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Government of India
Wildlife Institute of India, Dehradun
Wildlife Institute of India,
Chandrabani, Subhash Nagar, Dehradun, Uttarakhand

Dated: 08/06/2022

To

Shri Babita Adiley
C-52, Sector-1
Shanker Nagar, Raipur
Near Nagar Nigam Water Tank
492004

Registration Number : WLIOI/R/T/22/00004

Dear Sir/Madam

I am to refer to your Request for Information under RTI Act 2005, received vide letter dated 07/05/2022 and to say that *kindly see the attached cover letter and Annexure-I is being sent by email to you dated 8 June 2022 due to its large size..*

In case, you want to go for an appeal in connection with the information provided, you may appeal to the Appellate Authority indicated below within ***thirty days*** from the date of receipt of this letter.

Dean, FWS
FAA & Dean
Address: Wildlife Institute of IndiaChandrabaniDehradun
Phone No.: 01352646202

Yours faithfully

(Rajiv Mehta)
CPIO & Deputy Registrar
Phone No.: 9286140979
Email : dyregistrar@wii.gov.in

सूचना का अधिकार
RIGHT TO INFORMATION

भारतीय वन्यजीव संस्थान
Wildlife Institute of India

No. WII/RTI/CPIO/2022-23 (Qtr-I)/19

Date: 8th June 2022

To,

Mr. Babita Adiley
C-52, Sector-1,
Shanker Nagar, Raipur,
Near Nagar Nigam Water Tank,
Chattisgarh, Pin:492004
Email: babitaadiley567@gmail.com

Sub.: Information under RTI Act, 2005–reg.

Ref.: Your Online RTI No. WLIOI/R/T/22/00004 dated 25/05/2022 transferred from Ministry of Environment, Forest and Climate Change on 25/05/2022 with Reference Number MOENF/R/E/22/00441

Sir,

Please refer to your application cited above under RTI Act, 2005. In this context, point-wise response to your queries is given below:

Information Sought under RTI	Reply
1. Copy of Biodiversity study in the entire Hasdeo -Arand coalfield comprising of Tara, Parsa, Parsa East & Kanta Basan and Kente Extension coal blocks in Chhattisgarh.	The consolidated report was compiled by ICFRE and is not available with WII.
2. Copy of Biodiversity assessment done by Wildlife Institute of India in Hasdeo Arand coalfields, Chhattisgarh	The WII report submitted to ICFRE is attached herewith as **Annexure-I**

If you are not satisfied with the above reply, you may appeal to the Appellate Authority of Wildlife Institute of India, Dehradun.

Thanking you,

Yours faithfully,

Rajiv Mehta

(Rajiv Mehta)
CPIO

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Biodiversity assessment with emphasis on select faunal groups in the Hasdeo Arand Coal Field, Chhattisgarh

Biodiversity assessment with emphasis on select faunal groups in the Hasdeo Arand Coal Field, Chhattisgarh

Report submitted to

Indian Council for Forestry Research & Education (ICFRE)

भारतीय वन्यजीव संस्थान
Wildlife Institute of India

Citation: Wildlife Institute of India (2021). Biodiversity assessment with emphasis on select faunal groups in the Hasdeo Arand Coal Field, Chhattisgarh: Technical report. Wildlife Institute of India, Dehradun. Tr No/2021/08 Pp: 272.


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Government of Chhattisgarh for initiating the biodiversity assessment study in the Hasdeo - Arand coal fields comprising of Tara, Parsa, Parsa East & Kente Basan (PEKB), and Kente Extension. The PCCF (HoFF) and the PCCF (Wildlife and Biodiversity Conservation) & the CWLW, APCCF (Wildlife) and DCF (Wildlife, HQ) are gratefully acknowledged for the permits and field logistics.

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ABBREVATIONS

TR = Tiger Reserve

WS = Wildlife Sanctuary

PA = Protected Area

MCP = Minimum Convex Polygon (an estimate of animal home ranges)

PF = Protected Forest

RF = Reserved Forest

ICFRE = Indian Council for Forestry Research and Education

MT = Metric tonne

MTPA = Metric tonne per annum

MW = Megawatt

FAC = Forest Advisory Committee of the Hon'ble Supreme Court

NGT = Hon'ble National Green Tribunal

SC = Hon'ble Supreme Court of India

MoEF&CC = Ministry of Environment, Forests and Climate Change, Government of India

HEMM = Heavy Earth Moving Machinery

PM = Particulate matter

SPM = Suspended Particulated Matter

CHP = Coal handling Plants

STP = Sewage Treatment Plant

SO_2 = Sulphur Dioxide

NO_X = Nitrogen Oxide

TPH = Total Petroleum Hydrocarbon

OB = Over burden

ETP = Effluent Treatment Plant

STP = Sewage Treatment Plant

ICMM = International Council for Mining and Metal

CSR = Corporate Social Response

VFR = Village Fodder Committee

CR = Conservation Reserve

GIS = Geographic Information System

GPS = Global Position System

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"Diversion of forest lands for coal mining in Category-A areas, which are rich repository of biological wealth of the country will have avoidable serious impacts on forests and wildlife. In case coal mining is undertaken in these areas, even after best efforts in afforestation and reclamation, it will not be possible to retrieve their intricate biological features of biodiversity.

- Comments of MoEF&CC on a draft note for cabinet infrastructure regarding the need for making available more coal bearing areas for enhancing coal production

EXECUTIVE SUMMARY

In India, the coal reserves predominantly occur in the Gondwana sediments of the East Central region in the states of Odisha, Jharkhand, Chhattisgarh, Madhya Pradesh and parts of West Bengal. **The Hasdeo - Arand coal fields comprising of Tara, Parsa, Parsa East & Kente Basan (PEKB), and Kente Extension (collectively known as HACF henceforth in the report)** in Chhattisgarh is one of the identified coal-bearing areas. More than 80% of the HACF and the landscape surrounding it is forested. The coal blocks demarcated HACF and the landscape surrounding it mostly occur in the forests. The Ministry of Forests and Climate Change, Government of India under section 2 (ii) of Forest Conservation Act vide F.Bo.8-31/210-FC dated 6th July 2011 granted in-principle (Stage I) forest clearance for diversion of 1898.328 hectares of forest land in Parsa East and Kante Besan captive coal block (PEKB coal block) situated in Surguja Forest Division. This approval was given despite the FAC recommending to reject this proposal in FAC meeting dated 23rd June 2011. Subsequently, the Stage II final forest clearance was granted by Government of India vide MoEF&CC's letter no 8-31/2010/FC dated 15th March 2012.

Aggrieved by the clearance granted by the MoEF&CC, an appeal no 73 of 2012 (Sudiep Shrivastava Vs Union of India Ors) was filed in the Hon'ble National Green Tribunal (NGT) principal bench in Delhi. The Hon'ble NGT pronounced its judgement on 24th March, 2014 directing MoEF&CC to seek a fresh advisory from the FAC with emphasis on seeking answers to the following questions: (reproduced from the order) *- (i) What type of flora and fauna in terms of bio-diversity and forest cover existed as on the date of the proposal in PEKB Coal Blocks in question. (ii) is/was the PEKB Coal Blocks habitat to endemic or endangered species of flora and fauna. (iii) Whether the migratory route/corridor of any wild animal particularly, elephant passes through the area in question and, if yes, its need. (iv) Whether the area of PEKB Block has that significant conservation/protection value so much so that the area cannot be compromised for coal mining with appropriate conservation/management strategies. (v) What is their opinion about opening the PEKB Coal Blocks for mining as per the sequential mining and reclamation method proposed as well as the efficacy of the translocation of the tree vis-a-vis the gestation period for regeneration of the flora (vi) What is their opinion about the Wildlife Management plan finally prescribed. (vii) What conditions and restriction do they propose on the mining in question, if they favour such mining?*

The judgement granted liberty to FAC to get expert opinion/specialized knowledge/advice from authoritative sources such as Indian Council of Forestry Research and Education (ICFRE), Dehradun or Wildlife Institute of India (WII). This judgement of the Hon'ble NGT and stage-I clearance granted for prospecting over 1745.883 hectares of forest land of Kente Extension coal block for exploration of coal reserves vide MoEF&CC letter No. F.No 8-46/2017-FC dated 19th December 2017 impose a condition that a biodiversity assessment study for entire HACF would be conducted by the State Government of Chhattisgarh through ICFRE, Dehradun in consultation with the WII . The condition is reproduced for reference: *"(ii) A biodiversity assessment study is to be conducted by the state government through ICFRE, Dehradun in consultation with the Wildlife Institute of India, Dehradun for the whole Hasdeo Arand coal field comprising of Tara, Parsa, Parsa East, kante to be funded by M/s Rajashthan Rajya Vidyut*

Utpadan Nigam Limited (RRVUNL). The study is to be awarded by the state Government by associating the Indian Council of Forestry Research and Education (ICFRE) Dehradun or Wildlife Institute of India (WII) and integrated wildlife management plan (IWMP) will be prepared and conservation area will be identified and mitigation measures will be recommended by the expert committee. The cost of the study and cost of implementation of the recommendations shall be borne by the M/s Rajasthan Rajya Vidyut Utpadan Nigam Limited (RRVUNL). The report will be submitted within two years".

The main objectives of the biodiversity assessment that ICFRE and WII would jointly focus include:

- **a.** Provide details of flora & fauna with special reference to endemic/threatened species reported from the study area
- **b.** Describe the habitat for such endemic/threatened species and identify likely threats for conservation
- **c.** Details of migratory route/corridor/critical areas for wildlife species especially umbrella species like elephants and tigers
- **d.** Document socio-economic values of the affected area vis-à-vis biodiversity values
- **e.** Consult with forest department officials, local communities in HACF and
- **f.** Identification of conservation areas within HACF

Consequently, the biodiversity assessment focusing on faunal aspects of HACF was carried out by WII with ICFRE as the nodal agency for the overall assessment.

The biodiversity assessment focusing on faunal aspects carried out by WII in the HACF and the landscape surrounding it using on-foot sign surveys and camera trap surveys (for mammalian baseline assessment); transect surveys (for avifaunal baseline assessment), *ad libitum* sampling for Herpetofauna in conjunction with secondary data and information obtained from Chhattisgarh Forest Department and the village interview surveys established the ecological baseline information on faunal biodiversity. **It is envisaged in the ToR that impact assessment would be done for the Hasdeo-Arand coal field comprising of Parsa, Parsa East & Kente Basan (PEKB), Tara Central and Kente Extension coal blocks. Of the four coal blocks mentioned, only PEKB is currently operational. Therefore, WII's impact assessment (Chapter-7), mitigation of impacts (Chapter-8) and preparation of biodiversity conservation and management plan (Chapter-9) focuses on PEKB coal block. Nevertheless, landscape-level suggestions for managing wildlife in HACF and the landscape surrounding it have been detailed in the report.**

Opencast mining and associated developmental activities in forested habitats could potentially affect a variety of taxonomic groups. Nevertheless, measurement of every aspect of biodiversity in forested landscapes that span several hundred squares kilometers of mosaic habitats in a short period of time is seldom easy. In order to overcome this constraint, short-cut approaches that focus on monitoring large mammal populations, which serve as keystone, flagship or umbrella species have been advocated. As this biodiversity assessment, impact assessment and mitigation strategies are to be studied at a landscape level, this study emphasized specially on the "umbrella species concept". The umbrella species concept is a globally accepted concept wherein conservation efforts targeted for a well-chosen representative species can confer a protective umbrella to numerous other co-occurring species in the

landscape. Asian elephant and tigers serve as umbrella species in the tropical forested landscapes. Both tigers and elephants are long ranging and have specific ecological needs. Understanding the ecological requirements of these species can augur well for all other species found in the landscape.

The results of the assessment show that HACF and the landscape surrounding it is rich in fauna. The HACF and landscape surrounding it supports over 25 species of mammals. The mammals of the Order Chiroptera and Rodentia (except for *Ratufa indica* that is included in the list) were not surveyed as that would require a long term duration and thus, the number of species reported in the assessment is best considered minimal. Among the mammal species recorded the Hasdeo – Arand area, **nine species are listed in the Schedule - I, which are accorded the highest level of legal protection under the Wildlife (Protection) Act, 1972**. Mammalian species diversity includes threatened large carnivores like common leopard, Indian grey wolf, striped hyena, sloth bear, and others that appears to be widely distributed as evidenced by camera trap captures as well as detections during sign surveys. **The Hasdeo Arand area is spread across three districts, *viz.* Surguja, Surajpur and Korba. The Korba district has two Forest Divisions (FD) *viz.* Korba FD and Katghora FD. The Korba FD had reported occurrence of tigers**. **The habitat connectivity between HACF along with the landscape surrounding it, and Achanakmar TR, Boramdeo WS and Kanha TR is strong, and may support sporadic tiger dispersal**.

Elephant occurrence was reported by the Forest Department in 148 out of 647 compartments in HACF and the landscape surrounding it with an area of 363.98 km^2 during the period 2018 to 2020. The elephant occurrence is not restricted to any particular area and is spread across the landscape (Map-21, page 56). A conservative estimate of about 40 to 50 elephants could use different parts of the landscape at different times of the year. Human–elephant conflict in the form of crop losses and occasional property damage is widespread too. Elephant conservation and management in the landscape hinges on effective conflict resolution strategies by actively engaging with local communities and at the same time enriching the habitat condition for elephants.

Chhattisgarh human-elephant conflict situation is a paradox with a relatively low number of elephants (<300, which is <1% of India's wild elephant population) but high levels of HEC with over 60 human lives are lost every year due to conflict (>15% of the reported human deaths due to HEC). In addition to loss of human lives, crop loss and damage to property due to HEC are severe. There is continuous dispersal of elephant herds from the neighbouring states of Jharkhand and Odisha. The study carried out by WII in collaboration with Chhattisgarh Forest Department from the year 2017 onwards clearly highlight that elephants have large home ranges. The forests that elephants currently occur are highly fragmented and degraded due to incompatible land-use. Infrastructure development and mining are further fragmenting the habitats making conflict mitigation a huge challenge. In fragmented habitats conventional fencing approaches minimally work due to high perimeter to area ratio of habitats.

The EC region harbours less than 1/10th (<3000) of country's elephants, but loses over 40% (over 200 HEC-related deaths) of reported 500 HEC-related human fatalities in the country. The HEC-related

human fatalities reported in the region are highly disproportionate to its elephant population in the country. The increasing levels of HEC have resulted in considerable public resentment against the management and elephant conservation as a whole. HEC resolution is challenging in EC region due to fragmentation, loss and degradation of intact elephant habitats. In highly fragmented areas, the elephant home ranges tend to be large as small, degraded forest patches cannot sustain herds. It is observed that home range size is a function of habitat quality – in areas that support good intact habitats, the elephant home ranges are relatively small (eg. Rajaji, Mudumalai etc). However, in fragmented areas, elephant home ranges are typically large. The elephant herds are generally interlinked and home ranges spread over two or more states.

One of the main reasons as to why elephants start dispersing into human-use areas is the threat to habitat. In particular, threat to elephant home ranges. While threat to habitat can be identified and sometimes even addressed, threats within individual home ranges of elephants are hard to evaluate and hence, difficult to mitigate. The latter threats are more insidious and lasting. Major disturbances to habitats such as mining not only cause habitat loss and fragmentation (as understood generally) but can affect individual herd's home ranges. Such disturbances can lead to abandonment of habitats as threats to home ranges have a threshold limits. The effect of mining on elephant habitat may not reflect in the same habitat, but could be a silent trigger for HEC in some other area within the landscape. In general, one of the reasons for HEC being disproportionately high in EC region is the elephant dispersal from forest habitats through fragmented human use areas. This large scale elephant dispersal out of intact forests coincide with commencement of large-scale mining projects and associate infrastructure developments in the EC region, particularly in the states of Odisha and Jharkhand.

During the biodiversity assessment, a total of 92 species of birds were recorded with in HACF and the landscape surrounding it. The list is best considered minimal. As per the ebird (https://ebird.org/) a total of 406 species of birds have been reported in the three districts of Surguja, Surajpur, and Korba – the districts in which the HACF and the landscape surrounding it occurs. It is quite likely that many of the species of birds reported in HACF either use or pass through it. However, it may be noted that HACF and the landscape surrounding it just supports ~ 12.4% of the combined area (~ 15,110 km^2) of the three districts.

Local communities in HACF and the landscape surrounding it are predominantly tribal. The livelihood of local communities is closely dependent on forest resources. The NTFP collection (of four major commodities) contribute nearly 46% of the monthly income reported by the households. This does not include the fuelwood, fodder, medicinal plants, water and other resources that local communities collect from the forests. If such resources are pooled as income to local communities, it may be conservatively mentioned that over 60 to 70% of the total annual income of local communities come from forest-based resources. Thus, forest dependence substantially adds to income security of local communities. In addition to financial gains, forest produce collection is critical for medicine, food and other health benefits thereby providing food security and overall well-being. The local communities have reported coming across a variety of wildlife in and around their settlements. A few respondents (n = 4) have even sighted tiger in and around their settlements. They expressed concern about human-wildlife conflict involving

crop losses, loss of livestock, loss of property and occasional loss of human lives. Garnering the support of local communities for wildlife conservation would be conditional on addressing human–wildlife conflict on a real-time manner. In general, the local communities are apprehensive of mining, which is perceived as a threat to livelihood as the land as well as forests are lost in the process of mining. The community respondents interviewed expressed concern and were anxious over loss of forests (and consequently material base for livelihood) and loss of land due to mining. The loss of forests due to mining is perceived as a direct threat to livelihood by the local communities. The local communities express positivity towards forest conservation and at the same-time insist on timely resolution of human–wildlife conflicts. Conservation initiatives in the landscape need to be participative and actively involve local communities. Considering this, as part of the biodiversity assessment, and as envisaged in the ToR of the study, the impact of the ongoing mine of PEKB in the HACF has been assessed.

It may be noted that the impact assessment carried out by WII for PEKB coal block is not a true Environmental Impact Assessment (EIA) as PEKB coal block is already operational covering nearly 1000 hectares of the 1898 hectares cleared for mining. Coal extraction is already being done and is in operational stage. Therefore, visualizing the true picture of the likely impacts on the physical environment as well as the wildlife the area supports is not possible. Nevertheless, selected impacts of the physical environment that are likely to impact directly on select biodiversity and social values in the PEKB operation have been identified. For this purpose, the faunal biodiversity list provided by Indian Institute of Forest Management (IIFM) as part of the EIA for PEKB (IIFM, 2009) was used as the baseline for evaluating the impacts. In general, the impact assessment methods argue that the foremost step in impact appraisal must consider and identify project actions that are likely to bring significant changes in the project environment. Such impacts include: physical, biological and social environments. The potential impacts due to ongoing mining operations of PEKB on physical environment, fauna and local communities have been elaborated in Chapter-7.

The possible mitigation strategies for addressing the impacts of PEKB include progressive restoration, development of grass and leaf fodder plots, livelihood options to increase income sources, bio-filter check dams in the streams of the project sites, green-belt development – phytoremediation, development of “Green Gallery Belt”, eco-restoration of waste dump, construction of underpasses, construction of pipe and box culverts as safe passages in the roads as mitigation strategies for reducing road mortality. The detailed mitigation strategies have been provided in Chapter 8.

The biodiversity conservation and management for PEKB focusing on species groups, threatened plant & animals, resource base of local communities along with the social values have been given in detail in Chapter 9. The Human-Elephant conflict mitigation strategies in the HACF and surrounding landscape should include the following:

1. Maintaining the ecological integrity of intact natural habitats without fragmentation and degradation is critical. Any additional mining leading to loss of habitat would escalate HEC unpredictably high
2. Formation of landscape-level Rapid Response Teams by engaging village youth with adequate remuneration is essential. The RRT members should be adequately trained in elephant behaviour and conflict management methods.

3. Judicious use of mobile barriers in select areas of HACF and surrounding landscape where HEC is high need to be experimented with active community participation.
4. Ex gratia payment for crop, property and other losses due to elephants have adequate and timely. The overall process of filing and obtaining compensation by villages should be made smooth and transparent
5. Habitat enrichment by improving surface water availability in carefully selected locations, development of grasslands and fodder base based on the list of plants suggested in the report and protection of critical micro-habitats such as riparian tracts are critical (Refer Table 9.23).
6. Human-elephant conflict is dynamic in nature. The above mentioned mitigation measures need to be experimented in smaller areas and based on the evaluation of efficacy can be scaled up.

Question wise answers sought by the Hon'ble NGT judgement on 24th March, 2014 is provided below:

(i) What type of flora and fauna in terms of bio-diversity and forest cover existed as on the date of the proposal in PEKB Coal Blocks in question?

The faunal biodiversity that did occur in PEKB during the time of proposal has been reported in the EIA prepared by IIFM. The details have been provided in Chapter-7 of the report. The faunal inventory that presently occur HACF and the landscape surrounding it has been elaborated in Chapter-1[1]

(ii) is/was the PEKB Coal Blocks habitat to endemic or endangered species of flora and fauna.

Yes, the PEKB coal blocks is/was habitat to rare, endangered and threatened fauna

(iii) Whether the migratory route/corridor of any wild animal particularly, elephant passes through the area in question and, if yes, its need.

Elephant occurrence was reported by the Forest Department in 148 out of 647 compartments in HACF and landscape surrounding it during the period 2018 to 2020. A conservative estimate of about 40 to 50 elephants could use different parts of the landscape at different times of the year. The HACF and the landscape surrounding it are part of the elephant range in northern Chhattisgarh and serves as both habitat and corridor for movement. The Korba Forest Division had also reported occurrence of tigers in the vicinity of HACF and the landscape surrounding it. The habitat connectivity between Hasdeo - Arand area and Achanakmar TR, Boramdeo WS and Kanha TR is strong, and may support sporadic tiger dispersal.

(iv) Whether the area of PEKB Block has that significant conservation/protection value so much so that the area cannot be compromised for coal mining with appropriate conservation/management strategies.

Yes. The biodiversity assessment focusing on faunal aspects carried out by WII suggests that HACF has significant conservation value. Nevertheless, the PEKB block is already

[1] The response pertaining to floral diversity shall be provided by ICFRE

operational during the time of WII's assessment and large tracts of forests have already been opened up for mining operations. Considering this, the proposed conservation/management strategies addressing the impacts of mining in PEKB coal block as described in Chapters-7,8 & 9 need to be complied with stringent monitoring by the State Forest Department.

(v) **What is their opinion about opening the PEKB Coal Blocks for mining as per the sequential mining and reclamation method proposed as well as the efficacy of the translocation of the tree vis-a-vis the gestation period for regeneration of the flora?**[2]

(vi) What is their opinion about the Wildlife Management plan finally prescribed?

The wildlife management plan is a legal document prepared for management of the notified protected areas under the Indian Wildlife (*protection*) *act, 1972. Since HACF is not a protected area, the term wildlife conservation plan is more appropriate. The wildlife conervation plan of Parsa East and Kente Basen open cast coal mine and washery project prepared by the project proponent is basic and generic in nature. Due to this, it requires substantial revision and the management prescriptions need to be spatially explicit and closely consider the ecological, behavioral and social dimensions of the landscape. A detailed review of the same was carried out and specific comments to improve the plan have been provided in Annexure I.*

(vii) What conditions and restriction do they propose on the mining in question, if they favour such mining?

As certain portions of the PEKB block has already been opened for mining, the mining operation may only be permitted in the already operational mine of the block. The other areas in HACF and landscape surrounding it should be declared as "no-go areas" and no mining should be carried out considering the irreplaceable, rich biodiversity and socio cultural values.

The HACF and the landscape surrounding it support rich biodiversity with a multitude of mammalian species including elephants and also harbours forest-dependent communities. Therefore, sustaining the forest cover and maintaining its overall ecological integrity is essential. It is pertinent that Chhattisgarh Forest Department with due consultation and involvement of local communities identify areas within HACF and the landscape surrounding it for declaration as Conservation Reserve (CR) under the Wildlife (Protection) Act, 1972. Under the ambit of a CR, habitat improvement activities such as restoration of grasslands and restoration of degraded forests; improving surface water availability in relatively drier tracts during summer, regulating forest fires, and improving overall protection can benefit biodiversity.

[2] The response pertaining to this query shall be provided by ICFRE as it deals with flora and efficacy of translocation of the tree vis-à-vis the gestation period for regeneration of the flora

The coal mines along with the associated infrastructure development would result in loss and fragmentation of habitat. Mitigating such effects on wildlife, particularly the animals with large home ranges such as elephants is seldom possible. The human-elephant conflict in the state is already acute and has been escalating with huge social and economic costs on the marginal, indigenous local communities. Any further threat to elephants' intact habitats in this landscape could potentially deflect human-elephant conflict into other newer areas in the state, where conflict mitigation would be impossible for the state to manage. Opening up of coal blocks for minging in the HACF would compromise the imperatives of biodiversity conservation and livelihood of forest-dependent local. Even the effects of the operational PEKB mine need to be tactfully mitigated too, wherever possible.

The assessment findings are in conformity with the study undertaken jointly by the Ministry of Coal and Ministry of Environment, Forests and Climate Change across nine coal fields across the country during the year 2009, where it was concluded that the Hasdeo–Arand coal fields in north-central Chhattisgarh is identified as a 'no-go' area. The findings of this joint study of 2009 culminated into an important policy decision towards facilitating an objective, transparent and informed decision regarding forest lands being diverted for coal mining projects. However, the findings of the study were set aside during 2011. Considering the need to reconcile country's developmental needs with conservation priorities, the recommendations of the 2009 joint study holds substantial importance for ecologically balanced sustainable growth.

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GENERAL INTRODUCTION

Rapidly developing India's energy demands are on the rise, and the current demand is expected to double by 2040 (Mishra 2004). Of the installed power generation capacity, over 70% of power is produced by coal-based thermal power plants as coal is the most abundant fossil fuel available in India (Mishra 2004). There is an estimated 106 billion tonnes of coal reserves in India, which constitutes about 10% of the global coal reserves. The largest coal-bearing regions are in the East-Central zone of the country in the classic Gondwana region, in the states of Jharkhand, Odisha, Maharashtra and Chhattisgarh. The state of Chhattisgarh is estimated to have around 17% (~ 57 billion tonnes) of the total coal reserves that is estimated to occur in the country. One of the biggest coal fields in Chhattisgarh is reportedly the Hasdeo–Arand coalfield with a total estimated reserve of 5.528 billion tonnes of coal deposits, located is the watershed of Rihand (of the Gangetic river system) and Hasdeo (of the Mahanadi river system). The mineral rich Hasdeo-Arand coal fields is also arguably one of the biodiverse region of the country that is dominated by extensive forest cover. Several rare, endangered and threatened species of flora and fauna are reportedly present in the landscape. The landscape also harbors both the National Animal and National Heritage Animal, the tiger, and Asian elephant respectively.

The total extent of HACF and the landscape surrdounding it is about 1878 km^2, spread over the four Forest Divisions of Katghora, Korba, Surguja and Surajpur in the districts of Surguja, Surajpur and Korba in Chhattisgarh. This study was carried out to assess biodiversity in HACF and landscape surrounding it (Map-1). For the purpose of biodiversity assessment in reference to faunal aspects, the Geo-spatial layers of HACF and the landscape surrounding it provided by ICFRE, Dehradun – Nodal Agency and collaborative partner of the study were used.

Chronology of events pertaining to forest diversion

The Ministry of Coal allotted Parsa East & Kente Basan coal block vide its letter dated 19/25.06.2007 to Rajasthan Rajya Vidyut Utpadan Nigam Limited (RRVUNL) to meet the requirement of coal for their two thermal power project viz. Chabra phase-II and Jhalawar projects. The approximate area of the project is 27.11 km^2 which is situated in district Surguja, Chhattisgarh. The area proposed for Parsa East & Kente Basan coal block open cast mine, fall under Udaipur Range of Surguja Forest Division, Ambikapur. Total forest area in 16 compartments of Phatchpu, Matringa, Gumga and Ghatbarra protected forest block is 1654 hectares and revenue forest land is 244 hectares. Total forest land 1878 hectares.

As per the shape file shared by ICFRE to WII, there are 23 demarcated coal blocks. All these proposed coal fields are in forest areas. The Ministry of coal, Government of India allotted Parsa East and Kente Basan coal blocks to Rajasthan Rajya Vidyut Utpadan Nigam Limited. The total mineable reserves of coal are 452.4 MT. The reserve shall last 49 years at estimated production 10 MTPA. Mining is proposed by open cast mining. The initial mining lease period proposed it 30 years which is renewable in future. The coal produced shall be used in two thermal power projects 2 x 250 MW project unit no. 3 & 4 and Kalisindh Thermal power project 2 x 600 MW district Jhalawar which are under construction phase and different units are likely to be commissioned between the period 31.10.2011 - 31.12.2012 and 31.12.2011 - 31.03.2012. respectively. A joint venture company M/s Parsa Kente Collaries Limited has been formed

between Rajasthan Rajya Vidyut Utpadan Nigam Limited (RRVUNL) and Adani Group for development of mines.

The Ministry of Environment and Forests and (MoEF) vide order 8-31/2010-FC dated 06/07/2011 provided Stage-I approval for PEKB in favour of M/s. Rajasthan Rajya Vidyut Utpadan Nigam Ltd., (RRVUNL) for diversion of about 1898.3 hectares of forest land from PEKB for opencast coal mining based on the order dated 23.06.2011 by the then Honorable Minister of State. MoEF vide 8-31/2010-FC dated 15/03/2012 provided Stage-II approval in favour of RRVUNL for PEKB for diversion of about 1898.3 hectares of forest land from PEKB coal block for opencast coal mining. Government of Chhattisgarh vide 5-4/2010/10-2 dated 28/03/2012 granted environmental clearance in favour of RRVUNL for diversion of about 1898.3 hectares of forest land from PEKB for opencast coal mining. Following the clearances, the mining operations in PEKB formally began during the year 2013.

An appeal was filed by Mr. Sudiep Shrivastava before the Hon'ble National Green Tribunal (NGT) challenging the approval for diversion of forest land of PEKB coal block. The NGT passed an order suspending all the works except work related to conservation of flora and fauna in PEKB. It remanded the case to MoEF with directions to seek fresh advice from Forest Advisory Committee. The NGT order emphasized to seek answers to the following questions *(i) What type of flora and fauna in terms of bio-diversity and forest cover existed as on the date of the proposal in PEKB Coal Blocks in question. (ii) is/was the PEKB Coal Blocks habitat to endemic or endangered species of flora and fauna. (iii) Whether the migratory route/corridor of any wild animal particularly, elephant passes through the area in question and, if yes, its need. (iv) Whether the area of PEKB Block has that significant conservation/protection value so much so that the area cannot be compromised for coal mining with appropriate conservation/management strategies. (v) What is their opinion about opening the PEKB Coal Blocks for mining as per the sequential mining and reclamation method proposed as well as the efficacy of the translocation of the tree vis-a-vis the gestation period for regeneration of the flora (vi) What is their opinion about the Wildlife Management plan finally prescribed. (vii) What conditions and restriction do they propose on the mining in question, if they favour such mining?* The NGT also suggested the FAC to seek advice/opinion/specialized knowledge from any authoritative source such as Indian Council of Forestry Research and Education Dehradun or Wildlife Institute of India.

Aggrieved by the Hon'ble NGT order, project proponent RRVUNL filed a civil appeal (# 4395, 2014) at the Hon'ble Supreme Court, where the appeal was heard on 28.04.2014 which stayed Hon'ble NGT order with respect to suspension of mining activities in PEKB, but upheld the other points of Hon'ble NGT order *"…..we stay the direction in the impugned order that all works commenced by the appellant pursuant to the order dated 28th March, 2012 passed by the State of Chhattisgarh under Section 2 of the Forest Conservation Act, 1980 shall stand suspended till further orders are passed by the Ministry of Environment and Forests"*. From the year 2014 onwards, the matter is pending in the Honorable Supreme Court and the mining agency is working in the area based on the partial stay order regarding the suspension of all works by the Supreme Court.

Vide FAC minutes 8-46/2017-FC dated 26/10/2017, FAC grants approval for prospecting coal in 1745 hectares of Kente Extension coal block with a condition that a biodiversity assessment is carried out by

the State Government for HACF. The minutes envisaged preparation of an integrated wildlife management plan.

Ministry of Environment, Forests and Climate Change (MoEF&CC) vide F.No 8 46/2017-FC dated 19/12/2017 grants Stage-I clearance for prospecting coal in the Kente Extn coal block

Table A Summary of clearances of the coal blocks

S.No	Coal block	Districts	Status of the coal block
1	PEKB	Surguja	Operational. Mining is being done based on the partial stay order regarding the suspension of all works by the Supreme Court
2	Tara Central	Surajpur	Not operational yet.
3	Kente Extension	Surguja	Not operational yet. Stage-I clearance was granted for prospecting
4	Parsa	Surguja	Not operational yet.

Scope of the work to WII

Vide letter reference 331-228 dated 02/01/2018 from the PCCF, Government of Chhattisgarh, a joint proposal was solicited from ICFRE and WII with ICFRE as the Nodal Agency to coordinate the entire study by taking consultation from WII on aspects of wildlife. Consequently, in the study, WII focused on assessing biodiversity of select faunal group *viz.* mammals, avifauna and herpetofauna.

Area of survey

The survey was carried out in HACF and the landscape surrounding it. The area lies between 82° 24'48.65" in the east to 83° 7' 2.91" in the west to 22° 56'23.84" in the north to 22° 24'38.49" in the south.

Opencast mining and associated developmental activities in forested habitats could potentially affect a variety of taxonomic groups (Laurance et al. 2010, 2011). Nevertheless, measurement of every aspect of biodiversity in forested landscapes that span several hundred squares kilometers of mosaic habitats in a short period of time is seldom easy. Typically, multi-taxa surveys have to be multi-seasonal and multi-annual as habitat occupancy (a fundamental population parameter) of taxonomic groups like mammals, birds, amphibians, and reptiles can be profoundly influenced by seasons, and inter-annual climate-related vagaries that could affect habitat productivity (Corn and Bury 1990). In order to overcome this constraint, short-cut approaches that focus on monitoring large mammal populations, which serve as keystone, flagship or umbrella species have been advocated (Simberloff 1998). Large mammals serve as important "functional groups" in a biological community. They also help in arousing public interest, attention, support and involvement in conservation. Some of the charismatic wildlife species like tigers and elephants can contribute to local economy through eco-tourism ventures (Bowen-Jones and Entwistle 2002). Large mammals also play critical ecological roles such as seed dispersal, pollination, nutrient cycling, regulation of zoonotic diseases and maintaining habitats (Sinclair 2003, Jones and Safi 2011, Ripple et al. 2014) in the ecosystem thereby maintaining the biodiversity of the area.

Notwithstanding the critical role of large mammals in an ecosystem, many species of large mammals are also highly threatened (Karanth et al. 2010). Large mammals can be highly vulnerable to habitat-related

threats like roads and mines as they can disrupt animal home ranges with long-term demographic, behavioural, and genetic consequences (Madhusudan and Mishra 2003, Ripple et al. 2015). Therefore, in forested habitats, monitoring large mammals like carnivores (Panthera cats, sloth bear and large canids), their prey animals (large herbivores and primates), elephants, and meso-carnivores (vivverids, lesser cats and mustelids) can be useful for management to understand habitat status in general. Thus, WII's assessment focuses on assessing and monitoring large mammals such as carnivores, their prey animals, and meso-carnivores, which serve as an ideal option for monitoring in densely forested tropical habitats.

As the biodiversity assessment, impact assessment and mitigation strategies are to be studied at a landscape level, this study emphasized specially on the "umbrella species concept" (Lambeck 1997). The umbrella species concept is a globally accepted concept wherein conservation efforts targeted for a well-chosen representative species can confer a protective umbrella to numerous other co-occurring species in the landscape (Flieshman et al. 2000). Asian elephant and tigers serve as umbrella species in the tropical forested landscapes. Both tigers and elephants are long ranging and have specific ecological needs. Understanding the ecological requirements of these species can augur well for all other species found in the landscape. The funds for the study was received from ICFRE in August 2019 and the study was immediately initiated by engaging manpower and procuring field equipment following codal formalities. Consequently, the field work was initiated in October 2019 and field data was collected on the select faunal groups (mammals, avifauna and herpetofauna in the study area). Due to the unforeseen and unfortunate global pandemic, the field work had to be suspended from last week of March 2020 until October 2020. The field work and field data collection was resumed from November 2020.

The specific objectives of the study were to:

1) To prepare a faunal inventory of large mammals, avifauna and herpetofauna in the area
2) To assess the habitat use patterns of select mammalian species
3) To assess the migratory corridors especially for tigers and elephants
4) To develop an integrated wildlife and biodiversity management plan
5) To assess the efficacy of mine closure plan for the operational coal mine of PEKB for operational and upcoming coal blocks
6) To assess impacts to wildlife and suggest mitigation measures in the operational block of PEKB

In addition to the above objectives, the study also provides answers to the questions raised by the Hon'ble NGT:

1) What type of flora and fauna in terms of bio-diversity and forest cover existed as on the date of the proposal in PEKB Coal Blocks in question?
2) Is/was the PEKB Coal Blocks habitat to endemic or endangered species of flora and fauna?
3) Whether the migratory route/corridor of any wild animal particularly, elephant passes through the area in question and, if yes, its need?
4) Whether the area of PEKB Block has that significant conservation/protection value so much so that the area cannot be compromised for coal mining with appropriate conservation/management strategies?

5) What is the opinion about opening the PEKB Coal Blocks for mining as per the sequential mining and reclamation method proposed as well as the efficacy of the translocation of the tree vis-a-vis the gestation period for regeneration of the flora?
6) What is the opinion about the Wildlife Management plan finally prescribed?
7) What conditions and restriction do they propose on the mining in question, if they favor such mining?

LITERATURE REVIEW

Chhattisgarh has been an area of neglect as far as ecological studies and biodiversity assessments are concerned. Although the state harbours a rich biodiversity, which are under tacit threat from agricultural expansion, industrial and infrastructure growth, forest produce collection, and diversion of forest lands for non-forestry purposes; published information on the state of biodiversity in Chhattisgarh continues to be sparse and fragmented. During the last few years, there has been a positive change in this regard in recent past and important ecological assessments are being carried out across diverse regions in the state focusing on a variety of taxa. Ecological assessments, reports and other published information are collated and presented in this review:

Mammals

Through a rapid survey, (Singh 2002) assessed human–elephant conflict in the villages of northern Chhattisgarh through a rapid survey. In this assessment, the aspects of dispersal of elephants from the neighbouring states into Chhattisgarh were elaborated. Using a GIS and remote sensing framework, (Areendran et al. 2011) assessed habitat suitability and corridor viability for elephants in northern Chhattisgarh This work serves as an important reference for future works on elephants in the landscape. (Bisen 2017) had compiled aspects of human–elephant conflict for the entire state of Chhattisgarh by collating forest department records.

There were many individual studies focusing on the human–sloth bear (*Melursus ursinus*) conflict in northern Chhattisgarh, which seems to be a localised problem, but spread out almost all through the landscape. (Bargali et al. 2004, 2005, 2012) studied the characteristics of human-sloth bear conflict in and around the North Bilaspur FD, which comprises parts of the demarcated study area as well. (Akhtar et al. 2007) in addition to conflict aspects, had also studied the characteristics of sloth bear den use and highlighted the use of boulder-strewn hillocks as den sites for raising sloth bear litter. Using habitat suitability modelling, (Bargali et al. 2012) found that habitat selection by sloth bear was high in Sal-dominated mixed forests in boulder hillocks in the vicinity of waterbodies and agricultural fields. In Marwahi FD, which lies to the east of the HACF and the landscape surrounding it (Akhtar and Chauhan 2008) assessed the status of human-wildlife conflict and suggested management implications for conflict management for the species like sloth bear, jackal (*Canis aureus*) and leopard (*Panthera pardus*).

Golden jackal (*Canis aureus*) is commensal, and widespread in northern Chhattisgarh. (Akhtar and Chauhan 2009) studied the human-jackal interactions along with their food habits and showed that jackal diet is highly catholic.

In a landscape-level study encompassing large tracts of forests in the Central Indian landscape (Dutta et al. 2016) found several potential corridors for tigers (*Panthera tigris*) and indicated a strong habitat connectivity between Achanakmar, Kanha, Sanjay and other Central Indian tiger reserves located towards the west of HACF. This finding indicated potential tiger dispersal and range establishment in some of the Central Indian forest habitats if habitat protection, prey species recovery and other conditions known to recover tigers improve. (Mandal et al. 2017) assessed tiger recovery in Achanakmar tiger reserve, which is contiguous to HACF and a potential nearest source site for the tigers. The study also

assessed the status of other large carnivores like leopard (*Panthera pardus*) and striped hyena (*Hyaena hyena*). Using geospatial tools, (Singh et al. 2009) developed habitat suitability models for tigers and their prey in Achanakmar tiger reserve.

Based on villager interview surveys across 16 villages, (Ahmed et al. 2012) identified human-carnivores conflict in Kanha-Achanakmar corridor located towards the west of the HACF and the surrounding landscape. The study throws light on the fact that conflict concerning large carnivores is widespread in the landscape and that eco-development extensions in select villages may be critical to address conflict.

The last of the cheetahs (*Acinonyx jubatus*) to be shot in India were found inhabiting forests of Surguja in present day Chhattisgarh state as reported by (Kazmi 2019). This landscape is near Hasdeo Arand area indicating the historic importance of the landscape.

The smallest of the wild felids, the rusty-spotted cat (*Prionailurus rubiginosus*), was first reported from Udanti Sita-Nadi Tiger Reserve, located in the south-central Chhattisgarh (Basak et al. 2017)

One of the least studied large carnivores, the Asiatic wolf, *Canis lupus*, was studied in a larger landscape south of the Gangetic plains, using habitat suitability framework (Sharma et al. 2019). This survey indicated a wider distribution of the species in East Central region.

Avifauna

The ruddy-breasted crake (*Porzana fusca*) was reported for the first time in Dalpat Sagar lake in Bastar district of the state (Dutta 2017) it has also been reported that this species has been sighted in the Jangir-Champa district, located in the south of HACF of the state.

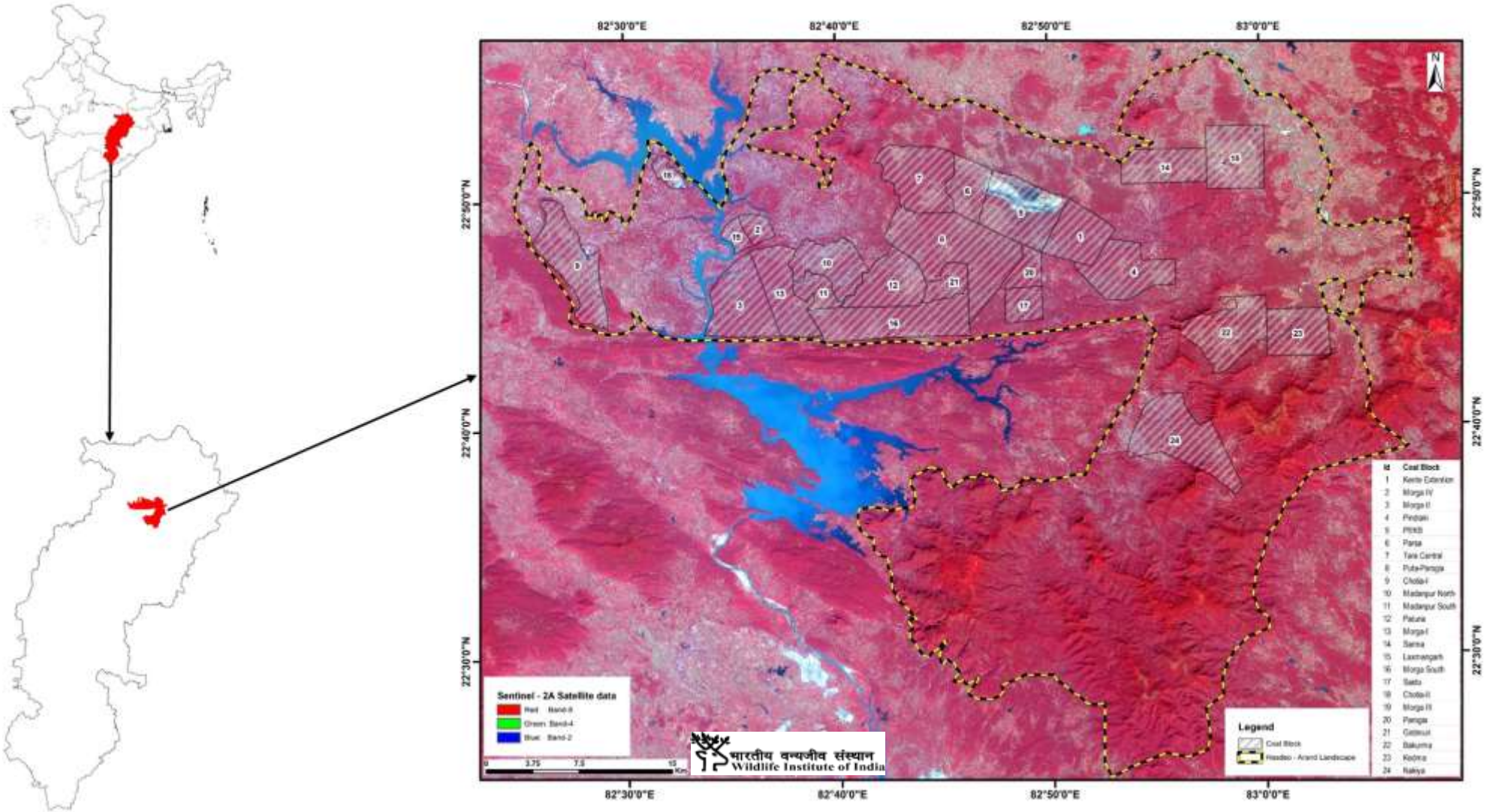
Many winter migrant birds have been reported in and around HACF. (Bharos et al. 2019) reported the first record of nesting of little-ringed plover (*Charadrius dubius*) in Chhattisgarh (location not mentioned in the paper). It may be noted that the reported species breeds in Pakistan and Kashmir and is a winter visitor to Indian Subcontinent. Further, the same assessment reported range extension of grey-headed lapwing in the states of Chhattisgarh, eastern Madhya Pradesh and Jharkhand.

(Vishwakarma et al. 2020) explored the avifaunal diversity in Kopra wetland, at Bilaspur district for three consecutive winters during the period between 2016 and 2018. They recorded a total of 133 avifauna species belonging to 18 orders and 47 families that includes four near-threatened species.

Invertebrates & Herpetofauna

(Sisodia 2019*a*, *b*) reported the presence of *Petrelaea dana*, a species of butterfly belonging to the family Lycaenid, from the Kurandi Range of Kanger Valley National park, Bastar, Chhattisgarh. Although this species was not reported from northern Chhattisgarh, its presence in southern Chhattisgarh elicits interest in species exchange and is important from biogeography point of view. An assessment of butterfly diversity in Achanakmar–Amarkantak biosphere reserve, located to the west of study area revealed reasonably high species richness with records of 133 species belonging to six families including 55 new species (Tiple and Ghorpadé 2012). A checklist prepared by (Gupta and Chandra 2017) reveals a total

of 174 species of butterflies, along with 100 sub-species across Chhattisgarh. A survey conducted in National parks, various wildlife sanctuaries and various districts in central Chhattisgarh by (Minz et al. 2020) recorded a total of 14 species of bees Hymenoptera order belonging to three different species in agro-climatic zones. (Dawn and Chandra 2014) discovered 10 new species of Odonata from the state of Chhattisgarh, increasing the total number to 95. (Gupta 2016) reported new addition of one species to the existing 41 species and subspecies under 37 genera belonging to five families of Orthopteran fauna in the Surguja district, Chhattisgarh. (Gupta and Chandra 2017) surveyed Achanakmar landscape located in the west of study area and reported 33 species and subspecies pertaining to 30 genera under five families. Literature analysis shows that few studies have been conducted to form a checklist or an inventory of herpetofauna in the Central India, most important of them would be the review work conducted by (Chandra and Gajbe 2005), which shows that Chhattisgarh accounts for 11 species of amphibians under nine genera of four families and 45 species of reptiles under 29 genera of 11 families.



Map 1 The study area in the demarcated Hasdeo–Arand landscape, located in northern Chhattisgarh

As per (Champion and Seth 1968) forests in Chhattisgarh belong to two broad types namely tropical moist deciduous and tropical dry deciduous. These two broad forest types have divided into 12 Forest types (FSI, 2017). The forest types and the floristics are described below:

Moist Peninsular Low-Level Sal Forest (3C/2E (II)
The floristics include *Shorea robusta, Terminalia elliptica, Adina cordifolia, Mitragyna parvifolia, Largerstroemia parviflora, Anogeissus latifolia, Bridelia retusa, Bombax ceiba, Gmelina arborea* in the top storey*; Clestanthus collinus, Careya arborea, Diospyros melanoxylon, and Mallotus philippensis* in the middle storey*; Woodfordia fruticosa, Clerodendrum viscosum, Bauhinia vahlii, Butea monosperma, and Combretum decandrum in the lower storey.* Bamboo *(Dendrocalamus strictus)* has become relatively rare.

Dry Peninsular Sal Forest (5B/C1c)
The floristics include *Shorea robusta, Terminalia elliptica, Pterocarpus marsupium, Largerstroemia parviflora, Anogeissus latifolia, Adina cordifolia, Terminalia bellerica, Acacia catechu, and Buchnania lanzen* in the top storey*; Clestanthus collinus, Chloroxylon swietenia, Phyllanthus emblica, Cassia fistula, Terminalia chebula, Wendlandia tinctoria, Symplocos racemosa in the middle storey, Indigofera pulchella and Phoenix acaulis* in the lower storey.

Northern Dry Mixed Deciduous Forests (5B/C2)
The floristics include *Terminalia tomentosa, Diospyros melanoxylon, Buchnania lanzan, Terminalia chebula, Cleitanthus collinus, Madhuca indica, Boswellia serrata, Largerstroemia parviflora, in the top storey; Phyllanthus emblica, Zizyphus xylopyrus, in the middle storey; Pheonix acaulis and Woodfordia fruticosa* in the lower storey.

Soil profile

According to 'Soil Taxonomy' (7th approximation) soil of Chhattisgarh fall under 5 orders and 9 dominant sub-groups. In general, in northern Chhattisgarh, the soil in the flat areas is typically shallow with less developed features and is eroded as well (Anon, Govt. of Chhattisgarh). In the slopes, the soil appears well-developed. The dominant soil type is red-yellow, from the main Gondwana rock system, which covers over 60 to 65% of northern and central zones of the state. It may be noted that this soil favours cultivation of paddy.

Drainage

Hasdeo - Arand coal field lies in the watershed of the River Mahanadi – one the largest rivers in peninsular India. The northern portion lies in the catchment of River Rihand. River Rihand is a major tributary of River Sone. Rihand originates in the Matringa Hills in the landscape surrounding HACF. River Hasdeo originates in Koriya district of Surguja and is one of the main tributaries of River Mahanadi. River Hasdeo has an annual flow of 3540 MCM and thus drains substantial quantity of water into River Mahanadi. Many perennial Main tributaries of River Hasdeo that include Gej, Tan, Ahiran, Chornai, Arpa, and Maniari drain the study area. Thus, study area is an important catchment for River Hasdeo in particular and River Mahanadi in general.

Climate and precipitation

The climate in northern Chhattisgarh is sub-tropical with three distinct seasons namely dry (March – May), monsoon (June – September) and winter (October – February). The annual temperatures range from 5º C (minimum) to 45º C (maximum). Southwest monsoon accounts for more than 90% of the region's annual rainfall of which the annual average is around 1200 to 1600 mm (Indian Meteorological Department, 2020).

Demography & socio-economic attributes

In Surguja and Surajpur districts, the population density is 150 persons per km^2 with a sex ratio of 978 females per 1000 males (https://censusindia.gov.in/2011census/dchb/2202_PART_B_DCHB_SURGUJA.pdf).
The scheduled tribes constitute 55% of the total population (https://censusindia.gov.in/2011census/dchb/2202_PART_B_DCHB_SURGUJA.pdf). The main tribes include Agaria, Gond, Binjwar, Manjwar, Pahadi Korwa, Pando, Rajwar, Nai, Teli, Nagesiya, Oraon, Baiga, Kanwar, Panika, and DandKorwa. Literacy rates in the district are around 60% (Directorate of Census Operations 2011). Tribal and forest dependent communities in Surguja collect a variety of non-timber forest products including timber, food plants, fodder, medicinal plants, honey, and others (Ekka and Ekka 2016). The population density in Korba is about 183 persons per km^2 with a sex ratio of 969 females per 1000 males.

CHAPTER-1: INVENTORY OF MAMMALS AND BIRDS

1.1 Introduction

In the faunal group, assessing mammalian inventory can be a useful starting point for biodiversity assessments, particularly in areas published literature are few. Mammals play vital ecosystem functions and are integral part of the biodiversity. A few species of mammals like tigers are charismatic and arouse public interest in conservation. In comparison to mammals, birds are ubiquitous in the landscape. Birds are important group of species providing ecosystem services like pest control, pollination, seed dispersal, nutrient cycling and others (Whelan et al. 2015). Birds also serve as important indicators of habitat quality in particular and environment in general as being highly mobile among the vertebrate fauna, birds are often the first to abandon habitats that do not provide them with essential resources (Whelan et al. 2008). As part of the biodiversity assessment, the list of mammals and birds that occur in the landscape was prepared based on the field surveys.

1.2 Methods

Biodiversity surveys focussing on getting the inventory of a wide array of taxonomic groups need to be conducted for a longer duration spanning multiple years to capture the potential inter-annual variations in species occurrence. Regardless of the survey methods used, there could be biases as field surveys tend to observe only a fraction of morphologically, behaviourally, and ecologically diverse group of animals. Biodiversity assessments that are short-term in nature may not capture the whole suite of faunal diversity that the landscape might actually support. To circumvent this problem, conducting interview surveys with knowledgeable local communities and forest department staff would be useful. In this assessment, occurrence of mammalian species was assessed through on-foot animal sign surveys and camera trap surveys. Mammals and their signs observed during the field visits were also included. Mammalian species identified by the villagers during the interview surveys were also included. List of birds was prepared based on the transect surveys as well as those recorded during the occasional visit (Detailed information on methodology and study area is provided in Chapter 5).

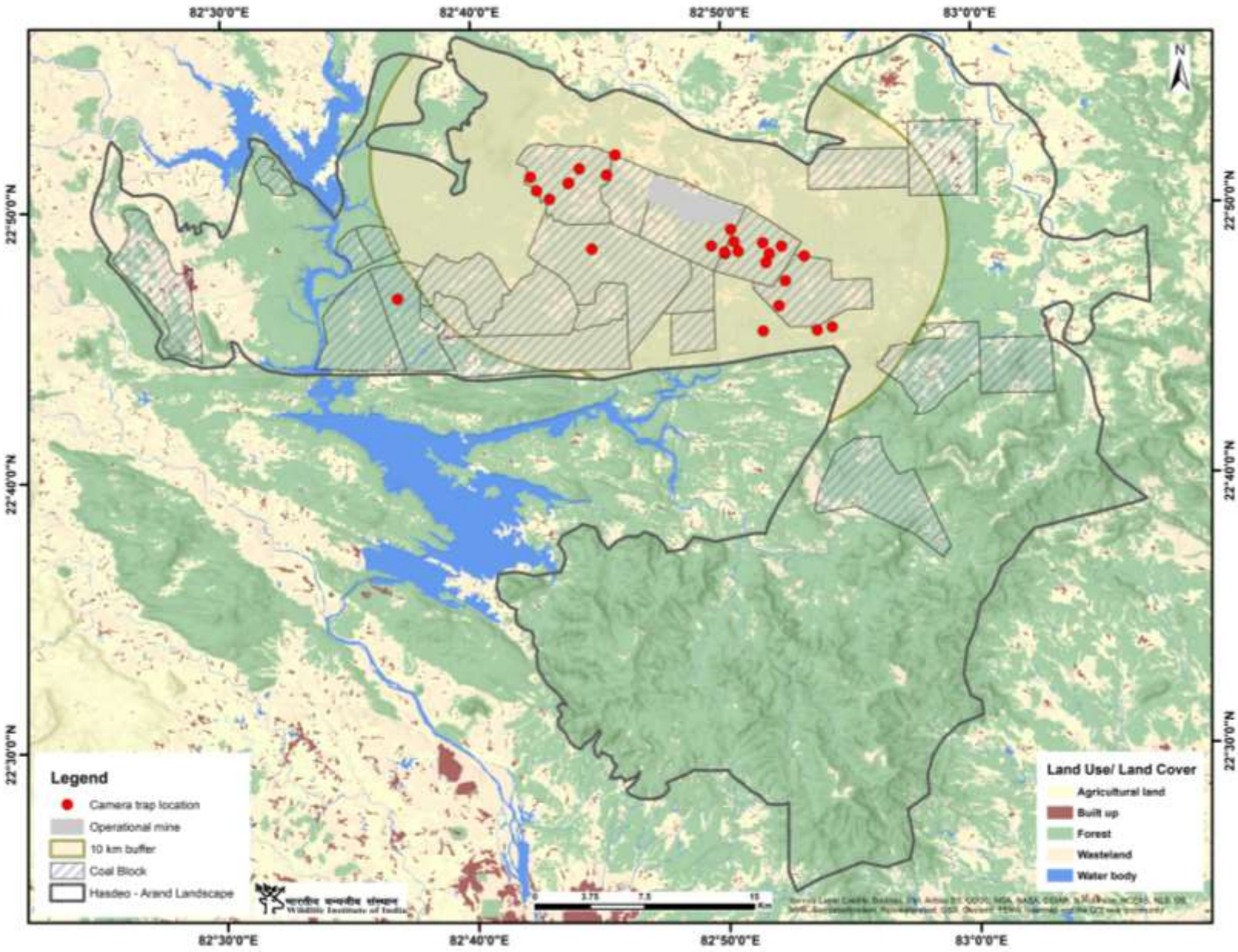
Mammals

Table-1.1: Mammalian species recorded during the survey

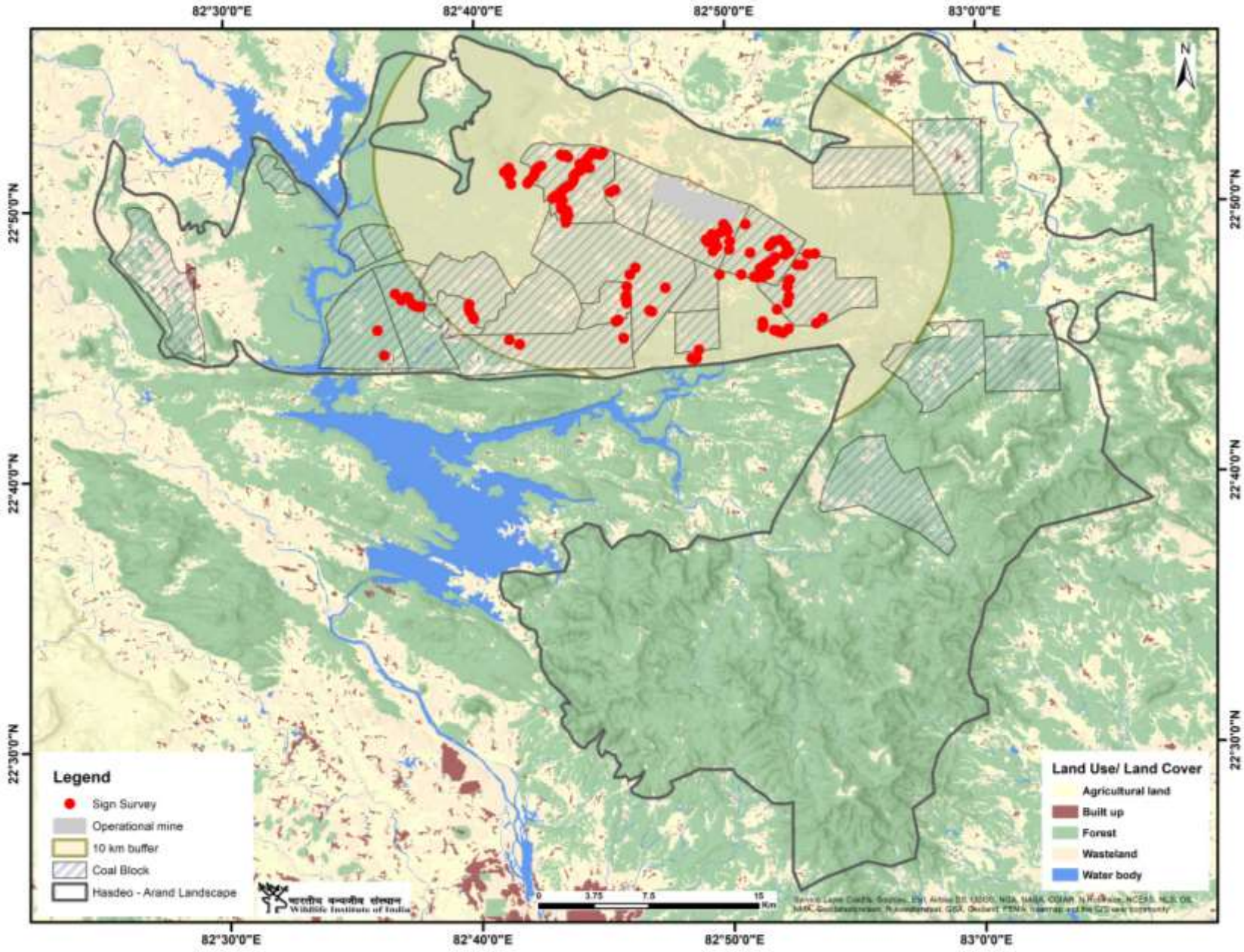
SNo	Species	Scientific name	Sign survey	Camera trap survey	Interview survey	IUCN	Wildlife (Protection) Act
1	Golden jackal	*Canis aureus*	✓	✓	✓	LC	Schedule II (Part II)
2	Striped hyena	*Hyaena hyaena*	✓	✓	✓	NT	Schedule III
3	Sloth bear	*Melursus ursinus*	✓	✓	✓	VU	Schedule I
4	Indian grey wolf	*Canis lupus*	✓	✓	✓	LC	Schedule I
5	Jungle cat	*Felis chaus*	✓	✓	✓	LC	Schedule II (Part II)
6	Honey badger	*Mellivora capensis*		✓		LC	Schedule I

7	Common leopard	*Panthera pardus*	✓		✓	VU	Schedule I
8	Elephant	*Elephas maximus*			✓	EN	Schedule I
9	Spotted deer	*Axis axis*	✓	✓	✓	LC	Schedule III
10	Four-horned antelope	*Tetracerus quadricornis*		✓	✓	VU	Schedule I
11	Indian fox	*Vulpes bengalensis*		✓	✓	LC	Schedule II (Part II)
12	Rhesus macaque	*Macaca mulatta*	✓	✓	✓	LC	Schedule II (Part I)
13	Common langur	*Semnopithecus entellus*	✓	✓	✓	LC	Schedule II (Part I)
14	Barking deer	*Muntiacus muntjac*	✓	✓		VU	Schedule III
15	Rusty spotted cat	*Prionailurus rubiginosus*		✓		NC	Schedule I
16	Black-naped hare	*Lepus nigricollis*	✓	✓	✓	LC	Schedule IV
17	Giant squirrel	*Ratufa indica*	✓		✓	NT	Schedule I
18	Palm civet	*Paradoxurusherm aphroditus*		✓		LC	Schedule II
19	Small Indian civet	*Viverricula indica*		✓		LC	Schedule II
20	Indian crested porcupine	*Hystrix indica*	✓	✓	✓	LC	Schedule IV
21	Smooth-coated otter	*Lutragale perspicillata*	✓		✓	VU	Schedule II (Part II)
22	Indian pangolin	*Manis crassicaudata*	✓		✓	EN	Schedule I
23	Wild pig	*Sus scrofa*	✓	✓	✓	LC	Schedule III
24	Ruddy mongoose	*Herpestes smithii*	✓	✓	✓	LC	Schedule II
25	Common grey mongoose	*Herpestes edwardsii*	✓	✓	✓	LC	Schedule II

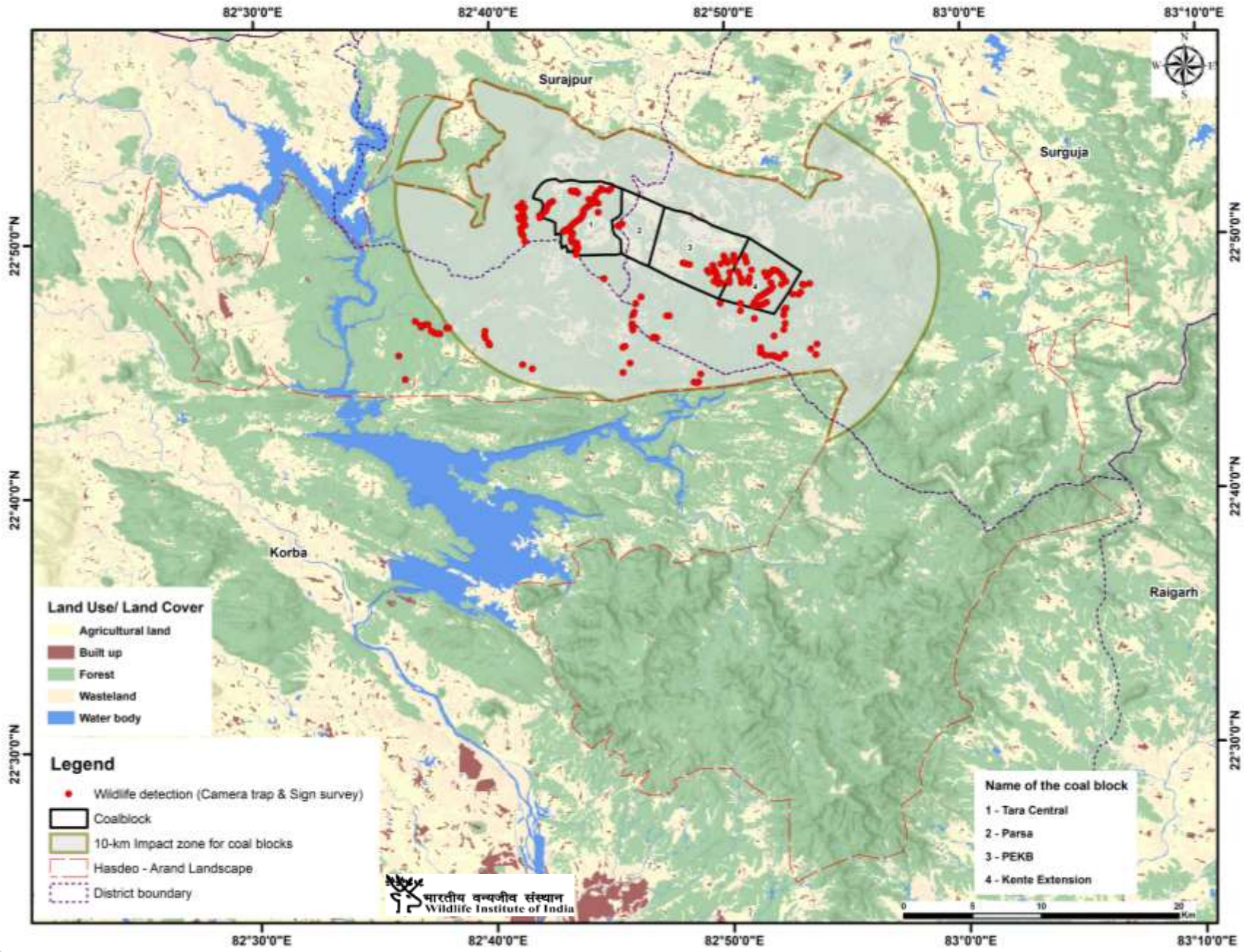
During the field surveys, 25 mammalian vertebrates were recorded in the field. The signs of Indian wild dogs (dhole, *Cuon alpinus*) and sambar (*Rusa unicolor*) were not recorded. Nevertheless, during interview surveys 16% (n = 18) respondents reported presence of dhole and 34.2% (n = 38) of respondents reported presence of sambar.



