landscape Management Council under the Special Purpose Vehicle, and Monitoring	5	50	-	-	-	-	50
8.	Research, monitoring, capacity building and feedback for adaptive management	10	100	5	5	5	5	80
	Sub-total		**500**	**15**	**10**	**55**	**105**	**315**
	GST	**@18%**	**90**					
	Total		**590**					
Sub-Total		**2700**						
GST		**486**						
Grand Total		**3186***						

* Total of 3186 crores for 10 years and year-wise break-up of the expenditure will be based on the activities listed above and subsequently by the Annual Plan of Operation as per implementation agency/organisation/individuals and as decided by the Greater Panna Landscape Council, based on performance indicators, approved by SPV. Where additional fund is required, funds transferred to the state by NWDA for CAMPA and EMP under KBLP should be used. Some interventions that fall within the jurisdiction of other line agencies such as construction of under and over passes coming under NHA and other concerned line agencies can be approached to allocate budget and in the future take measures accordingly.

As mentioned in the previous section, a separate bank account will be created under the Special Purpose Vehicle and the total fund would be placed in the dedicated account for implementation of ILMP.

Expected Fund Disbursal to Concerned Lead/Implementing Agencies/Arrangements (the fund includes admissible taxes)

S. No.	Activities/Interventions	Total Fund (INR Crore)	Panna Tiger Reserve (INR Crore)	Other Protected Areas (INR Crore)	Forest Division (INR Crore)	District Administration (INR Crore)	Greater Panna Landscape Council & IRLC (INR Crore)
1	Tiger Conservation Strategies	826	390.58	70.80	94.40	123.90	146.32
2	Vulture Conservation Strategies	354	20.06	18.88	67.26	107.38	140.42
3	Crocodilians Conservation Strategies	236	146.32	0	0	2.36	87.32
4	Biodiversity Conservation Strategies	354	97.94	70.80	80.24	29.50	75.52
5	Community Engagement Strategies	826	94.40	23.60	35.40	481.44	191.16
6	Integrated Landscape Management Strategies	590	17.70	11.80	64.90	123.90	371.70
	Total	**3186**	**767**	**195.88**	**342.20**	**868.48**	**1012.44**

10.6. Expected Quantitative Outcomes

Tiger Conservation

- Number of tiger reserves in the landscape to be increased: **03**
- Total area to be consolidated for tiger conservation: **7380 km^2** (which will be 60% of the forested area and 16% of the landscape area)
- Area occupied by tiger in PTR to be increased: **22%** (from current 41% to 63%)
- Tiger population size to be increased in GPL: **150-200**

Vulture Conservation

- Additional Important Vultures Sites to be protected: **04**
- Nesting and roosting sites to be protected: **106 km^2**
- Number of feeding sites to be protected: **129**
- Dedicated vulture rehabilitation centres to be established: **11**

Crocodile Conservation

- Protection of suitable area to be increased: **22.8 km^2**
- Number of Gharial sites to be increased: **03**
- Gharial reintroduction area to be increased: **2.12 km^2**
- Reduction hatchling mortality to be accomplished: **50%**
- Number of Gharial to be increased: **80**

Biodiversity Conservation

- Habitat restoration/management from weed-removal in PTR**: 390 km^2**
- Habitat restoration/management from weed-removal in GPL**: 3800 km^2**
- Experimental manipulation of habitat area from vacated villages: **60 km^2**
- Enhanced conservation in river zone: **258.51 km^2 area**
- High biodiversity area to be conserved: **15548 km^2 area**
- New Conservation Reserves to be established: **01**
- Number of Community Reserves to established: **02**

Community Engagement

- Number of villages to be focused: **500**
- Number of co-operatives/growth centres to set-up: **103**
- Number of model village tourism centres to be developed: **08**

Integrated Management

- Number of SDG goals to be addressed: **11**
- Number of technical and problem-solving facilities to be established: **03**
- Number of model research and learning centre to be established: **01**
- Number of capacity building units/centres to be addressed: **80**
- Total additional fund flow for the landscape: **3000 crores**

10.7. Monitoring Protocol

(1) Monitoring Protocol for Tiger Management Interventions

S. No.	Interventions	Indicators	Methods	Periodicity	Performance Score
1	Special Performance Unit (SPU)	-Area covered by SPU -Devotion of time in each beat -Interactions/ engagements with villagers -Critical situation handling/ rescue operation	-Routine patrolling and surveillance -Provide protection -Awareness in villagers -Intelligence gathering	Weekly - Monthly	
2	Continuous Camera-trap Monitoring System (CCMS)	-Area covered under CCMS -Monitoring of carnivores and herbivores -Monitoring of human and cattle movement	-Calculation of capture rate of wild animals -Encounter rate of human and cattle	Seasonal	
3	Crime Deduction and Alert System (CDAS)	-Area covered through camera trap and intelligence gathering -Identification of crime hotspot -Number of reported cases	-Analysis and report the crime pattern	Monthly	
4	Intelligence Network and Incentives	-Detection of early warning -Community engagement	-Assessment, report and necessary action	Monthly	
5	Unmanned Aerial System (UAV) for monitoring and supply of essentials	-Areas covered by UAV -Detection of fire -Detection and tracking of the animal during conflict situation	-Routine surveillance	Weekly	

6	Strengthening Staff Infrastructure and Logistics	-Availability of staff quarters -Condition of the established structure -Location of the camp (vantage point) -Health care facility for the staff -Staff welfare	-Assessment and report the condition of the quarter	Yearly	
7	Virtual Fence Network	-Area covered under virtual fence network -Detection of trespassers -Detection and tracking of animal movement	-Establishment of Wireless Sensor Network and Communication Tool (WSNCT) -Monitor human-wildlife interference	Weekly	
8	Social Fencing Network (SFN)	-Number of Ecodevelopment committee -Number of people coming under EDC -Area covered under SFN	-Impact assessment and report	Half-yearly	
9	Fine Scale Distribution Mapping and Monitoring	-Protection and management of the suitable area -Monitor the space use strategy of the animal and pattern analysis -Management intervention at unsuitable areas	-Monitoring the movement and space use of the animals through camera trap and radio-telemetry -Change detection/analysis	Yearly	
10	Spatially Explicit Population Estimation and Monitoring with Effect	-Population status -Population trends over the year	-Monitoring of the population through camera trap and radio-telemetry	Yearly	

	Size and Required Sample Size	-Monitoring the dispersal event and management	-Carrying capacity evaluation		
11	Demographic Management	-Population size and sex ratio -Age class -Immigration and emigration events -Translocation events (management intervention)	- Monitoring of the population through camera trap and radio-telemetry -Male-female ratio and age-pyramid calculation -Population viability analysis	Yearly	
12	Genetic Management	-Sex determination -Quantification of heterozygosity -Gene flow monitoring	- Scat/ blood collection	Five years interval	
13	Establishment of Controlled Population Management Facility	-Conflict management -Monitor and translocation of animal (health and behaviour) -Can be used as supplementary population during the genetic and demographic crisis	-Site inspection and establishment of the in-situ facility -Translocation of the target animal	As per requirement	
14	Transfer of Landownership of Compensatory Village Area	-Identification of target villages -Monitoring of relocated village sites	-Monitoring and evaluation of target sites - Habitat restoration	Once	
15	Transfer of Landownership of Revenue Areas and development of Conservation Reserve	-Identification of target sites -Monitoring of target sites	-Monitoring and evaluation of target sites - Habitat restoration	Once	

16	Restoration of Consolidated Village Areas	-Area demarcation -Monitor the succession rate	- Habitat restoration	Once	
17	Construction of Structural Connectivity across Ken River	-Frequency of movement of the animal -Movement of animals with seasonal variation	-Monitor through camera trap (yearly report)	Once	
18	Diversion of Road Traffic Volume, Strategic Fencing and Alert System	-Area covered under strategic fencing -Spatio-temporal movement of animal across/alongside the road -Affects of Anthropause in animal movement	--Monitor the movement of the animal through camera trap and radio-telemetry -Impact assessment and report	Once	
19	Retrofitting of Under Passes and Over Passes	-Current status of the sites -Impact of animals after the intervention	-Impact assessment and report	Once	
20	Recognition and declaration of important tiger habitats for satellite cores, stepping stones and corridors	-Identification of potential areas -Secure the movement of the animal through steppingstone and corridor -Monitor the home range and demography of the small population in satellite core	-Side identification through GIS-based approach -Monitor the animal movement through camera tarp, sign survey and radio-telemetry	Once	
21	Research, monitoring and capacity building towards adaptive management	-Ensure protection outside the PA	-Establishment and modification of monitoring protocol	Yearly	

		-Dedicated action and awareness by engaging local NGO, EDC and local community	-Evaluation of performance and report		

(2) Monitoring Protocol for Vulture Management Interventions

S. No.	Interventions	Indicators	Method	Periodicity	Performance Score
1	Establishment of Surveillance System	-No. of towers constructed and being used -Human presence reported monthly	Annual Progress Report & Site inspection	Each year	
2	Fencing of Carcass Dump Sites	-No. of dumping sites fenced -No. of feral dogs reported	Annual Progress Report & Site inspection	Each Year	
3	Deployment of Alert System	-No. of alert system deployed -No. of incidence alerted through the system	Annual Progress Report & Site inspection	Each Year	
4	Aerial Surveillance of Fire and Prevention	-Amount of hours drones deployed -Amount of area covered through drone surveillance in vulture sites	Annual Progress Report	Each Year	

5	Establishment of Network of Vulture Champions	-No. of people engaged as 'jatayu mitra' or 'vulture champion'	Annual Progress Report & Recruitment Report	Each Year	
6	Gaushala Coordination Committee	-Proportion of 'cattle' in the gaushala whose medical history has been maintained -No. of workshop held by 'GCC' and No. of 'gaushala' came under surveillance by 'GCC'	Annual Progress Report & Report of workshop held by 'GCC'	Each Year	
7	Robust Population Estimation and Monitoring	-Yearly population reported for each species separately -No. of vultures tagged with telemetry device	Annual Progress Report & Census Report	Each Year	
8	Demographic and Genetic Structure Profiling	-Reporting of genetic profiling of vultures in landscape	Annual Progress Report	Each Year	
9	Roosting Site and Nest-site Monitoring	-Time spent in nest monitoring	Annual Progress Report & Census Report	Each Year	
10	Biochemical Analyses and Monitoring	-No. of reporting of biochemical analysis	Annual Progress Report	Each Year	
11	Establishment of Vulture Rehabilitation Centres (VRC)	-No. of VRCs established and running	Annual Progress Report & Site inspection	Each Year	
12	Awareness and Engagement of People and Veterinary Professionals	-No. of veterinary personnel engaged -No. of workshop held	Annual Progress Report	Each Year	

13	Implementation of Flyway Action Plan	-No. of forest officials and related staff engaged during workshop of flyway action plan	Annual Progress Report and report of CMS	Each Year	
14	Disease Surveillance and Monitoring	-Incidence of zoonotic disease reported	Annual Progress Report	Each Year	
15	Augmentation of Nesting Tree Species	-No. of vulture nesting trees augmented -Area covered with augmentation of nesting tree species	Annual Progress Report & Site inspection	Each Year	
16	Management of Dumping Site/ Feeding Point	-No. of feeding points developed and managed	Annual Progress Report & Site inspection	Each Year	
17	Developing Community/ Conservation Reserve	-No. and area notified as community/ conservation reserve important for vulture nesting and roosting	Annual Progress Report and Site inspection	Each Year	
18	Vulture-based Tourism	-No. and proportion w.r.t total tourists in the vulture exclusive tourist zones	Annual Progress Report	Each Year	
19	Research, monitoring and capacity building towards adaptive management	-No. of research done -No. of monitoring protocol developed and implemented -No. of capacity building workshop held and people engaged	Annual Progress Report	Each Year	

(3) Monitoring Protocol for Gharial Management Interventions

S. No.	Intervention	Indicators	Methods	Periodicity	Performance Score
1	Protection of Crocodile Priority (CPZ) and Restricted Zones (CRZ)	- Establishing CPZ and CRZ - Patrolling of potential river stretches	- Routine patrolling - Intervention	Regularly	
2	Enforcement of Ban or Strategic Regulation on Fishing	-Establishment of regulations and implementation	- Routine patrolling - Intervention	Regularly	
3	Protection and Co-Management of River Habitats (Zonation of Riparian habitat)	-Establishing riparian conservation zones and river conservation zones	- Study of sites - Restoration and Management		
4	Deployment of Unmanned Aerial System for Security-based Monitoring	- Area monitored for anthropogenic activities in PA and CRZ - Tracking of conflict animals in such situations	- Regular surveillance for trespassing - Intervention	Weekly/ frequently	
5	Population Estimation and Monitoring	- Area surveyed and analysis of river stretch for crocodiles -Monitoring dispersal - Survey and analysis of population trend - Preparation of Annual Plan of Action (APO)	- Regular monitoring for population estimation, nesting and habitat quality. - Annual census by boats/ river walk survey for crocodiles	Frequently (Survey post-winter)	

6	Demographic and Genetic Management	- Sex ratio and age class of population - Dispersal records - Gene flow study	- Sampling and sexing of population - Estimation of sex ratio and age class - Hematological sampling	Five years interval	
7	Coordinated Gharial Recovery Program (re-introduction and *ex-situ*)	- Setting a planned reintroduction of Gharials - Soft release strategies - Establishment of *ex-situ* hatchery and management of population	-Preparation of DPR for reintroduction of Gharials -Coordinated release and monitoring of individuals -Inclusion of telemetry -Maintenance of *ex-situ* population and regular releases	Annually	
8	Crocodile Rehabilitation Centre (CRC)	-Establishment of rehabilitation centre -Capacity building	-Maintenance of the centre -Setup of Quick alert system -Monthly report of CRC	Regularly	
9	Management of Environment Flow and Sediments	- Follow-up of prescribed EFR - Regular updates of sediment flow from embankments - Monitoring water quality for aquatic animals	- Establishing flow monitoring stations -Regular monitoring - Biochemical tests	Regularly	
10	Prey Population Management	- Availability of fish prey, density and health - Monitoring of spawning grounds - Density evaluation of nuisance species	- Fish species sampling, population evaluation - Weight-length relationship - Virological screening/ haematological/toxicological study	Annually	

11	Management of Artificial Sandbanks	- Maintenance of suitable sand banks/bars -Augmentation of artificial sandbanks - Vegetation management	- Removal of threats/ barriers from the banks - Sand addition at suitable sites - Removal of problematic vegetation	Frequently (as required)	
12	Alternative Livelihood Opportunities	-Providing alternative opportunities and awareness -Engagement in conservation strategies	-Workshops regarding alternative livelihood opportunities -Awareness of schemes and programme	Annually	
13	Awareness, Training and Stakeholder Workshop	-Involving relevant stakeholders in implementation strategies	-Workshops for involvement - Training	Annually (as per requirement)	
14	Research, monitoring and capacity building towards adaptive management	- Proposals for research projects - Collaborative research - Capacity building of staff for implementation of projects	- Implementation of research projects - Regular assessment and international collaborations - Involvement of relevant departments and staff in implementation	Regularly	

(4) Monitoring Protocol for Biodiversity Management Interventions

S. No.	Interventions	Indicators	Method	Periodicity	Performance Score
1	Management of Lantana camara and Hyptis suaveolens (Van Tulsi) in PTR	-No. of restoration sites -Area of restoration sites -Extent of restoration sites -No. and type of manpower involved -Restoration success	-Site inspection -Recruitment report -Annual progress report	Each year	
2	Management of Lantana camara and Hyptis suaveolens (Van Tulsi) in the Landscape	-No. of restoration sites -Area of restoration sites -Extent of restoration sites -No. and type of manpower involved -Restoration success	-Site inspection -Recruitment report -Annual progress report	Each year	
3	Grassland management in PTR in Core and Buffer: augmentation and experimental design in relocated villages	-No. of restoration sites -Area of restoration sites -Extent of restoration sites -No. and type of manpower involved -Restoration success	-Site inspection -Recruitment report -Annual progress report	Each year	
4	Management and augmentation of existing ponds/water bodies	-No. of restoration sites -Area of restoration sites	-Site inspection -Recruitment report		

		-No. and type of manpower involved -Restoration success	-Annual progress report		
5	Augmentation/restoration of riparian habitat based on Riparian Vegetation Index (RVI) inside PTR	-No. of restoration sites -Area of restoration sites -No. and type of manpower involved -Restoration success	-Site inspection -Recruitment report -Annual progress report	Each year	
6	Establishment of Riparian Conservation Zone/ Community Reserve	-Type of restoration intervention in Zone 1 -No. of restoration sites in Zone 1 -Area of restoration sites in Zone 1 -No. and type of manpower involved -Restoration success -No. of communities engaged in Zone 2 -No. and type of social estasblishment in zone 2 -Success of social establishment	-Site inspection -Recruitment report -Annual progress report -Site inspection	Each year	
7	Conservation measures for vegetation species: Assisted Natural Regeneration (ANR) of tree species, conservation	-No. of survey and sample size -Area of survey	-Annual progress report -Site inspection -Procurement report		

	measures for SCS (Species of Conservation Significance)	-No. and type of conservation inputs -No. and type of infrastructure developed -No. and type of material (desk,field,lab) procured -No. and type of manpower involved	-Recruitment report	Each year	
8	Conservation measures for mammal species: conservation measures for SCS (endangered, indicator species)	-No. of survey and sample size -Area of survey -No. and type of conservation inputs -No. and type of infrastructure developed -No. and type of material (desk,field,lab) procured -No. and type of manpower involved	-Annual progress report -Site inspection -Procurement report -Recruitment report	Each year	
9	Conservation measures for bird species: conservation measures for SCS (woodland, grassland, water and migratory birds)	-No. of survey and sample size -Area of survey -No. and type of conservation inputs -No. and type of infrastructure developed	-Annual progress report -Site inspection -Procurement report -Recruitment report	Each year	

		-No. and type of material (desk,field,lab) procured -No. and type of manpower involved			
10	Conservation measures for herpetofauna species: conservation measures for SCS, creation of Micro-habitats	-No. of survey and sample size -Area of survey -No. and type of conservation inputs -No. and type of infrastructure developed -No. and type of material (desk,field,lab) procured -No. and type of microhabitats developed -No. and type of manpower involved	-Annual progress report -Site inspection -Procurement report -Recruitment report -Site inspection	Each year	
11	Spatial delineation of freshwater fish safe zone	-No. of sites surveyed -No. of suitable sites established -No. and type of manpower involved	-Annual progress report -Site inspection -Recruitment report	Each year	
12	Conservation awareness and species recovery plan for Mahseer	-No. of survey and sample size -Area of survey -No. and type of conservation inputs	-Annual progress report -Site inspection -Procurement report -Recruitment report		

		-No. and type of infrastructure developed -No. and type of material (desk,field,lab) procured -No. and type of manpower involved		Each year	
13	Research, monitoring and capacity building towards adaptive management	-No. of research done -No. of monitoring protocols developed -No. of capacity building workshops done -No. of people engaged	-Annual progress report	Each year	

(5) Monitoring Protocol for Community Engagement Interventions

S. No.	Interventions	Indicators	Methods	Periodicity	Performance Score
1	Water Security Measures	-Number of villages that have benefited from the water management activities listed in the plan. -Increase in amount of water availability for irrigation and drinking -Increase in number of functional water sources in each village. Increase in irrigation area in a district.	Village site inspection for condition of infrastructure, identifying water resources, measuring surface and ground water flow to identify water yield of an area, GIS based modules to map irrigation and non-irrigated areas	Every year	

2	Health Improvement Measures	-Mortality and burden of disease estimates for communicable and non-communicable diseases -Child health indicators: Incidence/prevalence of stunting, wasting, overweight and underweight in children -Health accessibility and availability indicators including public health services usage and ambulance availability and usage (especially for pregnant woment) -Mental health indicators including health related quality of life	Population based household surveys, health facility and healthcare worker based surveys, health system characteristic surveys, usage of appropriate Health Related Quality of Life (HRQoL) survey instruments measuring both physical and mental dimensions (including stigma)	Year round	
3	Education and Skill Development	-Changes in school dropouts -Changes in literacy rate -Number of schools and students brought under training programs	Household and school surveys prioritizing education, curriculum and age wise literacy	Every two years	
4	Waste management	-Number of villages covered under waste management programs -Number of locals involved in garbage segregation -Number of garbage collectors employed	Household surveys on segregated waste, recycling, composting. Interviews with garbage collectors and site inspection of landfills.	Every three months	
5	Employment opportunities	-Number of villages under green skill-based trainings -Reduction in migration rate	-Household surveys and participatory observation at village infrastructure, cooperatives, BMCs and EDCs.	Every year	

		-Number of meetings and projects initiated and completed by EDCs -Changes in land use land cover (increase in forest cover through plantations/silvi-pasture/social forestry/agro-forestry, cropping pattern) -Increase in community knowledge about local biodiversity -Number of BMCs established and registers maintained -Number of carbon neutral villages -Per capita income and financial turnover rate through novel livelihood opportunities including cooperatives and eco-tourism	Interviews with women, children, forest department and tribal communities. -GIS based modules to map land use land cover.	Every three years	
6	One Health Management	-Changes in incidence/ prevalence of priority zoonotic, epizootic diseases and non-communicable diseases of public health concern, and their actual disease burden. -Number of joint intersectoral risk assessments conducted for priority diseases	Disease burden estimations and intersectoral health surveys, supplemented with participatory epidemiology techniques for prioritization	Every year	