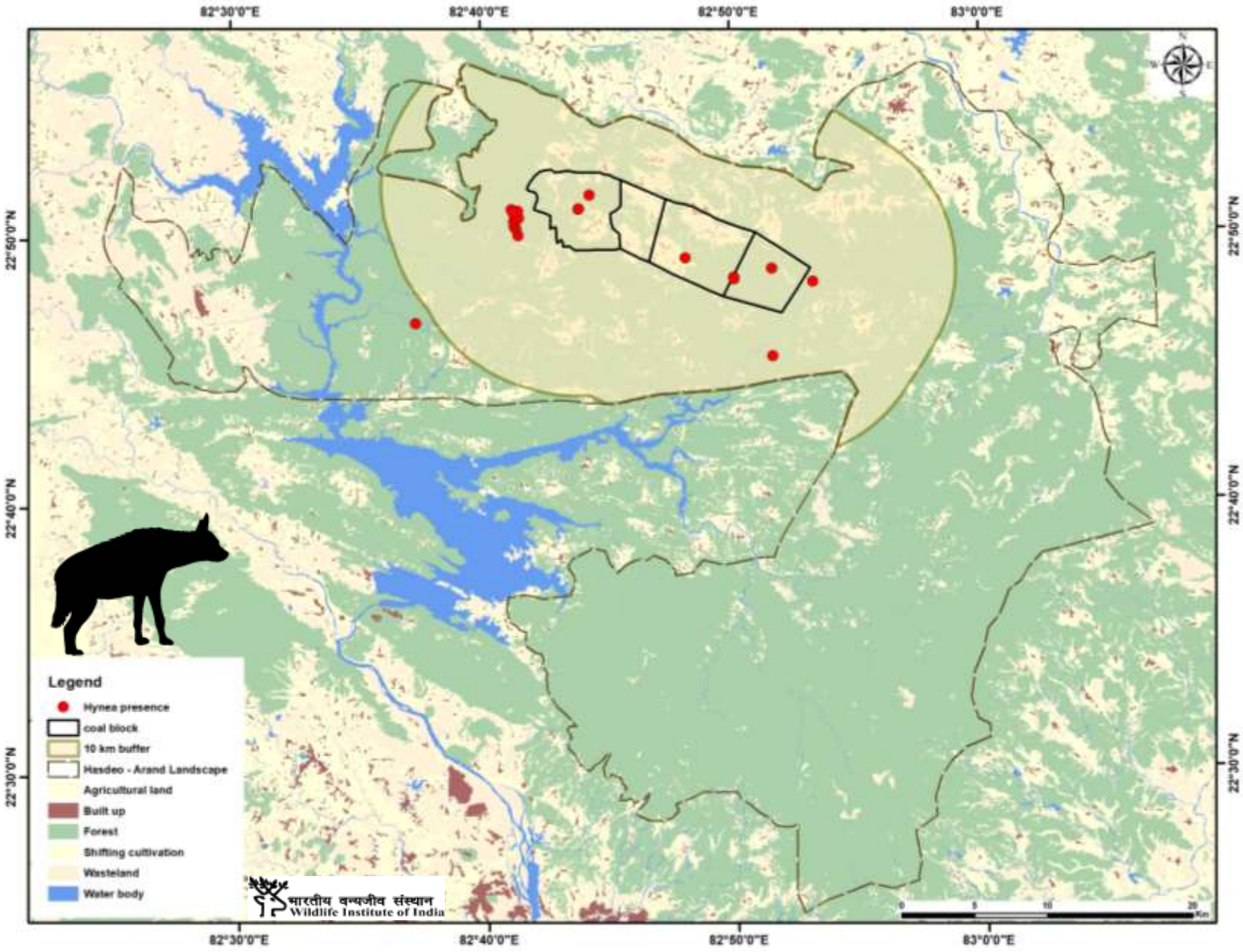
Map 2 Placement of camera traps in the study area



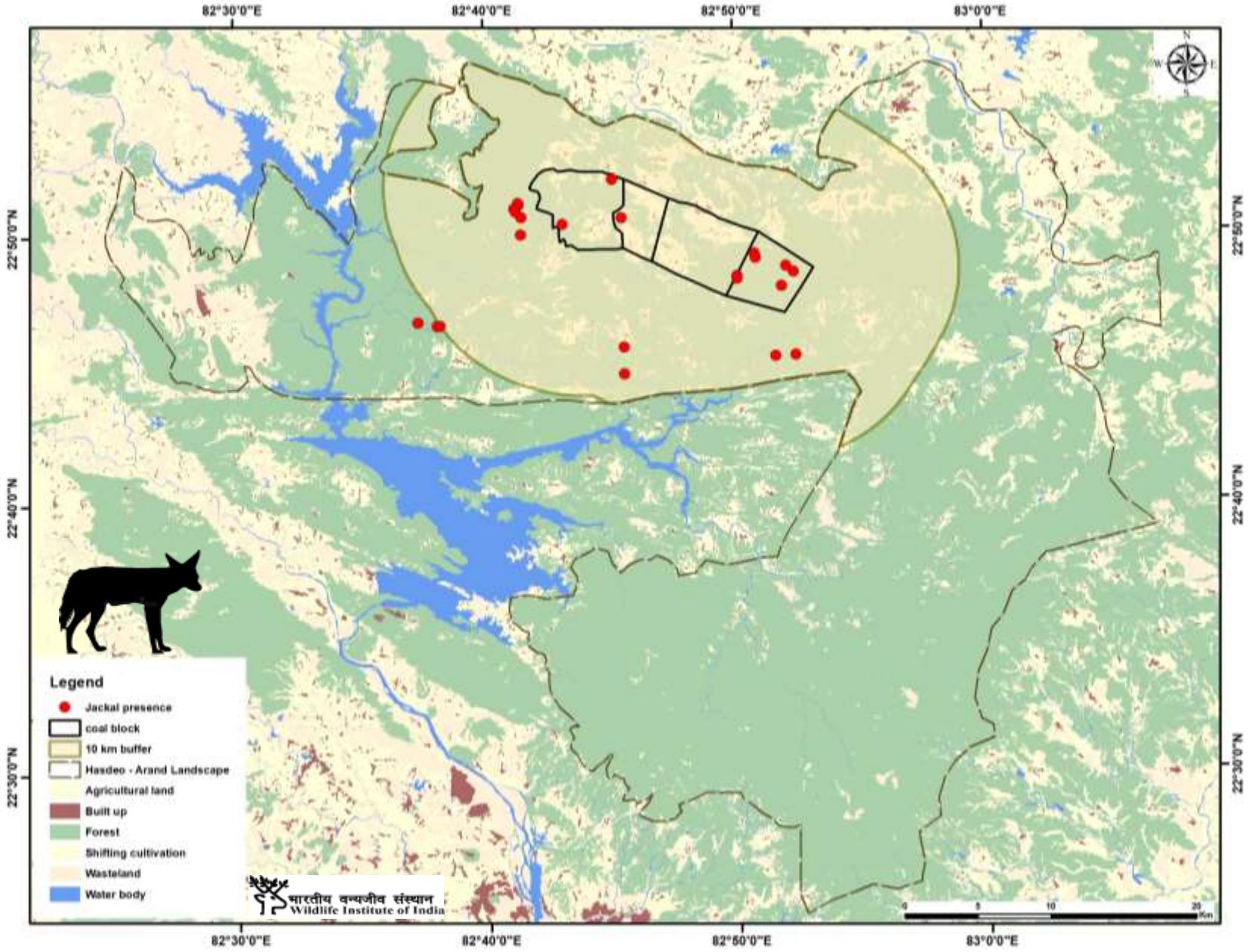
Map 3 Sign survey carried out in the study area



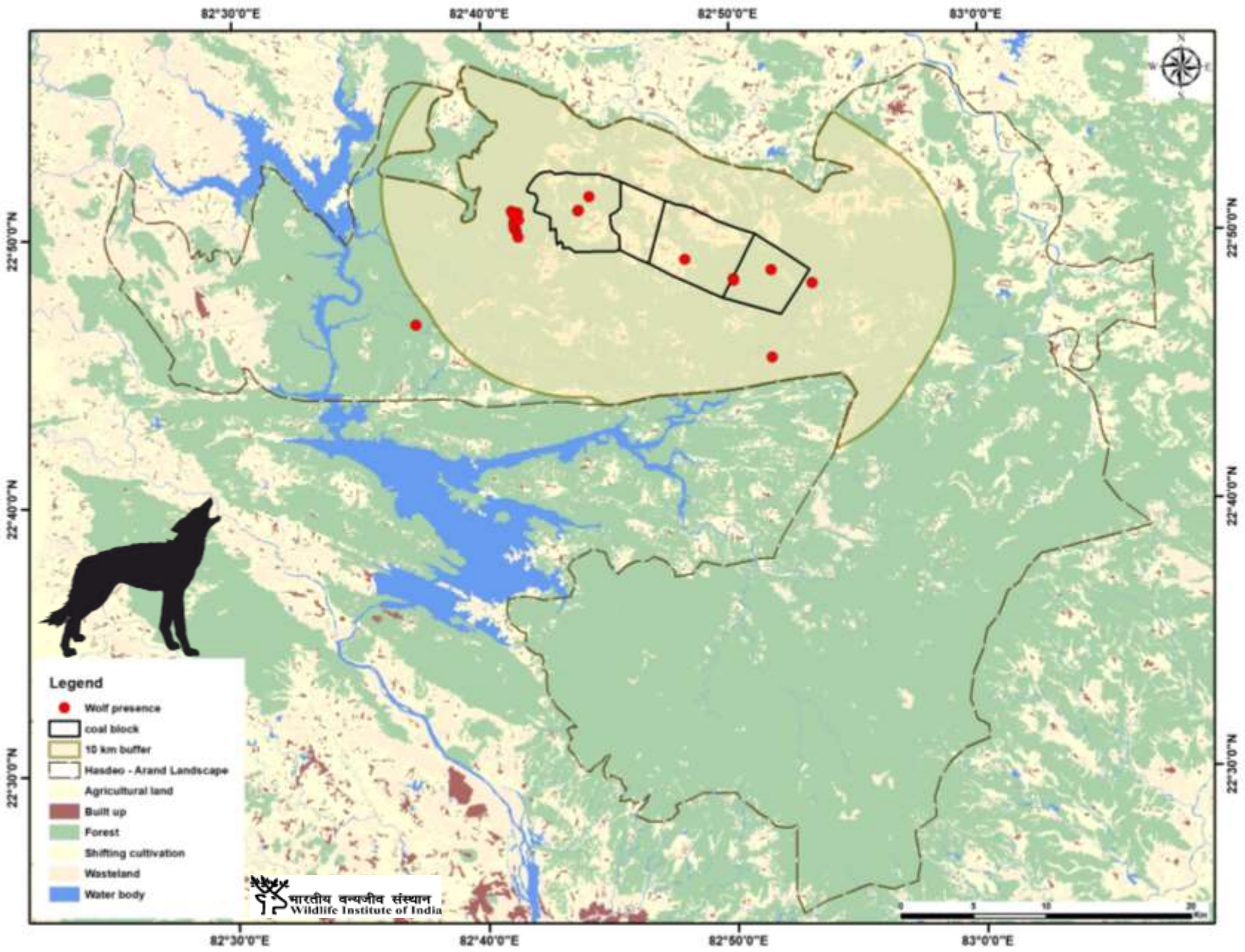
Map 4 Wildlife detections recorded during the field surveys (camera trap and sign surveys)



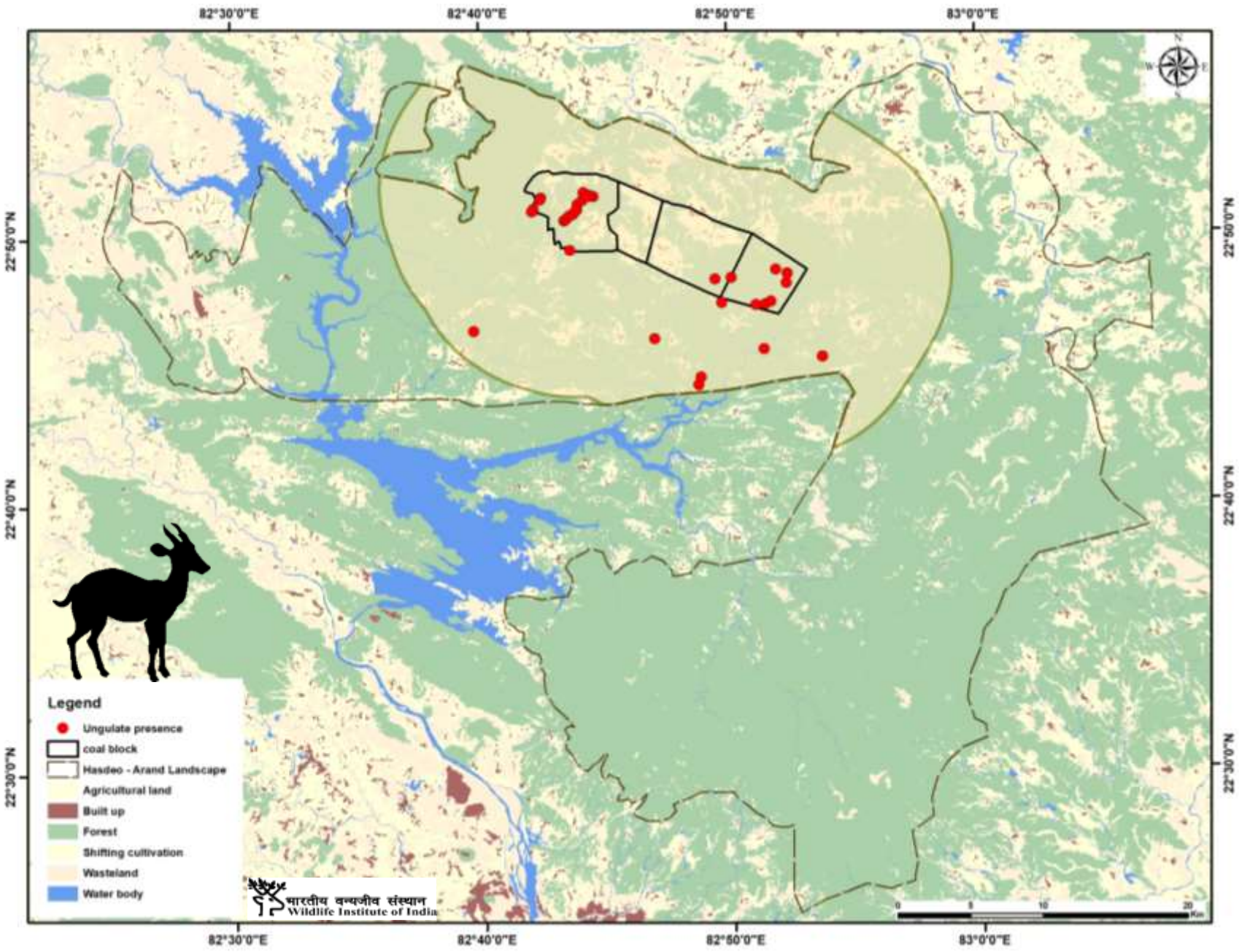
Map 5 Stripped Hynea presence in the study area



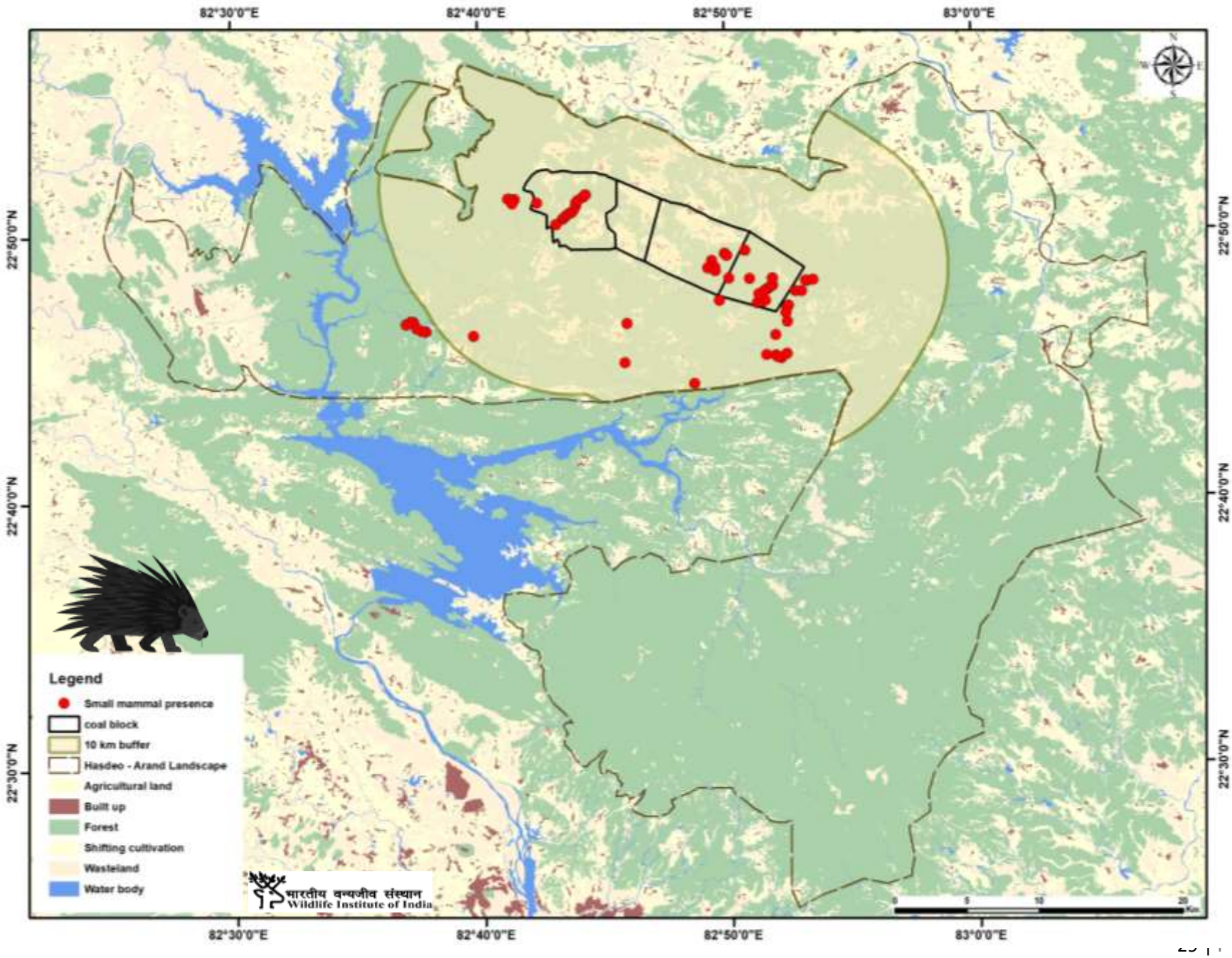
Map 6 Golden Jackal presence in the study area



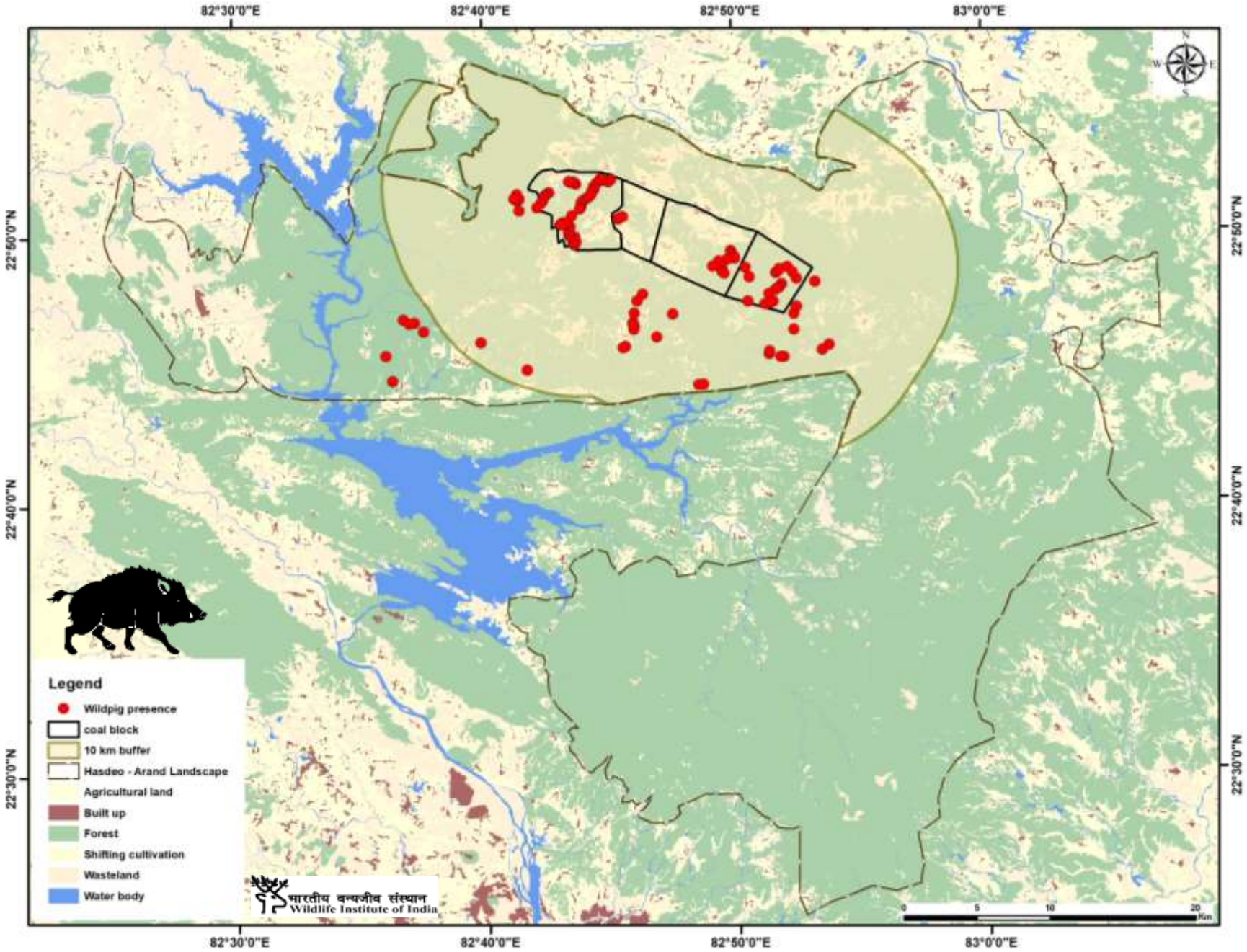
Map 7 Indian Grey Wolf presence in the study area



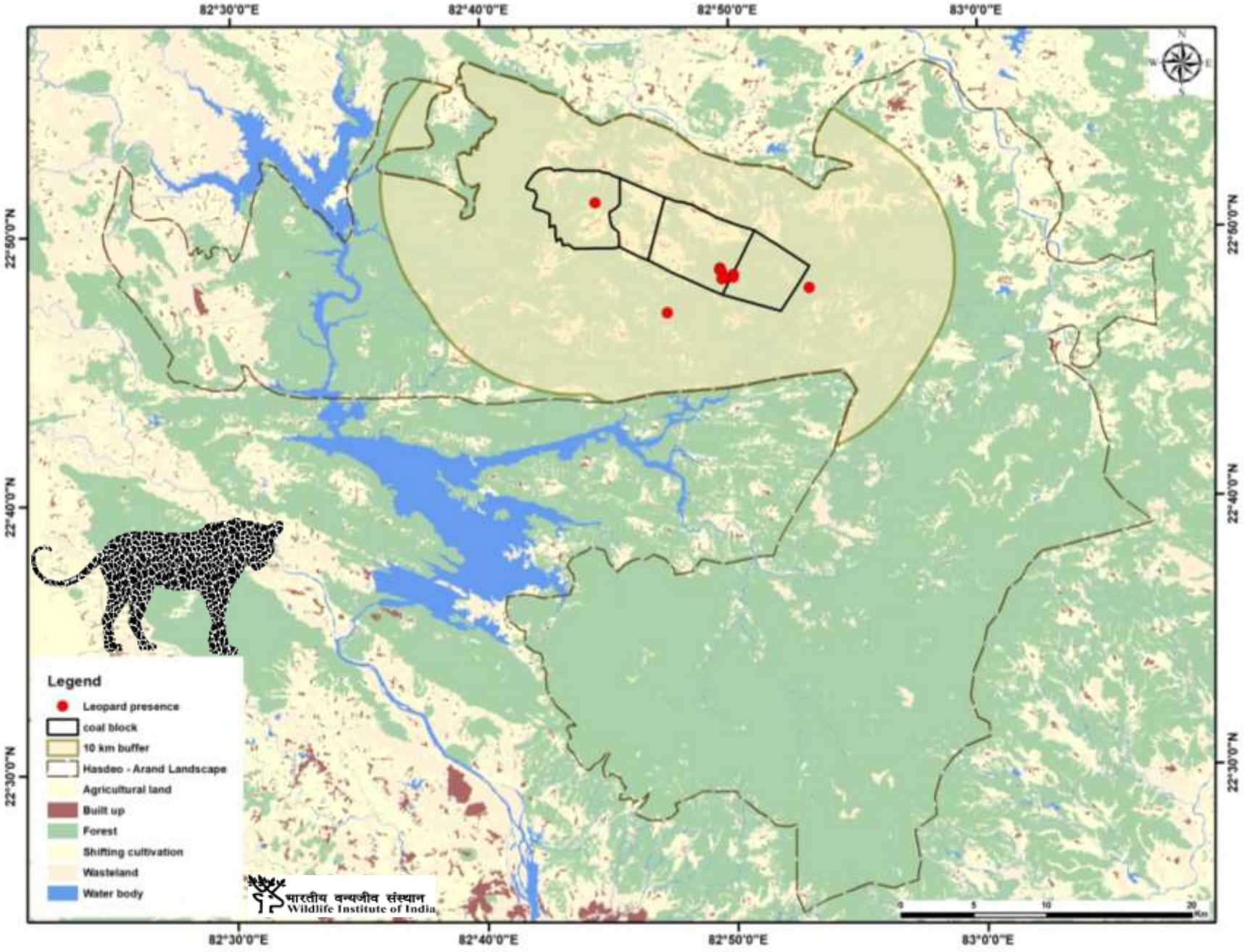
Map 8 Ungulate presence in the study area



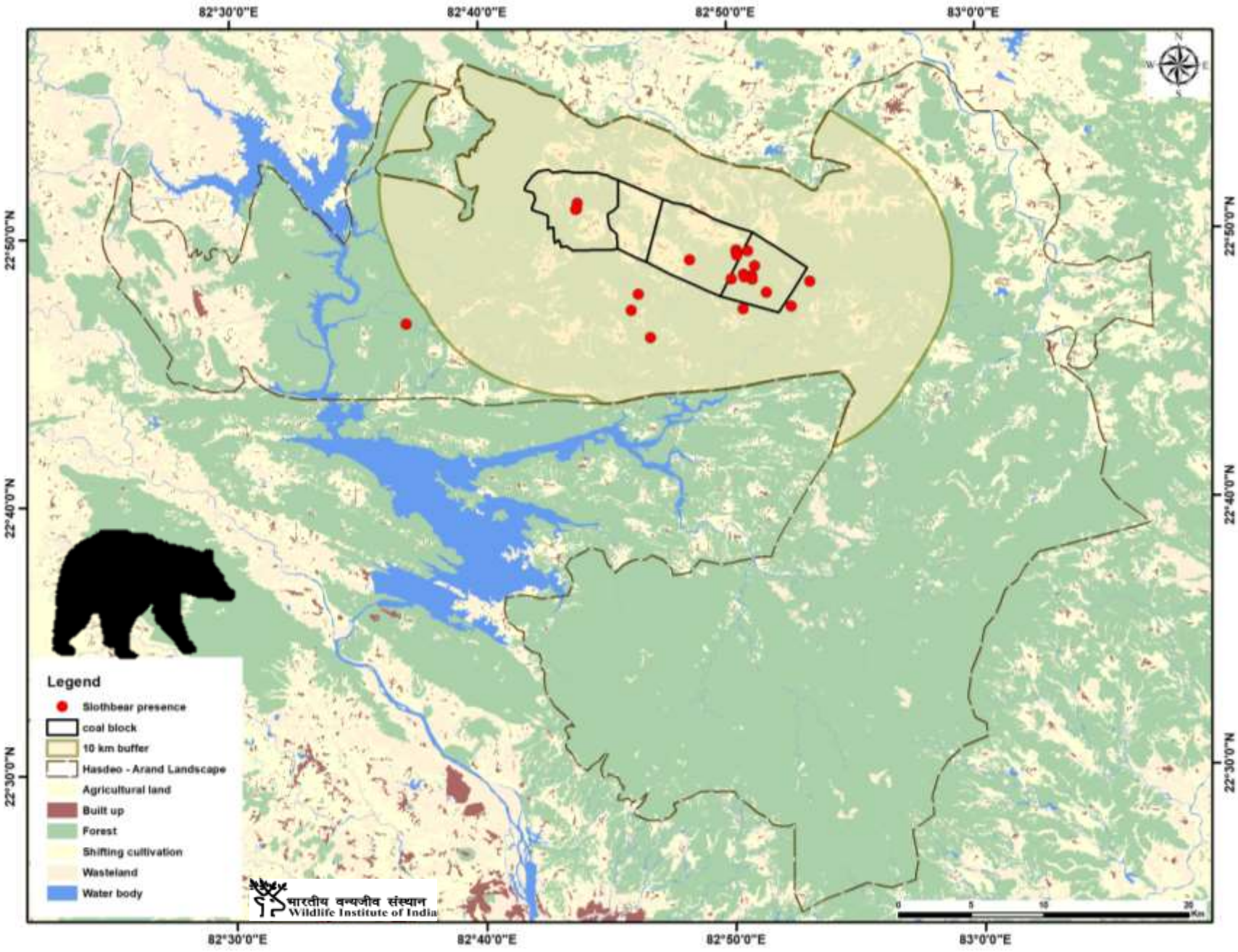
Map 9 Small Mammals presence in the study area



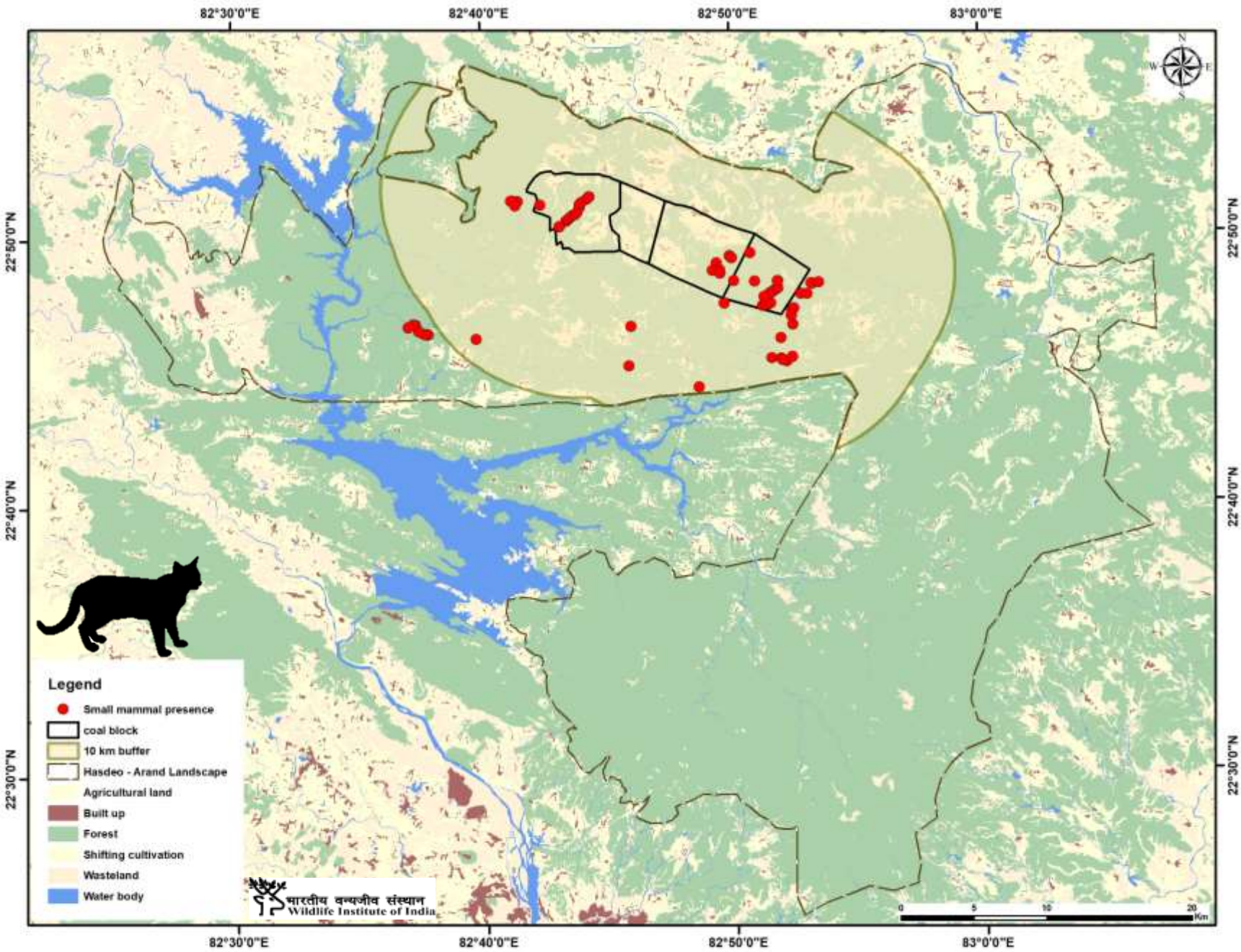
Map 10 Wildpig presence in the study area



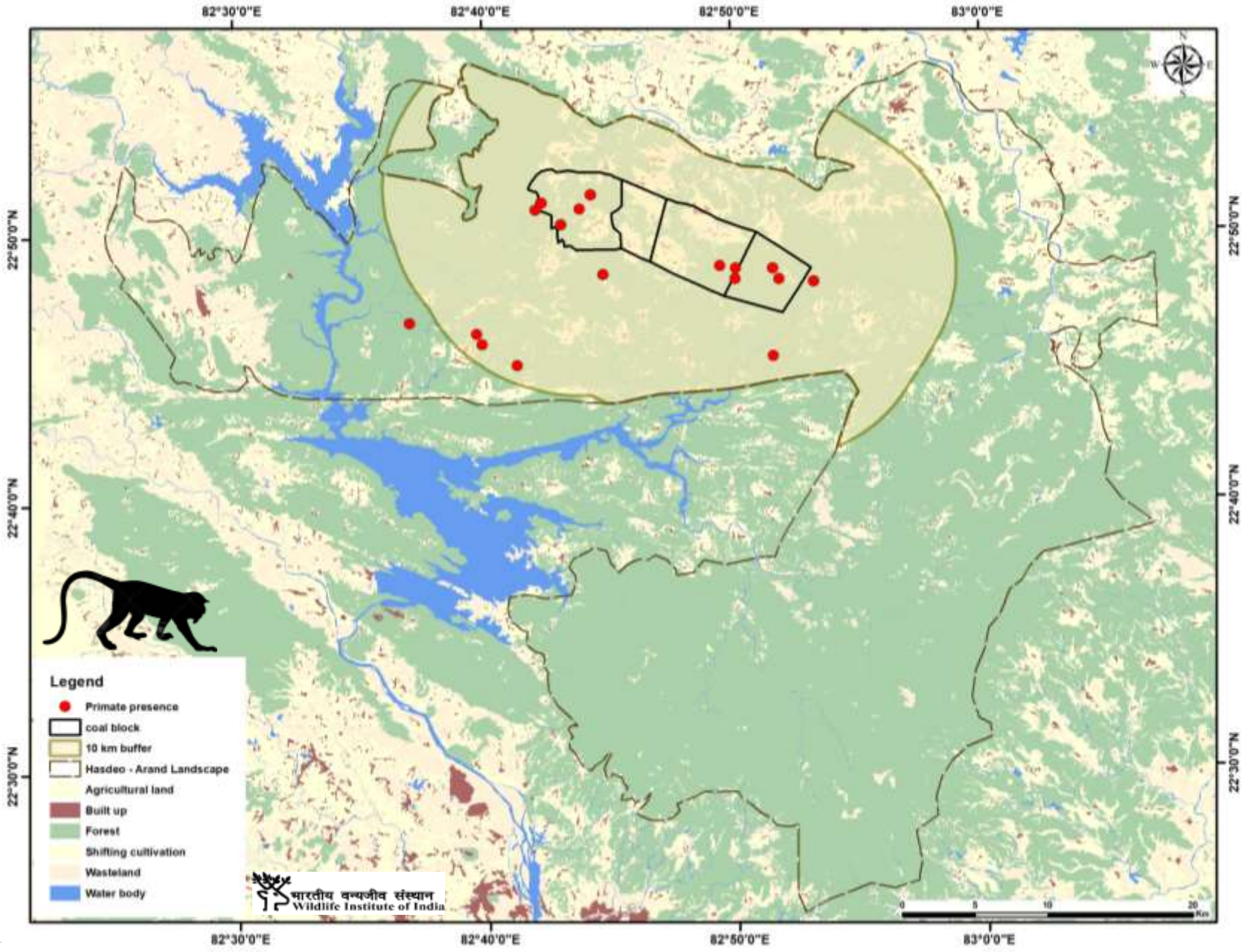
Map 11 Common Leopard presence in the study area



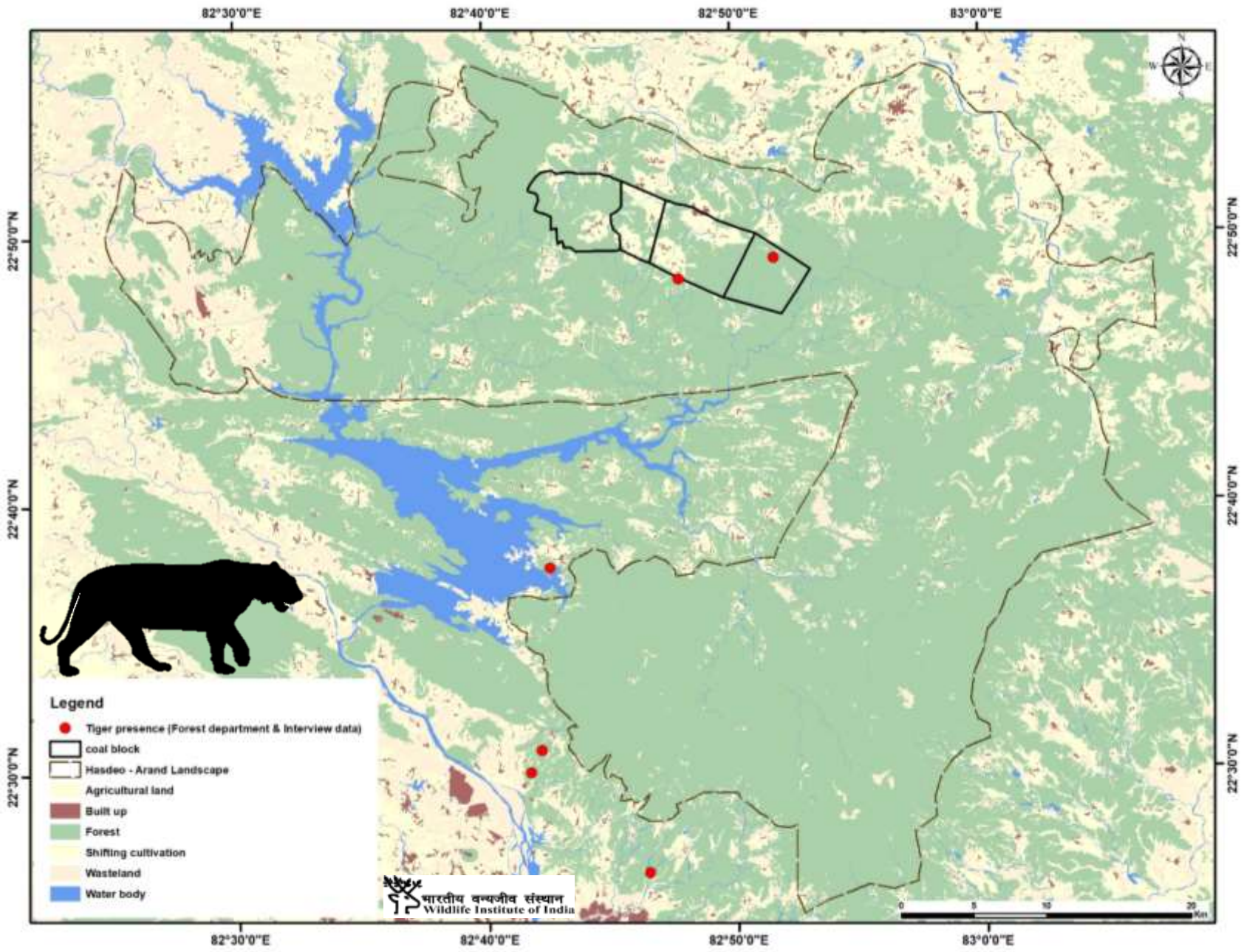
Map 12 Slothbear presence in the study area



Map 13 Small cats presence in the study area



Map 14 Primate presence in the study area



Map 15 Tiger detection reported (based on Forest Department records and villager reports during interview surveys)

Plate 1.1 Mammalian species occurrence

Elephant (*Elephas maximus)*

Common langur (*Semnopithecus entellus*)

Indian crested porcupine (*Hystrix indica)*

Black-naped hare *(Lepus nigricollis)*

Jungle cat *(Felis chaus)*

Rusty spotted cat *(Prionailurus rubiginosus)*

	
Common leopard *(Panthera pardus)*	Small Indian civet *(Viverricula indica)*
	
Common palm civet *(Paradoxurus hermaphroditus)*	Grey mongoose *(Herpestus edwardsi)*
	
Striped hyena *(Hyaena hyaena)*	Golden jackal *(Canis aureus)*

	
Indian grey wolf *(Canis lupus)*	Indian fox *(Vulpes bengalensis)*
	
Sloth bear *(Melursus ursinus)*	Honey badger *(Mellivora capensis)*
	
Wild pig *(Sus scrofa)*	Four-horned antelope *(Tetracerus quadricornis)*

Table: 1.2 – Avifaunal checklist

Family/ Common Name		Scientific Name	Migration Status	Wildlife (Protection) Act Schedule	Endemic status	Relative abundance status
S.N.	**Accipitridae**					
1	White-eyed Buzzard*	*Butastur teesa*	R	I	Widespread	Common
2	Crested Serpent Eagle*	*Spilornis cheela*	R	I	Widespread	Common
3	Shikra*	*Accipiter badius*	R	I	Widespread	Common
4	Black-Winged Kite	*Elanus caeruleus*	R	I	Widespread	Uncommon
5	Black Eagle	*Ictinaetus malaiensis*	R	I	Widespread	
6	Black Kite	*Milvus migrans*	R	I	Widespread	
	Aegithinidae					
7	Common Iora	*Aegithina tiphia*	R	IV	Widespread	
	Alcedinidae					
8	White-throated Kingfisher	*Halcyon smyrnensis*	R	IV	Widespread	Common
	Apodidae					
9	Crested Treeswift	*Hemiprocne coronata*	R	-	Widespread	Fairly common
	Ardeidae					
10	Asian Pond Heron*	*Ardeola grayii*	R	IV	Widespread	Common
11	Cattle Egret	*Bubulcus ibis*	R	IV	Widespread	Uncommon
12	Little Egret	*Egretta garzetta*	R	IV	Widespread	Fairly common
13	Intermediate Egret	*Ardea intermedia*	WM	IV	Widespread	
14	Great Egret	*Ardea alba*	R	IV	Widespread	
	Campephagidae					
15	Small Minivet*	*Pericrocotus cinnamomeus*	R	IV	Widespread	Very common
16	Large Cuckooshrike	*Coracina javensis*	R	-	Widespread	Fairly common
17	Black-headed cuckooshrike	*Lalage melanoptera*	SM	-	Widespread	Fairly common
18	Black-winged CuckooShrike	*Lalage melaschistos*	WM	-	Widespread	Uncommon
	Caprimulgidae					
19	Indian Nightjar	*Caprimulgus asiaticus*	R	IV	Widespread	Fairly common
20	Savanna Nightjar	*Caprimulgus affinis*	R	IV	Widespread	Uncommon
	Charadriidae					

21	Red-wattled Lapwing	*Vanellus indicus*	R	-	Widespread	Fairly common
	Ciconiidae					
22	Asian Openbill	*Anastomus oscitans*	R	IV	Widespread	Common
	Cisticolidae					
23	Grey-breasted Prinia	*Prinia hodgsonii*	R	-	Widespread	Fairly common
24	Common Tailorbird*	*Orthotomus sutorius*	R	-	Widespread	Fairly common
25	Plain Prinia	*Prinia inornata*	R	-	Widespread	Uncommon
	Columbidae					
26	Spotted Dove	*Streptopelia chinensis*	R	IV	Widespread	Common
27	Rock Pigeon	*Columba lia*	R	-	Widespread	Fairly common
28	Yellow-legged Green Pigeon	*Treron phoenicopterus*	R	IV	Widespread	
	Coraciidae					
29	Indian Roller*	*Coracias benghalensis*	R	IV	Widespread	Very common
	Corvidae					
30	Rufous Treepie*	*Dendrocitta vagabunda*	R	IV	Widespread	Common
31	Large-billed Crow	*Corvus macrorhynchos*	R	-	Widespread	
32	House Crow	*Corvus splendens*	R	V	Widespread	
	Cuculidae					
33	Common Hawk Cuckoo*	*Hierococcyx varius*	R	IV	Indian subcontinent	Very common
34	Greater Coucal*	*Centropus sinensis*	R	-	Widespread	Common
35	Asian Koel	*Eudynamys scolopaceus*	R	IV	Widespread	Fairly common
36	Indian Cuckoo	*Cuculus micropterus*	SM	IV	Widespread	Fairly common
37	Sirkeer Malkoha	*Taccocua leschenaultii*	R	-	Indian Subcontinent	Fairly common
	Dicaeidae					
38	Pale-billed Flowerpecker	*Dicaeum erythrorhynchos*	R	IV	Indian Subcontinent	Common
39	Thick-billed Flowerpecker	*Sirkeer Cuckoo*	R	IV	Widespread	Fairly common
	Dicruridae					
40	Black Drongo*	*Dicrurus macrocercus*	R	IV	Widespread	Very common
41	White-bellied Drongo*	*Dicrurus caerulescens*	R	IV	Indian Subcontinent	Fairly common

42	Greater Racquet-tailed Drongo	*Dicrurus paradiseus*	R	IV	Widespread	Uncommon
43	Lesser Racquet-tailed Drongo	*Dicrurus remifer*	R	IV	Widespread	
44	Hair-crested Drongo	*Dicrurus hottentottus*	R	IV	Widespread	
	Leiothrichidae					
45	Jungle Babbler*	*Turdoides striata*	R	IV	Indian Subcontinent	Very common
	Meropidae					
46	Green Bee-eater*	*Merops orientalis*	R	-	Widespread	Very common
	Monarchidae					
47	Indian paradise-flycatcher	*Terpsiphone paradisi*	SM	-	Widespread	Uncommon
48	Black-naped Monarch	*Hypothymis azurea*	R	-	Widespread	Uncommon
	Motacillidae					
49	Tree Pipit-	*Anthus trialis*	WM	IV	Widespread	Common
50	Grey Wagtail-	*Motacilla cinerea*	WM	-	Widespread	Uncommon
	Muscicapidae					
51	Oriental Magpie Robin*	*Copsychus saularis*	R	IV	Widespread	Common
52	Red-breasted Flycatcher	*Ficedula parva*	WM	IV	Widespread	Common
53	Tickell's Blue Flycatcher*	*Cyornis tickelliae*	R	IV	Indian Subcontinent	Fairly common
54	Blue Rock Thrush	*Monticola solitarius*	WM	IV	Widespread	Uncommon
55	Blue-capped rock Thrush	*Monticola cinclorhynchus*	WM	IV	Indian Subcontinent	Uncommon
	Nectariniidae					
56	Purple Sunbird	*Cinnyris asiaticus*	R	IV	Widespread	Common
57	Purple-rumped Sunbird	*Leptocoma zeylonica*	R	IV	Indian Subcontinent	Uncommon
	Oriolidae					
58	Black-hooded Oriole*	*Oriolus xanthornus*	R	IV	Widespread	Very common
59	Indian Golden oriole	*Oriolus kundoo*	R	IV	Widespread	Fairly common
	Paridae					
60	Cinereous Tit*	*Parus cinereus*	R	IV	Widespread	Common
	Passeridae					
61	Yellow-throated sparrow	*Gymnoris xanthocollis*	R	-	Widespread	Very common
62	House Sparrow	*Passer domesticus*	R	-	Widespread	Very common

	Phalacrocoracidae					
63	Indian Cormorant	*Phalacrocorax fuscicollis*	WM	IV	Widespread	Uncommon
	Phasianidae					
64	Common Quail	*Coturnix coturnix*	WM	IV	Widespread	Common
65	Red Jungle Fowl*	*Gallus gallus*	R	IV	Widespread	Fairly common
	Phylloscopidae					
66	Greenish leaf Warbler	*Seicercus trochiloides*	WM	-	Widespread	Very common
67	Hume's leaf-Warbler	*Abrornis humei*	WM	-	Widespread	Common
68	Common Chiffchaff	*Phylloscopus collybita*	WM	-	Widespread	
	Picidae					
69	White-naped Woodpecker*	*Chrysocolaptes festus*	R	IV	Indian Subcontinent	Very common
70	Yellow-fronted Pied Woodpecker*	*Dendrocopos mahrattensis*	R	IV	Widespread	Very common
71	Brown-capped Pygmy Woodpecker	*Dendrocopos moluccensis*	R	IV	Widespread	Fairly common
72	Lesser Golden-backed Woodpecker	*Dinopium benghalense*	R	IV	Indian Subcontinent	Uncommon
	Pittidae					
73	Indian Pitta	*Pitta brachyura*	SM	IV	Indian Subcontinent	Uncommon
	Podicipedidae					
74	Great Crested Grebe	*Podiceps cristatus*	WM	IV	Widespread	
	Psittaculidae					
75	Plum-headed Parakeet*	*Psittacula cyanocephala*	R	IV	Indian Subcontinent	Very common
76	Rose-ringed Parakeet	*Psittacula krameri*	R	IV	Widespread	Fairly common
	Pycnonotidae					
77	Red-vented Bulbul*	*Pycnonotus cafer*	R	IV	Indian Subcontinent	Fairly common
	Rallidae					
78	White-breasted Waterhen*	*Amaurornis phoenicurus*	R	-	Widespread	Very common
	Ramphastidae					
79	Brown-headed Barbet*	*Psilopogon zeylanicus*	R	IV	Indian Subcontinent	Very common
	Rhipiduridae					

80	White- browed Fantail	*Rhipidura aureola*	R	-	Widespread	Fairly common
81	White-throated Fantail	*Rhipidura albicollis*	R	-	Widespread	Uncommon
	Sittidae					
82	Indian Nuthatch*	*Sitta castanea*	R	-	Indian Subcontinent	Very common
	Strigidae					
83	Spotted Owlet*	*Athene brama*	R	IV	Widespread	Common
84	Jungle Owlet*	*Glaucidium radiatum*	R	IV	Indian Subcontinent	Common
	Sturnidae					
85	Common Myna*	*Acridotheres tristis*	R	IV	Widespread	Very common
86	Chestnut-tailed Starling	*Sturnia malabarica*	R	IV	Widespread	Fairly common
	Threskiornithidae					
87	Indian Black Ibis*	*Pseudibis papillosa*	R	IV	Indian Subcontinent	Common
	Turdidae					
88	Tickell's Thrush	*Turdus unicolor*	WM	IV	Indian Subcontinent	Uncommon
89	Indian Blackbird	*Turdus simillimus*	R	IV	Indian Subcontinent	
	Upupidae					
90	Common Hoopoe	*Upupa epops*	R	-	Widespread	Fairly common
	Vangidae					
91	Common Woodshrike	*Tephrodornis pondicerianus*	R	-	Widespread	Very common
	Zosteropidae					
92	Oriental White-eye	*Zosterops palpebrosus*	R	IV	Widespread	Uncommon

Plate 1.2 Avifaunal species occurrence

Black drongo (*Dicrurus macrocerus)*

Black eagle *(Ictinaetus malaiensis)*

Black-hooded oriole *(Oriolus xanthornus)*

Scarlet minivet (*Pericrocotus flammeus)*

Tickell's thrush *(Turdus unicolor)*

Crested serpented eagle *(Spilornis cheela)*

Spotted owlet (*Athene brama*)

White-eyed buzzard (*Butastur teesa*)

Yellow throated sparrow *(Gymnoris xanthocollis)*

Great crested grebe *(Podiceps cristatus)*

Tickells blue flycatcher *(Cyornis tickelliae)*

Asian openbill stork *(Anastomus oscitans)*

CHAPTER-2: PATTERNS OF HABITAT USE BY SELECT MAMMALIAN SPECIES

2.1 Introduction

Ecological niche modelling techniques are useful in understanding geographic distributions of the species (Elith and Leathwick 2009). The knowledge of where species occurs in a landscape is an essential aspect of biodiversity conservation. Species Distribution Models (SDM) are widely used adaptive management tools in understanding patterns of species occurrence as well as their responses to change in environmental conditions (Guisan and Thuiller 2005, Elith and Leathwick 2009). The SDMs can be carried out by two methods – one by using presence only locations and the other by using both presence and absence locations of the species of interest (Brotons et al. 2004). The spatial extent of the study are plays a major role in the performance of models, as the models are highly influenced by pseudo-absences (Van Der Wal et al.2009). Conservation planning decisions such as the Environmental Impact Assessment can benefit using SDM approaches (Ferrier 2002, Syfert et al. 2014). As part of biodiversity assessment in HACF focusing on faunal aspects, using SDM, habitat-use patterns of select species in the functional guilds *viz.* large carnivores, meso-carnivores (as functional role) and ungulates (Table.2.1) were estimated and discussed.

2.2 Study area and Methodology

2.2.1 Area demarcated for Habitat-use surveys

An area of ca 630 km^2 of total area comprising HACF and a 10-km circular buffer around it was demarcated in GIS. The total area of the four identified coal blocks of Tara, Parsa, PEKB and Kente Extension is around 87 km^2. Within this, in PEKB there is an operational mine measuring about 10.0 km^2 (these measurements were made in GIS and would be subject to variations on ground).

2.2.2 Animal sign surveys and camera trap surveys

The sign surveys were carried out during the dry months of December 2019 to March 2020. A field team comprising of three to four surveyors, including the forest guard from the Forest Department walked the forest trails, streams, and forest roads to record the presence of mammals. Fresh and reasonably fresh signs of large carnivores, lesser carnivores, and wild ungulates were recorded during the surveys along with their GPS coordinates. Signs recorded include faecal deposition, tracks, and occasional direct signs as well. A total of 120 km of walk effort was invested to carry out sign surveys. To reliably record wildlife presence in the area and to develop a photo-repository of rare, elusive and nocturnal mammals that could occur in the area, camera traps (Cuddeback C1) were placed in the forest trails and dry stream beds. A total of 37 camera traps were deployed during the study period. The cameras were mounted at a height of 40-50 cm on the trees in order to photo capture a wide variety of animals that could occur in the area. The cameras were left operational for 24 hours for a period of 20 to 30 days as determined by field logistics.

2.2.3 Data analysis

The species occurrence data collected using camera traps and sign survey were cumulated. The presence-only data can either be interpolated or extrapolated based on the study requirements (Feeley and Silman 2011). The species occurrence data was spatially thinned using 'spThin' package (Aiello-Lammens et al. 2015) in R to create a data set such that the locations were spatially apart from each other. The thinning was repeated for 100 times for the random process of removing nearest-neighbour to different of coordinates. Considering the spatial occupancy characteristics of species, the location dataset of large carnivores and ungulates were thinned 1 km apart and 0.5 km in case of meso-carnivores. A total of ten environment variables (Table 2.2), which includes six Bioclimatic variables (BIO3, BIO4, BIO7, BIO15, BIO17, BIO18), as well as population density, distance to water and distance to the nearest village were used as predictor variables. As the environment variables used for prediction are scale-dependent (Hortal et.al 2010), the relative variable importance was estimated. Highly correlated variables (Pearson's $r < 0.75$) were removed from analysis (Elith and Leathwick 2009, Elith et al. 2011). Rasters of different resolution were re-sampled using resample function in raster package of R, which transfer values between the raster for projection into coordinate system (Hijmans et al. 2015). To predict the distribution of species in the prescribed area maximum entropy algorithm in Program Maxent) was used (Phillips et al. 2006). Model selection was done using 'SSDM' package (Schmitt et al. 2017), which provides tools to evaluate individual species distribution probabilities.

Table 2.1 List of Mammal species guild used for Habitat use predictions

Common Name	Scientific name	IUCN	Wildlife (Protection) Act, 1972
Large Carnivores			
Common Leopard	*Panthera pardus*	V	Schedule I
Striped hyena	*Hyaena hyaena*	NT	Schedule I
Indian Grey wolf	*Canis lupus*	LC	Schedule I
Sloth bear	*Melursus ursinus*	V	Schedule I
Meso-carnivores			
Indian fox	*Vulpes bengalensis*	LC	Schedule II
Honey badger	*Mellivora capensis*	LC	Schedule I
Golden jackal	*Canis aureus*	LC	Schedule III
Ruddy mongoose	*Herpestes smithii*	LC	Schedule II
Jungle cat	*Felis chaus*	LC	Schedule I
Common Grey mongoose	*Herpestes edwardsii*	LC	Schedule II
Asian palm Civet	*Paradoxurus hermaphroditus*	LC	Schedule II
Small Indian Civet	*Viverricula indica*	LC	Schedule II
Ungulates			
Wild Pig	*Sus scrofa*	LC	Schedule III
Barking deer	*Muntiacus muntjac*	LC	Schedule III
Spotted deer	*Axis axis*	LC	Schedule III
Four-horned antelope	*Tetracerus quadricornis*	V	Schedule I

Table 2.2 List of Variables used for Habitat use predictions

Variable		Code	Source	Type
Climate	BIO1 = Annual Mean Temperature		Worldclim	Continuous
	BIO2 = Mean Diurnal Range (Mean of monthly (max temp - min temp))			
	BIO3 = Isothermality (BIO2/BIO7) (×100)	BIO3		
	BIO4 = Temperature Seasonality (standard deviation ×100)	BIO4		
	BIO5 = Max Temperature of Warmest Month			
	BIO6 = Min Temperature of Coldest Month			
	BIO7 = Temperature Annual Range (BIO5-BIO6)	BIO7		
	BIO8 = Mean Temperature of Wettest Quarter			
	BIO9 = Mean Temperature of Driest Quarter			
	BIO10 = Mean Temperature of Warmest Quarter			
	BIO11 = Mean Temperature of Coldest Quarter			
	BIO12 = Annual Precipitation			
	BIO13 = Precipitation of Wettest Month			
	BIO14 = Precipitation of Driest Month			
	BIO15 = Precipitation Seasonality (Coefficient of Variation)	BIO15		
	BIO16 = Precipitation of Wettest Quarter			
	BIO17 = Precipitation of Driest Quarter	BIO17		
	BIO18 = Precipitation of Warmest Quarter	BIO18		
	BIO19 = Precipitation of Coldest Quarter			
Population Density			CIESIN	Continuous
Distance to the nearest water source (m)			RRSC-IRSO	Continuous
Distance to the nearest village/ tribal settlement (m)			RRSC-IRSO	Continuous

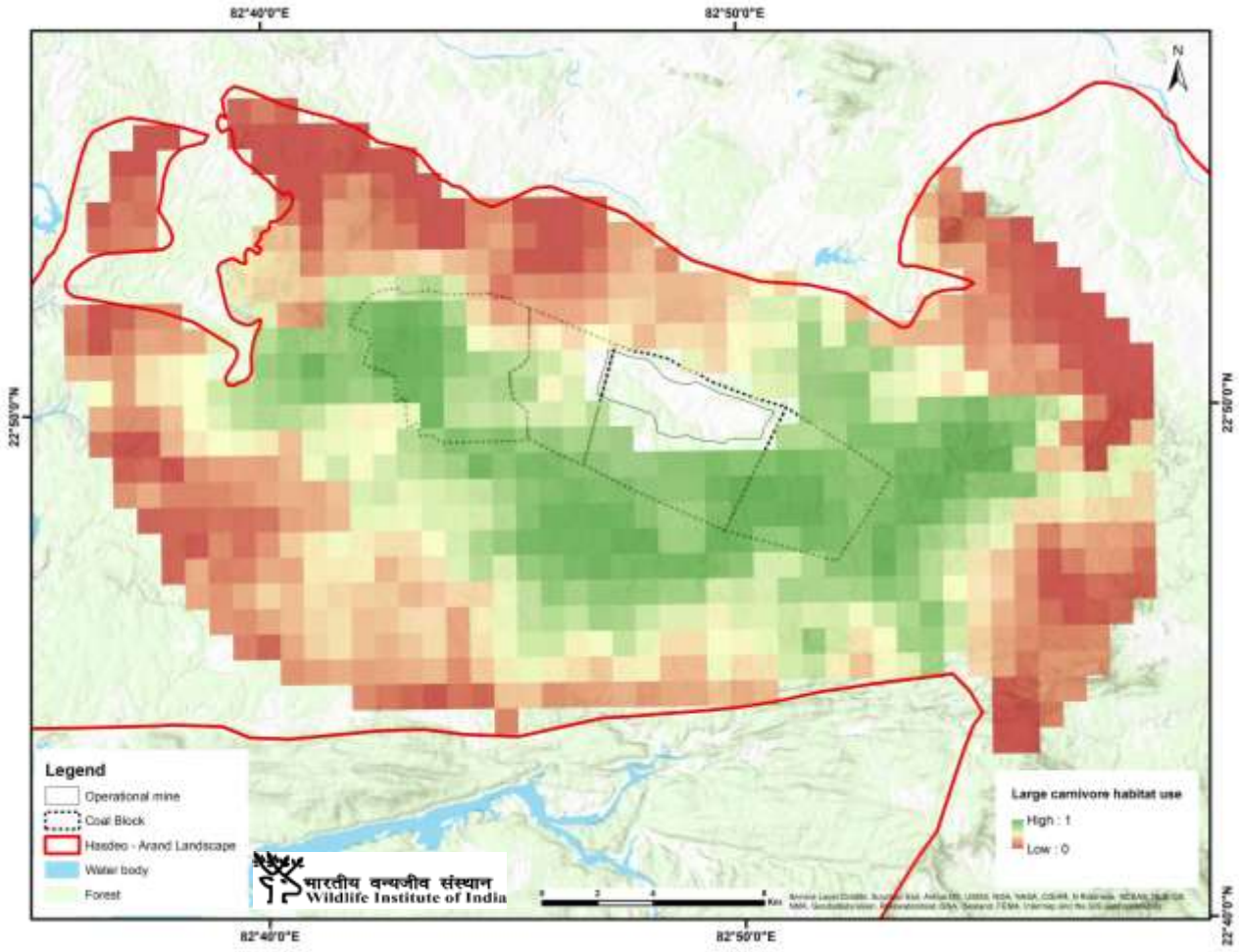
2.3 Results

Predicted habitat-use maps for each functional guild large carnivore (Map 16), meso-carnivore (Map 17), ungulates (Map 18) and overall species richness (Map 19) depict habitat use in the demarcated area within. The AUC values of the models suggests good prediction accuracy with estimated values of 0.71, 0.63 and 0.66 for large carnivores, meso-carnivores and ungulates respectively. The variable "Precipitation of Warmest Quarter" emerged as the significant variable to predict habitat-use of large carnivores (variable contribution in the model = 30%). The variable "Precipitation Seasonality" emerged as the significant variable for to explain habitat-use by ungulates (variable contribution in the model = 33%). The variable, human population density emerged as the significant variable to predict habitat-use of meso-carnivores (variable contribution in the model = 29%).

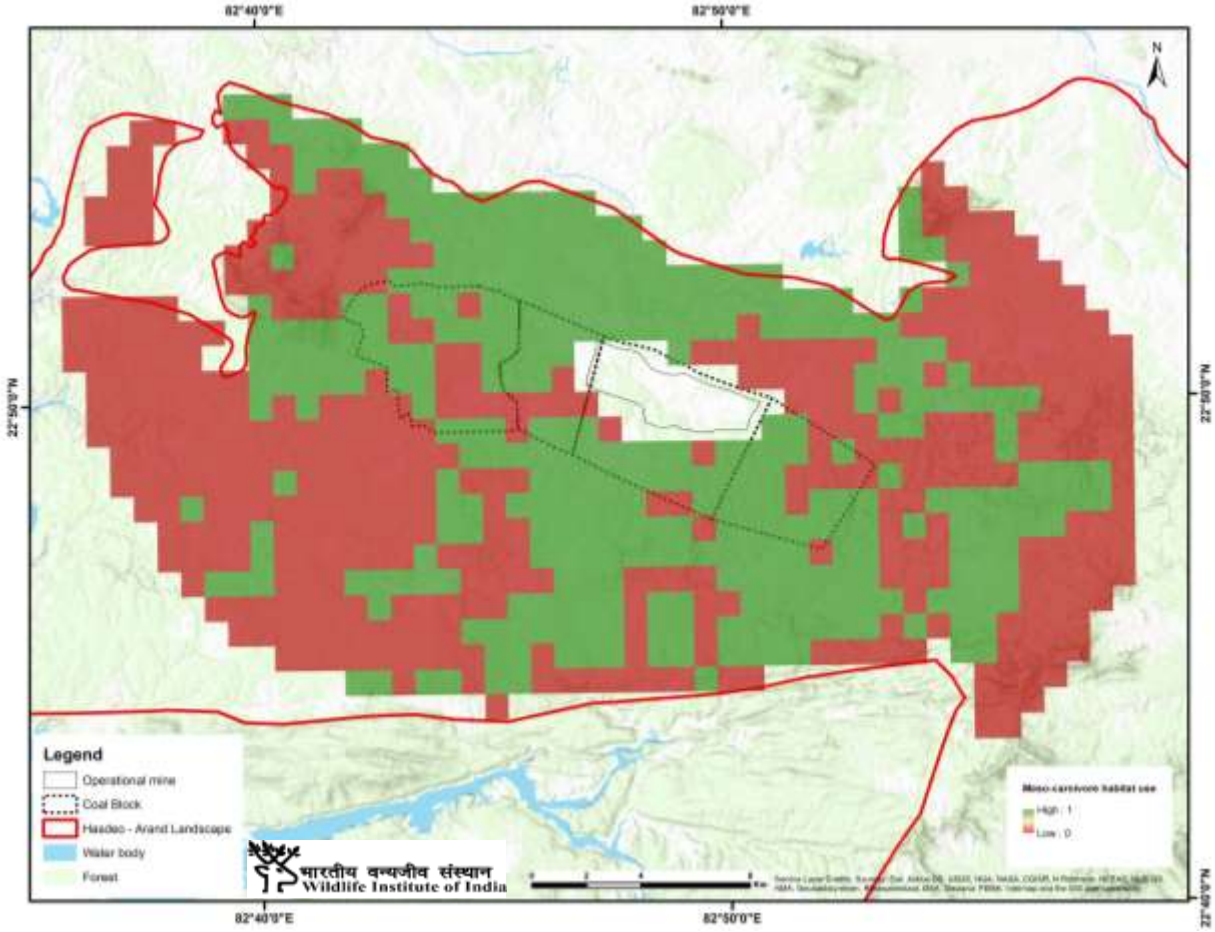
2.4 Discussion

The habitat-use patterns of the species under the guilds large carnivores, meso-carnivores and ungulates, modelled under SDM framework suggests relatively high habitat-use in the forested habitats of the four coal blocks, Tara, Parsa, PEKB and Kente Extn. and the surrounding areas. Observed habitat-use by all large carnivores (common leopard, stripped hyena, sloth bear and Indian grey wolf) and the ungulates modelled show relatively high use in forests – a pattern that is consistent with general understanding of the occurrence of forest-dwelling carnivores and ungulates. Asiatic wolves are typically a species of open

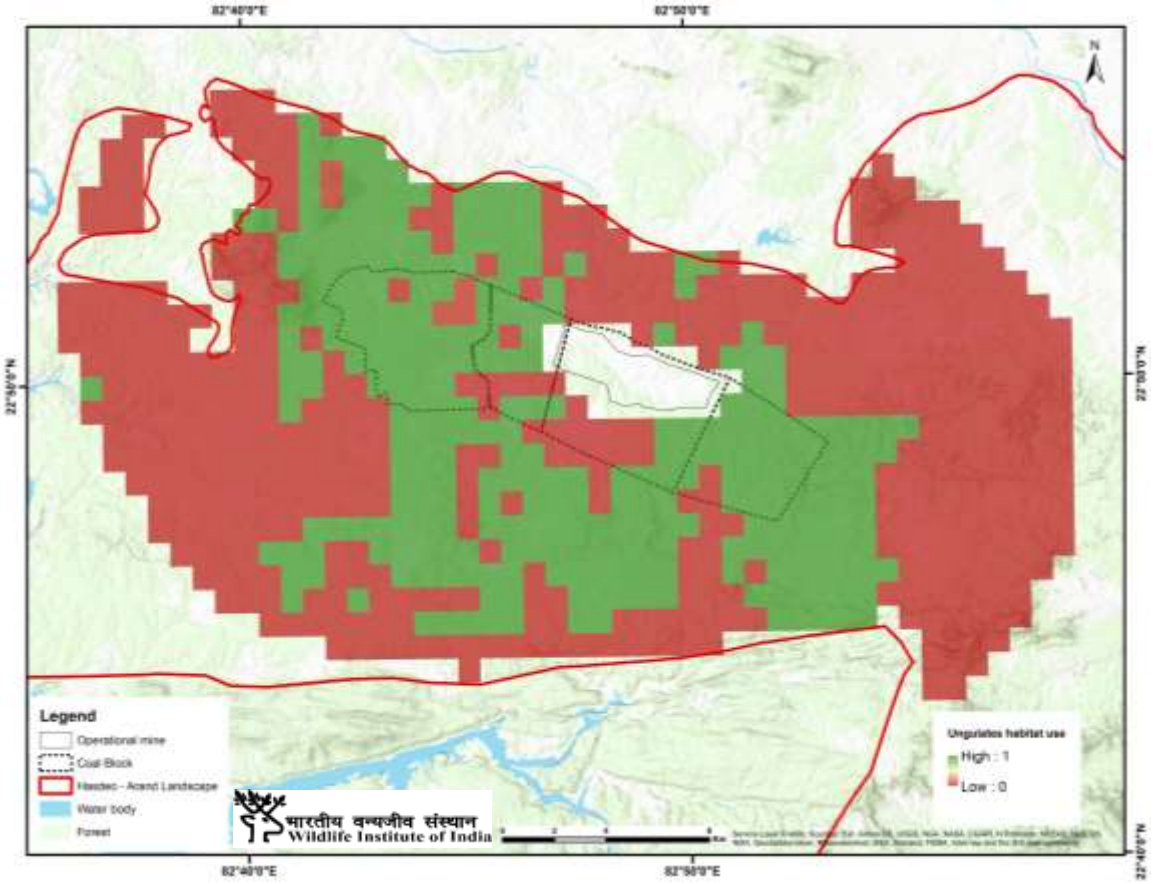
grasslands and scrub, grasslands and scrub. In HACF and surrounding landscape there are no large grasslands, and wolves selecting forests may hint at the adaptation of the species to local habitat conditions. The forests in the study area are heterogeneous and may provide essential micro-habitats like denning sites to the wolves. The ungulate species that occur in study area, such as the barking deer (would prefer relatively dense forests), four-horned antelope (would prefer relatively light forests), spotted deer and wild pigs are typically forest-dwelling species (Johnsingh and Manjrekar 2012). Thus, the ungulates showing high use in the forests is counter-intuitive. Many species of the meso-carnivores (or the lesser carnivores) modelled in the assessment are commensal. The commensal lesser carnivores include golden jackal, Indian fox, jungle cat, honey badger and others. This could explain high habitat-use of meso-carnivores in the vicinity of the villages. Around the villages, meso-carnivores may opportunistically subsist on domestic foul, cattle and ground birds like partridges that are known to occur close to human-use areas in the village settings. Availability of sufficient spaces as habitat near the settlement are known to play a role in fulfillment of ecological needs of small carnivores, as observed in many protected areas in India (Kalle et al. 2013).



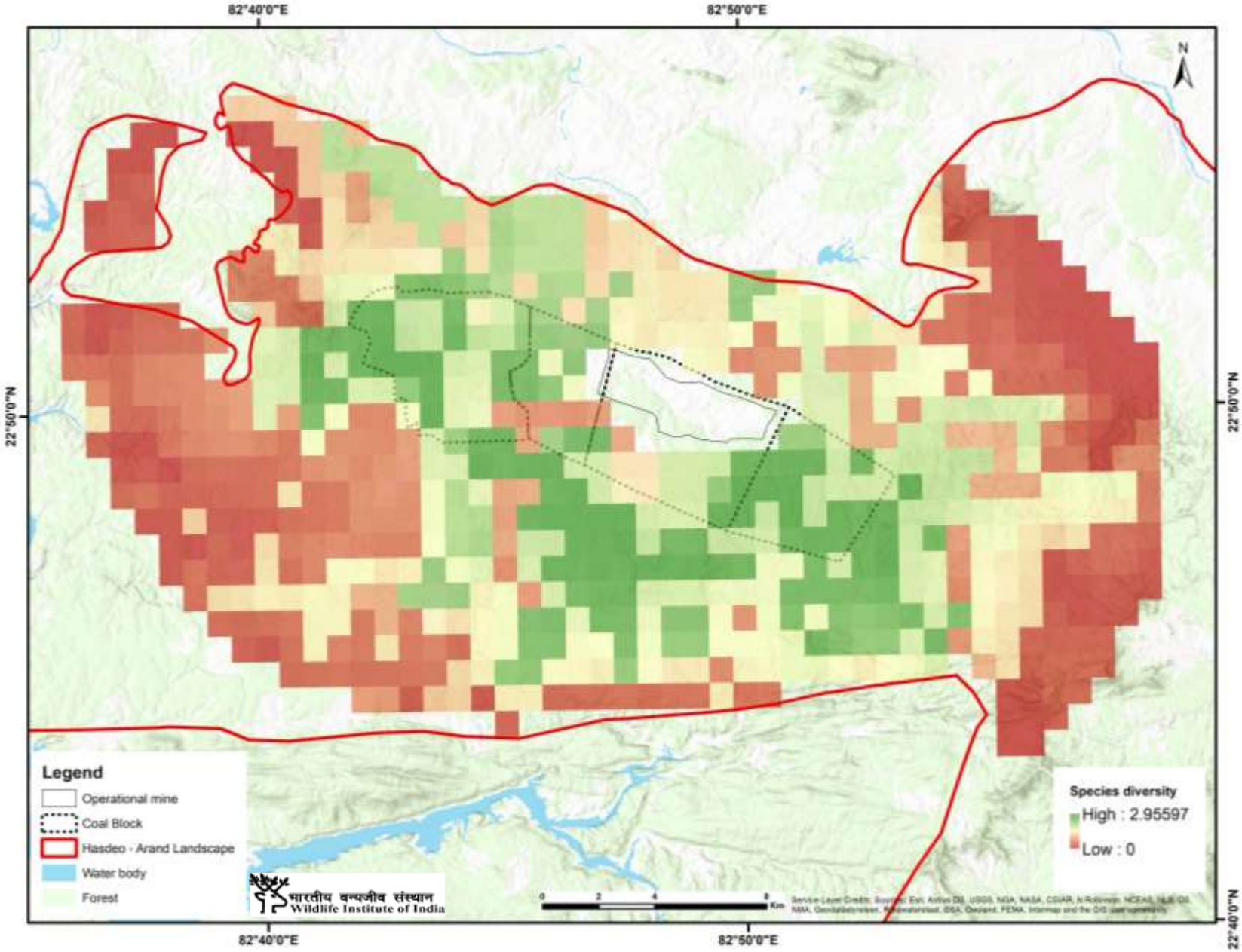
Map 16 Estimated habitat use for large canivores in and around 10-km buffer of HACF



Map 17 Estimated habitat use for meso canivores in and around 10-km buffer of HACF



Map 18Estimated habitat use for ungulates in and around 10-km buffer of HACF



Map 19 Species diversity of select mammalian species

CHAPTER-3: ELEPHANT HABITAT USE, MOVEMENT PATTERNS AND ASPECTS OF HUMAN-ELEPHANT CONFLICT

3.1 Introduction

The Asian elephants, *Elephas Maximus*, are highly endangered and presents a huge challenge for conservation. Among the many threats facing Asian elephant conservation, habitat-related threats and human-elephant conflict (HEC) are overriding (Leimgruber et al. 2003). India harbours over 60% of the wild Asian elephant population across four regions of the country namely south, north-east, north-west and east-central and holds the key for long-term conservation of the species. Among the four regional elephant populations, the East-Central population spanning the states of Chhattisgarh, Jharkhand, south West Bengal and Odisha suffer disproportionately high levels of HEC (Rangarajan et al. 2010). East Central region harbours about one-tenth of the wild elephant population in the country (about 2500), but loses over 200 human lives annually (>40% of reported HEC-related human fatalities in India). The increasing levels of HEC is primarily due to loss, fragmentation of degradation of in-tact elephant habitats, which had led to frequent dispersal of elephants from their forested home ranges into human-dominated areas. The central Indian elephant habitat is one of the most fragmented and degraded due to mining activities (Rangarajan et al. 2010) . Degradation, fragmentation and loss of forest cover to due to developmental activities have severely threatened long ranging species like elephants as they require large, undisturbed inviolate landscapes to fulfill their ecological needs. Activities like mining have depleted and fragmented the elephant habitats. This has led to increase in negative interaction of elephants and humans resulting in loss of previous human lives, injuries and structural damages in the landscape.

Understanding HEC situation in Chhattisgarh would require an appraisal of HEC situation in the whole East Central region comprising of the states of Chhattisgarh, Jharkhand, south West Bengal, Madhya Pradesh and Odisha. The EC region harbours less than 1/10th (<3000) of country's elephants, but loses over 40% (over 200 HEC-related deaths) of reported 500 HEC-related human fatalities in the country. The HEC-related human fatalities reported in the region are highly disproportionate to its elephant population in the country. The increasing levels of HEC have resulted in considerable public resentment against the management and elephant conservation as a whole. HEC resolution is challenging in EC region due to fragmentation, loss and degradation of intact elephant habitats.

Chhattisgarh human-elephant conflict situation is a paradox with a relatively low number of elephants (<300, which is <1% of India's wild elephant population) but high levels of HEC with over 60 human lives are lost every year due to conflict (>15% of the reported human deaths due to HEC). In addition to loss of human lives, crop loss and damage to property due to HEC are severe. There is continuous dispersal of elephant herds from the neighbouring states of Jharkhand and Odisha.

As per the latest population estimates, there are about 250 elephants (Project Elephant 2017) in Chhattisgarh. Of the estimated 250 elephants, over 80 to 90% of the elephants occur in northern Chhattisgarh, in Bilaspur and Surguja forest circles. In the Bilaspur forest circle elephants predominantly

occur in Dharamjaigarh, Raigarh, Katghora and Korba Forest Divisions. In the Surguja Forest Circle elephants predominantly occur in Surajpur, Surguja, Balrampur, Koriya and Jashpur Forest Divisions. Human–Elephant Conflict is relatively high in northern Chhattisgarh resulting in crop and property loss and occasional human fatalities.

Here, using data on elephant occurrence at the compartment level; movement patterns of elephants based on insights gained from WII's on-going elephant project (2017 onwards) that involves monitoring of satellite-collared elephants, and collation of HEC data, the present status of elephants in HACF and surrounding landscape is discussed. Furthermore, approaches to address HEC and conservation potential for elephants are discussed.

3.2 Methods

Conventional approaches involving short-duration elephant sign surveys may not capture elephant occurrence, especially over large spatial scales. This is typically the case in forested habitats where sign detections tend to be low. In order to circumvent this challenge and to have a robust assessment of elephant occurrence, using a multi-pronged approach could be ideal. In order to assess elephant, use of HACF and the landscape surrounding it to understand their movement patterns, a combination of methods is used:

1. Elephant occurrence is mapped at the compartment level. For this, data on elephant occurrence meticulously maintained by the respective Forest Divisions at the compartment level were obtained from the Forest Department for a period of 2018 to 2020. The data obtained was decoded as 1 (recorded use of elephants in the compartment) and 0 (non-detection in the compartment)

2. As part of WII-CGFD collaborative project on elephants in northern Chhattisgarh, the WII research team has been monitoring elephants using (i) individual recognition of elephants and re-sighting approach and (ii) satellite collaring of select elephants that operate in the landscape. The monitoring program has begun during the year 2017 and is on-going. Data obtained from the monitoring program is used to understand elephant home range and movement pattern in the HACF and the landscape surrounding it. **Elephant home ranges presented in the Map 20** were computed using Minimum Convex Polygon (MCP) approach (Powell 2000).

3. Incidents of crop and property losses caused by elephants, and HEC-related human fatalities were mapped in GIS based on compensation data collated from the State Forest Department. Using this, the spatio-temporal patterns of HEC
were assessed.

3.3 Results and Discussion

3.3.1 Elephant occurrence in Hasdeo Arand Area

The whole of HACF and its surrounding landscape comprise of 647 forest compartments spread over 12 forest ranges in 4 forest divisions. Of the 647 forest compartments, elephant occurrence is recorded in 148 compartments during the period 2018 – 2020 (Map 21). Elephant occurrence during the period 2018-2020 was reported in the all the 12 ranges located within HACF and the landscape surrounding it. Elephant occurrence is not limited to any particular part of the landscape, however it spread across in

HACF and the landscape surrounding it. The number of compartments with reported elephant occurrence is best considered minimum, as obtaining compartment-level information in large forested tracts is seldom easy as elephants could occur undetected in dense conditions and elephants do occur outside of HACF and landscape surrounding it as well entailing back and forth movement.

3.3.2 Elephant movement and home range patterns

The study carried out by WII in collaboration with Chhattisgarh Forest Department from the year 2017 onwards clearly highlight that elephants have large home ranges. The forests that elephants currently occur are highly fragmented and degraded due to incompatible land-use. Infrastructure development and mining are further fragmenting the habitats making conflict mitigation a huge challenge. In fragmented habitats conventional fencing approaches minimally work due to high perimeter to area ratio of habitats An adult bull tusker elephant satellite collared by CGFD-WII during July 2019, viz Ganesh (CGM023) has a large home range and include habitats located in the southern portion of HACF and the surrounding landscape (Map 20). During the year 2018-2019, CGM023 had operated with a breeding herd of over 30 elephants. The home range of a cow elephant Gautami (CGF010) satellite collared by CGFD-WII during June 2018 includes north-eastern parts of landscape (Map 21). This cow was part of a breeding herd of elephants that was collared and monitored by WII and Chhattisgarh FD for a period of 18 months. The size of the herd during the monitoring period was highly variable (9 to 22 individuals were observed along with CGF010 in different locations and across different seasons). In general, the elephant social organization is fluid, with seasonal fission and fusion of groups. The group dynamics of CGF010 and its group confirms to this patterns of social organization.

In addition to the collared elephants, a breeding herd of elephants that CGFD-WII has been monitoring using an approach involving sighting-re-sighting of known individuals operates in the northern portion of the Hasdeo Arand area (Map 20). This group, which, as per WII's elephant monitoring program known as Torn Ear (CGF002) group has an estimated group size of 7 to 12 elephants.

In highly fragmented areas, the elephant home ranges tend to be large as small, degraded forest patches cannot sustain herds. It is observed that home range size is a function of habitat quality – in areas that support good intact habitats, the elephant home ranges are relatively small (eg. Rajaji, Mudumalai etc). However, in fragmented areas, elephant home ranges are typically large. The elephant herds are generally interlinked and home ranges spread over two or more states.

Elephant ID	Sex and age-class	Home range (100% Minimum Convex Polygon)
CGM001	Adult male	1416.00 sq.km
CGF010	Adult female	2562.00 sq.km
CGM003	Young male	1711.99 sq.km

One of the main reasons as to why elephants start dispersing into human-use areas is the threat to habitat. In particular, threat to elephant home ranges. While threat to habitat can be identified and sometimes even addressed, threats within individual home ranges of elephants are hard to evaluate and hence, difficult to mitigate. The latter threats are more insidious and lasting.

3.3.3 Patterns of Human–Elephant Conflict (HEC)

A total of 2357 elephant-related crop and property damage incidents were reported during the period 2015-2018 in HACF and surrounding landscape. High fraction (19.3%) of crop loss cases were reported during December followed by October (18.45%) coinciding with paddy harvest. House/building damage instances (Fig. 4) were recorded mostly during July and January. A total of ten HEC-related human fatalities were reported between 2018 and 2019.

In general, one of the reasons for HEC being disproportionately high in EC region is the elephant dispersal from forest habitats through fragmented human use areas. This large scale elephant dispersal out of intact forests coincide with commencement of large-scale mining projects and associate infrastructure developments in the EC region, particularly in the states of Odisha and Jharkhand.

Major disturbances to habitats such as mining not only cause habitat loss and fragmentation (as understood generally) but can affect individual herd's home ranges. Such disturbances can lead to abandonment of habitats as threats to home ranges have a threshold limits. The effect of mining on elephant habitat may not reflect in the same habitat, but could be a silent trigger for HEC in some other area within the landscape.

3.4 Summary

Elephants are wide ranging animals with reported home ranges in East Central landscape spanning over 1000-km^2. The effect of loss of part of range for elephants is difficult to assess. Based on the general understanding of elephant ecology and behaviour gleaned from long-term studies, it is certain that habitat loss is one of the major triggers for elephant dispersal into human-use landscapes culminating into HEC. In light of this, the following points may be noted:

1. As a conservative estimate, about 40 to 50 elephants may use HACF and the landscape surrounding it at different times of the year. Use of by elephants is not limited to any specific area, but is spread out across the landscape
2. Elephants (both breeding herds and bulls) use with varying intensities. Home range polygons of some of the elephants that were monitored using satellite collars fall within the landscape.
3. In general, elephants operating in Chhattisgarh have large home ranges as the forests are highly fragmented and elephants cannot be contained in small patches
4. If habitat conditions improve in southern parts of HACF and landscape surrounding it, elephant use could increase in such areas, which is highly desirable from HEC management standpoint as the habitat along the southern portion is relatively less fragmented
5. HEC management strategies that include improving habitat condition for elephants in the forests needs to be prioritized in the wake of HEC incidences. Conflict management strategies may include:
    a. Judicious use of physical barriers (like solar-powered electric fences). Choice of barriers and placement of them may require a detailed assessment
    b. Temporary fences around settlements may be experimented in areas where elephant-related property damage is reportedly high
    c. Provisioning electric lights (high-mast lights) around settlements would be beneficial to villagers

d. Improving habitat conditions for elephants is crucial. The habitat needs to be protected from further levels of degradation and fragmentation. Loss of any forest cover due to anthropogenic activities should strictly be avoided.

Figure 1A: Monthly patterns of crop damage incidents between 2015 and 2018

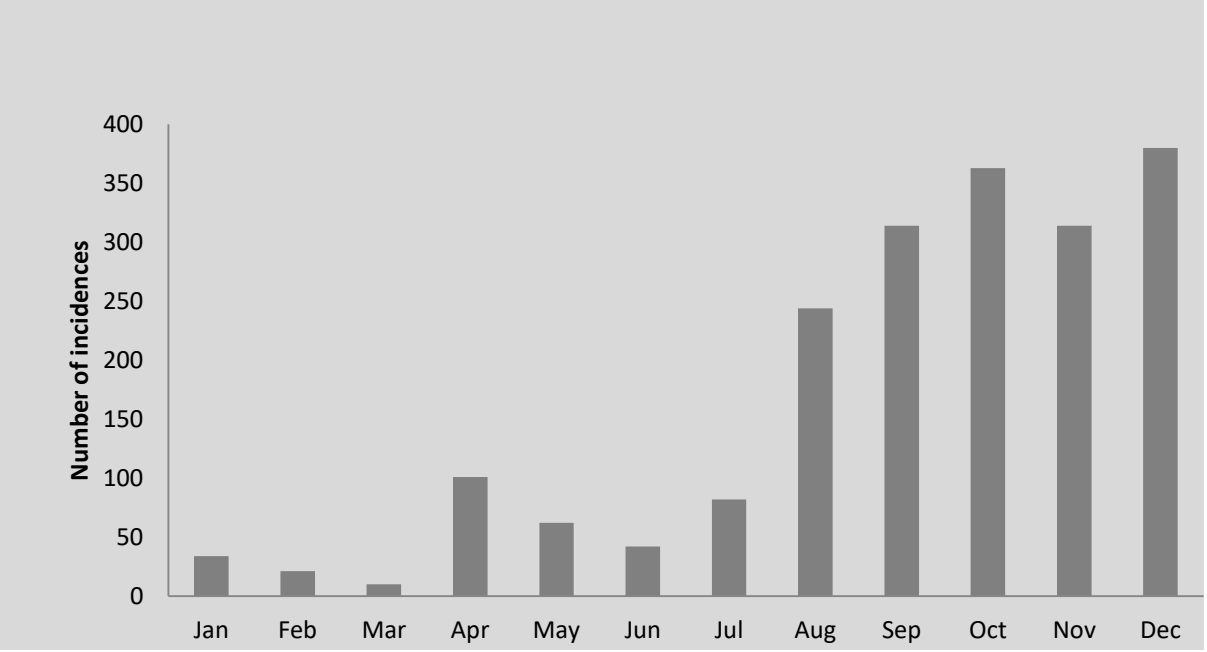
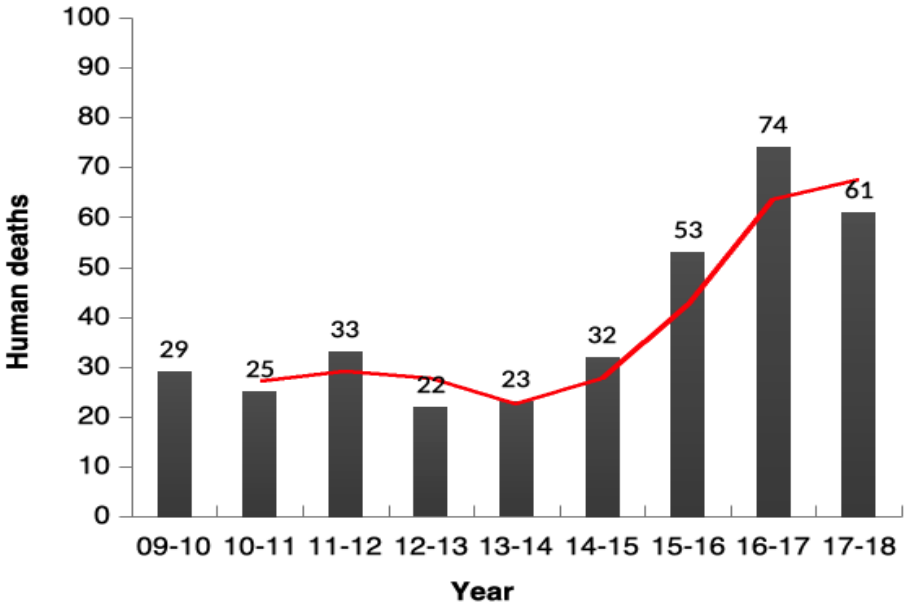
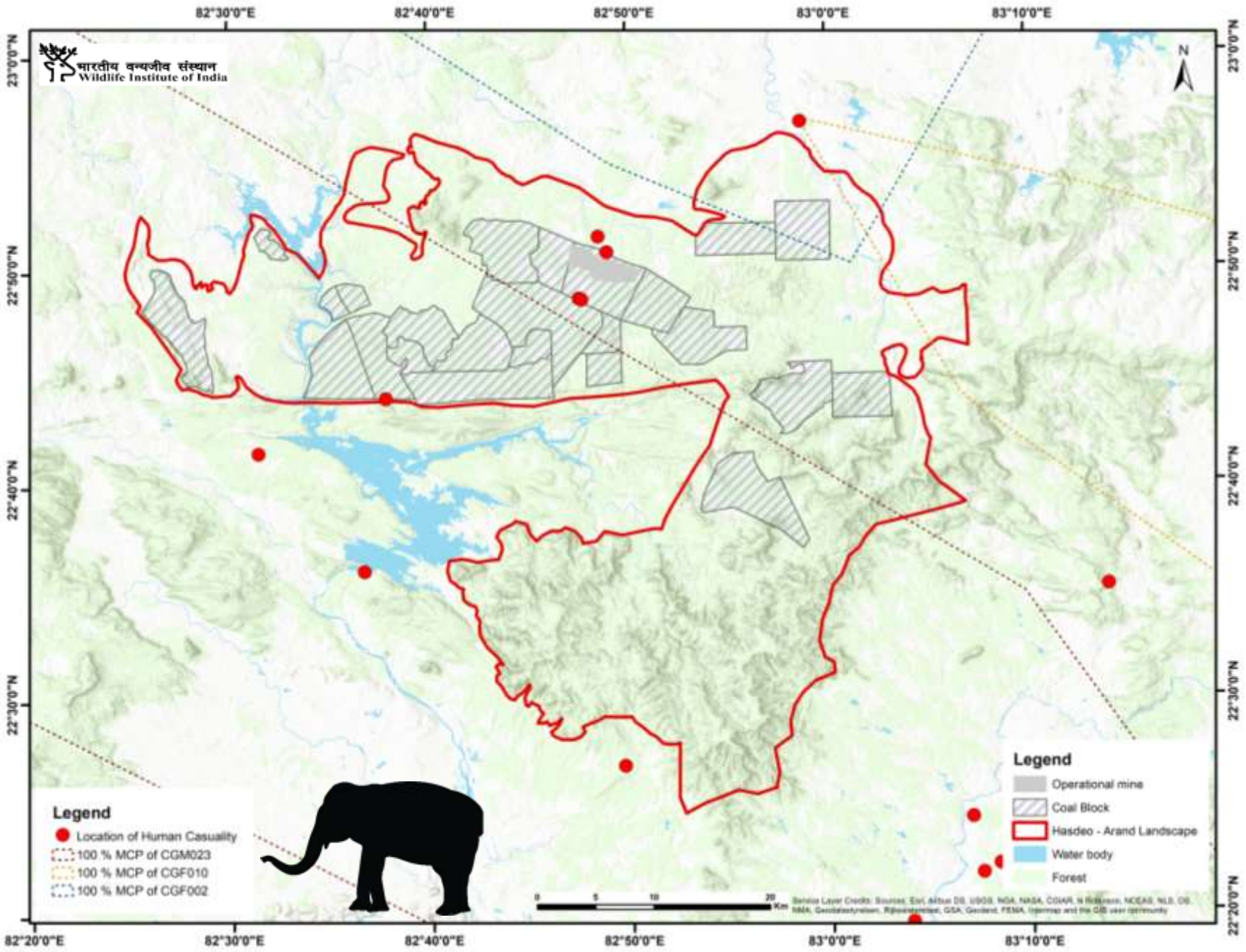
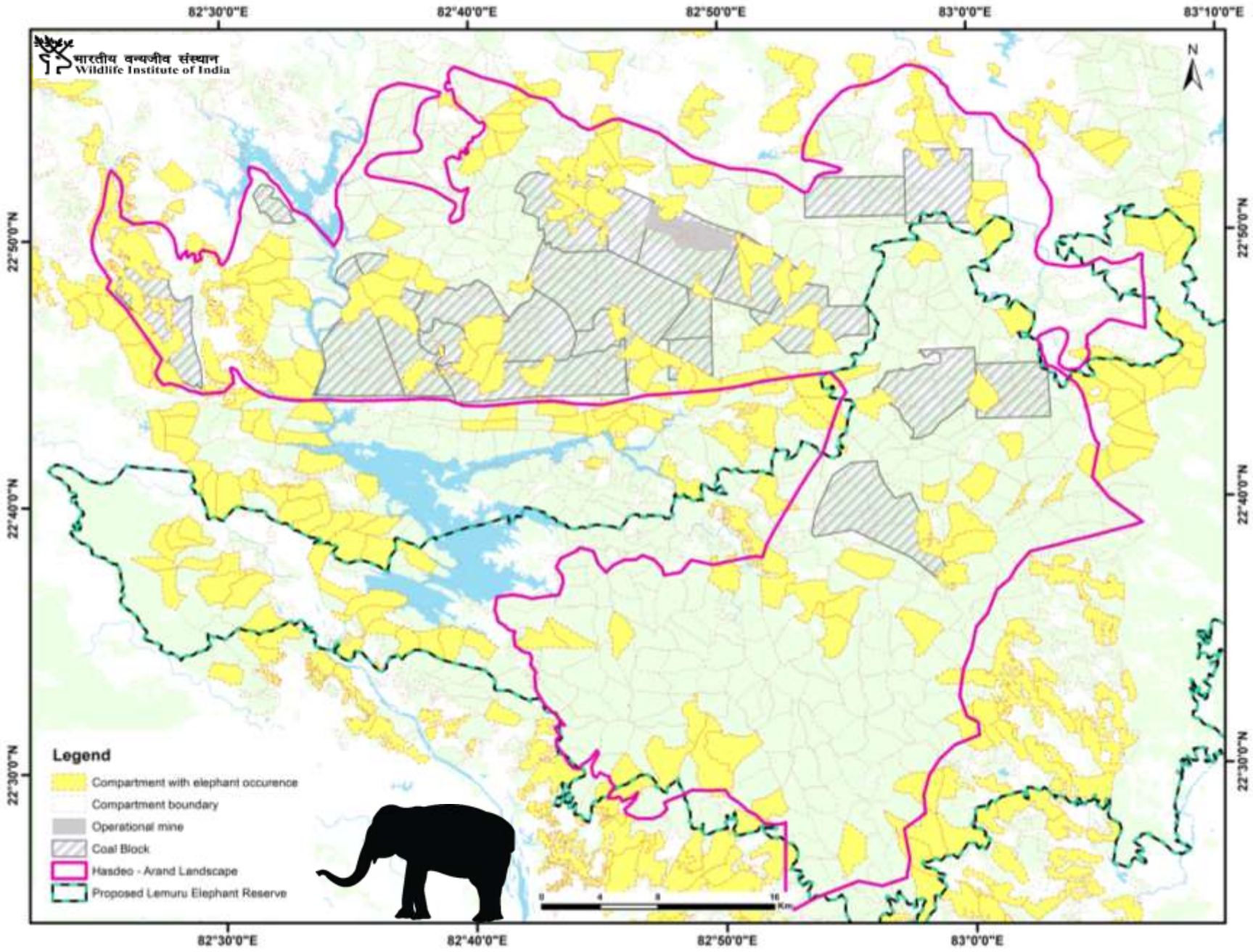


Figure 1B: Yearly patterns of human casuality incidents between 2010 and 2018





Map 20 Ranging patterns of elephants within and around the HACF and surrounding landscape



Map 21 Elephant occurrence in and around HACF. Map prepared based on compartment-level information obtained from Chhattisgarh FD for the period 2018-2020

CHAPTER-4: POTENTIAL FOR RECOVERY OF TIGERS, *PANTHERA TIGRIS*

4.1 Introduction

Indian tigers (*Panthera tigris*) serve as flagship and umbrella species in biodiversity conservation (Karanth et al., 2004). Global tiger recovery strategies envision doubling tiger numbers by the year 2022 in order to buffer the species from the threat of extinction. Vision of doubling tiger numbers is far from easy as tiger habitats are small, insular and some of the good habitats already support high density of tigers. Thus, tiger recovery hinges on inter-connected large landscapes rather than individual protected areas (Hebblewhite et al. 2014). The Central Indian landscape in the states of Madhya Pradesh, Chhattisgarh and Maharashtra still has large tracts of potential habitats with high potential for tiger recovery (Dutta et al. 2016). The Central Indian landscape support over 40% of the total tiger population in India (Jhala et al. 2018). A number of protected areas and intact connectivity between tiger habitats make Central Indian landscape tenable for long-term tiger conservation (Dutta et al. 2016, Thatte et al. 2018).

Kanha–Boramdeo–Achanakmar (KBA) complex in Central India is one such habitat complex that has high tiger recovery potential (Dutta et al. 2016). Hasdeo–Arand Landscape is located towards the east of KBA complex. Working plans of Korba Forest Division suggest presence of sizeable number of tigers in the area during 1970s (Working Plan, 1970, Korba Forest Division, Chhattisgarh Forest Department). Over time, tigers have become rare in the area. Presently, only sporadic tiger movement around the area is reported by the Forest Department (Annexure-6). Here, potential habitat of tigers in the area by factoring in availability of habitat, extent of habitat connectivity and dispersal potential from the nearby tiger habitats using a hypothetical framework, is assessed.

4.2 Methods

Probability of tiger presence in a landscape is determined by combination of factors that include availability of forest cover, availability of ungulate prey (Karanth et al. 2004, 2011, Andheria et al. 2007) and minimal human disturbance to the habitat (Hebblewhite et al. 2014). Habitat potential for harbouring tigers is assessed following a hierarchical approach:

1. Land-use land-cover (LULC) layer developed by RRSC-IRSO for northern Chhattisgarh is used to delineate potential tiger habitat in the area. The LULC was re-sampled to 100-m resolution to create a resistance layer for the landscape. For settlements, transportation infrastructure and active mines, low conductance value is assigned as these could impede animal movement. For crop fields and water bodies, moderate conductance values were assigned. For the forests and scrubs, higher conductance values were assigned
2. Circuitscape Plug-in tool in ArcGIS (10.6.1) was used to assess the strength of habitat connectivity between (KBA) complex, which is the nearest potential tiger source habitat, and the area

3. A total of 12 ecologically similar protected areas in Central India were selected and vegetation productivity of the area was compared with those PAs
4. A qualitative SWOT (Strength, Weakness, Opportunity and Threat) analysis was carried out for the area to evaluate its tiger conservation potential

4.3 Results and discussion

Literature on tiger ecology suggests that tigers prefer areas that have sizeable forest cover and support medium, to large-sized wild ungulates together with minimal human disturbance (Harihar et al., 2009). Floristically intact tiger habitats that do not support ungulate prey may not hold resident tiger population (Smith et al., 1998). Thus, recovering ungulate populations in intact habitats is central to recovering tiger populations. A multifaceted approach focusing on recovery of both potential habitat as well as ungulate prey may be critical to achieve the vision to India's vision to double tiger numbers. Opportunities to augment tiger population in the existing tiger reserves and PAs may be limited as many well-managed PAs already do support density of tigers at carrying capacity. The Central Indian landscape spanning the states of Maharashtra, Madhya Pradesh and Chhattisgarh still has immense potential to recover tigers and augment their population in many landscapes like the area.

4.3.1 Habitat connectivity

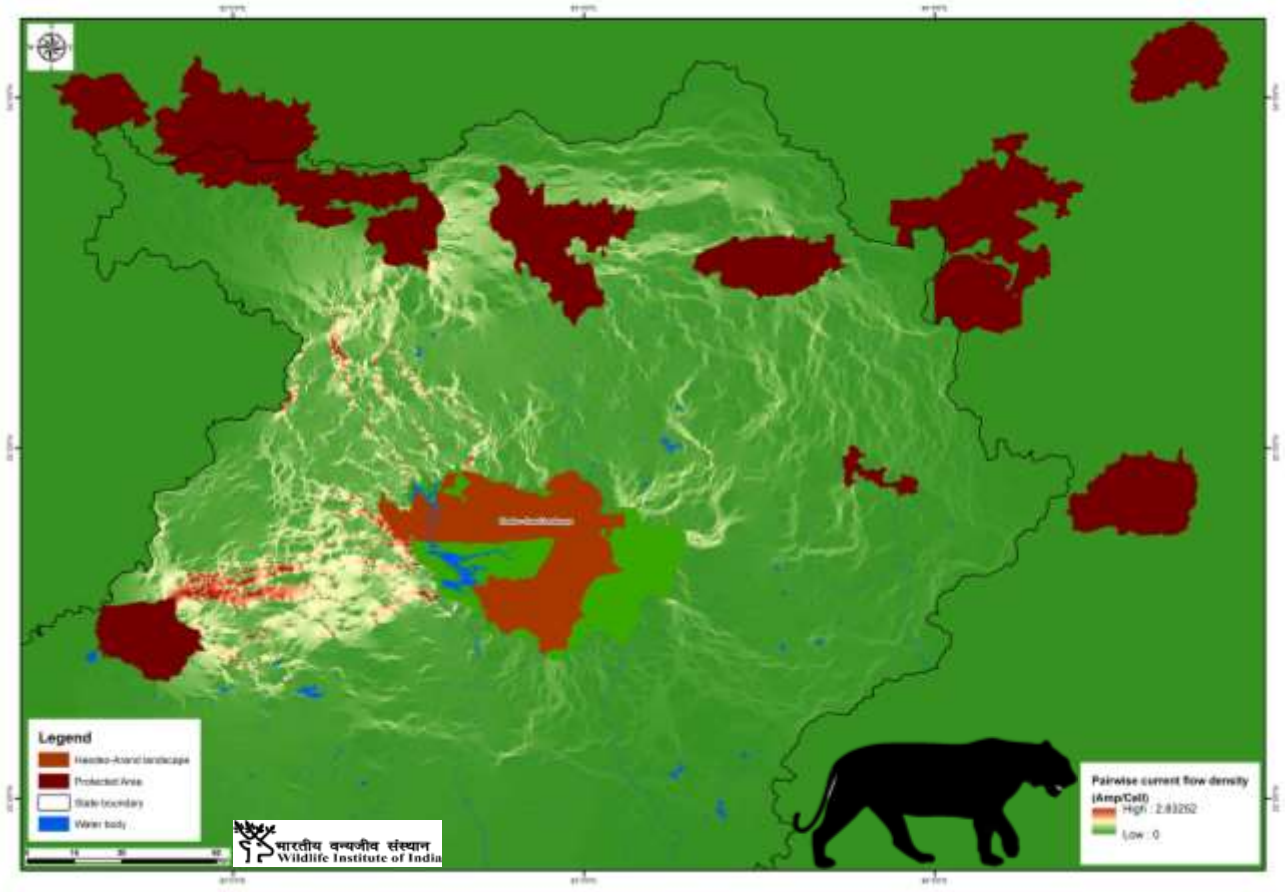
The habitat connectivity between KBA and the area is strong, and offers minimal resistance for wildlife movement (Map-22). *Circuitscape* models show higher conductance values (2 – 2.8) indicate strong connectivity. Sporadic reports of tiger presence in Korba forest division suggest that habitat connectivity between KBA and Hasdeo Arand area could be still functional for tigers. It is pertinent to note that the forest department at Korba Forest Division has recorded tiger presence in a few locations within Hasdeo Arand area (Annexure-6). The major linear infrastructure in KBA and Hasdeo Arand area tiger dispersal corridor include Ambikapur to Bilaspur National Highway and the Bilaspur–Anuppur Railway line. Maintaining the current level of connectivity would be essential to facilitate putative tiger dispersal from KBA to Hasdeo Arand Area.

4.3.2 Habitat status

The forested habitats in Hasdeo Arand area in conjunction with other connected forested areas in Surguja, Surajpur, Dharamjaigarh, Korba and Katghora forest divisions is large. The total forest cover in the demarcated HACF and the landscape surrounding it is around 1518 km^2 of which around 1160 km^2 of habitat is reasonably intact. In the tropical deciduous forests, dry-season habitat productivity can be a limiting factor in determining the carrying capacity of large-bodied mammals (Harihar et al., 2020). The dry-season (February to April) mean NDVI (Normalized Difference Vegetation Index) – a proxy for habitat productivity in Hasdeo Arand area is comparable with other Central Indian tiger habitats like Bandavgarh TR, Achanakmar TR, Guru Ghasidas National Park and Sitanadi Wildlife Sanctuary. Although NDVI is a crude measure of vegetation productivity, it may not reflect edible biomass for ungulates (Vaidyanathan et al. 2010). Therefore, field assessment of vegetation productivity from large herbivore point of view is essential in Hasdeo Arand area to estimate carrying capacity of tigers and their main prey animals.

4.3.3 Target tiger densities and factors pre-empting tiger colonization

HACF and the landscape surrounding it is ecologically similar to other tiger habitats in central India. What seems to preclude tiger recovery in the landscape is low density of ungulate prey. Tiger recovery and persistence in Hasdeo Arand area seems conditional on four main factors namely 1. recovery of ungulate prey, 2. maintaining the existing habitat connectivity with KBA, 3. enriching habitat conditions through protection and habitat management, and 4. real-time mitigation of human-wildlife conflict (like compensation for livestock loss). If these conditions are met, Hasdeo Arand area can support a minimum crude density of 1 tiger/ 100 km^2 (this density is arrived at based on the median tiger densities in ecologically comparable tiger habitats in Central India) Thus, in highly suitable areas encompassing over 1000 km^2 in Hasdeo Arand area, it could be possible to support 10 to 15 tigers. It may also be noted that the Hasdeo Arand area is contiguous to other forests in Surguja, Raigarh and Surajpur districts. Thus, the estimates of potential tiger abundance in Hasdeo Arand area are best considered conservative.



Map 22 Pairwise current flow density, shown in shades of pale yellow to red gradient, indicate areas where current flow is high between adjacent pair of PAs from Hasdeo-Arnad landscape

Table-4.1: Tiger population status (size) in select Central Indian tiger habitats (as per all-India tiger estimation report of 2018)

Protected Area	State	Area in Km^2	Abundance (±density) # 2006	Abundance (±density) # 2010	Abundance (±density) # 2014	Abundance (±density) # 2018
Kanha	Madhya Pradesh	917.4	89	60, 28 (6.83)	74 (6.10)	88 (4.40)
Bandavgarh	Madhya Pradesh	1536.9	47	59, 37 (16.25)	60 (4.47)	104 (5.83)
Sanjay Dubri	Madhya Pradesh	1674.5	NA	NA	6 (4.4)	5 (0.23)
Tadoba-Andheri	Maharashtra	1727	34	NA	47 (4.85)	82 (6.09)
Nagzira Navegaon	Maharashtra	1706.3	NA	20	6 (0.95)	6 (0.49)
Achanakmar	Chhattisgarh	532	19	12, 1(0.11)	11	5 (0.46)
Boramdeo	Chhattisgarh	170.4	NA	NA	NA	NA
Udanti-Sitanadi	Chhattisgarh	1842.5	6 to 8	8	4	1
Guru Ghasidas	Chhattisgarh	1093.9	NA	NA	NA	NA
Pench	Madhya Pradesh	1179.3	33	65, 23 (3.62)	44 (5.67)	56 (5.50)
Panna	Maharashtra	1545	24	4	17	25 (1.41)
Indravati	Chhattisgarh	1258	NA	NA	12	3

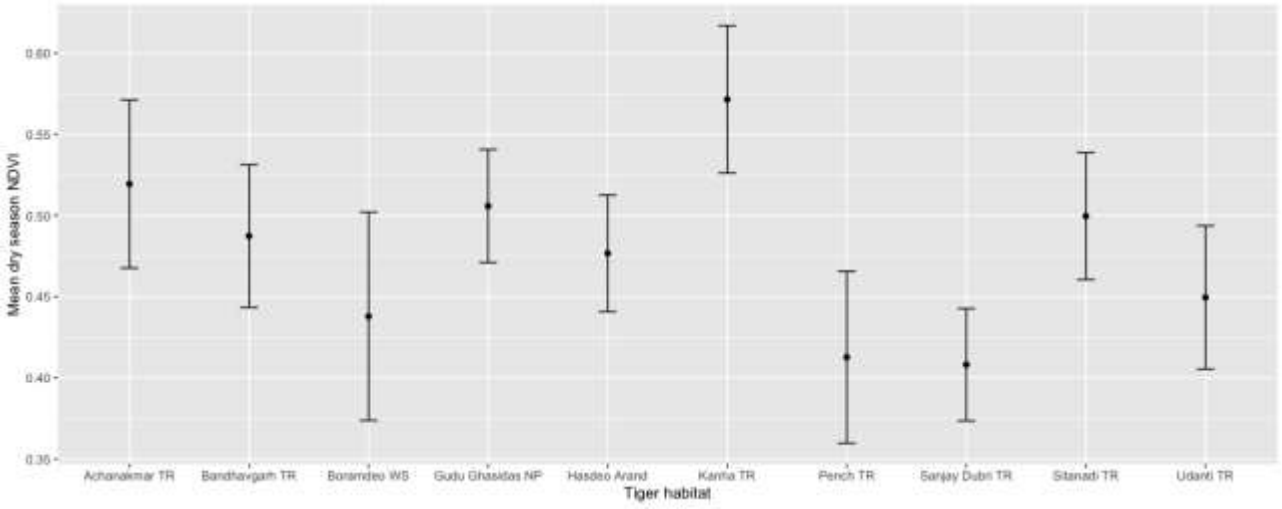


Figure-2: Mean (±Std. deviation) of dry season NDVI for some of the Central Indian tiger habitats

CHAPTER-5: ASSESSMENT OF AVIFAUNAL DIVERSITY

Bird data used in this chapter was provided by Dr. Arun Pratap Singh, Scientist-F, Forest Research Institute, Dehradun, Uttarakhand

5.1 Introduction

Industrialization including mining converts over 19.5 million hectares of land area annually, globally (United Nations Environment Programme, 2008). In particular, several developing countries are experiencing "mining booms" that have damaged many natural landscapes (Hilson 2002, Aryee et al. 2003). Conversion of natural ecosystems to mining may affect biodiversity. The matrix surrounding remnant patches plays a key role in the structure and sustainable functioning of landscapes (Ovaskainen and Hanski 2003, Newbold et al. 2013). Birds are a good indicator of environment quality (Morrison 1986; Bibby 1999). Insectivorous birds influence tree growth by reducing the effect of folivorous arthropods. Birds are also important seed dispersers and pollinators in the tropical forests (Stratford and Sekercioglu 2015). Many of these ecosystem functions vary by latitude and by season. In return, forests provide food, nesting sites, and, in some cases, thermal refugia for birds (Selwood et al. 2015). Forest structure, particularly in tropical sites, is closely tied to avian species richness at different spatial scales.

The Central Indian landscape is a well-recognized for avian diversity in the country, near 39% of the Indian birds are found in this landscape (Ramesh et al. 2011). The region is home of various resident species and also serves as an important flyway for a variety of migratory species (Chandra and Singh, 2004; Bharos et al. 2020). As part of the biodiversity assessment in Hasdeo Arand area, an assessment on the avifaunal diversity was carried out.

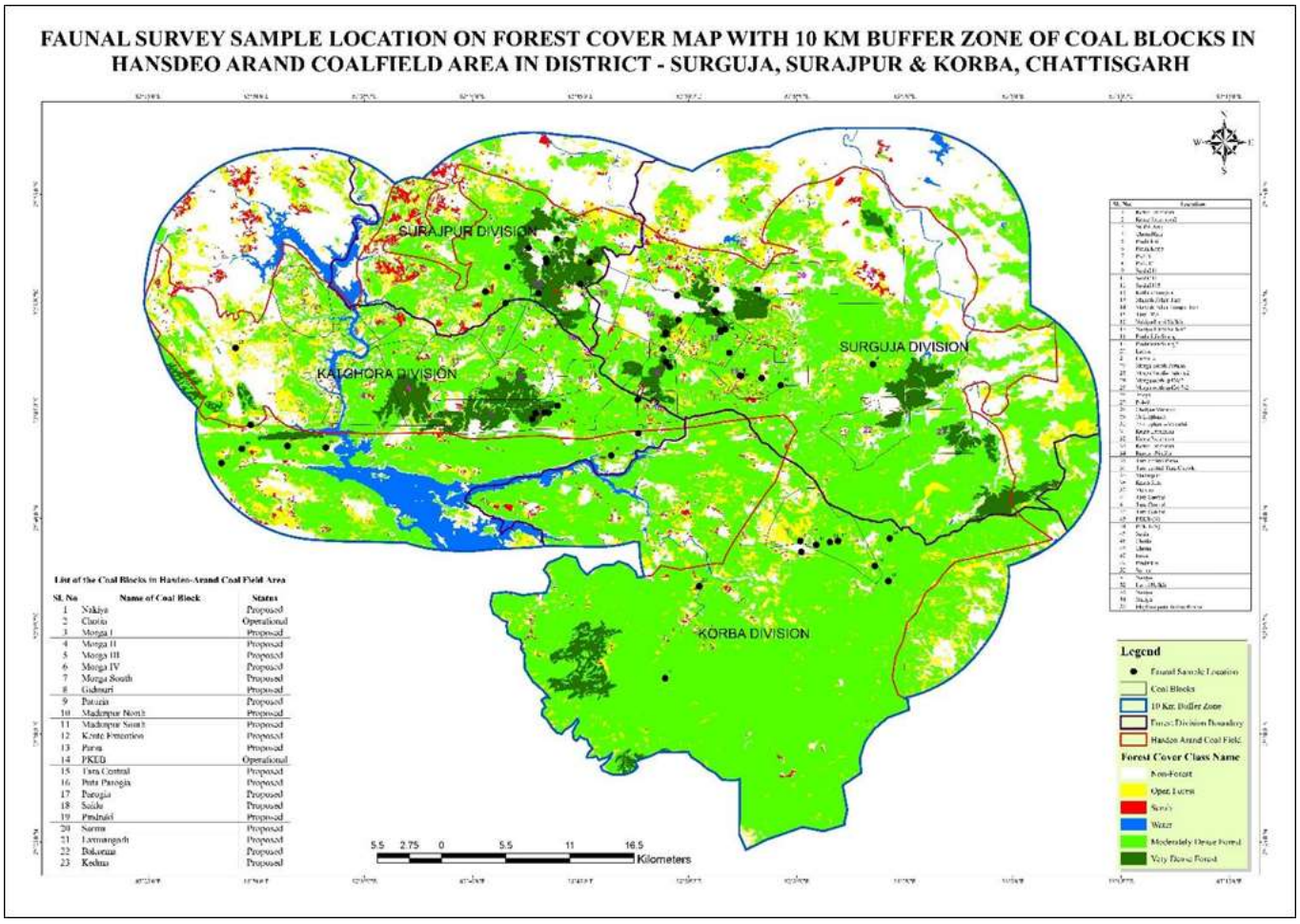
5.2 Methods

A total of 30 transects were laid for bird sampling in and around 12 of the coal blocks (in blocks 1, 10, 12, 13, 14, 15, 17, 19, and Near the blocks 4,18, 20, and 22) and adjoining areas during the summer (May – June 2019) and winter (Feb 2019) seasons (15 transects in each season). The survey was conducted during morning and evening hours when birds are known to be more active (Tranka et al. 2006). Each transect was walked on the existing forest trails for an hour between the length of 400m to 1000m. All the encountered species were recorded in the list along with their individuals. Species were identified with the help of a field guide (Grimmett et al. 2011).

In addition to field surveys, bird species that were observed and recorded during the recce surveys and field visits have been included in the checklist of birds.

5.3 Data Analysis

Shannon diversity and Margalef richness was computed for each transect by using Past 4x software (Hammer et al. 2001). For blocks with more than one transects, the mean value was taken of the diversity (D) and richness (R) to represent the bird diversity in the block. Abundance status was assigned to the species based on the number of individuals sighted of the species in the study area. Species individuals recorded 8 or more than 8 are assigned as very common, between 4 to 7 is Common, 2 and 3 is fairly common, and only an individual is uncommon. Birds of the World (2021) was followed to assign the endemic status to the bird species. Migration status to the species was assigned based on the field observations and Grimmett et al. (2011). In addition to this 12 species of birds were opportunistically observed during the field visit carried out between 20 and 23 February 2021 that are included in the checklist. The encounter rate and abundance status to opportunistic bird sightings are not assigned in the checklist.



Map 23 Avifaunal survey carried out in the study area

Table: 1 – List of blocks and their current status.

Block ID	Block	Current status
1	Nakiya	Proposed
2	Chotia	Operational
3	Morga I	Proposed
4	Morga II	Proposed
5	Morga III	Proposed
6	Morga IV	Proposed
7	Morga South	Proposed
8	Gidmuri	Proposed
9	Paturia	Proposed
10	Madanpur North	Proposed
11	Madanpur South	Proposed
12	Kente Extention	Proposed
13	Parsa	Proposed
14	PKEB	Operational
15	Tara Central	Proposed
16	Puta Parogia	Proposed
17	Parogia	Proposed
18	Saidu	Proposed
19	Pindraki	Proposed
20	Sarma	Proposed
21	Laxmangarh	Proposed
22	Bakurma	Proposed
23	Kedma	Proposed

Table:2 Details of sites taken up for sampling in different blocks and adjoining areas of the Hasdeo-Arand Coalfields.

Sl. no. of sampling points	A. Sampling locations during winter season survey (Feb.2020)				
	Transect codes	Sampling points	Coordinates		Altitude (m)
			Latitude (N)	Longitude (E)	
1	1	Kente Extension1	22°49'31".7	82°51'16".5	548
2	2	Kente Extension2	22°48'41".8	82°51'26".9	560
3	3	NCPA Area	22°47'40".2	82°51'53".4	518
4	4	ChorniNadi	22°46'37".2	82°52'22".1	428
5		Pindirikhi	22°46'29".8	82°53'22".2	489
6		PatharKorja	22°47'08".3	82°58'31".5	574
7	5	PKEB1	22°49'11".9	82°49'31".8	562
8		PKEB2	22°48'31".7	82°48'54".5	564
9	6	Saidu2111	22°47'51".2	82°48'49".0	564
10		Saidu2111	22°47'14".9	82°48'56".3	534
11	7	Saidu2113	22°47'00".8	82°49'07".5	548

12	8	Kothri-Parogiya	22°43'56".6	82°47'40".3	413
13	9	Mahesh Pahar-Tara	22°51'39".0	82°41'37".2	575
14		Mahesh Pahar Temple Top	22°51'51".5	82°43'25".3	941
15		Tara-PPA	22°50'35".7	82°51'16".5	590
16	10	Nakiya-Lamti Nullah	22°38'46".0	82°55'54".0	503
17		Nakiya-Lamti Nullah2	22°38'57".3	82°56'54".6	519
18	11	Pindarikih-Syang	22°37'05".6	82°59'14".4	587
19		Pindarikih-Syang2	22°37'47".3	82°58'36".6	546
20	12	Lamru	22°36'51".3	82°50'29".4	419
21		Lamru 2	22°32'35".6	82°48'54".8	487
22	13	Morga South-Paturia	22°44'36".8	82°42'46".1	503
23		Morga South- Paturia2	22°44'52".5	82°42'54".9	503
24	14	Morga South -p426/7	22°44'53".3	82°43'31".3	511
25		Morga South -p426/7-2	22°45'13".0	82°43'55".9	541
26		Arsiya	22°44'54".0	82°43'20".2	450
27		P-449	22°42'54".6	82°46'25".0	413
28	15	Chotyia-Maradai	22°47'53".6	82°29'02".5	401
29		18 Elephants	22°42'33".5	82°28'23".5	410
30		25 Elephants-Maradai	22°43'13".0	82°29'19".9	427

Sl. no. of sampling points as per Map - 23	**B.Sampling locations during summer season survey (May2019)**				
	Transect codes	**Sampling points**	**Coordinates**		**Altitude (m)**
			Latitude (N)	**Longitude (E)**	
31	A	Kente Extension	22°49'37.6''	82°51'12.4''	564
32	B	Kente Extension	22°48'38.4''	82°51'28.4''	567
33	C	Kente Extension	22°48'45.0''	82°51'40.8''	541
34	D	Barsen -Pindikri	22°46'35.7''	82°52'26.1''	422
35	E	Tara central-Parsa	22°51'51.6''	82°45'25.9''	529
36	F	Tara central-Tara Chowki	22°50'51.3''	82°44'59.1''	522
37	G	Madanpur	22°49'58.3''	82°41'31.8''	458
38	H	Kanta Roti	22°52'02.3''	82°43'23.9''	516
39	I	Mendra	22°52'57.0''	82°43'53.8''	501
40	J	Tara Central	22°51'91.6''	82°42'35.7''	538
41	K	Tara Central	22°50'25.5''	82°43'03.0''	578
42	L	Tara Central	22°50'30.0''	82°40'36.0''	465
43	M	PEKB (N)	22°49'80.0''	82°49'28.0''	566
44	N	PEKB (N)	22°48'36.0''	82°48'56.0''	565
45	O	Saidu	22°45'30.0''	82°47'39.0''	478
46	P	Chotia	22°44'20.0''	82°29'44.0''	442
47	Q	Chotia	22°43'21.0''	82°31'27.0''	443
48	R	Buka	22°43'17.0''	82°33'13.0''	355
49	S	Pindirikhi	22°46'10.0''	82°54'15.0''	581

50	T	Sarma	22°50'36.0"	82°53'10.0"	544
51	U	Nakiya	22°38'57.0"	82°55'10.0"	484
52	V	Lamti Nullah	22°38'27.0"	82°55'13.0"	456
53	W	Nakiya	22°38'54.0"	82°56'32.0"	502
54	X	Nakiya	22°39'04.0"	82°59'18.0"	517
55	Y	Elephant point before Korba	22°32'13.0"	81°54'28.0"	578

5.4 Results

A total of 92 species belonging to 44 families were recorded of which six species are protected under the schedule I of Indian Wildlife (Protection) Act, 1972 and 19 species are range restricted to the only Indian subcontinent. A total of 74 resident four summer migrants and 14 species are winter migrants were observed, and Twelve species that are endemic to Indian subcontinent were also observed. (see Table 1.2 of Chapter 1)

Family status - Accipitridae (Raptors and Scavengers), Muscicapidae (Flycatchers, Robins, Rock-chat) and Cuculidae (Koel, Cuckoo, Coucal), Ardeidae (Egrets), Dicruridae (Drongos) and Ardeidae (Herons and Egrets) were the most species-rich family in the study area (Figure-3).

Figure 3. - Family status of Birds in the Hasdeo Arand landscape

Abundance status - Fairly common species were highest (29%) followed by Common (25%), Uncommon (24) and Very common classes of the abundance category in the HACF (Figure-4).

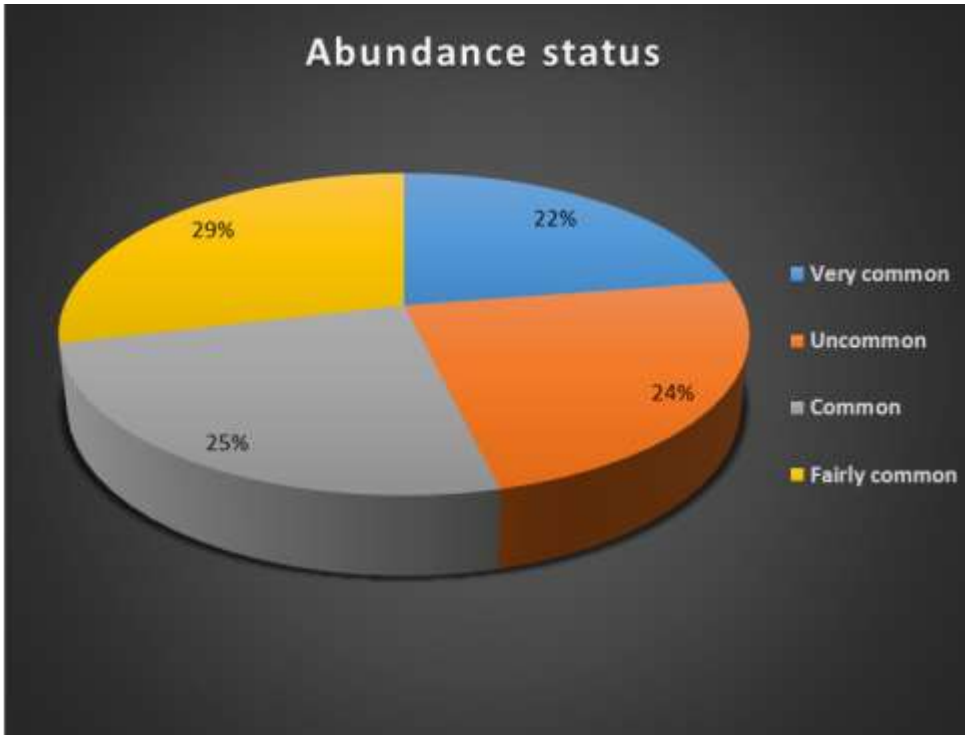


Figure-4 - Abundance status of Birds in the Hasdeo Arand landscape

Diversity indices in different blocks - Overall, maximum diversity (D 2.49) and richness (R 4.27) of birds was recorded near block 4 *Morga II* followed by near block 18 *Saidu* (D 2.48 and R 4.23) and in block 19 *Pindraki* (D 2.42 and R 4.05) (Table 3).

Table: 5.1 - Overall diversity and richness of birds in different blocks and adjoining areas.

Blocks	1	Near 4	10	12	13	14	15	17	Near 18	19	Near 20	Near 22
DIVERSITY	1.58	**2.49**	1.92	2.18	1.91	2.4	1.97	1.85	**2.48**	2.42	**1.1**	**1.39**
RICHNESS	2.15	**4.27**	2.95	3.55	2.65	3.75	3.13	2.66	**4.23**	4.05	**1.82**	**2.16**

During the summer season, maximum species diversity (2.56) and richness (4.53) was recorded from block 14 *PKEB* followed by block 19 *Pindraki* (D 2.55 and R 4.41) and near block 4 *Morga II* (D 2.49 and R 4.27) (Table 5.2).

Table: 5.2 - Diversity Indices for birds during summer in surveyed Sampling blocks

Blocks	1	Near 4	10	12	13	14	15	19	Near 20
Diversity	1.58	2.49	1.92	2.32	1.91	**2.56**	1.66	2.55	1.1
Richness	2.15	4.27	2.95	3.8	2.65	**4.53**	2.3	4.41	1.82

During the winter season, highest bird species diversity was recorded near block 18 *Saidu* (D 2.48) followed by block 19 *Pindraki* (D 2.29) and block 15 *Tara central* (D 2.28), while species richness was highest in block 18 *Saidu* (R 4.24) followed by block 15 *Tara central* (R 3.97) and block 19 *Pindraki* (R 3.69) (Table 5.3).

Table: 5.3 - Diversity Indices for birds during Winter in surveyed Sampling blocks.

Blocks	12	14	15	17	Near 18	19	Near 22
Diversity	2.05	2.25	2.28	1.85	**2.48**	2.29	1.39
Richness	3.3	2.97	3.97	2.66	**4.23**	3.69	2.16

Diversity indices in different transects -Transect wise species diversity indices represent the maximum bird species diversity and richness was recorded from the transect M, N, O followed by D and P, Q during the summer season, where overall diversity (3.51) and richness (9.59) is slightly lower than the winter season (Table 5.4).

Table: 5.4 - Diversity Indices in different transects during the summer season

Sampling Transects	A,B,C	D	E	F	G	H	I	K	L	M,N,O	P,Q	T,U	V	W,X	Overall
Diversity	2.38	2.55	1.91	1.78	1.75	.69	1.79	2.4	2.11	**2.56**	2.49	1.61	1.1	1.54	3.51
Richness	3.8	4.41	2.65	2.34	2.57	.56	2.38	3.94	3.34	**4.53**	4.53	2.22	1	2.08	9.59

In the Winter season highest species diversity and richness was recorded from transect 4 (D 2.61, R 4.72) followed by 1 (D 2.59, R 4.53) and 14 (D 2.49, R 4.58) (Table 5.5).

Table: 5.5 - Diversity Indices in different transects during the winter season.

Sampling transects	1	2	3	4	5	6	7	8	10	11	12	13	14	15	Overall
Diversity	2.59	2.14	1.73	**2.61**	1.97	1.39	2.44	2.06	1.68	2.02	2.48	2.08	2.49	1.73	3.64
Richness	4.53	3.3	2.28	**4.72**	2.67	2.16	3.78	3.25	2.28	3.04	4.23	3.37	4.58	3.06	10.19

Discussion –

The HAC supports rich fauna with over 92 species recorded in a short study duration. Hortal (2009) suggests high habitat diversity could support high avifaunal diversity. This is probably the case in HAC the landscape supports a diversity of habitats that include dense forests, relatively open forests, scrubland and riparian tracts. HAC is part of a large forested landscape in the Central Highlands, which itself is an amalgamation of diverse landforms.

Among the recorded species, six species are under Schedule I of Wildlife (Protection) Act, 1972, 12 species are endemic to Indian Subcontinent, and 19 are winter visitors, it represents the importance of the landscape in providing the suitable habitat to these critical species. All the coal blocks, particularly the Morga II, Saidu

and Pendrakki and the surrounding habitats support high species richness as well as diversity of birds. Presence of high number of birds of prey may indicate good habitat quality (eg Sergio et al, 2004) and abundance of prey species. Family Muscicapidae, Cuculiade are species-rich HAC and as most them are insect eaters. The diversity of insectivorous birds is usually high the forest ecosystems (Stratford and Sekercioglu 2015).

Among the winter migrants' species, most of them are insectivores in the study area and probably migrate from the Himalayas to spend the harsh, cold months in Peninsular India (McGuir et al. 2013).

CHAPTER-6: LOCAL COMMUNITIES' PERCEPTIONS ON WILDLIFE AND VIEWS ON MINING

6.1 Introduction

Maintaining balance between ensuring well-being of local communities, achieving economic development through infrastructure projects. and securing ecological well-being through conservation initiatives is complex and challenging. Even for developmental projects the overarching goal is human welfare. Therefore, developmental projects would require attending to material and non-material costs as well as the potential impacts on local communities (Thondhlana et al. 2020). An assessment of societal dimensions of local communities where developmental projects are planned is thus critical to understand the relationship between communities, environment, forests and wildlife (Madden and McQuinn 2014). This is particularly true in the case of landscapes where the communities are predominantly tribal and show dependence on the forest-based resources for livelihood. For such forest-dwelling communities, in addition to resource needs, the cultural identity may be deeply rooted in the local flora, fauna and the landscapes. In the Hasdeo Arand area, the local communities are predominantly tribal. Their views regarding developmental projects, cultural values and social ties with the land, economic needs as well as vulnerabilities are essential to gauge. It is also equally important to assess the perceptions of local communities in Hasdeo Arand area towards wildlife, human–wildlife conflict and conservation. In this assessment, using structured interview surveys, information from local communities on aspects of livelihood and forest dependence, perceptions regarding wildlife, and human–conflict in the area and perceptions regarding mining was recorded

6.2 Methods

Interview surveys as part of the assessment were carried out in 23 villages in Hasdeo Arand area. A five–page questionnaire containing 66 questions were prepared. The questionnaire focused on six sections: (1) respondents' background and demographic information, (2) agricultural and animal husbandry practices, (3) resource dependence on forests, (4) natural history, animal distribution and conflict, (5) attitude towards conservation, and (6) perceptions regarding mining. The purpose of the survey is explained to each respondent and prior verbal consent is obtained before commencing the interview. The interview was conducted on the basis of access, and voluntary readiness of the respondents to participate in the survey. The village communities in Surguja are largely homogenous. Therefore, instead of increasing the number of respondents within a settlement, attempts were made to maximize representation by interviewing respondents from various settlements. The questionnaires were printed in English, and the interviews were administered in Surguja – a local dialect of Hindi. Descriptive statistics are used to tabulate and present the findings of the community interview surveys. In order to ensure reliability of information on wild animals, during the interview surveys, the respondents were asked to identify the animals from the photo plates.

6.3 Results

A total of 111 households from 22 communities across 23 villages located in Hasdeo Arand area were interviewed.

6.3.1 Livestock & agricultural practices and forest dependence

Among the tribal respondents interviewed, 30% (n = 34) were Gonds, 16% (n = 18) were Majhwars, 10% (n = 11) were Uraos, 9% (n=10) and 6% (n=7) were that of Pando and Kanwar each and others about 29% (n=31). About 93% (n = 103) respondents were men and 7% (n = 8) were women. The average age of respondents is 43.3 (±12.0). Over 52% (n= 58) of respondents had basic primary education (< standard five) and about 26% (n= 29) did not have formal education.

S.No	Occupation	Number of respondents (numbers are not mutually exclusive)
1	Agriculture	107 (96.3%)
2	Livestock rearing	100 (90.0%)
3	Village labour works	25 (22.5%)
4	Rojgar Yojana	12 (11%)
5	Government and other jobs	10 (9%)

The primary occupation of the respondents is agriculture 97% (n = 108) and other allied activities including work in the village or own a shop etc. Agriculture is seasonal with paddy as the main crop, which is cultivated once a year. Wheat and lentils are cultivated in negligible quantitates. About 95% (n = 106) of the respondents reported using monsoon water collected in pits and ponds for irrigation. Average monthly income of the households interviewed is Rs. 3880 (± 3225).

About 87 % (n = 97) own livestock in the form of cattle (72%, n = 81), goats (37%, n = 42), sheep (3%, n=3), pig (2%, n=2) and foul (9%, n = 10). The average number of livestock per family is about 7.0 (±6.6). About 74 % (n = 82) of respondents reported taking their livestock for grazing in the forests. An overwhelming number of respondents (96 %, n = 106) collect a variety of Non timber forest products (NTFP) from the forests for their own bonafide use, sale in local markets, and for the government as laborers on a daily wage basis (Table 6.1).

Table-6.1 Self-reported list of forest products collected by households

Commodity (Local Name)	Scientific name	Season of collection	% Commercial use	% Own use	Minimum Income (median)
Mahua (Flower)	*Madhuca latifolia*	March	97% (n =108)	4% (n = 5)	9000
Dori (Mahua Fruit)	*Madhuca latifolia*	March	NA	30% (n =33)	-
Char (Fruit)	*Buchanania lanzen*	Apr – May	52% (n =58)	7% (n = 8)	2250
Tendu patta (Tendu leaf)	*Diaspyros melanoxylon*	Apr – May	95 %(n = 106)	NA	9500
Tendu fruit	*Diaspyros melanoxylon*	Apr – May	NA	58% (n = 66)	-
Puttu and Khukhdi (Mushroom plant)	*Mushrooms and saprophytes of different species*	July – Sep	6% (n =7)	52% (n =58)	-
Sal seeds	*Shorea robusta*	Jun – Jul	20% (n =23)	NA	1000

Among the various NTFP collections, *mahua* is evidently the major commodity collected by majority 97% (n=84) of respondents. The individual-level collection varies from 100 kg (minimum) to 2000 kg (maximum).

In every household, typically, all the family members participate in collection of various types of resources from the beginning of summer to monsoon season. Collection of "*tendu patta"* 94% (n =82) is mainly for income generation purpose. The collection varies from 2000 to 5000 bundles. A bundle of 1000 *tendu patta* amounts to INR 4000. The market price range of *chaar* and *sal seeds* are respectively 1 kg = INR 100 and 1 kg = INR 10. Besides, the items; *dori, tendu fruit* and *mushrooms* collection are primarily for consumption, only a small fraction accounts for occasional business. The families self-reported annual earnings from NTFP collection (just based on four major products namely *Madhuca latifolia* flowers, *Buchnania lanzen* fruits, *Diospyros melanoxylon* leaf flush and *Shorea robusta* seeds) is about Rs. 21,750, which roughly constitutes 46% of the monthly income of the respondents.

6.4 Wildlife occurrence and perception of conflict

Respondents reported occurrence of a many species of wild animals, in and around their villages/settlements in the Hasdeo Arand area. The list of species reported by respondents during the survey has been provided in figure-5. About 4 respondents reported seeing a tiger in and around their villages in Hasdeo Arand area.

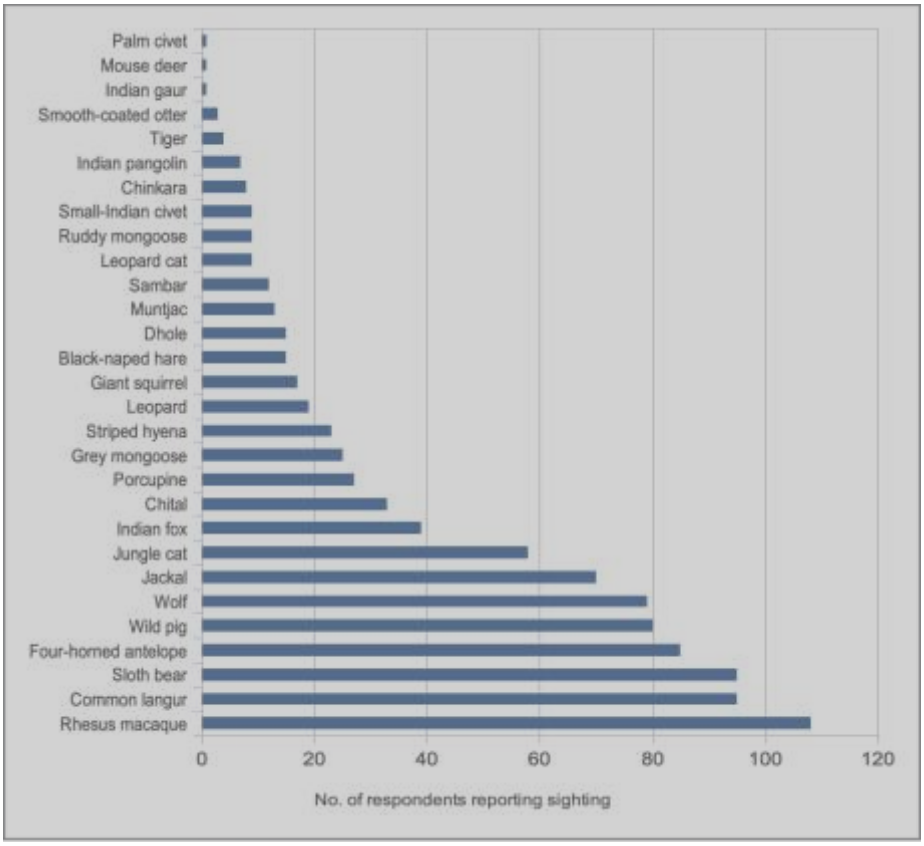


Figure-5: Self-reported patterns of wildlife sighting by respondents

Respondents reported widespread conflict with wildlife in the form of livestock losses due to carnivores and crop losses due to herbivores. The species that reportedly cause livestock losses include dhole (15%, n = 13), golden jackal (70%, n = 63), leopard (19%, n = 17), wolf (79%, n = 71), and tiger (4%, n = 3). Most (63%) of the livestock depredation cases (n = 29) were attributed to Indian wolf, followed by leopard (26% n = 12).

6.4.1 Perception about forests

In general, the tribal communities interviewed show high affinity towards forests as reflected in their agricultural, religious and livelihood practices. The respondents reported receiving significant benefits from the forests that include medicinal plants (3%, n = 3), fuel wood (98%, n = 109), food (100%, n = 111), fodder for livestock (19%, n = 21), soil benefits (2%, n = 3) and water as well (1%, n = 1). A large majority of respondents (97%, n = 109) mentioned that conservation of forests is the best way of using forests.

6.4.2 Perceptions about mining

Among the respondents interviewed, about 55% (n = 50) reported having land in the vicinity of mining/ proposed mining sites. About 60% (n = 66) of the respondents mentioned that they have not participated in the public hearing regarding mines. In general, a majority of respondents (88%, n = 79) were unwilling to give their lands for the purpose of mining. The perceived impacts of mining include loss of agricultural lands that they have nurtured over generations (52%, n = 58), loss of lands in general (67%, n = 75), loss of forests that they are highly dependent on (69%, n = 77), loss of NTFP yields (68%, n = 76) and health deterioration (38%, n = 42).

6.5 Discussion

The livelihood of local communities Hasdeo Arand area is closely dependent on forest resources. The NTFP collection (of four major commodities) contribute nearly 46% of the monthly income reported by the households. This does not include the fuelwood, fodder, water and other resources that local communities collect from the forests. If such resources are pooled as income to local communities, it may be conservatively mentioned that over 60 to 70% of the total annual income of local communities come from forest-based resources. Thus, forest dependence substantially adds to income security of local communities. In addition to financial gains, forest produce collection is critical for medicine, food and other health benefits thereby providing food security and overall well-being.

Notwithstanding the monetary compensation paid to local communities to provide lands for mining, the local communities attach rational values based on attachment to the place and traditional practices. As demonstrated in the case of River Ib valley in Odisha, despite fair and generous compensation, the overall human development and environment were at costs (Mishra 2009). Overall, the respondents interviewed expressed concern and were anxious over loss of forests (and consequently material base for livelihood) and loss of land due to mining. The loss of forests is perceived as a direct threat to livelihood by the local communities.

The local communities come across a variety of wildlife in and around their settlements. The reported list of animals includes 29 species (Figure-5) of wildlife listed in Schedule I & II of the Wildlife (Protection) Act, 1972. A few respondents (n = 4) have even sighted tiger in and around their settlements in Hasdeo Arand area. The human–wildlife conflict – in the form of crop, property and livestock losses was expressed as a concern

by the local communities. Garnering the support of local communities for wildlife conservation would be conditional on addressing human–wildlife conflict on a real-time manner.

In spite of the prevailing levels of human–wildlife conflict the local communities expressed willingness to participate in conservation. The information regarding Joint Forest Management (JFM) appears to have trickled down to the communities and its effect in improving the overall awareness about forests and wildlife is palpable.

CHAPTER-7: ASSESSMENT OF IMPACTS OF OPERATIONAL COAL MINE ON FAUNAL BIOTA IN PEKB COAL BLOCK

7.1. Introduction

Conservation of biodiversity occupies a very high ethical value in the backdrop of rapid pace of development that comes as a necessity to the developing countries in order to keep them abreast to the cutting edge with rest of the world. The explosive growth of human population and its use of natural resources: land, soil, water, wood, biomass and energy have impinged heavily on earth's biodiversity (Mooney et al. 1995). In the face of climate change and allied threats to human welfare, loss of earth's biological diversity has become one of the most critical environmental and developmental issues.

In addition to direct loss of forests, incompatible human resource use had resulted in depletion of biotic wealth and had degraded the forest lands as a consequence of agricultural expansion and infrastructure development (Puri et al. 1983). In India, the era of industrial development has witnessed clearance of large tracts of species rich forests (Turner et al. 1996). Further, development of network of roads and railways urban and other energy related developmental projects have fragmented forests with long-term consequences (Turner et al, 1996; Rajvanshi et al. 2001). The combination of loss of natural habitat, reduction in habitat size and isolation of habitat patches are the results of forest fragmentation. All this lead to decline in biological diversity within the original habitat and even the entire ecosystem as well (Wilcox 1980, Wilcox and Murphy 1985).

Mineral resources contribute to the state/country's economy. Often mineral resources are used a yardstick to measure the economic growth because mineral consumption is an indicator of industrial development of a particular area. Minerals either directly or indirectly provide basic raw material for strategic industries. Nevertheless, although, mineral resources and associated industrial developments play a major role in the economic growth of a country, mineral wealth occurs in forests and the process of extraction of mineral resources generate wide range of impacts on physical, biological and social values of the project area. Therefore, it is essential to consider and mainstream biodiversity in dealing with mineral resources.

The major and diverse environmental impacts associated with the mining project start with land accusation (loss of land /habitat), land clearing (deforestation), soil erosion, disturbance to topography, hydrological regime, pollution (water, air and noise), and reduction of floral and faunal diversity, and loss of livelihood by the locals (ED-World Bank 1998). These impacts are inevitable and ultimately lead to degradation of land which affects the overall biomass productivity and quality of human life in the vicinity of project areas.

7.2. Environmental Impact Assessment

Environmental Impact Assessment is mandatory to any development project. It describes present condition of the environment in and around the project site, and makes prescription about how to deal the environment at the time of implementation of the project and monitor it, so that damages in the future would minimize.

Environmental Impact Assessment involves identification, quantification, prediction and evaluation of the impacts of various developmental activities on natural resource and environment. According to Westman (1985), Environmental Impact Assessment (EIA) provides an opportunity to identify costly and undesirable effects and to modify projects in the designing stage itself. Timely appraisal on the proposed project will allow better mitigation plans. Therefore, developmental projects in any given region must learn to recognize and comply with the ecological integrity and biodiversity values of the region as these are going to be the determinants of the environment quality as well as the economical and ecological sustainability of the project.

With an appropriate scientific approach and effort, these unwanted consequences/impacts of project can be avoided and minimised significantly, as progressively the technical and managerial skills are honed for mitigating them. In addition to the existing technical and managerial intervention and or the mitigation plans of the project, binding biological interventions in the management plan would enhance the biodiversity attributes and thereby improve the ecosystem services they provide which is the prime objective of this BMP project.

7.3. Biodiversity Risks: Physical, Biological and Social Components

The major environmental issues of any given mine project on three the major environmental components are: 1. physical environments; land/soil, water and air (dust, noise and gas emission) and these impacts are directly and indirectly impact on the 2. biological environments (flora, fauna and habitats), and 3. social values of the local community (dependency of forest and non -forest resources and livelihood) of the project area. A long list impacts likely to occur on those three components during different developmental stages of a project like; project development, operational and closing phases need to be understood thoroughly. The detailed list of impacts likely to occur on the three environmental components all through the three phases of the project are given in Table 7.1.

The magnitude of these likely impacts would be dependent on the existing geo-physical (landscape) condition of the project site and existing habitat types as well as the type and nature of the proposed/ongoing project in terms of types of ore, extractive technology and infrastructure availability etc.

7.4. Impact Identification

7.4.1 Conceptual Approach - PEKB

In general, impact assessment methods stress that the foremost step in impact appraisal must consider and identify project actions that are likely to bring significant changes in the project environment which include: physical, biological and social environments. Although, this proposed Biodiversity Management Plan (BMP) study in the PEKB is not a true EIA (Environmental Impact Assessment) study as PEKB being an ongoing project covering 1898 ha of area with coal extraction already being carried out and the project status is in operational stage. Therefore, visualizing the true picture of likely impacts on physical environment is not feasible in the case of PEKB.

Further this study aimed to assess the impacts on biodiversity attributes of the project study area and to suggest mitigation and biodiversity management plan (BMP), the impacts identification approach focused mainly on biological attributes (fauna, habitats and RET species). In addition, only selected impacts of physical environments which are likely to impact directly on the biodiversity and social values (dependency

on biodiversity resources) are identified and suggested mitigation and management plan. The selected likely impact factors determined to identify on biological and social values of the project's operational phase are given in Table 7.1. with double tick (√ √) marks.

Further, the identified impacts are evaluated based on the existing information on project's (coal extraction and washery) operation and management activities out lined in the EIA report (2016) shared by the project proponent and corroborated the baseline information on flora and fauna (biodiversity values) given in the EIA study reports (2009 and 2016) carried out for the PEKB.

The following sections discussed the likely impacts of operational phase on biological and selected social components of the ongoing PEKB Opencast Mine and Pit Head Coal Washery Expansion Project (from 10 Mtpa to 15 Mtpa) Project at Udaipur Tehsil, Surguja District, Chhattisgarh of the mine grantee Rajasthan Rajya Vidyut Utpadan Nigam Ltd., (RRVUNL) Rajasthan. The biological interventions in BMP to enhance and conserve the biodiversity values of PEKB is provided.

7.4.2. Evaluation of Biodiversity Attributes

Evaluation of biodiversity attribute was assessed based on the species richness of flora and different faunal groups as provided in the EIA study reports (2009 and 2016) for PEKB. Evaluation of the biodiversity attributes was done by comparing the relative percent of the number of species reported in the core zone (i.e, the mine block) with the overall species richness of the entire coal block of PEKB (i.e., the core zone + the buffer zone). The buffer zone covers the extent area of 10km radius from the boundary of the core zone. The relative percent obtained was categorized into five rating classes such as very low with the R% of species richness of core zone up to 20%, low with >20-40%, medium >40-60%, high >60-80% and very high >80% (Table 7.2).

Table 7.1: The likely Impacts of Mining into Project Development, Operation and Closure Phases on Physical, Biological and Social Environments

Project Activities	Physical						Biological			Social			
	Land & Soil	Water /Pollution		Air/pollution			Flora & RET Species	Fauna & RET species	Habitat & ESA	Resource & Life quality			
		Surface	Ground	Dust	Noise/ Vibration	Oxides				Forest	Non forest	Livelihood	Health
PROJECT DEVELOPMENT – Phase I													
Exploration and early stages of exploration including drilling, access road constructions, obtaining construction-related materials and other infrastructure	√	√	√	√	√	√	√	√	√	√	√	√	
Construction of ancillary infrastructures land clearance for transportation facilities: road & rail, pipeline, conveyer belt - energy and power transmission lines water sources and waste water treatment Ore processing units, office,	√			√	√	√	√	√	√				√

residential complexes, health centre, workshops -vehicle, machineries, storage godowns													
Social interfaces with biodiversity													
Re-location of villages												√	
Access denied to natural resources use: fishing, NTFP collection, crops, grazing and others							√			√	√	√	
Increased hunting pressures								√					
Induced development impacts on biodiversity							√	√	√				
PROJECT OPERATION – Phase II													
Excavation of ore & processing													
Land clearance,	√			√	√ √		√ √	√ √	√ √				
Drilling & blasting				√	√√	√	√ √	√ √					√
Ore excavation	√	√	√	√	√ √	√	√ √	√ √	√ √				√
Ore handling: loading, transporting, storing				√	√ √	√		√ √					√

Operation of heavy vehicles and machineries								√ √					
Processing of ore - washery	√	√	√					√ √					
Transportation of ore and OB							√√	√√	√ √				
Inflex of outside labors							√ √	√ √	√ √			√ √	
Waste management													
Mine waste dump and subgrade dump handling	√	√		√					√ √				√
Storm water management – dewatering from the mine pit		√	√						√ √				√
Rain washed runoff - Dump and overall lease area		√	√						√ √				√
Domestic sewage water generation and solid waste disposal	√	√	√						√ √				√
Service sites: oil and grease and solid waste generation and disposal	√	√	√	√					√ √				√
Social interfaces with biodiversity All social issues likely to continue							√ √	√ √	√ √	√ √	√ √	√ √	√

PROJECT CLOSURE AND PLANNING - Phase III													
Planning, implementation, monitoring and evaluation	Emphasizing mainly on the implementing biodiversity management action plans suggested and monitoring												

Table 7.2: Subjective rating of Biodiversity values of flora and fauna of PEKB study area

	Biodiversity evaluation – ratings				
Parameters	Very Low	Low	Medium	High	Very High
Species richness (R%)	20%	>20-40%	>40-60%	>60-80	> 80 %

7.4.3. Review of biodiversity values of - PEKB

The evaluation of biodiversity values of the project study area (proposed expansion of Parse East and Kanta Basen Opencast mine and Pit head Coal washery from 10 MTPA to 15 MTPA at Udaipur Tehsil, Surguja district, Chhattisgarh of Rajasthan Rajya Vidyut Utpadan Nigam Ltd., Rajasthan) was assessed fully based on data presented under the ecological study carryout by IIFM (2009), Nagpur, and incorporated in both the EIA (2009 and 2016) study reports.

Evaluation of the species richness of the floral component showed that out of 180 species reported in the entire study area, the core zone reported 97 (57.06%) of the plant species reported. Among the different faunal groups studied, 21 (91.3%) occurred in the core area out of the total 23 species reported for the entire study area (Table 7.3). Furthermore, in the core area, a total of 67 (71%) species of avifauna out of 82 species reported for the study area was recorded. Status of these three faunal groups showed that the core area comprises of over 80% of the species reported for the study area. With regards to mammalian fauna, a total of 12 species (66.6%) of mammals out of 18 species were reported from the core area (Table 7.3)

Even comparing the bird and mammalian fauna reported in the core zone by IIFM study with the entire area (which is considerably overlapping the 10km buffer zone of the PEKB study area) surveyed by WII during 2019-20 showed that 67 species of the birds of the core zone shared 72.04% of the total species (92 species) and mammalian fauna of the core zone (12 species) showed 48.00% of the species (25 species) Table 7.3. **This relative percent estimation of the different faunal groups of the core zone of PEKB before coal mining began showed high species richness during the pre-mining status.**

Table 7.3: Overall Status of Floral and Faunal Species richness of the PEKB Study area.

Flora/Fauna	PEKB Study Area			WII 2020
	CZ	BZ	SA	
PLANT				
Species richness	97	167	170	
Relative %	57.06 %			
REPTILES				
Species richness (R%)	21	23	23	
Relative %	91.30 %			
TERRESTRIAL BIRDS				
Species richness	67	80	82	
Relative %	81.71%			
Relative %	72.045			93
MAMMALS				
Species richness	12	18	18	
Relative %	66.67 %			
Relative %	48.00%			25
Source: Evaluated from IIFM 2009 (EIA Report 2016)				

CZ- Core Zone, BZ - Buffer Zone, SA - Study Area.

7. 5. Impact Assessment and Evaluation

The estimated biodiversity values of the study components were correlated with the different types of mining activities and exiting /proposed management plans to evaluate the types and magnitudes of the project impacts.

7.5.1. Loss of Forest Habitats and Biodiversity

In mining, acquisition and conversion of forest land for the excavation of mineral and construction of associated infrastructures is considered as the first level of impact in the form of loss of land, habitat and others. Following the conversion of the status quo of the forest land, the likely impacts are as under:

Impact 1:

Direct loss of forest land due to mining activities followed by deforestation, excavation of land - Direct impact.

Impact 2:

Loss of forest land would impact upon the loss of associated faunal occurrence and distribution, home ranges, behaviour, life-history aspects and diversity as habitat forms the basis for sustaining faunal biota - Direct impact

Evaluation-Forest land: The total mine lease area of the PEKB coal block including the coal washery covers 2682.856 hectares. Of the total extent 1871.118 hectares of the lease area is under forest cover and constitutes 70.0% of the total lease area. The other land uses cover 701.786 hectares (26%) and 109.952 hectares (4%) of private and government lands (Table 7.4). Further classification of the forest lands showed that out of 1871.118 hectares of forest land, major portion comprising of 1629.551 hectares (87.08%) of area fall under protected forests, while a total of 241.607 hectares are under two types of revenue forests (Table 7.5).

The PEKB mine lease would result in the forest loss to the tune of 1871.118 hectares of different forests habitats. As per the IIFM (2009) ecological study and incorporated in both the EIA studies (2009 and 2016) the core area, i.e, the lease area reported 97 plant species, 21 reptiles, 67 bird and 12 mammals. Considering the relatively high faunal values, the conversion cum loss of forest lands can have a high impact (Impact 2).

TABLE-7.4: Details of land-use of the PEKB Mine Lease Area

Sr. No.	Particular	Forest	Government	Private	Total
A	**Mining**				
1	Excavation area & barrier	1704.744	104.262	579.241	2388.247
B	**Infrastructure & OB Dump Area**				
1	External dump	58.502	3.919	50.234	112.655
2	Infrastructure	24.242	0.018	11.964	36.224
3	Coal evacuation route	21.690	0.102	8.468	30.260
4	CHP & washery	12.127	0.000	16.254	28.381
5	Reject based thermal power project	29.090	0.140	13.340	42.570
6	Plantation area	3.973	0.011	0.002	3.990
4	Rationalization area	16.751	1.499	22.282	40.532
	TOTAL (B)	166.374	5.690	122.545	294.609

	Grand Total (A + B)	1871.118	109.952	701.786	2682.856
Relative %		**70.00**	**4.00**	**26.00**	**100.00**

TABLE-7.5: Status of Different types Forest land

Name of the Village	Total Area (ha)	Forest Land			Total Land (ha)
		Revenue Forest		Protected Forests	
		Chhote Jhhar ka Jungle	Bade Jhhar ka Jungle		
Salhi	1171.00	14.165	-	34.820	48.985
Hariharpur	441.00	2.768	19.321	110.156	132.245
Parsa	1266.00	50.378	8.542	138.036	196.956
Kente	1284.00	83.380	0.782	505.928	590.09
Ghatbarra	2447.00	61.660	0.611	706.783	769.054
Parogiya	3956.00	-	-	128.130	128.13
Basan	1519.00	-	-	5.698	5.698
Total		212.351	29.256	1629.551	1871.158
Relative %				**87.08 %**	

In order to obtain Environmental Clearance and under Forest (Conservation) act 1980, compensatory afforestation is mandatory. Accordingly, the state Forest Department shall identify degraded forest lands twice the extent of area under clearance for compensatory afforestation and maintenance at the project cost. In addition, it is mandatory that the project proponent and or the user agency develop afforestation within the lease area; like safety zone, external dumps along the roads outside the lease area diverted under EC approval.

Even though, all these afforestation programs are expected to compensate the loss of forest habitat, it is critical to implement the afforestation mitigation measures / ecological restoration in a scientific, time-bound manner so that there could be possibility of some of the resilient faunal groups re-colonize afforested areas long after restoration efforts are properly executed. If such earnest efforts to restore habitats are invested and stringent biodiversity monitoring principles are followed, the overall loss of forest habitat and associated faunal biodiversity of the study area can be re-evaluated as moderate impacts for some of the very resilient faunal species that might recolonize restored areas (Impact 1 and2).

Since, all the afforestation and plantation activities are given within the time period of 30 years, the ongoing afforestation activities are suggested to adopt the basic eco-restoration concept to restore the areas i.e., “Eco-restoration of Compensatory Afforestation Sites” (See Chapter 8. and Sections 8.4.1, and Table 8.2.) is recommended under mitigation measures.

7.5. 2. Loss of Non-Forest Land and Associated Biodiversity

Other than forest, other habitats like: community forest, revenue land, tree groves, open scrub, agricultural land and village grazing lands also support diverse flora and fauna and provide ecosystem services to the dependent rural communities. Those non-forest lands are also under intensive use of the local villagers for natural resources; like leaf fodder, grass fodder, berries (small fruits), flowers, fuel wool, medicinal plants, small pools and grazing (Chapter-6). Therefore, even use of non-forest land for mining and associated activities is predicted to have the following direct and indirect impacts;

Impact 3: Decrease in the probability of occurrence and abundance of commensal species of fauna non-forest lands due to habitat loss, degradation, fragmentation, and isolation - Direct impact.