		-Number of multi-sectoral surveillance investigations conducted and time taken to identify, diagnose and manage an outbreak -Number of personnel (by department) who have been trained in surveillance	Health impact assessments and surveillance impact assessments in various sectors. Measures of health/ disease burden that were averted through coordinated surveillance and response	Every year	
		-Number of review meetings held, activities and operations executed and inter-sectoral representation in the One-Health Committee	Independent internal and external assessments, health system performance assessments	Year round	
		-Awareness and practices in communities to prevent and tackle zoonotic/ epizootic disease threats -Number of 'health facilitators/mobilizers' identified and trained	Household surveys assessing Knowledge, Attitude and Practices (KAP) regarding prioritized diseases, and animal/public health threats	Every year	
7	Human Wildlife Conflict Management	-Incidence of tiger attacks on human and livestock -Tiger mortality due to poaching/retaliatory killing	Monitoring movement of tigers dispersing from PTR using radio-telemetry and camera traps and providing protection to individuals in human-dominated landscape.	Year round	
		-Incidence of carnivore attacks on human and livestock	Human attack/Livestock kill site inspection and recording of pugmark, drag and scrape signs/ victim's statement, GPS location and microhabitat features for species wise hotspot identification	Year round	

		-Presence of livestock in diet	Food habit analyses of carnivore scat to understand livestock dependency	Twice each year	
		-Incidence of crop loss and human attacks	Farm/Crop raiding site inspection and recording of victim statement, GPS location and microhabitat features for species wise hotspot identification and understanding of seasonality and specific crop dependence.	Year round	
		-Total area covered under bio, solar & wall fencing. -Number of Conflict Task Force/Rapid Response Team setup. -Number of Capture and Translocation of Carnivores & Herbivores carried out. -Number of Rescue and Rehabilitation Facility setup.	Progress Report	Annual	

(6) Monitoring Protocol for Integrated Landscape Management Interventions

S. No.	Intervention	Indicators	Methods	Periodicity	Performance Score
1	Establishment and declaration of Interstate Tiger Reserve, Conservation Reserves, Community Reserves, Riverzone and Important Conservation Units including Satellite Cores, Steppingstones and Corridors	Number/Status of notification declaring tiger reserve, conservation and community reserve	Gazette Notification & Progress Report	One Time	

2	Structural Interventions	Number of structural interventions created	Progress Report	One Time	
3	Restoration Programs based on One Village and One Hectare Concept	Number of villages identified and brought under the One Village One Hectare Scheme	Annual Progress Report	Year Round	
4	Engagement of Biodiversity Monitoring Committee, Joint Forest Management Committee and Gaushala Coordination Committee	Number of awareness workshops conducted	Annual Progress Report	Year Round	
5	Establishment of Green Economy Cooperatives and Growth Centre	-Number of Cooperatives and Growth Centre set up. -Total turnover of cooperatives.	Annual Progress Report	Year Round	
6	Establishment and functioning of Integrated Research and Learning Centre (IRLC)	-Identification of site for setting up of IRLC. -Status of setting up of IRLC and institutional framework. -Number of research proposals reviewed, and approved & number of capacity building training workshops conducted.	Annual Progress Report	Year Round	
7	Integrated Landscape Management Council under the Special Purpose Vehicle, and Monitoring	Status of setting up of Integrated Landscape Management Council	Annual Progress Report	Year Round	
8	Integrated research, monitoring, capacity building and feedback for adaptive management	Number of research initiated, and completed & number of capacity building training workshops conducted.	Annual Progress Report	Year Round	

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Appendices

Appendix 3.1: List of participants during the meeting held on 22nd September 2018 on 'Operational issues related to development of Landscape Management Plan and Monitoring with Reference to Ken-Betwa River Link Project in Panna Tiger Reserve, Madhya Pradesh' at Wildlife Institute of India, Dehradun

S. No.	Name	Designation
1	Mr. Pawan Kumar	PCCF (WL), Uttar Pradesh Forest Department
2	Mr. Kaushlendra Singh	CWLW, Uttar Pradesh Forest Department
3	Dr. Deleep Kumar	APCCF (WL), Madhya Pradesh Forest Department
4	Dr. V. B. Mathur	Director, Wildlife Institute of India
5	Dr. Amit Mallick	IG, National Tiger Conservation Authority
6	Mr. K. S. Bhadauria	Field Director, Panna Tiger Reserve
7	Mr. Amarshri Nayak	Consultant, National Water Development Agency
8	Mr. H. K. Pandey	Executive Engineer, National Water Development Agency
9	Dr. R. G. Soni	Consultant, National Water Development Agency
10	Dr. S. F. Wesley	Green Future Foundation
11	Dr. Justus Joshua	Director, Green Future Foundation
12	Mr. P. C. Tyagi	Senior Fellow, Wildlife Institute of India
13	Dr. H. S. Pabla	Chairman TRAC, Wildlife Institute of India
14	Mr. V. B. Sawarkar	Former Director, Wildlife Institute of India
15	Mr. Alok Saxena	Senior Fellow, Wildlife Institute of India
16	Dr. K. Ramesh	Scientist E and Principal Investigator of the project, Wildlife Institute of India
17	Dr. J. A. Johnson	Scientist E, Wildlife Institute of India
18	Dr. Abhijit Das	Scientist D, Wildlife Institute of India
19	Dr. Satyam Verma	Project Scientist, Wildlife Institute of India
20	Dr. H. S. Mogalekar	Project Scientist, Wildlife Institute of India
21	Mr. Ajay Singh	Project Fellow, Wildlife Institute of India
22	Ms. Nazrukh Sherwani	Project Fellow, Wildlife Institute of India
23	Ms. Priyanka Das	Project Fellow, Wildlife Institute of India
24	Ms. Kamana Pokhariya	Project Fellow, Wildlife Institute of India
25	Mr. Amit Kaushik	Project Fellow, Wildlife Institute of India
26	Mr. Dibyendu Biswas	Project Fellow, Wildlife Institute of India
27	Mr. Supratim Dutta	Project Fellow, Wildlife Institute of India
28	Mr. Babu Lakhan	Project Fellow, Wildlife Institute of India
29	Ms. Deepti Gupta	Ph.D Scholar, Wildlife Institute of India
30	Mr. Rahul Gandhi	Project Manager, Wildlife Institute of India
31	Ms. Priyanka Kumari	Technical Assistant, Wildlife Institute of India

Appendix 3.2: List of participants at Range-level Stakeholder Workshop held from 03rd January 2020 – 15th January 2020 at Panna Tiger Reserve

Forest Department		
S. No.	**Name**	**Designation**
1	Mr. K. S. Bhadoriya	Field Director
2	Mr. H. C. Chauhan	Range Officer
3	Mr. B. R. Bhagat	Range Officer
4	Mr. L. B. Tiwari	Range Officer
5	Mr. Manoj Singh Bagel	Range Officer
6	Mr. Ram Atar Panday	Range Officer
7	Mr. R. S. Nargesh	Range Officer
8	Mr. Ramji Sharma	Range Officer
9	Mr. Amar Singh	Range Officer
10	Mr. M. M	Range Officer
11	Mr. V. K. Gautam	Range Officer
12	Mr. Ram Bhuvan Mishra	Deputy Ranger
13	Mr. Ram Kishor	Deputy Ranger
14	Mr. Rampati Saket	Deputy Ranger
15	Mr. S. Kumar	Deputy Ranger
16	Mr. Ram Prasad Prajapati	Deputy Ranger
17	Mr. R. A Sriwastrav	Deputy Ranger
18	Mr. Nanesh K. Panday	Deputy Ranger
19	Mr. Kopchand Maravi	Deputy Ranger
20	Mr. M. L. Chaurasia	Deputy Ranger
21	Mr. Ram Sevak	Deputy Ranger
22	Mr. Hari Singh	Deputy Ranger
23	Mr. Munna Lal Varma	Deputy Ranger
24	Mr. Santosh Panday	Deputy Ranger
25	Mr. G.S. Yadav	Deputy Ranger
26	Ms. Rani Prasad Rawat	Range Assistant
27	Mr. Surendra Siwastrav	Range Assistant
28	Mr. Rameshre Aherwal	Range Assistant
29	Mr. Babu Singh Chandel	Range Assistant
30	Mr. Moradhwaj	Forester
31	Mr. Asharam Srivas	Forester
32	Mr. Ram Chandra Gupta	Forester
33	Mr. Mahindra Singh Gosh	Forester
34	Mr. Vindevan Ramdev	Forester
35	Mr. Nanne Singh	Forester
36	Mr. Chandra Prakesh Piyasi	Forester
37	Mr. Satishchandra Ahirwal	Forester
38	Mr. Santhosh Kumar Khol	Forester

39	Ms. Madhuri Prajapati	Forest Guard
40	Mr. Ram Gopal Choudhary	Forest Guard
41	Mr. C. Sahu	Forest Guard
42	Mr. Tulsidas Varman	Forest Guard
43	Mr. Raj Kumar Gupta	Forest Guard
44	Mr. Rajesh Gupta	Forest Guard
45	Mr. Santosh Prajapati	Forest Guard
46	Ms. Uma Patel	Forest Guard
47	Mr. Indra Pal Singh Ahirwar	Forest Guard
48	Mr. Daya Ram Ahirwar	Forest Guard
49	Mr. Rajkumar Ahirwar	Forest Guard
50	Mr. Ram Gupta	Forest Guard
51	Mr. Bhupat Singh Ragawat	Forest Guard
52	Mr. Rajesh Kumar	Forest Guard
53	Mr. Chand Prakash	Forest Guard
54	Mr. Vadish Sharma Mishra	Forest Guard
55	Mr. Puspendra Kumar Namdev	Forest Guard
56	Mr. Ram Shvapal	Forest Guard
57	Mr. Hemnandan Singh Bhagel	Forest Guard
58	Mr. Ramakanth Tripathi	Forest Guard
59	Mr. Verendra Singh	Forest Guard
60	Mr. Arvind Raikwar	Forest Guard
61	Mr. Divakar Singh	Forest Guard
62	Mr. Dilip Singh	Forest Guard
63	Mr. Ram Patel	Forest Guard
64	Mr. Veer Bhadra Singh	Forest Guard
65	Mr. Ramuprasad Airhwal	Forest Guard
66	Mr. Chote Baijha	Forest Guard
67	Ms. Komal Singh	Forest Guard
68	Mr. Ramnaresh Singh Rajput	Forest Guard
69	Mr. Dasraj Singh	Forest Guard
70	Mr. Nehelal Bija	Forest Guard
71	Mr. Doli Ram Jatar	Forest Guard
72	Mr. Punit Kumar Tiwari	Forest Guard
73	Mr. Rajesh Panday	Forest Guard
74	Mr. Akhilesh Mishra	Forest Guard
75	Mr. Bhupat Prasad Kori	Forest Guard
76	Mr. Indrajeet Singh Lodhi	Forest Guard
77	Mr. Ramcharan Charamkar	Forest Guard
78	Mr. Om Prakash Konele	Forest Guard
79	Mr. Mahen Pratap Singh	Forest Guard
80	Mr. Rajendra Kumar Ahirwal	Forest Guard

81	Mr. Rajesh Kumar Panday	Forest Guard
82	Mr. Sanjay Kumar	Forest Guard
83	Mr. Brahm Prakash	Forest Guard
84	Mr. Brij Mohan Sahai	Forest Guard
85	Mr. Omesh Kumar Yadav	Forest Guard
86	Mr. Vupesh Siwastrav	Forest Guard
87	Mr. Guru Prasad Prajapati	Forest Guard
88	Mr. Amit Kumar Lodhi	Forest Guard
89	Mr. Ravindra Singh Yadav	Forest Guard
90	Mr. Sunil Pathak	Forest Guard
91	Mr. Chandra Pal Prajapati	Forest Guard
92	Mr. Anoop Kumar	Forest Guard
93	Mr. Mukesh Kumar Rawat	Forest Guard
94	Mr. Nitish Singh	Forest Guard
95	Mr. Pradeep Kumar	Forest Guard
96	Mr. Subham Singh	Forest Guard
97	Mr. Pushpendra Singh	Forest Guard
98	Mr. Ramdhar Dhayal	Forest Guard
99	Ms. Komod Singh	Forest Guard
100	Mr. Dhirendra Prajapati	Forest Guard
101	Mr. Dhirendra Singh	Forest Guard
102	Mr. Jitendra Singh Kumar	Forest Guard
103	Mr. Gauri Sankar Yadav	Forest Guard
104	Mr. Ram Naresh Panday	Forest Guard
105	Mr. Manoj Kumar Mahobia	Forest Guard
106	Mr. Ram Khilawan Barman	Forest Guard
107	Mr. Jitendra Singh	Forest Guard
108	Mr. Krishna K. Valmik	Forest Guard
109	Mr. Chandranbhan Thakur	Forest Guard
110	Mr. Sanjay Singh Solani	Forest Guard
111	Mr. Chandra Prakash Bhaat	Forest Guard
112	Mr. Rohit Gupta	Forest Guard
113	Mr. Prayanch Gupta	Forest Guard
114	Mr. Sunil Dirran	Forest Guard
115	Mr. Ram Gopal Ahirwal	Forest Guard
116	Mr. Satish Kumar	Forest Guard
117	Mr. Mohint Kumar Rawat	Forest Guard
118	Mr. Prahelash Bundela	Forest Guard
119	Mr. Kehlash Ahirwal	Forest Guard
120	Mr. Rai Singh	Forest Guard
121	Mr. Bakdraiya Prasad Chauthari	Forest Guard
122	Mr. C. Lal Jatav	Forest Guard

123	Mr. Ramji Dangi	Forest Guard
124	Mr. Ram Gopal Ahirwar	Forest Guard
125	Mr. Sunil Diwan	Forest Guard
126	Mr. Komal Kishor	Forest Guard
127	Mr. Mohsin Khan	Forest Guard
128	Mr. Dev Prasad Tiwari	Forest Guard
129	Mr. Harri Kishan Gujjar	Forest Guard
130	Mr. Ayodhya Prasad	Forest Guard
131	Mr. Grijeshwar Prasad Kondra	Forest Guard
132	Mr. Akhilesh Saksena	Forest Guard
133	Ms. Vina Nayak	Forest Guard
134	Mr. Nand Kishor Sharma	Forest Guard
135	Mr. Surendra Kumar Tiwari	Forest Guard
136	Mr. Munna Lal	Forest Guard
137	Mr. Puran Lal Kushwaha	Forest Guard
138	Mr. Amit D.	Forest Guard
139	Mr. Veeresh Katik	Forest Guard
140	Mr. HarPal Sour	Forest Guard
141	Mr. Manoj Kumar Bega	Forest Guard
142	Mr. Anand Singh Tomar	Forest Guard
143	Mr. Suresh Prasad Garg	Forest Guard
144	Mr. Devendra Mishra	Forest Guard
145	Mr. Ashok Kumar Raikawad	Forest Guard
146	Mr. Jitendra Kumar Patel	Forest Guard
147	Mr. Sachin Tiwari	Forest Guard
148	Mr. Rishi Pateriya	Forest Guard
149	Mr. Ram Pal Prajapati	Forest Guard
150	Mr. Sudhakar Panday	Forest Guard
151	Mr. Dinesh C. B	Forest Guard
152	Mr. Anil Patel	Forest Guard
153	Mr. Rupkumar Aherwal	Forest Guard
154	Mr. Santal Prajapati	Forest Guard
155	Mr. Santosh Kumar Sen	Forest Guard
156	Ms. Lalit Savita	Forest Guard
157	Mr. Abdul Qureshi	Forest Guard
158	Mr. Jiten Kumar Siwastrav	Forest Guard
159	Mr. Bhagchoran Rajok	Forest Guard
160	Mr. Ashok Kumar	Forest Guard
161	Mr. Bhakkal Ram	Regular Field Staff
162	Mr. Ram Kishor Rai	Regular Field Staff
163	Mr. Dhuram Yadav	Regular Field Staff
164	Mr. Jahar Singh Bundela	Regular Field Staff

165	Mr. Kamal SinghYadav	Regular Field Staff
166	Mr. Lalu Kewat	Regular Field Staff
167	Mr. Bandu Ram Adivasi	Regular Field Staff
168	Mr. Sarada Prasad Yadav	Regular Field Staff
169	Mr. Hakim Singh Rajput	Regular Field Staff
170	Mr. Chand Kahen	Regular Field Staff
171	Mr. Swarna Singh	Regular Field Staff
172	Mr. Kamal Pratap Aherwal	Regular Field Staff
173	Mr. Ramdhin Yadav	Regular Field Staff
174	Mr. Govind Sorvan Pal	Special Duty Staff
175	Mr. Rajendra Kumar	Contractual Field Staff
176	Mr. Loknath Gond	Contractual Field Staff
177	Mr. Ram Besal	Contractual Field Staff
178	Mr. Sumer Singh Gond	Contractual Field Staff
179	Mr. Jai Khan	Contractual Field Staff
180	Mr. Aaram	Contractual Field Staff
181	Mr. Bhagvan Das	Contractual Field Staff
182	Mr. Shiv	Contractual Field Staff
183	Mr. Vikram Singh Yadav	Contractual Field Staff
184	Mr. Arjun Patel	Contractual Field Staff
185	Mr. Sai Ram Yadav	Contractual Field Staff
186	Mr. Mannu Yadav	Contractual Field Staff
187	Mr. Vikram Singh	Contractual Field Staff
188	Mr. Guman Singh	Contractual Field Staff
189	Mr. Radha Charan	Contractual Field Staff
190	Mr. Nanda Adivasi	Contractual Field Staff
191	Mr. Umeshkhor Yadav	Contractual Field Staff
192	Mr. S. Prasad Yadav	Contractual Field Staff
193	Mr. Bablu Barman	Contractual Field Staff
194	Mr. Ganesh Yadav	Contractual Field Staff
195	Mr. Rangilal	Contractual Field Staff
196	Mr. Lakhan Singh Gond	Contractual Field Staff
197	Mr. Rampal Kushwaha	Contractual Field Staff
198	Mr. Pushagwa	Contractual Field Staff
199	Mr. V. Patel	Contractual Field Staff
200	Mr. Badri Raj Barman	Contractual Field Staff
201	Mr. Hakka Dhimar	Contractual Field Staff
202	Mr. Meera Adivasi	Contractual Field Staff
203	Mr. Lakhan Adhivasi	Contractual Field Staff
204	Mr. Jeevan Singh	Contractual Field Staff
205	Mr. Ranvar Singh	Contractual Field Staff
206	Mr. Ramesh Prasad Panday	Contractual Field Staff

207	Mr. Naresh Adivasi	Contractual Field Staff
208	Mr. Ayodhyo Adivasi	Contractual Field Staff
209	Mr. Anan	Contractual Field Staff
210	Mr. Ram Singh Parmar	Contractual Field Staff
211	Mr. R. Panday	Contractual Field Staff
212	Mr. S. Prasad Adivasi	Contractual Field Staff
213	Mr. Laxman Singh Parmar	Contractual Field Staff
214	Mr. A. Lal Adivasi	Contractual Field Staff
215	Mr. Chalur Singh	Contractual Field Staff
216	Mr. Gyadin Gore	Contractual Field Staff
217	Mr. Munni Lal Adivasi	Contractual Field Staff
218	Mr. Banjor Singh Yadav	Contractual Field Staff
219	Mr. Prithvi Gond	Contractual Field Staff
220	Mr. Rajesh Yadav	Contractual Field Staff
221	Mr. Ram Pal	Contractual Field Staff
222	Mr. Santosh Kumar Pathak	Contractual Field Staff
223	Mr. Shik Kumar Omi	Contractual Field Staff
224	Mr. Chandra Pal Raikowad	Contractual Field Staff
225	Mr. Jagadish Singh	Contractual Field Staff
226	Mr. Chandilal Raikawad	Contractual Field Staff
227	Mr. Hari Yadav	Contractual Field Staff
228	Mr. Dhal Chand	Contractual Field Staff
229	Mr. Lakhan Yadav	Contractual Field Staff
230	Mr. Ghan Sham	Contractual Field Staff
231	Mr. Bahadur Singh	Contractual Field Staff
232	Mr. Suresh Yadav	Contractual Field Staff
233	Mr. Ram Prakash Avasti	Contractual Field Staff
234	Mr. Lakhan Raikwar	Contractual Field Staff
235	Mr. Shiv Singh Yadav	Contractual Field Staff
236	Mr. Chandra Singh	Contractual Field Staff
237	Mr. Kabel Singh	Contractual Field Staff
238	Mr. Govind Singh	Contractual Field Staff
239	Mr. Rajesh Tiwari	Contractual Field Staff
240	Mr. Daven Singh	Contractual Field Staff
241	Mr. Rajendra Singh	Contractual Field Staff
242	Mr. Govind	Contractual Field Staff
243	Mr. Bhupat Yadav	Contractual Field Staff
244	Mr. Amar Singh Yadav	Contractual Field Staff
245	Mr. Sairam Yadav	Contractual Field Staff
246	Mr. Dassu Kuswaha	Contractual Field Staff
247	Mr. Marin Sigh Parmar	Contractual Field Staff
248	Mr. Krishan Murari Khadi	Contractual Protection Staff

249	Mr. Guman	Contractual Protection Staff
250	Mr. Ram Sang Paul	Contractual Protection Staff
251	Mr. Hempal Singh	Contractual Protection Staff
252	Mr. Lakhan Paul	Contractual Protection Staff
253	Mr. Betu Pal	Contractual Protection Staff
254	Mr. Ram Singh Vishakarma	Contractual Protection Staff
255	Mr. Pream Nrayan	Contractual Protection Staff
256	Mr. Laxman Yadav	Contractual Protection Staff
257	Mr. Rajjan Yadav	Contractual Protection Staff
258	Mr. Mangal Singh Yadav	Camp Guard
259	Mr. Annant Singh	Camp Guard
260	Ms. Anandi	Camp Guard
261	Mr. Santhu Gour	Camp Guard
262	Mr. Arvind Aherwal	Computer Operator
263	Mr. Vinod Mishra	Wireless Operator
264	Mr. Mulayam Sigh	Wireless Operator
265	Mr. Laxmiprasad Barman	Driver
266	Mr. Mohan Singh Yadav	Driver
267	Mr. Srisingh Yadav	Driver
268	Mr. Brijlal Patel	Driver
269	Mr. Dhrendra Singh Yadav	Driver
Village Representatives		
S. No.	**Name**	**Designation**
1	Mr. S. H. Sujan	Village/Panchayat President
2	Mr. Rup Narayan Singh	Village/Panchayat President
3	Mr. Nattu Singh	Village/Panchayat President
4	Mr. Pratap Viswas	Village/Panchayat President
5	Mr. Raja ram	Village/Panchayat President
6	Mr. Vinod Kumar	Village/Panchayat President
7	Mr. Pritam Aherwal	Village/Panchayat President
8	Mr. Manendra Rai	Village/Panchayat President
9	Mr. Sakku Ahiwal	Village/Panchayat President
10	Ms. Badi Bahu	Village/Panchayat President
11	Ms. Goni Bai	Village/Panchayat President
12	Mr. Mani Ram Aherwal	Village/Panchayat President
13	Mr. Muluna Ahirwal	Village/Panchayat President
14	Mr. Ramesh Prasad Yadav	Village/Panchayat President
15	Mr. Ashok Yadav	Village/Panchayat President
16	Mr. Uma Mishra	Village/Panchayat President
17	Mr. Uday Shankar	Village/Panchayat President
18	Mr. Deven Tripathi	Village/Panchayat President
19	Mr. Amal Singh	Village/Panchayat President

20	Ms. Maya Rani	Village/Panchayat President
21	Mr. Khemi Banjara	Village/Panchayat President
22	Mr. Sebak Yadav	Village/Panchayat President
23	Ms. Sanjili Bahu	Village/Panchayat President
24	Mr. Ram Moti Tiwari	Village/Panchayat President
25	Mr. Mahesh Prasad	Ecodevelopment Committee (EDC) Representative
26	Mr. Soni Lal	EDC President
27	Mr. Ram Kripapal	EDC President
28	Mr. Kallu Yadav	EDC President
29	Mr. Sobi Lal	EDC President
30	Mr. Balveer Singh	EDC President
31	Mr. Girja Prasad	EDC President
32	Mr. Rakesh Tiwari	EDC President
33	Mr. Nonelal Yadav	EDC President
34	Mr. Ram Prasad	EDC President
35	Mr. Surendra Lal P	EDC President
36	Mr. Parsilal Tiwar	EDC President
37	Mr. Ram Milan Tune	EDC President
38	Ms. Bhumani Bai	EDC President
39	Mr. Shyamra	EDC President
40	Ms. Sumira Adivasi	EDC President
41	Mr. Gulab Kushwaha	EDC President
42	Ms. Gyashi Kushwaha	EDC President
43	Mr. Ratn Singh Yadav	EDC President
44	Mr. Bharat Singh	EDC President
45	Mr. Sukhai	EDC President
46	Ms. Kamla	EDC President
47	Mr. Mithai Lal	EDC President
48	Mr. Rajhi Pal	EDC President
49	Mr. Dhirendra Singh	EDC President
50	Mr. Gajraj Singh	EDC President
51	Mr. Raghunandan Prasad Yadav	EDC President
52	Ms. Bharat	EDC President
53	Mr. Halkay	EDC President
54	Mr. Uttilal	EDC President
55	Mr. Fulniya	EDC President
56	Mr. Dasarat Singh Yadav	EDC President
57	Mr. NishPal	EDC President
58	Mr. Jagan Singh Patel	EDC President
59	Mr. Pritam Singh	EDC President
60	Mr. Ganesh Singh	EDC President
61	Mr. Pream Lal yadav	EDC President

62	Mr. Rakesh Ahirwal	EDC President
63	Mr. Ram Adivasi	EDC President
64	Mr. Bishanath	EDC President
65	Mr. Bhayia Lal	EDC President
66	Ms. Kiran Sharma	EDC President
67	Mr. Mihilal	EDC President
68	Mr. Swami Prasad	EDC President
69	Mr. Matadin Kosuha	EDC President
70	Mr. Kailash Sahoo	EDC Secretary
71	Mr. Monu Gupta	EDC Secretary
72	Mr. Sheikh Ansan	EDC Secretary
73	Mr. Ashabani	EDC Secretary
74	Mr. Iman Khan	EDC Secretary
75	Mr. Puspen Panday	EDC Secretary
76	Mr. Garib Das	EDC Secretary
77	Mr. Ram Chndra Sahu	Buffer Deputy Secretary
78	Mr. Malkhan Singh Yadav	FRC President
79	Mr. Parsu	FRC President
80	Mr. Bhagwat	FRC President
81	Mr. Dadu Ram	FRC President
82	Mr. Basant Lal Adhivasi	FRC President
83	Mr. Deven Singh	FRC Secretary
84	Mr. Rajan Singh	VEDC President
85	Mr. Bharat Pratap Singh Yadav	VEDC President
86	Ms. Sona Bai	VFC Chairman
87	Ms. Simla	Vice President of EDC
88	Mr. Kamla Kanth	EDC Deputy President
89	Mr. Jait Singh	EDC Deputy President
90	Mr. Nandlal	EDC Deputy Secretary
91	Mr. Santosh Yadav	Deputy Village/Panchayat President
92	Mr. Naval Singh	Deputy Secretary
93	Ms. Sahag Rani	EDC Member
94	Ms. Sadarani	EDC Member
95	Mr. Ratan Gaur	EDC Member
96	Mr. Neeraj	EDC Member
97	Ms. Tijibai	EDC Member
98	Mr. Rajesh Kumar	EDC Member
99	Mr. Kanipal	EDC Representative
100	Mr. Bade Mannu Yadav	Ex-Village/Panchayat President
101	Mr. Sita Ram Rai	Ex- Village/Panchayat President

102	Mr. Ramesh Prasad Billa	Ex- Village/Panchayat President
103	Mr. Rati Ram Yadav	Ex- Village/Panchayat President
104	Ms. Rekha Konar	Aganwadi Kariya Karta
105	Ms. Mamta Bhatnagar	VEDC Mahila Adhyakash
106	Mr. Hukum Singh	Village Ecodevelopment Committee (VEDC) Chairman
107	Mr. Nonilal	President Aganwadi
108	Mr. Prakash. R	President Aganwadi
109	Mr. Mangal Singh Lodhi	Gram Panchayat Secretary
110	Ms. Asha Rani	Mahila Samiti Adhyakash
111	Mr. Ramnath Adivasi	Panchayat Member
112	Mr. Nannu Aherwal	Panchayat Member
113	Mr. Swami Prasad	Panchayat representative
114	Mr. Jairaj Singh Parihar	Panchayat Ward Member
115	Mr. Sushil Kumar Roy	Ret. Head Constable
116	Mr. Hanuman Singh Yadav	Assistant Secretary
117	Mr. Mohit Yadav	Assistant Secretary
118	Mr. Jitendra Singh Parihar	Secretary
119	Mr. Ram Kishan	Secretary
120	Mr. Murat Singh Yadav	School Adhyakash
121	Mr. Ganesh Gupta	SDE
122	Ms. Prem Rani	Community Representative
123	Mr. Sanjeet Kumar Roy	Community Representative
124	Mr. Gopal Yadav	Community Representative
125	Mr. Rajendra Singh Rajgond	Community Representative
126	Mr. Pran Singh Yadav	Community Representative
127	Mr. Lal Bahadoor Yadav	Community Representative
128	Ms. Uma Bai	Community Representative
129	Ms. Ushama Bai	Community Representative
130	Mr. Jahar	Community Representative
131	Mr. Bharat Singh	Community Representative
132	Mr. Kelash Agarwal	Community Representative
133	Mr. Bal Dev Singh	Community Representative
134	Mr. Ram Kishor	Community Representative
135	Ms. Tesri Bai	Community Representative
136	Mr. Ravin Yadav	Community Representative
137	Ms. Indra Kumar Tiwari	Community Representative
138	Mr. Pream Lal	Community Representative
139	Mr. Rajesh Tiwari	Community Representative
140	Ms. Babita	Community Representative
141	Mr. Phula	Community Representative

142	Ms. Majhali Bahu	Community Representative
143	Mr. Khargibar	Community Representative
144	Ms. Bhupat Rani	Community Representative
145	Mr. Ashok Kumar Viswakarma	Community Representative
146	Mr. Govind Singh	Community Representative
147	Mr. Gopal Kuswaha	Community Representative
148	Mr. C. Ram Vishkarma	Community Representative
149	Ms. Sumant Rani	Community Representative
150	Ms. Phul Rani	Community Representative
151	Ms. Gulab Rani	Community Representative
152	Mr. Hariya	Community Representative
153	Mr. Suresh Chan Puri	Community Representative
154	Mr. Gunnu	Community Representative
155	Mr. Girja Prasad	Community Representative
156	Mr. Bhijlal Singh	Community Representative
157	Mr. Bhagwati	Community Representative
158	Mr. Om prakesh Dubey	Community Representative
159	Mr. Prabesh Prajapati	Community Representative
160	Mr. Panna Lal	Community Representative
161	Ms. Mallu bai	Community Representative
162	Mr. Rajkumari Prajapati	Community Representative
163	Mr. Babu Lal Yadav	Community Representative
164	Ms. Maya Rani	Community Representative
165	Ms. Hakkai	Community Representative
166	Mr. Thari	Community Representative
167	Mr. Gauri Sakar Yadav	Community Representative
168	Ms. Heena Bai Yadav	Community Representative
169	Ms. Janki Bai	Community Representative
170	Ms. Sita Rani	Community Representative
171	Ms. Raj Payari	Community Representative
172	Ms. Kamla Bai	Community Representative
173	Ms. Sobha Rani	Community Representative
174	Mr. Akbar Ali	Community Representative
175	Mr. Manoj Adivasi	Community Representative
176	Mr. Harikvand	Community Representative
177	Mr. Halke Yayan	Community Representative
178	Ms. Phuliya Yadav	Community Representative
179	Mr. Nalden Yadav	Community Representative
180	Ms. Komal	Community Representative
181	Mr. Ram Kripa Pal	Community Representative
182	Mr. Santosh D	Community Representative
183	Mr. Sachin Singh Yadav	Community Representative

184	Mr. Raju Yadav	Community Representative
185	Mr. Ramsarud Adivasi	Community Representative
186	Mr. Ganesh Bishkarma	Community Representative
187	Ms. Kamla Raj	Community Representative
188	Mr. Santosh	Community Representative
189	Mr. Surendra	Community Representative
190	Mr. Bhagwan Das	Community Representative
191	Mr. Bihari Patel	Community Representative
192	Mr. Mijaji Patel	Community Representative
193	Mr. Nonilal Ahirwal	Community Representative
194	Mr. Churan	Community Representative
195	Mr. Ram KhilaWan	Community Representative
196	Mr. Kishori Adivadi	Community Representative
197	Ms. Mina Yadav	Community Representative
198	Mr. Ram Singh	Community Representative
199	Mr. Roop Singh Yadav	Community Representative
200	Mr. Pran Singh Yadav	Community Representative
201	Mr. Dev Singh	Community Representative
202	Mr. Denesh Kumar Sagar	Community Representative
203	Mr. Teeka Ram Prajapati	Community Representative
204	Mr. Malu	Community Representative
205	Ms. Kesh Rani	Community Representative
206	Mr. Ashish Avasti	Community Representative
207	Mr. Suhan Singh	Community Representative
208	Mr. Veer Singh	Community Representative
209	Mr. Bhaan Pratap	Community Representative
210	Mr. Bhagbati	Community Representative
211	Ms. Pushpa Pal	Community Representative
212	Mr. Bharat Yadav	Community Representative
213	Mr. Munna Lal	Community Representative
214	Ms. Rani	Community Representative
215	Ms. Parvati	Community Representative
216	Ms. Maya	Community Representative
217	Mr. Hariram	Community Representative
218	Mr. Puran Sen	Community Representative
219	Mr. Rajkumar Yadav	Community Representative
220	Mr. Dani Ram	Community Representative
221	Mr. Mohan Banjara	Community Representative
222	Ms. Shama Dhar	Community Representative
223	Mr. Rajeev	Community Representative
224	Mr. Bali Ram Yadav	Community Representative
225	Mr. Khilan	Community Representative

226	Mr. Dasarath	Community Representative
227	Mr. Ram Vishal	Camp Guard
228	Mr. Har Govind	Camp Guard
229	Mr. Babulal Singh	Contractual Protection Staff
230	Mr. Babu Lal	Contractual Protection Staff
231	Mr. Ramsaj Kewat	Ward Member
Wildlife Institute of India team		
1	Dr. K. Ramesh	Scientist E and Principal Investigator of the project
2	Dr. Satyam Verma	Project Scientist
3	Ms. Manjari Malviya	Project Scientist
4	Mr. Amit Kaushik	Project Fellow
5	Mr. Dibyendu Biswas	Project Fellow
6	Ms. Priyanka Das	Project Fellow
7	Mr. Babu Lakhan	Project Fellow
8	Ms. Pallabi Mitra	Project Fellow

Appendix 3.3: List of Participant at Landscape-level Stakeholder Workshop held from 18th January 2020 – 19th January 2020 at Panna Tiger Reserve

S. No.	Name	Designation
1	Mr. Surendra Mehra	DIG, National Tiger Conservation Authority
2	Dr. V. K. Melkani	PCCF (Retd.), Tamil Nadu Forest Department
3	Dr. K. K. Jha	PCCF (Retd.), Madhya Pradesh Forest Department
4	Mr. K. S. Bhadoriya	Field Director, Panna Tiger Reserve
5	Mr. R. P. Rai	CCF, Chhatarpur and Sagar
6	Mr. P. P. Singh	CCF, Bundelkhand Zone, Jhansi
7	Dr. Ravikant Mishra	Former Field Director, Panna Tiger Reserve
8	Ms. Meena Mishra	DFO, South Panna
9	Mr. Naveen Garg	DFO, Nauradehi and South Sagar
10	Mr. Y. S. Parmar	SDO, Chhatarpur
11	Mr. G. R. Singh	SDO, Chitrakoot
12	Mr. G. D. Mishra	Wildlife Warden, Ranipur Wildlife Sanctuary
13	Mr. R. K. Rai	DFO, Katni
14	Mr. Prashant Kumar Singh	DFO, North Sagar
15	Mr. Vipin Patel	DFO, Damoh
16	Mr. Gaurav Sharma	AD, Panna Tiger Reserve
17	Dr. Sanjeev Gupta	Veterinary Officer, Panna Tiger Reserve
18	Mr. P. S. Thakur	AD, Khajuraho
19	Mr. Devinder Singh Dadhwal	DFO, Himachal Pradesh Forest Department
20	Dr. Aditi Sharma	Veterinary Officer, Uttarakhand Forest Department
21	Dr. Sandeep Agarwal	Veterinary Officer, Kanha Tiger Reserve
22	Dr. Meena Venkataraman	Principal Consultant, Carnivore Conservation and Research, Mumbai
23	Dr. Justus Joshua	Director, Green Future Foundation

24	Dr. Vidya Venkatesh	Director, Last Wilderness Foundation
25	Dr. Ambika Aiyadurai	Assistant Professor, Indian Institute of Technology, Gandhinagar
26	Dr. Amrita Neelakanthan	Coordinator, Network for Conserving Central India
27	Dr. Venkatesh Dutta	Associate Professor, Ambedkar University
28	Mr. Dilsher Khan	Independent Professional, Vulture Committee Bhopal
29	Dr. Aishwarya Maheshwari	Assistant Professor, Banda University
30	Dr. Ritu Singh	Project Director, Indian National Trust for Art and Cultural Heritage
31	Dr. Mriganka Sekhar Sarkar	Scientist B, G.B. Pant National Institute of Himalayan Environment
32	Dr. Anjana Rajput	Senior Research Officer and HOD Wildlife Branch, State Forest Research Institute, Jabalpur
33	Dr. K. P. Singh	Assistant Professor, State Forest Research Institute, Jabalpur
34	Dr. Aniruddha Majumder	Research Associate, State Forest Research Institute, Jabalpur
35	Dr. P. K. Khare	Professor, Sagar University
36	Dr. M. L. Khan	Professor, Sagar University
37	Dr. Manjula Srivastava	Advocate, Katni
38	Mr. R. K. Gupta	Executive Engineer, National Water Development Agency
39	Mr. P. C. Gupta	Executive Engineer, National Water Development Agency
40	Mr. H. K. Pandey	Assistant Executive Engineer, National Water Development Agency
41	Mr. P. N. Soni	Assistant Engineer, National Water Development Agency
42	Mr. R. K. Bijoriya	Assistant Engineer, National Water Development Agency
43	Mr. Shubham Jain	Junior Engineer, National Water Development Agency
44	Mr. R. K. Patel	Junior Engineer, National Water Development Agency
45	Dr. K. Ramesh	Scientist E and Principal Investigator of the project, Wildlife Institute of India
46	Dr. J. A. Johnson	Scientist E, Wildlife Institute of India
47	Dr. K. Sivakumar	Scientist F, Wildlife Institute of India
48	Dr. S. K. Gupta	Scientist E, Wildlife Institute of India
49	Dr. Bindu Raghavan	Professional Fellow, Wildlife Institute of India
50	Dr. Satyam Verma	Project Scientist, Wildlife Institute of India
51	Ms. Manjari Malviya	Project Scientist, Wildlife Institute of India
52	Ms. Amrita Laha	Independent Researcher
53	Ms. Deepti Gupta	PhD Scholar, Wildlife Institute of India
54	Mr. Rahul Gandhi	Project Manager, Wildlife Institute of India
55	Mr. Sankarshan Chaudhuri	Senior Project Fellow, Wildlife Institute of India
56	Mr. R. Rajasekar	Senior Project Fellow, Wildlife Institute of India
57	Ms. Pallabi Mitra	Research Fellow, Wildlife Institute of India
58	Mr. Supratim Dutta	Project Fellow, Wildlife Institute of India
59	Ms. Vaishali Vasudeva	Project Fellow, Wildlife Institute of India
60	Mr. Shashank Sawan	Project Engineer, Wildlife Institute of India
61	Ms. Susmita Khan	Project Fellow, Wildlife Institute of India
62	Ms. Kamana Pokhariya	Project Fellow, Wildlife Institute of India
63	Mr. Vishal Prasad	Researcher, Wildlife Institute of India

64	Mr. Ajay Singh	Project Fellow, Wildlife Institute of India
65	Mr. Dibyendu Biswas	Project Fellow, Wildlife Institute of India
66	Mr. Amit Kaushik	Project Fellow, Wildlife Institute of India
67	Ms. Nazrukh Sherwani	Project Fellow, Wildlife Institute of India
68	Mr. Babu Lakhan	Project Fellow, Wildlife Institute of India
69	Ms. Priyanka Das	Project Fellow, Wildlife Institute of India
70	Ms. Nimisha Srivastava	Independent Researcher
71	Ms. Priyanka Kumari	Technical Assistant, Wildlife Institute of India
72	Mr. Ashish Kumar	Project Assistant, Wildlife Institute of India
73	Ms. Divya Srinivisan	Project Intern, Wildlife Institute of India
74	Ms. Avishna A.	Project Intern, Wildlife Institute of India
75	Mr. Darshan Singh	Field Coordinator

Appendix 3.4: List of Participant during internal review meeting conducted on 1st February 2019 at Wildlife Institute of India, Dehradun

S. No.	Name	Designation
1	Dr. V. B. Mathur	Director, Wildlife Institute of India
2	Mr. Jitendra Agrawal	PCCF (Retd.), Madhya Pradesh Forest Department
3	Dr. Y. V. Jhala	Scientist G, Wildlife Institute of India
4	Dr. K. Ramesh	Scientist E and Principal Investigator of the project, Wildlife Institute of India
5	Dr. C. Ramesh	Scientist C, Wildlife Institute of India
6	Dr. Navendu Page	Scientist C, Wildlife Institute of India
7	Dr. Nehru Prabakaran	Inspire Faculty, Wildlife Institute of India
8	Dr. Satyam Verma	Project Scientist, Wildlife Institute of India
9	Mr. Rahul Gandhi	Project Manager, Wildlife Institute of India
10	Ms. Priyanka Kumari	Technical Assistant, Wildlife Institute of India

Appendix 3.5: List of Participant during review meeting with MP Forest Department conducted on 17th February 2020 at PCCF office, Bhopal

S. No.	Name	Designation
1	Mr. Rajesh Srivastav	PCCF (WL), Madhya Pradesh Forest Department
2	Dr. H. S. Negi	APCCF (WL), Madhya Pradesh Forest Department
3	Mr. R. Sreenivasa Murthy	Member Secretary, Madhya Pradesh Biodiversity Board, Bhopal
4	Dr. K. Ramesh	Scientist E and Principal Investigator of the project, Wildlife Institute of India
5	Mr. R. I. Jarande	Deputy Director, Panna Tiger Reserve