Impacts 4: Major faunal groups likely to impacted are: invertebrates, herpetofauna, small birds and commensal species of mammals. These animals play a crucial role in agro-pastoral landscapes through pollination, pest control etc - Direct impact

Impact 5: Loss of non-forest lands expected to increase the biotic pressures into the adjacent additional forest areas -Indirect impact.

Evaluation – Non forest land: As discussed above under the section of 'Evaluation of forest land', out of 1871.158 hectares of forest land 241.607 hectares belong to two types of revenue forests that come under seven villages (Salhi, Hariharpur, Parsa, Kente, Ghatbarra, Parogiya and Basan) sharing a total of 12.91% of the total forest land (Table 7.5). It is obvious that, villagers from the aforementioned villages were dependent on the surrounding forests and were using the above said forest resources from the revenue forest.

The study area is dominated by tribal populace with dependence on the forest land for fuel, timber and small poles as well as for their dietary needs. During the surveys, cutting of larger trees and movement of traditional hunters (tribes) were often observed in the forest habitats adjacent to the lease area. The occupational details of the study area revealed that out of 10 main worker groups, three categories of activities (livestock, fishing and other forest-based activities) depend on forest and river-based resources. Therefore, conversion of both the protected and revenue forest lands for the mining would have the above impacts (Impact 3 and 4) and the biotic pressures will be pushed into the adjacent forest habitat (Impact 5).

Hence, to address and mitigate the likely impacts, in addition to the existing diverse mine restoration, afforestation programs, it is suggested to implement selected Natural Resource Development and Management (NRDM) plans for the affected seven villagers (Refer Chapter 9) to reduce the biotic pressure into the adjacent forest. Awareness education programs and alternative livelihood strategies for the local traditional hunters would help in minimizing the biotic pressure. This mitigation/management plan needs to be implemented on a need basis and in consultation with the concerned villagers /individuals who last their land resources and the CSR division of the project proponent.

7.5.3. Direct Loss of Aquatic Ecosystem (Wetland) and Biodiversity

Acquisition of land area for mining and plant development interspersed with natural water bodies like rivers, major streams, nullah, lake, small dam and diversion of natural flow of those aquatic habitats is expected to have impacts on aquatic ecosystems (wetland). Adding to that, overexploitation of water from the natural water bodies will also affect the surface water regime and hydroperiod which can be viewed as impacts on wetland habitat as follow;

Impact 6: Loss of natural water bodies and network major streams would potentially impact on the overall hydrological regimes: It would potentially reduce the surface water flow into the aquatic ecosystems (major riverine habitat) and would eventually affect the ecological processes in the aquatic ecosystem with consequences leading reduced primary productivity, biomass and fish stocks - Direct impact.

Impact 7: Withdrawal of excess water from the natural resource would affect the surface water regimes and hydroperiod in the riverine habitat tracts: Direct Impact.

Impact 8: Disturbance to aquatic ecosystem would lead to reduction in the overall aquatic floral and faunal diversity- Direct impact.

Evaluation: Disturbance to water bodies:

Drainage from the PEKB mine lease area would collect into Atem Nadi (a perennial River) which is 2 km from the northern boundary of the coal block. A seasonal nullah namely Parsa nullah flows on the South eastern part of the block and drains into Atem Nadi. The pre-project status of the drainage pattern snowed that, the PEKB lease area is drained by only Parsa nullah which act as a micro basin (Map 24).

Evaluation – Water resource requirement and use: As per the EIA report (2016), the total water requirement for the coal mine and coal washery projects would be approximately 6880 m^3 /day and 5700 m^3 /day respectively and will be sourced from the mine de-watering. The portable water for all the domestic uses estimated to be 615 m^3 /day will be sourced from the tube wells with statutory permission of the concerned state authority (CGWA), which has already been sought.

Due to absence of aquatic habitat and or true wetland ecosystem within and in the close vicinity of the PEKB mine lease area and sourcing of filtered and treated water from the mine dewatering and through designated tube wells, the impacts (Impacts 6,7 and 8) of direct loss aquatic habitat and associated aquatic fauna not likely to occur within the coal block, but would have cascading effects on the River Atem Nadi in the absence of stringent mitigation measures. In spite of no impacts of mining on aquatic habitat within PEKB coal block, but at the same time recognizing that the impact would occur to water bodies outside of the block, keeping the opportunity of post mining land use management and appropriate mine closure plan and diverse ecosystem services of the wetland habitats, it is suggested to develop "Mine pit Wetland Habitat" under BMP plan (Refer Chapter 9)

7.5.4. Mining Impacts on Hydrological Regime – Surface Water Pollution

Dewatering and releasing of mine storm water generated due to deeper excavation of pits for the extraction of ore and disturbance to the ground water regime, rain water runoff from the waste dumps and mined out areas are the coal-mining related direct sources of water pollution. Therefore, rain water runoff of with mine, including the suspended solid wastes will finally drain into major streams and river systems and pollute the aquatic habitats of the project area.

Impact 9: Discharge of storm/rain water from the mine into natural water bodies lead to their degradation - Direct impact.

Impact 10: Releasing the rain-washed runoff from the mine lease, waste dump and washery during rainy days or natural draining of the mine water will reduce the water quality of the adjacent water bodies and aquatic habitat. - Indirect impact.

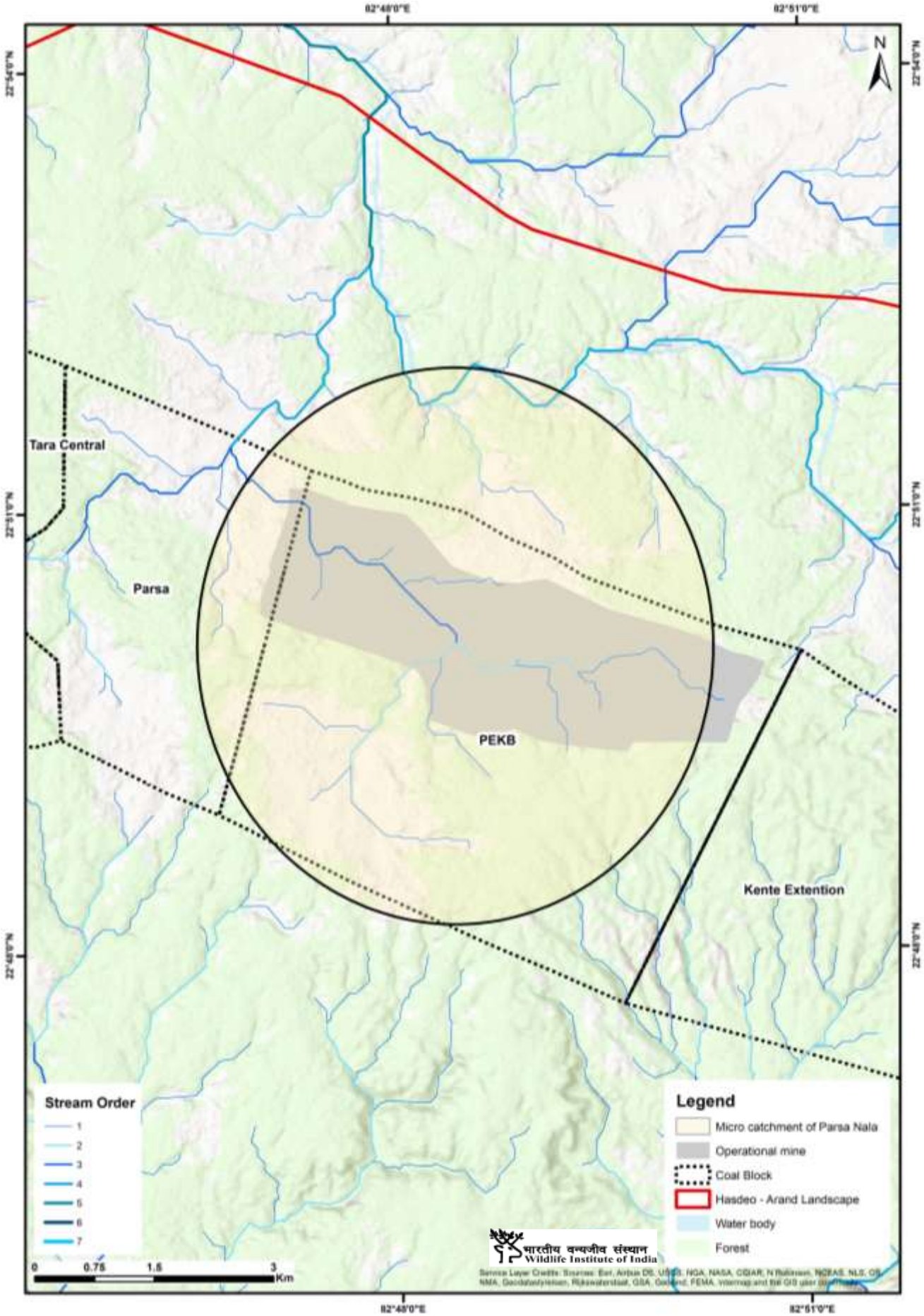
Impact 11: Water pollution due to mine water draining into natural water bodies would affect the health and well-being of the local communities the depend on the river system for their day-to-day needs: Indirect impact.

Evaluation of Surface water pollution:

The major sources of surface water pollution due to mine include sources dump runoff, oil spillage from the workshop, sanitary waste water generated from domestic facilities and dewatering of storm water from the mine pits. The run-off estimation done on monthly rainfall basis during monsoon period for the core zone of PEKB is estimated to be 8.88 million cubic meter (MCM) of water, which will be generated and flow as run-off to Parsa nullah dring pre-mining. Whereas during the post-mining condition, over the overburden land, it is estimated that 5.01 MCM water will be generated. The generation of waste water from the mine operations is expected to be approximately 50 m^3 /day from workshop (EIA Report 2016)

Different levels of mitigation plans have been proposed to address the surface water pollution (Box: 8.1). Waste water generated from the workshop and sanitary waste should be treated with oil traps (ETP) and STP respectively. Only after successful mitigation, finally the waste water generated from those sources will be pumped out and discharged into the natural drainage system, possibly into Parsa nullah after de-silting in settling ponds. Hence the impacts of surface water pollution (9, 10, and 11) of all the mining activities have been visualized as moderate

Therefore, in spite of existing safety mitigation measures, it is not possible to fully handle the runoff generated from the large extent of lease and washery areas especially during heavy rains and flood days. Keeping this in mind, the third level of mitigation measure suggested is to construct "Bio-filter Check Dams" across the downstream of stream/nullah. Bio-filter check dams are sort of biological interventions to further bring down the ill-effects of surface water pollution (Refer Chapter 8 and Section 8.7.1 and Table 8.8).



Map 24 Micro catchment of the Parsa nullah – tributary of Atem River - North of PEKB

7.5.5. Impacts of Air Pollution- Dust and Oxides on Forest and Fauna

The major pollutants in mining will be particulate matter (PM) and gaseous emission. Land clearing, drilling, blasting, crushing, loading, haulage and other transport activities are the major sources of dust emission. Emission of gaseous pollutants are anticipated due to movements of **HEMM** like, excavator, dumpers, dozer and other transportation vehicles.

These activities generate enormous quantity of windblown dust particles (Particulate Matters) and gaseous emission (SPM, SO_2 & NOx) which is inventible and that would deposit upon the adjacent forest and other habitats (agriculture and human habitats) and impact the faunal diversity in terms of;

Impact 12: Habitat degradation and loss of forest cover within the lease and adjacent forest habitats - Direct and primary impact

Impact 13: Air pollution is known to affect the species richness and abundance status of faunal species of the adjacent forest habitat- mainly the butterfly and avifauna immediately and other faunal groups later - Indirect and secondary impact.

Impact 14: windblown suspended solids would deposit/settle down in the adjacent agriculture habitats and impact its productivity as well as biodiversity values.

Evaluation - sources of air pollution (PM, Oxides and Noise): Air pollution sources of mine project can be classified into three categories: Extraction of coal by various activities as an area source. Transportation of coal and overburden within the mine lease area as line sources. The summary list of heavy machineries and vehicles in coal handling and other activities showed that, at every fifth year a total of 340 HEMM are in use (Table 7.6). The detailed list of HEMM with different capacities will be in actions is given in Annexure 3.

Table 7.6: Summary details of Heavy machineries and Vehicles in use in project activities

S. No	Particulars	YEAR WISE PHASING				
		1	2	3	4	5
A	Overburden	141	184	191	228	235
B	Coal	40	42	43	44	45
C	Common	41	60	60	60	60
Sub Total		**222**	**286**	**294**	**332**	**340**

Source: Summarized from EIA Report - 2016

Evaluation of the air quality:

The project proponent planned diverse mitigative measures from the point of view of maintenance of an acceptable ambient air quality in the region and detailed in Box 7.2. Under the greenbelt development and plantation activities to mitigate dust control and restoration of dumps and excavated area includes planting of around 56.86 lakh trees covering an area of 2,240.210 hectares within PEKB coal block (Table 7.7).

Although the mitigation measures would minimize the air pollution, planting of specific tree species which act as bio-filter agent is very important for effective control of air pollution (Impacts 12, 13 and 14). Therefore, it is recommended to develop “Green shelter belt” within the concept of – “Phytoremediation” to address air pollution (dust, oxides and noise) with the suggested tree species (Refer Chapter 8, Section 8.8.1 and 8.9)

Box: 7.2: Existing dust control measures proposed and in use (EIA report 2016)

The production of blast fumes containing noxious gases should be reduced by: 1. Proper and proportionate mixing of fuel oil with ammonium nitrate to ensure complete detonation; 2. Use of adequate booster/primer; and 3. Proper stemming of the blast hole.

Dust due to drilling will be minimized by using wet drilling methods:

Regular maintenance of vehicles and machinery will be carried in order to control emission;

Cabins for shovel and dumper and dust respirators to workmen should be provided: Depending on the water availability, sprayer system will be incorporated with shovel loaders, which can also wet the coal during loading and unloading.

Dust suppression will be done on exposed area using water trucks and sprinkler;

Dust generated due to traffic on haul roads will be reduced by water spraying at regular interval;

Greenbelt development will be taken up all along the haul roads and overburden dumps;

A good housekeeping and proper maintenance will be practiced which will be help in controlling pollution.

Table- 7.7: Details of afforestation program

Period	Greenbelt on Safety Area and ML Boundary		Reclaimed Area O/B Dump (Internal & External)		Total saplings
	Area	No of Saplings	Area	No of Saplings	
At the end of 5th year	57.464	86198	112.655	281639	367837
At the end of 10th year	-	0			
At the end of 20th year	-	0			
Conceptual Stage	-	0	2,127.555	5318888	5318888
Total	57.464	86198	2,240.210	5600527	5686725

7.5.6. Impacts of air pollution- fugitive emission from coal handling

The source of emissions from the proposed expansion of coal washery unit will be particulate matter. There are also fugitive emissions arising during the transport of coal, unloading of coal, conveying and coal storage. As in the case of dust emission, fugitive emission will also impact the project environment in terms of habitat degradation, reduction in faunal abundance and impacts on the adjacent agricultural lands (Impacts; 12, 13 and 14).

Evaluation – fugitive emission: In order to meet the fluctuations of coal output from the mine due to irregularities of the transport system and seasonal fluctuations, the design capacity of the CHP has been fixed at 2640 TPH. It has been planned to bring coal from coal face to surface by belt conveyor. Another set of conveyors are to be provided to transport coal into washing plant receiving stock yard. Belt conveyor has been envisaged for less fleet of dumper, negligible air pollution and negligible noise

pollution. Coal washery provision of control systems to achieve the fugitive emission standards of the difference in the value of suspended particulate matter, delta, measured between 25 and 30 m from the enclosure of coal crushing plant in the downward and leeward wind direction shall not exceed 150 micrograms per cubic meter. However, the dust fall rate different locations estimated seems to be high in coal washery area (195 mg/m2/day) followed by coal mine area (185 mg/m2/day) while minimum of 85 at Saidu village (Table 7.8).

TABLE-7.8: Dust fall rate in different locations of the project site-PEKB

Location Code	Location	Dust Fall Concentration (mg/m2 /day)
AAQ1	Coal Mine Area	185
AAQ2	Coal Washery Area	195
AAQ3	Parsa Village	148
AAQ4	Basan Village	109
AAQ5	Parogiya Village	98
AAQ6	Near Saidu Village	85

Source: EIA report 2016

In addition to adopting less pollution free conveyor system, it is mentioned in the EIA by the project proponent to adopt some more technical mitigation measures to address the impacts of coal handling and washery plan (See Box 7.3.). Given this situation, it has been evaluated that, the impacts of coal handling would be low to moderate level and considering the long term impacts in the project area this needs to be addressed under Phytoremediation concept by developing effective "Green Gallery Belt" around the coal handling areas (see chapter 8 and section 8.9.1 and table 8.11).

Box 7.3: Existing mitigation measures to minimize the impact of fugitive emission

Provision of suitable wind breaking walls to be examined along the storage yards to minimize generation of fugitive dust emission; -

Dust suppression system of fog type will be provided to suppress dust laden air from coal handling areas at junction house, crusher house, bunkers, conveyor chutes

Dusty air from various material transfer points will be controlled with dry fog system, which will allow through vent only clean air to the surrounding environment; and

The coal crushing and screening plant to be provided with skirt boards and enclosures along with dry fog type dust suppression system.

Coal stock yard (raw coal, washed coal, coal rejects and coal fines) will be housed in closed sheds.

Adequate moisture will be maintained in coal handling area to ensure that dust is not getting air borne. Regular sprinkling will be carried out in the open area to arrest fugitive dust. Further, greenbelt/ green cover will be provided with native species.

7.5.7. Impacts of Noise – Drilling, Blasting and Vibration on Faunal Groups

The major sources of noise pollution in open cast mining are the starting of mining operations, deployment of machinery, drilling, blasting, excavation, crushing/processing and transportation of ore. Among these, noise generated due to drilling and blasting would be intermittent, but will also add to the background

noise level. Ground vibration, fly rock, air blast, noise, dust and fumes are the deleterious effects of blasting on environment. Ground vibration is likely to have adverse impact on ground dwelling faunal groups. Overall, these activities will have some adverse impact not only on the ambient noise levels of the project area, which would also directly affect the selected faunal species of the forest habitats within and adjacent to the mines in the form of:

Impact 15: Changing the normal behavioural pattern (feeding, movement, resting and breeding) of major faunal groups of the project area – secondary and indirect impact.

Impact 16: Noise and ground vibration would affect reptiles and ground dwelling small mammals in terms of restriction of movement - secondary and indirect impact.

Impact 17: In addition to reptiles and small mammals, some larger groups of faunal species might move away and or disappear from the project area and affect the local abundance - primary and direct impact.

Evaluation of noise level: Drilling & blasting would be required only for over-burden benches before excavation by shovel. There will not be any blasting for coal extraction as coal extraction has been proposed through surface miner.

There will be an instantaneous increase in the noise levels expected at the mining site throughout the operational phase. Moreover, there is no prescribed tolerance noise level specific to wildlife. The lease area covers over 70% of forest habitat and out of 17 forest blocks, six blocks are surrounded within 5-km distance from the lease (Annexure 3). Hence the instantaneous noise developed due to drilling and blasting are expected to have moderate levels of impacts (Impacts 15, 16 and 17) on the wildlife of the forest habitats within and close vicinity of the project area. In spite of the technical and managerial mitigation measures are in action (Box 7.4), it is suggested to include specific tree species that have the potential to minimize the noise levels in greenbelt development plan under Phytoremediation concept as biological mitigation (Refer Chapter 8, Section 8.8.1. and Table 8.9)

Box 7.4: Existing Protective measures for ground vibration/ air blast caused by blasting
Blasting will be performed strictly as per the guidelines specified under blasting technology; Overcharging will be avoided; The change per delay will be minimized and preferably more number of delays will be used per blasts; Blasting operations will be carried out only during day time as per mine safety guidelines; During blasting, other activities in the immediate vicinity will be temporarily stopped; and Drilling parameters like over burden, depth, diameter and spacing will be properly designed to give proper blast.

7.5.8. Hazardous and Domestic Waste Disposal – Impact on Forest and River System

Mining generates waste material in the form of waste rocks, earthen materials, sub-grade ore and screen rejects from the washery. Since mining involves many heavy machineries and vehicles, oil and grease spillage, empty oil barrels and containers from the workshops will be accumulated due to maintenance of machineries and vehicles.

In addition, domestic solid and sewage waste generated will be disposed into adjacent areas. Haphazard way of disposing these wastes is expected to have serious impact on both the terrestrial (forest) and aquatic (river) environments.

Impact 18. Disposal and dumping of all the solid wastes (other than mine waste) into the forest habitat - Pollution and degradation of the forest habitat and affects terrestrial biodiversity -Indirect Impact.

Impact 19. Solid and sewage disposal into stream/river system will impact water quality and associated aquatic biodiversity - Indirect Impact.

Evaluation- use of heavy equipment: As per the report, the mining involves use of 222-340 heavy machineries and vehicles of 24 different capacities in the mine operation (Table 6.6 and Annexure 3). Hazardous waste will be generated during expansion and operational phase, from machinery and equipment maintenance (fuel, lubricating oil, batteries). Similarly, domestic sewage /solid waste generated from the colony areas in mine site will be biodegradable as well as non- biodegradable.

Evaluation waste management: The waste management of other than mine waste in practice showed that, the waste water generated at mine workshop is cleaned by passing it through Oil-Water separator and the clean water is used in dust suppression work. If this sufficiently works, then no industrial waste will be generated through mining. A full-fledged STP is in operation to treat the domestic waste water generated in the colony, mine office and other site services. Consequently, the impacts related to waste disposal and management on forest and aquatic habitats and biodiversity (Impacts 18 and 19) is not expected to occur and not warranted any additional mitigations.

7.5.9. Mine Waste Dumps and Impact on Physical and Biological Resources

One of major impacts, that one would expect from the mining activity is dumping of mine waste as external dumps into excess/additional land area or close to the forest and aquatic habitats and create over burden that would impact on the biodiversity values as follows:

Impact 20. Loss of additional land/forest to store the waste dump/overburden, directly impact the biodiversity of the project area - Direct impact.

Impact 21. Windblown suspended particulate matters pollute the soil and lands of forest and agriculture habitats of adjacent areas

Impact 22. The overburden developed as waste dump create visual intrusion impact in the middle of forest landscape

Evaluation- Mine Waste Dump: The opencast mine is planned up to 225 m depth with overall average stripping ratio of 5.24 m3 /t. The total volume of OB has been estimated as 2368.72 Mm^3. The OB removed during initial years will be placed beyond the incrop of the seam-IV. The total volume of external dump has been estimated as 43.52 Mm^3 solid. Rest of the OB will be placed in internal dumps.

For external dumps no additional land will be required and the two external dumps i.e external dump in the west and east have been proposed to accommodate on the north western and north eastern sides and within the block boundary respectively. This qualifies that no impacts of additional forest land requirement (Impact 20).

The post mining land use of the core zone/lease area showed that, 112.655 hectares of the lease area would remain as external dump (Annexure 3). Even though the dump restoration activities involved dump stabilization and plantation to address dust, soil erosion, siltation impacts (Impact 21), since the lease area is located in the middle of forest habitats, it is necessary to restore the mine waste dumps in an

ecological manner to avoid visual impact (Impact 22) and also to facilitate to recolonization of the faunal species in the restored area after the mine closed. Therefore, it is suggested to restore the earmarked external dumps area of 112 hectares, which is a fairly large extent of area adopting "Eco-restoration of mine dump" plan (Ref Chapter 8 and section 8.10. and Table 8.14).

7.5.10. Unregulated Vehicle Movement - Road Mortality on Selected Faunal Groups

Construction of network of new roads, widening of existing roads (progressive planning) and frequent movement of heavy vehicles and machineries for excavation, transportation of ore, to the crushing and or processing units are the internal movements of vehicles. Transportation of ore to nearby areas and or to the end use are the impacts of vehicle movement of outside project sites. Therefore, unregulated and heavy vehicle movements anticipated to impact upon the selected faunal groups of the project area like;

Impact 23: Fragmentation of natural habitats and isolation of populations of lesser mammals and herpetofauna, which are reluctant to cross the roads - Indirect and long-term impact.

Impact 24: Herpetofauna and smaller mammals are prone to road kill due to intensive vehicle movements - Direct or secondary impact.

Impact 25: Intensive movement of vehicles will reduce the birds and other mammal species richness and abundance in the habitats along the road sides of forest areas.

Evaluation- Roads and Vehicle Movements: Road transportation in mining consists of internal movement of vehicles for handling of waste OB to the internal and external dump sites. Vehicles will also fly between residential areas to mine site. The coal will be transported from mine face to CHP by conveyor belt systems. Long distance transportation include rail to transport of coal from the mine site to Rajasthan.

Although the vehicle movements are restricted to mine lease blocks and few roads are in use by the vehicles outside the lease; i.e. transporting manpower and may also importing other supporting materials for mine operation during different time period from nearby town. There will be vehicular movement between the mine sites to owner's parking sites. The impacts of the vehicular movement can be brought down by implementing "Technical and Regulatory Mechanism" measures as suggested to minimise the road-related wildlife mortality as construction/maintenance of underpasses within the project area and the roads are in use outside the lease area (See Chapter 8, Section 8.11 and Table 8.16).

7.5.11. Impacts of conveyer belt on the forest habitat and associated fauna

The mining projects in some cases use to have conveyer belt to transport the ore to the plant if it is located in short distance. The conveyer system is agreed to be comparatively less impactful on the wildlife habitats than the vehicular transportation (even if it is existing) in terms of dust, gas emission and road accidents etc. The impacts related to conveyer system are mostly construction phase impacts and include:

Impact 26: Clearing of dense forest cover for the construction of conveyer system outside lease area - loss of habitat and associated fauna - Direct impact

Impact 27; Ground level conveyer system restrict the movement of wildlife and local livestock- Direct impact

Impact 28: Coal dust emission along conveyer belt route and create air pollution – direct impact

Evaluation - Conveyer System: The PEKB mining project propose sets of conveyors belts for transportation of coal from the pit itself. Each conveyor will be provided with mobile hoppers to receive coal by pay loaders and feed the coal into conveyors. Another set of conveyors are provided on surface

to transport coal into washing plant receiving stock yard. At loading point coal will be transported by belt conveyors from washery and discharged into silo.

While both the conveyor systems are located well within the lease area and not leading to even short distance outside lease, the above said impacts (Impact 26, 27 and 28) are not envisaged. In order to mitigate the coal dust emission, it is suggested to develop green belt along the conveyor system on both the sides wherever possible.

7.5.12. Labour Force Related Biotic Pressure - Impact on Forest Resources and Faunal Species

Involvement of outside work forces for the project development and operation activities, establishment of labor and un-skilled worker's colony in the forest land area, likely to impacts the forest resources, faunal species and social aspects are visualized and listed below;

Impact 29: Migrant or outside labors would depend on forest-based resources and involve in tree cutting for small timbers and fuel wood and thereby depletion of forest and local resources - Direct impact.

Impact 30: Conflict between the migrant labors and local tribal/villagers due to resource sharing -Indirect Impact.

Impact 31: Labourers sometimes do indulge in illegal activities like poaching of birds and animals – Direct impact

Evaluation- Work Forces and Migrant Labor: The total manpower required for PEKB coal mine project is reportedly 1805 personnel. Among those, 837 and 186 are seems to be technical personnel designated to work in mine operation (overburden removal, coal, common) and in coal plant (coal handling and washery plant) respectively. The other two categories include maintenance (477) common services (305) and total of 782 personal (Table 7.9).

Table 7.9: Details of manpower requirement and in use

S. No.	Designation	Total
I	Operation- Overburden removal, Coal, Common	837
II	Maintenance	477
III	Coal handling plant, Washery	186
IV	Common services	305
	Grand Total	1805

Source; EIA report 2016

The designations and relevant categories of the manpower have been adopted are proposed to be outsourced: 1) Security: Entire security manpower is required to be arranged by outsourcing except skeleton manpower for supervision. 2) Welfare Facilities; Canteen, Transport requirement, civil repair & maintenance are proposed to be outsourced. 3) Light Vehicles: Only a few drivers are provided for Senior Executives. This may be the workforce belonging to outsider group.

Under the site services, the company would provide housing for work forces, which may include colonies for officials and technical staff. The above mentioned three contact work forces may stay on and are likely to depend on forest based natural resources (fire wood and poles) from the adjacent forests and may also indulge in illegal activities (hunting) if not monitored properly. Thus strict monitoring and management interventions can help reduce those impacts (Impacts: 29, 30 & 31) (See Chapter 9)

7.5.13. Impacts of project activities on threatened faunal species

Presence of any threatened faunal species in the habitats within and adjacent to the project study area is likely to get impacted in the form of:

Impact 32: Loss and degradation of specific habitat of the threatened faunal species of the project area - Direct and primary impact.

Impact 33: Restrict the movements of larger threatened mammals and they forced to enter into the human habitat and create man-animal conflicts

Impact 34: Habitat degradation, fragmentation and impact on threatened faunal population/abundance- Indirect and secondary habitat.

The assessment of impacts of project on threatened species was discussed considering the threatened categories suggested by ICMM (2006) and those categories are: Critically Endangered (CR), Endangered (EN) and Vulnerable (VU) species of IUCN Red List and Schedule I species of IWPA (1972).

Evaluation Flora: Based on the IIFM study carried out for EIA and discussed, PEKB and the buffer area reported relatively high floral values with species richness of a total of 167 plant species in the study area. The core zone reported 101 plant species, which shows moderate species richness of the study area. This species list of the study area includes 18 threatened plants of different categories of IUCN red list. However, based on the ICMM's suggestion a total of 1 endangered 12 vulnerable species identified in the study area need to be given high priority under "Threatened flora conservation plan" (See Chapter 9) (Table 7.10)

Table 7.10: List of Threatened plant species reported in PEKB Study area

S.No	Family and Scientific Name	Local Name	Habit	Conservation Status (IUCN)
	Acoraceae			
1	*Acorus calamus*	Bach	Herb	Endangered
	Asteraceae			
2	*Peucedanum nagpurense*	Tejraj	Herb	Vulnerable
	Burseraceae			
3	*Boswellia serrata*	Saliha	Tree	Vulnerable
	Celastraceae			
4	*Calastrus paniculata*	Unjain	Woody climber	Vulnerable
	Combrataceae			
5	*Terminalia chebula*	Harra	Tree	Vulnerable
	Dioscoraceae			
6	*Dioscorea bulbifera*	Agitha	Climber	Vulnerable
	Euphorbinaceae			
7	*Phyllanthus emblica*	Awala	Tree	Vulnerable
	Leguminoceae			
8	*Pterocarpus marsupium*	Biju	Tree	Vulnerable
	Liliaceae			
9	*Chlorophytum tuberosum*	Safed musli	Herb	Vulnerable

10	*Gloriosa superba*	Kharha godi, karihari	Herb	Vulnerable
	Sterculiniaceae			
11	*Sterculia urens*	Khurlu	Tree	Vulnerable
	Zingiberaceae			
12	*Costus speciosus*	Kewu, ban haldi	Herb	Vulnerable
13	*Curcuma angustifolia*	Tikhur	Herb	Vulnrable

Due to lack of species specific ecological information, it is not feasible to suggest any specific conservation plan. Therefore, butterfly group being ecosystem service provider as pollinator and considering the relatively high species richness of the project study area, in the biodiversity management plan "Habitat for butterfly fauna" is suggested to enhance the overall species diversity (Ref Chapter 9 Section 9.3.1.1 and Table 9.3).

Evaluation- Reptile: The reptile faunal group reported was around 23 species, of which 21 species were reported from the core zone indicating relatively high species richness. This list included one threatened fauna, Indian rock python (*Python molurus*) and also *Varanus bengalensis* -Bengal Monitor Lizard (reported in the study area by WII-team based on direct observations) (Table 7.11). Those species being highly secretive and temperature dependent, recommending species specific conservation plan is needs long term field observation. It is recommended to develop "Reptile Habitat Niche" (Chapter 9, Section 9.3.2.1. and Table 9.5) as an experimental approach, and it would possibly improve the species richness of the reptiles in the study area and may provide habitat niche for this threatened species.

In addition, among the reptile species, the study area reported 15 species of snakes, it is suggested to initiate "Status survey of Snake species" to generate quantitative database under research and monitoring concept of ICMM (2006) Ref Chapter 9 and Table 9.6.

Evaluation – Aquatic Birds: Survey of exclusively aquatic bird was not initiated under ecological the study, only few aquatic specie like grey heron, cattle egret, great egret, little egret, and three species of king fishers (pied kingfisher, common kingfisher and white-throated kingfisher) were given in the bird list. This being the scenario and no record of any threatened aquatic bird species, those common species use small water bodies and streams may get benefited through bio-filter check dam suggested under aquatic pollution mitigation measure (See Section 7.71. and Table 7.8). Added to this, development of mine pit-wetland suggested under habitat development plan likely to attract and provide habitat for some of the true wetland birds (ref chapter 9. Section 9.4.1.1 Table 9.7).

Evaluation – terrestrial birds: Terrestrial bird survey resulted in 82 species in the study area with over 67 species in the core zone. This list includes only two threatened species, Indian peafowl (*Pavo cristatus*) and grey hornbill (*Ocyceros birostris*) come under Schedule-I of WPA reported in only buffer zone and in both core and buffer zones respectively. Indian peafowl being hardy species and use wider habitat types and feed on diverse food, not required any specific conservation plan. The grey hornbill is a hole-nester and predominately feed on figs, hence development of nesting niche by providing nesting boxes of suitable size may support and planting of large number of *Ficus* trees in all the restoration and green-belt development programs would provide additional food resource for this threatened hornbill species.

Avifauna survey carried out by the WII (2020) and IIFM study added, six species of birds of prey each, overall possibility of presence of eight species in the study area. Although all the species belong to *Accipitridae* family schedule I under of WPA (1972), suggesting even group specific conservation plan is not feasible due to use of different habitats like; forest, open scrub land, agriculture and urban areas and

diverse food they feed on not supported to suggest any species-specific conservation plan. Keeping the ecological constraints, it is suggested to include status survey of birds of prey under research and monitoring head. (Table 7.11).

Table 7.11: List of birds of prey reported in the PEKB study area

S.No	Scientific Name	Common name	IIFM 2009	WII 2020
1	*Accipiter badius*	Shikra	✓	✓
2	*Aquila rapax*	Tawny Eagle	✓	
3	*Butastur teesa*	White-eyed Buzzard*		✓
4	*Elanus caeruleus*	Black-shouldered Kite	✓	✓
5	*Ictinaetus malaiensis*	Black Eagle		✓
6	*Milvus migrans*	Black Kite	✓	✓
7	*Spilornis cheela*	Crested Serpent Eagle	✓	✓
8	*Spizaetus cirrahatus*	Changeable Hawk Eagle	✓	
	Total species		6	6

Evaluation of the mammalian fauna: the study area reported 18 species of mammalian fauna with 12 species in the core zone. The WII survey carried out using camera trap and other field survey techniques (record of direct sightings and indirect evidences) for Hasdeo Arand area overlapping with the buffer of PEKB reported 25 mammals. The cumulative list identified eight threatened mammals (Table 7.12) categorized as Schedule I of WPA and brought different categories of Least concerned to Endangered under IUCN. Except elephant, sloth bear and four-horned antelopes, the rest of the specis are carnivorous in nature. Therefore, habitat improvement through planting of food plant species would directly benefit by those three herbivores, and may indirectly support the other two carnivores (common leopard and Indian grey wolf) by improving the abundance status of the prey species like; chital (*Axis axis*), sambar (*Rusa unicolor*), and barking deer (*Muntiacus muntjac*) of the study area. Hence, the following are the habitat improvement-based management plans suggested to conserve some of the threatened mammals of the study area

"Food plants enhancement for three threatened herbivores" elephant, sloth bear and four-honed antelope

"Grassland habitat development" – chital (A*xis axis*), sambar (*Rusa unicolor*), barking deer and, four-horned antelope

Other ancillary habitat improvement plans include; check dams – waterhole for overall wildlife, salt-licks – for ungulates and swamp pits - wallowing points

The details of management plans are discussed in Chapter-9.

Table 7.12: Status of threatened fauna in the study area – PEKB

S.No	Scientific/Common Name	IIFM 2009		WII 2020	Conservation Status	
		CZ	BZ		IUCN	WPA
1. Butterfly*						
1	*Hypolimnas misippus* Danaid eggfly*			✓*		Sch II

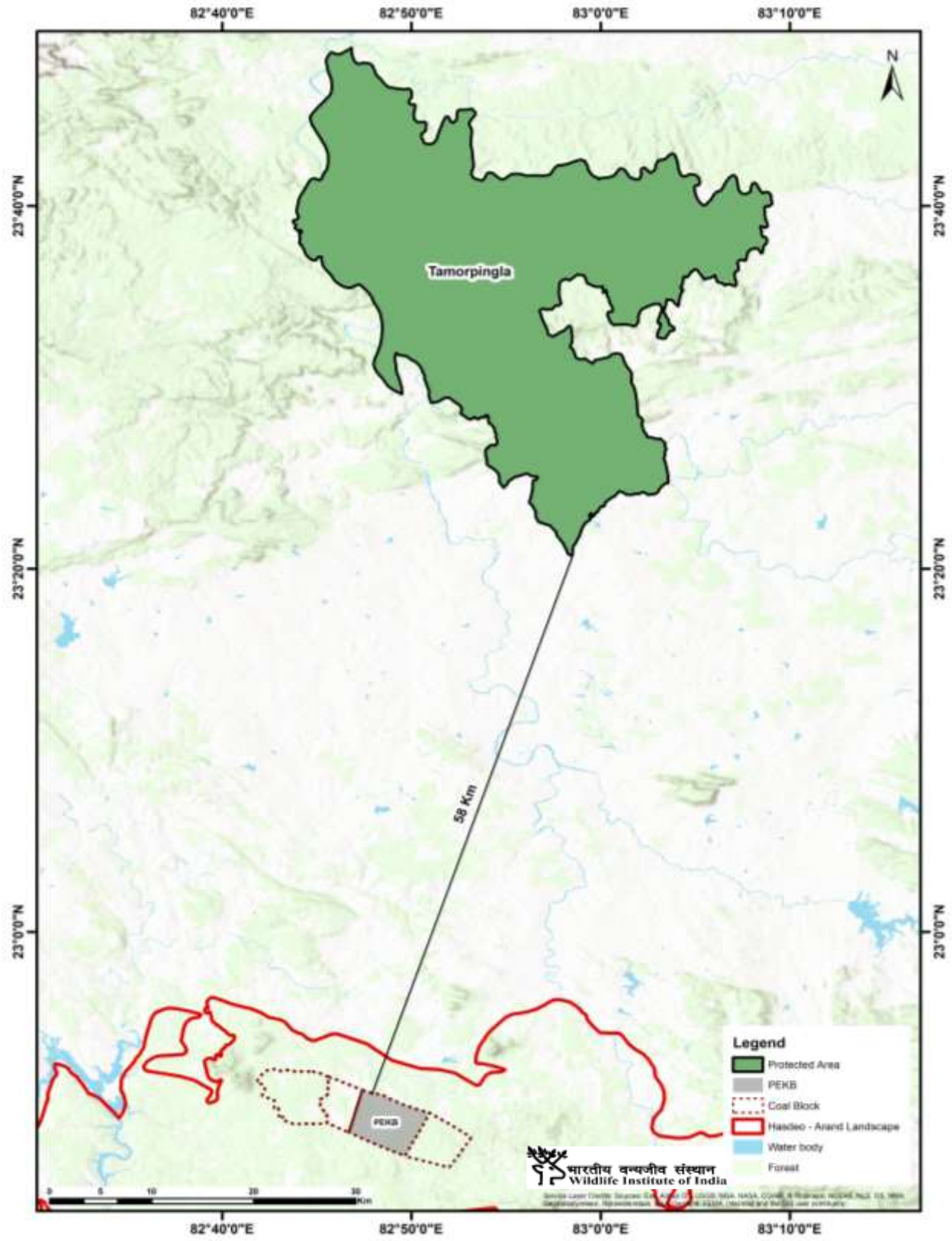
2	*Charaxes bernardus* Tawny Rajah*			✓*		Sch II
2. Reptiles						
3	*Python molurus* - Indian rock python	✓	✓			Sch-I
4	*Varanus bengalensis* -Bengal Monitor Lizard **			✓		Sch-I
3.Terrestrial Birds						
5	*Accipiter badius* - Shikra	✓	✓	✓		Sch-I
6	*Aquila rapax* - Tawny Eagle		✓			Sch-I
7	*Butastur teesa* - White-eyed Buzzard*			✓		Sch-I
8	*Elanus caeruleus* - Black-shouldered Kite	✓	✓	✓		Sch-I
9	*Ictinaetus malaiensis*-Black Eagle			✓		Sch-I
10	*Milvus migrans* - Black Kite	✓	✓	✓		Sch-I
11	*Spilornis cheela* - Crested Serpent Eagle	✓	✓	✓		Sch-I
12	*Spizaetus cirrahatus* - Changeable Hawk Eagle	✓	✓			Sch-I
13	*Pavo cristatus*- Indian Peafowl		✓			Sch-I
14	*Ocyceros birostris* - Grey hornbill	✓	✓			
4. Mammals						
15	*Elephas maximus* - Elephant	✓	✓	✓	En	Sch I
16	*Melursus ursinus* - Sloth bear		✓	✓	Vu	Sch I
17	*Tetracerus quadricornis* - Four-horned antelope			✓	Vu	Sch I
18	*Canis lupus* - Indian grey wolf			✓	Lc	Sch I
19	*Panthera pardus* – Common leopard			✓	Vu	Sch I
20	*Manis crassicaudata* -Indian pangolin			✓	En	Sch I
21	*Lutragale perspicillata* - Smooth-coated otter			✓	Vu	Sch II
22	*Mellivora capensis* - Honey badger			✓	Lc	Sch I
Total Species		10	13	15		

CZ- Core Zone, BZ - Buffer Zone, SA - Study Area, VU= Vulnerable, Nt – Near Threatened, WPA – Wildlife Protection act, ** - sighted in PEKB study area, * - data provided by ICFRE

7.5.14. Impacts on Ecologically Sensitive Area - ESA

Presence of any Ecologically Sensitive Area (ESA)/ or area of conservation significance of state, national and international levels (Protected Areas, Wetlands, Mangrove habitats, Important Bird Areas-IBA etc.) in the close vicinity of the project site (within 10km radius) are likely to be impacted at different level due to the above discussed impacts owing to the project and associated activities.

Evaluation – ecologically sensitive area: As per the EIA report (2016) of the coal mine and coal washery plant, 17 forests blocks under the category of Protected forest (PF) located within 10-km radius of the project site. The spatial distribution of those PFs ranging from two forests within the lease and other from minimum of 1.6km (Pidiya Reserve Forest) to maximum of 9.9-km (Bhandargaon Protected Forest) Annexure 3.



Map 25 Showing the spatial distribution of the nearest Protected Areas (Tamorpingla WLS) from the PEKB project site.

CHAPTER-8: SUGGESTED MITIGATION STRATEGIES TO REDUCE THE IMPACT OF COAL MINING ON FAUNAL GROUPS IN THE OPERATIONAL PEKB COAL BLOCK

8.1. Introduction

The present biodiversity assessment study was carried out for **Parsa East and Kanta Basan (PEKB) Opencast Mine and Pit Head Coal Washery Expansion Project (from 10 Mtpa to 15 Mtpa)** Project (PEKB) at Udaipur Tehsil, Surguja District, Chhattisgarh of Rajasthan Rajya Vidyut Utpadan Nigam Ltd., (RRVUNL), Rajasthan. With the understanding of the overall biodiversity status of the project area and the ongoing project activities and overall operational and planning purposes, the likely impacts of the projects have been visualized and evaluated. It is an ongoing project and all the technical and managerial mitigation measures are already in line with the impacts that were identified under EIA study (2009 and 2016). Therefore, this mitigation chapter recommended predominantly the biological interventions to minimize the impacts envisaged. The overall mine operation and planning suggested to follow and implement all necessary mitigation measures not only to minimise the project associated impacts, keeping the aim of the BMP study, this section suggested additional mitigation measures to enhance and conserve the biodiversity values of the project study area.

8.2. Mitigation Approach

"Mitigation measures," refer to the action that can be implemented to minimize the magnitude of the project related detrimental impacts on different physical, biological and social attributes of the project area through three possible courses of actions, either by changing (1) at source, (2) path and (3) at the receiving end. Mitigation involves selecting and implementing plans of action to protect biological resources, the users of biodiversity and other affected stakeholders, from potentially adverse impacts as a result of the project associated activities. Rehabilitation refers to the process that is carried out to return the mined-out land to agreed post-closure uses. However, this being the ongoing project, it completely recognizes that impacts on biodiversity have occurred due to operational phase and management interventions. Biodiversity enhancement refers to measures undertaken to enhance or improve biodiversity – to go beyond mitigation or rehabilitation and explore opportunities to enhance the conservation of biodiversity of the project area.

Mitigation are implemented on the need basis considering the hierarchy of their desirability: **Avoiding impacts** by modifying a proposed **expansion of mining or existing operation** in order to prevent or limit a possible impact, which is a high priority that should always be afforded in mitigation. **Minimizing the impacts** by implementing decisions that are designed to reduce the unwanted impacts of a proposed activity on biodiversity. **Rectifying impacts** by rehabilitating or restoring the affected environment and **compensating** for the impact by replacing or providing substitute resources or environments, which is a last option and might include so-called **offsets** (GPG-ICMM 2006). This mine and coal washery plant

being ongoing project the mitigation measures suggested are for minimizing the impacts into insignificant level adding biological interventions and also to enhance the biodiversity values of the project area in operation and mine closer plan.

8.3. Impacts Assessed and Mitigation Plan Suggested

Even though, mining, metal and non-metal are the integrated projects, the nature of project and associated activities across the planning, operational and mine closing/management are entirely different. The mitigation and biodiversity conservation and management plans (BMP) suggested here are mainly the operational phase of the coal mining and washery associated impacts/risks identified by consulting the EIA reports (IIFM 2009, EIA 2009 and 2016) and during the survey pertaining to biodiversity values and interaction with the local stakeholders by the WII 2019-20. The following are the impact mitigation measures with the combined biodiversity management plans recommended under this study, detailed in Table 8.1.

Table 8.1: Summary Details of Mitigation Plans Suggested

Biodiversity impact/risks	Recommended mitigations and action plans
1. Loss of forest habitats and biodiversity	**1. Progressive Restoration:** **1.1. Eco-restoration of compensatory afforestation sites**" To improve the habitat quality of afforestation sites/range forest
2. Loss of non-forest land and biodiversity	**2. Natural resource development:** **2.1. Development of grass and leaf fodder plots** **2.2. "livelihood options to increase income sources" (discussed in chapter 9)** Mitigate the biotic pressures on the adjacent forest habitat – outside mine lease
3. Mining impacts on hydrological regime – surface water pollution	**3. Biological interventions:** **3.1. Bio-filter check dams- stream of project sites** Mitigation to address soil erosion and mine sedimentation and aquatic pollution
4. Impacts of air pollution-dust and oxides emission on forest and fauna	**4. Green Belt Development - Phytoremediation** **5.1. Mine and washery plant** **5.2. Infrastructure area** **5.3. Roads – of mine**
5. Impacts of air pollution- fugitive emission from coal handling	**5.1 Development of "Green gallery belt"** **5.1.1. Coal handling and washery areas**
6. Mine waste dumps and impact on physical and biological resources	**6. Eco-restoration of waste dump -** **6.1. Waste dump – forest habitat**

7. Unregulated vehicle movement - road mortality on selected faunal groups	**7. Technical and regulatory mechanism** **7.1 Construction of underpasses within the project area and other approach roads**
8. Biodiversity conservation and management plan- species groups	**Discussed in chapter 9**
9. Impacts of project activities on threatened floral and faunal species	**Discussed in chapter 9**

8.4. Impact Mitigation - Loss of Forest Habitat and Biodiversity

8.4.1 ECO-Restoration of Compensatory Afforestation Sites

Compensatory afforestation is one of the foremost mitigatory measure that comes under the compliance of MOEF&CC to address the loss of forest habitat and associated biodiversity to be implemented by any mining/metal and non-metal and other developmental projects. As per land use patterns of the PEKB site showed, out of 2682.856 hectares of area acquired, 1871.118 hectares was forest land. This forest land falls under protected forest of 1629.551 hectares while 241.607 hectares belonging to two types of revenue forests (Table 7.5). As per the EC norms, the loss of forest land needs to be compensated by the user agency through afforestation of double the extent of degraded range forest land. Hence, **Eco-restoration of Compensatory Afforestation Sites**" is suggested under progressive afforestation which would support to attract or re-colonize the faunal species of adjacent protected forests. The details of Eco-restoration plan are discussed in **Table 8.2.**

8.4.1.1. Action Plan – Eco-restoration of Compensatory Afforestation Sites"

Considering the record of relatively high species richness of some of the species groups like; flora, reptile, avifauna and mammalian species richness in the core zone of the project (**Table 7.2**), it is recommended to develop at least 500 hectares (tentatively) of the compensatory afforestation of the range forest land under eco-restoration concept rather than the normal tree plantation. The ecological survey identified high species richness of 170 plant species, which includes 75 trees, 41 shrubs, 32 annuals (grass and herbs) and 11 species of climber and woody climbers each. However, only selected species under three major habits like tree, woody shrub and woody climbers are recommended under eco-restoration plan and the plan of actions are detailed in **Table 8.2**.

8.4.1.2. Selected Tree, Shrub and Climber species

In the study area, a total of 75 tree species have been reported (listing of species). Of that, 49 species were reported from the core zone, while 75 species were reported from the buffer zone (Annexure 7, life farm status of flora). The IVI values depict three parameters such as relative frequency, relative density and relative dominance which stands for wider distribution, higher abundance and larger size respectively in the given habitat. Therefore, they have been considered as promising species, which would provide higher rates of survival. Under this ecological concept, all those 23 trees species and 15 species of shrub have been recommended to include in the afforestation plan.

Table 8.2: Action Plan - eco-restoration – compensatory afforestation site/ range forest land

Mitigation Theme	Action Plan Restoration and enhancement of Biodiversity in afforestation sites
Habitat for forest biodiversity enhancement Maintain ecological integrity of the afforestation site and range forest land Floral, reptile, terrestrial avifauna and mammalian faun – recolonize	**1.** It is suggested to restore 500 hectares of range forest land identified for compensatory afforestation under the compliance of Environment Clearance **2.** In case the range forest land identified and transferred for the compensatory afforestation site is located more than 100-km from the project study area, it is recommended to restore the same extent of 500 hectares within the refilled mine voids – i.e. 2127.55 hectares planned for greenery development (**Table 7.3**.). **3.** The quantitative assessment i.e., IVI estimated for the tree and shrub species reported only in the sample plots were considered for eco-restoration plan. Thereby, 25 tree and 15 shrub species suggested for restoration plan and their IVI values have been given in **Table 8.3 and Table 8.4.** **4.** The study area reported 22 climber species which includes 11 woody climbers. Hence only all the 11 woody climbers have been suggested to include in this plan and the list is given in **Table 8.5** **5.** This restoration should be planned progressively with the mine planning at the rate of restoration of 50 hectares/year in the next 10 years (tentatively) and thereby complete the eco-restoration well before the mine closure plan to compensate the loss of habitat and improve the faunal diversity of this region. **Planting.** **6.** Best practice to collect seeds of all these possible tree, shrub and climber species involving the local villagers and tribes those who are having vast knowledge on local plants. **7.** Since the PEKB is surrounded by rich forests no special efforts needed for growing grass and herb species. Instead the restoration principles should be followed. **8.** The restoration plan should be planting of mixed species (life form)/ Leave 2-m gaps between the trees and plant shrub species between the trees. Creeper species should be planted close to the tree species (less than 0.5m distance). Overall, the forest patch should have the combination of tree, shrub and climber species.

	9. All the technical aspects of land preparation, planting, after care, and management need to be carried out with the well experienced (at least 10 years) restoration and forestry expert/plant taxonomist with two field biologists as a core team.

Table 8.3: List of tree species Estimated IVI suggested for Eco-restoration of compensatory afforestation sites of PEKB

S.no	Scientific name	Local Name	IVI
1	*Shorea robusta*	Sal	108.50
2	*Madhuca indica*	Mahuwa	39.15
3	*Diospyros melanoxylon*	Tendu	26.95
4	*Buchanania lanzan*	Char	22.94
5	*Anogeissus latifolia*	Dhaura	17.66
6	*Boswellia serrata*	Saliha	11.27
7	*Ficus bengalensis*	Bargud	9.66
8	*Syzygium salcifolium*	Jamli	9.63
9	*Lagerstroemia parviflora*	Sidha	7.90
10	*Phyllanthus emblica*	Amla	7.31
11	*Adina cardifolia*	Karmi	5.61
12	*Terminalia tomentosa*	Saja	4.83
13	*Semecarpus anacardium*	bhelwa	4.26
14	*Garuga pinnata*	Kenkarn	4.09
15	*Bridelia retusa*	Kasayi	3.81
16	*Symplocus racemosa*	Lodli	3.43
17	*Terminalia chebula.*	Harra	2.16
18	*Odina wodier*	Gunja	1.80
19	*Gardenia latifolia*	Mali	1.76
20	*Albizzia procera*	Kari	1.60
21	*Delbergia paniculata*	Dhobia	1.41
22	*Ougenia dalbergioides*	Tilsa	1.18
23	*Terminalia bellerica*	Baheda	1.12
24	*Schleichera oleosa*	Kusum	1.07
25	*Casearia graveolens*	Chilhi	0.86

Table 8.4: List of Shrub species estimated IVI and suggested for Eco-restoration of compensatory Afforestation sites of PEKB

S.no	Scientific name	Local name	IVI
1	*Flacourtia indica*	Ramkonyi	40.82
2	*Woodfordia fruticosa*	Dhawayi	36.08
3	*Butea monosperma*	Parsa	22.28

4	*Elaeodendron glaucum*	Jamrasi	18.21
5	*Thespesia populnea*	Masbundi	12.98
6	*Ipomoea carnea*	Ipomoea	6.89
7	*Phyllanthus emblica*	Amla	6.63
8	*Asparagus racemosus*	Asparagus	5.84
9	*Desmodium palchellum*	Chipi	5.84
10	*Helictorus isora*	Aelhi	5.84
11	*Embelia robusta*	Phodo	5.81
12	*Dendrocalamus strictus*	Bans	2.92
13	*Antidesma diandrum*	Saroli	2.02
14	*Ricinus communis*	Arandi	2.02
15	*Ziziphus xylopyrus*	Dhonta	NA

Table 8.5: List of climber and woody climber recommended for eco-restoration of compensatory afforestation sites of PEKB

Sl. No	Botanical Name	Local Name	Habit
1	*Abrus precatorius*	Kwunti	Climber
2	*Acacia caesia*	Guriyar, Garur	Woody Climber
3	*Acacia pennata*	Arel	Climber
4	*Alangium salvifolium*	Akol	Climber
5	*Bauhinia vahlii*	Mahul	Climber
6	*Butea monosperma*	Nar parsa	Climber
7	*Caesalpinia bonducella*	Gataran	Woody Climber
8	*Celastrus paniculata*	Unjain	Woody Climber
9	*Ceropegia bulbosa*	Bosiy kandha	Climber
10	*Cissus quadrangularis*	Hathjod	Climber
11	*Cryptolepis buchanani*	Dudhnar	Climber
12	*Derris scandens*	Nakuwa kandha	Woody Climber
13	*Dioscorea bulbifera*	Agitha	Climber
14	*Ipomea mauritiana*	Patal kohra	Woody Climber
15	*Marsdenia tenacissima*	Chikti	Climber
16	*Spatholobus roxburghii*	Bendo	Woody Climber
17	*Tinospora cordifolia*	Gurudhi	Climber
18	*Vallaris solanacea*	Dhudhiyakandha	Woody Climber
19	*Ventilago madraspatana*	Kyonti, Keuti	Woody Climber
20	*Vitis carnosa*	Dhokarbela	Woody Climber
21	*Vitis latifolia*	Dhokarbela	Woody Climber
22	*Ziziphus rugosa*	Churaban, churna	Woody climber

8.5. IMPACT MITIGATION - LOSS OF NON-FOREST LAND AND BIODIVERSITY

8.5.1. Natural Resource Development - Grass and Leaf Fodder Development

The conversion 1871.158 hectares of forest land includes 241.607 hectares of two types of revenue forests come under seven village areas (Salhi, Hariharpur, Parsa, Kente, Ghatbarra, Parogiya and Basan) and shared 12.91% of the total forest land (**Table 7.5**). Hence, the dependency of local villagers on those forest areas had been denied due to the implementation of this mine project. The loss of access to the forest resources visualized the shifting of biotic pressure from the revenue forests to the undisturbed protected forests of the adjacent areas. To minimize the impacts of shifting of biotic pressures, it is recommended to mitigate by providing some basic resources like grass and leaf fodder resources to support their livestock population and to reduce the tree cutting for leaf fodder.

Use of forest habitat for grass and leaf fodder and deriving forestry-based income may include collection of all the NTFP (small pole, fruits, seeds, plants parts for medicine, tubers, fibres and medicinal plants etc). Therefore, providing **grass and leaf fodder (Table 8.5)** under natural resource development and management – NRDM and facilitating to enhance their income source through **livelihood options (See Chapter 9)** could potentially reduce the biotic pressures in the protected forests

8.5.1.1. Action Plan - Grass and Leaf fodder plot Development.

The **grass and leaf fodder plots** can be developed in two locations; first in the village Gaucher land (grazing land or waste land) and secondly within the refilled mine lease area. The villagers can start using the fodder from their own land and then the grass and leaf fodder developed in the lease area as additional resource. The technical details and action plans are discussed in **Table 8.5.**

Table 8.5: Action Plans – Grass and Leaf fodder plots (GLFP) development

Development of Grass and leaf fodder plots – mitigate grazing and tree lopping pressure	
BMP Themes	**Action Plan**
Grazing land for local livestock	1. It is proposed to develop 35ha of "**Grass and leaf fodder" plots (GLFP)** within the village areas of seven villages transferred their revenue forest for mine lease. Each village should be developed five ha with a total of 20ha in the first two years while 15ha in the 3rd and 4th year. 2. In addition, 50 ha of fodder plots at the rate of 10ha/year within 2127.555ha of backfilled area in five different locations suggested with 10ha each from the sixth to till 10th year. 3. The study area reported a total of 39 grass species, of that, only 12 species recommended to grow in the grass land development plan. This list includes 10 species reported in the core zone while all the 12 from the buffer zone of the study area (**Table 8.6**) 4. Plow the land area earmarked for GLFP development at sub-surface level. Collect the seeds of the native and palatable 12 grass species detailed in

Additional Grasslands Habitat developed Improve Grassland faunal diversity – birds and rodents Mitigate grazing and tree cutting pressure in the adjacent forest habitat.	**Table 8.6,** and make grass pellets by mixing native soil and farmyard manure with water and sow the grass pellets before the onset of monsoon. **5.** It is recommended not to open the grass plots for grazing in the first two years so that, the plot will have enough seed bank to regenerate every year and therefore, protecting the grass plots is very crucial. **<u>Leaf Fodder plots</u>** 6. The leaf fodder plot land can be developed along the boundary of the grass plots covering 5-10m belt plots and no additional land required 7. Grow all the 16 tree species suggested with the distance of 2m between the trees and rows so that, 2-4 rows can be grown (**Table 8.7**). The leaf fodder tree species prepared based on the literature (Hocking 1993) listed more than 50 fodder trees based on their fodder value and growth rate with 1-10 ranks. 8. Among the 16 species recommended and selected from the literature showed 8 species secured fodder value (FV) of > 5, while rest of 8 with < 5 fodder value, and according high preference to be given to the species ratted > 5 FV. 9. The growth rate varied from 4-8 out of maximum of 10 value assigned. Within the list, except five species, rests of 11 species secured more than five growth rate expected to give quick establishment of the fodder species. 10. This grass and leaf fodder plots expected to provide habitat for the local faunal biodiversity like: most of the small mammals (rodents), birds and also some species of butterflies and micro habitat for reptiles. 11. In addition to the grass and fodder tree species suggested, it is very important to consult the local grazers for their indigenous knowledge to add more grass and fodder species in the list 12. The leaf fodder should be harvested only after gaining 6 years maturity and both the grass and leaf fodder should be sustainably used under the control of the Village Fodder Committee VFC formed under this plan 13. The 50 hectares of grass and fodder plots developed within the refilled area should be managed under cut and carry system by the affected villagers. 14. This Grass and leaf fodder development plan should be initiated through CRS department and sustainably managed by the Village Fodder Committee – VFC formed under CRS division

Table 8.6: List of Grass species suggested for the development of Grass fodder plots

S. No	Botanical Name	Local Name	S. No	Botanical Name	Local Name
1.	*Andropogon contortus*	Sukra, Churant	7	*Eragostis tenella*	Bhur bhusi
2.	*Apluda varia*	Phuliban	8	*Eulaliopsis binata*	Bagayi
3.	*Cynodon dactylon*	Doob	9	*Imperata cylindrica*	Chhir ban
4.	*Desmostachya bipinnata*	Kush	10	*Ischaemum pilosum*	Kunda
5.	*Dichanthium annulatum*	Biri ban, marbal	11	*Saccharum spontaneum*	Kansa
6.	*Echinochlou colonum*	Sawa, sama	12	*Sehima sulcatum*	Sedu

Table 8.7: List of tree species suggested for the development of fodder plots

S.No	Botanical Names	FV	GR	PO	
				1st	2nd
1	*Acacia catechu*	5	5		@
2	*Holoptelia intergrifolia*	3	5		@
3	*Ficus religiosa*	7	8	@	
4	*Madhuca indica*	5	4	@	
5	*Pongamia pinnata*	6	6	@	
6	*Anogeissus latifolia*	5	4		@
7	*Syzygium cumini*	7	6	@	
8	*Bauhinia variegata*	8	8	@	
9	*Boswellia serrata*	6	7	@	
10	*Butea monosperma*	4	5		@
11	*Cassia fistula*	3	7		@
12	*Dichrostachys cinerea*	6	6	@	
13	*Diospyros melanoxylon*	4	6		@
14	*Ficus bengalensis*	6	7	@	
15	*Terminalia arujuna*	4	7		@
16	*Terminalia bellerica*	4	7		@
Total				8	8

@ Preference order based on fodder values and growth rate of 16 species, Rank 1-10, higher the rank more the use value, FV-Fodder values, GR – Growth Rate, Source Hocking 1993.

8.6. Impact mitigation - biotic pressure on forest land and biodiversity

The second level of mitigation to address the additional biotic pressure will be shifted to the adjacent forest land is enhancement of income sources, so that their purchase power will be increased and decency on forest for cutting tree for pole and timbers minimised. Further, it has to be addressed through providing different livelihood options to increase their income sources as well as minimize the dependency of forest.

8.7. Impact Mitigation on aquatic habitat - Surface water pollution

The probable causes of surface water pollution in the mining area are soil erosion and rain-washed runoff from the waste dumps (OB), releasing of storm water generated due to ground water disturbance and rain water collected in the mine pits into the natural stream systems. In addition to the waste water management plan that is proposed in the EIA report (Box 8.1), It is proposed to adopt a biological intervention of construction of **Bio-filter Check dams** across the streams flowing out of the lease to make the surface water management as full proof mitigation system.

Box 8.1: Surface Water Pollution Control Measures (EIA Report 2016)

- Retaining walls will be provided at the toe of dumps and the unstable overburden benches within the mine to prevent wash off from dumps and sliding of material from benches.
- This will help in preventing silting of water drains/channels.
- The water channels/drains carrying the rain water from the mine will be provided with baffles and settling pits to arrest the suspended solids, if any, present in this water.
- The worked-out slopes will be stabilized by planting appropriate shrub/grass species on the slopes.
- The mine water will be regularly tested and appropriate measures will be taken in case any element is found exceeding the limits.
- Seepage water and rain water collected in the open pits will be pumped out and discharged with natural drainage system after de-silting in settling ponds.
- Oil spillage from the workshop in the wastewater will need to pass through a bar screen followed by oil trap where oil content of wastewater will be recovered.
- Sanitary wastewater generated from domestic facility at mine site and the residential colony located outside ML area is proposed to be treated before discharge.

8.7.1. Bio-filter check dams

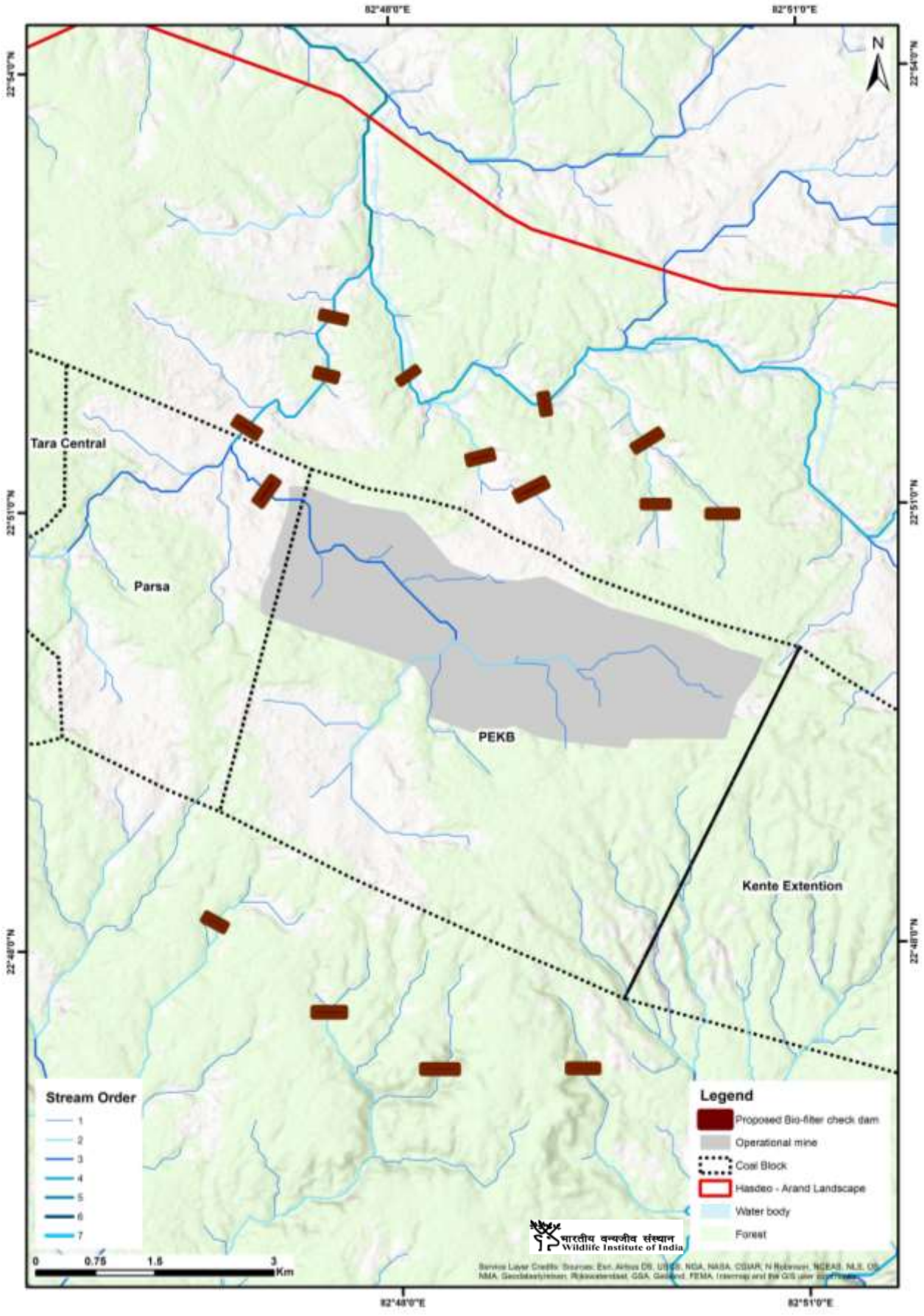
Considering the heavy surface water runoff from both the mine and washery area during the heavy rainy season and floods, it is proposed to construct bio-filter check dams across the streams to filter the rain-wash runoff from the project sites. This would filter the suspended solid and other pollutants discharged by the mine to improve the water quality for irrigation and domestic use and also support diverse aquatic biodiversity. Therefore, construction of **bio-filter check dams** in select locations across the streams leading from the mine boundaries would potentially reduce the surface water pollution.

8.7.1.1. Action plan - Bio-filter check dams

The suggested bio-filter check dams a kind of biological intervention to address the impacts of surface water pollution expected due to rain-washed runoff from the active mining area. This small micro dam structures to store the storm water and filter it through proposed planting of aquatic sedges can be an effective and biological management plan anticipated to support aquatic fauna. The ways to construct such dams are discussed in **Table 8.8.**

Table 8.8: Action Plans: Bio-filter Check Dams across stream systems

Mitigation Themes	Action Plans – mitigation to surface water pollution
Mitigation – soil erosion Addressed surface water pollution and ensured clean water – village areas Support -Aquatic Biodiversity – Especially, Fishes, Amphibians, few aquatic birds and invertebrates	**B. Biofilter Check Dams** 1. Bio-filter check dams are suggested across the streams which have been disturbed due to mining and leading from the mine boundary to feed the Parsa nullah (Map 26) from the northern. It is nothing but medium size concrete and or small lose boulder dams (depends on the stream width) with spill over (**Plate 8.1).** 2. Strategically select the sites where the stream banks are with gentle to moderate slope (not very steep slope). Possibly wider the stream width 2-3m on either sides and up to 20-30 in the upstream. This structural modification would maximize the water storage capacity and act as sediment traps, improve storm water treatment and to enhance biodiversity. 3. It is suggested to plant aquatic sedges (Cyperus sp), *Colocasia, Ipomoea,* Typha and water Lilly commonly found along the edges of village ponds and river edges (**Plate 8.1**). 4. Village ponds and edges of the Atem river should be surveyed for the full complement of potential aquatic sedges, which could be then included in the final design as brush wood dam. 5. Make sure that the root cutting of the sedges should planted well inside the water front so that, efficiently filter the mine sediments. The streams being seasonal, the root cuttings of the sedges should be planted just before the onset of monsoon and once the waster start flowing in the stream they can easily regenerate and established. 6. These small bio-filter check dams can also act as man-made micro aquatic niche and would support aquatic faunal species like fishes, amphibians, and small water birds and aquatic invertebrates of the study area 7. Regular monitoring of the downstream water quality of these check dams/bio-filter dam sites is essential to determine their effectiveness and guide in adaptive re-design or sediment dredging where warranted. 8. This bio-filter check dam also ensures the flow of filtered and portable water available to wildlife and locals residing and pend on them.



Map 26 Proposed bio-filter check dams to construct across the streams flowing out of mine lease of the PEKB

Plate 8.1: Verities of aquatic sedges commonly found in the village pond, streams and river edges (Representational visuals)





Water Lilly

Colocasia




Modal Bio-filter-Check dam and aquatic sedges suggested to incorporate

8.8. Impact Mitigation - Air Pollution on Terrestrial Habitat and Fauna

In mining operations air pollution occurs in two ways like; addition of gaseous pollutants to the atmosphere and the dust particles. The gaseous pollutants include NOx, SO_2 and Hydrocarbons. The sources of pollutants from the existing mining activity include: Operation of Heavy Earth Moving Machinery (HEMM), vehicle movements for loading /unloading and transportation of ore and mine waste. Suspended Particulate Matter (SPM) generated due to all the activities related to excavation of ore includes; land clearing, drilling, blasting, crushing and processing of ore etc. Therefore, there will be an instantaneous increase in the pollutant loads during operational phase, which needs to be attended effectively through phytoremediation technique

8.8.1. Green Belt- Phytoremediation

There are many mitigation measures to reduce the air pollution related to mining and washery plant. This management also includes plantation and green belt development in different locations.

It is well known fact that, plants can act as bio-filter agent to control air related pollution problems, that has been discussed and proved through many studies (**Box 8.2**), which helps in maintaining the ambient air quality of the project environs. The greenery developed under **Greenbelt phytoremediation** would enhance selected faunal diversity of the project sites.

Therefore, it is recommended to implement **Greenbelt development** under the concept of **"phytoremediation"** with site specific multi species plantations, which would be biologically effective, economically feasible (onetime investment) and ecologically sustainable.

BOX 8.2: Plant Species– Bio-filter agent to Control Air Pollution
Many studies have proved that, tree species have major role in air pollution tolerance (Garsad and Rutter 1982 and Scholz, 1981) and performance at population and species level, which can be related to pollution (Mansfield, 1976 and Sanders 1976). Therefore, plant species act as bio-filtering agent to improve the air environment. Further, studies have discussed the role of plant species in controlling the accumulation of dust and gaseous emissions, respect to tree size and shape and leaf structures and foliage area (Martin and Barber 1971, Das 1981, Giridhar and Chaphekar 1983 and Chaphekar 1994). According to Martin and Barber (1971) green belts developed, within their tolerant limits, can remove up to 70% of gaseous pollution from ambient air.

8.8.1.1. Action plan: Green belt development – phytoremediation

The green belt development suggested is to mitigate the air pollution like dust, (particulate matters), oxides (NOx, SO_2) and hydrocarbons generated due to mining activities. As discussed above, in the **Box 8.2,** the effect of dust capturing efficiency of specific species, the action plan suggested below discussed the list of selected species and site specific strategies to mitigate the pollution impacts (**Table 8.9**)

Table 8.9: Action Plan Greenbelt - Phyto-remediation and Mitigation to Air Pollution- Project Site

Mitigation Theme	Action Plan
Minimize air pollution (dust, noise and gas) **Green shelter belt – habitat for faunal diversity**	1. Overall, a total of 39 tree species have been identified and selected from different sources based on their efficiency of air pollution control/tolerance performance. 2. Of the 39 species provided in the list, the priority should be provided to the first 23 as they are reported in PEKB. 3. Among those 39 species, 24 were identified as good dust capturing species (Anon 2005) and their percent of efficiency is given. About 17 species are suggested to minimize noise, while seven species suggested are for absorbtion of gaseous emissions (Saxena 1919). This list also includes 38 species suggested as pollution tolerant by CPCB (**Table 8.10**).

Enhancement of Biodiversity values of the project area **Improver the visual quality of the infrastructure areas** **Stabilize Ambient Air Quality**	4. According to the mine lease afforestation program, the active mine area i.e, the safety zone, waste dumps and washery areas are recommended to plant 29 species of dust-tolerant plants (**Table 8.10**). **5.** The roads under the use of mine's vehicles like dumpers and loaders, and the mine access roads outside of the lease should be planted with 20 species of plants. These species would potentially control noise levels (17 species), absorb gas emissions (7 species) and act as dust tolerant species. **6.** About 19 species are suggested to be grown in and around the office and residential areas. These would be common species normally found in human habitations and includes *Butea monosperma, Cassia fistula, Bauhinia variegata and Alstonia scholaris*. **7.** The aforementioned species may be planted as avenue trees along the roads office and other establishments. The visual effect of some of the tree species suggested is given in **Plate 8.2.** 8. Assortment of native species' plantations would serve as Phytoremediation to minimize the mine-related effects of air pollution, increase the visual quality (aesthetic value) and would help in improviding micro climate at the project site. These avenus plantations do not hold much biodiversity values though.
General – Techniques Strict compliance of standard forestry techniques in terms of pit preparation (dimensions), manoeuvring, watering and also after care with the help of forestry expert. Trees have to be planted at 2m X 2m gap between the trees and rows and strictly follow the suggestion to plant the list of species suggested specific to the sites/areas.	

8.8.1.2. Selected Tree and Shrub species

To mitigate the impacts of particulate matter and gaseous emissions from the mine, 39 species of plants have been selected based on the review of literature. The cumulative list of species includes 27 tree species and their performance of dust control vary significantly. The list includes *Holoptelia integrifolia* (35.0%), *Phoenix sylvestris (*32.7%), *Melia azedarach* (31.7%), Terminalia *arjuna* (30.5%), *Termanilia catappa (30.1%)* were estimated to be more than 35% of and they have to be given high preference. dust capturing efficiency. *Alstonia scholaris (*25.3%), *Azadirachta indica* (25.5%), *Butea monosperma* (24.4%) and *Cassia fistula* (23.0%) were the second order species estimated more 20-25%. This list of tree species also recommended by CPCB as pollution tolerant species (**Table 8.10**).

In the list, a total of 17 species serve as noise control plants and seven species help absorb gaseous emissions. Out of 39 species selected, 23 species were reported in the study area either in the core zone or in the buffer zone and they are recognized as bio-filter agent to control air pollution (**Table 8.10**).

Table 8.10: Tree Species Suggested for Green Shelter Belt Plantation to Control Air Pollution Impacts- PEKB project sites

S. No	Species Name	Local Name	S1	S2		S3-CPCB	Location -Proposed			
			DC	NC	OEO	DT	AM	RD	AS	O/R
1	*Acacia catechu* **					Sd	*			
2	*Aegle marmelos* **	Bel, Bili Patra,	18.9	NC		Sd/Rc	*	*	*	
3	*Albizia lebbeck*	Siris, Karo Sirish	18.3	NC	GE	Sd	*	*	*	*
4	*Albizia odoratissima***					Sd	*	*		
5	*Albizia procera* **					Sd	*	*		
6	*Alstonia scholaris*	Satani	25.39	NC	GE	Sd	*	*		
7	*Anogeissus latifolia***					Sd	*			
8	*Annona squamosa*	Jamfal	12.09			Sd	*	*	*	*
9	*Azadirachta indica*	Neem	25.54	NC	GE	Sd	*	*	*	*
10	*Bauhinia variegate* **	Kanchnar	18.58			Sd	*	*	*	*
11	*Buchanania lanzan* **					Sd	*			
12	*Butea monosperma* **	Palas, Kesudo	24.44	NC		Sd	*	*	*	
13	*Cassia fistula* **	Amaltas **	23.03			Sd	*	*	*	
14	*Dalbergia latifolia* **					Sd	*			
15	*Dalbergia sissoo* **	Shesham **	17.02			Sd	*	*	*	*
16	*Diospyros melanoxylon* **	Tendu		NC		Sd/Rs	*	*	*	
17	*Ficus benghalensis* **	Banyan, Vad	7.72	NC		Ct/Sd	*	*	*	*
18	*Ficus racemosa*	Pipal		NC		Ct/Sd		*		
19	*Ficus religiosa* **	Peepal, Piplo	12.94	NC	GE	Ct/Sd	*	*	*	*
20	*Holoptelia integrifolia*	Kanjo, Papada	35.01			Sd	*	*	*	
21	*Madhuca indica* **					Sd	*	*		
22	*Mallotus philippensis*	Kamala				Sd	*			
23	*Mangifera indica* **	Mango, Aam	12.25			Sd	*		*	*
24	*Melia azedarach*	Melia, Bakani Nim	31.77	NC	GE	Sd		*		*
25	*Phoenix sylvastris*	Khajur	32.07	NC		Sd			*	
26	*Polyalthia longifolia*	Ashoka,	29.84	NC	GE	Sd		*		*
27	*Pongamia pinnata*	Karanja		NC		Sd		*	*	*

28	*Syzygium cumini* **	Jamun, Jambu	14.39	NC		Sd		*		*
29	*Tamarindus indica*	Imli		NC		Sd		*		*
30	*Tectona grandis* **	Teak, Sag,	14.94			Sd	*	*		
31	*Termanilia catappa*	Desi Badam	30.12	NC					*	*
32	*Terminalia arjuna* **	Arjun Sadad	30.54	NC	GE	Sd/Ct	*	*		
33	*Terminalia bellirica* **	Bahera				Sd/Ct	*	*		
34	*Terminalia chebula* **					Sd	*	*		
35	*Terminalia tomentosa* **					Sd	*	*		
Total			**24**	**17**	**7**	**38**	**29**	**29**	**17**	**19**

AM - ACTIVE MINE LEASE AREA	Mine peripheral areas-safety zones, around external dumps, washery area, along the conveyor belt.
RD – Roads	Permanent internal mine roads, access/approach roads outside the lease area
AS – Area of site services	workshops, storage godowns, Domestic/industrial waste dumping sites, Canteen, HEMM – parking area etc.
O/R- Office and Residential area	Site office, Guest house, colony, School etc

**** Species reported in the study area, DC-Dust capture, NC –Noise control, OE –Absorb Gaseous emission, Sd –by seeds, Ct- by Cutting, Rt –Root cutting, Rs-By Root sucker, AM – active mining area, RD – Roads sides, AS- Areas of Site services, (Storage and Processing area), O/R – Office and Residential area, S1-Source of literature -Anon 2005, S2 - Saxena 1991. S3 – CPCB/ PROBES/75/1999-2000**

Cassia fistula

Bauhinia purpurea/varigata

Alstonia scholaris

Plate 8.2. Common trees species suggested for avenue plantation - Habitation areas

8.9. Impacts Mitigation - Fugitive Emission from Coal Handling

Coal handling sites and washery are the major source of fugitive emission. The impacts of fugitive emission are very common not only in coal mining and also in projects like thermal power plant and cement plants, which are handling coal as base material and the impacts are inevitable. In addition to fugitive emission, these areas also give visual intrusion by deposition of fine coal particles in and around the site and adjacent forest habitats. Therefore, this impact needs to be handled in effective manner by developing "**Green Gallery Belts**" around the site in addition to the existing technical intervention.

8.9.1. Action Plan: Green Gallery Belt Development – Phytoremediation

Development of **Green Gallery Belt** around the coal handling and washery area is nothing but development three tier/ layers of plantation with woody shrub species, small trees and larger trees in staggered manner to capture the fugitive emission very effectively even from the ground. It is also, control the deposition of coal dust on adjacent forest and other habitats, minimise visual impact of dusty environ of the project site. The plantation approach and species selection are discussed in details (**Table 8.11**).

8.9.1.1. Selected Tree species

To mitigate the impacts of deposition fugitive emission generated from the coal handling areas, at total of 22 shrub species were selected based on different criterion. The shrub list prepared from the shrub species given in IIFM (2009) report. Nine species scored high (more than 5% of IVI) Important Value Index included, 10 species recommended by CPCB (1999-2000) as well as reported in the study area, while five species reported very frequently in the field during Hasdeo Arand area survey. These 22 species given in the list are dust tolerant species, which would effectively capture fugitive emission at ground level (**Table 8.12)**.

Table 8.11: Action Plan Green Gallery Belt (GGB) development - Mitigation to control coal dust dispersal – PEKB Project Site

Mitigation Theme	Action Plan
Minimize the spreading of goal dust and improve the visual quality of site. **Stabilize Ambient Air Quality**	1. To develop three layers Green Gallery Belt (GGB) 22 woody shrub species selected from the shrub list given in IIFM (2009) study. Those species should be planted in the inner line as ground layer with close distance of 0.5m gap between the shrubs (**Table 8.12**). 2. Mode of propagation of those shrub species also given in the table as mentioned in CPCB list. 3. Among the 39 tree species suggested for Green belt development, only 22 dust capturing trees are selected and suggested for GGB plantation (**Table 8.13**). 4. Within the tree list 10 small or medium size tree species are suggested to plant in the middle layer to develop middle canopy layer, while the rests of 12 species identified as tall and larger canopy trees, recommended to grow in the outer layer as top canopy. 5. All those shrub, small and tall trees have to planted three staggered rows as shown in plate 8.3 to get the gallery effect and to efficiently capture the coal dust. 6. The development of **Green Gallery Belt System** is entirely on the availability of space in and around the coal handling and not necessarily to plant as ring pattern shown in the plate.

Table 8.12: List of Shrub species selected and suggested to develop GGB and mitigate goal dust dispersal at PEKB project site.

S.No	Scientific Name	Local Name	SR	CPCB	IVI (IIFM)	Mode of Propagation
1	*Antidesma acidum*	Shroti, Sarwat	F			seeds
2	*Bougainvillea spectabilis*			@		Cutting
3	*Calotropis gigantea*			@		Seeds, cutting
4	*Calotropis procera*			@		Seeds, root suckers
5	*Carissa spinarum*	Kari		@		seeds, suckers
6	*Desmondium pulchellum*	Chipi, chipti			5.84	
7	*Flacourtia indica*	Ramkatayi, kakaer			40.82	
8	*Elaeodendron glaucum*	Mamri, Mimri, Jamrasi			18.21	
9	*Embelica robusta*	Soso podo			5.81	

10	*Grewia hirsuta*	Khamhar	F			
11	*Helicterus isora*	Aaithi, Marophali		@	5.84	
12	*Ipomoea carnea*				6.89	
13	*Murraya koenigii*	Mithi neem	F			Seeds, Cutting
14	*Murraya Paniculata*			@		By seeds, Cutting
15	*Nyctanthes orbor-trisis*	Khirsali	F			
16	*Nerium indicum*			@		Cutting
17	*Ricinus communis*	Arandi		@		Seeds,
18	*Sesbania aegyptiaca*	Dhandhani, Dhandhan		@		Seeds
19	*Thespesia lampas*	Masbandi, Mundi			12.98	
20	*Vitex negundo*	Chindwar	F			
21	*Woodfordia floribunda*	Dhari, Dhawai			36.08	
22	*Ziziphus xylophyrus*			@	23.61	seeds
	Total Species		**5**	**10**	**9**	

F-Frequently available in the study area, @ species suggested by CPCB, Species secured high IVI value

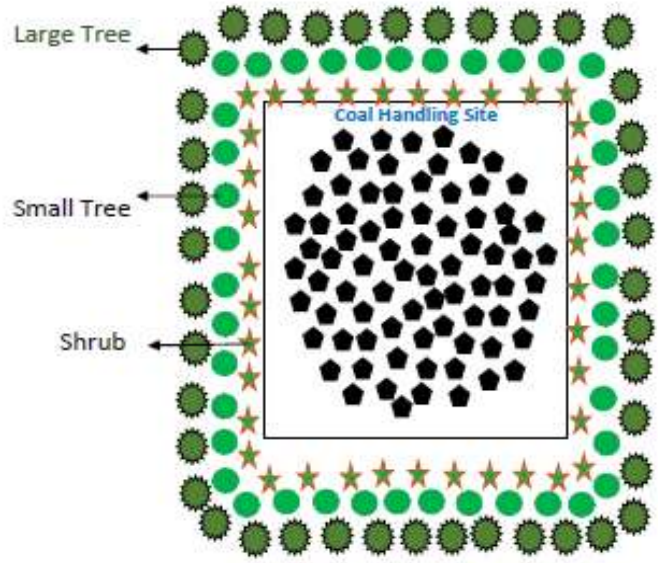
Table 8.13. List of tree species selected and suggested to develop GGB and mitigate Goal dust dispersal at PEKB project site.

S. No	Species Name	Local Name	S1	Small trees - MR	Large trees OR
			DC		
1	*Aegle marmelos* **	Bel, Bili Patra,	18.9	ST	
2	*Albizia lebbeck*	Siris, Karo Sirish	18.3		LT
3	*Alstonia scholaris*	Satani	25.39	ST	
4	*Azadirachta indica*	Neem	25.54	S/MT	
5	*Bauhinia variegate* **	Kanchnar	18.58	ST	
6	*Butea monosperma* **	Palas, Kesudo	24.44	ST	
7	*Cassia fistula* **	Amaltas **	23.03	ST	
8	*Citrus aurantium*	Nebu	15.59	ST	
9	*Dalbergia sissoo* **	Shesham **	17.02	ST	
10	*Delonix regia*	Gulmohar	18.05		LT
11	*Ficus benghalensis* **	Banyan, Vad	7.72		LT
12	*Ficus religiosa* **	Peepal, Piplo	12.94		LT
13	*Holoptelia integrifolia*	Kanjo, Papada	35.01		LT
14	*Mangifera indica* **	Mango, Aam	12.25		LT
15	*Manilkara zapota* **	Chikkoo	16.39	ST	
16	*Melia azedarach*	Melia, Bakani Nim	31.77		LT
17	*Phoenix sylvastris*	Khajur	32.07	ST	
18	*Polyalthia longifolia*	Ashoka,	29.84		LT

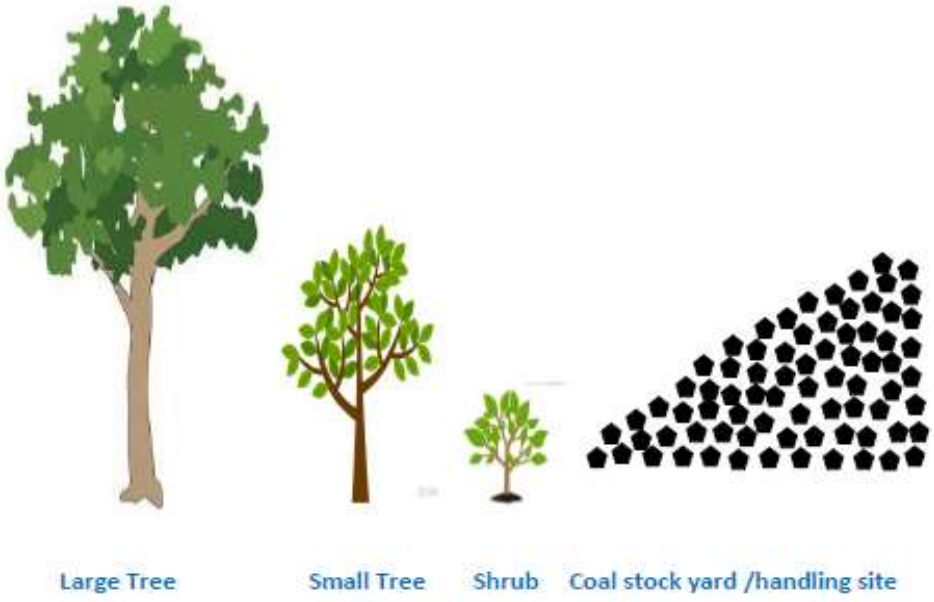
19	*Syzygium cumini* **	Jamun, Jambu	14.39		LT
20	*Tectona grandis* **	Teak, Sag,	14.94		LT
21	*Termanilia catappa*	Desi Badam	30.12		LT
22	*Terminalia arjuna* **	Arjun Sadad	30.54		LT
	Total		**22**	**10**	**12**

****- Species of the study area, MR-middle row, OR – outer row, St- small tree, Lt- large and tall tree.**

Plate 8.3. Aerial view of GREEN GALLERY BELT- Coal Handling Areas



One Side Vertical View of GREEN GALLERY BELT-GGB



8.10. Impact Mitigation Mine Waste Dumps- on Physical and Biological Resources

The mining showed that, the total volume of OB has been estimated as 2368.72 Mm^3. The total volume of external dump has been estimated as 43.52 M m^3 solid. Rest of the OB will be placed in internal dumps. The post-mining land use of the core zone/lease area showed that, 112.655 hectares of the lease area will remain as external dump. The geo-matting and tree spading are the latest techniques in implementation. The visuals of the plantation sites show that plantations of *Tectona grandis, Dalbergia sissoo, Delonix regia, Azadirachata Indica, Peltophorum Pterocacarpum* and *Acacia auriculiformis* in the reclamation area **Plate 8.4.** A few of these species are exotics and also the plantation depict single species monoculture. It is crucial to develop all the plantation with multispecies strands of native trees suggested in this assessment.

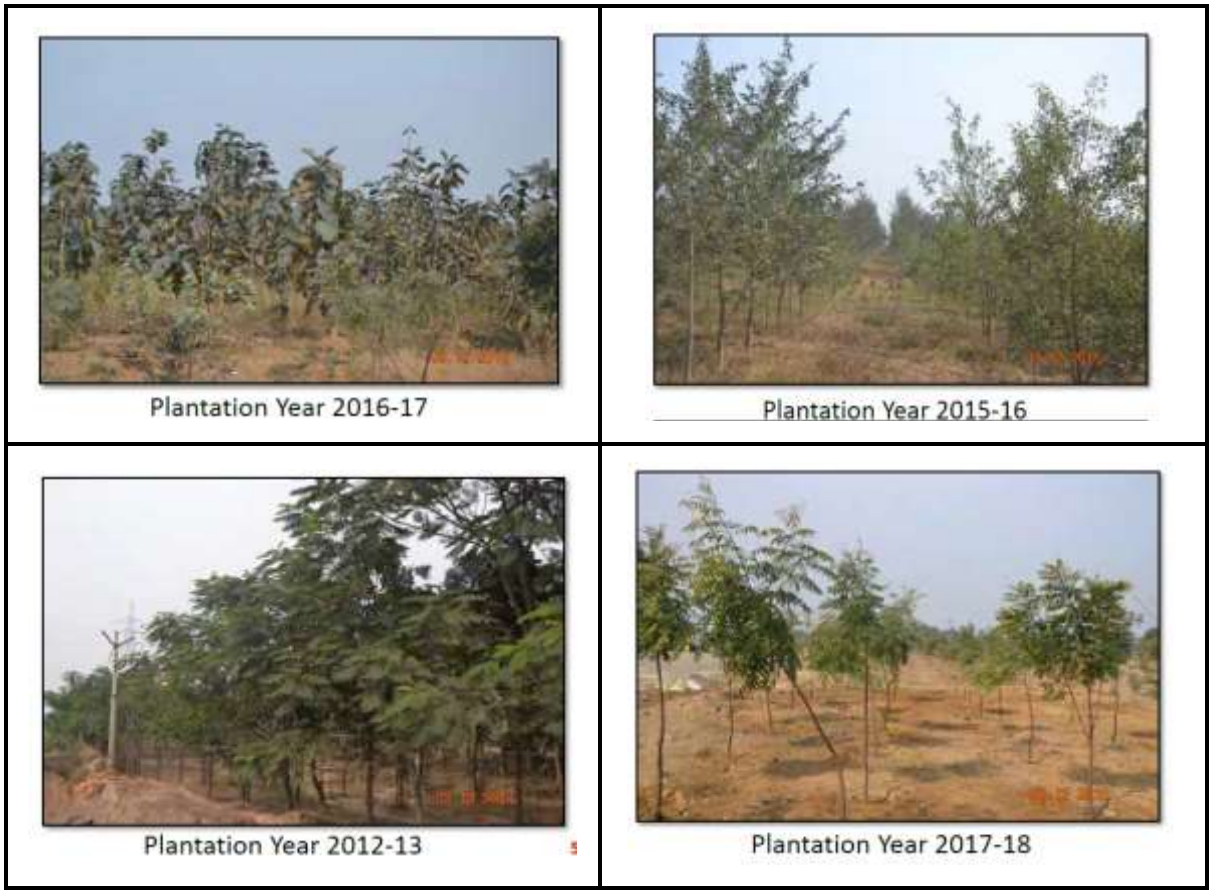


Plate 8.4. Single species plantation – monoculture (Source Mine Recalamation Doccument)

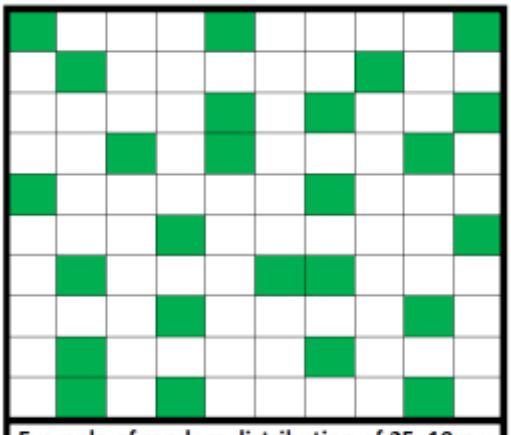
8.10.1. ECO-Restoration of Mine Dumps

Since 70% the total mine lease area is forest land, the reclamation of the mine lease should focus to restore the forest. Therefore, it is suggested to restore the remaining earmarked external dumps area adopting "Eco-restoration of Mine Dump - Forest habitat" plan. All the technical aspects and the Miyawaki plots techniques are discussed in **Table 8.14.**

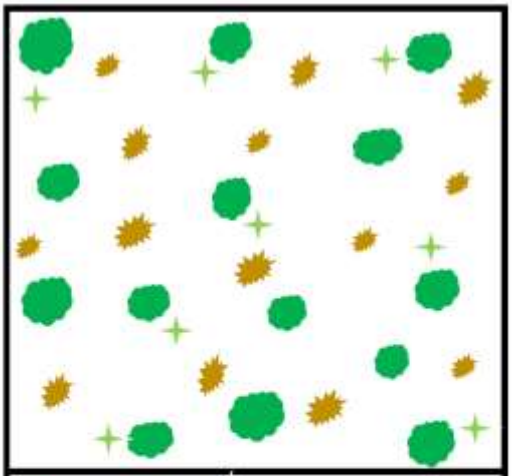
Table 8.14: Action Plans – Restoration of Waste Dump – Forest habitat

Mitigation of waste dump related dust and surface water pollution impacts.	
BMP Themes	**Action Plan**
Some extent of forest habitat developed on waste dumps Recovery and habitat use of some faunal groups after mine closer is ensured	1. The present status of the extent of mine dump for restoration is not available as mine extraction is going on. Therefore, it is proposed to develop the remaining area of waste dump into forest habitat with planting only forest species of tree, shrub and climbers. 2. Maintain the slope of the waste dump not more than 28^{O} and develop terracing and counting as per the technical requirements of the dump development. 3. Since the extent of mine dump area is comparatively smaller than the compensatory afforestation sites, it is recommended to adopt **Miyawaki Plot** techniques to improve the survival rate with high stocking rate of the saplings considering the natural mortality and maintain the ecological integrity of the restored area. *4.* **Miyawaki plots**: At least 25 Miyawaki plots/hectares (provides for 25% Miyawaki/ha) will be planted, each being 100-m^2 in area. Each randomly placed 100-m^2 Miyawaki plot will be stocked with 300-500 saplings (3-5/m^2) in a manner that maximizes native species diversity. Plots will be located within each hectares on the basis of a formal randomized selection (**Plate 8.5**).

The dump related dust and surface water pollution and visual impacts mitigated	5. Using the top-soil during land preparation can be an excellent source of seed bank of native herb and grass species. Therefore, no special effort needed for growing grass and herb species (Hall et at 2009). 6. The sapling pits and Miyawaki plot pits would be exposed for 10– 15 days before filling with prepared soil mixture. **Technical aspects - Dump management** 7. Design dump dimensions (height and slope) to facilitate vegetation re-establishment, control sheet run-off and erosion, facilitate lateral and vertical wildlife movement, and to avoid unnecessary loss of adjacent vegetation. 8. Overburden dumps and backfill areas will be formed in lifts, each being a maximum height of 30m and a maximum slope angle that is $\leq 30^{o}$. 9. Terraces will be provided between each lift, the wider the better 10. Wherever feasible and perceived to benefit wildlife movement, create terrace access ramps 1/3 or ½ terrace width between terraces going both directions every 200m.



Example of random distribution of 25, 10m x 10m plots within a 1 ha Miyawaki plots



Example of distribution of tree, shrub and woody climbers within 10 x 10 m sub plots within 1 ha Miyawaki plots of restoration site.

Plate: 8.5 Random distribution of 10m² plot within 1 ha Miyawaki Plots and stocking of tree, shrub and creeper species within it.

8.11. Impact Mitigation of Vehicle Movement - on Road Mortality of Selected Faunal Groups

8.11.1 Technical and Regulatory Plans

The internal movement of vehicles restricted to transportation of waste OB to the internal and external dump sites and few vehicles ply between residential areas to mine sites to facilitate transportation of manpower. In addition to that, there will be trucks in use to supply mine supportive material and other goods from the far-off places to and fro mine site passing through forest habitats. Wildlife road mortality is one of the direct impacts of mining project (**Plate 8.6**). Some level of mitigation is possible to reduce road wildlife roadkill's.

8.11.1.1. Action Plan- Construction of Culverts as Underpasses

Considering high species richness of herpetofauna (23 species) and mammalian species (18 species) within the core and buffer zones the are prone to road collisions, it is suggested to construct underpasses in the roads within the mine lease area. About 15 species of snakes have been reported in both the core and buffer zones and these species are expected are expected to impact upon vehicle movements (**Table 8.15**). Construction of two types of underpasses specific to the mine road and outside roads is expected to minimize the road mortality of the snake and small mammals of the project area and technical details are discussed in **Table 8.17.**

Table 8.15: List of Snake species reported in the study area

S. No	Scientific name	Common name
1.	*Eryx johnii*	Red sand boa
2.	*Eryx conicus*	Common Sand Boa
3.	*Python molurus*	Indian rock python
4.	*Amphiesma stolata*	Buffstriped keelback
5.	*Ptyas mucosa*	Indian rat snake
6.	*Dendrelaphis tristis*	Bronze back tree snake
7.	*Rhabdophis plumbicolor*	Indian green keelback
8.	*Oligodon taeniolatus*	Streaked kukri snake
9.	*Fowlea piscator*	Checkered keelback
10.	*Naja naja*	Spectacled cobra
11.	*Calliophis melanurus*	Slender coral snake
12.	*Daboia russelii*	Russell's viper
13.	*Echis carinatus*	Indian saw-scaled viper
14.	*Bungarus caerulus*	Common krait
15.	*Boiga trigonata*	Common cat snake
16.	*Elaphe helena*	Common trinket snake

Table 8.16. Action Plan – Construction of Pipe and Box culverts as underpasses mitigation to road mortality

Mitigation Theme	Action Plan
Population isolation small mammals minimized Reduces the road mortality (herpetofauna and small mammals)	**<u>Construction of pipe and box type Underpasses</u>** 1. It is recommended to construct concrete pipe culverts/under passes across the permanent mine roads and also wherever streams are cutting across the roads. 2. Develop and maintain roadside trenches all along the mine approach road and connect these trenches through two or three, 1-m diameter strong pipe culverts at every 0.5-1 km intervals across the roads. In case the road is crossing small streams construct simple box culverts (2mx2m) or wherever possible (**Plate 8.7**). 3. Herpetofauna and small mammals would follow the trenches and use the pipe and box culverts as underpasses to cross the roads (**Plate 8.6 & 8.7**). **4.** In the roads under the control of mine administration and roads outside of the lease but under the use of project vehicles, speed breakers should be constructed at strategic locations. Consultation with Forest Department would be required to identify such strategic locations. **<u>Regulatory management</u>** 5. It is suggested to erect sign boards at regular intervals along the mine roads to control the speed limit and regular checking of the speed limit of the vehicles. 6. The truck drivers need to be strictly instructed to maintain the speed limit of 20-30 km/hour while driving through the forest roads to avoid wildlife mortality and avoid using horns. 7. Strictly avoid vehicular movement during night hours in the forest roads 8. The truck drivers should be given regular awareness education on safe driving, speed limits and emphasizing the concept of "**Way to Wildlife**".

Common Sandboa

Indian rock python (schedule I)

Common langur

Sloth bear

Small Indian civet	Common langur	Sloth bear (Schedule I)

Plate 8.6: Road kills along the nearby roads passing within 10km from the project site Reported by WII – Chhattisgarh project team

Plate 8.7. Model Pipe and Box culverts suggested to minimise road mortality of Herpetofauna

Box Culverts of outside roads

Construction of pipe culverts across the roads within mine lease

8.12. Threatened Species Conservation

Assessment of threatened biota revealed that, a total of 13 species of plants, two species of butterflies, two species of reptiles, nine species of terrestrial birds and seven species of mammals occur in and

around the project study area. In case of threatened species conservation, mitigation needs to focus on management plan which would have direct effect on conservation as discussed in **Chapter-9**

8.13. Mitigations and Biodiversity Management Plan – Subjective Evaluation

This section discusses how the above suggested mitigation and management interventions likely to enhance the overall biodiversity values, in addition to minimizing the project related impacts on physical environment, which are interlinked to biological component (habitat, flora and fauna). Among the 7 mitigations and action plans recommended, the following five biological interventions expected to improve the floral and faunal biodiversity of the project study area include:

1. **Eco-restoration of compensatory afforestation sites**
2. **Natural resource development: Grass and leaf fodder plots**
3. **Green belt development – phytoremediation**
4. **Bio-filter check dams- across the streams**
5. **Eco-restoration of waste dump**

The aforementioned mitigations are in compliance with the ***sustainable development principal 7*** of ICMM (2006) and ***performance standard 6*** of IFC World Bank Group (2012). In order to evaluate the effectiveness of the mitigation plans and combined BMP activities suggested, subjective values have been credited based on the prevailing environmental, ecological and social setup of the project area.

8.13.1. Progressive Restoration - Eco-restoration of Compensatory Afforestation Sites"

The **Eco-restoration of Compensatory Afforestation Sites** plan recommended to develop least 500 hectares (tentatively) of the compensatory afforestation site with the selected tree, shrub and woody creeper species to create near close to the forest habitat of the rage forest land diverted for the same purpose. This plan suggested only native and multiple forest species with three strata, evaluated to support the faunal biodiversity and associate invertebrates (**Table 8.18**).

8.13.2. Natural Resource Development – Grass and leaf fodder plots development

Development of grass and leaf fodder plots planned to be developed at 35 hectares in the village grass lands and 50 hectares of refilled mine pit area. Although not a true forest habitat development, it is expected to at least resemble and provide functions of a grassland. The prevailing situation and improvement of flora, invertebrates expected to gain low species, while terrestrial birds and reptiles may gain species richness at moderate level and mammals mainly some rodents at low level (**Table 8.18**).

8.13.3. Green Shelter Belt- Phyto-Remediation – Different green belt areas

This management plan pertaining to development of greenbelt areas with select species of plants along the periphery of mine lease (safety zone), washery area, surrounding waste dumps, infrastructure areas (office premises, residential areas school and guest house etc) and the mine lease roads. Floral component, invertebrates, reptiles and terrestrial avifauna can be expected to have some gain. This being terrestrial habitat development plan at a smaller scale, many species of mammals, amphibians, aquatic birds and fishes may not benefit (**Table 8.18**).

8.13.5. Bio-Filter Check Dams – Across Stream

Development of bio-filter check dams across the streams leading from the mine site is recommended to control the aquatic pollution. Being a major development of aquatic habitat, the flora associated with aquatic habitats, invertebrates, fishes, amphibians and aquatic birds would benefit from the effort at moderate level (**Table 8.18**).

8.13.6. Waste Dump Restoration - Waste Dump Grass Hillocks

This management plan pertaining to waste dump restoration is to try and develop habitat structure similar to natural forests in the mine dump area. In this regard, it has been planned to adopt **Miyawaki Plots** approach with high stocking rate of trees, shrub and creeper species, which are expected to improve the floral and invertebrate diversity at high level. The Miyawaki plots approach may benefit reptiles and forests birds to a moderate level and if successfully implemented and habitat restoration is complete, towards the end of lease period, even mammalian species could start benefiting from the efforts **(Table 8.18).**

8.13.7. Overall biodiversity value gain

Overall, this subjective evaluation is based on operational status of the mine. It indicates that, out of five management interventions in eight locations, and among the faunal groups, reptiles and terrestrial bird species are evaluated to be benefiting at moderate levels under four management plans. Floral component and invertebrate groups showed similar gains in eco-restoration of compensatory afforestation sites and restoration of mine waste dumps. Moderate level of increase is expected under green-belt development – phytoremediation. Mediocre level of benefit is being visualized for grassland habitat development.

Fish fauna, amphibian and aquatic bird components would potentially gain moderate levels through water resource development under bio-filter check dams. Mammalian fauna assessed might not gain at all, except for a marginal gain under eco-restoration of afforestation sites after the restoration is completed (**Tables 8.18**). In addition, few habitat niche developments, and habitat quality improvement suggested under direct Biodiversity Management Plan (**Chapter 9**) would support most of the faunal groups.

Table 8.18. Predicted relative benefits of habitat development proposed under the Mitigation Measures to different species groups.

Proposed Habitat Development and Restoration Programs	BIODIVERSITY ATTRIBUTES							
	FL	IV	FS	AM	RT	TB	AB	MA
PROGRESSIVE RESTORATION: Eco-restoration of Compensatory Afforestation Sites	H	H	N	N	M	M	N	M
Natural Resource Development: Development of Grass and Leaf fodder plots	L	L	N	N	M	M	N	L
Green Shelter Belt – Phytoremediation	M	**M**	N	N	M	M	N	L

Mine lease, plant area, infrastructure areas and roads								
Technical and Biological Bio-filter Check Dams	**M**	**M**	**M**	**M**	**N**	**M**	**M**	**L**
Waste Dump Restoration Forest habitat	H	H	N	N	M	M	N	L
BIOTA: FL = Flora, IV-Invertebrates, FS-Fishes, AM-Amphibians, RT-Reptiles, TB-Terrestrial Birds, AB-Aquatic birds, MA-Mammals. N- No Material Benefit, L-Low, M- Moderate, H –High,								

CHAPTER-9: BIODIVERSITY CONSERVATION MANAGEMENT PLAN FOR PEKB COAL BLOCK ALONG WITH THE REVIEW OF EXISTING PLAN

9.1. Introduction

The present biodiversity assessment done based on select list of flora and faunal groups reported by IIFM (2009) and the present assessment carried out by WII & ICFRE suggest that the study area of PEKB support threatened species that include 13 species of plants, two butterfly species, two reptile species, 10 terrestrial bird species, and eight mammalian species (**Table 9.1)**. The survey carried out by WII covers whole of Hasdeo Arand area, nevertheless, many sampling points cover the buffer zone of the PEKB. Overall, the list of threatened fauna indicates that the area in and around the mine lease surrounded by 15 protected forests justify the potential of forest habitat to support high species richness of the threatened fauna. The core zone and buffer zones reported 9 and 14 threatened biota, and shared 40% and 63% of the overall list of the entire Hasdeo Arand area emphasizing the importance of conservation value of PEKB (**Table 9.1**).

Unfortunately, no quantitative information is available on any faunal group except for the list and therefore, selective plans are suggested at a broader level i.e., **Species Group Conservation.** Understanding of species distribution and habitat use and requirement through selected research and monitoring is one of the priorities of ICMM biodiversity conservation policy. Therefore, based on the possibilities of presence of threatened species, **status survey of selected faunal groups** was also suggested under research and monitoring concept of ICMM (2006). Presence of large extent of 15 protected forests -PFs, (excluding two PFs converted for mine lease) within 10km radius of the project study area is an added advantage to implement **species specific conservation** plans especially for the larger threatened herbivores outside the mine lease in consultation with the concerned forest division.

Table 9.1: Summery Status of Threatened Biota of the Study Area

Threatened Biota	Core Zone	Buffer Zone	WII	Overall
Plant	13			13
Reptiles		2		2
Terrestrial birds	6	8	6	10
Mammals	1	2	8	8
Total Species	9	14	14	22
Relative % of only fauna	40.90 %	63.63%		

9.2. Issues Identified and BCMP Approach

Biodiversity conservation and management plans suggested here are considering the biodiversity risks identified based on the salient features, project environment (mainly the biological components) and project types and technological interventions discussed in both the EIA studies (2009 and 2016) and ecological status discussed in IIFM study (2009). In addition, the evaluated impacts of loss of forest

habitat and or other habitat types and diversion of biotic pressure on additional adjacent forest habitat was also considered under biodiversity resource use. Only records of presence of threatened species, and lack of information on their abundance and distribution status, the BCMP plans are focused only on three levels such as: 1. Species group specific conservation plan – habitat/niche development, 2. Threatened species conservation plan and 3. Biodiversity resource use by the local communities. The following are the major biodiversity conservation and management plans -BCMP recommended under this study (**Table 9.2).**

Table 9.2: Issues identified on Threatened Biota and People's Biodiversity Use Values and suggested BCMP Action Plans

Biodiversity Conservation and Management Plan (BCMP) – Action Plans	
BCMP-Components	**Action Plans**
1. BCMP- Species group specific conservation plan	1**. Development of butterfly habitat** 1. Mine lease and human habitation areas (1. Site offices, 2. township /colony 3. School premises)
	2. Development of "Reptile Habitat Niche" Reptile Habitat niche - core zone Five protected forests -buffer zone
	3.Facilitating nesting niche (nest box) - hole nesting birds 1. Reclaimed mine lease area - dumps, 2. Green belt area 3. Township-guesthouse/colony area
	4. Development of denning niche - small mammals 1. Mine lease-dumps and 2. Protected forest - denning niche for selected small mammal Species
	5. Wetland habitat development 5.1 Mine-pit wetland – conservation of aquatic fauna amphibian, fishes and aquatic birds
2. BCMP- Conservation of threatened plant & animals	**6. Conservation of threatened flora** 6.1. Threatened floral conservation plot 6.2. Development of herbal garden
	7. Conservation of threatened fauna 7.1. Status survey of snake species 7.2. Status survey of selected birds of prey 7.3. Survey of selected small mammals – reserved forest
	8.2. Forest habitat development plan 8.1. Conservation of threatened mammal 8.1.1. Sloth bear - food plant development 8.1.2. Four horned antelope – food plant development 8.1.3. Elephant – food plant development
3. Biodiversity Resource- People's Use Values	9. **Natural resource and life quality enhancement** **9.1. Livelihood and life quality improvement** **9.1.1. Vegetable and Fruit - organic farming program** **9.1.2. Apiculture - honey-bee farming** **9.1.3. Aquaculture – Village level fish farming** **9.1.4. Awareness education**

9.3. BCMP – Species group conservation plan

9.3.1. Butterfly conservation – Development of butterfly habitat

Butterfly conservation through development of open and closed butterfly park is become common practice. However, development of such park needs to be followed some compliance under wildlife protection act, it is very easy to create and or enhance butterfly food resource in and around the project area. Hence it is suggested to develop "**butterfly habitat**" in term of planting both larval and adult host plants in specific sites under habitat development plans for species group conservation plan.

9.3.1.1. BCMP action plan - butterfly habitat

Record of relatively high species richness of butterfly and the importance of the ecological service they provide as pollinator (Ehrlich and Raven 1964), indicators of the habitat quality (Kunte 2000, Bonebrake et al. 2010), human disturbances (Kunte 2000 and Koh 2007), climatic conditions (Kunte 1997) making butterfly diversity a priority to maintain and enhance the richness and abundance status of this group. Therefore, development of "**Butterfly Habitat**" is recommended in selected sites of the project area. Kehimkar, 2008 and Singh, 2010 listed 62 butterfly host plants, from which 35 species were selected for development of butterfly habitat with 28 trees and 7 shrub species. The plan of actions and locations to implement this conservation plan are discussed in **Table 9.3**

Table 9.3: BCMP Action Plans for the development of Butterfly Habitat

Butterfly Conservation- Butterfly Habitat–Habitat Quality Indicator and pollinator	
BCMP- Themes	**Action Plans**
Species Diversity Enhancement **Facilitate Ecosystem Services-pollination** **Recreation and Awareness & Education for locals and students**	1. Five areas that fall under the mine lease and human habitation were selected. They include a. restored mine dumps, b. safe zone within the lease and c. site offices, d. township/colony e. school premises under human habitation are the areas suggested for developing butterfly habitat. 2. Since those five areas have been already developed as greenery, and under the control of the mine administration, it is easy to develop butterfly habitat by just adding these butterfly host plants (**Table 9.4**) along the boundary or the peripheral areas of the sites. 3. From the list of 62 butterfly host plants (larval and adult), 35 host plants reported in the study area were identified which includes 24 study area species, while 11 were reported outside of the study. This list includes 28 tree and seven shrub of forest species as well as common species of village/urban areas. 4. A total of 24 forest species are suggested to be planted in the mine lease area of restored dump and safety zone, while 14 common species are recommended in and around human habitation. **5.** Butterfly habitat can be designed and developed in consultation with subject experts to protect. The basic concept to develop butterfly habitat briefed in **BOX 9.1.** 6. In addition, verities of ***Nerium, Bougainvillea, Ixora, and Hibiscus*** species of shrub and ***Delonix regia, Cassia fistula, Butea***

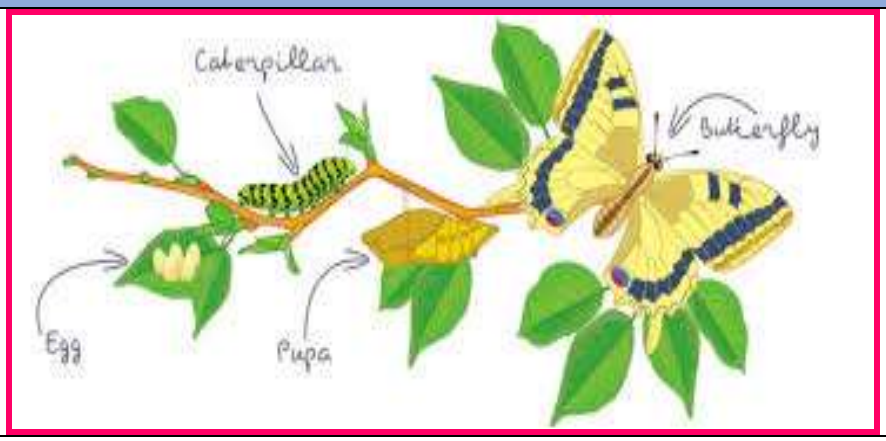
	monosperma, Lagestroemia Speciose, Bauhinia purpurea and Alstonia scholaris are the very common species and locally available can be included and they will add aesthetic value to the colony/township and school complex (**Plate 9.1**)

Table 9.4: Butterfly Larval Food and Adult Host plants recommended as part of Butterfly Habitat development plan – PEKB project site

S.no	*Scientific Name*	Habit	Mine area RD/SZ	Habitation SO/CO/Sc	Species Availability
1	*Acacia catechu*	Tree	M		+
2	*Aegle marmelos*	Tree	M		+
3	*Albizialebbeck*	Tree		H	++
4	*Albizzia odoratissima*	Tree	M		+
5	*Albizzia procera*	Tree	M	H	+
6	*Annona squamosa*	Small Tree		H	++
7	*Azadirachta indica*	Tree		H	++
8	*Bauhinia purpurea*	Tree		H	+
9	*Bauhinia variegata*	Tree		H	+
10	*Bombax ceiba*	Tree		H	++
11	*Bridelia retusa*	Tree	M		+
12	*Butea monosperma*	Tree	M		+
13	*Calotropis gigantea*	Shrub	M		++
14	*Calotropis procera*	Shrub	M		++
15	*Capparis grandis*	Shrub	M		++
16	*Careya arborea*	Tree	M		+
17	*Cassia fistula*	Tree		H	+
18	*Chloroxylon swietenia*	Tree	M		+
19	*Citrus limon*	Woody shrub		H	++
20	*Dalbergia latifolia*	Tree	M		+
21	*Diospyros melanoxylon*	Tree	M		+
22	*Ficus bengalensis*	Tree	M		+
23	*Ficus religiosa*	Tree	M	H	+
24	*Helicteres isora*	Shrub	M		+
25	*Hibiscus ovalifolius*	Shrub		H	++
26	*Mallotus philippensis*	Tree	M		+
27	*Mangifera indica*	Tree		H	+
28	*Mitragyna parvifolia*	Tree	M		+
29	*Pongamia pinnata*	Tree		H	++
30	*Pterocarpus marsupium*	Tree	M		+
31	*Ricinus communis*	Shrub	M		+
32	*Schleichera trijuga*	Tree	M		+
33	*Shorea robusta*	Tree	M		+
34	*Terminalia ballerica*	Tree	M		+
35	*Terminalia catappa*	Tree		H	++
	Total species	**28 /7**	**24**	**14**	**+=24, ++=11**

Source: Kehimkar 2008 and Singh 2010; Tr-Tree species, Sh-Shrub species, + Study area species, ++ -out side species, M-Mine area, RD -Restored dump, Safety Zone, H-Habitation, SO – site office, Co-Colony, SC-Schools

Box 9.1. The basic needs and concept of how to develop butterfly Park



It's simple to attract butterflies to the garden and keep them coming back. A butterfly-friendly environment needs to be created by:

- Growing a combination of host plants for the caterpillars and nectar plants for the adults
- Planting brightly coloured flowers
- Growing regional plants rather than exotic species
- Planting flowers that bloom rotationally so that when one plant finishes blooming another one starts
- Refusing to use pesticides and insecticides, which can make the butterflies sick or kill them
- Creating puddling spots that provide the butterflies with water

Plate 9.1. Some varieties of garden shrub species suggested for butterfly habitat development

Bougainvillea species	*Nerium species*	*Ixora species*	*Hibiscus species*
			
			

9.3.2. Development of "Reptile Habitat Niche"

Ecological survey in PEKB recorded 23 reptile species of which 21 are reported from the core zone. The list includes two threatened species and Schedule I (under WPA); Indian rock python (*Python molurus)* reported in both the core and buffer zones while *m*onitor lizard (*Varanus bengalensis)* is reported in the buffer zone. Considering the presence of overall relatively high species richness of reptiles in the landscape, it is recommended to develop **Reptile Habitat Niche** so that, the abundance status of some of the species reported in this study can be enhanced.

9.3.2.1. BCMP Action Plan - "Reptile Habitat Niche"-

Reptiles have close affinity with their habitat and specifically the micro habitat and are temperature dependent, the preparation of conservation plan at species level for the threatened species is not possible. Interestingly, out of 23 species of reptiles, out of 23 species of reptiles, 15 species are snakes of which 65% appeared as road kill. This showed vulnerability of this group towards vehicular traffic and need for proper mitigation measure. The advantage of presence of restored old external dump and protected forests adjacent to the lease area can be used to develop **Reptile Habitat Niche** and the proposed experimental action plans are detailed in **Table 9.5.**

Table 9.5 BCMP Action Plans for the Reptile Habitat Niche

Reptile habitat niche – habitat for ignored species group	
BMCP Themes	**Action Plans**
Creation of additional Habitat **Reptile Species Diversity Enhancement**	1. Five locations in the restored external dump with dense tree cover can be developed as reptile habitat niche leaving at least 100-m distance from each other. 2. The five nearest protected forests (PF) in the vicinity (Pidiya Reserve Forest, Janardhanpur PF, Tara East PF, Shivnagar PF and Paturiya Protected Forest) can be selected to develop reptile habitat niches per protected forest (i.e., 10 niches). 3. Develop rock /boulder heaps of 1m height and spreading 3m radius using the boulder/rocks of size 0.5m^3 dimension is preferable. This size boulders, can provide compactness with required gaps for reptiles to occupy. Artificial burrows with varying sizes should be constructed under the rock heaps

Possibly habitat for threatened species	4. Multiple 10 sq m black tar surfaces may be created within each reptile niches which can provide hot surfaces for thermoregulation especially for nocturnal snakes. 5. These rock heaps should be partly covered with top soil for natural regeneration of shrubs and grasses from seed bank within it after the monsoon. 6. Any natural logs, snag, termite mounds, leafitter or large rocks should be kept as potential reptile habitat. 7. A portion of waste wood and dead logs generated during any land clearing should be strategically placed within this area. 8. Availability of rocky boulders and earthen materials in the mining site is common and using those waste materials to develop this kind of experimental reptile habitat is easy and economically viable. 9. Each reptile niches should be fenced with barbed wire with signages not to trespass the area. This habitat development plan is expected to provide habitat for the reptiles in the study area including threatened species *viz.* Indian rock python and Bengal Monitor Lizard and other snake species (**Table 9.6**). 10. This reptile niche plot should be monitored for efficacy. Visual example of use of such rocky niches/habitat by snake species showed as **Representational visual (Plate 9.2**).

Table 9.6: List of snake species reported in the PEKB study area

S.no	Scientific name	Common name	Core	Buffer	WPA, 1972
A	**Boidae**				
1	*Eryx johinii*	Red sand boa			
2	*Python molurus*	Indian rock python	✓	✓	I
B	**Colubridae**				
3	*Amphiesma stolata*	Buff-striped Keelback	✓	✓	IV
4	*Ptyas mucosa*	Indian Rat Snake	✓	✓	
5	*Dendrelaphis tristis*	Common Bronzeback Tree Snake	✓	✓	IV
6	*Rhabdophis plumbicolor*	Green Keelback	✓	✓	IV
7	*Oligodon taeniolatus*	Streaked kukri snake	✓	✓	IV
8	*Fowlea piscator*	Checkered Keelback Water Snake	✓	✓	

9	*Elaphe helena helena*	Common Indian Trinket Snake	✓	✓	IV
10	*Naja naja*	Spectacled Cobra	✓	✓	**??**
11	*Boiga trigonata*	Common Indian Cat Snake	✓	✓	IV
12	*Calliophis melanurus*	Slender Coral snake	✓	✓	IV
C	**Viperidae**				
13	*Daboia russelii*	Russell's Viper		✓	
14	*Echis carinatus*	Indian Saw-scaled Viper	✓	✓	IV
D	**Elapidae**				
15	*Bungarus caeruleus*	Common Indian Krait	✓	✓	IV
	Total		**13**	**14**	

Plate 9.2. Rocky & Boulders type of micro habitats provide niche for Snake species – (REPRESENTATIONAL VISUALS)



9.3.3. Facilitating Nesting Niche (Nest Box) – For Hole Nesting Birds

9.3.3.1. BCMP Action Plan: Nesting Niche - Hole Nesting Birds

Among those 92 species of avifauna reported in the study area (IIFM and WII studies), 28 species were found to be hole nesters with 19 species from the core zone and all 28 species occur in the buffer zone. This species list includes 10 species as primary hole-nesters and 18 as secondary nesters. This being one of the biodiversity management plans suggested under ICMM of Good Practice Guide (GPG) 2006 and the same has been recommended to develop "**Nesting Niche for Hole Nesting Birds**" under species group conservation plan. The plan of actions to facilitate nest boxes is detailed in **Table 9.7.**

Table 9.7: BCMP Action Plans for the Proposed Enhancement of Nesting Niche (Nest Box)

Creative Conservation Plan for Hole Nesting Birds	
BCMP-Themes	**BCMP- Action Plans**
	1. The mine reclamation details showed that, the plantation was initiated since 2012-13. There are four areas that have been identified and suggested to deploy nest boxes for the hole nesting

Creation of nesting Niche for hole nesting birds **Enhancement of status of hole nesters** **Research and Monitoring** **Awareness education to local communities and Forest staffs**	birds: 1. The oldest reclaimed plantation area. 2. Green belt area of safety zone and 3. office premises, and 4. Township-guesthouse/colony area 2. The list of 28-hole nester species was prepared combining IIFM (2009) and WII (2020) studies, and the list includes 10 primaries and 18 secondary hole nesters. 3. Prepare 200 nest boxes of different dimensions/measurement suggested with the proper materials for the 28 species (excluding two species of bee-eaters that use earthen bunds for nesting) (**Table 9.8**). Preparation of nest boxes and deploying in strategic locations should be done in consultation with the subject experts. 4. The location suggested should be deployed 50 nest box each as Phase I. Since all the areas come under the control of the project proponent it is very safety and easy to monitor. 5. Monitoring and research activities should be initiated for a period of two years (covering all seasons) with a well-trained field biologist and supervision of subject experts and or the locally trained field personnel. 6. Replicate this plan in those same areas deploying additional 200 nest boxes after two years as Phase II. monitoring the deployed nest boxes for the next two years. 7. This management plan of habitat niche development for hole nester expected to support 28-hole nesters and may be few missed out species of the project study area. 8. The outcome of the success of management plan should be published as outreach program. The visual showing some of the hole nesting species occupying the nest boxes provided – earlier success story of IUCN & GFF initiative (**Plate 9.3**)

Table 9.8: List of Hole Nesting Bird and Nest Box details to Facilitate Hole nesting birds

S.no	Family/Scientific name	Common name	P/S	Size of Box	Hole Diameter in cm	WII 2020
1. Bucerotidae						
1	*Ocyceros birostris*	Indian Grey Hornbill	P	Large	14	
2. Meropidae						
2	*Merops persicus*	Blue Cheeked Bee-eater		+++		
3	*Merops orientalis*	Green Bee-eater		+++		
4	*Coracias benghalensis*	Indian Roller		Medium	9	
3. Muscicapidae						

5	*Saxicoloides fulicata*	Indian Robin	S	Small	4	
6	*Copsychus Saularis*	Oriental Magpie Robin	S	Small	4	
4. **Paridae**						
7	*Cinereous Tit*	*Parus cinereus*	S	Small	3	@
5. Passeridae						
8	*Gymnorisxanthocollis*	Yellow-throated Sparrow	S	Small	3	@
9	*Passer domesticus*	House Sparrow	S	Small	3	@
6. Picidae						
10	*Chrysocolaptes festus*	White-naped Woodpecker	p	Medium	7	@
11	*Dendrocopos moluccensis*	Brown-capped Pygmy Woodpecker	p	Small	3	@
12	*Dendrocopos mahrattensis*	Yellow-fronted Pied Woodpecker	p	Medium	5	@
13	*Dinopim benghalensis*	Black rumped Flameback	p	Medium	7	
14	*Dinopium javanense*	Common Golden-backed Woodpeck	p	Large	8	@
15	*Picus xanthopygaeus*	Streak Throated Woodpecker	p	Medium	7	
16	*Hermicircus canente*	Heart Spotted Woodpecker	p	Medium	7	
7. Psittaculidae						
17	*Psittacula eupatira*	Alexandrin Parakeet	S	Large	9	
18	*Psittacula eupatira*	Rose ringed Parakeet	S	Medium	7	
19	*Psittacula cyanocephala*	Plum headed Parakeet	S	Medium	7	
8. Ramphastidae						
20	*Megalaima haemacephla*	Coppersmith Barbet	P	Small	3	
21	*Psilopogon zeylanicus*	Brown-headed Barbet	P	Medium	6	@
9. Strigidae						
22	*Athene bromah*	Spotted owlet	S	Medium	7	
23	*Glaucidium radiatum*	Jungle Owlet	S	Medium	7	
10. Strurnidae						
24	*Sturnia malabarica*	Chestnut-tailed Starling	S	Small	5	
25	*Sturnus pogodarum*	Brahminy starling	S	Small	5	
26	*Sturnus roseus*	Rosy starling	S	Small	5	
27	*Sturnus contra*	Asian Pied Starling	S	Medium	8	
28	*Acridotheres ginginianus*	Bank Myna	S	Medium	8	
29	*Acridotheres tritis*	Common Myna	S	Medium	8	
	Acridotheres fuscus	Jungle Myna	S	Medium	8	

11. Upupidae						
30	*Upupa epops*	Common Hoopoe	S	Medium	8	
Size of Nest Box: Small - height / depth = 20 cm, Length & width = 13 cm, Medium - height / depth =40 cm. length & Width = 25 cm, Large - height /depth = 75 cm, Length & width = 50 cm						

P/S - Primary Hole Nester/Secondary Hole Nester, CT – Crone Zone Total, BT – Buffer Zone Total, SA – Study Area; ++ Constructs hole nest on Sandy and mud walls, bunds and river/stream banks, @ species reported by WII Team -2020

Plate 9.3. Using of nest boxes by the hole nesting birds (modal Experimental site)

White-rumped Shama

Common myna

Oriental Magpie robin

9.3.4. Development of Denning Niche

This study area reported 18 species of mammalian fauna, of which 16 species were reported from the core that include, five ground dwelling species. While adding the WII survey list, the number of ground dwelling species increased to nine species such as: addition of Indian crested porcupine *(Hystrix indica),* Grey wolf (*Canis lupus*), Indian fox (*Vulpes bengalensis)* and Honey badger *(Mellivora capensis)*. Among those species, two species are placed under schedule I of WPA (Grey wolf and Honey badger), and, therefore it is very crucial to devise conservation plan under species group conservation (**Table 9.9**). Giving importance to the ground dwelling small mammals, it is proposed to develop habitat niche for small mammals that would enhance the abundance status of these species and specifically the two threatened species.

Table 9.9. List of Ground dwelling small mammals (Prefer Dens) reported in the study area

S.no	Scientific and Common Name	IIFM-PEKB		WII	WPA
		Core	Buffer		
1	*Hystrix indica*- Indian crested porcupine			@	
2	*Lepus nigricollis*- Black nape hare	@	@	@	
3	*Felis chaus*- Jungle cat		@	@	
4	*Herpestes edwardsii* - Common grey mongoose	@	@	@	
5	*Hyaena hyaena* - Striped hyena	@	@	@	
6	*Canis aureus* - Golden jackal	@	@	@	
7	*Canis lupus* - Grey wolf			@	Sch I
8	*Vulpes bengalensis* - Indian fox			@	
9	*Mellivora capensis* - Honey badger			@	Sch

	Total	**4**	**5**	**9**	

@ species reported in the specific zone and area, IIFM -Indian Institute of Forest Management, Nagpu, WII- Wildlife Institute of India, Dehradun

9.3.4.1. BCMP action plan: Development of denning niche – small mammals

Development of Denning niche for small mammals is nothing but providing similar kind of habitat development plan like reptile habitats. This includes two types of developments of denning sites (rock boulder dens and earthen dens) and possibly all the nine small mammal species are expected to benefit and the technical details are discussed in **Table 9.10.**

Table 9.10: BCMP Action Plans for the Development of Denning Niche for small mammals

Creative Conservation Plan for Hole Nesting Birds	
BCMP-Themes	**BCMP- Action Plans**
Additional Denning Niche – selected small mammals **Enhancement of abundance status of ground dwelling small mammals** **Research and Monitoring**	1. Under the habitat development plan two types of denning niches are proposed to be developed for the possible nine small mammalian fauna occurring in the study area and includes development of rocky boulder and earthen dens. 2. **Rock boulders den**: This is similar kind of management plan like development of reptile habitat niche, the only changes that needed is the size of rock /boulder should be $1m^3$ in size and the heap dimension should be 1.5m height covering 4-5m radius spread to provide larger gaps and space between the rocks so that, small mammals can freely move in and out and occupy the niche as natural den. 3. **Earthen dens:** it is also recommended to use mixture of local earthen materials with screen rejects to develop earthen denning sites for, hare, Porcupine, jackals, and Indian fox. Develop 1m height of earthen heaps mixed with the ratio of 2:1 screen rejects and normal mud respectively spreading 3 m radius. 4. Cover both the rocky boulders and earthen heaps with top soils to naturally regenerate native grass and herbs on it. Plant local shrub species in and around those artificial denning sites to give naturalness 5. Initially suggested to develop 10 such niches (5 rock and 5 earthen dens within the matured and restored dump area and monitor it for next two years for the occupancy record. 6. Based on the success of this experimental management plan the same can be replicated in the nearest areas, so that, 30 (15 rock and 15 earthen dens) such denning niches can be developed.

	7. Some of the mammalian species reported using waste rock dumping sites during the field surveys of other mine projects shown **as Representative visuals in Plate 9.4.** 8. The areas selected should be free from human disturbance and can be more frequently monitored by the forest department and research personnel

All the three different habitat niche development and conservation programs suggested for reptiles (reptile habitat niches), birds (Nesting niches – hole nesting birds) and selected small mammals (denning niche for small mammals) can be monitored under a well-planned research and monitoring project by hiring subject expert/wildlife researchers for a period of 2 years. The success stories can be published under Biodiversity Conservation Policy program of the project proponent (**RRVUNL**)

Plate 9.4. Small mammals using the waste boulder and earthen heaps as natural den (Representational Visuals)

Jungle Cat - Natural Rocky Den

Striped Hyena pups Den Inside the Rock heaps

Indian Fox – den in waste rock heaps

Indian fox – den in earthen heaps

9.4. BCMP - HABITAT DEVELOPMENTS FOR OVERALL BIODIVERSITY VALUES

9. 4.1. Development of Mine Pit Wetland Habitat

In order to enhance the biodiversity attributes of aquatic habitat like; aquatic invertebrates, fishes, amphibians, aquatic birds and possibly some reptile fauna, it is suggested to develop two **Mine-Pit Wetlands** within the lease area and come under the **offset development or habitat creation** which is the fifth hierarchical mitigation option.

9.4.1.1. BCMP Action Plan- Wetland Habitat

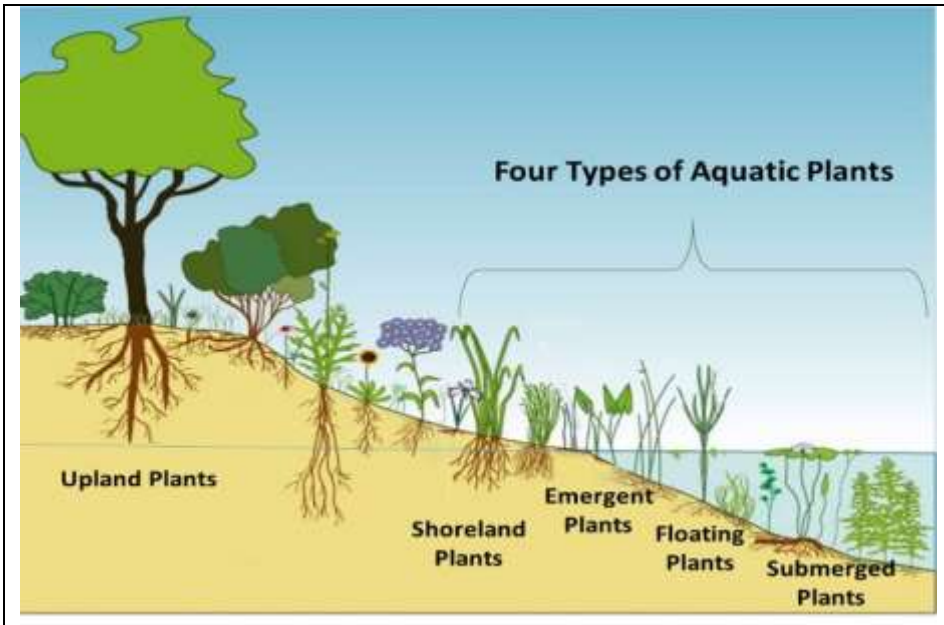
Post mining land use of the mine lease area showed that, out of 2388.247ha area excavated, 2127.555ha will be backfilled while 260.692ha will be remain as mine pit or void (**Annexure 7 Impact Chapter**). Those mine pits will store rainwater and act as mine pit reservoirs and help in improving the ground water recharge and not likely to support much aquatic fauna due to very deep in nature. Therefore, while backfilling the mine pits leave two 4-5 ha of areas as shallow pits to develop mine pit wetland to create **wetland habitat** and enhance the local aquatic biodiversity. The action plan is detailed in **Table 9.11.**

Table 9.11: BMP Action Plans- Proposed Mine pit Wetland Development

Wetland – within the project site – aquatic biodiversity conservation	
BMP Themes	**Action Plans**
Creating new wetland habitats **Habitat- Aquatic faunal diversity – fish, amphibian, aquatic birds** **Waterhole for Wildlife** **Improve – Ground Water Resources** **Additional fish resource for locals**	1. It is suggested to develop two mine pit wetland habitats of 4-5 ha each within the refilled mine pit area. 2. Identify the two sites far from each other and while refilling the pits 4-5 ha of area in each site should be filled as shallow pits and not up to top level of pit. 3. The engineered structured mine pit wetlands should have a maximum depth of 6m. Terminal pit voids will be converted to wetlands with a well-defined, shallow (grading from 0 – 1m) water littoral zone (edge) – (Porej and Hetherington 2005). 4. The littoral edge on the wetlands will strive for a slope gradient of 20:1 (horizontal: vertical) (Bayley et al 2014) and extending at least 10m – 15m from shore on larger wetlands. Littoral area will occupy at least 10% of permanent water bodies/pit lakes etc. 5. Along the banks / embankment and outer most of the wetland habitats will be planted with medium to large size common tree species like: (*Albizia procera, Albizia lebbeck, Syzygium cumini, Tamarindus indica, Azadirachta indica, Ficus benghalensis, Ficus religiosa, Mangifera indica, Pongamia pinnata, Terminalia bellerica*), having wider canopy spread which can provide perching, roosting and possibly nesting sites for the aquatic birds (**Ref Table 9.5**). 6. The second or inner middle layer needs to be developed with woody shrubs while the inner most layer and close to water edges with the locally available sedges and aquatic plants such as water lily, *Indian lotus)*, *Colocasia* and *Ipomoea aquatica* can also be used where suitable conditions are created (**Ref plate 9.2**.) 7. The basic concept to develop vegetation profile of wetland habitat in different zones (Bank to submergence) and how those vegetation cover provide niche for the birds to perch and rest has been shown in **Plate 9.5.** 8. Bank stability, strategic access for wildlife/livestock gradual sloping - depth profiles, enhanced water circulation, and providing habitable conditions for targeted aquatic species (plants, amphibians, turtles, fish and or invertebrates) and waterfowls.

	9. Create small island structures in the middle of the wetlands using boulder generated from the pit excavation and cover them with earthen materials to facilitate aquatic birds to rest and bask. 10. It is also suggested to incorporate dead tree like structures and snags in few locations in the mid and periphery of the wetland and developed for the birds to perch (**Plate 9.5.**) 11. Releasing of fingerlings of local fish species into these wetlands is an option to provide additional fish resource for the locals. It is recommended to take consultation with the state fishery department. 12. Construct small watchtowers at strategic locations to facilitate bird watching and photography only for the limited local public.

Plate 9.5. Visual to develop different layers of vegetation along littoral edges, slopes and banks of the proposed – Mine Pit Wetland Habitat (perching niche provided by aquatic sedges and herbs)



Colocasia

Water Lilly

Water hyacinth

9.5. BCMP- Conservation of Threatened Flora

9.5.1 Threatened Flora Conservation Plots

The study area reported overall 18 threatened flora within the study area, however, only 13 plant species come under endangered and vulnerable status of IUCN list and rest fall under near threatened category. Hence, according to ICMM (2006) recommendation, only those 13 species have been considered for biodiversity conservation and management plan.

The review of ecological and conservation issues of those 13 threatened flora showed that, all most all the plant species have been over exploited due to medicinal values, parts for trade, and destructive mode of collection and thereby affected the regeneration and abundance status (**Table 9.12**). Keeping the conservation significance of these species, it is recommended to develop **Threatened Flora Conservation Plots** within the lease area and in nearby areas.

Table 9.12: Summery review of conservation issues of the threatened species of the study area

No	Scientific/Common Name	Local Name	Habit	Conservation Issues
1	*Acorus calamus* L	Buch		Overexploitation for preparing herbal drug
2	*Boswellia serrata* Roxb.,	Saliha	Tree - EN	Extracting gum through destructive harvesting imposes major threat
3	*Celastrus peniculata* Willd.,	Unjain	Woody Climber- VU	Removal of this climber for seeds has resulted in the population decline
4	*Chlorophytum tuberosum* Baker,	Safed Musli	Herb -VU	Tubers of this species are in trade for medicine and being used in carpet and tobacco industry creating pressure on the wild populations
5	*Costus speciosus* (Koen.) Sm.	Kewu/ ban haldi	Herb-VU	Rhizomes are collected for trade and used in medicine threat to this species
6	*Curcuma angustifolia* Roxb.,	Tikhur	Herb-VU	Rhizomes are collected for trade and medicine. continuous decline of this species in the wild due to overharvesting.
7	*Dioscorea bulbifera L.,*	Agitha	Climber- VU	Tubers are collected for trade and used as medicine- Over exploitation
8	*Gloriosa superba* L.,	Kalihari/Kharha godi	Herb-VU	Rhizomes are collected for trade and medicine. Overharvesting from the wild and seeds are in local, national and international trade
9	*Peucedanum nagpurense* (Cl.) Pr	Tejraj	Herb-VU	Roots and seeds are collected for local, national and international trade for preparing herbal medicine

10	*Phyllanthus emblica* L.,	Awala	Tree-VU	Destructive harvesting of fruits is the major cause of concern for the conservation of this species.
11	*Pterocarpus marsupium* Roxb.,	Bija	Tree-VU	Wood and gum are collected for local to global trade.
12	*Sterculia urens* Roxb.,	Khurul /Khaurlu	Tree-VU	Gum of this species is collected for preparing medicine. Overexploitation for gum is the cause of
13	*Terminalia chebula* Retz	Harra	Tree-VU	Fruit of this species are collected for curing cough and cold.

9.5.1.1 BCMP Action Plan - Threatened Flora Conservation Plots

Though, 13 threatened species have been recommended for TFCP, three tree species (*Phyllanthus emblica, Pterocarpus marsupium, and Terminalia chebula)* may be left out as they are common in the study area, other 10 species need to be brought under this plan. Lack of information on the ecology, regeneration potential, and even the basic information on their abundance status in the study area the following conservation measures are recommended.

1. Status survey of threatened flora of the study area
2. Conserve through development of threatened gene pool plot
3. Create awareness education focusing on sustainable use

The action plans devised are detailed in the following **Table. 9.13.**

Table 9.13: Action Plan- Development of Threatened Flora Plant Conservation plot

Threatened Flora Conservation	
BCMP –Themes	**Action Plans**
Additional information on the status of the threatened flora Threatened flora in-situ and ex-situ conservation ensured Local people educated on conservation and sustainable use of threatened flora conservation	1. Using the pictorial representation interact with the locals to understand the distribution of the species in the forest areas. 2. Carryout status survey of the nine threatened species in the Protected forests sharing 10km radius of the study area (**Table 9.14**) and possibly specific areas/location suggested by the locals 3. The survey should quantify the abundance status of the species and earmark the sites having more species with good number of plants. 4. Fence and protect few of those sites from further overexploitation and grazing pressures under in-situ conservation. Erect sign boards to aware the people not disturbed and collect the plants 5. Collect few plants (seed, tubers and or cuttings) parts to propagate in the threatened flora conservation plot.

	6. Identify minimum of two 1ha plots within the lease area in and around the office site and or the area not likely to be disturbed till the end of mine closer as ex-situ conservation. 7. Create well-structured awareness education programs for the local villagers involve in collection of plants and plant parts for local and international tread.

9.5.2. Development of Herbal Garden

The ecological study identified and discussed about 35 plant species of medicinal use, of that, 10 species have been listed under threatened category (**Annexure 4**). This list includes 12 tree species excluding *Soymida febrifuga* (local name-Rohina), rests of 11 species and one grass species (*Cynodon dactylon)* seems to be fairly common and widely distributed. Hence leaving the 10 threatened species, 11 tree and one grass species rest of 13 species (herb, shrub and woody climbers) need to be protected and conserved under **development of Herbal Garden** in the selected villages.

9.5.2.1. BCMP Action Plan - Development of Herbal Garden

This plan is similar to the above TFCP, but include local herbal healers as one of the stakeholders and the sites need to be developed in and around the village area/forests. The plan of action detailed in **Table 9.14**

Table 9.14: Action Plan- Development of Village Level Herbal Gardens

Medicinal Plant Conservation	
BCMP –Themes	**Action Plans**
Additional information on the status of the medicinal plants Facilitated the availability of herbal medicines within the reach Local people educated on conservation and sustainable use the resources	1. Identify the local herbal healers from the nearby villages, and have discussion about their kind of treatment and plants in use and source of the herbal medicine. 2. Carryout status survey of medicinal plants mainly the annuals, shrubs and creepers (**Table 9.15**) in the Protracted forests to collect only the important medicinal plans from the abundance sites to develop herbal garden. 3. Develop at least five Herbal gardens within herbal healer's village areas to facilitate emergency use. The size of the plots should be 1-2ha. 4. Fence and protect those sites and also create water sources and watering facilities like pipe connections and sprinkler systems etc and advise them not to use for trade and only for local use.

	5. Create well-structured awareness education programs for herbal healers about protection and sustainable use of the rare medicinal plants.

The above suggested two threatened flora and medicinal plant conservation plans should be implemented with the involvement of subject experts of plant taxonomist and person having good knowledge on traditional medicine. All the necessary statutory permissions and procedures should be strictly followed in consultation with the concerned forest department authorities.

Table 9.15: list of selected Medicinal plants species used by local people of the study area of PEKB for curing various ailments (IIFM)

S.no	Family and Species name	Local Name	Habit	Medicinal use	Plant parts
1	**Acoraceae**				
1	*Acorus calamus* *	Bach	Herb	Medicine	Root
2	**Amaranthaceae**				
2	*Achyranthes aspera*	Gathiya, aghada	Herb	Diuretic tonic, insect and scorpion bite	Leaf
3	*Vallaris solanacea*	Dhudhiyakandha	Woody Climber	Lactating mother	Latex
3	**Aselepiadaceae**				
4	*Ceropegia bulbosa Roxb.*	Bosiy kandha	Climber	Oil, Wounds	Seed
4	**Asteracease**				
5	*Peucedanum nagpurense* *	Tejraj	Herb	Medicine	Root
5	**Caesalpiniaceae**				
6	*Caesalpinia bonducella*	Gataran	Woody Climber	Medicine	Resin
6	**Celastraceae**				
7	*Celastrus paniculate* *	Unjain	Woody Climber	Tonic	Seed
8	*Elaeodendron glaucum*	Mamri, Mimri, Jamrasi	Shrub	Snake bite	Root
7	**Convolvulaceae**				
9	*Ipomea mauritiana*	Patal kohra	Woody Climber	Indigestion	Root
8	**Dioscoraceae**				
10	*Dioscorea bulbifera* *	Agitha	Climber	Medicine	Tuber

11	*Dioscorea spp.*	Gethi kandha/kanruha	Herb	Medicine	Fruit
9	**Hyacinthaceae**				
12	*Urginea indica*	Ban pyaz	Herb	Scorpion bite	Tuber
10	**Liliaceae**				
13	*Asparagus racemosus*	Kargi	Shrub	Medicine	Fruit
14	*Chlorophytum tuberosum* *	Safed musli	Herb	Medicine	Root
15	*Gloriosa superba* *	Kharha godi, karihari	Herb	Wounds	Root
11	**Malvaceae**				
16	*Hibiscus abelmoschus*	Kapalsiya kandha	Herb	Bleeding in Urine	Root
12	**Palmaceae**				
17	*Phoenix acaulis*	Chind	Herb	After child birth	Fruit
13	**Poaceae**				
18	*Cynodon dactylon*	Doob	Grass	Medicine	Root
14	**Rhammacea**				
31	*Ziziphus rugosa*	Churaban, churna	Woody climber	Bodyache	Whole
15	**Sterculiaceae**				
19	*Helicteres isora*	Aaithi, Marophali	Shrub	Colic intestinal disorder	Bark, fruit
16	**Vitaceae**				
20	*Cissus quadrangularis*	Hathjod	Climber	Mosquito repellent	Leaf
21	*Vitis carnosa*	Dhokarbela	Woody Climber	Bodyache	Root
17	**Zingiberaceae**				
22	*Curcuma angustifolia**	Tikhur	Herb	Medicine	Root

9.6. BCMP - Conservation of Threatened Fauna

Overall, the biodiversity management plan focuses on the select faunal groups; butterfly, amphibian, reptile, terrestrial avifauna and mammal. Because information is presently inadequate, status surveys as recommended as per the sustainable development principal 7 of ICMM (2006), should focus on 1. survey of snake species 2. status survey of selected birds of prey and 3. status survey of selected threatened mammals under this BCMP project of PEKB covering buffer zone.

9.6.1. Threatened Butterfly

Suggesting conservation plan exclusively for just two species is not effective. Hence the conservation action should focus to conserve all species of butterflies in the study area. The importance of ecosystem services that butterflies provide as pollinators, recognition and conservation of butterfly habitats in select locations of the project site are suggested and discussed in the above section (**9.3.1.1.**) under species group conservation.

9 6.2. Threatened Reptile

Two threatened species of reptiles, Indian rock python (*Python molurus*) and monitor lizard (*Varanus bengalensis)* were reported in the study area (**Table 7.12**). Reptile habitat niche suggested is aimed at improving micro habitat conditions for the commonly distributed reptilian species in general (**see section 9.3.2.1**). In addition to development of reptile habitat niche, it is recommended to carry out status survey of snake species to establish base line information.

9.6.2.1. Survey of snake species

The study area reported 23 species of reptiles of which 15 species are snakes (Annexure -7). Therefore, "**Survey of Snake Species**" within the 15 protected forests sharing the buffer zone of PEKB study area is proposed under research and monitoring. This survey plan will add baseline information on snakes for the study area. The plan of action for status survey of snake species discussed in **Table 9.16.**

Table 9.16: BCMP Action plan – Status Survey of Snake Species

Threatened Fauna Conservation	
BCMP –Themes	**Action Plans**
Additional information on selected faunal group **Population and distribution status established in the study area** **Possibly additional habitat identified for conservation**	1. This study area reported 15 species of snake species in and around the study area (**Table 8.15**). Considering the relatively high species richness of snakes a survey plan has been suggested. 2. Initiate baseline surveys in the nearest five protected forests sharing the buffer zone of the PEKB. Based on the availability of the species the survey can be extended to the rests of next five PFs 3. This survey should collect quantitative information as well as habitat status and existing threats to the snake species. **4.** Use pictorial representation of both the threatened species of the study area (monitor lizard and Indian rock python) while discussing with the local villagers. Since skins and meats of both the species are in local and international trade, the local tribes would be an important source of field information. 5. Possibly identify python den/nest sites for protection under in-situ and ex-situ conservation with the help of the state forest department.