Appendix 3.6: List of Participant during review meeting with NWDA, MP Forest Department, UP Forest Department & NTCA conducted on 21st July 2020, virtually

S. No.	Name	Designation
1	Mr. S. K. Mandal	PCCF (WL), Madhya Pradesh Forest Department
2	Mr. H. S. Negi	APCCF (WL), Madhya Pradesh Forest Department
3	Mr. J. S. Chauhan	APCCF (WL), Madhya Pradesh Forest Department

4	Mr. K. S. Bhadoriya	Field Director, Panna Tiger Reserve
5	Mr. R. I. Jarande	Deputy Director, Panna Tiger Reserve
6	Mr. Raja Mohan	On behalf of PCCF (WL), Uttar Pradesh Forest Department
7	Mr. Bhopal Singh	DG, National Water Development Agency
8	Mr. R. K. Jain	Chief Engineer, National Water Development Agency
9	Mr. P. C. Gupta	Executive Engineer, National Water Development Agency
10	Mr. Muzaffar Ahmed	Director (Technical), National Water Development Agency
11	Mr. K. P. Gupta	Chief Engineer, National Water Development Agency
12	Mr. D. K. Sharma	Superintending Engineer, National Water Development Agency
13	Mr. H. K. Pandey	Executive Engineer, National Water Development Agency
14	Dr. Amit Mallick	IGF, National Tiger Conservation Authority
15	Mr. Surender Mehra	DIG, National Tiger Conservation Authority
16	Dr. Dhananjai Mohan	Director, Wildlife Institute of India
17	Dr. K. Ramesh	Scientist E and Principal Investigator of the project, Wildlife Institute of India
18	Dr. J. A. Johnson	Scientist E, Wildlife Institute of India
19	Dr. Satyam Verma	Project Scientist, Wildlife Institute of India
20	Ms. Manjari Malviya	Project Scientist, Wildlife Institute of India
21	Mr. Rahul Gandhi	Project Manager, Wildlife Institute of India

Appendix 3.7: List of Participant during review meeting with NWDA, MP Forest Department, UP Forest Department & NTCA conducted on 10th September 2021, virtually

S. No.	Name	Designation
1	Dr. H. S. Negi	APCCF (WL), Madhya Pradesh Forest Department
2	Mr. Abu Arshad Khan	Deputy CWLW, Uttar Pradesh Forest Department
3	Dr. Dhananjai Mohan	Director, Wildlife Institute of India
4	Mr. Hemant Singh	AIG, National Tiger Conservation Authority
5	Dr. K. Ramesh	Scientist E and Principal Investigator of the project, Wildlife Institute of India
6	Mr. Neeraj Kumar	CCF, Uttar Pradesh Forest Department
7	Mr. Bhopal Singh	DG, National Water Development Agency
8	Mr. R. K. Jain	Chief Engineer, National Water Development Agency
9	Mr. D. K. Sharma	Director (Tech.), National Water Development Agency
10	Mr. S. C. Awasthi	Superintending Engineer (North), National Water Development Agency
11	Mr. B. L. Sharma	Superintending Engineer, National Water Development Agency
12	Mr. R. K. Gupta	Executive Engineer, National Water Development Agency
13	Mr. S. K. Gawande	Executive Engineer, National Water Development Agency

14	Mrs. Jaswinder Kaur	Assistant Engineer, National Water Development Agency
15	Mr. R. K. Sharma	Consultant III, National Water Development Agency
16	Mr. M. S. Dabar	Engineer in Chief, Water Resources Department, Govt of Madhya Pradesh
17	Mr. Rajeev Soni	Senior Consultant, Water Resources Department, Govt of Madhya Pradesh
18	Mr. O. P. S. Kushwaha	Senior Consultant, Water Resources Department, Govt of Madhya Pradesh

Appendix 3.8: List of Participant during consultation meeting with District Collector, Panna held on 15th December 2021 at Panna District Collector office, Panna

S. No.	Name	Designation
1	Mr. Sanjay Kumar Mishra	District Magistrate, Panna
2	Mr. J. P. Dhurwe	Addl. District Magistrate, Panna
3	Mr. Uttam Kumar Sharma	Field Director, Panna Tiger Reserve
4	Mr. T. Vejayanantham,	Deputy Director, Panna Tiger Reserve
5	Dr. Priyanka Singh	Veterinary Officer, Department of Animal Husbandry
6	Mr. R. K. Mishra	Department of Animal Husbandry
7	Mr. Ravi Patel	District Mining Officer, Mineral Resources Department
8	Representative	Department of Agriculture
9	Representative	Public Works Departments
10	Dr. K. Ramesh	Scientist E and Principal Investigator of the project, Wildlife Institute of India
11	Ms. Manjari Malviya	Project Scientist, Wildlife Institute of India
12	Mr. Sankarshan Chaudhuri	Senior Project Fellow, Wildlife Institute of India
13	Mr. R. Rajasekar	Senior Project Fellow, Wildlife Institute of India
14	Ms. Kamana Pokhariya	Project Associate, Wildlife Institute of India
15	Mr. Ajay Singh	Project Fellow, Wildlife Institute of India
16	Mr. Dibyendu Biswas	Project Fellow, Wildlife Institute of India
17	Mr. Shri Lak N. C.	Project Assistant, Wildlife Institute of India

Appendix 3.9: List of Participant during consultation meeting with District Collector, Damoh held on 17th December 2021, at District Collector office, Damoh

S. No.	Name	Designation
1	Mr. S. Krishna Chaitanya	District Magistrate, Damoh
2	Mr. Nathuram Gound	Addl. District Magistrate, Damoh
3	Mr. Abhishek Tiwari	Superintendent of Police, Damoh
4	Mr. Mahendra Singh Uikey	DFO, Forest Department
5	Dr. Sangita Trivedi	Chief Medical and Health Officer
7	Representative	Department of Animal Husbandry
8	Representative	Department of Agriculture
9	Representative	Mineral Resources Department
10	Representative	Public Works Department

11	Representative	IT Department
12	Dr. K. Ramesh	Scientist E and Principal Investigator of the project, Wildlife Institute of India
13	Ms. Manjari Malviya	Project Scientist, Wildlife Institute of India
14	Mr. R. Rajasekar	Senior Project Fellow, Wildlife Institute of India
15	Mr. Sankarshan Chaudhuri	Senior Project Fellow, Wildlife Institute of India
16	Ms. Kamana Pokhariya	Project Associate, Wildlife Institute of India
17	Mr. Ajay Singh	Project Fellow, Wildlife Institute of India
18	Mr. Dibyendu Biswas	Project Fellow, Wildlife Institute of India
19	Mr. Supratim Datta	Project Associate, Wildlife Institute of India
20	Ms. Srishti Manna	Project Associate, Wildlife Institute of India
21	Mr. Shri Lak N. C.	Project Assistant, Wildlife Institute of India
22	Mr. Rahul Gandhi	Project Manager, Wildlife Institute of India

Appendix 3.10: List of Participant during consultation meeting with District Collector, Chhatarpur held on 17th January 2022, at District Collector office, Chhatarpur

S. No.	**Name**	**Designation**
1	Mr. Sandeep G. R.	District Magistrate, Chhatarpur
2	Dr. Vimal Tiwari	Department of Animal Husbandry
3	Mr. R. S. Shukla	Executive Engineer, Public Works Department
4	Representative	Forest Department
5	Representative	Chief Medical & Health Officer
6	Representative	Department of Agriculture
7	Representative	Mineral Resources Department
9	Representative	IT Department
10	Representative	Executive Engineer, Water Resources Department
11	Dr. K. Ramesh	Scientist E and Principal Investigator of the project, Wildlife Institute of India
12	Ms. Manjari Malviya	Project Scientist, Wildlife Institute of India
13	Mr. Sankarshan Chaudhuri	Senior Project Fellow, Wildlife Institute of India
14	Mr. R. Rajasekar	Senior Project Fellow, Wildlife Institute of India
15	Ms. Kamana Pokhariya	Project Associate, Wildlife Institute of India
16	Mr. Ajay Singh	Project Fellow, Wildlife Institute of India
17	Mr. Dibyendu Biswas	Project Fellow, Wildlife Institute of India
18	Mr. Supratim Datta	Project Associate, Wildlife Institute of India
19	Ms. Srishti Manna	Project Associate, Wildlife Institute of India
20	Mr. Shri Lak N. C.	Project Assistant, Wildlife Institute of India
21	Mr. Rahul Gandhi	Project Manager, Wildlife Institute of India

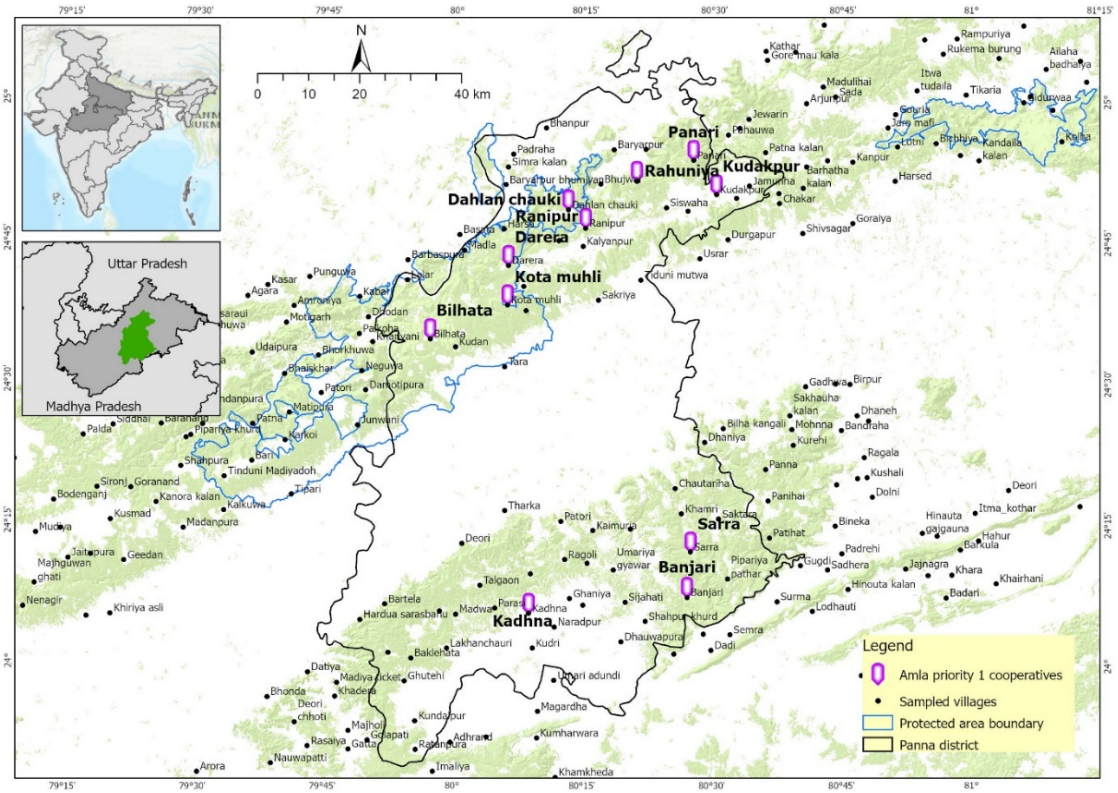
Appendix 3.11: List of Participant during Experts Consultation Workshop on Integrated Landscape Management Plan for Greater Panna Landscape, Madhya Pradesh, and Uttar Pradesh, 4th & 5th April 2022 at Interpretation centre, Delhi

S. No	Name	Designation
1	Dr. Rajesh Gopal	Secretary General, Global Tiger Forum, New Delhi
2	Mr. Uttam Kumar Sharma	Field Director, Panna Tiger Reserve
3	Dr. K. K. Jha	PCCF (Retd.), Madhya Pradesh Forest Department
4	Dr. Justus Joshua	Director, Green Future Foundation
5	Dr. P. K. Khare	Professor, Sagar University
6	Dr. M. L. Khan	Professor, Sagar University
7	Dr. G. Areendran	Director, IGCMC, World Wide Fund for Nature, India
8	Dr. Meena Venkatraman	Principal Consultant, Carnivore Conservation and Research, Mumbai
9	Dr. S. R. Ganesh	Deputy Director and Scientist, Chennai Snake Park
10	Dr. Vidya Venkatesh	Director, Last Wilderness Foundation
11	Dr. Robert John Chandran	Associate Professor, Indian Institutes of Science Education and Research, Kolkata
12	Dr. K. P. Singh	Assistant Professor, School of Wildlife Forensic and Health, Jabalpur
13	Dr. Ambika Aiyadurai	Assistant Professor, Indian Institute of Technology, Gandhinagar
14	Dr. Aishwarya Maheshwari	Assistant Professor, Banda University
15	Dr. Aditi Sharma	Deputy Chief Veterinary Officer, Animal Husbandry Department, Uttarakhand
16	Dr. Bahar Baviskar	President, Wild-Conservation Education Research
17	Dr. Anjana Rajput	Senior Research Officer, State Forest Research Institute, Jabalpur
18	Dr. Milind Pariwakam	Head, Linear Infrastructure Policy and Ecology, Wildlife Conservation Trust
19	Dr. Mriganka Sekhar Sarkar	Scientist B, G.B. Pant National Institute of Himalayan Environment
20	Mr. Mohnish Kapoor	Head, Pro and Partnerships, Global Tiger Forum, New Delhi
21	Dr. Neetika Mehta	Visiting Faculty, University of Petroleum and Energy Studies
22	Dr. Ridhima Solanki	Wildlife Biologist and GIS Expert, Global Tiger Forum, New Delhi
23	Dr. K. Ramesh	Scientist E and Principal Investigator of the project, Wildlife Institute of India
24	Dr. S. K. Gupta	Scientist E, Wildlife Institute of India
25	Dr J. A. Johnson	Scientist E, Wildlife Institute of India
26	Dr. Navendu Page	Scientist C, Wildlife Institute of India
27	Dr. C. Ramesh	Scientist C, Wildlife Institute of India
28	Ms. Manjari Malviya	Project Scientist, Wildlife Institute of India
29	Mr. R. Rajasekar	Senior Project Fellow, Wildlife Institute of India
30	Mr. Sankarshan Chaudhuri	Senior Project Fellow, Wildlife Institute of India
31	Ms. Kamana Pokhariya	Project Associate, Wildlife Institute of India
32	Ms. Zainab Khan	Project Associate, Wildlife Institute of India

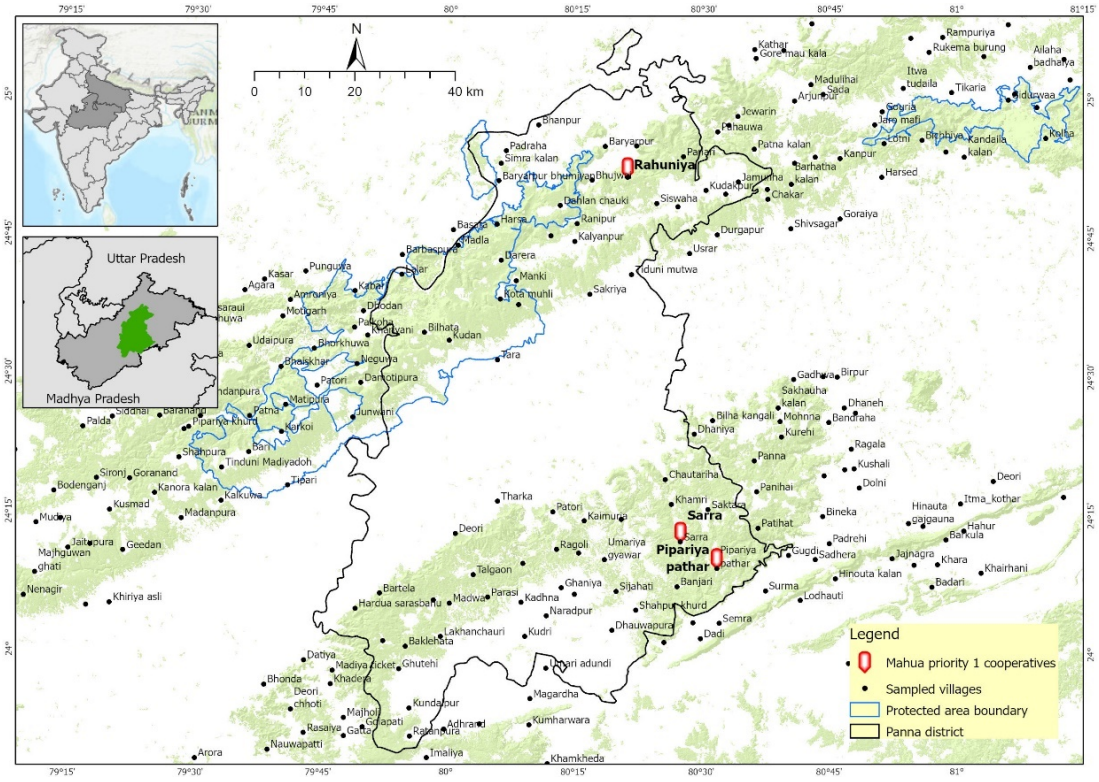
33	Ms. Meera Makwana	Project Associate, Wildlife Institute of India
34	Ms. Srishti Manna	Project Associate, Wildlife Institute of India
35	Mr. Supratim Dutta	Project Associate, Wildlife Institute of India
36	Mr. Dibyendu Biswas	Project Fellow, Wildlife Institute of India
37	Mr. Ajay Singh	Project Fellow, Wildlife Institute of India
38	Mr. Rahul Gandhi	Project Manager, Wildlife Institute of India
39	Mr. Shri Lak N.C.	Project Assistant, Wildlife Institute of India
40	Mr. Manu Mohan	Project Assistant, Wildlife Institute of India
41	Mr. Niket Alashi	Project Assistant, Wildlife Institute of India
42	Ms. Vandana Tomar	Project Assistant, Wildlife Institute of India
43	Mr. Ashish Kumar	Project Assistant, Wildlife Institute of India
44	Ms. Priyanka Kumari	Technical Assistant, Wildlife Institute of India

Appendix 3.12: List of participants of the Finalisation of Development of Integrated Landscape Management Plan along with the five Supplementary Plans prepared by WII, Dehradun with reference to Ken-Betwa Link Project in Panna Tiger Reserve, Madhya Pradesh held on 06.04.2022 at Palika Bhawan, New Delhi

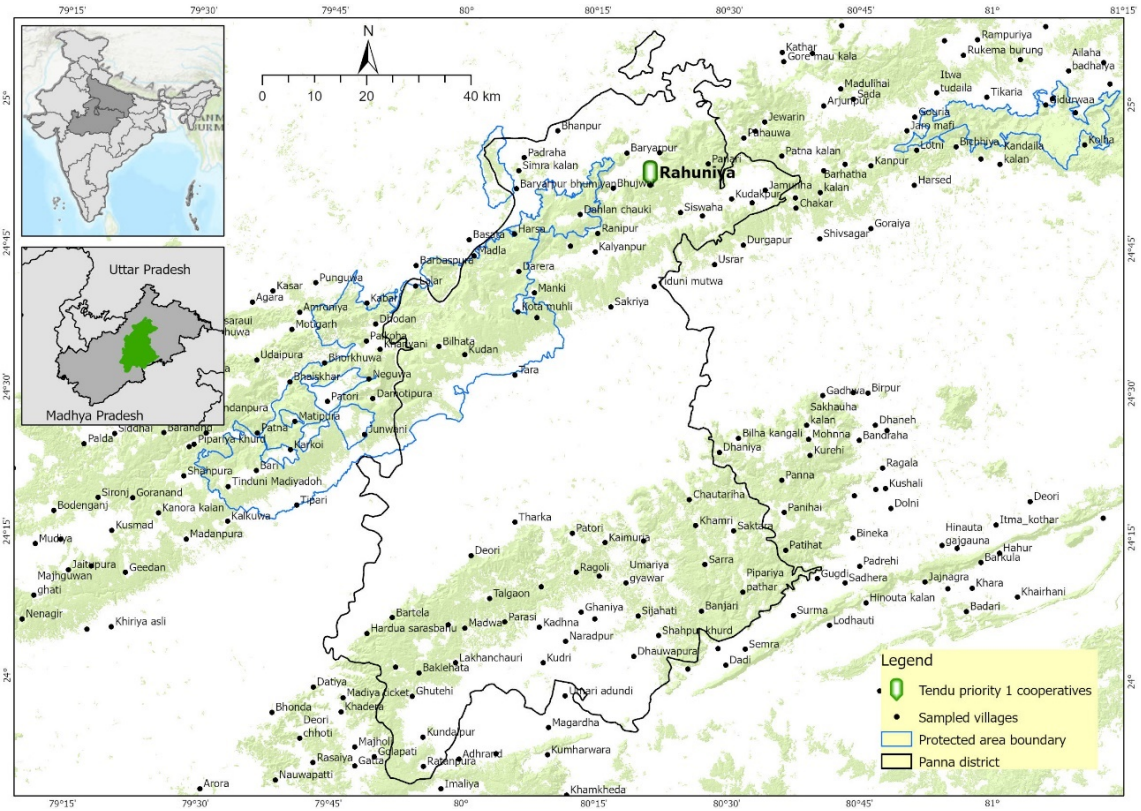
S. No	**Name**	**Designation**
1	Mr. Bhopal Singh	DG, National Water Development Agency
2	Mr. D. K. Sharma	Director (Tech.), National Water Development Agency
3	Mr. Krishnamurthy M. P.	Assistant Director, National Water Development Agency
4	Mr. Shiva Prakash	Chief Engineer, National Water Development Agency
5	Mr. R. K. Jain	Chief Engineer, National Water Development Agency
6	Mr. S. C. Awasthi	Superintending Engineer (North), National Water Development Agency
7	Mr. B. L. Sharma	Superintending Engineer, National Water Development Agency
8	Mr. J. S. Chauhan	PCCF (WL), Madhya Pradesh Forest Department
9	Mr. Shesh Narayan Mishra	CCF, Uttar Pradesh Forest Department
10	Mr. Uttam Kumar Sharma	Field Director, Panna Tiger Reserve
11	Dr. K. Ramesh	Scientist E and Principal Investigator of the project, Wildlife Institute of India
12	Mr. Hemant Singh	AIG, National Tiger Conservation Authority
13	Mr. Amarshri Nayak	Consultant, National Water Development Agency
14	Mr. O. P. S. Kushwaha	Senior Consultant, Water Resources Department, Govt of Madhya Pradesh