9.6.3. Threatened Avifauna Fauna

9.6.3.1. BCMP- Action Plan Status Survey of Selected Birds of Prey.

Terrestrial bird survey resulted 92 species in the study area (including WII survey list) with 67 species in the core zone. This list includes 10 threatened avifauna including the Indian Peafowl (*Pavo cristatus*) and Grey hornbill (*Ocyceros birostris*) and eight species of birds of prey come under Accipitridae family listed under schedule I (**Table 7.12**). Though different habitat restoration and greenery development plans are

proposed under mitigation plan which would provide habitat for those threatened species, it is very crucial to initiate **"Status Survey of Birds of Prey" (Table 9.17).** This survey would help to understand the basic information on abundance, distribution and possibly nesting and roosting sites to protect and further devise long term conservation plan.

Table 9.17: BCMP Action plan – "Status Survey of selected Birds of Prey".

Threatened Fauna Conservation	
BCMP –Themes	**Action Plans**
Additional information on selected birds of prey faunal group **Abundance and distribution status established in the study area** **Possibly additional habitat identified and protected for conservation**	1. This study area reported eight species of birds of prey in and around the study area (**Table 7.12**) and fall under Schedule I of WPA, hence, they were decided for status assessment 2. This survey needs to be initiated covering three major habitats like: dense forest habitats, Agriculture patches, grassland and Human habitations. 3. This survey should adopt field techniques to collect quantitative data to assess the abundance data, information on roosting and nesting sites as well as the existing conservation issue. 4. Possibly protect the nesting and roosting sights identified during the survey with the help of local people. 5. Improve the perching sight for these species by incorporation dead tree snag (**Plate 9.6**) along the edges of open and agriculture habitats using tree salvage (translocation live trees) techniques which is already in practice to translocate the trees into the dump reclamation 6. Translocate at least 45 such death trees into the nearby agriculture and open habitats and grasslands (5 sites in each habitat and five tree sage in each site) and monitor them for use of the desired species to check the success of this conservation intervention

Plate 9.6.: Birds of prey using dead tree-snags as perching place to search of prey	
	
White-eyed Buzzard	**Crested Serpent Eagle**

9.6.4 Threatened mammals

The study area reported 18 species of mammalian fauna with 12 species in the core zone. The WII survey for the entire Hasdeo Arand area generated a list of 25 mammals (excluding the Order Chiroptera and Rodents other than giant squirrel). The cumulative list (WII survey + previous EIAs) of 31 species identified eight threatened mammals (**Table 7.12**) categorized as Schedule I of WPA, 1972.

Among the 31 species of the mammalian fauna of the study area, 16 species were reported from the core zone of PEKB. Elephants and sloth bear use the core zone. **Intensive monitoring of threatened mammals** both in PEKB as well as the whole of HACF for two to three consecutive years involving experts is essential (**Table 9.18)**.

Table 9.18: List of Threatened mammals of PEKB and HACF areas

S.No	Scientific/Common Name	IIFM 2009		WII	IUCN	WPA
		CZ	BZ			
1	*Elephas maximus* **-** Elephant	✓	✓	✓	**En**	**Sch I**
2	*Melursus ursinus* - Sloth bear		✓	✓	**Vu**	**Sch I**
3	Four-horned antelope-*Tetracerus quadricornis*			✓	**Vu**	**Sch I**
4	*Canis lupus* **-** Grey wolf			✓	**Lc**	**Sch I**
5	*Panthera pardus* **-** Leopard			✓	**Vu**	**Sch I**
6	*Manis crassicaudata* -Indian pangolin			✓	En	Sch I
7	*Lutragale perspicillata* - Smooth-coated otter			✓	**Vu**	**Sch II**
8	*Mellivora capensis* - Honey badger			✓	Lc	Sch I
	Total Species	**1**	**2**	**8**		

9.6.4.1 BCMP Action plan - Status Survey of Selected Threatened Mammals

The mammal list includes eight threatened mammals. Although grey wolf (*Canis lupus*) presence and use of the area is known, it is critical to **initiate a long-term population monitoring of the grey wolf** in PEKB and the whole of Hasdeo Arand area considering the species' endangerment. Considering the presence of rare and nocturnal species like the Indian pangolin (*Manis crassicaudata*) and honey badger (*Mellivora capensis*) it is recommended to initiate **Status survey of selected threatened mammals,** these lesser known species for effective conservation plan in the last phase of mining (**Table 9.19**).

Table 9.19: BCMP Action plan – Status Survey of selected Threatened Mammals

Threatened Fauna Conservation	
BCMP –Themes	**Action Plans**
Additional information on selected threatened mammals **Population and distribution status established in the study area** **Possibly additional habitat identified for conservation with special emphasis for Indian grey wolf**	1. *Canis lupus* **-** Grey wolf, *Manis crassicaudata* -Indian pangolin, and *Mellivora capensis* - Honey badger is three lesser known small mammals considered and recommended for status survey 2. This survey needs to be initiated covering Dense forest habitats of the nearest five Protected forests 3. This survey should adopt field techniques like: camera trap study to collect quantitative data to assess the abundance data, information on denning sights as well as the existing conservation issue. 4. Possibly protect the denning sites identified during the survey with the help of deputed wildlife watchers with the joint venture of the forest staffs.

9.7 Habitat development – selected mammalian fauna

Habitat improvement focusing on enriching grasslands, restoration might benefit herbivores like spotted deer, sambar, four-horned antelope and barking deer of the study area. Considering this, **habitat improvement** plans have been suggested to support and conserve threatened major herbivores in PEKB

9.7.1. Habitat development - elephant food resource enhancement

Asian Elephant – *Elephant Maximus*, the endangered mammal reported to use Hasdeo Arand area (Chapter-3). WII has been intensively monitoring elephants in the landscape since the year 2017. With the established scientific information, as the immediate plan of action, it is suggested to enrich the habitat by focusing on restoration with emphasis on elephant food plants prepared based on the review of literature and field observation by WII team. (**Table 9.20**)

Table 9.20: Plant species observed to be fed by wild elephants in Chhattisgarh by WII research team during 2017 to 2020 and secondary source list

S.No	Species	Local name	Habit	Part eaten by elephants	Secondary source list
1	*Acacia catechu*	khair	Tree	bark	
2	*Aegle mermelos*	bael	Tree	Bark	✓
3	*Anogeissus latifolia*				✓
4	*Bauhinia vahilii*		Climber	bark	✓
5	*Bombax ceiba*	simal	Tree	bark	✓
6	*Bridelia retusa*				✓
7	*Buchanania lanzen*	chaar	Tree	root (of saplings)	
8	*Careya arborea*				✓
9	*Cassia fistula*				✓
10	*Carissa spinarum*	jangli karunda	Shrub	bark	
11	*Dalbergia sisoo*	sisham	Tree	Bark	✓
12	*Dendrocalamus strictus*		Grass	leaves and stem	
13	*Diospyros melanoxylon*	tendu	Tree	root (of saplings)	✓
14	*Ficus benghalensis*	bargad	Tree	leaves and bark	✓
15	*Ficus racemosa*		Tree	bark	✓
16	*Ficus religiosa*	pipal	Tree	leaves and bark	✓
17	*Garuga pinnata*				✓
18	*Grewia tiliaefolia*	dhaman	Tree	bark	✓
19	*Helicteres isora*		Shrub	bark	✓
20	*Holarrhena pubescens*		Tree	root (of saplings)	
21	*Lannea coromandelica*	gurjan	Tree	bark	
22	*Largerstromia parviflora*	sejha	Tree	leaves	✓
23	*Madhuca longifolia*	mahua	Tree	Bark	✓
24	*Mallatous philippensis*	rori	Tree	bark	✓
25	*Mangifera indica*	aam	Tree	Bark & fruits	✓
26	*Phoenix sp*		Shrub	young leaves	
27	*Phyllanthus emblica*	amla	Tree	fruits	
28	*Pterocarpus marsupium*				✓
29	*Schleichera oleosa*	kusum	Tree	bark	✓

30	*Semecarpus anacardium*	bhilwa	Tree	bark	
31	*Shorea robusta*	saal	Tree	bark	✓
32	*Streblus asper*				✓
33	*Sterculia urens*		Tree	bark	✓
34	*Syzygium cumini*	jamun	Tree	bark	✓
35	*Tectona grandis*	sagon	Tree	bark	
36	*Terminalia bellerica*	baheda	Tree	bark	✓
37	*Terminalia chebula*				✓
38	*Terminalia elliptica*	saja	Tree	bark	
39	*Ziziphus mauritiana*	ber	Shrub	leaves and bark	✓
40	*Ziziphus rugosa*		Shrub	bark	
41	*Ziziphus xylopyrus*		Shrub	bark	
	Total species		**33**		**28**

Field observation by WII research Team

9.7.2 Habitat Development - Sloth bear food resource enhancement

Sloth bear (*Melursus ursinus*), a vulnerable species (IUCN 2010) is catholic in diet being an omnivore. Sloth bears play vital ecological roles in the form of seed dispersal (Willson 1993, Sreekumar and Balakrishnan 2002), and aid in improving the diversity of floral species in the forest. Their principal diet is fruits (Bhaskaran *et al.* 1997), followed by termites and ants, in addition to honey, offal and others. With the available information on the food plants for the sloth bear, the action plan emphasizes on improving the food resources in the study area. The cumulative list of 16 food species was prepared based on the literature (12 species) and field observation by WII team (13 species) (**Table.9.21**).

Table: 9.21: Sloth Bear plant species Recommended for Habitat improvement and Food Resource Enhancement

S.No.	Scientific name	Life Form	Secondary Source	WII (Field Observation)
1	*Aegle marmelos*	*Tree*	@	
2	*Cassia fistula*	*Tree*	@	++
3	*Cordia macleodii*	*Tree*		++
4	*Cordia myxa*	*Tree*		++
5	*Diospyros melanoxylon*	*Tree*	@	++
6	*Emblica officinalis*	*Tree*	@	
7	*Ficus benghalensis*	*Tree*	@	
8	*Ficus glomerata*	*Tree*		++
9	*Ficus infectoria*	*Tree*		++
10	*Ficus racemosa*	*Tree*	@	++
11	*Ficus religiosa*	*Tree*	@	++

12	*Flacourtia indica*	*Tree*	@	++
13	*Madhuca indica*	*Tree*	@	++
14	*Mangifera indica*	*Tree*	@	++
15	*Syzygium cumini*	*Tree*	@	++
16	*Zizyphus mauritiana*	*Tree*	@	++
	Total Species		**12**	**13**

SS – Secondary sources, @ - food species reported (Bhaskaran *et al.* 1997), ++ Species observed to be fed in the study area (WII -Research Team)

9.7.3. Habitat Development - Four-horned antelope food resource enhancement

Four horned antelopes mostly occur in dry deciduous forests, especially in areas that support short grasses with stunted and sparse tree growth (Baskaran *et al.* 2011). Some studies suggest that they prefer 'open' habitats (Sankhala, 1977; Chundawat *et al.* 1999), while Sharma *et al*. (2009) reported that this species was found using closed canopy thickets, with dense undergrowth or grass cover for resting. They occur at low densities across its distributional range and are predominantly solitary in nature, occasionally forming loosely associated groups of three to five animals and shows preference for browsing over grazing (Rice 1990. Sharma *et al*. 2009). Four-horned antelope occuring in low density are vulnerable to human disturbance and might suffer local extinction too (Baskaran and Desai 1999; Krishna 2006; Baskaran *et al*. 2009; Krishna *et al*. 2008). In PEKB and whole of Hasdeo Arand area the field observation revealed that hunting, livestock grazing, illicit felling of trees are prevalent and these threats are of high concern when the population of a species is considered to be low and fragmented. With the understanding of the basic information on habitat preference, feeding, social organization and common threats, the following food plants of FHA suggested to enhance the food resource in the project study area under habitat development plan). Overall, 16 food plants have been selected based on the literature (Kunwar et al 2006) and also checked with the plant list of the study area (**Table. 9.22**)

Table 9.22: Food Plant Species recommended for restoration and Development of habitat for Four-Horn Antelope Habitat

S.no	Scientific Name	Habit	S.no	Scientific Name	Habit
1	*Acacia catechu*	Tree	9	*Hymenodictyon orixense*	Tree
2	*Asparagus racemosus*	Shrub	10	*Mallotus philippensis*	Tree
3	*Bauhinia malabarica*	Tree	11	*Mitragyna parvifolia*	Tree
4	*Bauhinia retusa*	Tree	12	*Nyctanthes arbor-tristis*	Tree
5	*Bauhinia vahlii* -	Creeper	13	*Phyllanthus emblica*	Tree
6	*Bridelia retusa*	Tree	14	*Schleichera oleosa*	Tree
7	*Buchanania lanzan*	Tree	15	*Shorea robusta*	Tree
8	*Dendrocalamus strictus*	Bamboo sp	16	*Ziziphus mauritiana*	Tree
Extracted from Kunwar et al. 2006					

9.7.3.1: BCMP Action Plan - Habitat Restoration – Food Resource for Threatened Mammals

Among the eight threatened mammals, BCMP – plan was suggested for Sloth bear, Four-horned antelope and Elephant to restore the degraded forest habitats to improve the food resources as immediate management action plan and implementation measures are suggested in **Table 9.23.**

Table 9.23: Habitat restoration – Food Resource enhancement for threatened mammals (Sloth bear, FHA and Elephant) – action plan

BCMP-Themes	Action plan
Food resources for threatened mammals improved ***Other herbivore mammals benefited*** ***Increase in overall faunal diversity within the food habitat developed***	1. Identification of degraded forest patches of not less than 2-4ha each in all the 15 Protected forests in the buffer zone of the study area 2. Within those PFs develop one 4ha, in each forest to plant 41 elephant food trees as gap plantation. This list includes 33 species reported in the field by the WII research team and 28 species identified based on literature reported in the study area as well as overlap with the WII list. 3. overall 60ha forest patch in 15 PFs will be restored for the enhancement of elephant food resources 4. In addition, identify another 4ha of open forest as well as partly dense (degraded) patches within those 15 PFs and develop 2h each for planting 16 food plants of sloth bear (**Table 9.21**) and 16 species of Four-Horn Antelope food plants (**Table 9.22**). Therefore, another 60h of forest patches 30ha each for FHA and sloth bear restored to improve the food resource. 5. The forest patches should be selected from gentle to moderate slope in nature and preferably far from the human habitation and grazing pressure. 6. While selecting those restoration plots also look for presence of elephant dungs and droppings of sloth bear and pellet groups of FHA to ensure the use of those area by those threatened mammals 7. Restore those species-specific patches with the food specific plant species suggested with the help of restoration and forestry expert. 8. All the planting activities should be completed before the onset of monsoon and monitor those plots /patches for survival and growth with the needed care.

	9. The list of food plants suggested for sloth bear, four horned antelope and elephant should also be include in all the mine restoration and reclamation sites, so that after the completion of mining the restored mine area can be used by these threatened mammals

9.8. Biodiversity Resource- Peoples Use Values

Management of the biodiversity used by the local communities and other ecosystem services, is one of the important concepts of GPG of ICMM (2006), which states that, in areas where communities are directly dependent on biodiversity as 'provisioning services', need to be given priority to ensure that, the management plans improve the biodiversity resources on which communities depend on. Even though, the scope of this work does not include the detailed assessment of biodiversity resource dependency of the villagers in the project area, based on some of the field observations the following natural resource management plans are recommended with the hope that, these management plans would improve the life quality and there by reduces their dependency on forest resources and existing biotic pressures.

Table- 9.24: Villages located in / immediate periphery of the PEKB block

Sr. No.	Name	Distance and Direction w.r.t Mining Site	
1	Salhi	1.6	**NW**
2	Hariharpur	0.3	**NW**
3	Parsa	0.2	**N**
4	Kanta	**Mine Lease**	
5	Ghatbarra	**Mine Lease**	
6	Parogiya	3.0	**SE**
7	Basan	2.0	E

9.8.1. Livelihood and Life Quality Improvement

9.8.1.1. Vegetable and Fruit Crop - Organic farming Program

Encouraging the impacted people to start organic farming as livelihood options to enhance their income status. This would also give way for healthy life system for the locals as well as healthy ecosystem for the faunal diversity of agro-ecosystem. Taking the advantage of the water resource availability it is suggested to support the Organic Farming at village level as well as individual level.

Organic Vegetable Farming

1. *Survey to identify the affected villagers and interested marginal farmers to support Organic farming and their perception and willingness to be part of this plan.*
2. *Identify the area based on the presence of good water resources and suitable land for cultivation.*
3. *Before the initiation, construct small farm pond to ensure the availability of water throughout the year.*

4. *The program should start with organic farming of suitable vegetable in consultation with the villagers and also as per the market survey and demand based.*
5. *The stakeholders should provide required organic seeds of vegetable crops, free of cost*
6. *Series of capacity building programs need to be conducted by the CSR department with the subject consultant on technical, management, marketing aspects for the successful implementation and progress of this action plan.*
7. *All the organic vegetables cultivated under this plan can be purchased and used by the project proponent (mining companies) for their office canteen, guesthouse, colony and link with local vegetable market owners of the nearest town on regular basis.*

Organic Fruit Orchard Development

1. *A total of seven possible fruit tree species are suggested to grow under Fruit Orchard Development plan which area commonly grown in the village areas (Table 10.16).*
2. *Fruit orchard development is different from vegetable farming and its need larger area and investment. Therefore, identify the villages based on land suitability and water availability and with the stakeholder's interest. Select at least, four to five species which can fetch good income and easily marketable and specific to the local condition.*
3. *Develop minimum of 2ha of such fruit Orchard plantation in Common Property Land Resources CPLR / Community land of those seven villages*
4. *Initially, the project proponent should facilitate all the expenditure related to the construct of needed water storage and irrigation facilities, providing fruit crop saplings, manure, tree guard and fencing etc.*
5. *The initial expenditure incurred for the project implementation can be pay backed by the Fruit Orchard Development (FOD) – Village Committee to the project proponent and it is the overall responsible for the annual maintained management of this FOD Committee*

The Organic farming program can be initiated under CSR division through Village Organic Farming Committee – VOFC to maintain and manage both the programs as well as benefit sharing. Local villagers should be educated on the successful use and advantages of organic farming techniques as one means of reducing the risk of potentially hazardous agricultural chemicals to biodiversity and human health.

Table 9.25: Fruit crop species suggested for Fruit Orchard Development Plan -FODP

S. No.	Scientific Name	Common name
1	*Carica papaya*	Papaya
2	*Citrus lemon*	Lemon
3	*Citrus maxima*	Lemon
4	*Phyllanthus emblica*	Indian gooseberry
5	*Psidium guava*	Guava
6	*Mangifera indica*	Mango
7	*Manilkara zapota*	Chikku

9.8.1.2. Apiculture - Honeybee Farming

Domination of forest and agriculture land uses in the project study area is the major sources of honey. Tapping of this wild resource, especially from the village areas through apiculture is one of the good income sources for the locals. Hence, it is proposed to implement this natural resource use plan through "**Honeybee farming**" and recommended for the interested locals and brief plan of actions detailed below;

1. *Recommended to initiate Honey-bee Farming within the seven villages listed in the above **Table 9.24***
2. *Initially start with this program providing five villagers in each village i.e 35 villagers provided 20 boxes each (35 villagers x 20 boxes = 700) and based on the progress the same can be extended further*
3. *Train the interested villagers/persons on technical aspects through capacity building program with the experts.*
4. *Provide all the necessary equipment or honey comb boxes and other gears free of cost by the project proponent*
5. *Form honey collection team to collect honey and store it in one place for further marketing*
6. *The project proponent should facilitate market link for regular buying from the nearby towns.*

9.8.1.3. Village level Fish Farming

The study area is dominated by tribes and they hunt small mammals and birds for wild meat. It is common sighting of the local tribes moving in the forests with bow and arrow, catapults for hunting birds and small mammals. In addition, in few locations evidences of old snare/animal traps were seen (**Plate 9.7**). Though, it is a traditional right of tribes, this will have severe impact on selected faunal species which need to be attended through some alternative to minimize this direct impact. In spite of no direct influence of any project activities, the outside labors employed in the project may also indulge in such illegal activities. Therefore, in addition to controlling the project labor with strict vigilance, it is very important to facilitate at least those seven villages with alternate options.

Aquaculture – Fish farm pond

1. *The villagers depend on the seasonal streams, rivers and village ponds for fish resource using the local techniques (**Plate 9.7**). All most all the villages have ponds for micro irrigation and other domestic uses.*
2. *Keeping the field condition in mind, under CSR activity development **fish farm ponds** is suggested in the adjacent 20 villages.*
3. *In consultation with the local fishery department native fingerlings may be introduced to improve the fish abundance in the village ponds.*
4. *Select locals should be trained in all the technical and management aspects, sustainable harvest and benefit sharing with the affected villages through the village committee.*

The above suggested all the three options are fully community based supportive plans and recommended based on the field observations. Therefore, it is essential to take up well formatted social survey focusing

the three major aspects: 1. Natural resource dependency, 2. Life quality and Income source and 3. People's perception and willingness to support those projects.

Plate 9. 7. People's dependency on wild meat and fishing from the stream

9.9 Awareness Education

The success of the above suggestions regarding habitat development and natural resource enhancement plans entirely depend on the support of local villagers. Systematic and well planned series of awareness education camps should be initiated targeting different groups of stakeholders starting from school children, youths, womenfolk, elders of local villages and also migrant project people. This can be done by involving a reputed NGO with good experience in conducting awareness and education programs specific to wildlife and biodiversity conservation. The themes need to be focused are given below:

- Importance of biodiversity conservation and ecosystem service – Villagers/agriculturalists and also
- Nature conservation – students
- Sustainable use of the natural resources – local villagers
- Creation of PEKB Nature Club – local students
- Ecologically sustainable development – Inhouse Technocrats of RRVUNL
- Hunting of wildlife – local tribes

9.10 Human-Elephant conflict mitigation strategies

The Human-Elephant conflict mitigation strategies in the HACF and surrounding landscape should include the following:

1. Maintaining the ecological integrity of intact natural habitats without fragmentation and degradation is critical. Any additional mining leading to loss of habitat would escalate HEC unpredictably high
2. Formation of landscape-level Rapid Response Teams by engaging village youth with adequate remuneration is essential. The RRT members should be adequately trained in elephant behaviour and conflict management methods.
3. Judicious use of mobile barriers in select areas of HACF and surrounding landscape where HEC is high need to be experimented with active community participation.
4. Ex gratia payment for crop, property and other losses due to elephants have adequate and timely. The overall process of filing and obtaining compensation by villages should be made smooth and transparent
5. Habitat enrichment by improving surface water availability in carefully selected locations, development of grasslands and fodder base based on the list of plants suggested in the report and protection of critical micro-habitats such as riparian tracts are critical (Refer Table 9.23).
6. Human-elephant conflict is dynamic in nature. The above mentioned mitigation measures need to be experimented in smaller areas and based on the evaluation of efficacy can be scaled up.

CONCLUSIONS

1. Opencast mining and associated developmental activities in forested habitats could potentially affect a variety of taxonomic groups. Nevertheless, measurement of every aspect of biodiversity in forested landscapes that span several hundred squares kilometers of mosaic habitats in a short period of time is seldom easy. In order to overcome this constraint, short-cut approaches that focus on monitoring large mammal populations, which serve as keystone, flagship or umbrella species have been advocated. As this biodiversity assessment, impact assessment and mitigation strategies are to be studied at a landscape level, this study emphasized specially on the "umbrella species concept". The umbrella species concept is a globally accepted concept wherein conservation efforts targeted for a well-chosen representative species can confer a protective umbrella to numerous other co-occurring species in the landscape. Asian elephant and tigers serve as umbrella species in the tropical forested landscapes. Both tigers and elephants are long ranging and have specific ecological needs. Understanding the ecological requirements of these species for conservation can augur well for all other species found in the landscape.

2. From WII's biodiversity assessment, it is evident that HACF and the landscape surrounding it, is biodiversity rich and supports an intact faunal diversity typical to peninsular India. Even the habitats within the coal blocks (both proposed and operational) support wildlife, particularly the threatened species of mammals.

3. HACF and the landscape surrounding it supports a minimum of 25 species of mammals. Amongst them, the RET list is as follows:

Wildlife (Protection) Act, 1972	**IUCN RED-list**
Schedule – I = 9 species	Endangered = 2
Schedule – II = 10 species	Vulnerable = 5
Schedule – III = 4 species	Near threatened = 3
Schedule – IV = 2 species	Least Concern = 15

4. The list is best considered minimal as it excludes species from the Order *Chiroptera* (bats, which is species rich in India with a recorded 117 species) and species from the Order *Rodentia* except that of the Indian giant squirrel (*Ratufa indica*). These faunal groups were not assessed due to the short term duration of the project.

5. During village interview surveys, villagers reported the presence of Asiatic wild dog (*Cuon alpinus*) and sambar (*Rusa unicolor*), which were not detected during field surveys, probably due to survey duration being limited. Given the vastness of the landscape, and availability of suitable habitats, it is likely that these two species do occur.

6. The study area and the surrounding forested landscapes in Korba, Surajpur and Surguja districts occasionally have tigers dispersing into; probably from Kanha – Boramdeo - Achanakmar landscape complex located towards the west of Hasdeo Arand area. The habitat connectivity for large mammals

like tigers and elephants between Hasdeo Arand area and Achanakmar Tiger Reserve is strong. Intact habitat connectivity with tiger source population and relative vastness of the landscape could augur well for recovering tigers. However, tiger conservation would be conditional on maintaining habitat connectivity, retaining forest cover, and augmenting prey species in select areas (that are reasonably free of biotic pressure). During interview surveys, 4 respondents from the villages of Ghatbarra, Basen, and Ajgar Bahar reported sighting tigers. Korba Forest Division staff had recorded tiger presence during the last three years.

7. The local communities are predominantly tribal, and show high dependence on forests for their livelihood, food and medicinal needs. Over 46% of the annual income directly comes from NTFP collection of four commodities. If firewood, fodder and other resources provided by forests are pooled, families get a minimum of 60 to 70% of their annual income from forest based resources. Agriculture is largely conventional and monsoon and forest dependent. Based on WII's interview surveys in a total of 23 villages, the local communities do not favour mining and perceive mining as a direct threat to their livelihood due to high forest dependency as well as social and cultural factors.

8. Due to strong affinity of tribal communities towards wildlife and forests, local communities favour nature conservation. Garnering the support of local communities towards conservation would rest on participatory approaches by actively involving local communities and at the same-time developing mechanisms for real-time mitigation of human-wildlife conflicts.

9. The area supports rich biodiversity with a multitude of mammalian species including elephants and also harbours forest-dependent communities. Therefore, sustaining the forest cover and maintaining its overall ecological integrity is essential. It is pertinent that Chhattisgarh Forest Department with due consultation and involvement of local communities identify areas for declaration as conservation reserves. Under the ambit of a conservation reserve, habitat improvement activities such as restoration of grasslands and restoration of degraded forests; improving surface water availability for wildlife in relatively drier tracts during summer, regulating forest fires, and improving overall protection can benefit wildlife.

10. In the operational mine of PEKB, a thorough impact assessment carried out enlists range of impacts on different faunal groups. Considering the impacts, a diversity of mitigation strategies has been proposed for PEKB. Notwithstanding the mitigation strategies prescribed, it is understood that mitigating all the impacts on faunal groups such as mammals due to largescale mining is impossible. This is particularly true in the case of wide ranging animals with large home ranges like elephants.

11. HACF and the surrounding landscape is an integral part of the elephant range in northern Chhattisgarh. Different herds and individual elephants use this area as part of their range. A conservative minimal estimate of 40 to 50 elephants could be using the area at different times of the year. For the period 2018 - 2020 elephant occurrence was reported by Forest Department in a minimum of 148 out of 640 forest compartments in this landscape. Elephant occurrence in HACF and the landscape surrounding it, is not limited to any particular portion, but spread throughout. Elephants use the area as both habitat as well as corridor for movement. With respect to human-elephant conflict, there are records of crop loss, property loss and even loss of human lives. Considering this,

advancing landscape-level HEC mitigation strategies by considering elephant movement and connectivity at a larger spatial scale is essential.

12. Chhattisgarh human-elephant conflict situation is a paradox with a relatively low number of elephants (<300, which is <1% of India's wild elephant population) but high levels of HEC with over 60 human lives are lost every year due to conflict (>15% of the reported human deaths due to HEC). In addition to loss of human lives, crop loss and damage to property due to HEC are severe. There is continuous dispersal of elephant herds from the neighbouring states of Jharkhand and Odisha. The study carried out by WII in collaboration with Chhattisgarh Forest Department from the year 2017 onwards clearly highlight that elephants have large home ranges. The forests that elephants currently occur are highly fragmented and degraded due to incompatible land-use. Infrastructure development and mining are further fragmenting the habitats making conflict mitigation a huge challenge. In fragmented habitats conventional fencing approaches minimally work due to high perimeter to area ratio of habitats.

13. The EC region harbours less than 1/10th (<3000) of country's elephants, but loses over 40% (over 200 HEC-related deaths) of reported 500 HEC-related human fatalities in the country. The HEC-related human fatalities reported in the region are highly disproportionate to its elephant population in the country. The increasing levels of HEC have resulted in considerable public resentment against the management and elephant conservation as a whole. HEC resolution is challenging in EC region due to fragmentation, loss and degradation of intact elephant habitats. In highly fragmented areas, the elephant home ranges tend to be large as small, degraded forest patches cannot sustain herds. It is observed that home range size is a function of habitat quality – in areas that support good intact habitats, the elephant home ranges are relatively small (eg. Rajaji, Mudumalai etc). However, in fragmented areas, elephant home ranges are typically large. The elephant herds are generally interlinked and home ranges spread over two or more states.

14. One of the main reasons as to why elephants start dispersing into human-use areas is the threat to habitat. In particular, threat to elephant home ranges. While threat to habitat can be identified and sometimes even addressed, threats within individual home ranges of elephants are hard to evaluate and hence, difficult to mitigate. The latter threats are more insidious and lasting. Major disturbances to habitats such as mining not only cause habitat loss and fragmentation (as understood generally) but can affect individual herd's home ranges. Such disturbances can lead to abandonment of habitats as threats to home ranges have a threshold limits. The effect of mining on elephant habitat may not reflect in the same habitat, but could be a silent trigger for HEC in some other area within the landscape. In general, one of the reasons for HEC being disproportionately high in EC region is the elephant dispersal from forest habitats through fragmented human use areas. This large scale elephant dispersal out of intact forests coincide with commencement of large-scale mining projects and associate infrastructure developments in the EC region, particularly in the states of Odisha and Jharkhand.

15. The Human-Elephant conflict mitigation strategies in the HACF and surrounding landscape should include the following:

a. Maintaining the ecological integrity of intact natural habitats without fragmentation and degradation is critical. Any additional mining leading to loss of habitat would escalate HEC unpredictably high
b. Formation of landscape-level Rapid Response Teams by engaging village youth with adequate remuneration is essential. The RRT members should be adequately trained in elephant behaviour and conflict management methods.
c. Judicious use of mobile barriers in select areas of HACF and surrounding landscape where HEC is high need to be experimented with active community participation.
d. Ex gratia payment for crop, property and other losses due to elephants have adequate and timely. The overall process of filing and obtaining compensation by villages should be made smooth and transparent
e. Habitat enrichment by improving surface water availability in carefully selected locations, development of grasslands and fodder base based on the list of plants suggested in the report and protection of critical micro-habitats such as riparian tracts are critical
f. Human-elephant conflict is dynamic in nature. The above mentioned mitigation measures need to be experimented in smaller areas and based on the evaluation of efficacy can be scaled up.

16. The coal mines along with the associated infrastructure development would result in loss and fragmentation of habitat. Mitigating such effects on wildlife, particularly the animals with large home ranges such as elephants is seldom possible. The human-elephant conflict in the state is already acute and has been escalating with huge social and economic costs on the marginal, indigenous local communities. Any further threat to elephants' intact habitats in this landscape could potentially deflect human-elephant conflict into other newer areas in the state, where conflict mitigation would be impossible for the state to manage. Opening up of the demarcated coal blocks in the HACF would compromise the imperatives of biodiversity conservation and livelihood of forest-dependent local communities. Even the effects of the operational mines of PEKB and Chotia need to be tactfully mitigated too, wherever possible.

REFERENCES

Ahmed, R. A., K. Prusty, J. Jena, C. Dave, and S. C. Vihar. 2012. Prevailing Human Carnivore Conflict in Kanha-Achanakmar Corridor , Central India Department of Wildlife and Conservation Biology , North Orissa University ,. Journal of Zoology 7:158–164.

Aiello Lammens, M. E., R. A. Boria, A. Radosavljevic, B. Vilela, and R. P. Anderson. 2015. spThin: an R package for spatial thinning of species occurrence records for use in ecological niche models. Ecography 38:541–545. Wiley Online Library.

Akhtar, N., H. S. Bargali, and N. P. S. Chauhan. 2007. Characteristics of sloth bear day dens and use in disturbed and unprotected habitat of North Bilaspur Forest Division, Chhattisgarh, central India. Ursus 18:203–208.

Akhtar, N., and N. P. S. Chauhan. 2008. Status of human wildlife conflict and mitigation strategies in Marwahi Forest Division, Bilaspur Chhattisgarh. Indian Forester 1349–1358.

Akhtar, N., and N. P. S. Chauhan. 2009. Food habitats and human-jackal interaction in Marwahi Forest Division, Bilaspur Chhattisgarh. Indian Forester October:1347–1356.

Andheria, A. P., K. U. Karanth, and N. S. Kumar. 2007. Diet and prey profiles of three sympatric large carnivores in Bandipur Tiger Reserve, India. Journal of Zoology 273:169–175.

Anon 2005. Low, Moderate & High Dust Capturing Plant Species In: Phyto-remediation of Particulate Matter from Ambient Environment through Dust Capturing Plant species. CPCB- Central Pollution Control Board (MoEF), Parivesh Bhanavn, East Arjun Nagar, Delhi- 110032,

Areendran, G., K. Raj, S. Mazumdar, M. Munsi, H. Govil, and P. K. Sen. 2011. Geospatial modeling to assess elephant habitat suitability and corridors in northern Chhattisgarh, India. Tropical Ecology 52:275–283.

Aryee, B. N. A., B. K. Ntibery, and E. Atorkui. 2003. Trends in the small-scale mining of precious minerals in Ghana: a perspective on its environmental impact. Journal of Cleaner production 11:131–140. Elsevier.

Bargali, H. S., N. Akhtar, and N. P. S. Chauhan. 2004. Feeding ecology of sloth bears in a disturbed area in central India. Ursus 15:212–217. BioOne.

Bargali, H. S., N. Akhtar, and N. P. S. Chauhan. 2005. Characteristics of sloth bear attacks and human casualties in North Bilaspur Forest Division, Chhattisgarh, India. Ursus 263–267. JSTOR.

Bargali, H. S., N. Akhtar, and N. P. S. Chauhan. 2012. Sloth bear (melursus ursinus) habitat in the forests of North Bilaspur forest division, Chhattisgarh=good on modeling,not much information given. Indian Forester 138:876–880.

Basak, K., M. Ahmed, M. Suraj, C. Sinha, V. B. Reddy, O. Yadav, and K. Mondal. 2017. Confirming presence of Indian mouse deer from Chhattisgarh, Central India with photographic evidence after 112 years. International Journal of Fauna and Biological Studies.

Baskaran, K., Kannan. V., Thiyagesan, K. and Desai, A.A. 2011.Behavioural ecology of four-horned antelope (*Tetracerusquadricornis* de Blainville, 1816) in the tropical forests of southern India. *Mammal. Biol*. doi:10.1016/j.mambio.2011.06.010.

Baskaran, N. Sivaganesan, N and J. Krishnamoorthy. 1997. Food habits of the sloth bear in Mudumalai Wildlife Sanctuary, Tamil Nadu, Southern India. *J. Bombay Nat. Hist. Soc*. 94(1):1-9

Baskaran, N. and Desai, A.A., 1999.*An ecological investigation on four-horned ante-lope (Tetracerusquadricornis) in Mudumalai Wildlife Sanctuary, Tamil Nadu*. Technical Report. Bombay Natural History Society, Bombay.

Baskaran, N., Desai, A.A. and Udhayan, A. 2009. Population distribution and conserva-tion of the four-horned antelope (*Tetracerusquadricornis*) in the tropical forest of Southern India. *J. Sci. Trans. Environ. Technol*. 2 (3): 139–144.

Bayley, S.E., Wilson, M.J., Rooney, R.C. and Bolding, M.T. (2014) Assessment methods for reclamation of permanent marshes in the oil sands: handbook and video, prepared by the Bayley Lab, Department of Biological Sciences, University of Alberta. Edmonton, AB.

Bharos, A. M. K., A. Mandavia, R. Naidu, and A. Badesha. 2019. Distribution range extension of grey-headed lapwing (Vanellus cinereus) in Chhattisgarh , Eastern Madhya Pradesh , and Jharkhand , India. 6:11–13.

Bisen, K. K. 2017. Managing human elephant conflict in Chhattisgarh. Chhattisgarh Forest Department.

Birds of the World (Billerman, S. M., Keeney, B. K., Rodewald, P. G. and Schulenberg, T. S. Editors). Cornell Laboratory of Ornithology, Ithaca, NY, USA. https://birdsoftheworld.org/bow/home. Assessed on 12 March 2021.

Bonebrake. T. C., Ponisio, L. C., Boggs, C. L. and Ehrlich, P. R. 2010. More than just indicators: A review of tropical butterfly ecology and conservation. Biological Conservation. 143(8): 1831-1841.

Bowen-Jones, E., and A. Entwistle. 2002. Identifying appropriate flagship species: the importance of culture and local contexts. Oryx 36:189–195. Cambridge University Press.

Brotons, L., W. Thuiller, M. B. Araújo, and A. H. Hirzel. 2004. Presence-absence versus presence-only modelling methods for predicting bird habitat suitability. Ecography 27:437–448. Wiley Online Library.

Champion, H. G., and S. K. Seth. 1968. Forest types of India. Government of India Press, Nasik.

Chandra, K., and P. U. Gajbe. 2005. An inventory of herpetofauna of Madhya Pradesh and Chhattisgarh. Zoos' Print Journal 20:1812–1819.

Chaphekar. S. B. 1994. Plantation Strategies for Eco-Management of a Thermal Power Plant. Pp:873-878. In: *Agroforestry systems for degraded lands*. Vol: 2 (eds). Punjab Singh, P. S. Pathak & M. M. Rey

Chundawat, R.S., Gogate, N. and Johnsingh, A.J.T. 1999. Tigers in Panna: preliminary results from an Indian tropical dry forest. Pp:123-129. In *Riding the tiger: tiger conservation in human-dominated landscapes*. (Eds.) J. Seidensticker, S. Christie and P. Jackson. Cambridge University Press, Cambridge.

Corn, P. S., and R. B. Bury. 1990. Sampling methods for terrestrial amphibians and reptiles. Gen. Tech. Rep. PNW-GTR-256. Portland, OR: US Department of Agriculture, Forest Service, Pacific Northwest Research Station. 34 p 256.

CPCB 2000.Guideline for Developing Greenbelt" Central pollution Control Board, Program objective series. PROBES/75/1999-2000.

Das, I. 2008. *A photographic guide to snakes and other reptiles of India*. OM Books International, New Delhi. 144 p.

Dawn, P., and K. Chandra. n.d. Ten new records of Odonata from Chhattisgarh state , India (Odo - nata : Coenagrionidae , Platycnemididae , Aeshnidae , Macromiidae , Libellulidae). 2:218–221.

Directorate of Census Operations, C. 2011. District Census Handbook: Surguja.

District, S., and S. K. Gupta. 2016. Records of Orthoptera (Insecta) fauna from. 4:258–263.

Dutta, S. K. 2017. First Report of Ruddy-breasted Crake Porzana fusca (Linnaeus, 1766) from Chhattisgarh, India. International Journal of Current Microbiology and Applied Sciences 6:472–476.

Dutta, T., S. Sharma, B. H. McRae, P. S. Roy, and R. DeFries. 2016. Connecting the dots: mapping habitat connectivity for tigers in central India. Regional Environmental Change 16:53–67. Springer

ED– World Bank. 1998. Environment assessment of Mining Projects. In. Environmental Assessment Source Book – UPDATE 9.1-12.

Ehrlich, P.R. and Raven, P.H. 1964. Butterflies and plants: a study in co-evolution. *Evolution*. 18: 586-608.

Ekka, N. S., and A. Ekka. 2016. Wild Edible plants Used by Tribals of North-east Chhattisgarh (Part-I), India. Research Journal of Recent Sciences 5:127–131.

Elith, J., and J. R. Leathwick. 2009. Species distribution models: ecological explanation and prediction across space and time. Annual review of ecology, evolution, and systematics 40:677–697. Annual Reviews.

Elith, J., S. J. Phillips, T. Hastie, M. Dudík, Y. E. Chee, and C. J. Yates. 2011. A statistical explanation of MaxEnt for ecologists. Diversity and distributions 17:43–57. Wiley Online Library.

Feeley, K. J., and M. R. Silman. 2011. Keep collecting: accurate species distribution modelling requires more collections than previously thought. Diversity and distributions 17:1132–1140. Wiley Online Library.

Ferrier, S. 2002. Mapping spatial pattern in biodiversity for regional conservation planning: where to from here? Systematic biology 51:331–363. Society of Systematic Zoology.

Flieshman, E., D. D. Murphy, and P. F. Brussard. 2000. A new method for selection of umbrella species for conservation planning. Ecological Applications 10.

Garsad, S.G. and A. J. Rutter. 1982. Relative performance of Conifer population in various tests for sensitivity to S and the implications for selecting trees for planting in polluted areas. *New Phytol*. 93:349-367.

Giridhar, B. A. & S. B. Chaphekar 1983. Pollutant absorption and removal capacity of plants as related to the quality of foliar surface. VI World. Cong. *On Air Quality.* Vol. II, Paris: 487-493.

Guisan, A., and W. Thuiller. 2005. Predicting species distribution: offering more than simple habitat models. Ecology letters 8:993–1009. Wiley Online Library.

Gupta, S. K., and K. Chandra. 2017. Diversity of Orthoptera (Insecta) fauna of Achanakmar Wildlife Sanctuary, Bilaspur, Chhattisgarh, India. Journal of Asia-Pacific Biodiversity 10:91–103. Elsevier Ltd. <http://dx.doi.org/10.1016/j.japb.2016.05.003>.

Hall, k.D., Zipper, C.E., and Burger, J.A. 2009. Recovery of Native Plant Communities After Mining. Virginia Cooperative Extension. Publication 460-140. Virginia Polytechnic Institute and State University, 2009

Hebblewhite, M., D. G. Miquelle, H. Robinson, D. G. Pikunov, Y. M. Dunishenko, V. V Aramilev, I. G. Nikolaev, G. P. Salkina, I. V Seryodkin, and V. V Gaponov. 2014. Including biotic interactions with ungulate prey and humans improves habitat conservation modeling for endangered Amur tigers in the Russian Far East. Biological Conservation 178:50–64. Elsevier.

Hijmans, R. J., J. Van Etten, J. Cheng, M. Mattiuzzi, M. Sumner, J. A. Greenberg, O. P. Lamigueiro, A. Bevan, E. B. Racine, and A. Shortridge. 2015. Package 'raster.' R package 734.

Hilson, G. 2002. An overview of land use conflicts in mining communities. Land use policy 19:65–73. Elsevier.

Hocking. D (Ed). 1993. Trees for Dry lands. Oxford and IBH Publishing Company Pvt Ltd. New Delhi. P. 370.

Hortal, J., Triantis, K. A., Meiri, S., Thébault, E. and Sfenthourakis, S. 2009. Island species richness increases with habitat dersity. The American Naturalist, 174(6), E205-E217.

ICMM 2006: Good Practice Guidance for Mining and Biodiversity. http://www.icmm.com/document/13

IFC 2012. Performance Standard 6 Biodiversity Conservation and Sustainable Management of Living Natural
Resource.http://www.ifc.org/wps/wcm/connect/bff0a28049a790d6b835faa8c6a8312a/PS6_English_2012.pdf?MOD=AJPERES

Jhala, Y. V., Q. Qureshi, and A. K. Nayak. 2018. Status of tigers, copredators and prey in India.

Johnsingh, A. J. T., and N. Manjrekar. 2012. Mammals of South Asia. Universities Press.

Jones, K. E., and K. Safi. 2011. Ecology and evolution of mammalian biodiversity. The Royal Society.

Kalle, R., T. Ramesh, Q. Qureshi, and K. Sankar. 2013. Predicting the distribution pattern of small carnivores in response to environmental factors in the Western Ghats. PLoS One 8:e79295. Public Library of Science.

Karanth, K. K., J. D. Nichols, K. U. Karanth, J. E. Hines, and N. L. Christensen Jr. 2010. The shrinking ark: patterns of large mammal extinctions in India. Proceedings of the Royal Society B: Biological Sciences 277:1971–1979. The Royal Society.

Karanth, K. U., R. S. Chundawat, J. D. Nichols, and N. S. Kumar. 2004. Estimation of tiger densities in the tropical dry forests of Panna, Central India, using photographic capture–recapture sampling. Animal Conservation 7:285–290. Wiley Online Library.

Karanth, K. U., A. M. Gopalaswamy, N. S. Kumar, S. Vaidyanathan, J. D. Nichols, and D. I. MacKenzie. 2011. Monitoring carnivore populations at the landscape scale: occupancy modelling of tigers from sign surveys. Journal of Applied Ecology 48:1048–1056. Wiley Online Library.

Kazmi, R. 2019. Asiatic Cheetah Acinonyx jubatus venaticus in India: A Chronology of Extinction and Related Reports. Journal of the Bombay Natural History Society (JBNHS) 116:22–43.

Kehimkar, I. 2008. The Text Book of Indian Butterflies, Bombay Natural History Society, Oxford University Press. Pp. 497.

Koh, L.P. 2007. Impact of land use change on South-east Asian forest butterflies: a review. Journal of Applied Ecology 44, 703–713.

Krishna, C. 2006.*Estimating occupancy and assessing the influence of covariates on the distribution of the four horned antelope (Tetracerusquadricornis) in a South Indian tropical forest*. CWS and NCBS. Bangalore, Manipal University. M.Sc. thesis. 54 p.

Krishna, Y.C., Krishnaswamy, J. and Kumar, N.S., 2008. Habitat factors affecting site occupancy and relative abundance of four horned antelope. *J. Zool. (Lond.)* 276: 63–70.

Kunte, K. 1997. Seasonal patterns in butterfly abundance and species diversity in four tropical habitats in northern Western Ghats. Journal of Bioscience 22, 593–603.

Kunte, K. 2000. Butterflies of Peninsular India. University Press (India) Ltd., Hyderabad, India.

Kunte, K., Joglekar, A., Utkarsh. G. and Padmanabhan, P. 1999. Patterns of butterfly, bird and tree diversity in the Western Ghats. *Current Science.* 77: 577-586.

Kunwar, A., Gaire, R., Pokharel, K. P., Baral, S. and Thapa, T. B. 2016. Diet of the Four-horned Antelope *Tetracerus quadricornis* (De Blainville, 1816) in the Churia Hills of Nepal. *Journal of Threatened Taxa*. 8(5):8745-8755.

Lambeck, R. J. 1997. Focal Species: A Multi-Species Umbrella for Nature Conservation: Especies Focales: Una Sombrilla Multiespecífica para Conservar la Naturaleza. Conservation biology 11:849–856. Wiley Online Library.

Laurance, W. F., J. L. C. Camargo, R. C. C. Luizão, S. G. Laurance, S. L. Pimm, E. M. Bruna, P. C. Stouffer, G. B. Williamson, J. Benítez-Malvido, and H. L. Vasconcelos. 2011. The fate of Amazonian forest fragments: a 32-year investigation. Biological conservation 144:56–67. Elsevier.

Laurance, W. F., I. G. Warkentin, B. S. Halpern, C. V. Kappel, F. Micheli, and K. A. Selkoe. 2010. Habitat destruction: Death by a thousand cuts. Conservation Biology for All 73–87.

Leimgruber, P., J. B. Gagnon, C. Wemmer, D. S. Kelly, M. A. Songer, and E. R. Selig. 2003. Fragmentation of Asia's remaining wildlands: Implications for Asian elephant conservation. Animal Conservation 6:347–359.

McGuire, L. P. and Boyle, W. A. 2013. Altitudinal migration in bats: evidence, patterns, and drers. Biological Reviews, 88(4), 767-786.

Madden, F., and B. McQuinn. 2014. Conservation's blind spot: The case for conflict transformation in wildlife conservation. Biological Conservation 178:97–106. Elsevier.

Madhusudan, M. D., and C. Mishra. 2003. Why big, fierce animals are threatened: conserving large mammals in densely populated landscapes. Pages 31–55 *in*. Battles over nature: science and the politics of wildlife conservation.

Mandal, D., K. Basak, R. P. Mishra, R. Kaul, and K. Mondal. 2017. Status of leopard Panthera pardus and striped hyena Hyaena hyaena and their prey in Achanakmar Tiger Reserve, Central India. The Journal of Zoology Studies 4:34–41. <www.Journalofzoology.com>.

Mansfield, T.A. 1976. *Effects of air pollutants on plants*. Society for Experimental Biology Seminar Series, Cambridge.

Martin. A. and F. R. Barber. 1971. Some Measurement of loss of atmospheric Sulphur dioxide near foliage. *Atoms. Environ*. 5: 345-352.

Minz, K. A., A. Gupta, and S. S. Shaw. 2020. Diversity of bees along elevational gradient in different agro-climatic zones of Chhattisgarh. 8:1864–1867.

Mishra, P. P. 2009. Coal mining and rural livelihoods: case of the Ib Valley Coalfield, Orissa. Economic and political weekly 117–123. JSTOR.

Mishra, U. C. 2004. Environmental impact of coal industry and thermal power plants in India. Journal of environmental radioactivity 72:35–40. Elsevier.

Mooney, H.A., Lubchenco, J. Dirzo, R. and Sala O.E. 1995a Biodiversity and ecosystem functioning: basic principles. Pp: 279-325. In: Global Biodiversity Assessment (Eds) V.H. Heywood and R.T. Watson. Cambridge University Press, Cambridge. 1140p.

Newbold, T., J. P. W. Scharlemann, S. H. M. Butchart, Ç. H. Şekercioğlu, R. Alkemade, H. Booth, and D. W. Purves. 2013. Ecological traits affect the response of tropical forest bird species to land-use intensity. Proceedings of the Royal Society B: Biological Sciences 280:20122131. The Royal Society.

Ovaskainen, O., and I. Hanski. 2003. How much does an individual habitat fragment contribute to metapopulation dynamics and persistence? Theoretical population biology 64:481–495. Elsevier.

Phillips, S. J., R. P. Anderson, and R. E. Schapire. 2006. Maximum entropy modeling of species geographic distributions. Ecological modelling 190:231–259. Elsevier.

Porej, D., and Hetherington.T.E. 2005.Designing wetlands for amphibians: the importance of predatory fish and shallow littoral zones in structuring of amphibian communities. Wetlands Ecology and Management (2005) 13: 445– 455.http://www.d.umn.edu/~vbrady/WE_website/wetlands101/WE-readings/Porej2005.pdf

Powell, R. A. 2000. Animal home ranges and territories and home range estimators. L. Boitani and T. K. Fuller, editors. Research techniques in animal ecology. Columbia University Press, New York.

Project Elephant, G. of I. 2017. Synchronized elephant population estimation: India 2017.

Puri. G.S., Meher-Homji, V.M. Gupta and Puri S. 1983. Forest Ecology. Vol. I&II. Oford and IBH Publishing Co. New Delhi.

Rajvanshi, A., V.B. Mathur., G.C. Teleki and Mukherjee S.K. 2001. Roads, Sensitive Habitat and Wildlife: Environmental Guideline for India and South Asia. Wildlife Institute of Indian, Dehra Dun and Canadian Environmental Collaborative Ltd., Toronto. P 215.

Ramesh, T., Sridharan, N., & Kalle, R. 2011. Birds of Kuno Wildlife Sanctuary, Central India. *Zoos' Print*, 26(12), 25-29.

Rangarajan, M., A. Desai, R. Sukumar, P. S. Easa, V. Menon, S. Vincent, S. Ganguly, B. K. Talukdar, B. Singh, D. Mudappa, S. Chowdhary, and A. N. Prasad. 2010. Gajah: securing the future for elephants in India, The report of the Elephant Task Force. Ministry of Environment and Forests.

Rice, C.G. 1991. The status of the four horned antelope *Tetracerusquadricornis*. *J. Bombay nat. Hist. Soc.* 88: 63–66.

Ripple, W. J., J. A. Estes, R. L. Beschta, C. C. Wilmers, E. G. Ritchie, M. Hebblewhite, J. Berger, B. Elmhagen, M. Letnic, M. P. Nelson, O. J. Schmitz, D. W. Smith, A. D. Wallach, and A. J. Wirsing. 2014. Status and ecological effects of the world's largest carnivores. Science 343.

Ripple, W. J., T. M. Newsome, C. Wolf, R. Dirzo, K. T. Everatt, M. Galetti, M. W. Hayward, G. I. H. Kerley, T. Levi, P. A. Lindsey, D. W. Macdonald, Y. Malhi, L. E. Painter, and C. J. Sandom. 2015. Collapse of the world ' s largest herbivores. Science e1400103:3–12.

Sanders, P.J.W. 1976. *The estimation of pollution damage*. Manchester Univ. Press.

Sankhala, K. 1977.*Tiger! the story of the Indian tiger*. Rupa& Co. / Collins, London, UK.

Saxena. V.S. 1991. Afforestation a tool for Environmental improvement. In: Executive Development program on greening the township. Vaniki Prasshikashan Sansthan. Jaipur. 301- 015. Pp13-44.

Sergio, F., Marchesi, L. and Pedrini, P. 2004. Integrating indidual habitat choices and regional distribution of a biodersity indicator and top predator. Journal of Biogeography, 31(4), 619-628.

Schmitt, S., R. Pouteau, D. Justeau, F. de Boissieu, and P. Birnbaum. 2017. ssdm: An r package to predict distribution of species richness and composition based on stacked species distribution models. Methods in Ecology and Evolution 8:1795–1803. Wiley Online Library.

Scholz, F. 1981. Considerations about of air pollution resistance in polluted stands and consequences for correlated trails. *Arch Och. Srod*. 2:91-100.

Sharma, K., Rahmani, A.R. and Chundawat, R.S. 2009. Natural history observation of For-horned Antelope (*Tetracerusquadricornis*). *J. Bombay nat. Hist. Soc*. 106(1): 72-82.

Sharma, L. K., T. Mukherjee, P. C. Saren, and K. Chandra. 2019. Identifying suitable habitat and corridors for Indian Grey Wolf (Canis lupus pallipes) in Chotta Nagpur Plateau and Lower Gangetic Planes: A species with differential management needs. PLoS ONE 14:1–17.

Singh, A.P. 2010. Butterfly diversity in tropical moist deciduous sal forests of Ankua Reserve Forest, Koina Range, Saranda Division, West Singhbhum District, Jharkhand, India. *Journal of Threatened Taxa.* 2(9): 1130-1139.

Simberloff, D. 1998. Flagships, umbrellas, and keystones: Is single-species management passe in the landscape era? Biological Conservation 83:247–257.

Sinclair, A. R. E. 2003. the Role of Mammals As Ecosystem Landscapers. Alces 39:161–176.

Singh, R., P. K. Joshi, M. Kumar, P. P. Dash, and B. D. Joshi. 2009. Development of tiger habitat suitability model using geospatial tools - A case study in Achankmar wildlife sanctuary (AMWLS), Chhattisgarh India. Environmental Monitoring and Assessment 155:555–567.

Singh, R. K. 2002. Elephants in Exile: A Rapid Assessment of the Human – Elephant Conflict in Chhattisgarh.

Sisodia, A. 2019*a*. Butterflies (Lepidoptera : Papilionoidea) of Chhattisgarh , India .

Sisodia, A. 2019*b*. Confirmation of the presence of the Dingy Lineblue butterfly Petrelaea dana (De Niceville [1884]) (Lepidoptera : Lycaenidae) in Bastar , Chhattisgarh.

Sreekumar, P.G. and Balakrishnan, M. 2002. Seed Dispersal by the Sloth Bear (Melursusursinus) in South India. *Biotropica*., 34 (3): 474-477.

Stratford, J. and Sekercioglu, C. 2015. Birds in Forest Ecosystems. In Handbook of forest Ecology. Pp 281-296.

Syfert, M. M., L. Joppa, M. J. Smith, D. A. Coomes, S. P. Bachman, and N. A. Brummitt. 2014. Using species distribution models to inform IUCN Red List assessments. Biological Conservation 177:174–184. Elsevier.

Thatte, P., A. Joshi, S. Vaidyanathan, E. Landguth, and U. Ramakrishnan. 2018. Maintaining tiger connectivity and minimizing extinction into the next century: Insights from landscape genetics and spatially-explicit simulations. Biological Conservation 218:181–191. Elsevier.

Thondhlana, G., S. M. Redpath, P. O. Vedeld, L. van Eden, U. Pascual, K. Sherren, and C. Murata. 2020. Non-material costs of wildlife conservation to local people and their implications for conservation interventions. Biological Conservation 246:108578. Elsevier.

Tiple, A. D., and K. Ghorpadé. 2012. Butterflies (Lepidoptera—Rhopalocera) of the Achanakmar-Amarkantak Biosphere Reserve, in Chhattisgarh and Madhya Pradesh, with a synopsis of the recorded butterfly fauna of the eastern Central Highlands in India. Colemania 26:1–38.

Turner, I.M., Chia, K.S. Ong, J.S.Y., Soong, B.C. and Tan. H.T.W. 1996. A Century of plant species loss from an isolated fragment of lowlnd tropical rain forest. Conservation Biology. 10: 1229-1244.

United Nations Environment Programme, (2008). *Annual Report*. UNEP, Nairobi.

Vaidyanathan, S., J. Krishnaswamy, N. S. Kumar, H. Dhanwatey, P. Dhanwatey, and K. U. Karanth. 2010. Patterns of tropical forest dynamics and human impacts: Views from above and below the canopy. Biological conservation 143:2881–2890. Elsevier.

Vishwakarma, A., F. M. Anthony, S. Tiwari, and S. Choubey. 2020. Avifaunal Diversity of Winter Season in Kopra Reservoir of Bilaspur, Chhattisgarh, India. Proceedings of the Zoological Society. Springer India. <https://doi.org/10.1007/s12595-020-00349-z>.

Westman, W.E. 1985. Ecology, Impact Assessment and Environmental Planning. John Wiley & Sons. New York. 531p.

Whelan, C. J., Ç. H. Şekercioğlu, and D. G. Wenny. 2015. Why birds matter: from economic ornithology to ecosystem services. Journal of Ornithology 156:227–238. Springer.

Whelan, C. J., D. G. Wenny, and R. J. Marquis. 2008. Ecosystem services provided by birds. Annals of the New York academy of sciences 1134:25–60. Citeseer.

Wilcox, B.A. 1980. Insular ecology and conservation. In: An evolutionary – ecological perspective. (Ed). M.A. Saunders. Sinauer. Pp 95-117.

Wilcox, B.A, and Murphy D.D. 1985. Conservation strategy: the effect of fragmentation on extinction. American Naturalist. 125:879-887.

Willson, M. E 1993. Mammals as seed-dispersal mutualists in North America. *Oikos.*67: 59-76

ANNEXURE-1

Review comments on Wildlife Conservation Plan of Parsa East and Kete Basen (PEKB) Opencast Coal Mine and Washery project

1. Page no 7: The list of mammals in the management plan is underrepresented. Hasdeo Arand Coal Field comprising of Tara, Parsa, Parsa East and Kente Basan (PEKB) and Kente Extension and the landscape surrounding it supports many species of elusive mammals. The list needs to be updated carefully and there are spelling errors in S. No 7 where flying fox is erroneously typed as Rlying flox. Typo errors may be rectified. The table needs to be provide IUCN status and Schedules as per Indian Wildlife (Protection) Act, 1972 so as to emphasize and enhance conservation efforts to RET species.
5. Page no 8: The lists of herpetofauna and birds are underrepresented too. This needs to be reworked with latest information.
6. Page 11: Elephants are using many areas. The details provided with respect to elephants in the management plan need to be updated. Information may be obtained from the Forest Department who have compartment wise data for elephant occurrence in the landscape. A map needs to be prepared overlaying Hasdeo Arand Coal Field with elephant occurrence data to depict spatial distribution of elephants using this landscape.
7. **Page 11:** The proposed Lemru Elephant Reserve falls within 10-km of the ER (please refer page-21 of the management plan). Similarly, tigers infrequently use the landscape. These needs to be elaborated and explained in detail.
8. **Page 16:** Under general protection measures, plantation of suitable species is proposed. It is essential to list down what species are proposed to be planted. Efforts should be made to do plantation only in appropriate places. Plantations should not be done in the grasslands in the area. Also only native trees provided in the impact mitigation chapter (Chapter-8) of the report needs to be planted. All the technical aspects of land preparation, planting, after care, and management need to be carried out with the well experienced (at least 10 years) restoration and forestry expert/plant taxonomist. Monoculture plantations should be avoided so as to have a heterogeneous habitat to facilitate re-colonization the faunal species from adjacent protected forests.
9. **Page 18:** Under soil and moisture conservation works, it is essential that the areas where earthen check dams, pucca check dams, water holes will be created needs to be provided with GPS coordinates. Suggestions of wildlife experts and forest department officials have to be sought while construction of water holes for suitable location and structural design to facilitate smooth usage of wildlife animals. Unplanned water hole management can have negative feedback on the habitat and can turn counterproductive. There are examples of poorly designed and built check dams in perennial streams leading to drying up of streams. It is suggested to carry out compartment-level field assessment of water availability so as to come up with a comprehensive plan to augment surface water in HACF.
10. **Page 18:** It is proposed that open areas will be planted. If these are critical grassland areas these should be avoided. Plantations should only be carried out in degraded forest areas.
11. **Page 19:** In habitat management prescriptions, there is lot of emphasis on weed management. The weed management is an important issue however; it is not a priority in the landscape at this moment.

Weeds are the result of variety of disturbances to the habitat. Weed removal and management is only a symptomatic treatment of the issue of habitat degradation. Efforts to reduce habitat disturbance would control weeds. Invasive plants, although a major threat to biodiversity do not appear to be a problem of high concern. Weeds could at least provide some cover for wildlife. Thus, the focus should be on reducing physical disturbances to the habitat in the first place. Efforts to reduce physical disturbances to the habitats would go a long way in reducing/controlling spread of weeds. Further, weed management can be taken up only in a few micro-habitats like the grasslands to augment wild ungulate numbers.

12. **Page 23:** While villagers should be educated how to guard their crops safely from elephants, the major efforts with respect to elephant conflict management will have to be handled by the rapid response teams (RRTs) which needs to be created and trained by the forest department.
13. **Page 20:** Grassland development suggestions provided are inadequate. It is noteworthy that the CG Forest Department has already initiated grassland restoration activities in certain areas. For this purpose, they have initiated partnership with leading grassland specialists. While grassland development is an absolute priority to augment depressed ungulate populations, identifying grasslands and ways to manage them should be done very carefully. Experimentation of grassland restoration is critical before investing funds for grassland management at large spatial scales. It is recommended by WII that grassland restoration should be done with active collaboration and guidance from leading grassland practitioners. The forest department in the neighboring state of MP is renowned for managing and restoring grasslands. CG FD should try and tap the expertise that is available with MP FD for grassland restoration.
14. **Page 24:** The research, monitoring and evaluation does not have any substance and needs clear elaborations as what exact research, monitoring and evaluation will be carried out. As it is a management plan, everything needs to be planned prior to implementation of the plan.
15. **Page 25:** A detailed table containing yearly work plan for each of 20 years have to be given in a table format. It is unclear as what will be done in which year. It is also pertinent to assess the effectiveness of the management interventions periodically. It is suggested the log frame approach may be used as an evaluation tool as it can assess goal, purpose, outputs and activities are clearly spelt out with objectively verifiable indicators, sources and means of verification and assumptions needs to be tabled.
16. **Page 28:** The budget calculation is very minimal and needs to be enhanced. Only 30 lakhs have been allocated for a period of 20 years and this needs to be substantially increased. A biologist and sociologist needs to engaged for continuous monitoring of biodiversity and socioeconomic aspects throughout the duration of plan period.
17. **Overall comments:** The wildlife conservation plan of PEKB opencast coal mine and washery project is a not so exhaustive work. Wildlife conservation is a multidisciplinary discipline and hence the plan can be improved by considering the following aspects and integrating in the plan:
    - **a.** Inventory, data collection and monitoring needs to be done scientifically in the area. As of now it is not evident how these inventories were made and what methods were used while collecting this field data.
    - **b.** Background information and attributes including boundaries, geology, rock, soil, terrain, climate, water sources, wildlife significance of the area, biogeographic, landscape and forest significance of the area, corridors, linkages, viable populations, limiting factors, Rare, Endangered and Threated Species, Schedule I species under IWMPA, threats to communities, species, habitats,

ecological process and functions, critical habitats (nesting areas of birds, macro habitats), stakeholders in the landscape and forest resource dependency, intensive land uses within the landscape, people participation, eco-development, resource dependency of local people, people-wildlife interface issues, wildlife conflict (loss of lives/injuries/structural damages etc), location of villages, socioeconomic details of villages, details of village relocation, detailed relocation and rehabilitation plan, forthcoming major projects/land use change, if any within the landscape and wildlife health issues needs to be elaborated and provided in the plan.

c. The Human-Elephant conflict mitigation strategies in the HACF and surrounding landscape should include the following:

1. Maintaining the ecological integrity of intact natural habitats without fragmentation and degradation is critical. Any additional mining leading to loss of habitat would escalate HEC unpredictably high
2. Formation of landscape-level Rapid Response Teams by engaging village youth with adequate remuneration is essential. The RRT members should be adequately trained in elephant behaviour and conflict management methods.
3. Judicious use of mobile barriers in select areas of HACF and surrounding landscape where HEC is high need to be experimented with active community participation.
4. Ex gratia payment for crop, property and other losses due to elephants have adequate and timely. The overall process of filing and obtaining compensation by villages should be made smooth and transparent
5. Habitat enrichment by improving surface water availability in carefully selected locations, development of grasslands and fodder base based on the list of plants suggested in the report and protection of critical micro-habitats such as riparian tracts are critical
6. Human-elephant conflict is dynamic in nature. The above mentioned mitigation measures need to be experimented in smaller areas and based on the evaluation of efficacy can be scaled up.

ANNEXURE – 2

Mine closure plan on biological component

As envisaged in the ToR, the Mine Closure Plans (MCP) have been reviewed. The biodiversity conservation aspects have not been dealt in detail and as such the plans are basic and generic without specific inputs. In view of this, suggestions to improve the MCP by incorporating biodiversity considerations in the plan have been provided below:

1. Introduction

Mine closure planning refers to the process for ensuring that mining operations are closed in an environmentally and socially responsible manner, usually with the overarching objective of ensuring sustainable post-mining land uses. Mine closure plan should consider a whole-of-mine-life perspective and address all aspects of closure, not just those relating to biodiversity conservation and rehabilitation. Closure implementation involves rehabilitation and pollution prevention measures to ensure that post-closure objectives are achieved, by implementing and monitoring the mitigation recommended to address the impacts visualised on physical, biological and social environments of the project area.

Based on the pre-mining biodiversity values, closure planning will need to consider whether these can realistically be replaced, using recognized good practice rehabilitation methods with adaptive management. The information needs to be viewed from an ecosystem perspective and take account of aspects such as floral, faunal communities, habitats, key indicator species, stakeholder aspirations and rare, threatened or endemic species.

The major environmental issues of any given mine project on three the major environmental components are: 1. **physical environments;** land/soil, water and air (dust, noise and gas emission) and these impacts are directly and indirectly impact upon the 2. **biological environments** (flora, fauna and habitats), and **3**. **social values** of the local community (dependency of forest and non -forest resources and livelihood) who's access to the dependency on forest resources denied from the day one of the mine planning. Hence the mine closer plan starts as progressive plan with the start of mining.

2. Impact identification and evaluation

Mining has the potential to affect the biodiversity values of the project area both directly and indirectly throughout the life cycle of a project which includes: 1. Project development or planning, 2. Project operation, and closure plan. In general, impact assessment methods argue that the foremost step in impact appraisal must consider and identify project actions that are likely to bring significant changes in the project environment which include: physical, biological and social environments. Though, the impacts of mining of those three environmental components start from the project development stage, the PEKB being an ongoing project the impacts identification focused predominately on the biological components with the understanding of all kinds of nature of the project (project type, resource requirement, infrastructure, technology involved and existing management interventions. In addition, only selected impacts of physical environments which are likely to impact directly on the biodiversity and social values (dependency on biodiversity resources) are identified and listed below (**Table 1**) and suggestions have been made for mitigation and management.

Table1. Summarised identified and evaluated impacts on biological attributes

Components	Sub-components	Magnitude of Impacts
Land/Habitat	Loss of forest habitats and biodiversity	high
	Loss of non-forest land and associated biodiversity	high
Water	Direct loss of aquatic ecosystem (wetland) and biodiversity	moderate
	Hydrological regime – surface water pollution	moderate
Air	Air pollution- dust and oxides on forest and fauna	low to moderate
	Fugitive emission from coal handling	low to moderate
Noise	Noise – drilling, blasting and vibration on faunal groups	moderate
	Hazardous and domestic waste disposal – impact on forest and river system	moderate
Waste Dump	Mine waste dumps and impact on physical and biological resources	low – visual impact
Transportation – **Vehicle movements**	Unregulated vehicle movement - road mortality on selected faunal groups	low to moderate
Transportation – **Conveyor belt**	Impacts of conveyer belt on the forest habitat and associated fauna	low level
Labor force	Labour force related biotic pressure	moderate
Threatened flora and fauna	Impacts of project activities on threatened faunal species	Flora – low to moderate Faunal specific – high

3. Suggested Mitigation for Mine Closure

"Mitigation Measures," refer to the action that can be implemented to minimize the magnitude of the project related detrimental impacts on different physical, biological and social attributes of the project area through three possible courses of actions, either by changing (1) at source, (2) path and (3) at the receiving end. Rehabilitation refers to the process that is carried out to return the mined-out land to agreed post-closure uses. However, this being the ongoing project, it completely recognizes that impacts on biodiversity have occurred due to operational phase and management interventions. Biodiversity enhancement refers to measures undertaken to enhance or improve biodiversity – to go beyond mitigation or rehabilitation and explore opportunities to enhance the conservation of biodiversity of the project area.

Mitigation are implemented on need basis considering the hierarchy of their desirability: **Avoiding impacts** by modifying some activities to prevent or limit a possible impact, which is highest priority that should always be afforded in mitigation., **Minimising impacts** by implementing decisions that are designed to reduce the unwanted impacts of a proposed activity on biodiversity., **Rectifying impacts** by rehabilitating or restoring the affected environment., and **Compensating** for the impact by replacing or providing substitute resources or environments, which is a last option and might include so-called **offsets** (GPG-ICMM 2006).

This mine and coal washery plant of PEKB being ongoing project, the project proponent (Rajasthan Rajya Vidyut Utpadan Nigam Ltd., RRVUNL- Rajasthan) is practicing well structure mitigation/management plans to address the project impacts on physical, biological and social values of the project area with more of towards technical and managerial interventions.

Nevertheless, the mitigation measures suggested under this study are to minimizing the even low – moderate levels of impacts visualised into insignificant level by suggesting more of biological interventions to scientifically strengthen the existing restoration and reclamation plans. The followings are the summarised mitigation plans suggested under this study **Table 2.**

Table 2. Summarised mitigation measures recommended on biological attributes

BIODIVERSITY IMPACT/RISKS	RECOMMENDED MITIGATIONS	DESIRABLE OUTCOME
1. Loss of forest habitats and biodiversity	**1. Progressive Restoration:** 1. Eco-restoration of Compensatory Afforestation Sites" OR 2. Refilled Mine pit areas	To improve the habitat quality of and overall floral and faunal biodiversity enhancement
2. Loss of non-forest land and biodiversity	**2. Natural Resource Development:** 1. Development of Grass and Leaf fodder plots 2. livelihood options to increase income sources	Mitigate the biotic pressures on the adjacent forest habitat – outside mine lease

3. Hydrological regime – surface water pollution	**3. Biological interventions:** 1. Bio-filter Check Dams- Stream of Project sites	Minimise Mitigation to address soil erosion and mine sedimentation and aquatic pollution
4. Air pollution-dust and oxides emission on forest and fauna	**4. Green Belt Development –** 1. Phytoremediation safety zones 2. Site service areas	Minimise all air pollution (Dust, Noise and Oxide – Climate stability at local level
5. Impacts of air pollution- fugitive emission	**5.1 Development of "Green Gallery Belt"** **1. Coal handling and Washery areas**	Mitigate and fugitive emission of coal handling areas - Climate stability at local level
6. Mine waste dumps and impact on physical and biological resources	**6. Eco-restoration of waste dump -** **1. Waste dump – Forest habitat**	Ecological restoration of mine dumps to enhance the biodiversity loss and minimise the visual impact
7. Transportation Vehicle movement	**7. Technical and Regulatory Mechanism** 1. all supporting roads	Construction of Underpasses to minimise road mortality on selected fauna as nil impact

4. Suggested Biodiversity Conservation Plan for Mine closure

Biodiversity conservation being integral part of this study, and one of the project objectives, in addition to impact identification, and suggesting mitigation measures, action plans for biodiversity conservation have been suggested. This study identified a total 14 threatened faunal species and 13 threatened flora species within the project study area (core and buffer zone) and considering the WII survey report, this threatened species list increased to 22 faunal species. The biodiversity conservation and management plan (BCMP) suggested are grouped under three major heads 1. Species specific group conservation through habitat – niche development for butterfly, reptiles, nest boxes for birds and habitat for selected small mammals. 2. Conservation plan for threatened mammals again enhance the food resources of three major herbivore including the umbrella species of the endangered elephants and 3. Biodiversity Resource-People's use value. Therefore, the following Biodiversity conservation plans are recommended in mine closure plan as BMCP-Action Plan (**Table 3**). Since these plans are aimed to conserve the threatened fauna and flora most of the plans are experimental basis plans, it is recommended to implement these within the lease as well as the adjacent forest habitats.

Table 3: Suggested BCMP Action Plans- Threatened biodiversity and People's use values

Biodiversity Conservation and Management Plan (BCMP) – Action Plans	
BCMP-Components	**Action Plans**
1. BCMP- SPECIES GROUP SPECIFIC CONSERVATION PLAN	
1.BUTTERFLY HABITAT	Development of butterfly habitat only within the selected mine lease area restored under the control of mine administration (1. Mine lease and Human Habitation

	areas (1. Site Offices, 2. Township /colony 3. School premises)
2. "REPTILE HABITAT NICHE"	Reptile habitat niche - core zone- protected and restored mine pits Five adjacent forests patches in the buffer zone
3. NESTING NICHE (NEST BOX) - HOLE NESTING BIRDS	1. Reclaimed Mine lease area- restored dumps with well-established canopy spread 2. Green belt area and 3. Township-Guesthouse/Colony area
4. DENNING NICHE - SMALL MAMMALS	1. Mine lease-dumps and 2. Protected Forest - Denning niche for selected small mammal Species
5. WETLAND HABITAT	1. Two mine-pit wetlands – well settled refilled mine pit area - conservation of Aquatic fauna amphibian, fishes and aquatic birds
2. BCMP- CONSERVATION OF THREATENED PLANT & ANIMALS	
6. THREATENED FLORA	1. Threatened Floral Conservation plot- within the lease 2. Development of Herbal Garden – selected villages
7. THREATENED FAUNA	1. Status survey of hepetofauna, birds of prey, small mammals.
8. THREATENED FAUNA	1. Sloth Bear - Food plant development 2. Four horned antelope – Food plant development 3. Elephant – Food plant development
3. BIODIVERSITY RESOURCE- PEOPLE'S USE VALUES	
9. LIVELIHOOD AND LIFE QUALITY IMPROVEMENT	1. Vegetable and Fruit - Organic farming Program 2. Apiculture - Honey-Bee Farming 3. Aquaculture – Village level Fish Farming 4. Awareness education

5. Existing Mine Closer Plan.

This ongoing project is practicing different management plans and under different heads and the same have been incorporated in the existing Mine closure. The major heads of the mine closure plan include 1. Dismantling of infrastructure, 2. disposal/rehabilitation of mine machinery 3. safety and security, 4. filling of void, 5. top soil management, 6. technical and biological reclamation of mined out area. 6. landscaping and plantation 7. post mining water quality management, 8. post mining air quality management 9. manpower cost and supervision and other. Under the mine closure plans involving technical and biological reclamation of mined out area, landscaping and plantations would support more towards floral and faunal recovery rather than just mitigating the impacts on physical environment and detailed in **Table 4.**

Table 4. Existing mine closer plan – Biological Reclamation

Heads	Particulars
Technical and biological reclamation of mined out area,	Terracing, Blanketing with soil and vegetation of external dumps
	Vegetating of infrastructure, road, rationalization area
Landscaping and plantation	Peripheral road, gates, view point, cemented steps on bank
	Beautification and landscaping of over dumps
	Plantation

The documentation on dump reclamation and plantation details shared by the project proponent showed that, they have established well facilitated company owned plant nursery site (manpower, watering facilities) and intensive plantation activities are in progress. The geo-matting and tree spading are the latest techniques in implementation (**Plate 1**). The plantation details showed they use diverse tree species of 41 species and from 2012-13 to 2018-19 a total of 3,04,465 trees have raised and the they have been well established with high survival rate. However, in many patches of plantation done with single species as monoculture (*Tectona grandis, Dalbergia sissoo, Delonix regia, Azadirachata Indica, Peltophorum Pterocacarpum* and exotic species *Acasia auriculifarmis* in the reclamation area.