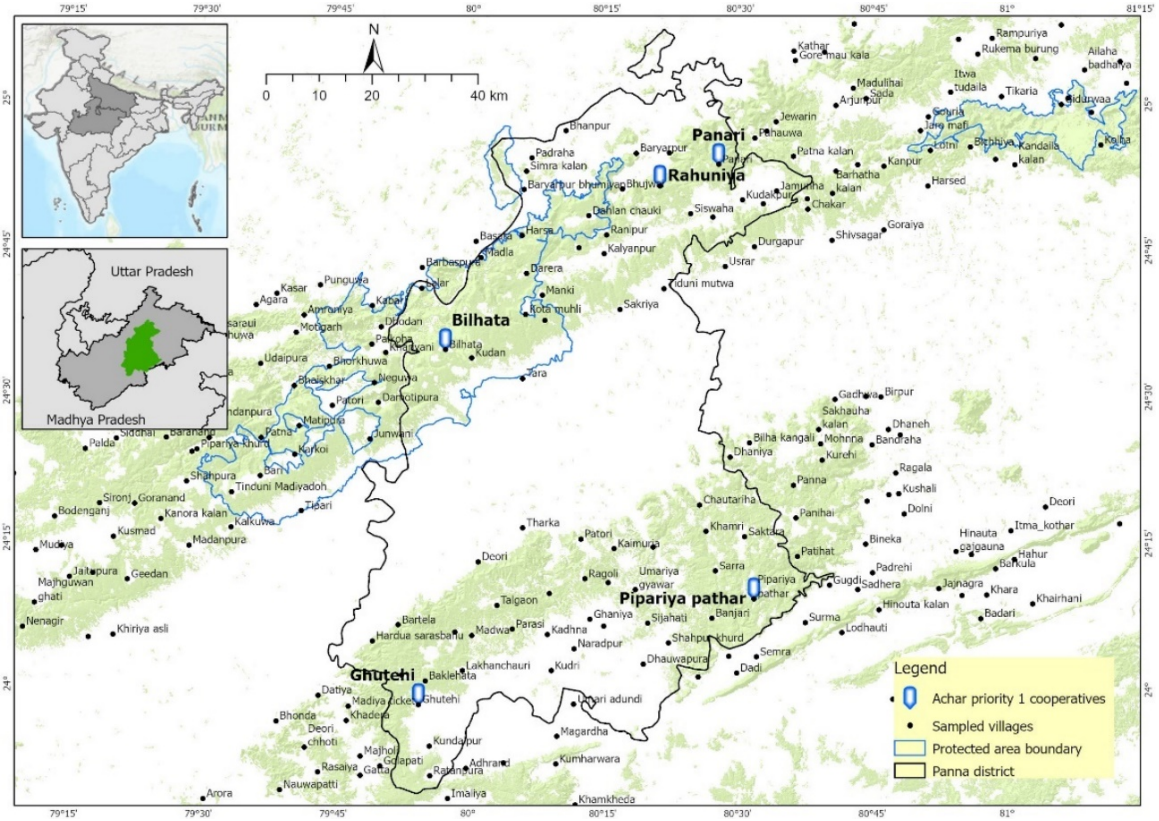
Appendix 10.1. Map showing villages within Panna District where Amla growth centres are proposed



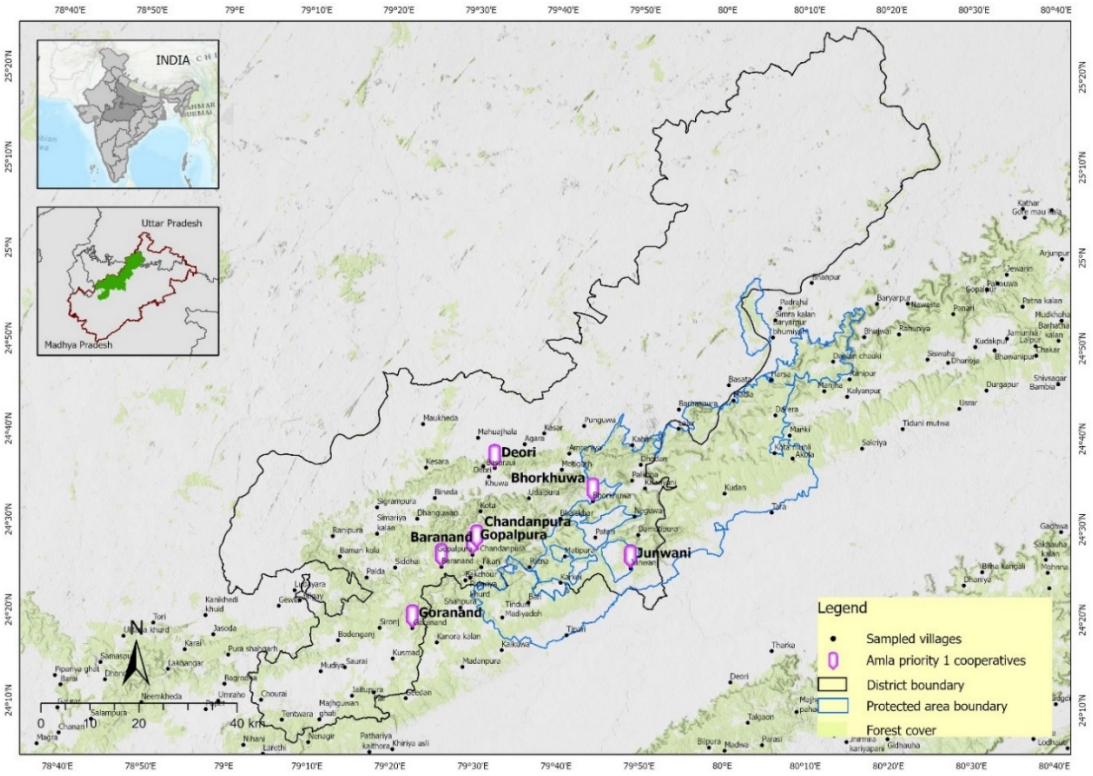
Appendix 10.2. Map showing villages within Panna District where Mahua growth centres are proposed



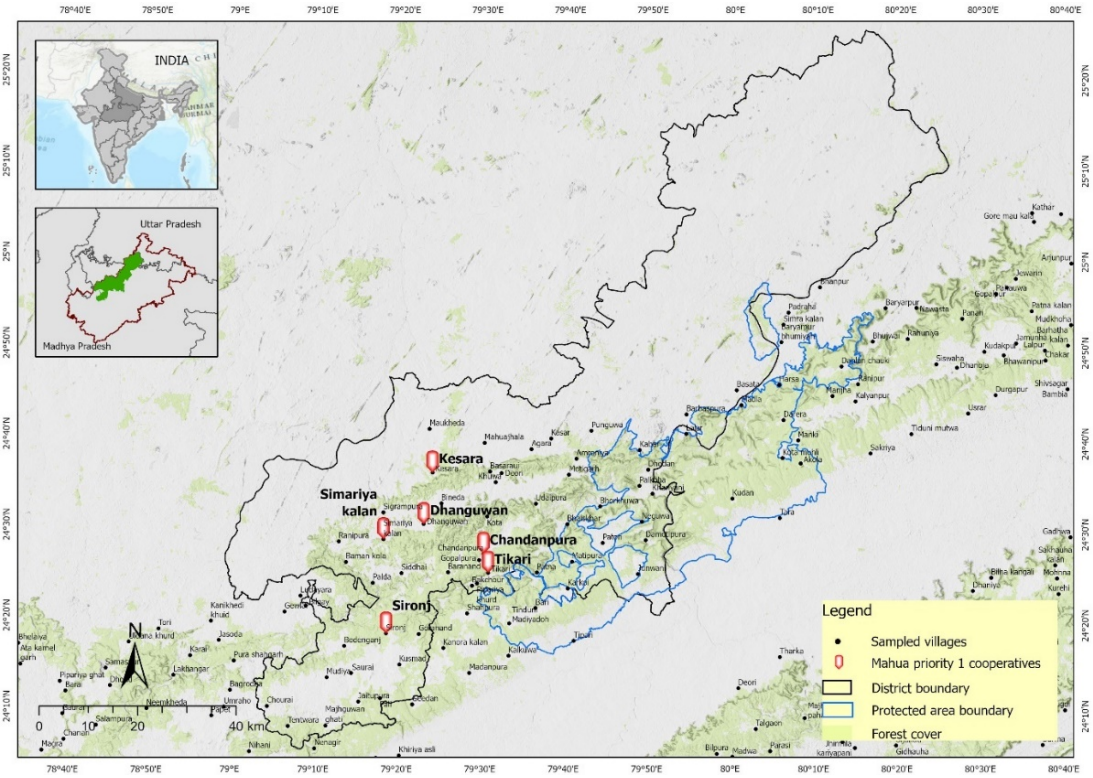
Appendix 10.3. Map showing villages within Panna District where Tendu growth centres are proposed



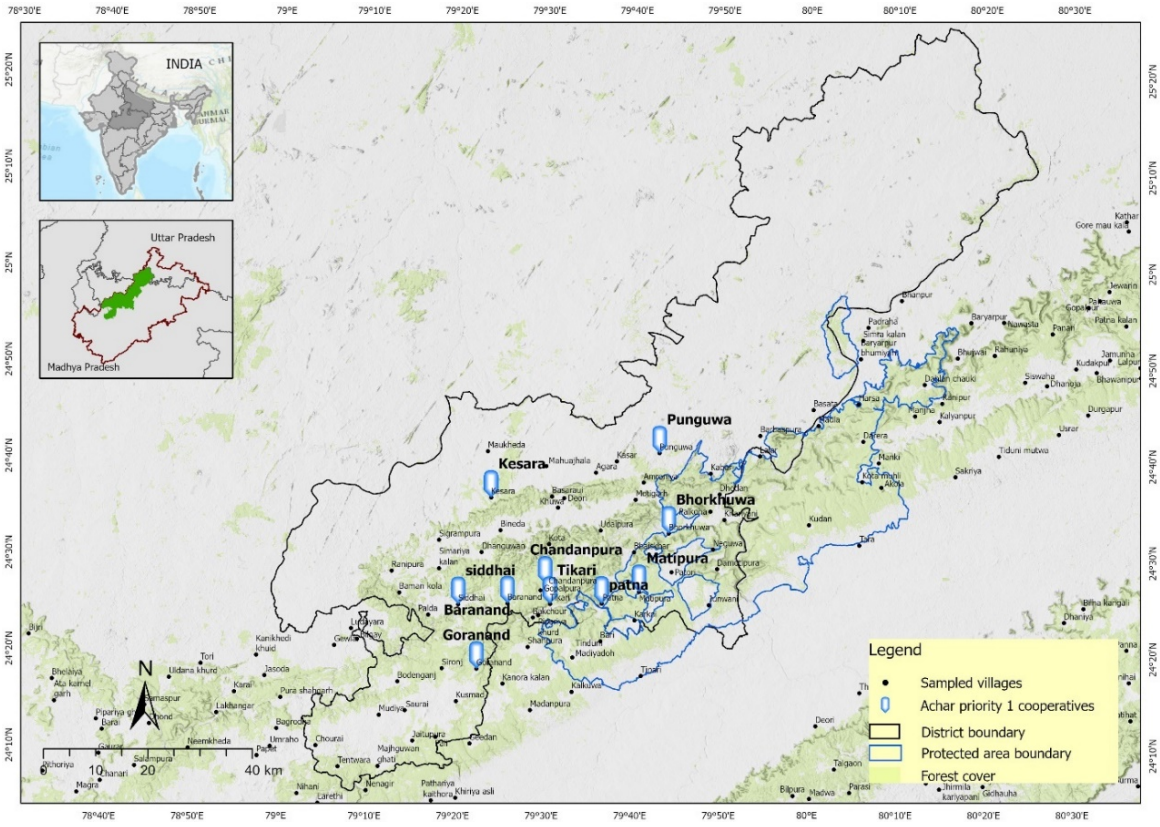
Appendix 10.4. Map showing villages within Panna District where Achar growth centres are proposed



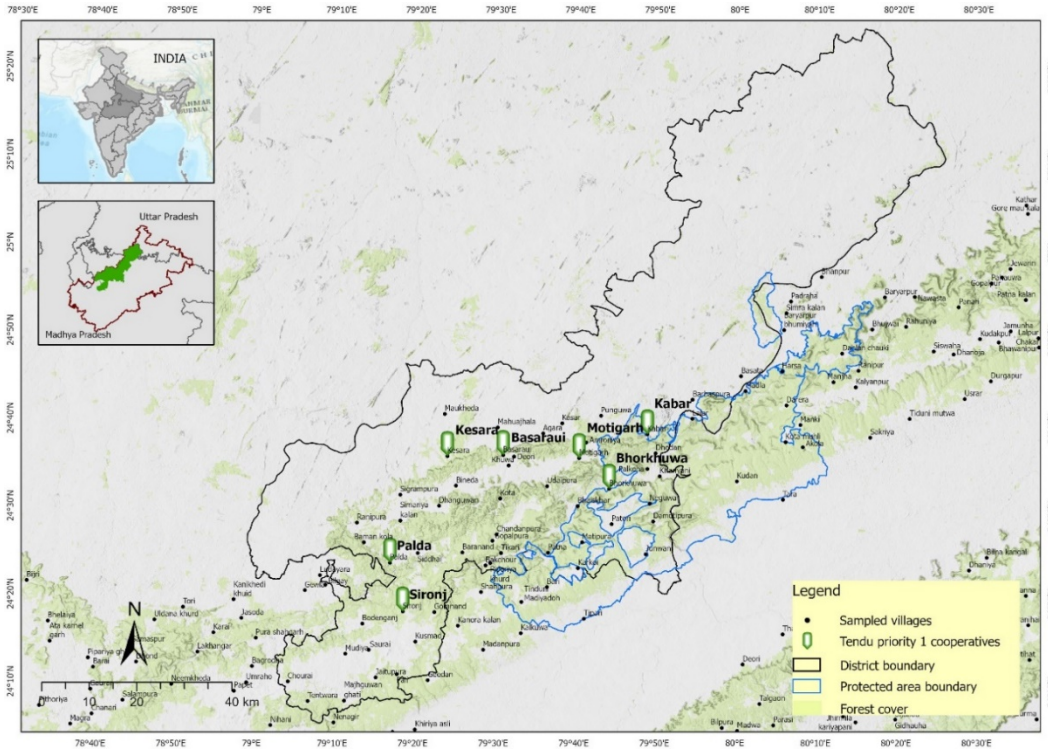
Appendix 10.5. Map showing villages within Chhatarpur District where Amla growth centres are proposed



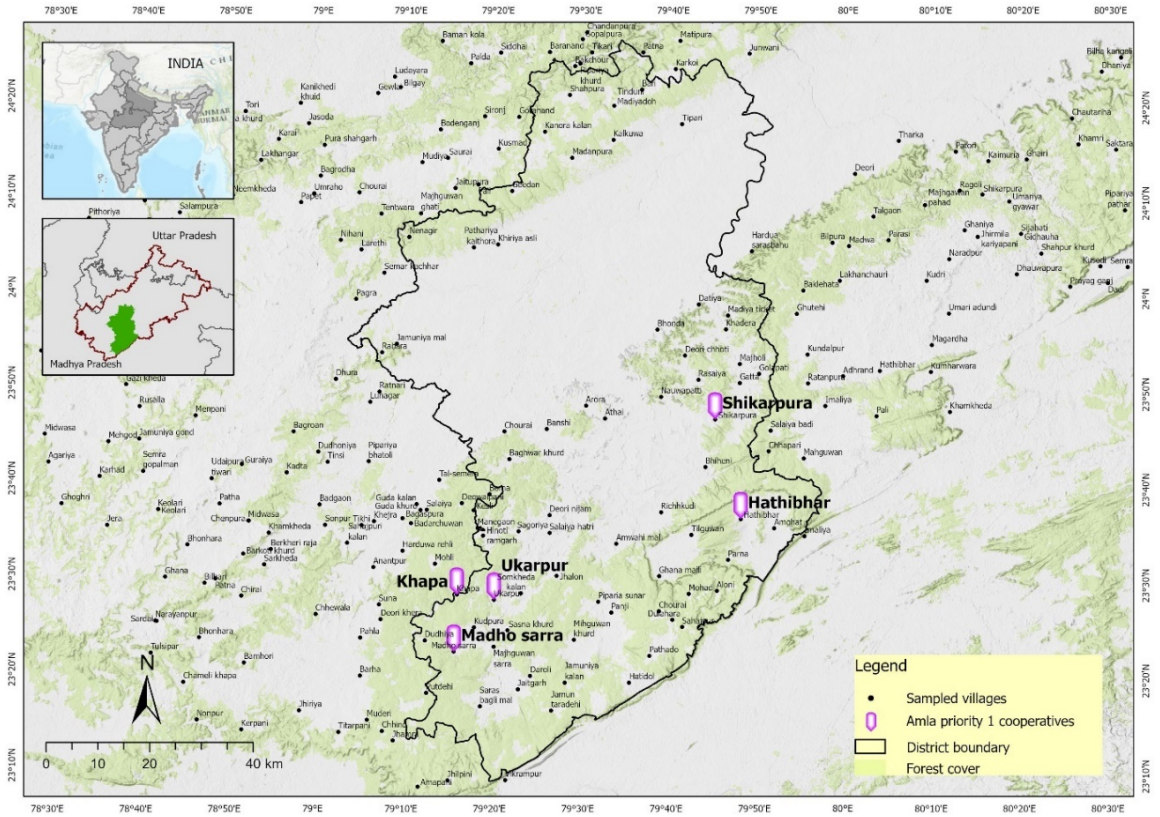
Appendix 10.6. Map showing villages within Chhatarpur District where Mahua growth centres are proposed



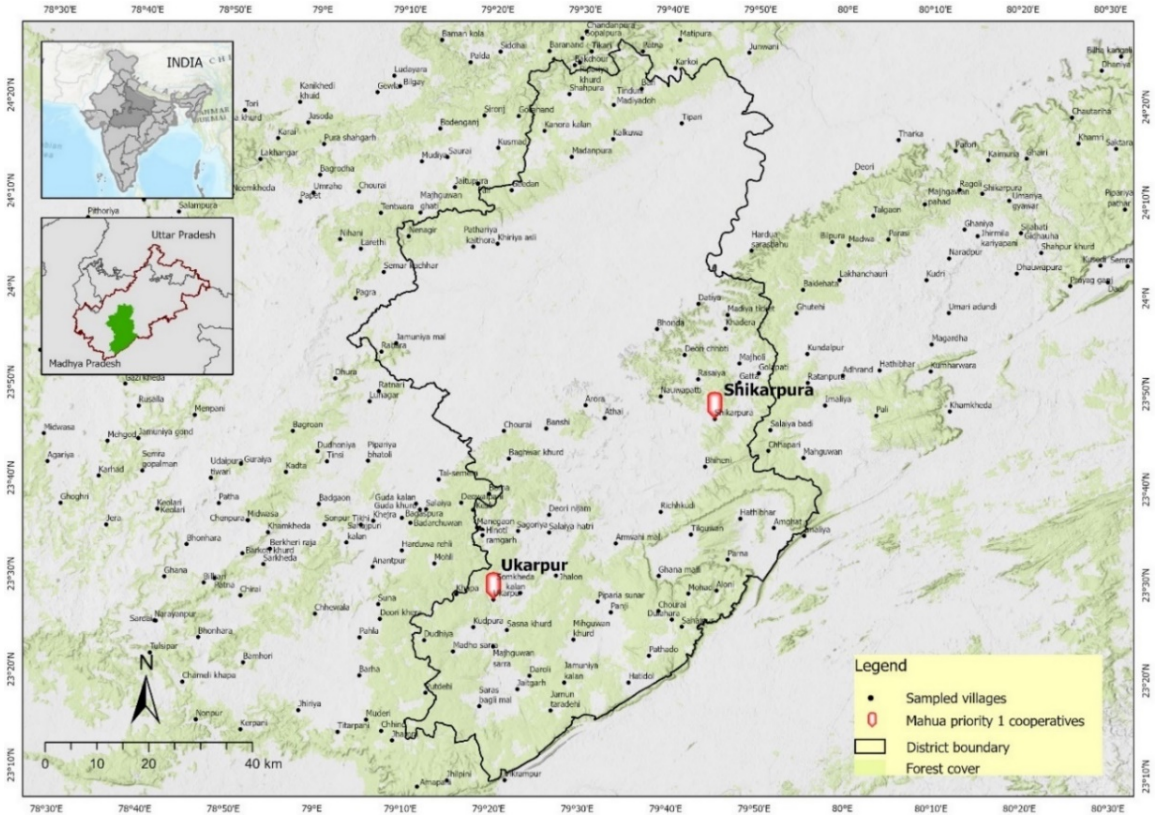
Appendix 10.7. Map showing villages within Chhatarpur District where Achar growth centres are proposed



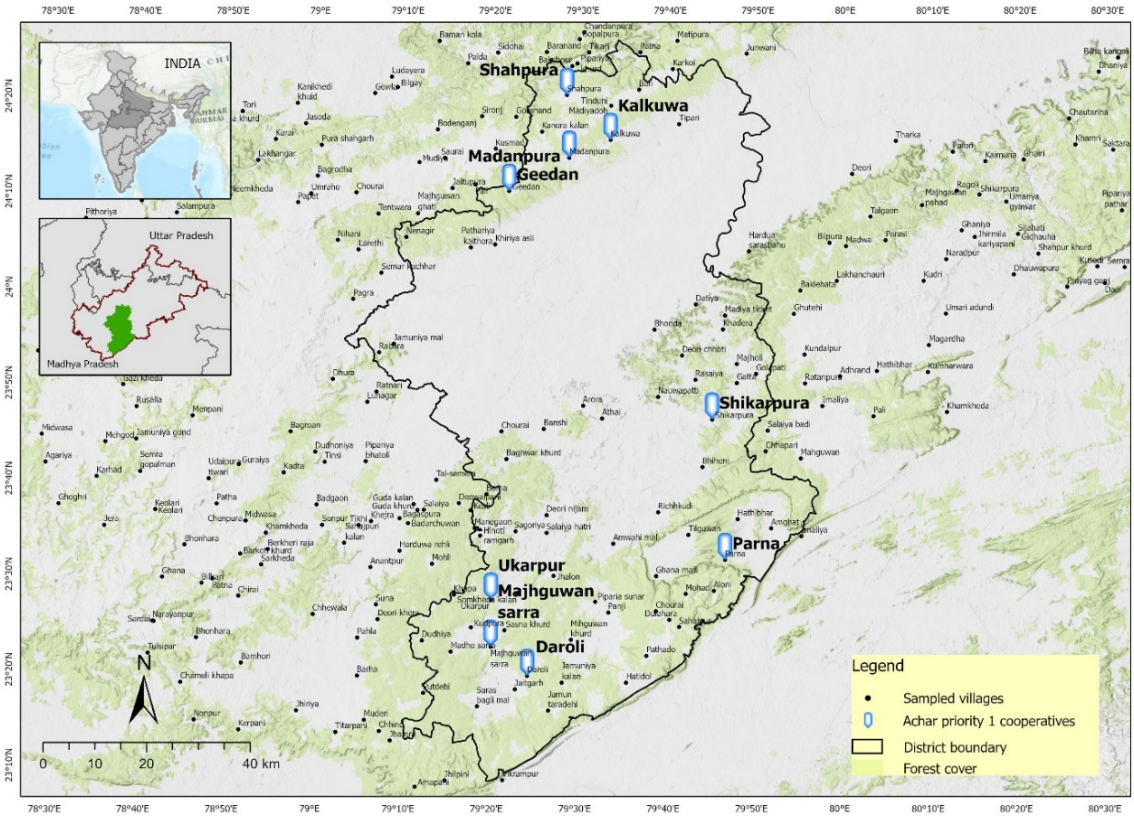
Appendix 10.8. Map showing villages within Chhatarpur District where Tendu growth centres are proposed



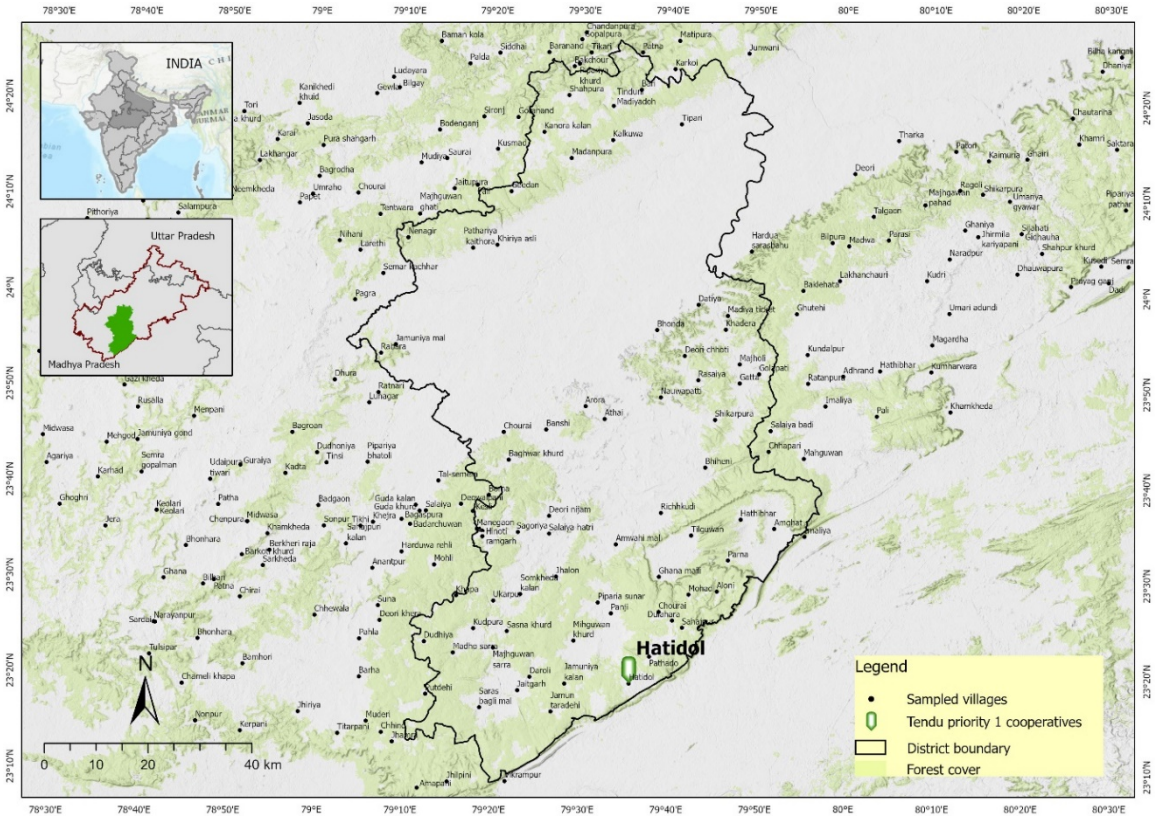
Appendix 10.9. Map showing villages within Damoh District where Amla growth centres are proposed



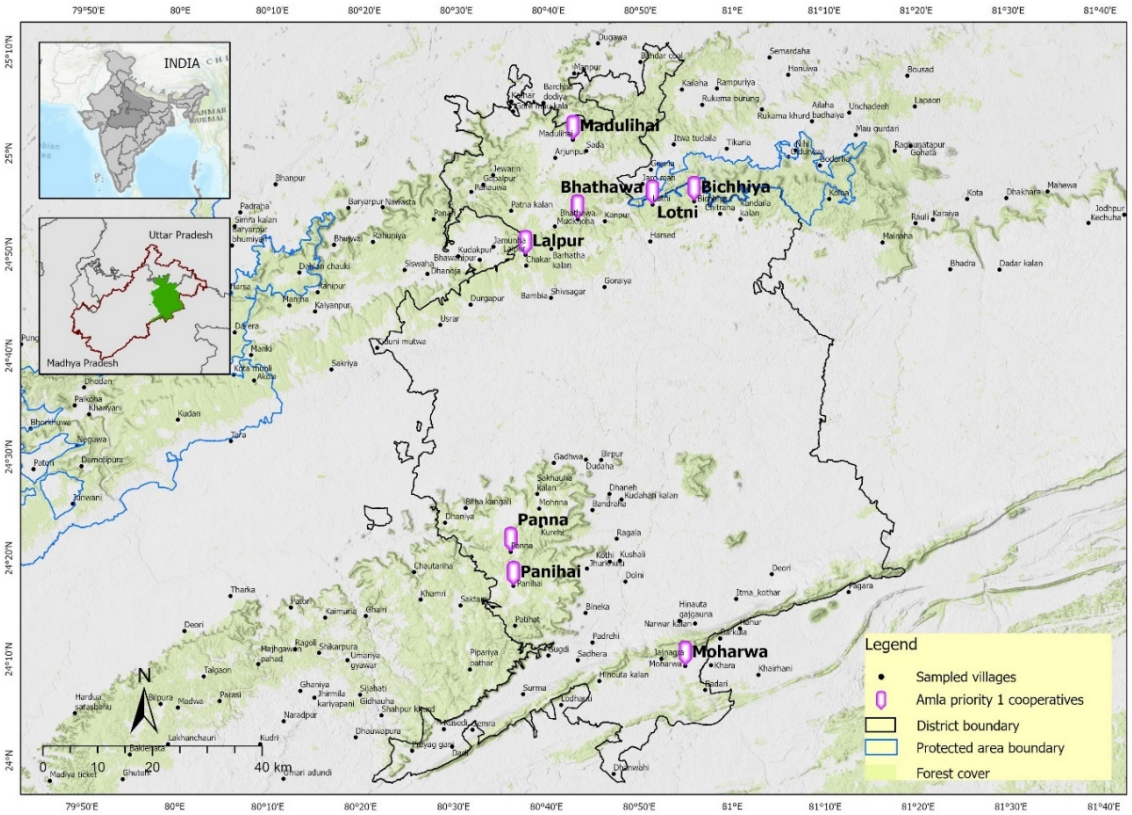
Appendix 10.10. Map showing villages within Damoh District where Mahua growth centres are proposed



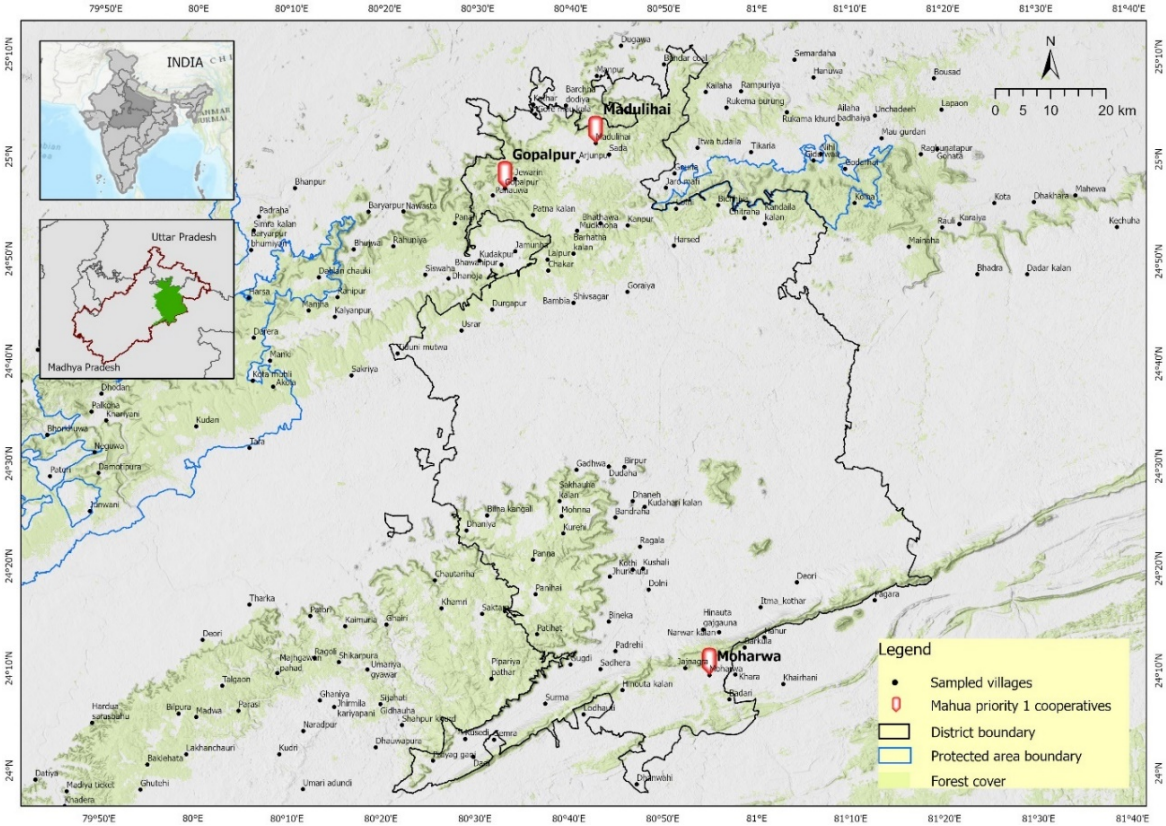
Appendix 10.11. Map showing villages within Damoh District where Achar growth centres are proposed



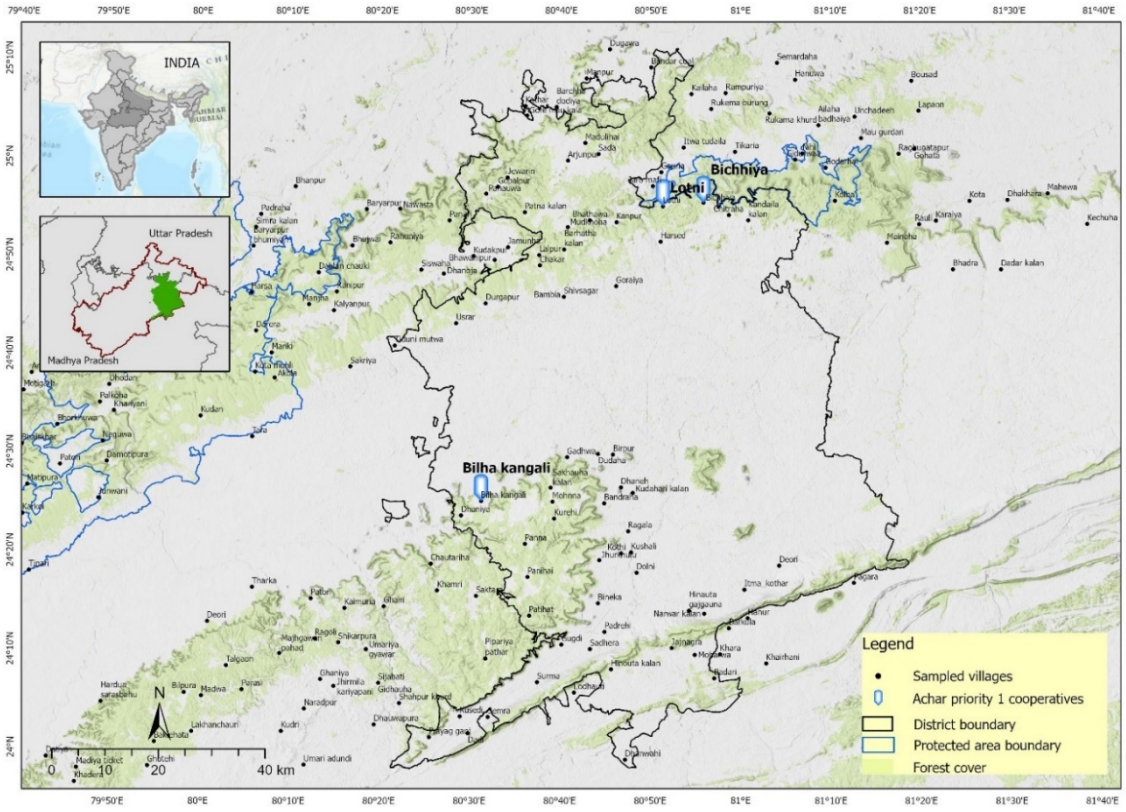
Appendix 10.12. Map showing villages within Damoh District where Tendu growth centres are proposed



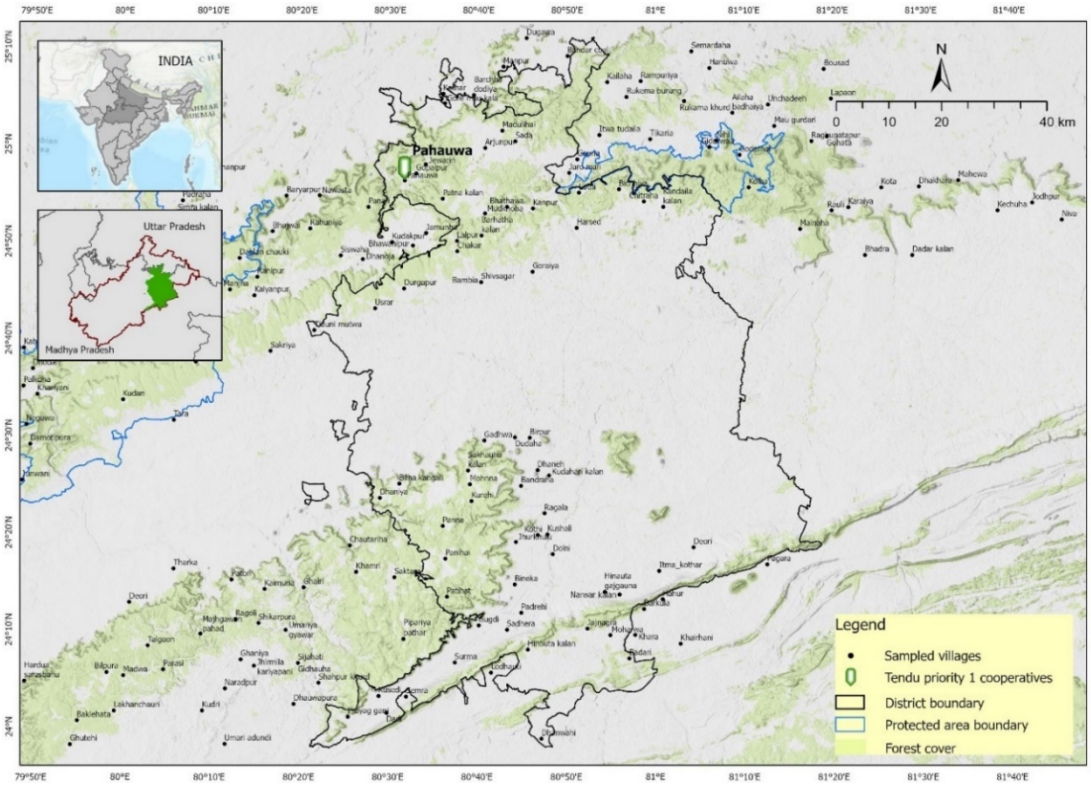
Appendix 10.13. Map showing villages within Satna District where Amla growth centres are proposed



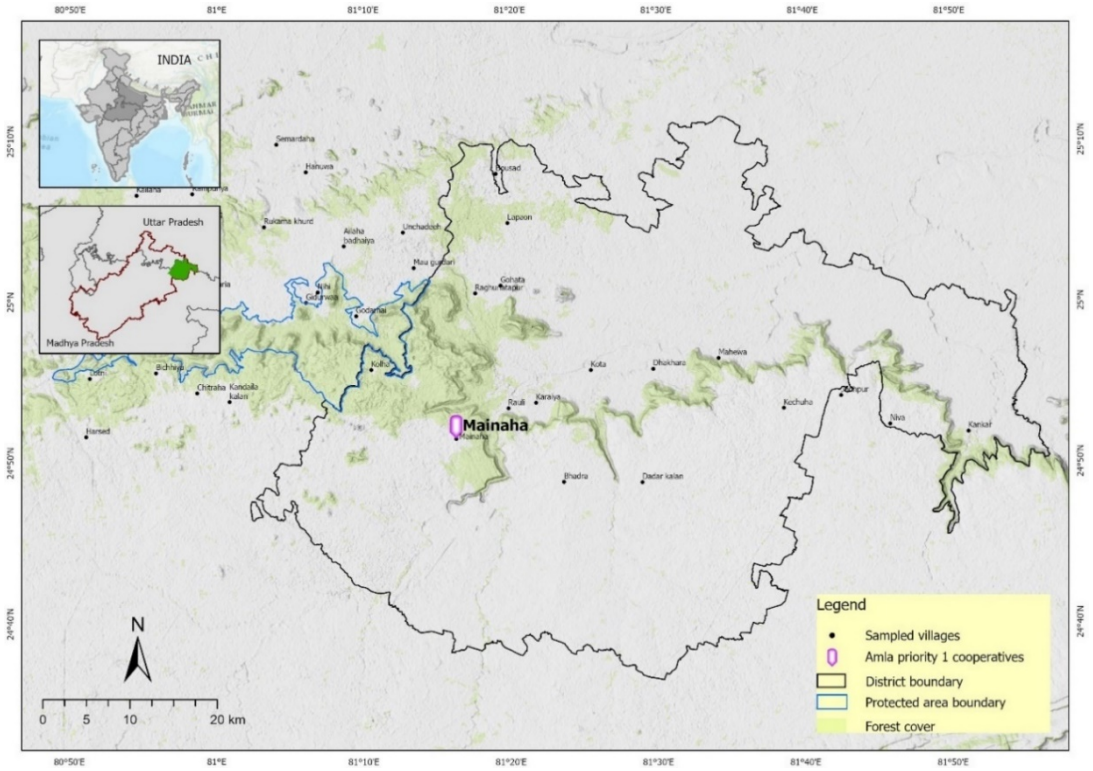
Appendix 10.14. Map showing villages within Satna District where Mahua growth centres are proposed