Plate 2 Plantation activities in PAKB Mine Project site

6. Ecological Approach in Mine Closure Plan

It is well known fact that, plants can act as bio-filter agent to control air related pollution problems. It has been widely discussed the role of plant species in controlling the accumulation of dust and gaseous emissions, respect to tree size and shape and leaf structures and foliage area (Martin and Barber 1971, Das 1981, Giridhar and Chaphekar 1983 and Chaphekar 1994). According to Martin and Barber (1971) green belts developed, within their tolerant limits, can remove up to 70% of gaseous pollution from ambient air.

Carbon storage in forest ecosystem occurs in components including biomass carbon and soil carbon. Due to the large areas of coverage by forests (global or regional) forest soil is an important component of the global carbon cycle (Detwiler and Hall, 1988; Bouwman and Leemans, 1995; Richter *et al.,* 1995; Sedjo, 1992 and Jabaggy and Jackson, 2000). Changes in land use patterns can lead to perturbations in ecosystem and this in turn can influence carbon cycle. It is one of the non-use values need to be addressed in the prevailing climate change context specifically in the plantation areas. Further, species perform diverse ecological functions, but the variety of function that a species can perform is limited and consequently ecologists frequently have proposed that an increase in species richness also increases functional diversity, and thereby increase ecological stability (Tilman *et al.* 1996).

Therefore, considering the basic concept of eco-restoration in mind and its multi-functional values, the mitigation measures suggested to address the impacts identified on biodiversity values and strongly recommended to incorporate in the mine closer plan not only to restore the area and bring it into the action plan for the conservation of biodiversity values and thereby make the project as ecologically sustainable project.

7. Recommended mitigations and action plans for the mine closer

This section discusses how the suggested mitigation and management interventions likely to enhance the overall biodiversity values, in addition to focused minimizing the project related impacts. Among the

7 mitigations and action plans recommended the following five biological interventions expected to improve the floral and faunal biodiversity of the project study area.

1. **Eco-restoration of Compensatory Afforestation Sites OR Refilled Mine pit area**
2. **Natural Resource Development: Grass and Leaf fodder plots**
3. **Green Belt Development – Phytoremediation**
4. **Bio-filter Check Dams- across the streams of Project sites**
5. **Eco-restoration of waste dump**

Those above listed mitigations are focused to improve the effectiveness and to bring down the magnitude of impacts to very minimal level and more importantly would facilitate and enhance the faunal biodiversity of the study area as per the compliance with the Sustainable Development principal 7 of ICMM (2006) and Performance Standard 6 of IFC World Bank Group (2012).

7.1. Eco-restoration of Compensatory Afforestation Sites OR Refilled Mine pit Areas

As per land use pattern of PEKB site showed, out of 2682.856 ha of area acquired, 1871.118ha was forest land and shared 70% of the total mine lease area. Conversion of large extent of forest land and loss of associated faunal biodiversity suggested to restore the at least 500 ha of the land under the eco-restoration concept using diverse and native tree, shrub and climber species to enhance the local faunal biodiversity

7.1.1. Eco-restoration Action Plan

1 It is suggested to restore 500 ha of forest land identified for compensatory afforestation under the compliance of environment clearance or the same extent of area within the refilled mine pit area

2. Based on Important Value Index (IVI) estimated for the tree and shrub species 25 tree and 15 shrub species suggested for restoration plan.

3. Eleven woody climbers have been suggested to include in this plan and the plants list is given in **Table 5, Table 6 and Table 7.**

4. This restoration should be planned progressively with the mine planning at the rate of restoration of 25 ha/year in the next 20 years (tentatively) to compensate the loss of habitat and improve the faunal diversity of this region.

Table 5: List of tree species suggested for Eco-restoration of compensatory afforestation sites or Refilled Mine pits of PEKB

S.no	Scientific name	Local Name	IVI
1	*Shorea robusta*	Sal	108.50
2	*Madhuca indica*	Mahuwa	39.15
3	*Diospyros melanoxylon*	Tendu	26.95
4	*Buchanania lanzan*	Char	22.94
5	*Anogeissus latifolia*	Dhaura	17.66
6	*Boswellia serrata*	Saliha	11.27
7	*Ficus bengalensis*	Bargud	9.66

8	*Eugenia heyneana*	Jamli	9.63
9	*Lagerstroemia parviflora*	Sidha	7.90
10	*Phyllanthus embelica*	Awala	7.31
11	*Adina cardifolia*	Karmi	5.61
12	*Terminalia tomentosa*	Saja	4.83
13	*Semecarpus anacardium*	bhelwa	4.26
14	*Garuga piñata*	Kenkarn	4.09
15	*Bridelia retusa*	Kasayi	3.81
16	*Symplocus racemosa*	Lodli	3.43
17	*Terminalia chebula.*	Harra	2.16
18	*Odina wodier*	Gunja	1.80
19	*Gardenia latifolia*	Mali	1.76
20	*Albizzia procera*	Kari	1.60
21	*Delbergia paniculata*	Dhobia	1.41
22	*Ougenia dalbergioides*	Tilsa	1.18
23	*Terminalia bellerica*	baira	1.12
24	*Schleichera trijuga*	Kusum	1.07
25	*Casearia graveolens*	Chilhi	0.86

Table 6: List of Shrub species estimated IVI and suggested for Eco-restoration of compensatory Afforestation sites OR Refilled Mine pits of PEKB

S.no	Scientific name	Local name	IVI
1	*Flacourtia indica*	Ramkonyi	40.82
2	*Woodfordia floribunda*	Dhawayi	36.08
3	*Butea monosperma*	Parsa	22.28
4	*Elaeodendro glaucum*	Jamrasi	18.21
5	*Thespesia lampas*	Masbundi	12.98
6	*Ipomoea carnea*	Ipomoea	6.89
7	*Phyllanthus emblica*	Awala	6.63
8	*Asparagus racemosus*	Asparagus	5.84
9	*Desmodium palchellum*	Chipi	5.84
10	*Helictorus isora*	Aelhi	5.84
11	*Embelia robusta*	Phodo	5.81
12	*Dendrocalamus strictus*	Bans	2.92
13	*Antidesma diandrum*	Saroli	2.02
14	*Ricinus communis*	Arandi	2.02
15	*Ziziphus xylopyrus*	Dhonta	NA

Table 7: List of Woody climber recommended for Eco-restoration of compensatory afforestation sites or refilled mine pits of PEKB

Sl. No	Scientific Name	Local Name	Habit
1	*Abrus precatorius*	Kwunti	Climber
2	*Acacia caesia*	Guriyar, Garur	Woody Climber
3	*Acacia pennata*	Arel	Climber
4	*Alangium salvifolium*	Akol	Climber
5	*Bauhinia vahlii*	Mahul	Climber
6	*Butea superba*	Nar parsa	Climber
7	*Caesalpinia bonducella*	Gataran	Woody Climber
8	*Celastrus paniculata*	Unjain	Woody Climber
9	*Ceropegia bulbosa Roxb.*	Bosiy kandha	Climber
10	*Cissus quadrangularis*	Hathjod	Climber
11	*Cryptolepis buchanani*	Dudhnar	Climber
12	*Derris scandens*	Nakuwa kandha	Woody Climber
13	*Dioscorea bulbifera*	Agitha	Climber
14	*Ipomea mauritiana*	Patal kohra	Woody Climber
15	*Marsdenia tenacissima*	Chikti	Climber
16	*Spatholobus roxburghii*	Bendo	Woody Climber
17	*Tinospora cordifolia*	Gurudhi	Climber
18	*Vallaris solanacea*	Dhudhiyakandha	Woody Climber
19	*Ventilago madraspatana*	Kyonti, Keuti	Woody Climber
20	*Vitis carnosa*	Dhokarbela	Woody Climber
21	*Vitis latifolia*	Dhokarbela	Woody Climber
22	*Ziziphus rugosa*	Churaban, churna	Woody climber

7.2. Natural Resource Development:

The conversion 1871.158 ha of forest land includes 241.607 ha of two types of revenue forests under seven villages. To mitigate the impacts of biotic pressure into the adjacent forest habitat due to loss of revenue forest of the seven villages, it is recommended to develop selected natural resources like grass and leaf fodder plots.

7.2.1 Grass and Leaf fodder plots - Action Plan

15. It is proposed to develop 35 ha of "**Grass and leaf fodder" plots (GLFP)** within the village areas of seven villages shared their revenue forest: Salhi, Hariharpur, Parsa, Kente, Ghatbarra, Parogiya and Basan
16. Each village should develop five ha with a total of 20 ha in the first two years while rests of 15 ha in the 3rd and 4th year.
17. Twelve grass species are recommended to grow in the grassland development plan. This list includes 10 species reported in the core zone while all the 12 from the buffer zone of the study area (**Table 8**). Local villagers have to be consulted to use more palatable grass species.
18. In addition, 50 ha of fodder plots at the rate of 10 ha/year within 2127.555 ha of backfilled area in five different locations suggested with 10 ha each from the sixth to till 10th year.

19. Grow 16 leaf fodder tree species suggested with the distance of 2m between the trees and rows so that, 2-4 rows can be grown (**Table 9**). The leaf fodder tree species prepared based on the literature (Hocking 1993) considering high fodder values and growth rate.
20. Grass and leaf fodder development plan should be initiated through CRS department and sustainably managed by the Village Fodder Committee – VFC formed under CSR division

Table 8: List of Grass species suggested for the development of Grass fodder plots

S. No	Scientific Name	Local Name	S. No	Botanical Name	Local Name
1	*Andropogon contortus*	Sukra, Churant	7	*Eragostis tenella*	Bhur bhusi
2	*Apluda varia*	Phuliban	8	*Eulaliopsis binata*	Bagayi
3	*Cynodon dactylon*	Doob	9	*Imperata cylindrica*	Chhir ban
4	*Desmostachya bipinnata*	Kush	10	*Ischaemum pilosum*	Kunda
5	*Dichanthium annulatum*	Biri ban, marbal	11	*Saccharum spontaneum*	Kansa
6	*Echinochlou colonum*	Sawa, sama	12	*Sehima sulcatum*	Sedu

Table 9: List of Tree species suggested for the development of Fodder plots

S.No	Scientific Names	FV	GR	PO		S.No	Scientific Names	FV	GR	PO	
				1st	2nd					1st	2nd
1	*Acacia catechu*	5	5		@	9	*Boswellia serrata*	6	7	@	
2	*Holoptelia intergrifolia*	3	5		@	10	*Butea monosperma*	4	5		@
3	*Ficus religiosa*	7	8	@		11	*Cassia fistula*	3	7		@
4	*Madhuka indica*	5	4	@		12	*Dichrostachys cinerea*	6	6	@	
5	*Pongamia pinnata*	6	6	@		13	*Diospyros melanoxylon*	4	6		@
6	*Anogeissus latifolia*	5	4		@	14	*Ficus bengalensis*	6	7	@	
7	*Syzygium cumini*	7	6	@		15	*Terminalia arujuna*	4	7		@
8	*Bauhinia variegate*	8	8	@		16	*Terminalia bellerica*	4	7		@

7.3 Bio-filter Check Dams- Stream of Project sites

In addition to the existing surface water pollution mitigation plan with toe wall and garland drainage and filter ponds around the mine waste dumps, treating of oil spillage from the workshops with oil trap and domestic sewage with ETP, it is suggested to construct 15 bio-filter check dams across the stream leading from the mine boundary and act as micro catchment of Parsa nalla which is conferencing Atem river in the north as biological intervention.

7.3.1 Bio-filter Check Dams – Action Plan

1. Fifteen bio-filter are recommended to construct across the streams leading from the mine lease

boundary using loss boulder.

2. Wider the streams 2-3 on either side till 20 to 30m in the upstream to increase the water holding capacity and incorporate locally available aquatic sedges to increase the filtering efficiency.
3. Regular monitoring of the downstream water quality of these check dams/bio-filter dam sites is essential. This water quality monitoring will be done with the ongoing water quality monitoring and management plan

7.4 Green Belt Development – Phytoremediation

Air pollution due to Suspended Particulate Matter and gaseous pollutants (NOx, SO_2 and CO2) generated due to all the mining activities related to excavation of ore (land clearing, drilling, blasting, crushing and processing and use of heavy earth moving machinery) are common and inevitable. In spite of all the mitigation measures are in practice, development of Greenbelt under phytoremediation suggested to minimise the impact at insignificant level with selected tree species.

7.4.1 Green Belt Development – Phytoremediation- Action Plan

1. A total of 39 tree species have been identified and selected from different sources based on their efficiency of air pollution control/tolerance performance.
2. This list included 24 were identified as good dust capturing species 17 species to minimize noise, while seven species would absorb gaseous emission.
3. According to the mine lease afforestation program, the active mine area i.e, the safety zone, waste dumps and washery areas are recommended to plant totally 29 species which are predominately dust tolerant species (**Table 10**).
4. The roads under the use of mine's vehicles; should be planted with 20 species suggested for mine roads. This species will efficiently control noise (17 species) and absorb gas emission 7 species) as well as dust tolerant species
5. Since plantation activities is in progress, it is strongly recommended to include all the 39 species and plant them with specific species in specific sites.

Table 10: Tree Species Suggested for Green Shelter Belt Plantation to Control Air Pollution Impacts- PEKB project sites

S. No	Species Name	Local Name	S1	S2		S3-CPCB	Location -Proposed			
			DC	NC	OEO	PT	AM	RD	AS	O/R
1	*Acacia catechu* **					Sd	*			
2	*Aegle marmelos* **	Bel, Bili Patra,	18.9	NC		Sd/Rc	*	*	*	
3	*Albizia lebbeck*	Siris, Karo Sirish	18.3	NC	GE	Sd	*	*	*	*
4	*Albizia odoratissima***					Sd	*	*		
5	*Albizia procera* **					Sd	*	*		
6	*Alstonia scholaris*	Satani	25.39	NC	GE	Sd	*	*		
7	*Anogeissus latifolia***					Sd	*			

8	*Annona squamosa*	Jamfal	12.09			Sd	*	*	*	*
9	*Azadirachta indica*	Neem	25.54	NC	GE	Sd	*	*	*	*
10	*Bauhinia variegate* **	Kanchnar	18.58			Sd	*	*	*	*
11	*Buchanania lanzan* **					Sd	*			
12	*Butea monosperma* **	Palas, Kesudo	24.44	NC		Sd	*	*	*	
13	*Cassia fistula* **	Amaltas **	23.03			Sd	*	*	*	
14	*Citrus aurantium*	Nebu	15.59			Sd/Ct	*	*	*	*
15	*Dalbergia latifolia* **					Sd	*			
16	*Dalbergia sissoo* **	Shesham **	17.02			Sd	*	*	*	*
17	*Delonix regia*	Gulmohar	18.05			Sd	*	*		*
18	*Diospyros melanoxylon* **	Tendu		NC		Sd/Rs	*	*	*	
19	*Ficus benghalensis* **	Banyan, Vad	7.72	NC		Ct/Sd	*	*	*	*
20	*Ficus racemosa*	Pipal		NC		Ct/Sd		*		
21	*Ficus religiosa* **	Peepal, Piplo	12.94	NC	GE	Ct/Sd	*	*	*	*
22	*Holoptelia integrifolia*	Kanjo, Papada	35.01			Sd	*	*	*	
23	*Madhuca longifolia* **					Sd	*	*		
24	*Mallotus philippensis*	Kamala				Sd	*			
25	*Mangifera indica* **	Mango, Aam	12.25			Sd	*		*	*
26	*Manilkara zapota* **	Chikkoo	16.39			Sd				*
27	*Melia azedarach*	Melia, Bakani Nim	31.77	NC	GE	Sd		*		*
28	*Phoenix sylvastris*	Khajur	32.07	NC		Sd			*	
29	*Polyalthia longifolia*	Ashoka,	29.84	NC	GE	Sd		*		*
30	*Pongamia pinnata*	Karanja		NC		Sd		*	*	*
31	*Psidium guajava*	Amrood,Jamphal	13.33			Sd/Ct				*
32	*Syzygium cumini* **	Jamun, Jambu	14.39	NC		Sd		*		*
33	*Tamarindus indica*	Imli		NC		Sd		*		*
34	*Tectona grandis* **	Teak, Sag,	14.94			Sd	*	*		
35	*Termanilia catappa*	Desi Badam	30.12	NC					*	*
36	*Terminalia arjuna* **	Arjun Sadad	30.54	NC	GE	Sd/Ct	*	*		
37	*Terminalia bellirica* **	Bahera				Sd/Ct	*	*		

38	*Terminalia chebula* **					Sd	*	*		
39	*Terminalia tomentosa* **					Sd	*	*		
	Total		**24**	**17**	**7**	**38**	**29**	**29**	**17**	**19**
AM - ACTIVE MINE LEASE AREA		Mine peripheral areas-safety zones, around external dumps, washery area, along the conveyor belt.								
RD – Roads		Permanent internal mine roads, access/approach roads outside the lease area								
AS – Area of site services		workshops, storage godowns, Domestic/industrial waste dumping sites, Canteen, HEMM – parking area etc.								
O/R- Office and Residential area		Site office, Guest house, colony, School etc								

**** Species reported in the study area, DC-Dust capture, NC –Noise control, OE –Absorb Gaseous emission, Pt-Planting techniques Sd –by seeds, Ct- by Cutting, Rt –Root cutting, Rs-By Root sucker, AM – active mining area, RD – Roads sides, AS- Areas of Site services, (Storage and Processing area), O/R – Office and Residential area, S1-Source of literature -Anon 2005, S2 - Saxena 1991. S3 – CPCB/ PROBES/75/1999-2000**

7.5 Development of "Green Gallery Belt"

Fugitive emission is one of the common pollution problems in coal mining and that need to be handled very effectively in addition to all the existing technical interventions. Hence it is suggested to develop green gallery belt in and around the coal handling areas with at most care by planting suggested plant species dust emission simply following the spacing of the different size of the species in the prescribed manner.

7.5.1 Development of "Green Gallery Belt" – Action Plan

7. To develop three layers Green Gallery Belt (GGB) 22 woody shrub species selected and those species should be planted in the inner line as ground layer with close distance of 0.5m gap between the shrubs (**Table 11**).
8. Among the 39 tree species suggested for Green belt development, only 22 dust capturing trees are selected and suggested for GGB plantation (**Table 12**).
9. Within the tree list 10 small or medium size tree species are suggested to plant in the middle layer to develop middle canopy layer, while the rests of 12 larger and tall tree species to grow in the outer layer as top canopy.
10. All those 22 shrub suggested, small and tall trees have to planted three staggered rows as shown in plate to get the gallery effect and to efficiently capture the coal dust.

Table 11: List of Shrub species selected and suggested to develop GGB and mitigate Goal dust dispersal at PEKB project site.

S.No	Scientific Name	Local Name	SR	CPCB	IVI (IIFM)	Mode of Propagation
1	*Antidesma acidum*	Shroti, Sarwat	F			seeds
2	*Bougainvillea spectabilis*			@		Cutting
3	*Calotropis gigantea*			@		Seeds, cutting
4	*Calotropis procera*			@		Seeds, Root suckers
5	*Carissa spinarum*	Kari		@		seeds, suckers
6	*Desmondium pulchellum*	Chipi, chipti			5.84	
7	*Flacourtia indica*	Ramkatayi, kakaer			40.82	
8	*Elaeodendron glaucum*	Mamri, Mimri, Jamrasi			18.21	
9	*Embelica robusta*	Soso podo			5.81	
10	*Grewia hirsuta*	Khamhar	F			
11	*Helicterus isora*	Aaithi, Marophali		@	5.84	
12	*Ipomoea carnea*				6.89	
13	*Murraya koenigii*	Mithi neem	F			Seeds, Cutting
14	*Murraya Paniculata*			@		By seeds, Cutting
15	*Nyctanthes orbor-trisis*	Khirsali	F			
16	*Nerium indicum*			@		Cutting
17	*Ricinus communis*	Arandi		@		Seeds,
18	*Sesbania aegyptiaca*	Dhandhani, Dhandhan		@		Seeds
19	*Thespesia lampas*	Masbandi, Mundi			12.98	
20	*Vitex negundo*	Chindwar	F			
21	*Woodfordia floribunda*	Dhari, Dhawai			36.08	
22	*Ziziphus xylophyrus*			@	23.61	seeds
	Total Species		**5**	**10**	**9**	

F-Frequently available in the study area, @ species suggested by CPCB, Species secured high IVI value

Table 12. List of tree species selected and suggested to develop GGB and mitigate Goal dust dispersal at PEKB project site.

S. No	Species Name	Local Name	S1	Small trees - MR	Large trees OR
			DC		
1	*Aegle marmelos* **	Bel, Bili Patra,	18.9	ST	
2	*Albizia lebbeck*	Siris, Karo Sirish	18.3		LT
3	*Alstonia scholaris*	Satani	25.39	ST	
4	*Azadirachta indica*	Neem	25.54	S/MT	

5	*Bauhinia variegate* **	Kanchnar	18.58	ST	
6	*Butea monosperma* **	Palas, Kesudo	24.44	ST	
7	*Cassia fistula* **	Amaltas **	23.03	ST	
8	*Citrus aurantium*	Nebu	15.59	ST	
9	*Dalbergia sissoo* **	Shesham **	17.02	ST	
10	*Delonix regia*	Gulmohar	18.05		LT
11	*Ficus benghalensis* **	Banyan, Vad	7.72		LT
12	*Ficus religiosa* **	Peepal, Piplo	12.94		LT
13	*Holoptelia integrifolia*	Kanjo, Papada	35.01		LT
14	*Mangifera indica* **	Mango, Aam	12.25		LT
15	*Manilkara zapota* **	Chikkoo	16.39	ST	
16	*Melia azedarach*	Melia, Bakani Nim	31.77		LT
17	*Phoenix sylvastris*	Khajur	32.07	ST	
18	*Polyalthia longifolia*	Ashoka,	29.84		LT
19	*Syzygium cumini* **	Jamun, Jambu	14.39		LT
20	*Tectona grandis* **	Teak, Sag,	14.94		LT
21	*Termanilia catappa*	Desi Badam	30.12		LT
22	*Terminalia arjuna* **	Arjun Sadad	30.54		LT
	Total		**22**	**10**	**12**

****- Species of the study area, MR-middle row, OR – outer row, St- small tree, Lt- large and tall tree.**

7.6 Eco-restoration of waste dump

The postmining land use of the core zone/lease area showed that, 112.655ha of the lease area will remain as external dump. Since 70% the total mine lease area is forested land, the reclamation of the mine lease should focus to bring back the lease are as near close to the forest habitat of adjacent forest to facilitate recovery of the faunal species in the restored area after the mine is closed.

7.6.1 Eco-restoration of waste dump – Action Plan

1. This management plan does not require any additional action plan and just need to plant the suggested 25 tree, 15 shrub and 11 woody climbers listed for restoration of compensatory afforestation site or refilled mine pit area.
2. Since the extent of mine dump area is comparatively smaller than the compensatory afforestation sites, it is recommended to adopt **Miyawaki Plots** techniques to improve the survival rate with high stocking rate of the saplings considering the natural mortality and maintain the ecological integrity of the restored area.
3. Using the top soil during land preparation can be excellent source of seed bank of native herb and grass species. Therefore, no special effort needed for growing grass and herb species
4. Since mine dump reclamation in progress, the remaining dump area should be implemented adopting eco-restoration with **Miyawaki Plots** techniques (**Box 1**).

Box 1: Miyawaki Plots: At least 25 Miyawaki plots/ha (provides for 25% Miyawaki/ha) will be planted, each being 100m^2 in area. Each randomly placed 100m^2 Miyawaki plot will be stocked with 300-500 saplings (3-5/m^2) in a manner that maximizes native species diversity. Plots will be located within each ha on the basis of a formal randomized selection

8. Recommended BMCP action plans for mine closure

Mining has the potential to affect biodiversity throughout the life cycle of a project, both directly and indirectly. The potential for significant impacts is greater when mining occurs in remote, environmentally or socially sensitive areas. Realizing the potential impacts of mining on biodiversity attributes which would affect the diverse ecosystem services they produce for the wellbeing of local community; it is very crucial to conserve the biodiversity and especially the threatened biodiversity of that region. Therefore, recorded of 13 threatened flora and 22 threatened fauna in the study area necessitated to advocate the following biodiversity conservation and management plan (BCMP) to implement in the mine closer plan.

8.1. BCMP- Species group specific conservation plan

8.1.1. Development of butterfly habitat – Action plan

As butterflies provide important ecosystem service like pollination, a common conservation plan – development of butterfly habitat recommended in the mine closer plan.

1. There are five areas 1. restored mine dumps, 2. safe zone within the lease and 3. site offices, 4. township/colony 5. school premises under human habitation are the areas suggested for developing butterfly habitat.
2. Since those five areas have already developed greenery, and are under the control of the mine administration it is easy to develop butterfly habitats by just adding these butterfly host plants (**Table 13**) along the boundary or the peripheral areas of the sites.
3. There are 35 plant species identified as host plants (larval and adult) for butterfly in the study area. This list includes 28 tree and seven shrub of forest species as well as common species of village/urban areas.
4. Butterfly habitat can be designed and developed in consultation with subject experts.

Table 13: Butterfly Larval Food and Adult Host plants recommended as part of Butterfly Habitat development plan – PEKB project site

S.no	*Scientific Name*	Habit	Mine area RD/SZ	Habitation SO/CO/Sc	Species Availability
1	*Acacia catechu*	Tree	M		+
2	*Aegle marmelos*	Tree	M		+
3	*Albizia lebbeck*	Tree		H	++
4	*Albizzia odoratissima*	Tree	M		+
5	*Albizzia procera*	Tree	M	H	+
6	*Annona squamosa*	Small Tree		H	++
7	*Azadirachta indica*	Tree		H	++

8	*Bauhinia purpurea*	Tree		H	+
9	*Bauhinia variegata*	Tree		H	+
10	*Bombax ceiba*	Tree		H	++
11	*Bridelia retusa*	Tree	M		+
12	*Butea monosperma*	Tree	M		+
13	*Calotropis gigantea*	Shrub	M		++
14	*Calotropis procera*	Shrub	M		++
15	*Capparis grandis*	Shrub	M		++
16	*Careya arborea*	Tree	M		+
17	*Cassia fistula*	Tree		H	+
18	*Chloroxylon swietenia*	Tree	M		+
19	*Citrus limon*	Woody shrub		H	++
20	*Dalbergia latifolia*	Tree	M		+
21	*Diospyros melanoxylon*	Tree	M		+
22	*Ficus bengalensis*	Tree	M		+
23	*Ficus religiosa*	Tree	M	H	+
24	*Helicteres isora*	Shrub	M		+
25	*Hibiscus ovalifolius*	Shrub		H	++
26	*Mallotus philippensis*	Tree	M		+
27	*Mangifera indica*	Tree		H	+
28	*Mitragyna parvifolia*	Tree	M		+
29	*Pongamia pinnata*	Tree		H	++
30	*Pterocarpus marsupium*	Tree	M		+
31	*Ricinus communis*	Shrub	M		+
32	*Schleichera trijuga*	Tree	M		+
33	*Shorea robusta*	Tree	M		+
34	*Terminalia ballerica*	Tree	M		+
35	*Terminalia catappa*	Tree		H	++
	Total species	**28 /7**	**24**	**14**	**+-24, ++=-11**

Source: Kehimkar 2008 and Singh 2010; Tr-Tree species, Sh-Shrub species, + Study area species, ++ -out side species, M-Mine area, RD -Restored dump, Safety Zone, H-Habitation, SO – site office, Co-Colony, SC-Schools

8.1.2. Development of "reptile habitat niche" – Action Plan

Ecological survey recorded 23 reptiles, of which species 21 species reported within the core zone. The study list includes two threatened species; Indian rock python (Python *molurus) and* Bengal Monitor Lizard (*Varanus bengalensis)* in the buffer zone and are listed in Schedule I species of WPA 1972. Reptile habitat niche development need to be included in mine closure plan to protect and conserve this species group.

11. Five locations in restored external dump with dense tree cover can be developed as reptile habitat niche leaving at least 100m distance from each other. Because the restored dump area is fenced and elevated from the ground level, it is not likely to have any vibration impact and further free from human interventions.
12. The five nearest protected forests (PF) from the lease boundary (Pidiya Reserve Forest, Janardhanpur PF, Tara East PF, Shivnagar PF and Paturiya Protected Forest) can also be selected to develop two reptile habitat niches in each (i.e., 10 niches).
13. Develop rocks /boulders heaps of 1m height and spreading 3m radius using the boulder/rocks size of 0.5m^3 dimension is preferable. These size boulders can provide compactness with needed gaps for reptiles to occupy. Artificial burrows in varying sizes should be constructed under the rock heaps.
14. These rock heaps should be partly covered with top soil for natural regeneration of shrubs and grasses from seed bank within it after the monsoon.

8.1.3 Facilitating nesting niche (nest box) - Hole nesting birds-Action Plan

Among those 92 species of avifauna reported in the study area (IIFM and WII studies) 28 species are found to be hole nesters. This is one of the important strategy of the biodiversity management plans as suggested under ICMM of Good Practice Guide (GPG) 2006 and the same has been recommended to develop closure plan with the component "**Nesting Niche for Hole Nesting Birds**" under Species group conservation plan.

9. There are four areas identified and suggested to deploy nest boxes for the hole nesting birds: 1. The oldest reclaimed well established plantation area. 2. green belt area of safety zone and 3. office premises, and 4. township-guesthouse/colony area
10. Prepare 200 nest boxes of different dimensions/measurement suggested with the proper nest size for the 28 species (**Table 14**). Preparation of nest boxes and deploying in strategic locations should be done in consultation with the subject experts.
11. The location suggested should be deployed 50 nest box each as Phase I. Since all the areas come under the control of the project proponent it is easy to monitor.
12. Monitoring and research activities should be initiated for a period of two years (covering four seasons) with the well-trained field biologist and supervision of subject experts.
13. Replicate this plan in those same areas deploying additional 200 nest boxes after two years as Phase II. Monitoring the deployed nest boxes for the next two years by trained biologists.

Table 14: List of Hole Nesting Bird and Nest Box details to Facilitate Hole nesting birds

S.no	Family/Scientific name	Common name	P/S	Size of Box	Hole Diameter in cm	WII 2020
Bucerotidae						
1	*Ocyceros birostris*	Indian Grey Hornbill	P	Large	14	
Meropidae						
2	*Merops persicus*	Blue Cheeked Bee-eater		+++		
3	*Merops orientalis*	Green Bee-eater		+++		
4	*Coracias benghalensis*	Indian Roller		Medium	9	
Muscicapidae						
5	*Saxicoloides fulicata*	Indian Robin	S	Small	4	
6	*Copsychus Saularis*	Oriental Magpie Robin	S	Small	4	
Paridae						
7	*Parus cinereus*	Cinereous Tit	S	Small	3	@
Passeridae						
8	*Gymnoris xanthocollis*	Yellow-throated Sparrow	S	Small	3	@
9	*Passer domesticus*	House Sparrow	S	Small	3	@
Picidae						
10	*Chrysocolaptes festus*	White-naped Woodpecker	p	Medium	7	@
11	*Dendrocopos moluccensis*	Brown-capped Pygmy Woodpecker	p	Small	3	@
12	*Dendrocopos mahrattensis*	Yellow-fronted Pied Woodpecker	p	Medium	5	@
13	*Dinopim benghalensis*	Black rumped Flameback	p	Medium	7	
14	*Dinopium javanense*	Common Golden-backed Woodpeck	p	Large	8	@
15	*Picus xanthopygaeus*	Streak Throated Woodpecker	p	Medium	7	
16	*Hermicircus canente*	Heart Spotted Woodpecker	p	Medium	7	
Psittaculidae						
17	*Psittacula eupatira*	Alexandrine Parakeet	S	Large	9	
18	*Psittacula krameri*	Rose ringed Parakeet	S	Medium	7	
19	*Psittacula cyanocephala*	Plum headed Parakeet	S	Medium	7	
Ramphastidae						
20	*Megalaima haemacephla*	Coppersmith Barbet	P	Small	3	

21	*Psilopogon zeylanicus*	Brown-headed Barbet	P	Medium	6	@
Strigidae						
22	*Athene bromah*	Spotted owlet	S	Medium	7	
23	*Glaucidium radiatum*	Jungle Owlet	S	Medium	7	
Strurnidae						
24	*Sturnia malabarica*	Chestnut-tailed Starling	S	Small	5	
25	*Sturnus pogodarum*	Brahminy starling	S	Small	5	
26	*Sturnus roseus*	Rosy starling	S	Small	5	
27	*Sturnus contra*	Asian Pied Starling	S	Medium	8	
28	*Acridotheres ginginianus*	Bank Myna	S	Medium	8	
29	*Acridotheres tritis*	Common Myna	S	Medium	8	
30	*Acridotheres fuscus*	Jungle Myna	S	Medium	8	
Upupidae						
31	*Upupa epops*	Common Hoopoe	S	Medium	8	
Size of Nest Box: Small - height / depth = 20 cm, Length & width = 13 cm, Medium - height / depth =40 cm. length & Width = 25 cm, Large - height /depth = 75 cm, Length & width = 50 cm						

P/S - Primary Hole Nester/Secondary Hole Nester, CT – Crone Zone Total, BT – Buffer Zone Total , SA – Study Area; ++ Constructs hole nest on Sandy and mud walls, bunds and river/stream banks, @ species reported by WII Team -2020

8.1.4 Development of denning niche - small mammals – Action Plan

This study reported 25 species of mammalian faun (IIFM and WII surveys), of that, nine species are ground dwelling species. Among those, species two species come under schedule I of WPA (Grey wolf and Honey badger), and, therefore it is very crucial to devise some conservation plan under species group conservation (**Table 9.9**) and include in the mine closer plan

1. **Rock boulders den**: This is similar kind of management plan like development of reptile habitat niche, the only changes that needed is the size of rock /boulder which should be $1m^3$ in size and the heap dimension should be 1.5m height covering 4-5m radius spread to provide larger gaps and space between the rocks so that, small mammals can freely move in and out and occupy the niche as natural den.
2. **Earthen dens:** It is recommended to use mixture of local earthen materials with screen rejects to develop earthen denning sites for hare, porcupine, jackals, and Indian fox. Develop 1m height of earthen heaps mixed with the ratio of 2:1 screen rejects and normal mud respectively spreading 3 m radius.
3. Cover both the rocky boulders and earthen heaps with top soils to naturally regenerate native grass and herbs on it. Plant local shrub species in and around those artificial denning sites to give naturalness
4. Initially suggested to develop 10 such niches (5 rock and 5 earthen dens within the matured and restored dump area and monitor it for next two years for the occupancy record.

5. Based on the success of this experimental management plan the same can be replicated in the nearest five protected forests, so that, 30 (15 rock and 15 earthen dens) such denning niches can be developed.

8.1.5 Development of mine pit wetland habitat – action plan

Post mining land use of the mine lease area showed that, out of 2388.247 ha area excavated, 2127.555 ha will be backfilled. Therefore, while backfilling the mine pits leave two 4-5 ha of areas as shallow pits to develop mine pit wetland to create **wetland habitat** and enhance the local aquatic biodiversity. This wetland habitat development can be included in mine closer plan to support the aquatic fauna of the project area.

13. Identify the two sites far from each other and while refilling the pits 4-5 ha of area in each site should be filled as shallow pits and not up to top level of pit.
14. The engineered structured mine pit wetlands should have a maximum depth of 6m. Terminal pit voids will be converted to wetlands with a well-defined, shallow (grading from 0 – 1m) water littoral zone (edge) – (Porej and Hetherington 2005).
15. The littoral edge on the wetlands will strive for a slope gradient of 20:1 (horizontal: vertical) (Bayley et al 2014) and extending at least 10m – 15m from shore on larger wetlands. Littoral area will occupy at least 10% of permanent water bodies/pit lakes etc.
16. Along the banks / embankment plant large size common tree species like: (*Albizia procera, lebbeck, Syzygium cumini, Tamarindus indica, Azadirachta indica, Ficus benghalensis, Ficus religiosaj, Mangifera indica, Pongamia pinnata, Terminalia bellirica*), which can provide perching, roosting and possibly nesting sites for the aquatic birds.
17. The second or inner middle layer needs to be developed with aquatic shrubs while the inner most layer and close to water edges with the locally available sedges and aquatic plants such as water lily, *Indian Lotus)*, *Colocasia* and *Ipomoea aquatica* can also be used where suitable conditions are created.
18. Hence, this offset wetland created can be monitored from 3rd year onward for wetland birds especially during winter months for a period of five years.

8.2. BCMP - Conservation of threatened flora and Fauna

8.2.1. Threatened flora conservation plots TPCP- action plan

The study area reported overall of 18 threatened flora within the study area, however, only 13 plant species come under endangered and vulnerable status of IUCN list and rests have been fall under near threatened category. Hence, according to ICMM (2006) recommendation, only those 13 species (endangered and vulnerable categories) have been considered to implement threatened flora conservation plot in the mine closure plan.

8. Carryout status survey for the 13 threatened plant species in the Protracted forests sharing 10km radius of the study area (**Table 15**) and possibly specific areas/location suggested by the locals with formal interview/dialogue
9. Fence and protect few of those sites from further overexploitation and grazing pressures under in-situ conservation. Erect sign boards to aware the people not disturbed and collect the plants

10. Collect few plants (seed, tubers and or cuttings) parts suits to propagate in the threatened flora conservation plot.
11. Identify minimum of two 1ha plots within the lease area in and around the office site and or the area not likely to be disturbed till the end of mine closer as ex-situ conservation.
12. Possibly develop demonstration TFCP in selected two or three protected forests which are having picnic spots with signages depicting the information on conservation importance of the threatened flora as outreach program.

Table 15: List of the threatened species of the study area

S.No	Scientific/Common Name	Local Name	Habit
1	*Acorus calamus*	Buch	
2	*Boswellia serrata*	Saliha	Tree - EN
3	*Celastrus peniculata*	Unjain	Woody Climber-VU
4	*Chlorophytum tuberosum*	Safed Musli	Herb -VU
5	*Costus speciosus*	Kewu/ ban haldi	Herb-VU
6	*Curcuma angustifolia*	Tikhur	Herb-VU
7	*Dioscorea bulbifera*	Agitha	Climber-VU
8	*Gloriosa superba*	Kalihari/Kharha godi	Herb-VU
9	*Peucedanum nagpurense*	Tejraj	Herb-VU
10	*Phyllanthus emblica*	Awala	Tree-VU
11	*Pterocarpus marsupium*	Bija	Tree-VU
12	*Sterculia urens*	Khurul /Khaurlu	Tree-VU
13	*Terminalia chebula*	Harra	Tree-VU

EN -Endangered, VU -Vulnerable

8.2.2 BCMP Action Plan - Development of Herbal Garden

This plan is similar to the above TFCP, but include local herbal healers as one of the stakeholders and the sites need to be developed in and around the village area/forests. The plan of action detailed below;

6. Identify the local herbal healers and carryout status survey of medicinal plants mainly the annuals, shrubs and creepers (**Table 16**) in the Protracted forests to collect only the important medicinal plans from the abundance sites to develop herbal garden.
7. Develop at least five herbal gardens within herbal healer's village areas to facilitate emergency use. The size of the plots should be 1-2 ha.

Table 16: list of selected Medicinal plants species used by the local people of the study area of PEKB for curing various ailments (IIFM)

S.no	Family and Species name	Local Name	Habit	Medicinal use	Plat parts
1	**Acoraceae**				
1	*Acorus calamus* *	Bach	Herb	Medicine	Root

2	**Amaranthaceae**				
2	*Achyranthes aspera*	Gathiya, aghada	Herb	Diuretic tonic, insect and scorpion bite	Leaf
3	*Vallaris solanacea*	Dhudhiyakandha	Woody Climber	Lactating mother	Latex
3	**Aselepiadaceae**				
4	*Ceropegia bulbosa Roxb.*	Bosiy kandha	Climber	Oil, Wounds	Seed
4	**Asteracease**				
5	*Peucedanum nagpurense* *	Tejraj	Herb	Medicine	Root
5	**Caesalpiniaceae**				
6	*Caesalpinia bonducella*	Gataran	Woody Climber	Medicine	Resin
6	**Celastraceae**				
7	*Celastrus paniculate* *	Unjain	Woody Climber	Tonic	Seed
8	*Elaeodendron glaucum*	Mamri, Mimri, Jamrasi	Shrub	Snake bite	Root
7	**Convolvulaceae**				
9	*Ipomea mauritiana*	Patal kohra	Woody Climber	Indigestion	Root
8	**Dioscoraceae**				
10	*Dioscorea bulbifera* *	Agitha	Climber	Medicine	Tuber
11	*Dioscorea spp.*	Gethi kandha/kanruha	Herb	Medicine	Fruit
9	**Hyacinthaceae**				
12	*Urginea indica*	Ban pyaz	Herb	Scorpion bite	Tuber
10	**Liliaceae**				
13	*Asparagus racemosus*	Kargi	Shrub	Medicine	Fruit
14	*Chlorophytum tuberosum* *	Safed musli	Herb	Medicine	Root
15	*Gloriosa superba* *	Kharha godi, karihari	Herb	Wounds	Root
11	**Malvaceae**				
16	*Hibiscus abelmoschus*	Kapalsiya kandha	Herb	Bleeding in Urine	Root
12	**Palmaceae**				
17	*Phoenix acaulis*	Chind	Herb	After child birth	Fruit
13	**Poaceae**				
18	*Cynodon dactylon*	Doob	Grass	Medicine	Root
14	**Rhammacea**				
31	*Ziziphus rugosa*	Churaban, churna	Woody climber	Bodyache	Whole

15	**Sterculiaceae**				
19	*Helicteres isora*	Aaithi, Marophali	Shrub	Colic intestinal disorder	Bark, fruit
16	**Vitaceae**				
20	*Cissus quadrangularis*	Hathjod	Climber	Mosquito repellent	Leaf
21	*Vitis carnosa*	Dhokarbela	Woody Climber	Bodyache	Root
17	**Zingiberaceae**				
22	*Curcuma angustifolia**	Tikhur	Herb	Medicine	Root

8.2.2 BCMP - conservation of threatened fauna

Overall, the biodiversity management plan study surveyed selective faunal groups; butterfly, amphibian, reptile, terrestrial avifauna and mammal. Among those species group, some of the faunal groups are suggested for status survey of threatened species due to the lake of information on their status and distribution. Therefore, giving the priority to the Sustainable Development principal 7 of ICMM (2006) and Performance Standard 6 of IFC World Bank Group (2012) Status survey of three faunal groups was suggested include: 1. Survey of Snake Species., 2. Status Survey of Selected Birds of Prey, and 3. Status Survey of Selected Threatened Mammals under this BCMP project of PEKB covering buffer zone.

8.2.3.1. Survey of Snake Species -Action plan

7. This study area reported 15 species of snake species and Initiate the survey in the adjacent forest patches and based on the availability of the species the survey can be extended to the rest of the areas for other areas.
8. Possibly identify python den to protect under in-situ and ex-situ conservation with the help of the state forest department.

8.2.3.2 Status Survey of Selected Birds of Prey-Action Plan

1. This study area reported eight species of birds of prey in and around the study area that are placed under Schedule I of WPA, hence, carryout survey covering three major habitats like: dense forest habitats, Agriculture patches, grassland and Human habitations.

2. Possibly protect the nesting and roosting sights identified during the survey with the help of local people.

3. Improve the perching sight for these species by incorporation dead tree snag along the edges of open and agriculture habitats using tree salvage (translocation live trees) techniques which is already in practice to translocate the trees into the dump reclamation.

4. Translocate at least 45 such dead trees into the nearby agriculture and open habitats and grasslands (5 sites in each habitat and five tree sage in each site) to facilitate perching sites/sage and monitor them for use of the desired species to check the success of this conservation intervention.

8.2.3.3 Status Survey of Selected Threatened Mammals-Action Plan

1. *Canis lupus* - Grey wolf, *Manis crassicaudata* -Indian pangolin, and *Mellivora capensis* - Honey badger is three lesser-known small mammals considered and recommended for status survey.

2. This survey needs to be initiated covering dense forest habitats of the nearest five Protected forests adopting field techniques like: camera trap study to collect quantitative data to assess the abundance data, information on denning sights as well as the existing conservation issue.

3. Possibly protect the denning sites identified during the survey with the help of deputed wildlife watchers with the joint venture of the forest staffs.

8.2.3.4 Habitat development – selected mammalian fauna

Except, elephant, sloth bear and Chousingha or Four-horned antelope the three major herbivores rests are carnivorous in nature. Therefore, habitat improvement through planting of food plant species would directly benefit by those three herbivores, and may indirectly support the other two carnivores (Leopard and Grey wolf) by improving the abundance status of other prey species like; Chital (*axis axis*), Sambar (*Rusa unicolor)*, and Barking deer **(***Muntiacus muntjac*) of the study area. Hence, the followings are the **habitat improvement**-based management plans suggested to support and conserve those threatened major herbivores of the study area and recommended to incorporate in mine closer plan.

8.2.3.5 Habitat development: Elephants, Sloth bear, Four-horned antelope – Action plan

1. Identification of degraded forest patches of not less than 2-4 ha each in the adjacent forest patches in the study area
2. Within those areas develop one 4ha, in each forest to plant 41 elephant food trees as gap plantation (**Table 17**).
3. This list includes 33 species reported in the field by the WII research team and 28 species identified based on literature reported in the study area as well as overlap with the WII list.
4. overall 60 ha forest patch in 15 PFs will be restored for the enhancement of elephant food resources
5. In addition, identify another 4 ha of open forest as well as partly dense (degraded) patches and develop 2h each for planting 16 food plants of sloth bear (**Table 18**) and 16 species of four-horned antelope food plants (**Table 19**). Therefore, another 60 ha of forest patches 30 ha each for four-horned antelope and sloth bear restored to improve the food resource.

Table 17: Plant species observed to be fed by wild elephants in Chhattisgarh by WII research team during 2017 to 2020 and Secondary source list

S.No	Species	Local name	Habit	Part eaten by elephants	SS
1	*Acacia catechu*	khair	Tree	bark	
2	*Aegle mermelos*	bael	Tree	Bark	✓
3	*Anogeissus latifolia*				✓
4	*Bauhinia vahilii*		Climber	bark	✓
5	*Bombax ceiba*	simal	Tree	bark	✓
6	*Bridelia retusa*				✓
7	*Buchanania lanzen*	chaar	Tree	root (of saplings)	
8	*Careya arborea*				✓

9	*Cassia fistula*				✓
10	*Carissa spinarum*	jangli karunda	Shrub	bark	
11	*Dalbergia sisoo*	sisham	Tree	Bark	✓
12	*Dendrocalamus strictus*		Grass	leaves and stem	
13	*Diospyros melanoxylon*	tendu	Tree	root (of saplings)	✓
14	*Ficus benghalensis*	bargad	Tree	leaves and bark	✓
15	*Ficus racemosa*		Tree	bark	✓
16	*Ficus religiosa*	pipal	Tree	leaves and bark	✓
17	*Garuga pinnata*				✓
18	*Grewia tiliaefolia*	dhaman	Tree	bark	✓
19	*Helicteres isora*		Shrub	bark	✓
20	*Holarrhena pubescens*		Tree	root (of saplings)	
21	*Lannea coromandelica*	gurjan	Tree	bark	
22	*Largerstromia parviflora*	sejha	Tree	leaves	✓
23	*Madhuca longifolia*	mahua	Tree	Bark	✓
24	*Mallatous philippensis*	rori	Tree	bark	✓
25	*Mangifera indica*	aam	Tree	Bark & fruits	✓
26	*Phoenix sp*		Shrub	young leaves	
27	*Phyllanthus emblica*	amla	Tree	fruits	
28	*Pterocarpus marsupium*				✓
29	*Schleichera oleosa*	kusum	Tree	bark	✓
30	*Semecarpus anacardium*	bhilwa	Tree	bark	
31	*Shorea robusta*	saal	Tree	bark	✓
32	*Streblus asper*				✓
33	*Sterculia urens*		Tree	bark	✓
34	*Syzygium cumini*	jamun	Tree	bark	✓
35	*Tectona grandis*	sagon	Tree	bark	
36	*Terminalia bellerica*	baheda	Tree	bark	✓
37	*Terminalia chebula*				✓
38	*Terminalia elliptica*	saja	Tree	bark	
39	*Ziziphus mauritiana*	ber	Shrub	leaves and bark	✓
40	*Ziziphus rugosa*		Shrub	bark	
41	*Ziziphus xylopyrus*		Shrub	bark	
	Total species		**33**		**28**

Table: 18: Sloth Bear plant species Recommended for Habitat improvement and Food Resource Enhancement

S.No.	Scientific name	Life Form	SS	WII (FO)	S.no	Scientific name	Life Form	SS	WII (FO)
1	*Aegle marmelos*	*Tree*	@		9	*Ficus infectoria*	*Tree*		++
2	*Cassia fistula*	*Tree*	@	++	10	*Ficus racemosa*	*Tree*	@	++
3	*Cordia macleodii*	*Tree*		++	11	*Ficus religiosa*	*Tree*	@	++
4	*Cordia myxa*	*Tree*		++	12	*Flacourtia indica*	*Tree*	@	++
5	*Diospyros melanoxylon*	*Tree*	@	++	13	*Madhuca indica*	*Tree*	@	++
6	*Emblica officinalis*	*Tree*	@		14	*Mangifera indica*	*Tree*	@	++
7	*Ficus benghalensis*	*Tree*	@		15	*Syzygium cumini*	*Tree*	@	++
8	*Ficus glomerata*	*Tree*		++	16	*Zizyphus mauritiana*	*Tree*	@	++

SS – Secondary sources, @ - food species reported (Bhaskaran *et al.* 1997), ++ Species observed to be fed in the study area (WII -Research Team)

Table 19: Food Plant Species recommended for restoration and Development of habitat for Four-Horn Antelope Habitat

S.no	Scientific Name	Habit	S.no	Scientific Name	Habit
1	*Acacia catechu*	Tree	9	*Hymenodictyon orixense*	Tree
2	*Asparagus racemosus*	Shrub	10	*Mallotus philippensis*	Tree
3	*Bauhinia malabarica*	Tree	11	*Mitragyna parvifolia*	Tree
4	*Bauhinia retusa*	Tree	12	*Nyctanthes arbor-tristis*	Tree
5	*Bauhinia vahlii* -	Creeper AD sp	13	*Phyllanthus emblica*	Tree
6	*Bridelia retusa*	Tree	14	*Schleichera oleosa*	Tree
7	*Buchanania lanzan*	Tree	15	*Shorea robusta*	Tree
8	*Dendrocalamus strictus*	Bamboo/Ad sp	16	*Ziziphus mauritiana*	Tree
Source Kunwar et al. 2006					

8.3 Natural resource development and life quality enhancement

8.3.1. Vegetable and Fruit - Organic farming Program

1. Survey and identify the affected villagers and interested marginal farmers to support organic farming and their perception and willingness to be part of this plan.
2. Identify the area based on the presence of good water resources and suitable land to develop suitable vegetable organic garden with the construction of small farm pond to ensure the availability of water throughout the year.
3. The stakeholders should be provided required organic seeds of vegetable crops, free of cost
4. Series of capacity building programs need to be conducted by the CSR department with the subject consultant on technical, management, marketing aspects for the successful implementation and progress of this action plan.
5. All the organic vegetables cultivated under this plan can be purchased and used by the project proponent (mining companies) for their office canteen, guesthouse, colony and link with local vegetable market owners of the nearest town on regular basis.

8.3.2. Organic fruit orchard development

1. A total of six possible fruit tree species are suggested to grow under Fruit Orchard Development plan which area commonly grown in the village areas (Papaya- *Carica papaya*, Lemon- Citrus lemon, Lemon - *Citrus maxima*, Indian gooseberry- *Phyllanthus emblica*, Guava- *Psidium guava*, Mango- *Mangifera indica*).
2. Develop minimum of 2ha of such fruit Orchard plantation in Common Property land Resources CPLR / Community land of those seven villages
3. Initially, the project proponent should facilitate to support all the expenditure related to the construct of needed water storage and irrigation facilities, providing fruit crop saplings, manure,

tree guard and fencing etc.

4. The initial expenditure incurred for the project implementation can be pay backed by the Fruit Orchard Development (FOD) – Village Committee to the project proponent and it is the overall responsible for the annual maintained management of this FOD Committee

The Organic farming program can be initiated under CSR division through Village Organic Farming Committee – VOFC to maintain and manage both the programs as well as benefit sharing

8.3.3. Apiculture - Honey-Bee Farming

1. Recommended to initiate Honey-bee Farming within the seven villages shared their forest land and Initially start with this program providing fiver villagers in each village i.e 35 villagers provided 20 boxes each (35 villagers x 20 boxes = 700) and based on the progress the same can be extended further
2. Train the interested villagers/persons on technical aspects through capacity building program with the experts.
3. Provide all the necessary equipment or honey comb boxes and other gears free of cost by the project proponent
4. Form honey collection team to collect and marketing and the project proponent should facilitate market link from the nearby towns.

8.3.4. Aquaculture – Village level Fish Farming

1. The villagers depend on the seasonal streams, rivers and village ponds for fish resource using the local techniques i.e., recommended to develop **fish farm ponds within the nearest** 20 villages under CSR activity
2. Consultation with the local fishery department introduce fingerlings to improve the fish abundance in the village ponds.
3. The selected locals should be trained in all the technical and management aspects.

8.4. Awareness education

The success of the above suggested all the habitat development and natural resource enhancement plans are entirely depending on the support of the local villagers. Therefore, the locals need to be seriously educated on sustainable use of natural resource and the importance of biodiversity conservation and the ecosystem services they provide for their wellbeing. This can be done by involving a reputed NGO with good experience in conducting Awareness and Education Programs specific to wildlife and biodiversity conservation. The themes need to be focused are given below:

- Importance of biodiversity conservation and ecosystem service – Villagers/agriculturalists and also
- Nature Conservation – students
- Sustainable use of the natural resources – local villagers
- Creation of PEKB Nature Club – local students
- Ecologically sustainable development – Inhouse Technocrats of RRVUNL

- Hunting of wildlife – local tribes

9. Manpower – Subject Expert

In order to implement the biological component in to the mine closer plan the following experts need to involved and the details given in Table (**Table 20**)**.** The wildlife experts can be hired on consultant basis as and when required from the national level institute.

Table 20. Details of Subject expert requirement

S.no	Subject experts	No of persons
1	Senior Plant taxonomist/Forestry expert (with > 20 years of experience)	1
2	Junior Plant taxonomist (with > 4 years' experience)	1
3	Fishery biologist (with > 4 years' experience)	1
4	Senior Wildlife /Biodiversity expert (with > 20 Years of Experience)	1
5	Wildlife Biologist (with > 4 years' research experience in the field of bird, herpetofauna reptile and mammal survey and ecology)	4
6	Butterfly Habitat Development -Subject expert (with > 4 years' experience)	1
7	Wildlife and Biodiversity Conservation Awareness Education Expert (with > 4 years' experience)	1

10. Time schedule

Implementation of all the biological interventions (mitigation measures) and Biodiversity Conservation plans in the mine closer plan is scheduled for next 20 years.

Table 21 Time schedule to Implement the Biological Intervention and BCMP for in Mine Closer Plan

Activity	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1. **Eco-restoration Action Plan Afforestation site/refilled mine pit** area 25/ha/year **(next 20 years)**																				
2. **Grass and Leaf fodder plots - Action Plan** 35ha in Five years																				
3.Bio-filter Check Dams – Action Plan (15 dams 3dams/year)																				
4. Green Belt Development – Phytoremediation As and when reclaimed area available																				
5. Development of "Green Gallery Belt" – Action Plan																				
6. Eco-restoration of waste dump – Action Plan As and when external dumps are ready																				

Activity	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
7. Development of butterfly habitat – Action plan Five locations 1. Restored Mine dumps, 2. Safe zone within the lease and 3. Site Offices, 4. Township/colony 5. School premises																				
8. Development of "reptile habitat niche" – Action Plan 5 Niches each in Restored dumps and 5 PFs																				
9. Development of denning niche - small mammals – Action Plan 5 Niches each in Restored dumps and 5 PFs																				
10. Facilitating nesting niche (nest box) - Hole nesting birds-Action Plan																				
11. Development of mine pit wetland habitat – action plan																				
1.Monitoring wetland birds																				
10.Threatened flora conservation plots TPCP- action plan																				
11. BCMP Action Plan - Development of Herbal Garden																				

Activity	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
12. Threatened Mammals-Action Plan 1.Survey of Snake Species -Action plan 2.Status Survey of Selected Birds of Prey-Action Plan 3. Status Survey of Selected Threatened Mammals																				
13. Food Habitat Development – Threatened mammals																				
Elephant – 4ha in each adjacent forest patches x 15 (60ha)																				
Sloth Bear- 2h in each in each adjacent forest patches x 15 nos																				
Four-Horn Antelope - 2h in each in each adjacent forest patches x 15 nos																				
14. Natural resource development and life quality enhancement																				
1. Vegetable and Fruit - Organic farming Program																				
2. Apiculture - Honey-Bee Farming																				
3. Aquaculture – Village level Fish Farming																				
15. Awareness Education																				

Reference

Bouwman, A.F. (Ed.), (1990). Soils and the Greenhouse Effect. J. Wiley & Sons, Chichester, UK, p. 575.
Detwiler, R.P. Hall, C.A.S. (1999). Tropical forests and the global carbon cycle. Science 239, 42–47.
Jabaggy, E.G. and Jackson, R.B. (2000). The vertical distribution of soil organic carbon and its relation to climate and vegetation. Ecol. Appl. 10, 423–436.
Richter, D.D., Markewitz, D., Wells, C.G., Allen, H.L., Dunscombe, J.K., Harrison, K., Heine, P.R., Stuanes, A., Urrego, B., and Bonani, G.(1995). Carbon cycling in a loblolly pine forest: implications for missing carbon sink and for the concept of soil. In: McFee, W., Kelly, J.M. (Eds.), Carbon Forms and Functions in Forest Soils. Soil Science Society American, Madison, WI, pp. 233– 251.
Sedjo, R.A. (1992). Temperate forest ecosystems in the global carbon cycle. Ambio 21, 274–277.
Tilman, D., Wedin, D. and Knops, J. 1996. Productivity and sustainability influenced by biodiversity in grassland ecosystems. *Nature* 379: 718-720.

ANNEXURE 3

List of Production and Auxiliary Equipment (HEMM) in Use

Sr. No	Particulars	Size/Cap	Year wise phasing				
			1	2	3	4	5
A	Overburden						
1	Diesel Hydraulic Shovel	12Cum / 15 Cum	3	7	7	9	9
2	DH Shovel	3.0 Cum	20	20	20	22	22
3	Rear Dumper	100 T	18	44	46	61	63
4	Dump truck	35 T	90	95	100	116	121
5	Drill	250 mm	2	7	7	8	8
6	Dozer	410 hp	5	7	7	7	7
7	Wheel dozer	320 hp	1	2	2	2	2
8	Drill	160 mm	2	2	2	3	3
B	Coal						
1	FEL	4.5 Cum	5	5	5	5	5
2	Dump truck	35 T	30	32	33	34	35
3	Surface Miner	3800 SM	5	5	5	5	5
C	Common						
1	Grader	280 hp	3	4	4	4	4
2	Crane	50T	1	1	1	1	1
3	Crane	30 T	2	2	2	2	2
4	Crane	10/8/5 T	2	4	4	4	4
5	Diesel B'hoe	0.9-1.2 Cum	1	3	3	3	3
6	Vibratory compactor	25 T	2	3	3	3	3
7	Fork lift truck		3	5	5	5	5
8	Tyre handler		3	5	5	5	5
9	Mobile maintenance Van		4	5	5	5	5
10	Water sprinkler	28kl	8	10	10	10	10
11	Fuel browser	12 KL	3	6	6	6	6
12	Tipping Truck	8 T	3	5	5	5	5
13	Dozer	410 HP	4	5	5	5	5
14	Fire Tender		2	2	2	2	2
Total			**222**	**286**	**244**	**332**	**340**

List of Forest Blocks located within 10m radius of the PEKB Study Area

Sr. No	Forest Block	Distance (km)	Direction
1	Phatepur Protected Forest	Within M.L.area	-
2	Matringa Protected Forest	Within M.L.area	-
3	Pidiya Reserve Forest	1.6 Km	W
4	Janardhanpur Protected Forest	2.3 km	NW
5	Tara East Protected Forest	2.8 Km	W
6	Shivnagar Protected Forest	3.7 km	N
7	Paturiya Protected Forest	4.0 km	SSW

8	Putter Protected Forest	4.5 km	ENE
9	Chakeri Protected Forest	5.1 km	ENE
10	Murgaon Protected Forest	6.0 km	N
11	Dhajag Protected Forest	7.4 km	NNE
12	Kotmi Protected Forest	7.8 km	NNE
13	Pendrakhi Protected Forest	8.1 km	SE
14	Ramgarh Protected Forest	8.2 Km	NE
15	Chandenagar Protected Forest	8.9 km	NNW
16	Chirwan Protected Forest	9.2 km	N
17	Bhandargaon Protected Forest	9.9 km	NNE

Post mining land use of the core zone – Mine block of PEKB

Sr. No.	Particular	Plantation/ Grass/Greenbelt	Water Body	Public Use	Dismantle led	Total
A	**Mining**					
1	Excavation area & barrier	2127.555	260.692	-	-	2388.247
B	**Infrastructure & OB dump area**					
1	External dump	112.655	-	-	-	112.655
2	Infrastructure	3.622	-	32.601		36.224
3	Coal evacuation route	3.026	-	-	27.234	30.260
4	CHP & Washery	2.838	-	-	25.543	28.381
5	Reject based Thermal Power Project	4.257	-	-	38.313	42.570
6	Colony & plantation area	0.399	-	3.588	-	3.986
7	Rationalization AREA	40.532	-	-	-	40.532
Total (B)		167.329	0.000	36.189	91.090	294.609
Grand Total (A + B)		**2294.884**	**260.692**	**36.189**	**91.090**	**2682.856**

ANNEXURE 4

List of Medicinal plants species used by local people of the study area of PEKB for curing various ailments (IFFM)

S.no	Family and Species name	Local Name	Habit	Medicinal use	Plat parts
1	**Acoraceae**				
1	*Acorus calamus* *	Bach	Herb	Medicine	Root
2	**Amaranthaceae**				
2	*Achyranthes aspera*	Gathiya, aghada	Herb	Diuretic tonic, insect and scorpion bite	Leaf
3	**Anacardiaceae**				
3	*Semecarpus anacardium*	Bhelwa	Tree	Infection	Fruit
4	**Apocynaceae**				
4	*Holarrhena antidysenterica*	Koriya	Tree	Fever, dysentery	Root, Bark
5	*Vallaris solanacea*	Dhudhiyakandha	Woody Climber	Lactating mother	Latex
5	**Aselepiadaceae**				
6	*Ceropegia bulbosa Roxb.*	Bosiy kandha	Climber	Oil, Wounds	Seed
6	**Asteracease**				
7	*Peucedanum nagpurense* *	Tejraj	Herb	Medicine	Root
7	**Burseraceae**				
8	*Boswellia serrata* *	Saliha	Tree	Internal pain	Root
9	*Garuga pinnata*	Khenkara, Kekad, Kenkar	Tree	Snake bite, Wounds	Bark, fruit
8	**Caesalpiniaceae**				
10	*Caesalpinia bonducella*	Gataran	Woody Climber	Medicine	Resin
9	**Celastraceae**				
11	*Celastrus paniculate* *	Unjain	Woody Climber	Tonic	Seed
12	*Elaeodendron glaucum*	Mamri, Mimri, Jamrasi	Shrub	Snake bite	Root
10	**Combretaceae**				
13	*Terminalia arjuna*	Kahua, Arjun	Tree	Medicine	Bark
14	*Terminalia ballerica*	Baira, Bahera	Tree	Cough	Fruit
15	*Terminalia chebula* *	Harra	Tree	Cough	Fruit
11	**Convolvulaceae**				
16	*Ipomea mauritiana*	Patal kohra	Woody Climber	Indigestion	Root
12	**Dioscoraceae**				
17	*Dioscorea bulbifera* *	Agitha	Climber	Medicine	Tuber
18	*Dioscorea spp.*	Gethi kandha/kanruha	Herb	Medicine	Fruit
13	**Ebenaceae**				
19	*Diospyros melanoxylon*	Tendu	Tree	Snake bite	Root

14	**Euphorbiaceae**				
20	*Phyllanthus emblica* *	Awala, Aonla	Tree	Indigestion	Fruit
15	**Hyacinthaceae**				
21	*Urginea indica*	Ban pyaz	Herb	Scorpion bite	Tuber
16	**Liliaceae**				
22	*Asparagus racemosus*	Kargi	Shrub	Medicine	Fruit
23	*Chlorophytum tuberosum* *	Safed musli	Herb	Medicine	Root
24	*Gloriosa superba* *	Kharha godi, karihari	Herb	Wounds	Root
17	**Malvaceae**				
25	*Hibiscus abelmoschus*	Kapalsiya kandha	Herb	Bleeding in Urine	Root
18	**Meliaceae**				
26	*Chloroxylon swietenia*	Bhirra, bharahi	Tree	Medicine	Tuber
27	*Soymida febrifuga*	Rohina, Rohan	Tree	Muscular Pain	Bark
19	**Moraceae**				
28	*Ficus bengalensis*	Gad mifir	Tree	Dysentery	Latex, bark
20	**Palmaceae**				
29	*Phoenix acaulis*	Chind	Herb	After child birth	Fruit
21	**Poaceae**				
30	*Cynodon dactylon*	Doob	Grass	Medicine	Root
22	**Rhammacea**				
31	*Ziziphus rugosa*	Churaban, churna	Woody climber	Bodyache	Whole
23	**Sterculiaceae**				
32	*Helicteres isora*	Aaithi, Marophali	Shrub	Colic intestinal disorder	Bark, fruit
24	**Vitaceae**				
33	*Cissus quadrangularis*	Hathjod	Climber	Mosquito repellent	Leaf
34	*Vitis carnosa*	Dhokarbela	Woody Climber	Bodyache	Root
25	**Zingiberaceae**				
35	*Curcuma angustifolia**	Tikhur	Herb	Medicine	Root

ANNEXURE 5

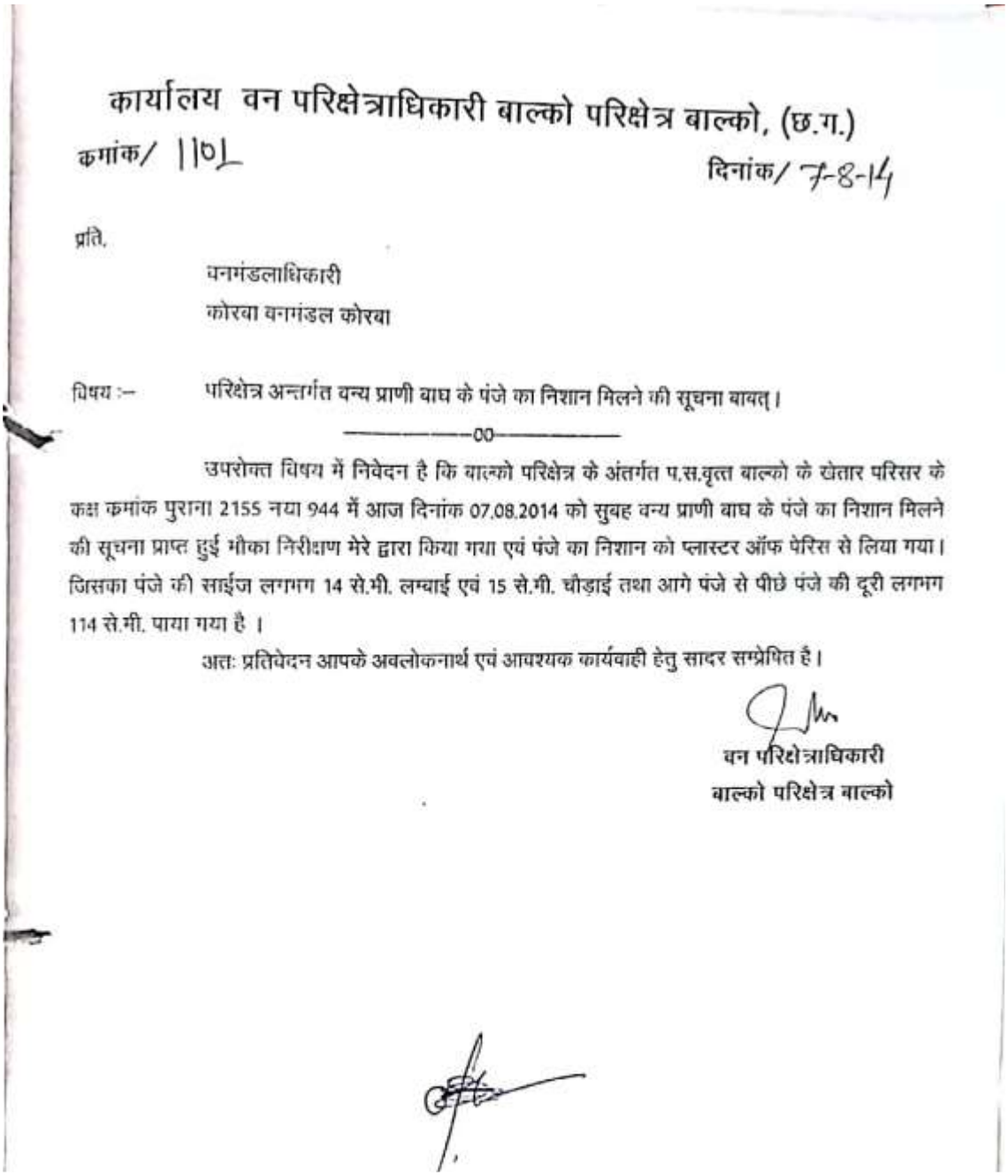
Financial outlay* for implementing Biodiversity Conservation and Management Plan (faunal component) for 5 years.

Expenditure Heads	Expert details	Amount in INR
NESTING NICHE (NEST BOX) - HOLE NESTING BIRDS 400 Nest boxes and Subject expert charges	**Subject expert (1) Technical input**	300000.00
WETLAND HABITAT	**Subject expert (1)**	300000.00
BCMP- CONSERVATION OF THREATENED PLANT & ANIMALS		
THREATENED FLORA AND FAUNA CONSERVATION	Threatened flora conservation plot Herbal Garden (In house expert) (1 plant Taxonomist)-Subject expert	2000000.00
	Senior Expert – Wildlife Ecology **4. Wildlife field biologist** 1. Status Survey of snake species – Protected forest 2. Status Survey of Selected Birds of Prey – buffer zone three habitats 3. Survey of Selected Small Mammals – Reserved Forest 4. Monitoring of wetlands birds (3 years survey and monitoring) 5. Awareness education expert	
	1. Sloth Bear - Food plant development 2. Four horned antelope – Food plant development 3. Elephant – Food plant development	
LIVELIHOOD AND LIFE QUALITY IMPROVEMENT	1. Vegetable and Fruit - Organic farming Program 2. Apiculture - Honey-Bee Farming 3. aquaculture – Village level Fish Farming **CSR – department will engage the expert and monitor the farming activities**	1000000.00
Total		**3,60,00000.00**
Rupees three crores sixty lakhs only		

* The budget indicated above pertains only towards monitoring of the suggested strategies. The resources (labour force, materials, equipment and consumables) required for implanting the suggestions have not been provided as it is site specific.

Annexure – 6

Forest department correspondence authenticating tiger occurence in Korba Forest Division in the areas adjoining Hasdeo Arand Coal Field



कार्यालय वन परिक्षेत्राधिकारी बाल्को परिक्षेत्र बाल्को, (छ.ग.)

क्रमांक/ 1101 दिनांक/ 7-8-14

प्रति,

वनमंडलाधिकारी
कोरबा वनमंडल कोरबा

विषय :– परिक्षेत्र अन्तर्गत वन्य प्राणी बाघ के पंजे का निशान मिलने की सूचना बाबत्।

———————00———————

उपरोक्त विषय में निवेदन है कि बाल्को परिक्षेत्र के अंतर्गत प.स.वृत्त बाल्को के खेतार परिसर के कक्ष कमांक पुराना 2155 नया 944 में आज दिनांक 07.08.2014 को सुबह वन्य प्राणी बाघ के पंजे का निशान मिलने की सूचना प्राप्त हुई मौका निरीक्षण मेरे द्वारा किया गया एवं पंजे का निशान को प्लास्टर ऑफ पेरिस से लिया गया। जिसका पंजे की साईज लगभग 14 से.मी. लम्बाई एवं 15 से.मी. चौड़ाई तथा आगे पंजे से पीछे पंजे की दूरी लगभग 114 से.मी. पाया गया है ।

अतः प्रतिवेदन आपके अवलोकनार्थ एवं आवश्यक कार्यवाही हेतु सादर सम्प्रेषित है।

वन परिक्षेत्राधिकारी
बाल्को परिक्षेत्र बाल्को

कार्यालय वनपरिक्षेत्राधिकारी बाल्को परिक्षेत्र बाल्को, (छ.ग.)

क्रमांक/ ५५१९ दिनांक/ ०१/०९/२०१५

प्रति.