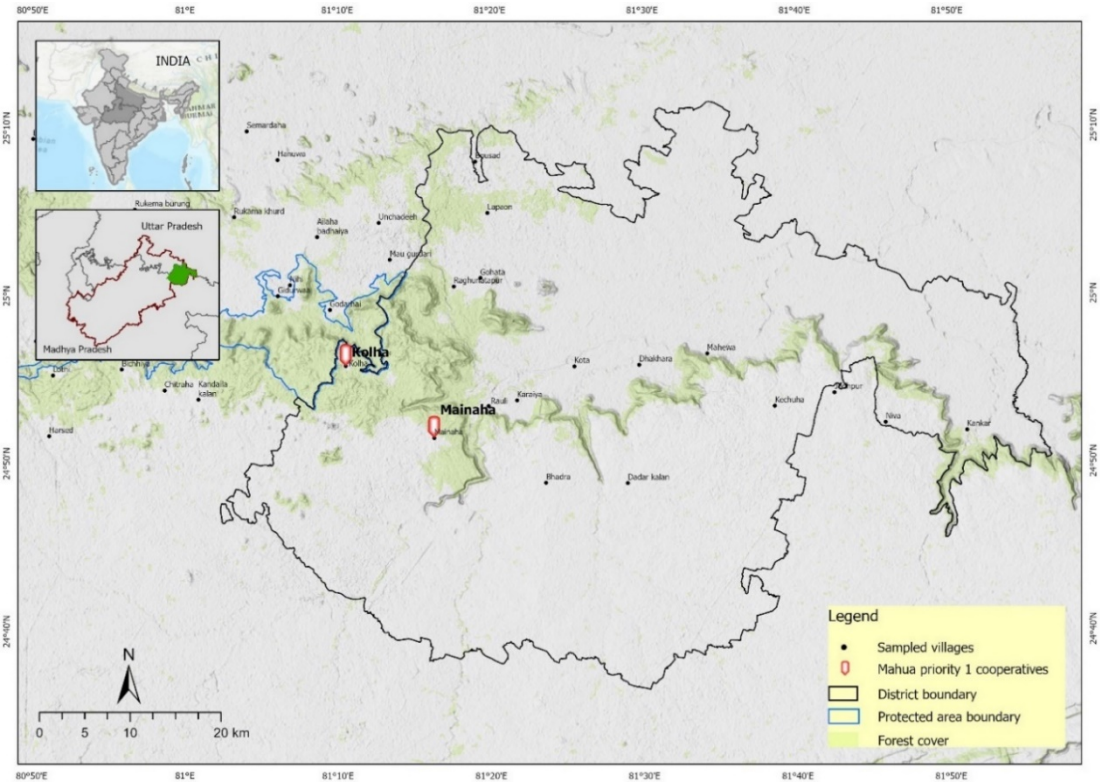
Appendix 10.15. Map showing villages within Satna District where Achar growth centres are proposed



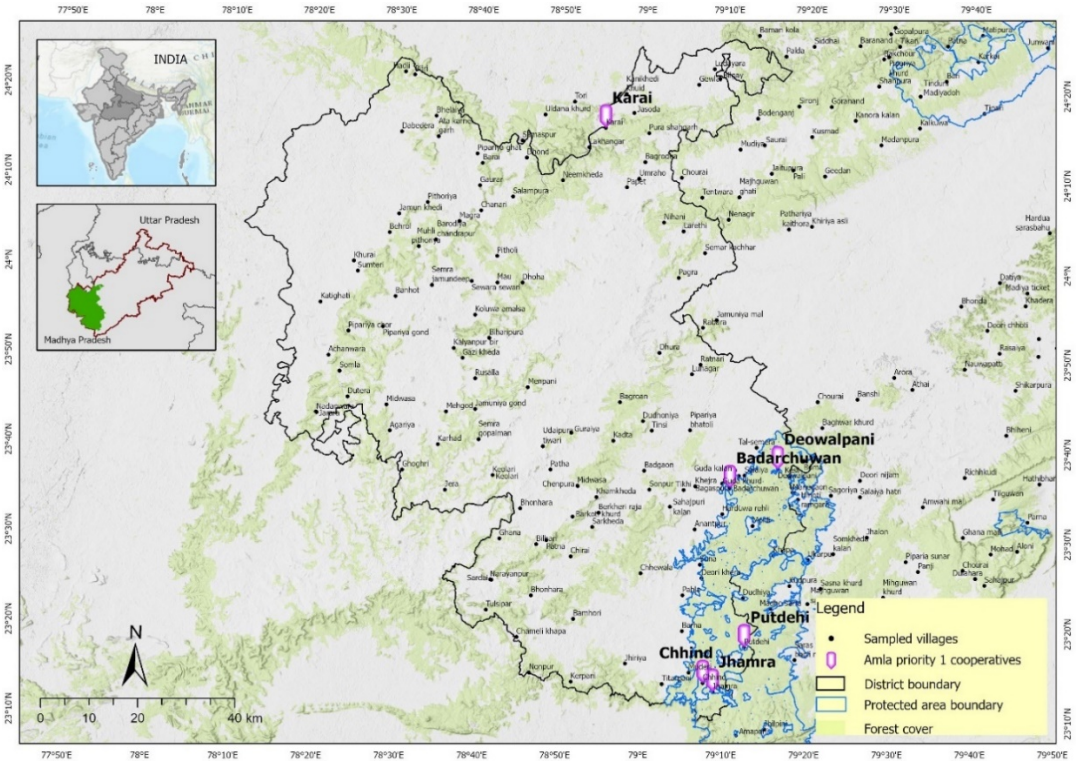
Appendix 10.16. Map showing villages within Satna District where Tendu growth centres are proposed



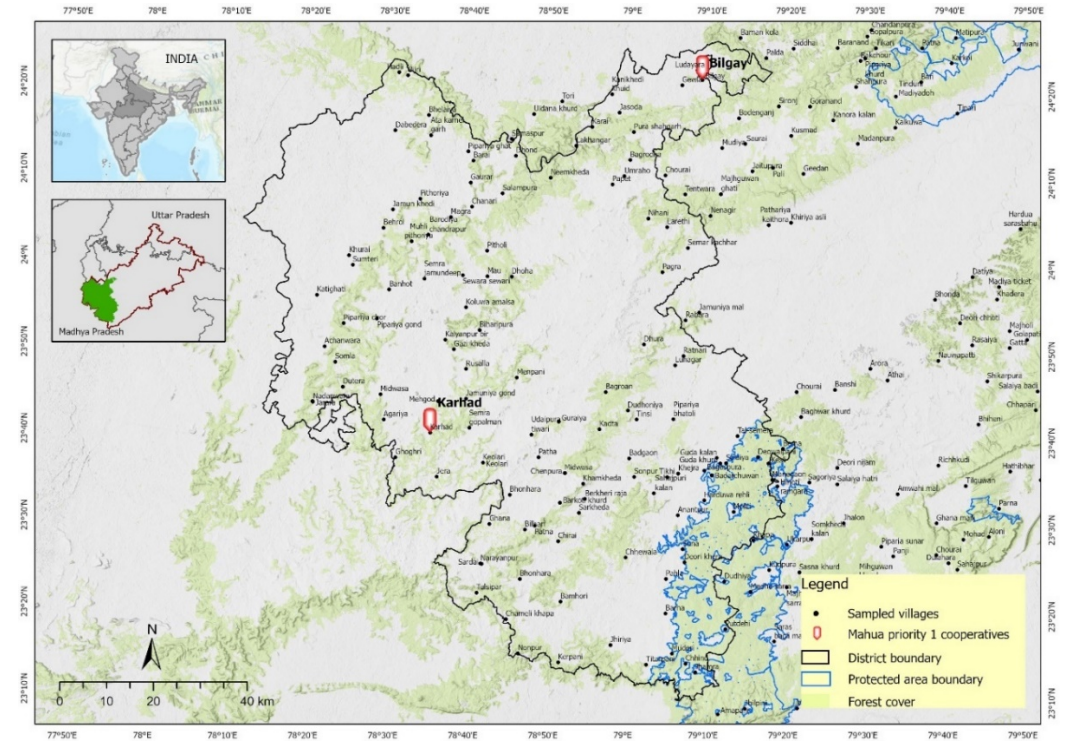
Appendix 10.17. Map showing villages within Rewa District where Amla growth centres are proposed



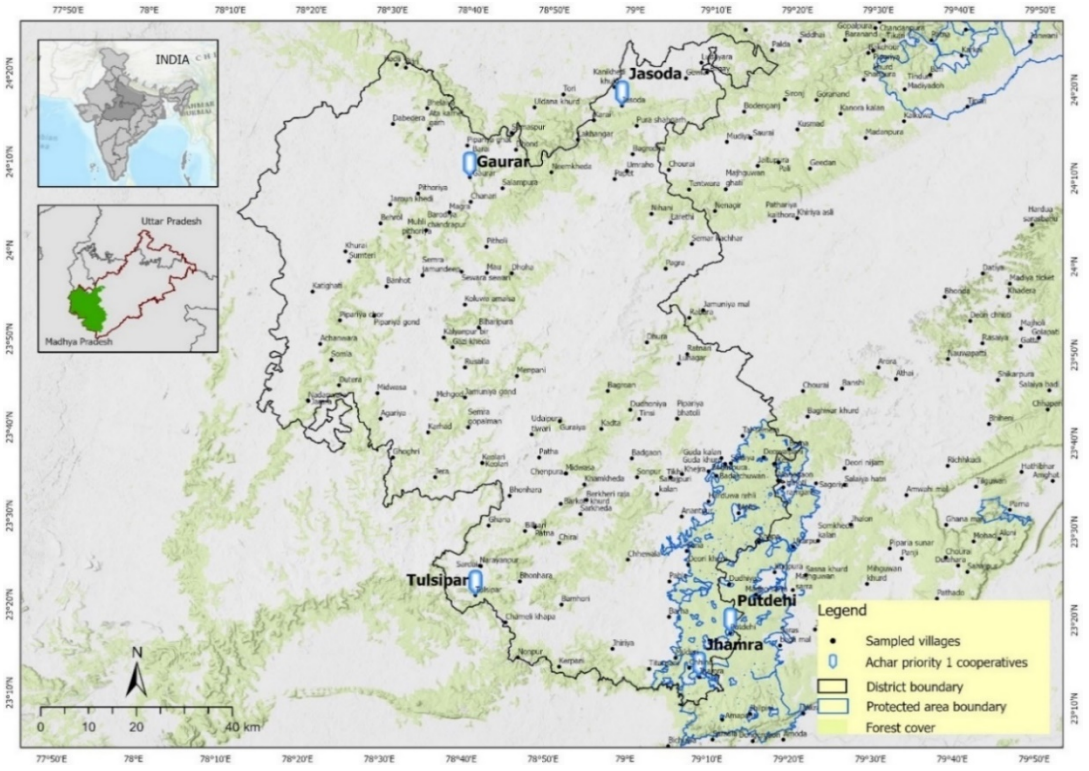
Appendix 10.18. Map showing villages within Rewa District where Mahua growth centres are proposed



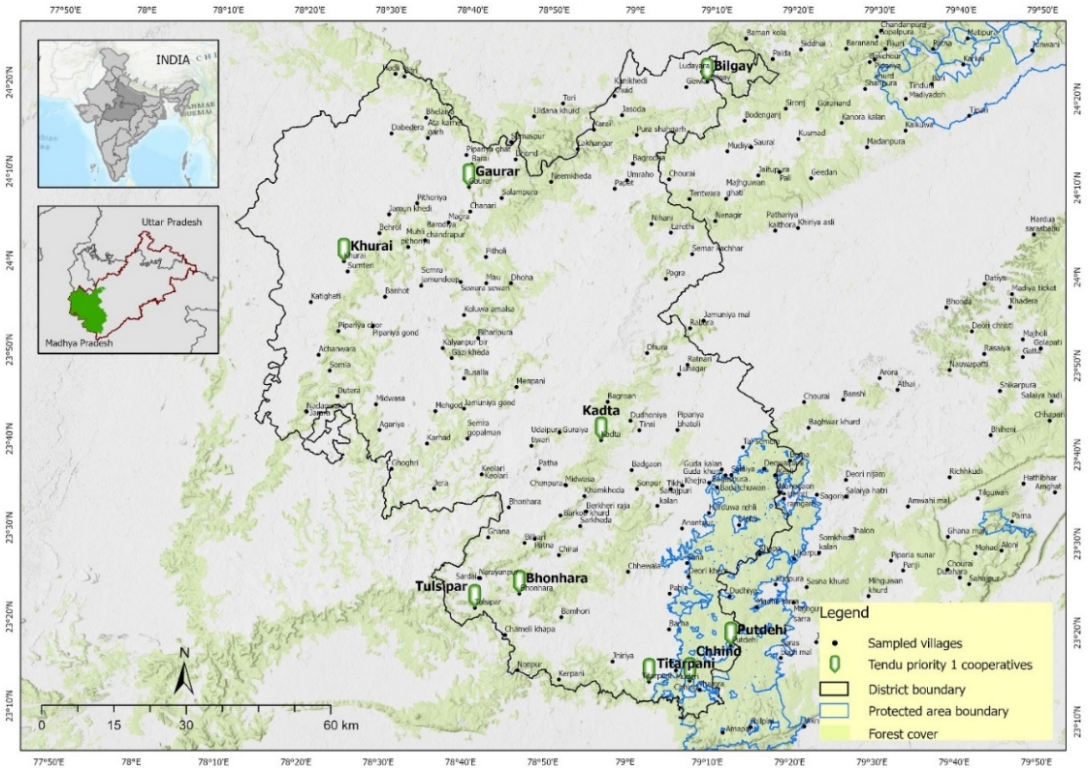
Appendix 10.19. Map showing villages within Sagar District where Amla growth centres are proposed



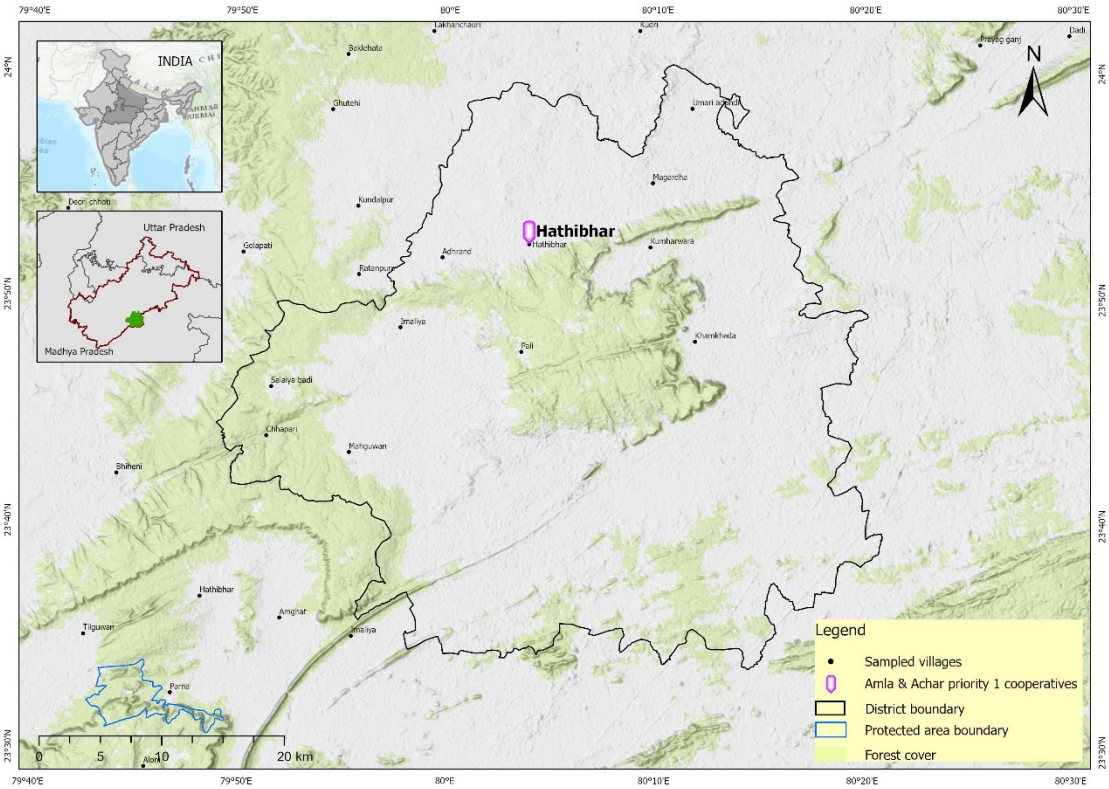
Appendix 10.20. Map showing villages within Sagar District where Mahua growth centres are proposed



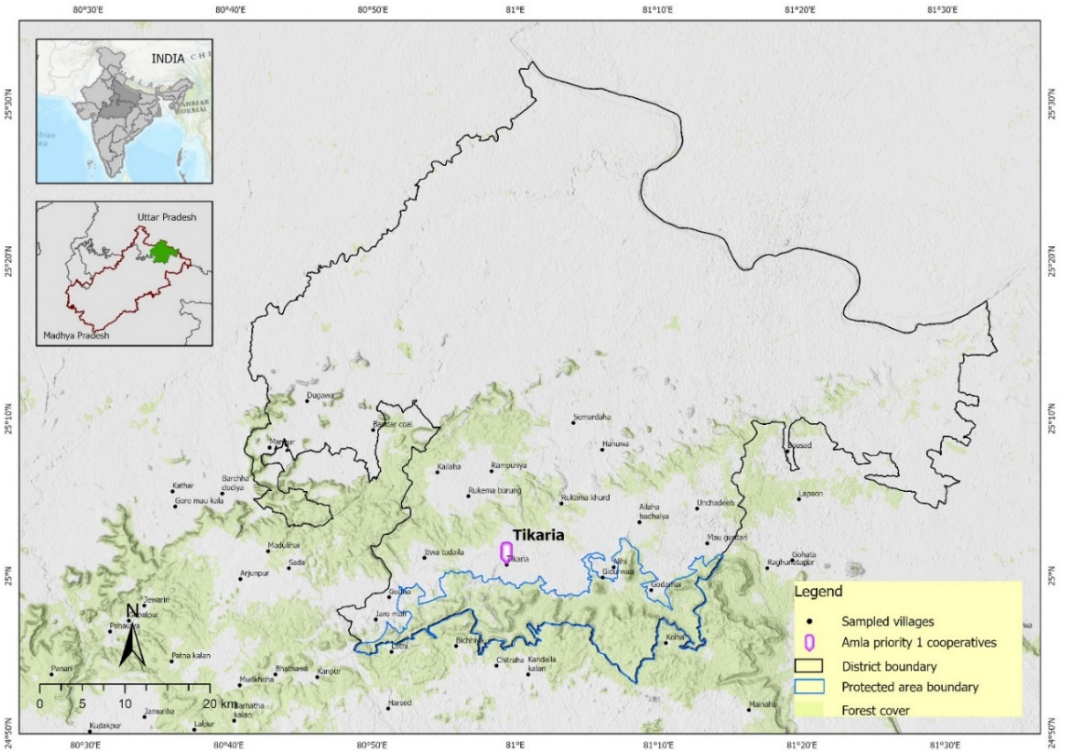
Appendix 10.21. Map showing villages within Sagar District where Achar growth centres are proposed



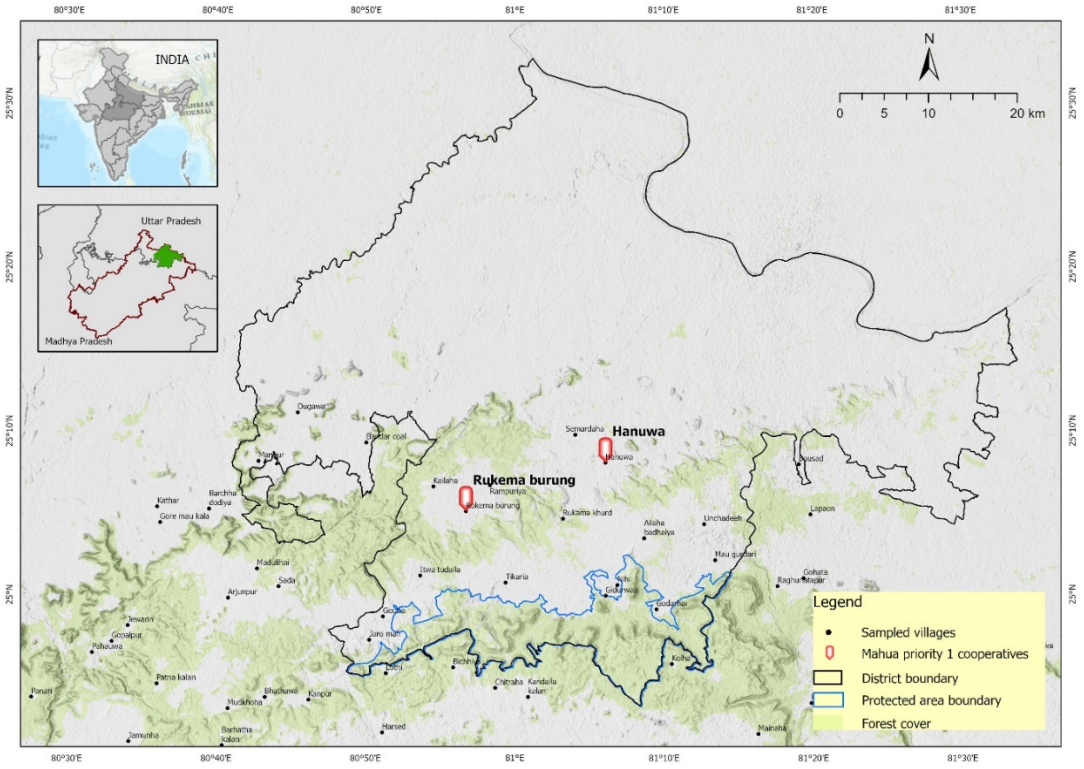
Appendix 10.22. Map showing villages within Sagar District where Tendu growth centres are proposed



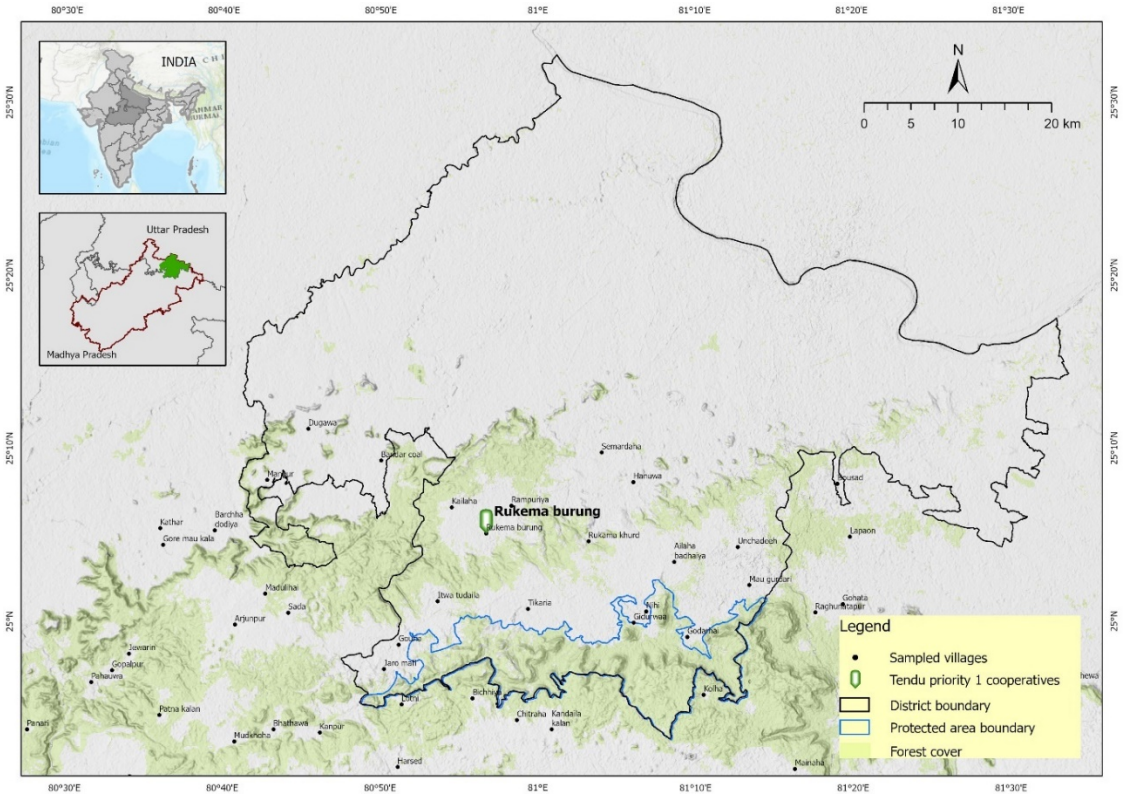
Appendix 10.23. Map showing village within Katni District where Amla and Achar growth centres are proposed



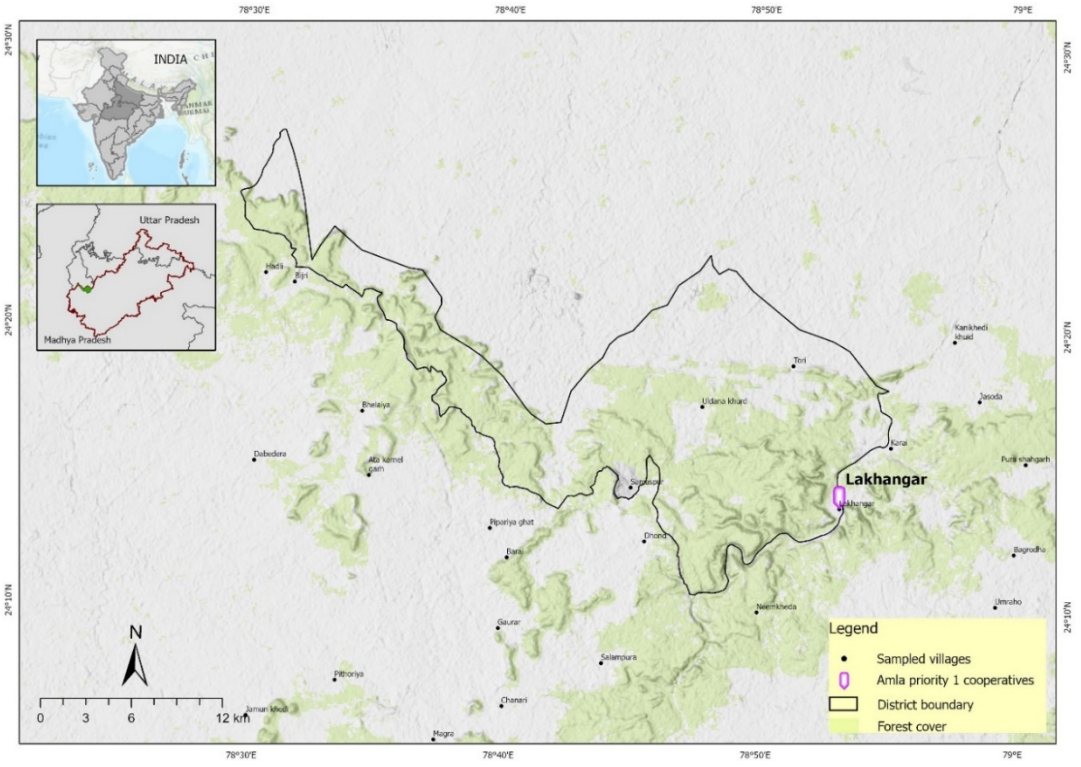
Appendix 10.24. Map showing villages within Chitrakoot District where Amla growth centres are proposed



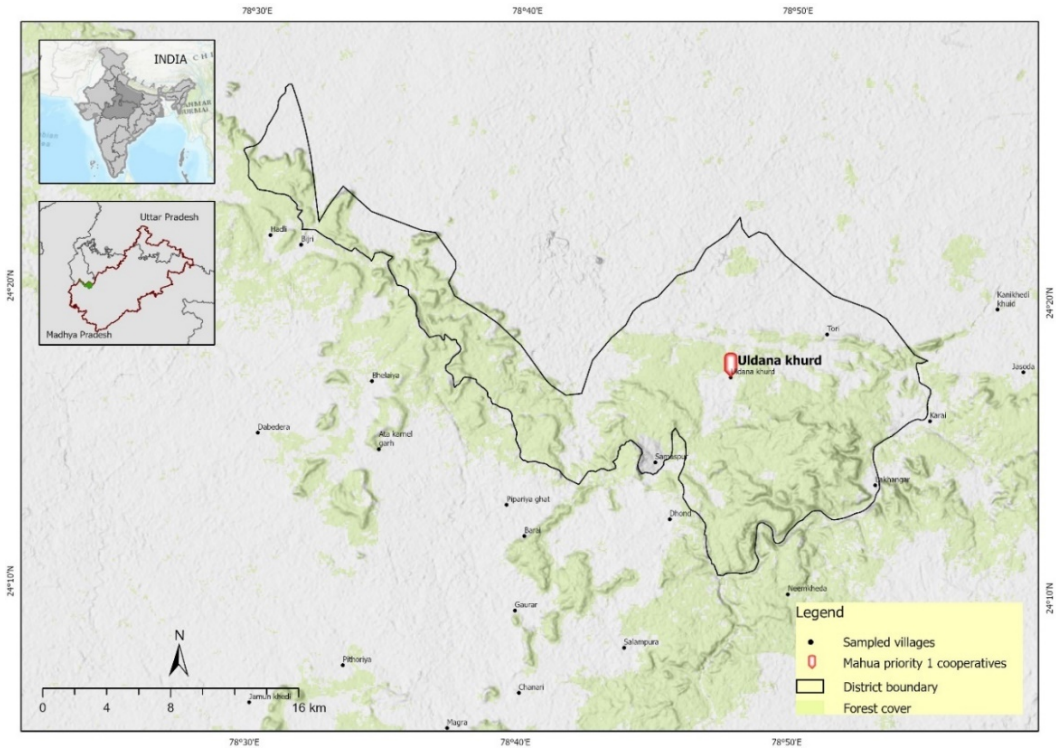
Appendix 10.25. Map showing villages within Chitrakoot District where Mahua growth centres are proposed



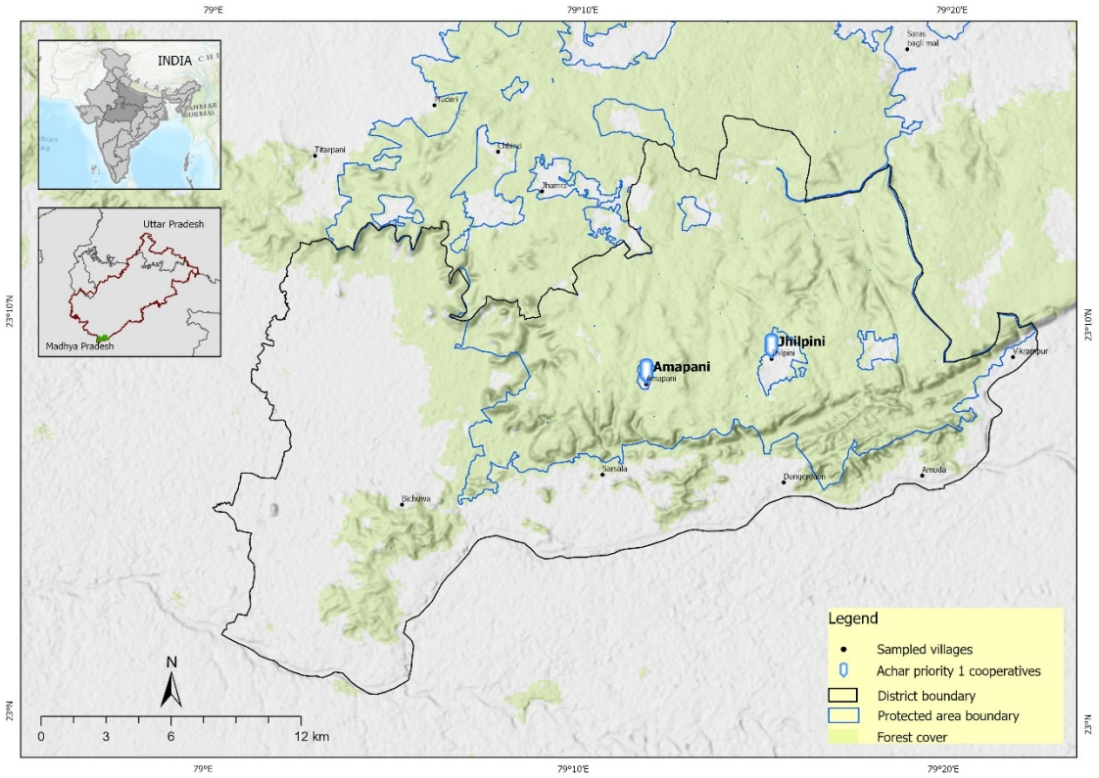
Appendix 10.26. Map showing villages within Chitrakoot District where Tendu growth centres are proposed



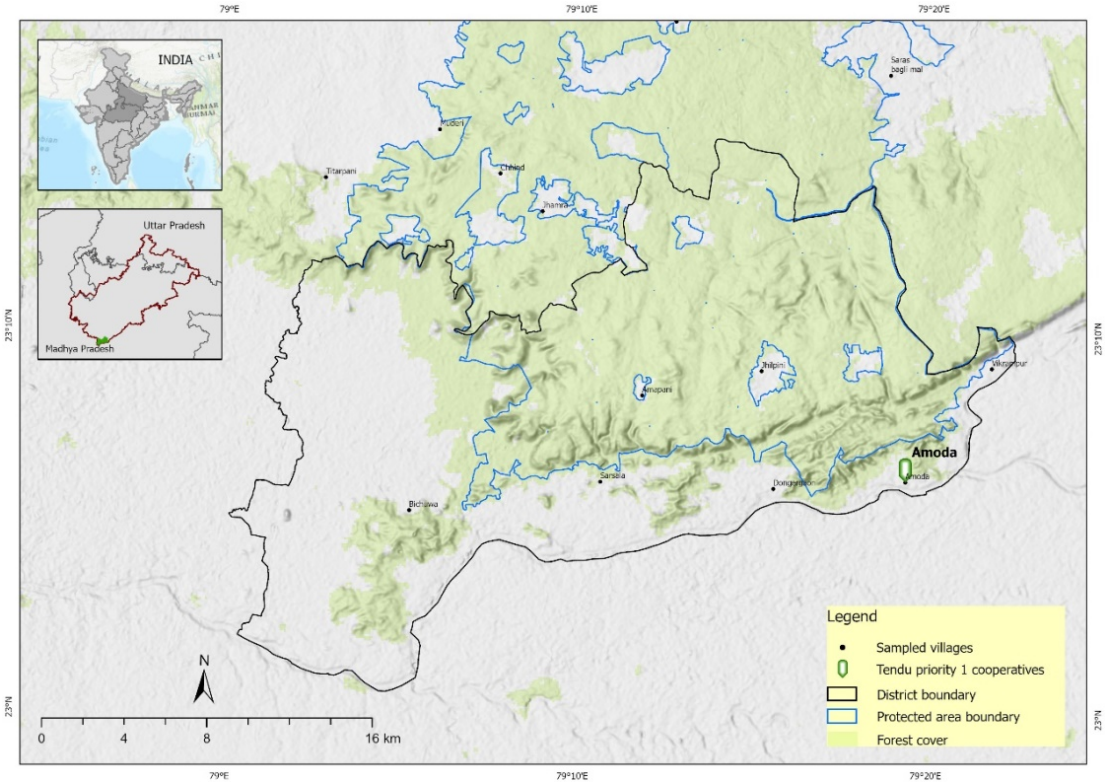
Appendix 10.27. Map showing villages within Lalitpur District where Amla growth centres are proposed



Appendix 10.28. Map showing villages within Lalitpur District where Mahua growth centres are proposed



Appendix 10.29. Map showing villages within Narsinghpur District where Achar growth centres are proposed



Appendix 10.30. Map showing villages within Narsinghpur District where Tendu growth centres are proposed

Project Team

Project Advisors: Dr. V.B. Mathur, Dr. Dhananjai Mohan and Dr. S.P. Yadav

Name	Designation	Component	Qualification/specialization
Dr. K. Ramesh	Scientist E	Overall in-charge and implementation of the project	Ph. D. in Forest Ecology and Environment
Dr. J. A. Johnson	Scientist E	Aquatic system	Ph. D. in Zoology
Dr. Bindu Raghavan	Prodessional Fellow	One Health	Ph. D. in Immunology & Infectious Diseases
Dr. Satyam Verma	Project Scientist	Coordination and landscape management	Ph. D. in Ecology and Environmental Sciences
Ms. Manjari Malviya	Project Scientist	Coordination and human-wildlife interface	M.Sc. in Forestry (Ph. D. in Wildlife Sciences submitted)
Mr. R. Rajasekar	Senior Project Fellow	Mammals	M.Sc. in Wildlife Biology
Mr. Sankarshan Chaudhuri	Senior Project Fellow	Mammals	M.Sc. in Forestry
Mr. Supratim Dutta	Project Associate	Mammals	M.Sc. in Zoology
Ms. Nazrukh Sherwani	Project Fellow	Mammals	M.Sc. in Environmental Science
Mr. Manu Mohan K	Project Assistant	Mammals	M.Sc. in Wildlife Science
Mr. Ajay Singh	Project Fellow	Vegetation and mammals	M.Sc. Environment Management
Ms. Susmita Khan	Project Fellow	Mammals and birds	M.Sc. in Environmental Science
Mr. Dibyendu Biswas	Project Fellow	Vulture	M.Sc. in Ecology and Environment Studies

Ms. Zainab Khan	Project Associate	Birds	M.Sc. in Wildlife Science
Mr. Vishal Prasad	Project Fellow	Herpetofauna	M.Sc. in Environmental Science
Mr. Niket Alashi	Project Assistant	Crocodile	M.Sc. in Biodiversity and Conservation
Ms. Pallabi Mitra	Project Fellow	Fishes	M.Sc. in Environmental Management
Mr. Amit Kaushik	Project Fellow	Socioeconomics	M.A. in Environment and Development
Ms. Srishti Manna	Project Associate	Socioeconomics	M.Sc. in Environment Management
Mr. Shri Lak	Project Assistant	One Health	M.Sc. in Health Sciences
Ms. Kamna Pokhariya	Project Associate	RS and GIS, Ecosystem services	M.Sc. in Remote sensing and GIS
Mr. Babu Lakhan	Project Fellow	RS and GIS, Database management	M.Sc. in Remote Sensing and GIS, and Geography
Ms. Priyanka Das	Project Fellow	RS and GIS, Database management	M.Sc. in Geo-informatics
Ms. Vandana Tomar	Project Assistant	RS and GIS, Database management	MSc in Remote sensing and GIS
Mr. Rahul Gandhi	Project Managesr	Project Management Unit	MBA in Finance and Marketing
Ms. Priyanka Kumari	Project Assistant	Project Management Unit	M.Sc. in Computer Applications
Mr. Ashish Kumar	Project Assistant	Project Management Unit	Graduation in Commerce

Resource Persons/Experts

Name	Designation	Component
Dr. Rajesh Gopal	Former Member Secretary NTCA, Secretary General Global Tiger Forum	Tiger, Integrated management
Dr. Kaushalendra Kumar Jha	Former PCCF, Uttar Pradesh and Professor, IIFM, Bhopal	Vulture
Dr. V.K. Melkani	Former PCCF and Head of Forest, Tamil Nadu	Community, Integrated management
Dr. Justus Joshua	Director and Principal Scientist, Green Future Foundation	Biodiversity, Vulture
Dr. Venkatesh Dutta	Associate Professor Babasaheb Bhimrao Ambedkar University	Integrated management
Dr. Ambika Ayyadurai	Assistant Professor IIT Gandhinagar	Community
Dr. Aishwarya Maheshwari	Assistant Professor, Banda University of Agriculture and Technology	Integrated management
Dr. Sujata Upgupta	Independent Researcher	Integrated management, Biodiversity
Dr. Neetika Mehta	Visiting Faculty University of Petroleum and Energy studies	Community
Dr. Ankita Sinha	Project Scientist, Biosciences, National Mission on Himalayan Studies, GBPNIHE, Almora	Biodiversity, Vulture

Project Interns

Name	Component
Ms. Meera Makwana	Tiger
Ms. Purnima Singh	Tiger
Ms. Mamta Nayal	Tiger
Ms. Subhechha Tapaswini	Tiger
Mr. Tryambak Dasgupta	Tiger
Ms. Neelanjana Saha	Vulture
Mr. Himadri Halder	Vulture
Mr. Shantanu Ekbote	Vulture
Ms. Anjali Verma	Crocodile
Mr. Amaljith AT	Biodiversity
Mr. Bijay Thakur	Biodiversity
Ms. Pompi Halder	Biodiversity
Mr. Satyasarathi Mishra	Biodiversity
Mr. Shailesh Kumar	Biodiversity
Mr. Kamran Husain	Biodiversity
Ms. Bhavika Vaghjiani	Biodiversity
Ms. Avishna Arappil	Biodiversity
Mr. Harbhajan Patel	Biodiversity
Mr. Geet Kale	Biodiversity
Ms. Priya Pradhan	Community
Ms. Nancee Uniyal	Community
Ms. Shivashri Rajput	Community
Ms. Khushboo Kumari	Community
Ms. Shivani Kukreti	Community

Project Assistants

Name	Component
Mr. Darshan Singh	Field Coordination & Logistics
Mr. Shivpratap Barman	Tiger
Mr. Puran Raikwar	Tiger
Mr. Pappu Gaderiya	Tiger
Mr. Amar Yadav	Vulture
Mr. Manoj Gond	Vulture
Mr. Rajesh Ahirwar	Vulture
Mr. Ramzaan Khan	Crocodile
Mr. Ravi Singh Yadav	Biodiversity
Mr. Bablu Gond	Biodiversity
Mr. Arun	Biodiversity
Mr. Betu	Biodiversity
Mr. Rajkumar Gond	Biodiversity
Mr. Rajan Khatik	Community
Mr. Kamal Ahirwar	Community
Mr. Tinku Raikwar	Basecamp support
Mrs. Anjana Raikwar	Basecamp support


राष्ट्रीय जल विकास अभिकरण
NATIONAL WATER DEVELOPMENT AGENCY
जलमेव जीवनम्


National Tiger Conservation Authority
राष्ट्रीय व्याघ्र संरक्षण प्राधिकरण


भारतीय वन्यजीव संस्थान
Wildlife Institute of India


मध्य प्रदेश शासन
सत्यमेव जयते


वन विभाग उत्तर प्रदेश