वनमंडलाधिकारी
कोरबा वनमंडल कोरबा

विषय :– परिक्षेत्र अन्तर्गत वन्य प्राणी बाघ के पंजे का निशान मिलने की सूचना बाबत्।

———————00———————

उपरोक्त विषय में निवेदन है कि बाल्को परिक्षेत्र के अंतर्गत प.स.वृत्त बाल्को के दोन्द्रो परिसर के कक्ष क्रमाक पी. 972 में आज सुबह दिनांक 07.09.2015 एवं दोपहर में अजगरबहार परिसर के कक्ष कमांक ओ.ए.1236 नर्बदा में वन्य प्राणी बाघ के पंजे का निशान मिलने की सूचना प्राप्त हुई मौका निरीक्षण मेरे द्वारा किया गया एवं पंजे का निशान को प्लास्टर ऑफ पेरिस से लिया गया। जिसका पंजे की साईज लगभग 14 से.मी. लम्बाई एवं 14 से.मी. चौड़ाई पाया गया है । जिसका विवरण एवं जी.पी.एस. रिडिंग नीचे निम्नानुसार है।

क.	दिनांक	परिसर का नाम	कक्ष कमांक	जी.पी.एस. रिडिंग	पंजे की साईज
1.	07.09.2015	दोन्द्रो	पी. 972	N - 22°26'11.28" E - 82°46'27.51"	लगभग 14 से.मी. लम्बाई
2.	07.09.2015	अजगरबहार	ओ.ए. 1236 ग्राम नर्बदा	N - 22°29'582" E - 82°41'442"	लगभग 14 से.मी. चौड़ाई

अतः प्रतिवेदन आपके अवलोकनार्थ एवं आवश्यक कार्यवाही हेतु सादर सम्प्रेषित है।

संलग्न :– उपरोक्तानुसार प्लास्टर ऑफ पेरिस से लिया गया पंजे का निशान।

वन परिक्षेत्राधिकारी
बाल्को परिक्षेत्र बाल्को

Annexure - 7

Salient Features of the PEKB Mining Project

Sr. No.	Description	15 MTPA	10 MTPA	Incremental
		Details	Details	
1	Project area	2682.856 ha as per revised mine plan	2711.034 Ha.	-
2	Coal bearing area	2388.247 ha	2388.525 ha	-
3	Non-coal bearing area	294.609 ha	368 Ha.	-
4	Type of mine	Opencast	Opencast	NA
5	Method of mining	Mechanized	Mechanized	NA
6	Rated capacity of mine	15 MT Per Annum	10 MT Per Annum	+
7	Expected life of mine	31 years	50 years	-
8	Average stripping ratio	5.24 m^3/T	5.16 m^3/T	+
9	Geological reserves	516.40 MT	532.86 MT	-
10	Mineable reserves	452.46 MT	452.46 MT	0
11	Average thickness of coal seam	Seam VI – 1.2 – 2.0 m Seam V – 2 – 7 m Seam IV - 7 – 8.5 m	Seam VI –1.2–2.0 m Seam V – 2 – 7 m Seam IV - 7 – 8.5 m	NA
12	Average no. of working days	330 day/year	330 day/year	NA
13	Number of shifts	3 shifts/day	3 shifts/day	NA
14	Working hours/shift	8 hr	8 hr	NA
15	Bench Height for OB	6 m & 10 m	6-m	0
16	Bench Height for coal	10 m or as the seam thickness	10 m - 12 m	0
17	Ultimate depth of mine	225 m	225 m	0
18	Overburden to be generated during entire life of mine	2368.72 million m3	2334.62 million m3	+
19	No. of waste dumps planned	4 Nos	4 Nos	NA
20	Area of waste dumps (External)	112.655 ha	187 ha	-
21	Maximum Bench Height			
	Top OB (for 15 m^3 Hydraulic Shovel)	10m	10 m -12 m	NA
	Top OB (for 3 m^3 backhoe Shovel)	6 m	6 m	NA
	Coal and Interveningparting	10 m or as seamthickness	10-12 m	NA
	Proposed minimum Bench Width			
	Working Bench Width for 15m^3 Hydraulic Shovel	40 m	40 m	0
	Non-Working Bench Width for 15 m^3 Hydraulic Shovel	20 m	20 m	0
	Working Bench Width for 3m^3 backhoe	6 m	6 m	0
	Non-Working Bench Widthfor 3 m^3 backhoe	6 m	6 m	0
22	Width of the permanenthaul road	40 m	30 m	+
23	Width of the temporarytransport ramp	20 m	20 m	0
24	Usual height of the spoildump	30 m	30 m	0

	bench			
25	The width of the activedump bench	30 m	60 m	**-**
26	Bench Slope			
27	OB Bench	70˚	70˚	**0**
	Coal Bench	70˚	70˚	**0**
	Dump bench	37˚	37˚	**0**
28	Overall (Ultimate) pit slope	45˚	45˚	**0**
29	Coal handling & Washing capacity	2500 TPH capacity	1000 –TPH Capacity	**+**
30	No. of crushers	2 Nos.	4 Nos. (plus 2stand by)	**-**
31	Power requirement	15 MVA	24 MW	**-**
32	Water requirement	6880 m^3/day	3600 m^3/day	**+**
33	Transport of OB to dumpsite	35 T/100 T capacity dumpers	100 –T Capacity dumpers	**NA**
34	Transport of coal from mineface to CHP	By covered beltconveyors	By covered belt Conveyors	**NA**
35	Distance and mode of Coal transport to user point			
	Chhabra Unit 3,4,5 &6 , Rajasthan	Transport by rail	Transport by rail	**NA**
	Jhalawar – Kalisind Unit1&2, Rajasthan	Transport by rail	Transport by rail	**NA**
	Suratgarh Unit 7 &8 , Rajasthan	**Transport by rail**	**Transport by rail**	**NA**

Details of Environmental Settings

Sr. No.	Particulars	Details	
1	**Location**	**North central part of Hasdeo-Arand coalfield**	
A	Village	**Core Zone is covered in the following villages** **1. Salhi** **2. Hariharpur** **3. Parsa** **4. Kente** **5. Ghatbara** **6. Parogiya** **7. Basan**	
B	Tehsil	**Udaipur**	
C	District	**Surguja**	
D	State	**Chhattisgarh**	
E	Coordinates	Latitude	**Longitude**
	Coal Mine Block	A-22° 51' 12" N B-22° 47' 37.50" N C-22° 49' 56.25" N D-22° 48' 56" N	**A-82° 47' 23" E** **B-82° 49' 29.03" E** **C-82° 50' 50.32" E** **D-82° 46' 38" E**
	Coal Washery	22° 50' 11"/22° 50' 24" N	**82° 48' 46"/82° 49' 22" E**
2	Elevation	**505 m to 569 m**	
3	Land use for the mine	**Total area of the mine is 2682.856 haForest area – 1871.118 ha (70.0%)** **Agricultural Land – 701.786 ha (26%)** **Govt. land – 109.952 ha (4%)**	
4	Coal washery land use within the ML area	**28.381 ha**	
Sr. No.	Particulars	**Details**	
5	Nearest major town	**Ambikapur (70 km, NE)**	

6	Nearest highway	**SH-2A Bilaspur-Ambikapur (5 km, NW)**	
7	Nearest railway station	**Bishrampur (62 km, NW)**	
8	Nearest major airport	**Raipur (290 km, SW)**	
9	Nearest tourist places	**Nil within 15 km radius from ML boundary**	
10	Defence installations	**Nil within 15 km radius from ML boundary**	
11	Archaeologically listed important place	**Nil within 15 km radius from ML boundary**	
12	Ecological sensitive zones	**No National Parks, Wildlife sanctuaries, Wildlife corridors, Tiger reserves, Elephant reserves and Biosphere Reserves exist within 25 km radius from the ML boundary**	
13	Reserved/Protected forest	Phatepur, P.F.	**Within M.L. area**
		Matringa, P.F.	**Within M.L. area**
		Pidiya, R.F.	**1.6 km, W**
		Janardhanpur, P.F.	**2.3 km, NW**
		Tara East, P.F.	**2.8 km, W**
		Shivnagar, P.F.	**3.7 km, N**
		Paturiya, P.F.	**4.0 km, SSW**
		Putter, P.F.	**4.5 km, ENE**
		Chakeri, P.F.	**5.1 km,, ENE**
		Murgaon, P.F.	**6.0 km, N**
		Dhajag, P.F.	**7.4 km, W**
		Kotmi, P.F.	**7.8 km, NNE**
		Pendrakhi, P.F.	**8.1 km, SE**
		Ramgarh, P.F.	**8.2 km, NE**
		Chandenagar P.F.	**8.9 km, NNW**
		Chirwan P.F.	**9.2 km, N**
		Bhandargaon, P.F.	**9.9 km, NNE**
14	Nearest streams/Rivers	**Atem Nadi– (2.7 km, N)**	
15	Other Industries / Mines	**Nil in 10 km radius**	
16	Coal user locations	**Motipura Choki, Chhabra, Distt-Baran (Rajasthan)**	
		Village-Undal, Tehsil-Jhalraptan,Distt-Jhalawar (Rajasthan)	
		Thukrana, Tehsil-Suratgarh, Distt-Shriganganagar (Rajasthan)	
17	Socio-economic factors	**No additional Resettlement and Rehabilitation issuesare involved.**	
18	**Seismic zone**	**Zone-II as per IS-1893 (Part-1)-2002**	

BASELINE STATUS – FAUNA AND FLORA (IIFM 2009)

Life form Status of the Flora of the PEKB study area

Core zone		**Buffer zone**		**Study area**	
Life forms	**No of Species**	**Life forms**	**No of species**	**Life forms**	**No of species**
Tree	49 65.33%	Tree	75	Tree	75
Shrub	22 53.66%	Shrub	39	Shrub	41
Herb & Grass	17 53.12 %	Herb & Grass	31	Herb & Grass	32
Climber	4 36.36%	Climber	11	Climber	11
Woody climber	5 45.45	Woody climber	11	Woody climber	11
Total	**97**	**Total**	**167**		**169**

Relative % of Lifeform of the Core zone with the overall study area

Study area		Core		Relative % with Study area
Life forms	No of Species	Life forms	No of species	
Tree	74	Tree	49	65.33%
Shrub	41	Shrub	22	53.66%
Herb & Grass	32	Herb & Grass	17	53.12 %
Climber	11	Climber	4	36.36%
Woody climber	11	Woody climber	5	45.45
Total	**170**	**Total**	**97**	**57.06 %**

Threatened Plant species reported in PEKB study area (IIFM 2009)

S.No	Family and Scientific Name	Local Name	Habit	Conservation Status (IUCN)
1	**Acoraceae**			
1	*Acorus calamus*	Bach	Herb	Endangered
2	**Anacardiaceae**			
2	*Buchanania lanzan*	Char	Tree	Near Threatened
3	**Asclepindaceae**			
3	*Ceropegia bulbosa*	Bosiya, kandha	Climber	Near Threatened
4	**Asteraceae**			
4	*Peucedanum nagpurense prain*	Tejraj	Herb	Vulnerable
5	**Burseraceae**			
5	*Boswellia serrata*	Saliha	Tree	Vulnerable
6	**Celastraceae**			
6	*Calastrus paniculata*	Unjain	Woody climber	Vulnerable
7	**Combrataceae**			
7	*Terminalia chabula*	Harra	Tree	Vulnerable
8	*Terminalia arjuna*	Arjun	Tree	Near Threatened
8	**Dioscoraceae**			
9	*Dioscorea bulbifera*	Agitha	Climber	Vulnerable
9	**Euphorbinaceae**			
10	*Phyllanthus emblica*	Awala	Tree	Vulnerable

10	**Leguminoceae**			
11	*Abrus precatorius*	Kwunti	Climber	Near Threatened
12	*Pterocarpus marsupium*	Biju	Tree	Vulnerable
11	**Liliaceae**			
13	*Asparagus racemosus*	Kargi	Shrub	Near Threatened
14	*Chlorophytum tuberosum*	Safed musli	Herb	Vulnerable
15	*Gloriosa superba*	Kharha godi, karihari	Herb	Vulnerable
12	**Sterculiniaceae**			
16	*Sterculia urens*	Khurlu	Tree	Vulnerable
13	**Zingiberaceae**			
17	*Costus speciosus*	Kewu, ban haldi	Herb	Vulnerable
18	*Curcuma angustifolia*	Tikhur	Herb	Vulnrable

List of plants reported in Core and Buffer zone of the PEKB (IIFM 2009)

S.No	Family and species name	Core Zone	Buffer Zone
1	**Acoraceae**		
1	*Acorus calamus*		✓
2	**Amaranthaceae**		
2	*Achyranthes aspera*	✓	✓
3	**Anacardiaceae**		
3	*Buchanania lanzan*	✓	✓
4	*Lannea coromandelica*	✓	✓
5	*Mangifera indica*	✓	✓
6	*Semecarpus anacardium*	✓	✓
4	**Anonaceae**		
7	*Saccopetalum tomentosum*	✓	✓
5	**Apocynaceae**		
8	*Holarrhena antidysenterica*	✓	✓
9	*Nerium odorum*		✓
10	*Vallaris solanacea*		✓
11	*Wrightia tomentosa*		✓
12	*Carissa spinarum*	✓	✓
6	**Araliaceae**		
13	*Heptapleurum venulosum*		✓
7	**Asclipidiaceae**		
14	*Cryptolepis buchanani*		✓
15	*Marsdenia tenacissima*	✓	✓

	16	*Ceropegia bulbosa Roxb.*		✓
8		**Asteracease**		
	17	*Peucedanum nagpurense*		✓
	18	*Xanthium strumarium*		✓
9		**Berberidaceae**		
	19	*Argemone mexicana*	✓	✓
10		**Bixaceae**		
	20	*Cochlospermum religiosum*		✓
	21	*Flacourtia indica*	✓	✓
11		**Boraginaceae**		
	22	*Cordia macleodii*	✓	✓
	23	*Cordia myxa*		✓
	24	*Ehretia laevis*		✓
12		**Buphorbiacea**		
	25	*Euphorbia neriifolia*		✓
13		**Burseraceae**		
	26	*Boswellia serrata*	✓	✓
	27	*Garuga pinnata*	✓	✓
14		**Caesalpimiaceae**		
	28	*Cassia obtusifolia*	✓	✓
	29	*Bauhinia malabarica*	✓	✓
	30	*Bauhinia variegata*	✓	✓
	31	*Caesalpinia bonducella*		✓
15		**Celastraceae**		
	32	*Celastrus paniculata*	✓	✓
	33	*Elaeodendron glaucum*	✓	✓
16		**Combretaceae**		
	34	*Anogeissus latifolia*	✓	✓
	35	*Terminalia arjuna*		✓
	36	*Terminalia ballerica*	✓	✓
	37	*Terminalia chebula*	✓	✓
	38	*Terminalia tomentosa*	✓	✓
17		**Convolvulaceae**		
	39	*Ipomea mauritiana*	✓	✓
	40	*Ipomoea carnea*	✓	✓
18		**Coranaceae**		
	41	*Alangium salvifolium*		✓
19		**Dilleniaceae**		
	42	*Dillenia pentagyna*		✓
20		**Dioscoraceae**		
	43	*Dioscorea bulbifera*	✓	✓
	44	*Dioscorea spp.*	✓	✓
21		**Dipterocarpaceae**		
	45	*Shorea robusta*	✓	✓
22		**Ebenaceae**		
	46	*Diospyros melanoxylon*	✓	✓
	47	*Diospyros montana*		✓
23		**Enphorbiaceae**		
	48	*Cleistanthus collinus*		✓
	49	*Glochidion zeylanicum*	✓	✓

	50	*Antidesma acidum*		✓
	51	*Antidesma diandrum*	✓	
	52	*Bridelia retusa*	✓	✓
	53	*Phyllanthus emblica*	✓	✓
	54	*Ricinus communis*	✓	✓
24		**Hyacinthaceae**		
	55	*Urginea indica*	✓	✓
25		**Lamiaceae**		
	56	*Eranthemum pulchellum*		✓
26		**Lauraceae**		
	57	*Litsea sebifera*		✓
27		**Leguminiceae**		
	58	*Ougeinia dalbergioides*	✓	✓
	59	*Abrus precatorius*		✓
	60	*Atylosia scarabaeoides*	✓	✓
	61	*Flemingia bracteate*		✓
	62	*Albizzia odoratissima*		✓
	63	*Bauhinia purpurea*		✓
	64	*Bauhinia retusa*		✓
	65	*Bauhinia vahlii*		✓
	66	*Butea monosperma*	✓	✓
	67	*Butea superba*	✓	✓
	68	*Cassia auriculata*		✓
	69	*Cassia fistula*		✓
	70	*Cassia tora*	✓	✓
	71	*Dalbergia latifolia*	✓	✓
	72	*Delbergia paniculata*	✓	✓
	73	*Dalbergia sissoo*	✓	✓
	74	*Derris scandens*		✓
	75	*Desmondium pulchellum*	✓	✓
	76	*Dichrostachys cinerea*	✓	✓
	77	*Flemingia chappar*		✓
	78	*Hardwickia binata*	✓	✓
	79	*Indigofera glandulosa*	✓	✓
	80	*Indigofera pulchella*	✓	✓
	81	*Pterocarpus marsupium*	✓	✓
	82	*Sesbania aegyptiaca*	✓	✓
	83	*Spatholobus roxburghii*		✓
28		**Liliaceae**		
	84	*Asparagus racemosus*	✓	✓
	85	*Chlorophytum tuberosum*		✓
	86	*Gloriosa superba*	✓	✓
29		**Lythraceae**		
	87	*Lagerstroemia parviflora*	✓	✓
	88	*Punica granatum*	✓	✓
	89	*Woodfordia floribunda*	✓	✓
30		**Malvaceae**		
	90	*Bergernia spp.*		✓

91	*Bombax malabaricum*	✓	✓
92	*Hibiscus abelmoschus*	✓	✓
93	*Thespesia lampas*	✓	✓
31	**Meliaceae**		
94	*Cedrela toona*		✓
95	*Chloroxylon swietenia*		✓
96	*Soymida febrifuga*		✓
32	**Menispermaceae**		
97	*Tinospora cordifolia*		✓
33	**Mimosaceae**		
98	*Acacia arabica*	✓	✓
99	*Acacia caesia*	✓	✓
100	*Acacia catechu*	✓	✓
101	*Acacia pennata*		✓
102	*Albizzia procera*	✓	✓
103	*Mimosa pudica*	✓	✓
34	**Moraceae**		
104	*Ficus bengalensis*	✓	✓
105	*Ficus glomerata*		✓
106	*Ficus infectoria*	✓	✓
107	*Ficus religiosa*	✓	✓
108	*Streblus asper*		✓
35	**Myrsinaceae**		
109	*Embelia robusta*	✓	✓
110	*Careya arborea*	✓	✓
111	*Eugenia heyneana*	✓	✓
112	*Syzygium cumini*	✓	✓
36	**Oleaceae**		
113	*Schrebera swietenioides*		✓
37	**Palmaceae**		
114	*Phoenix acaulis*	✓	✓
38	**Poaceae**		
115	*Andropogon contortus*	✓	✓
116	*Apluda varia*	✓	✓
117	*Cynodon dactylon*	✓	✓
118	*Dendrocalamus strictus*	✓	✓
119	*Desmostachya bipinnata*		✓
120	*Dichanthium annulatum*		✓
121	*Echinochloa colonum*		✓
122	*Eragrostis tenella*		✓
123	*Eulaliopsis binata*		✓
124	*Imperata cylindrica*	✓	✓
125	*Ischaemum pilosum*		✓
126	*Saccharum spontaneum*		✓
127	*Sehima sulcatum*		✓
39	**Rhammacea**		
128	*Ziziphus rugosa*	✓	✓
129	*Ventilago madraspatana*		✓
130	*Ziziphus xylopyrus*	✓	✓

40		**Rubiaceae**		
	131	*Adina cordifolia*	✓	✓
	132	*Hymenodictyon excelsum*	✓	✓
	133	*Mitragyna parvifolia*	✓	✓
	134	*Randia dumetorum*		✓
	135	*Randia uliginosa*		✓
	136	*Stephegyne parviflora*		✓
	137	*Wendlandia tinctoria*	✓	✓
	138	*Gardenia latifolia*	✓	✓
	139	*Gardenia turgida*	✓	✓
	140	*Hamiltonia suaveolens*	✓	✓
41		**Rutaceae**		
	141	*Aegle marmelos*	✓	✓
	142	*Limonia acidissima*		✓
	143	*Murraya koenigii*		✓
42		**Samydaceaa**		
	144	*Casearia graveolens*	✓	✓
	145	*Casearia bourdillonii*		✓
	146	*Casearia tomentosa*	✓	✓
43		**Sapindaceae**		
	147	*Schleichera trijuga*	✓	✓
44		**Sapotaceae**		
	148	*Madhuca indica*	✓	✓
45		**Solanaceae**		
	149	*Withania somnifera*		✓
46		**Sterculiaceae**		
	150	*Helicteres isora*	✓	✓
	151	*Sterculia urens*	✓	✓
	152	*Waltheria indica*		✓
	153	*Eriolaena hookeriana*		✓
47		**Symplocaceae**		
	154	*Symplocos racemosa*	✓	✓
48		**Tiliaceae**		
	155	*Grewia hirsuta*		✓
	156	*Grewia tiliaefolia*		✓
49		**Ulmaceae**		
	157	*Holoptelea integrifolia*		✓
	158	*Trema politoria*		✓
50		**Verbenaceae**		
	159	*Tectona grandis*		✓
	160	*Gmelina arborea*		✓
	161	*Lantana camara*	✓	✓
	162	*Nyctanthes arbor-tristis*		✓
	163	*Vitex negundo*	✓	✓
	164	*Vitis carnosa*	✓	
51		**Vitaceae**		✓
	165	*Cissus quadrangularis*	✓	✓
	166	*Vitis carnosa*	✓	✓
	167	*Vitis latifolia*		✓

52	**Zingiberaceae**			
168	*Costus speciosus .*			✓
169	*Curcuma angustifolia*			✓
	Total		**98**	**167**

List of reptiles reported in BEKB study area (IIFM 2009)

S.no	Scientific name	Common name		Core	Buffer	Study Area	WPA, 1972
1	**Gekkonidae**						
1	*Hemidactylus brooki*	Brook's geecko			✓	✓	-
2	*Hemidactylus flaviviridis*	Yellow-green house gecko		✓	✓	✓	LR-lc
3	*Hemidactylus leschenaulti*	Bark gecko		✓	✓	✓	-
4	*Hemidactylus triedrus*	Termite gecko		✓	✓	✓	-
2	***Agamidae***						
5	*Calotes versicolor*	Indian Garden Lizard		✓	✓	✓	-
6	*Psammophilus blanfordanus*	Blanford's Rock Agama		✓	✓	✓	-
7	*Sitana ponticeriana*	Fan throated lizard		✓	✓	✓	-
3	**Scincidae**						
8	*Eutropis carinata*	Common skink		✓	✓	✓	-
4	**Boidae**						
9	*Eryx johinii*	Red sand boa					
10	*Python molurus*	Indian rock python		✓	✓	✓	I
5	**Colubridae**						
11	*Amphiesma stolata*	Buff-striped Keelback		✓	✓	✓	IV
12	*Ptyas mucosa*	Indian Rat Snake		✓	✓	✓	
13	*Dendrelaphis tristis*	Common Bronzeback Tree Snake		✓	✓	✓	IV
14	*Rhabdophis plumbicolor*	Green Keelback		✓	✓	✓	IV
15	*Oligodon taeniolatus*	Streaked kukri snake		✓	✓	✓	IV
16	*Fowlea piscator*	Checkered Keelback Water Snake		✓	✓	✓	
17	*Elaphe helena helena*	Common Indian Trinket Snake		✓	✓	✓	IV
18	*Naja naja*	Spectacled Cobra		✓	✓	✓	??
19	*Boiga trigonata*	Common Indian Cat Snake		✓	✓	✓	IV
20	*Calliophis melanurus*	Slender Coral snake		✓	✓	✓	IV
6	**Viperidae**						
21	*Daboia russelii*	Russell's Viper			✓	✓	
22	*Echis carinatus*	Indian Saw-scaled Viper		✓	✓	✓	IV
7	**Elapidae**						
23	*Bungarus caerulus*	Common Indian Krait		✓	✓	✓	IV
	Total Species			**21**	**23**	**23**	

List of birds reported in PEKB study area (IIFM 2009)

S.no	Family/Scientific name	Common name	Core	Buffer	Study Area	WPA 1972
	Accipitridae					
1	*Elanus caeruleus*	Black-shouldered Kite	✓	✓	✓	I

2	*Milvus migrans*	Black Kite	✓	✓	✓	I
3	*Accipiter badius*	Shikra	✓	✓	✓	I
4	*Spizaetus cirrahatus*	Changeable Hawk Eagle	✓	✓	✓	I
5	*Aquila rapax*	Tawny Eagle		✓	✓	I
6	*Spilornis cheela*	Crested Serpent Eagle	✓	✓	✓	I
	Aegithinidae					
7	*Aegithina tiphia*	Common lora	✓	✓	✓	
	Alcedinidae					
8	*Ceryle rudis*	Pied kingfisher		✓	✓	
9	*Alcedo atthis*	Common kingfisher	✓	✓	✓	
10	*Halcyon smyrnensis*	White throated kingfisher	✓	✓	✓	
	Apodidae					
11	*Cypsirius balasiensis*	Asian palm swift	✓	✓	✓	
12	*Apus offinis*	Housed Swift	✓	✓	✓	
	Ardeidae					
13	*Ardea cinerea*	Grey Heron		✓	✓	
14	*Bubulcus idis*	Cattle Egret		✓	✓	
15	*Egretta albus*	Great Egret	✓	✓	✓	
16	*Egretta garzelta*	Little Egret	✓	✓	✓	
	Bucerotidae					
17	*Ocyceros birostris*	Indian Grey Hornbill	✓	✓	✓	**I**
	Campephagidae					
18	*Conacina macei*	Large Cuckoo shrike	✓	✓	✓	
19	*Pericrocolus Cinnomorneus*	Small Minivet	✓	✓	✓	
20	*Pericrocolus flammeus*	Scarlet Minivet	✓	✓	✓	
	Caprimulgidae					
21	*Caproimulgas asiaticus*	Indian Nightjar	✓	✓	✓	
	Charadriidae					
22	*Vanellus indicus*	Red-wattled lapwing	✓	✓	✓	
	Columbidae					
23	*Treron phoenicoptera*	Yellow footed green Pigeon	✓	✓		
24	*Columba livia*	Rock pigeon	✓	✓	✓	
25	*Streptopelia decaoeta*	Eurasian Collared Dove		✓	✓	
26	*Streptopelia chinesis*	Spotted Dove	✓	✓	✓	
27	*Streptopelia transquebarica*	Red collared Dove	✓	✓	✓	
	Corvidae					
28	*Corvus splendens*	House crow	✓	✓	✓	
29	*Corvus macroryynchos*	Large-billed crow	✓	✓	✓	
30	*Dendrocitta vagabunda*	Rufous Treepie	✓	✓	✓	
	Cuculidae					
31	*Herococeyx varius*	Common hawk cuckoo	✓	✓	✓	
32	*Eudynamys scolopacea*	Asian Koel		✓	✓	
33	*Centropus sinensis*	Greater Coucal	✓	✓	✓	
34	*Clamator jacobimus*	Pied crested cuckoo		✓	✓	
	Dicuridae					
35	*Dicrurus macroceros*	Blacked Drongo	✓	✓	✓	
36	*Dicrurus caerulescens*	White bellied Drongo	✓		✓	
37	*Dicrurus paradiseus*	Greater Racket-tailed Drongo	✓		✓	
	Hirundinidae					

38	*Hirundo smithii*	Wir-tailed Swallow		✓	✓	
	Laniidae					
39	*Lanius schach*	Bay-backed Shrike	✓	✓	✓	
40	*Lanus schach*	Long-tailed Shrike	✓	✓	✓	
	Leiothrichidae					
41	*Turdoides striatus*	Jungle Babbler	✓	✓	✓	
	Meropidae					
42	*Merops persicus*	Blue Cheeked Bee-eater	✓	✓	✓	
43	*Merops orientalis*	Green Bee-eater	✓	✓	✓	
44	*Coracias benghalensis*	Indian Roller		✓	✓	
	Muscicapidae					
45	*Cyornic tickelliae*	Tickells bule Flycatcher	✓	✓	✓	
46	*Terdoides striatus*	Asian Paradise Flycatcher	✓	✓	✓	
47	*Rhipidura aureola*	White Brown fantail Flycatcher	✓	✓	✓	
48	*Phoenicurus ochruros*	Black Redstrart	✓	✓	✓	
49	*Saxicoloides fulicata*	Indian Robin	✓	✓	✓	
50	*Copsychus Saularis*	Oriental Magpie Robin	✓	✓	✓	
51	*Soxicola caprata*	Pied Bush chat	✓	✓	✓	
	Oriolidae					
52	*Oriolus xanthomus*	Eurasian Golden Oriole	✓	✓	✓	
53	*Oriolus xanthomus*	Black-Hooded Oriole	✓	✓	✓	
	Phasianidae					
54	*Francolinus francolinus*	Black Francolin	✓	✓	✓	
55	*Francolinus Pictus*	Painted Francolin	✓	✓	✓	
56	*Cotuenix coturnix*	Common Quail	✓	✓	✓	
57	*Perdicula asiatica*	Jungle Bush Quail	✓	✓	✓	
58	*Galloperdix spondica*	Red Spur Fowl		✓	✓	
59	*Gallus gallus*	Red Jungle Fowl		✓	✓	
60	*Pavo cristatus*	Indian Peafowl		✓	✓	I
	Picidae					
61	*Dinopim benghalensis*	Black rumped Flameback	✓	✓	✓	
62	*Picus xanthopygaeus*	Streak Throated Woodpecker	✓	✓	✓	
63	*Hermicircus canente*	Heart Spotted Woodpecker	✓	✓	✓	
	Psittaculidae					
64	*Psittacula eupatira*	Alexandrin Parakeet	✓	✓	✓	
65	*Psittacula eupatira*	Rose ringed Parakeet	✓	✓	✓	
66	*Psittacula cyanocephala*	Plum headed Parakeet		✓	✓	
	Pycnonotidae					
67	*Pycnonotus cafer*	Red vented Bulbul	✓	✓	✓	
	Ramphastidae					
68	*Megalaima haemacephla*	Coppersmith Barbet	✓	✓	✓	
	Rhipiduridae					
69	*Prinia socialis*	Ashy Prinia	✓	✓	✓	
70	*Prinia inomata*	Plain Prinia		✓	✓	
71	*Prinia hodgsonii*	Grey-Breasted Prinia	✓	✓	✓	
	Strigidae					
72	*Athene bromah*	Spotted owlet	✓	✓	✓	
73	*Glaucidium radiatum*	Jungle Owlet	✓	✓	✓	
	Strurnidae					

74	*Sturnus pogodarum*	Brahminy starling	✓	✓	✓	
75	*Sturnus roseus*	Rosy starling	✓	✓	✓	
76	*Sturnus contra*	Asian Pied Starling	✓	✓	✓	
77	*Acridotheres ginginianus*	Bank Myna		✓	✓	
78	*Acridotheres tritis*	Common Myna	✓	✓	✓	
79	*Acridotheres fuscus*	Jungle Myna	✓	✓	✓	
	Upupidae					
80	*Upupa epops*	Common Hoopoe	✓	✓	✓	
	Vangidae					
81	*Tephrodornis pondicerianus*	Common wood Shrike	✓	✓	✓	
	Zosteropidae					
82	*Zosterops palpebrosus*	Oriental White Eye	✓	✓	✓	
	Total		**67**	**80**	**82**	

List of Mammals reported in PEKB (IIFM 2009) and Hasdeo Arand Area (WII-2019-20)

SN	Family and Scientific name	Common name	WII	IIFM		IUCN	WPA
				Core	BUFFER		
1	**Elephantidae**						
1	*Elephas maximus*	Elephant	✓	✓	✓	En	Sch I
2	**Cercopithecidae**						
2	*Macaca mulatta*	Rhesus macaque	✓		✓	Lc	Sch II
3	*Semnopithecus entellus*	Common langur	✓		✓	Lc	Sch II
3	**Sciuridae**						
4	*Ratufa indica*	Giant squirrel	✓			Lc	Sch II
5	*Funambulus pennantii*	Five striped Squirrel		✓	✓		
	Pteropodidae						
6	*Pteropus giganteus*	Indian flying fox		✓	✓		
4	**Hystricidae**						
7	*Hystrix indica*	Indian crested porcupine	✓			Lc	Sch IV
5	**Leporidae**						
8	*Lepus nigricollis*	Black nape hare	✓	✓	✓	Lc	Sch IV
6	**Manidae**						
9	*Manis crassicaudata*	Indian pangolin	✓			En	Sch I
7	**Felidae**						
10	*Felis chaus*	Jungle cat	✓		✓	Lc	
11	*Prionailurus rubiginosus*	Rusty spotted cat	✓			Nt	Sch I
12	*Panthera pardus*	Leopard	✓			Vu	Sch I
8	**Viverridae**						
13	*Paradoxurus hermaphroditus*	Asian Palm civet	✓			Lc	Sch II
14	*Viverricula indica*	Small Indian civet	✓			Lc	Sch II
9	**Herpestidae**						
15	*Herpestes edwardsii*	Common grey mongoose	✓	✓	✓	Lc	Sch II

16	*Herpestes smithii*	Ruddy mongoose	✓			Lc	Sch II
10	**Hyaenidae**						
17	*Hyaena hyaena*	Striped hyena	✓	✓	✓	Nt	Sch I
11	**Canidae**						
18	*Canis aureus*	Golden jackal	✓	✓	✓	Lc	Sch III
19	*Canis lupus*	Grey wolf	✓			Lc	Sch I
20	*Vulpes bengalensis*	Indian fox	✓			Lc	Sch II
12	**Ursidae**						
21	*Melursus ursinus*	Sloth bear	✓	✓	✓	Vu	Sch I
13	**Mustelidae**						
22	*Lutragale perspicillata*	Smooth-coated otter	✓			Vu	Sch II
14	**Mustelidae**						
23	*Mellivora capensis*	Honey badger	✓			Lc	Sch I
15	**Suidae**						
24	*Sus scrofa*	Wild Pig	✓	✓	✓	Lc	Sch III
16	**Cervidae**						
25	*Axis axis*	Chital	✓		✓	Lc	Sch III
26	*Muntiacus muntjac*	Barking deer (muntjac)	✓		✓	Lc	Sch III
27	*Rusa unicolor*	**Sambar**			✓		
17	**Bovidae**						
28	***Tetracerus quadricornis***	**Chousingha**	✓			Vu	Sch I
18	**Muridae**						
29	*Bandicota bengalensis*	*Lesser Bandicoot Rat*		✓	✓		
30	Nesokia indica	Short-tailed Bandicoot Rat		✓	✓		
31	*Rattus rattus-refescena*	**Common House Rat**		✓	✓		
	Total		**25**	**12**	**18**		

Species checklist list of butterflies (Rhopalocera) sampled in the study area* (ICFRE*2019-2020)

Sl.No.	Common Name	*Scientific name*
1	Large Oak Blue	*Arhopala amantes*
2	Indian Oak Blue	*Arhopala atrax*
3	Lemon Emigrant	*Catopsilia pomona*
4	Common Evening Brown	*Melanitis leda*
5	Common Grass Yellow	*Eurema hecabe*

6	Lime Swallowtail	*Papilio demoleus*
7	Spot Swordtail	*Graphium nomius*
8	Common Indian Crow	*Euploea core*
9	Striped Tiger	*Danaus genutia*
10	Baronet	*Symphaedr anais*
11	Common Leopard	*Phalanta phalantha*
12	Grey Count	*Tanaecia lepidea*
13	Indian Jezebel	*Delias eucharis*
14	Grey Pansy	*Junonia atlites*
15	Plain Tiger	*Danaus chrysippus*
16	Common Sailer	*Neptis hylas*
17	Lemon Pansy	*Junonia lemonias*
18	Common 4 Ring	*Ypthima huebneri*
19	Common Bushbrown	*Mycalesis perseus*
20	Peacock Pansy	*Junonia almana*
21	Blue Pansy	*Junonia orithya*
22	Chocolate Pansy	*Junoniai phita*
23	**Danaid Eggfly (IWPA-Sch.II)**	***Hypolimnas misippus***
24	Great Eggfly	*Hypolimnas bolina*
25	Common Sergeant	*Athyma perius*
26	Common Mormon	*Papilio polytes*
27	Mottled Emigrant	*Catopsilia pyranthe*
28	Pale Grass Blue	*Pseudozizeeria maha*
29	Blue Tiger	*Tirumala limniace*
30	Commander	*Moduza procris*
31	Common Cerulean	*Jamides celeno*
32	Indian Red Flash	*Rapala iarbus*
33	Painted Lady	*Vanessa cardui*
34	Peablue	*Lampide sboeticus*
35	Redspot	*Zesius chrysomallus*
36	**Tawny Rajah (IWPA-Sch.II)**	***Charaxes bernardus***

37	Common Castor	*Ariadne merione*
38	Common Silverline	*Spindasis vulcanus*
39	Plum Judy	*Abisara echerius*
40	Psyche	*Leptosia nina*
41	Silver Forget-me-not	*Catochrysop sstrabo*
42	Staff Sergeant	*Athyma selenophora*
43	Tawny Coster	*Acraea terpsicore*

The above list is provided by Dr. Arun Pratap Singh Scienist – F, FRI, ICFRE.

Annexure – 8

Data sheet of village interview survey

Form no/date: Interview team:

Site: Village:

GPS:

A. RESPONDENT BACKGROUND

1. Name: 2. Age, gender and caste:

3. Education: 4. Marital status: 5. No. of children:

6. Family members: M……. F…….C…….

7. Do your children go to school?

Level of education

Where do they study?

8. Earning members: 9: Dependent members

10. Occupation: {i} Agriculture {ii} Livestock {iii} Shop/ own business {iv} Govt (PSU/State Govt/Central Govt) {v} Private Enterprise {vii} Property rental {viii} Others

Notes……

11. Average monthly income (split source-specific):

12. For how long have you been living in this village? {i} From birth {ii} < 5 years {iii} < 10 years {iv} < 20 years {v} > 20 years

B. AGRICULTURE DETAILS

1) Agricultural profile

Crop	Area cultivated	Planting months	Harvest months	Units harvested	Land ownership	Sale/ Own use	Income (in RS)

2) What is the predominant land-use type in the village?

(i) Wet-land agriculture (ii) Dry-land agriculture (iii) Plantations (iv) Fruit orchards (v) Grazing lands and fallows

3) Source of water for irrigation?

(i) Run-off from forest collected in village pond (ii) Run-off from forest collected in pit (iii) Bore-well (iv) River (v) others

4) How many cropping seasons are there in the village?

5) Livestock

Animal	Number	Stall-fed	Free-ranging	Own-land	In forest
Cattle					
Buffalo					
Goat					
Sheep					
Fowl					
Others (specify)					

6) Who take the animals for grazing? (i) Men (ii) Women (iii) Children (iv) Elders

7) Where do you water your livestock? (i) Jungle stream (ii) Stream outside jungle (iii) Village ponds/check-dams (iv) Forest ponds/check-dams

8) Has there been any instance of wild animals killing livestock? (A) Yes (B) No

If yes, what and when:

C. DEPENDENCE ON FOREST

1) How is forestland best used?
   a. Conserve for resources
   b. Mine it
   c. Use judiciously
   d. Convert to agriculture

2) Which of the following is a major threat to their income security?

   a. Wildlife
   b. Disease
   c. Fire
   d. Mining

3) Benefits from forest

a. Don't know
b. None
c. Water
d. Plants for food and medicine
e. Fuel wood
f. Divinity / diety
g. Food (animal)
h. Soil
i. Fodder

5) How often do you go to the forest? Daily / Weekly / monthly / Yearly

---

6) Why do you go to the forest?

a. Route – (no other option or short cut)
b. Freetime activity
c. Grazing
d. Fuelwood
e. Forest produce collection
f. Others

7) What fuel do you use for cooking and other household requirements (including cooking & hot water)

(i) Firewood from forest (ii) Firewood from agriculture (iii) Kerosene (iv) LPG (v) Purchase of firewood (vi) Others (specify)

---

8) Where do you get your drinking water from?

(i) Borewell (ii) River (iii) Pond (iv) Spring

---

9) Forest produce collection (including medicinal plants as well)

Commodity	Own use/Selling	Uses	Total quantity (no of days x qty)	Months of collection (and no. of days)	Average income	Family members collecting
Mahua (*M.longifolia*)						
Chironji (*B.lanzen*)						
Tendu (*D.melanoxylon*)						
Saphrophyte						
Sal (*S.robusta*)						
Honey						

10) Did they discontinue collecting any MFP, and if yes, the reasons for that?

D. NATURAL HISTORY, ANIMAL DISTRIBUTION AND CONFLICT

1) What are the animals commonly found in the region?

Species	Frequency of sighting	Months seen	Last seen	Locations seen	Threat to crops/ livestock	Threat to life
Elephant						
Chital						
Sambar						
Barking deer						
Mouse deer						
Chousingha						
Chinkara						
Nilgai						
Gaur						
Common langur						
R.monkey						
S.loris						
G.squirrel						
Tiger						
Leopard						
Dhole						
Wolf						
Jackal						
Indian fox						
S.Bear						
Hyna						
Jungle cat						
Leopard cat						
Rusty spotted						
Fishing cat						
Caracal						
Small Indian civet						
Palm civet						
Common mongoose						
Ruddy mongoose						
Wild pig						
Smooth coated otter						
Porcupine						
Pangolin						

Honey Badger						

2) Do you trap animals and birds? (A) Yes (B) No

a. Which animals and birds
b. Methods - Snare / Catapult / Cast nets / others (elaborate)
c. Purpose - (i) kept as pets (ii) consumed as food (iii) sold as food (iv) sold as pets

3) What has been the trend in animal sighting over the last ten years or so? Provide possible reasons to support your observations.

---

4) Around your village, in which forest terrains do you commonly see animals and birds?

---

5) How common is elephant sighting near your village? And mostly where : (A) on the fringes of the village (B) outside the forest (C) inside the forest

---

6) How many elephants do you often see? (A) Group (B) Solitary

7) In the last ten years, has there been any change in the movement pattern of the elephants?

---

8) How common are the instances of crop raiding by elephants? If so, which crops does it prefer? Elaborate.

>In last 1 year > 5 years >10 years

Season – Monsoon/ Winter / Summer

---

9) Is the crop raiding done by a herd of elephants or a solitary elephant?

---

10) Is there a sense of fear associated with elephant sighting near your village?

---

11) Is there any history of elephant mahout relationship in the past from your village?

---

12) Have you discontinued cultivation of any crops due to damage by wild animals? (A) Yes (B) No. If yes, which crops?

---

13) Do you grow any crops that wild animals do not damage? (A) Yes (B) No

---

14) Were there any attacks on people by wild animals? (A) Yes (B) No

Describe in detail.

---

15) Do people kill wild animal? If yes, for what purpose?

---

16) Where are the crops stored immediately after harvest? (A) In the field itself (B) In the house

(C) Away from farm

17) If you guard the crops, who guards the crops during daytime and nighttime?

---

18) What measures are used to prevent crop raiding by wild herbivores (passive measures)?

Type	Ownership	Maintenance	Effectiveness	Reason
Wall				
Non-powered fence				
Electric fence				
Trench				
Others				

19) What measures are used to prevent crop raiding by wild herbivores (active measures)?

Type	Who's responsible	Effectiveness	Reason
Crackers			
Dogs			
Drums			
Guns			
Others			

20) What according to you is the best way of managing wild animal conflict? Conflict caused in your area by particular animal.

Notes:

---

21) Do people report losses to Forest Department? If yes, did they get compensated for losses?

E. PERCEPTION TOWARDS CONSERVATION

1) How to do want the forest to be, if given an option.

(A) Forest without wildlife, only plants and trees (B) Forest with Wildlife

---

2) Are you ready for experiment, which involves co existence between people and wildlife?

3) Has there been any drastic change in tree and vegetation in and around the village? Or any major change in the surrounding area? (A) Yes (B) No

If yes, what changed and reason

---

4) What do you know about Joint Forest Management committee?

---

5) Are there awareness programs or training held in the village? If yes, what kind of and how often?

---

6) Do these initiatives have positive impact on the people? (A) Yes (B) No

If yes, please elaborate how.

---

7) What is the age-wise participation among these conservation groups? Mostly participation is from:

(A) Young age (B) Middle age (C) Old age (D) All

F. PERCEPTION ON MINING

1) Did you participate in consultation/gram sabha, public hearing?

---

2) Do you have land in the mining area (or its buffer)? (A) Yes (B) No

3) Are you willing to give your land and the forest for mining? (A) Yes (B) No

Explain

4) Has the R and R package been finalized? (A) Yes (B) No

5) If yes, then what mode of compensation is offered from the mining company? (A) Alternate land offer (B) employment (C) cash (D) other

6) What benefit do you expect from the mining agency?

a. Healthcare
b. Education facilities
c. Technical training through tie-ups with ITI?
d. Other

7) Are you aware of the details of the mining agency and the lease term?

8) Has the condition of roads improved after the mining has started/ proposed?

(A) Yes (B) No

9) Has the traffic increased in the roads after mining has started and its potential impact?

10) Did you get direct employment in the mines? If yes, the exact nature of work

a. Amount paid for their job?
b. Contract and period?
c. Details of working hours, weekly holidays, night duties etc?
d. Payment on time?
e. What other perks and benefits do they get?
Insurance / Medical claim / School Fees / Vehicle

11) Indirect employment due to mines?

Job with transport company as driver or cleaner / petty shop / hotel or dhaba / rentals

12) Do mining companies operate schools? Do children from the village attend that school?

a. From where do the teachers come?
b. How much fee is charged?
c. Do the children get free food in the school?
d. Has education improved?

13) Has the employment levels have improved after mines were established?

14) Condition of agriculture after mining?

15) What is the health impact of mining activity? How does it affect the day-to-day life?

16) Is there a sense of loss-associated with land and forests?

17) What changes do you perceive in the years to come with mining and other activities being taken up? (High to low)

(A) Agriculture land use pattern will change (B) NTFP collection more/less (B) forest resource availability

18) What changes have occurred after identifying mining in the area/ proposal?

Annexure – 9

GPS location of camera traps placed in the study area

Sl.no.	Camera trap ID	Latitude	Longitude
1	CT 50	22.819260	82.839090
2	CT 55	22.808610	82.872820
3	CT 76	22.808150	82.746600
4	CT 83	22.805800	82.843900
5	CT 85	22.756490	82.860020
6	CT 87	22.756640	82.895900
7	CT 88	22.758440	82.905960
8	CT 96	22.778720	82.616740
9	CT 131A	22.804530	82.835140
10	CT 139	22.848760	82.731340
11	CT 150	22.802460	82.887810
12	CT 160	22.853808	82.756775
13	CT 175R	22.857720	82.738820
14	CT 00 Basan	22.809260	82.826090
15	CT 4	22.810810	82.860400
16	CT 5	22.804200	82.864610
17	CT 39	22.787220	82.875140
18	CT 180R Parogia	22.798630	82.862480
19	CT 187	22.852900	82.706060
20	CT 193	22.849070	82.731730
21	CT 237	22.866060	82.762700
22	CT 238	22.844420	82.710140
23	CT375	22.839190	82.718760
24	CT337	22.811710	82.841290
25	CT 131	22.805490	82.834820
26	CT-G86	22.771840	82.870690

GPS location of sign surveys carried out in the study area

S.no	Latitude	Longitude	S.no	Latitude	Longitude	S.no	Latitude	Longitude
1	22.79863	82.86248	41	22.79529	82.85695	81	22.86567	82.72736
2	22.79762	82.86111	42	22.78884	82.85428	82	22.86528	82.72557
3	22.79692	82.85964	43	22.79053	82.85982	83	22.86589	82.72403
4	22.79611	82.85857	44	22.78958	82.85799	84	22.8081	82.86174
5	22.79083	82.828526	45	22.84469	82.72592	85	22.80913	82.86293
6	22.78884	82.85428	46	22.85101	82.73248	86	22.81053	82.86414
7	22.78933	82.85613	47	22.85279	82.73253	87	22.81175	82.86935
8	22.78958	82.85799	48	22.85419	82.73377	88	22.80462	82.87526
9	22.79053	82.85982	49	22.85527	82.73556	89	22.76348	82.89667
10	22.79448	82.85538	50	22.85625	82.73717	90	22.76024	82.89227
11	22.84252	82.72343	51	22.85909	82.71096	91	22.73948	82.80941
12	22.84348	82.7246	52	22.85823	82.70929	92	22.7396	82.81274
13	22.84469	82.72592	53	22.85706	82.70798	93	22.74329	82.60539
14	22.84588	82.72752	54	22.85566	82.70699	94	22.75883	82.60105
15	22.84666	82.72939	55	22.85411	82.70667	95	22.77374	82.62618
16	22.84787	82.73067	56	22.85251	82.70548	96	22.77914	82.62024
17	22.85101	82.73248	57	22.84991	82.70287	97	22.78125	82.61301
18	22.85279	82.73253	58	22.82651	82.72762	98	22.82198	82.83165
19	22.85419	82.73377	59	22.8279	82.72678	99	22.8201	82.83235
20	22.85625	82.73717	60	22.82852	82.72858	100	22.81893	82.83373
21	22.8201	82.83235	61	22.83156	82.72786	101	22.81742	82.83427
22	22.81893	82.83373	62	22.83189	82.72586	102	22.81673	82.829365
23	22.75247	82.76447	63	22.83244	82.72406	103	22.84252	82.75686
24	22.77724	82.874447	64	22.83409	82.72382	104	22.84387	82.7599
25	22.78289	82.8735	65	22.83555	82.72407	105	22.81583	82.82367
26	22.78619	82.87389	66	22.83781	82.7249	106	22.81153	82.82569
27	22.78722	82.87514	67	22.83899	82.7239	107	22.81264	82.81976
28	22.75702	82.87384	68	22.8398	82.72204	108	22.80926	82.82609
29	22.75455	82.87022	69	22.83911	82.71832	109	22.80823	82.82716
30	22.82178	82.84611	70	22.84033	82.71975	110	22.78318	82.79253
31	22.80412	82.84906	71	22.84076	82.7215	111	22.76929	82.78178
32	22.777027	82.766159	72	22.8669	82.75211	112	22.7636	82.76099
33	22.854156	82.68968	73	22.86567	82.75069	113	22.76277	82.75943
34	22.855235	82.69104	74	22.86625	82.74668	114	22.78289	82.8735
35	22.85543	82.687582	75	22.86725	82.74523	115	22.78722	82.87514
36	22.85557	82.686443	76	22.86458	82.74275	116	22.75617	82.86642
37	22.8012	82.86562	77	22.86275	82.74114	117	22.75634	82.86428
38	22.79911	82.86366	78	22.86096	82.74099	118	22.75816	82.85662
39	22.79863	82.86248	79	22.85973	82.73964	119	22.7598	82.85714
40	22.79762	82.86111	80	22.86438	82.72878	120	22.77311	82.8734

S.no	Latitude	Longitude	S.no	Latitude	Longitude	S.no	Latitude	Longitude
121	22.76667	82.66449	**161**	22.80535	82.82437	**201**	22.81153	82.82569
122	22.74944	82.69528	**162**	22.76869	82.78344	**202**	22.81109	82.82097
123	22.795787	82.77271	**163**	22.79083	82.828526	**203**	22.76905	82.86649
124	22.791528	82.769036	**164**	22.78922	82.85171	**204**	22.85251	82.70548
125	22.784107	82.766988	**165**	22.78958	82.85799	**205**	22.84857	82.70178
126	22.778261	82.766194	**166**	22.79129	82.86154	**206**	22.81285	82.82501
127	22.775979	82.766741	**167**	22.84588	82.72752	**207**	22.77162	82.66179
128	22.79076	82.84293	**168**	22.85527	82.73556	**208**	22.7654	82.66517
129	22.774098	82.766704	**169**	22.8579	82.74129	**209**	22.81125	82.83559
130	22.777027	82.766159	**170**	22.84857	82.70178	**210**	22.75217	82.68851
131	22.848191	82.690839	**171**	22.82407	82.72699	**211**	22.852508	82.689257
132	22.854156	82.68968	**172**	22.86018	82.73653			
133	22.855235	82.69104	**173**	22.80861	82.87282			
134	22.858092	82.689306	**174**	22.7396	82.81274			
135	22.85516	82.688216	**175**	22.74469	82.81425			
136	22.85543	82.687582	**176**	22.77444	82.66206			
137	22.79991	82.86475	**177**	22.76163	82.8568			
138	22.77313	82.63017	**178**	22.77313	82.63017			
139	22.77903	82.6218	**179**	22.77318	82.62785			
140	22.77313	82.63017	**180**	22.77503	82.62423			
141	22.77903	82.6218	**181**	22.77914	82.62024			
142	22.75702	82.87384	**182**	22.77748	82.6171			
143	22.75533	82.86753	**183**	22.77313	82.63017			
144	22.75717	88.85762	**184**	22.77318	82.62785			
145	22.84252	82.72343	**185**	22.77503	82.62423			
146	22.84348	82.7246	**186**	22.77914	82.62024			
147	22.84469	82.72592	**187**	22.77748	82.6171			
148	22.84666	82.72939	**188**	22.78722	82.87514			
149	22.84919	82.73179	**189**	22.7963	82.88003			
150	22.85279	82.73253	**190**	22.80276	82.88705			
151	22.85849	82.73946	**191**	22.80313	82.89198			
152	22.8579	82.74129	**192**	22.75617	82.86642			
153	22.85758	82.74317	**193**	22.76997	82.66238			
154	22.85706	82.70798	**194**	22.78289	82.8735			
155	22.85566	82.70699	**195**	22.79622	82.88418			
156	22.84991	82.70287	**196**	22.75533	82.86753			
157	22.81103	82.86497	**197**	22.739	82.81118			
158	22.80861	82.87282	**198**	22.8201	82.83235			
159	22.80276	82.87206	**199**	22.81893	82.83373			
160	22.80636	82.83517	**200**	22.81583	82.82367			

Annexure 10

Compartment details extracted from the habitat suitability model – Large carnivore

S.no	Range	Beat Name	Compartment Number
1	Kendai	Arsiya	P423
2	Kendai	Gidhamudi	P434
3	Kendai	Gidhamudi	P439
4	Kendai	Gidhamudi	P440
5	Kendai	Gidhamudi	P441
6	Kendai	Gidhamudi	P442
7	Kendai	Paturiyadand	P430
8	Kendai	Paturiyadand	P433
9	Kendai	Paturiyadand	P436
10	Kendai	Puta	P432
11	Kendai	Salihapahri	P437
12	Ramanuj nagar	Abhaipur	1990
13	Ramanuj nagar	Abhaipur	P1995
14	Ramanuj nagar	Abhaipur	1994
15	Ramanuj nagar	Abhaipur	1926
16	Ramanuj nagar	Anandnagar	P1859
17	Ramanuj nagar	Anandnagar	P1858
18	Ramanuj nagar	Badhiya dand	VVN 1943
19	Ramanuj nagar	Badhiya dand	VVN 1942
20	Ramanuj nagar	Badhiya dand	VVN 1944
21	Ramanuj nagar	Badhiya dand	VVN P19
22	Ramanuj nagar	Badhiya dand	VVN 1941
23	Ramanuj nagar	Chitkhai	1927
24	Ramanuj nagar	Hariharpur	1974
25	Ramanuj nagar	Hariharpur	1972
26	Ramanuj nagar	Hariharpur east	VVN 1970
27	Ramanuj nagar	Hariharpur east	VVN 1971
28	Ramanuj nagar	Hariharpur east	VVN 1966
29	Ramanuj nagar	Kataroli	1932
30	Ramanuj nagar	Kataroli	1983
31	Ramanuj nagar	Kataroli	1984
32	Ramanuj nagar	Kataroli	1978
33	Ramanuj nagar	Kataroli	1977
34	Ramanuj nagar	Kataroli	1975
35	Ramanuj nagar	Kataroli	1976
36	Ramanuj nagar	Mendra	P1996
37	Ramanuj nagar	Mendra	1930
38	Ramanuj nagar	Mendra	P1992
39	Ramanuj nagar	Mendra	1991
40	Ramanuj nagar	Mendra	P1993

41	Ramanuj nagar	Premnagar	1924
42	Ramanuj nagar	Premnagar	1925
43	Ramanuj nagar	Salhi	1981
44	Ramanuj nagar	Tara	1979
45	Ramanuj nagar	Tara	P1997
46	Ramanuj nagar	Tara	1982
47	Ramanuj nagar	Tara	1980
48	Udaipur	Bassen	P2104
49	Udaipur	Bassen	P2098
50	Udaipur	Chakeri	P2056
51	Udaipur	Chakeri	P2101
52	Udaipur	Chakeri	2097
53	Udaipur	Chakeri	P2068
54	Udaipur	Chakeri	P2091
55	Udaipur	Chakeri	P2096
56	Udaipur	Chakeri	P2095
57	Udaipur	Chakeri	P2093
58	Udaipur	Dandgaon	P2014
59	Udaipur	Dandgaon	P2012
60	Udaipur	Dandgaon	P2011
61	Udaipur	Ghatbarra	P2113
62	Udaipur	Ghatbarra	P2114
63	Udaipur	Ghatbarra	P2115
64	Udaipur	Ghatbarra	P2070
65	Udaipur	Ghatbarra	P2117
66	Udaipur	Gumga	P2015
67	Udaipur	Khujhi (penderkhi)	P2122
68	Udaipur	Khujhi (penderkhi)	P2135
69	Udaipur	Khujhi (penderkhi)	P2120
70	Udaipur	Khujhi (penderkhi)	P2138
71	Udaipur	Korja	P2077
72	Udaipur	Korja	P2078
73	Udaipur	Manoharpur	P2053
74	Udaipur	Manoharpur	P2055
75	Udaipur	Manoharpur	P2054
76	Udaipur	Parasa	P2009
77	Udaipur	Parasa	P2010
78	Udaipur	Parasa	P2105
79	Udaipur	Parasa	P2106
80	Udaipur	Penerakhi	P2134
81	Udaipur	Penerakhi	P2133
82	Udaipur	Penerakhi	P2132
83	Udaipur	Penerakhi	P2073
84	Udaipur	Penerakhi	P2074
85	Udaipur	Ramgarh	P2057
86	Udaipur	Rarogiya	P2108
87	Udaipur	Rarogiya	P2107
88	Udaipur	Rarogiya	P2126

89	Udaipur	Rarogiya	P2124
90	Udaipur	Rarogiya	P2123
91	Udaipur	Rarogiya	P2127
92	Udaipur	Rarogiya	2109
93	Udaipur	Rarogiya	2110
94	Udaipur	Rarogiya	P2112
95	Udaipur	Rarogiya	P2118
96	Udaipur	Rarogiya	P2119
97	Udaipur	Sager	P2084
98	Udaipur	Sager	P2090
99	Udaipur	Saidu	P2002
100	Udaipur	Saidu	P2001
101	Udaipur	Saidu	P2000
102	Udaipur	Saidu	P1998
103	Udaipur	Saidu	P1999
104	Udaipur	Salhi	P2006

Compartment details extracted from the habitat suitability model –Meso carnivore

S.no	Range	Beat Name	Compartment number
1	Kendai	Gidhamudi	P439
2	Kendai	Gidhamudi	P440
3	Kendai	Salihapahri	P437
4	Kendai	Arsiya	P423
5	Kendai	Puta	P432
6	Kendai	Paturiyadand	P433
7	Kendai	Paturiyadand	P436
8	Kendai	Gidhamudi	P441
9	Kendai	Gidhamudi	P442
10	Ramanuj nagar	Badhiya dand	VVN 1943
11	Ramanuj nagar	Badhiya dand	VVN 1942
12	Ramanuj nagar	Badhiya dand	VVN 1944
13	Ramanuj nagar	Badhiya dand	VVN P19
14	Ramanuj nagar	Badhiya dand	VVN 1941
15	Ramanuj nagar	Hariharpur east	VVN 1970
16	Ramanuj nagar	Hariharpur east	VVN 1971
17	Ramanuj nagar	Hariharpur east	VVN 1966
18	Ramanuj nagar	Anandnagar	P1859
19	Ramanuj nagar	Mendra	P1996
20	Ramanuj nagar	Anandnagar	P1858
21	Ramanuj nagar	Premnagar	1924
22	Ramanuj nagar	Mendra	1930
23	Ramanuj nagar	Mendra	P1992

24	Ramanuj nagar	Mendra	1991
25	Ramanuj nagar	Abhaipur	1990
26	Ramanuj nagar	Kataroli	1932
27	Ramanuj nagar	Kataroli	1983
28	Ramanuj nagar	Kataroli	1984
29	Ramanuj nagar	Kataroli	1978
30	Ramanuj nagar	Kataroli	1977
31	Ramanuj nagar	Kataroli	1975
32	Ramanuj nagar	Hariharpur	1974
33	Ramanuj nagar	Tara	1979
34	Ramanuj nagar	Kataroli	1976
35	Ramanuj nagar	Hariharpur	1972
36	Ramanuj nagar	Abhaipur	P1995
37	Ramanuj nagar	Abhaipur	1994
38	Ramanuj nagar	Mendra	P1993
39	Ramanuj nagar	Tara	P1997
40	Ramanuj nagar	Tara	1982
41	Ramanuj nagar	Abhaipur	1926
42	Ramanuj nagar	Premnagar	1925
43	Ramanuj nagar	Chitkhai	1927
44	Ramanuj nagar	Salhi	1981
45	Ramanuj nagar	Tara	1980
46	Udaipur	Parasa	P2009
47	Udaipur	Dandgaon	P2014
48	Udaipur	Gumga	P2015
49	Udaipur	Dandgaon	P2012
50	Udaipur	Salhi	P2006
51	Udaipur	Manoharpur	P2053
52	Udaipur	Manoharpur	P2055
53	Udaipur	Chakeri	P2056
54	Udaipur	Manoharpur	P2054
55	Udaipur	Chakeri	P2101
56	Udaipur	Dandgaon	P2011
57	Udaipur	Rarogiya	P2108
58	Udaipur	Parasa	P2105
59	Udaipur	Rarogiya	P2107
60	Udaipur	Bassen	P2104
61	Udaipur	Rarogiya	P2126
62	Udaipur	Rarogiya	P2124
63	Udaipur	Rarogiya	P2123
64	Udaipur	Khujhi (penderkhi)	P2122
65	Udaipur	Khujhi (penderkhi)	P2135
66	Udaipur	Penerakhi	P2134

67	Udaipur	Penerakhi	P2133
68	Udaipur	Rarogiya	P2127
69	Udaipur	Ghatbarra	P2113
70	Udaipur	Saidu	P2002
71	Udaipur	Ghatbarra	P2114
72	Udaipur	Saidu	P2001
73	Udaipur	Saidu	P2000
74	Udaipur	Ghatbarra	P2115
75	Udaipur	Ghatbarra	P2070
76	Udaipur	Saidu	P1998
77	Udaipur	Saidu	P1999
78	Udaipur	Chakeri	2097
79	Udaipur	Bassen	P2098
80	Udaipur	Parasa	P2106
81	Udaipur	Rarogiya	2109
82	Udaipur	Rarogiya	2110
83	Udaipur	Rarogiya	P2112
84	Udaipur	Rarogiya	P2118
85	Udaipur	Ghatbarra	P2117
86	Udaipur	Rarogiya	P2119
87	Udaipur	Khujhi (penderkhi)	P2120
88	Udaipur	Khujhi (penderkhi)	P2138
89	Udaipur	Chakeri	P2068
90	Udaipur	Korja	P2077
91	Udaipur	Chakeri	P2091
92	Udaipur	Korja	P2078
93	Udaipur	Sager	P2084
94	Udaipur	Sager	P2090
95	Udaipur	Chakeri	P2096
96	Udaipur	Chakeri	P2095
97	Udaipur	Penerakhi	P2073
98	Udaipur	Penerakhi	P2074
99	Udaipur	Chakeri	P2093
100	Udaipur	Ramgarh	P2057

Compartment details extracted from the habitat suitability model – Ungulates

S.No	Range Name	Beat Name	Compartment Number
1	Kendai	Gidhamudi	P434
2	Kendai	Gidhamudi	P439
3	Kendai	Gidhamudi	P438
4	Kendai	Paturiyadand	P435
5	Kendai	Madanpur	P364
6	Kendai	Madanpur	P386
7	Kendai	Paturiyadand	P430
8	Kendai	Puta	OA724
9	Kendai	Puta	P432
10	Kendai	Paturiyadand	P433
11	Kendai	Paturiyadand	P436
12	Kendai	Khotkhori	P444
13	Kendai	Gidhamudi	P441
14	Kendai	Paturiyadand	P426
15	Lemru	Surwe	P866
16	Ramanuj nagar	Badhiya dand	VVN 1942
17	Ramanuj nagar	Mendra	P1996
18	Ramanuj nagar	Maheshpur	1929
19	Ramanuj nagar	Mendra	1930
20	Ramanuj nagar	Mendra	1931
21	Ramanuj nagar	Mendra	P1992
22	Ramanuj nagar	Mendra	1991
23	Ramanuj nagar	Abhaipur	1990
24	Ramanuj nagar	Kataroli	1932
25	Ramanuj nagar	Kataroli	1983
26	Ramanuj nagar	Kataroli	1984
27	Ramanuj nagar	Kataroli	1978
28	Ramanuj nagar	Kataroli	1977
29	Ramanuj nagar	Tara	1985
30	Ramanuj nagar	Kataroli	1975
31	Ramanuj nagar	Kataroli	1933
32	Ramanuj nagar	Tara	1979
33	Ramanuj nagar	Kataroli	1976
34	Ramanuj nagar	Abhaipur	P1995
35	Ramanuj nagar	Mendra	P1993
36	Ramanuj nagar	Tara	P1997
37	Ramanuj nagar	Tara	1982
38	Ramanuj nagar	Abhaipur	1926
39	Ramanuj nagar	Premnagar	1925
40	Ramanuj nagar	Chitkhai	1927

41	Ramanuj nagar	Tara	P1986
42	Ramanuj nagar	Salhi	1981
43	Ramanuj nagar	Tara	1980
44	Udaipur	Dandgaon	P2012
45	Udaipur	Salhi	P2006
46	Udaipur	Parasa	P2103
47	Udaipur	Rarogiya	P2107
48	Udaipur	Bassen	P2104
49	Udaipur	Rarogiya	P2126
50	Udaipur	Rarogiya	P2124
51	Udaipur	Rarogiya	P2123
52	Udaipur	Khujhi (penderkhi)	P2122
53	Udaipur	Khujhi (penderkhi)	P2137
54	Udaipur	Khujhi (penderkhi)	P2135
55	Udaipur	Rarogiya	P2125
56	Udaipur	Penerakhi	P2134
57	Udaipur	Penerakhi	P2133
58	Udaipur	Rarogiya	P2127
59	Udaipur	Bassen	P2130
60	Udaipur	Bassen	P2128
61	Udaipur	Bassen	P2129
62	Udaipur	Khujhi (penderkhi)	P2071
63	Udaipur	Ghatbarra	P2111
64	Udaipur	Ghatbarra	P2113
65	Udaipur	Saidu	P2002
66	Udaipur	Ghatbarra	P2114
67	Udaipur	Saidu	P2001
68	Udaipur	Saidu	P2000
69	Udaipur	Ghatbarra	P2115
70	Udaipur	Ghatbarra	P2070
71	Udaipur	Saidu	P1998
72	Udaipur	Saidu	P1999
73	Udaipur	Bassen	P2069
74	Udaipur	Parasa	P2106
75	Udaipur	Rarogiya	2109
76	Udaipur	Rarogiya	2110
77	Udaipur	Ghatbarra	2116
78	Udaipur	Ghatbarra	P2117
79	Udaipur	Khujhi (penderkhi)	P2121
80	Udaipur	Khujhi (penderkhi)	P2136

Annexure – 11

Compartment-level information of Elephant occurrence - obtained from Chhattisgarh FD for the period 2018-2020

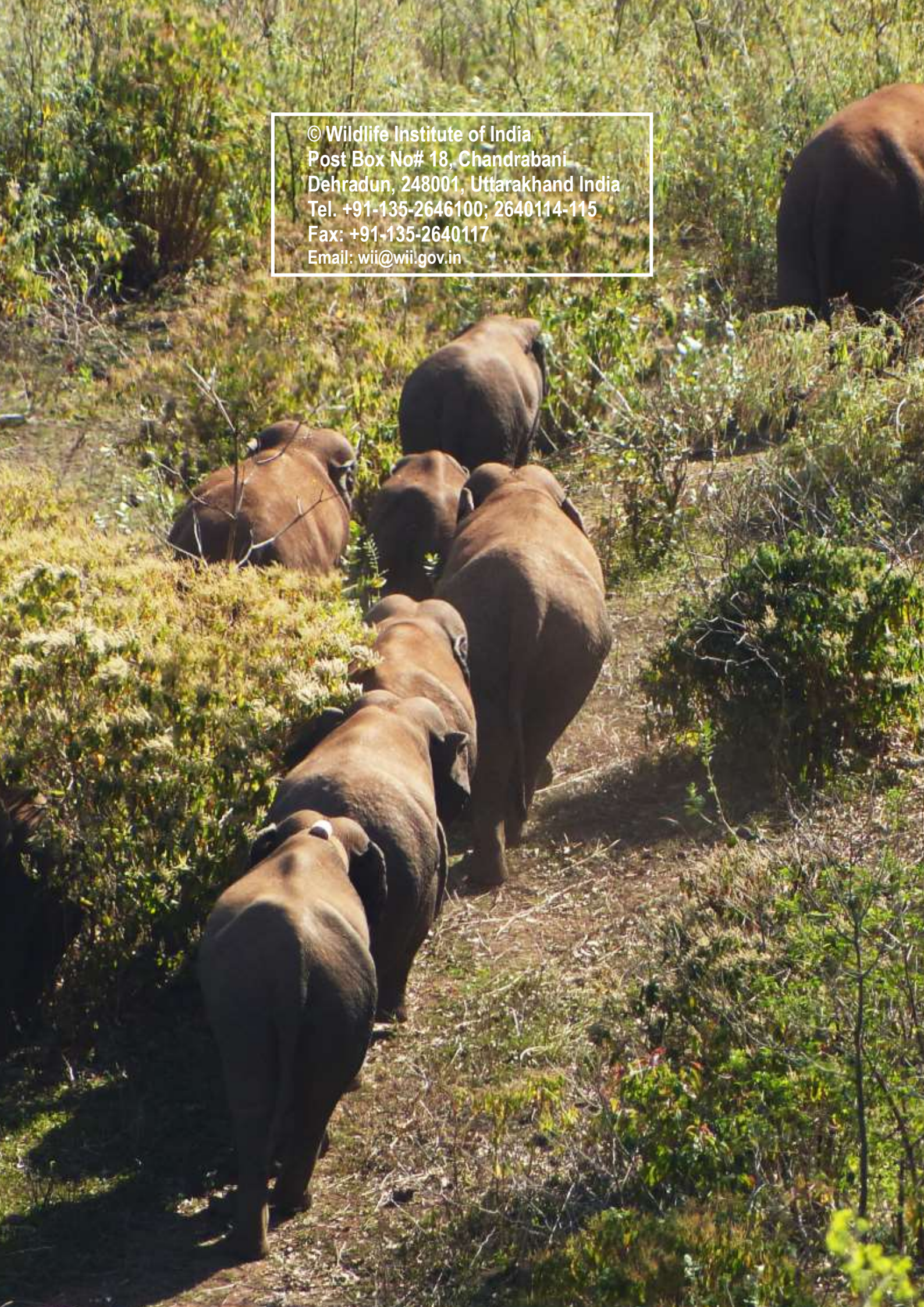
S.no	Range	Beat	Compartment number	Area (Sqkm)
1	Udaipur	Udaypur	P2029	1.06
2	Udaipur	Dandgaon	P2013	3.73
3	Udaipur	Salhi	P2007	2.75
4	Ramanuj nagar	Mendra	P1996	3.39
5	Ramanuj nagar	Premnagar	1924	0.84
6	Ramanuj nagar	Chitkhai	1928	3.13
7	Ramanuj nagar	Maheshpur	1935	1.83
8	Ramanuj nagar	Maheshpur	1929	1.86
9	Ramanuj nagar	Mendra	P1992	3.07
10	Ramanuj nagar	Kataroli	1983	2.54
11	Ramanuj nagar	Kataroli	1984	2.23
12	Ramanuj nagar	Tara	1985	0.91
13	Ramanuj nagar	Maheshpur	1936	2.53
14	Ramanuj nagar	Chitkhai	P1989	0.25
15	Ramanuj nagar	Hariherpur	1959	2.47
16	Ramanuj nagar	Abhaipur	P1995	1.04
17	Ramanuj nagar	Mendra	P1993	4.33
18	Ramanuj nagar	Tara	P1997	3.30
19	Ramanuj nagar	Tara	1982	3.88
20	Ramanuj nagar	Premnagar	1925	0.63
21	Ramanuj nagar	Chitkhai	1927	1.50
22	Ramanuj nagar	Tara	P1986	1.10
23	Udaipur	Manoharpur	P2053	1.58
24	Udaipur	Chakeri	P2101	3.39
25	Udaipur	Parasa	P2105	2.25
26	Udaipur	Bassen	P2104	3.06
27	Udaipur	Rarogiya	P2123	3.25
28	Udaipur	Khujhi (penderkhi)	P2137	2.74
29	Udaipur	Penerakhi	P2134	2.79
30	Udaipur	Rarogiya	P2127	2.87
31	Udaipur	Bassen	P2130	2.32
32	Udaipur	Khujhi (penderkhi)	P2071	0.63
33	Udaipur	Bakoi	P2146	3.03
34	Udaipur	Ghatbarra	P2111	1.06
35	Udaipur	Khujhi (penderkhi)	P2072	1.08
36	Udaipur	Bakoi	P2139	2.18
37	Udaipur	Sontarai	P2024	0.24
38	Udaipur	Kodma	P2228	3.91
39	Udaipur	Pangoti	P2180	2.21
40	Udaipur	Maheshpur	P2032	0.48

41	Udaipur	Maheshpur	P2030	3.84
42	Udaipur	Puta	P2048	2.72
43	Udaipur	Maheshpur	P2031	2.36
44	Udaipur	Sukhari bhander	P2086	2.72
45	Udaipur	Part kedama	P2164	3.65
46	Udaipur	Pangoti	P2183	4.28
47	Udaipur	South bhakurma	P2154	1.93
48	Udaipur	Marttnga	P2194	0.66
49	Udaipur	Marttnga	P2196	1.08
50	Udaipur	Kahrra nagar	P2216	0.28
51	Udaipur	Udaypur	P2027	2.67
52	Udaipur	Kahrra nagar	P2199	2.15
53	Udaipur	Laxmangarh	P2046	2.63
54	Udaipur	Kumerwa	P2045	3.87
55	Lakhanpur	Manja	P2241	0.31
56	Udaipur	Laxmangarh	P2036	2.90
57	Udaipur	Bankeshma	P2215	0.84
58	Lemru	Dokarmana	OA 1191	0.28
59	Kudmura	Simkeda	P1094	1.54
60	Kudmura	Aliong	P1098	2.55
61	Lemru	Kharakhet	P897	5.15
62	Lemru	Keubahar	P883	3.70
63	Kudmura	Laved	P1070	3.24
64	Pasarkhet	Suidhorha	P1068	1.32
65	Pasarkhet	Suidhorha	P1067	0.82
66	Lemru	Kuturwa	P871	0.24
67	Balco	Dudhitangar	P943	3.12
68	Balco	Makhurpani	OA 1237	0.09
69	Balco	Roomgara	OA 1238	0.24
70	Lemru	Keubahar	P889	4.86
71	Lemru	Bimalta	OA 1196	1.81
72	Lemru	Rapta	P910	2.74
73	Balco	Balco	P971	0.01
74	Pasarkhet	Pathrapali	P1048	3.31
75	Pasarkhet	Pathrapali	OA 1257	0.13
76	Pasarkhet	Thakurkheta	P1046	1.25
77	Balco	Dudhitangar	P955	6.57
78	Balco	Khetar	P944	7.33
79	Balco	Khetar	P936	6.55
80	Balco	Chuhiya	P953	3.04
81	Balco	Chuhiya	P952	2.73
82	Pasarkhet	Madanpur	P1024	4.69
83	Lemru	Lemru	P855	3.40
84	Balco	Satrenga	P834	3.61
85	Lemru	Bahera	P831	2.75
86	Lemru	Aretara b	P844	3.47
87	Lemru	Lemru	OA 1202	2.92
88	Lemru	Nakiya	P900	5.26

89	Lemru	Kharakhet	P899	3.80
90	Lemru	Rapta	P907	5.15
91	Lemru	Bimalta	P912	5.24
92	Lemru	Bimalta	P913	5.86
93	Lemru	Dokarmana	P867	0.07
94	Lemru	Surwe	P865	2.71
95	Lemru	Surwe	P866	0.93
96	Pasan		OA628	5.22
97	Kendai		OA711	2.09
98	Kendai		OA701	0.25
99	Kendai	Gidhamudi	P434	2.02
100	Atmanagar	Kathmorga	P523	0.05
101	Atmanagar	Madai	P464	0.11
102	Kendai	Kapanawapara	P352	5.49
103	Kendai	Kapanawapara	P353	3.95
104	Kendai		OA719	0.20
105	Pasan		OA627	2.07
106	Kendai		OA714	2.79
107	Kendai	Parla	P347	2.97
108	Kendai	Parla	P349	2.09
109	Pasan	Semrha	P212	0.54
110	Kendai	Salihapahri	P451	0.18
111	Kendai	Khotkhori	P443	1.16
112	Kendai	Khotkhori	P447	0.04
113	Kendai		OA713	7.45
114	Kendai		OA704	0.31
115	Kendai	Botopal	P374	4.27
116	Kendai	Botopal	P375	3.62
117	Kendai	Morga	P367	4.91
118	Kendai	Ghjak	P358	2.72
119	Kendai	Ghjak	P373	4.49
120	Kendai	Ladkorbi	P346	0.59
121	Kendai	Sakhoda	P333	2.87
122	Kendai	Ladkorbi	P344	2.06
123	Pasan	Baniya	P210	1.39
124	Kendai	Parla	P350	3.00
125	Kendai	Gidhamudi	P440	2.34
126	Kendai	Lalpur	P336	4.10
127	Kendai	Lalpur	P339	3.22
128	Kendai	Lalpur	P335	4.01
129	Kendai	Ladkorbi	P343	1.95
130	Kendai		OA708	5.01
131	Kendai		OA707	3.37
132	Kendai		OA709	0.84
133	Kendai		OA710	1.41
134	Kendai	Arsiya	P421	0.38
135	Kendai	Morga	P366	3.31
136	Kendai	Morga	P365	3.10

137	Kendai	Uchlainga	P428	2.85
138	Kendai		P425	1.20
139	Kendai	Morga	P385	2.52
140	Kendai	Ketma	P403	2.50
141	Pasan	Ladkorbi	P211	0.10
142	Kendai	Gidhamudi	P441	1.98
143	Kendai	Khotkhori	P445	1.94
144	Kendai	Khotkhori	P446	2.13
145	Kendai		OA715	0.03
146	Kendai		OA705	0.81
147	Kendai	Ghjak	P357	3.99
148	Kendai	Gidhamudi	P442	3.21

*****



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