A final report on

Habitat Suitability Assessment for Tiger in Trijuga Forest, East Nepal

Submitted by

Himalayan Nature

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Acronyms and Abbreviations

AIC: Akaike Information Criteria

ASCII: American Standard Code for Information Interchange

CFs: Community Forests

CFUGs: Community Forest User's Group

CIB: Crime Investigation Bureau

CITES: Convention on International Trade in Endangered Species of Wild Fauna and Flora

CR: Critically Endangered

DD: Data Deficient

DFO: District Forest Office/Officer

EN: Endangered

GIS: Geographic Information System

GPS: Global Positioning System

GTI: Global Tiger Initiative

IUCN: International Union for Conservation of Nature and Natural Resource

KTWR: Koshi Tappu Wildlife Reserve

LC: Least Concern

NPWC Act: National Parks and Wildlife Conservation Act

NT: Near Threatened

NTFPs: Non-Timber Forest Products

PAs: Protected Areas

Sp.: Species

SSC: Species Survival Commission

TAL: Terai Arc Landscape

VU: Vulnerable

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Executive summary

Historically, tigers were distributed across the lowland forests of Nepal including Trijuga forest of Udayapur and Saptari districts, but were extirpated due to anthropogenic disturbance like illegal hunting and lack of connectivity with the source population. Rampant poaching of tiger itself and its prey base had eliminated the tigers from Trijuga forest. Restoration of habitat, corridor and elimination of human disturbance would support the reintroduction of tiger in the forest. Currently, tigers are found in Protected Areas (PAs) of west of Bagmati River where their population is continuously increasing. Thus, habitats inside the PAs are congested. As the number keeps growing up, some are pushed towards the fringes. Whenever they come out of the PAs, they face confrontation with people, resulting in human-tiger conflict. The conflict often leads to injury and/or loss of life of either side. This trend may hinder long term conservation of the tiger. Therefore, expansion of tiger habitat east of Bagmati River seems to be vital. Trijuga forest situated in Udayapur and Saptari districts is the largest and historic forest patch in the east Nepal. As such, this study was carried out to assess the habitat suitability for tiger in Trijuga forest.

To achieve the intended objectives literature review, vegetation survey, species occupancy survey, opportunistic survey, informal interactions, questionnaire survey and habitat modeling were carried out. These methods generated vital information on vegetation, prey base availability, ethnozoology, water availability, topography, canopy and ground covers, human-wildlife conflict, types and extent of disturbance, impact of community forestry and perception. Occupancy modeling was done to derive the prey index while disturbance index was made from the data obtained during the field survey. Among the prey base, occupancy of Barking deer and primates (Blue bull and Rhesus macaque) was found to be acceptable. Out of 442km^2 only an area of 97.88km^2 was found to be suitable for tiger. Illegal hunting and other anthropogenic disturbances were found to be high. Therefore, instant reintroduction of tiger does not seem possible. However, long term and comprehensive study of habitat suitability, restoration of forest and corridor, increasing population of existing prey species, introduction of large ungulates like Sambar Deer and mitigation of poaching and other human disturbance are critical. Eventually, it is strongly recommended to declare the forest as a Protected Area for reintroduction of the tiger and its principal prey species in the eastern Nepal.

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Chapter 1: Introduction

Background

The Bengal Tiger *Panthera tigris tigris* (Linnaeus, 1758) is among the five extant sub-species of tiger living on the earth and among four sub-species roaming in the wild (Luo, 2010). Bengal tiger ranks among the biggest wild cats alive today (Mazák, 1981; Heptner and Sludskij, 1992). It is considered as belonging to the world's charismatic mega fauna (Sankhala, 1978). It is the most abundant sub-species of tiger; distributed in India, Nepal, Bhutan and Bangladesh (Kitchener and Yamaguchi, 2010). The Tiger have great social, cultural and economic value in the range countries. Moreover, its ecological importance in the nature is invaluable. Tigers are the top predators in the pyramid of Asian ecosystem, whose viable population indicates the ecological integrity, sustainability and ecosystem health (del Rio, 2001). Tiger is well adapted to diverse habitat from hot and dry desert to steamy tidal mangrove swamps and from the tropical forest to dry forest and snowy mountains (Sunquist, 2010). It prefers hunting large ungulates like Chital, Sambar, Gaur, and to lesser extent also Swamp deer, Wild water Buffalo, Blue bull and Serow. Among medium-sized prey species it frequently hunts Wild boar, and occasionally Hog deer, Barking deer and Grey langur. Small prey species like Porcupine, Hares and Peafowl form a very small part of its diet. Tigers are highly territorial and thus require huge area to accommodate them. However, the exact size of home range depends upon the quality of forest, accessibility to water, availability and abundance of prey base, and human disturbance.

Habitat loss, poaching of the tiger itself and prey base, human-tiger conflict and other disturbances are posing serious threats to tigers. Today, tiger is confined to only 6% of its historical range (Joshi, 2016) and therefore has been categorized as Endangered on the IUCN Red List (Goodrich, 2015). With the aim to double the wild tiger population by 2022, tiger range countries made the St. Petersburg Declaration in 2010 (GTI, 2011), yet tiger population continue to decline in many countries (Goodrich, 2015). Nepal is one of the signatory nations and is committed to meet the target. The result of 2017's tiger count (235) indicates that Nepal will achieve the target 242 individuals (tiger population in 2010 was 121) before 2022. However, it is in questions that; are the existing Protected Areas (PAs) sufficient to hold the increasing population of tiger in Nepal?

1.1. Rationale

Historically, tigers were distributed across the lowland forests of Nepal, but surveys between 1987 and 1997 documented only three isolated sub-populations: Chitwan-Parsa, Bardia and Shuklaphanta, with no reported occurrence east of the Bagmati River (Smith 1998; Gurung 2006; Karki 2009). According to the Tiger Conservation Action Plan (2008-2012), preliminary findings of research on tigers outside protected areas suggested that potential habitats in Kailali, Jhapa and Trijuga could hold about

5-7 tigers. The tiger population is currently increasing in Nepal, with numbers having gone up from 98-123 in 1999/2000 to 198 in 2013 (Dhakal et al., 2014). Even this number has soared in the last four years to 235, as indicated by the result of 2017 tiger census (Nepal Government's press release as of 29 July 2018). As the tiger population continues to rise, habitats become narrower, and the need for immediate expansion and management of future habitats seems apparent. Establishment of Banke National Park in 2010 was one step towards this, and tiger numbers boomed from 4 adults in 2013 to 21 in 2017. Similarly, on-going conservation efforts have led to expansion and status update of Parsa National Park where, the numbers have nearly tripled in four years. A similar habitat which may support another viable population is Trijuga and adjoining forests in east Nepal. Tigers inhabited Trijuga forest until a few decades ago but were extirpated due to habitat degradation, fragmentation, lack of connectivity with source population, and excessive poaching of prey base and the tiger itself. The forest is now a national forest with peripheral sections divided into community forests managed by local people. This area is also important for resident species like the Gaur and Sloth Bear, as well as wild elephant populations coming all the way from Kanziranga National Park, India that use this forest as a corridor. Trijuga forest also lies within the proposed conservation landscape, Eastern Terai Chure Complex, which would be an eastern annex to Terai Arc Landscape. Therefore, assessment of habitat suitability is important, so that possibility of forest occupancy by tigers in the future can be understood.

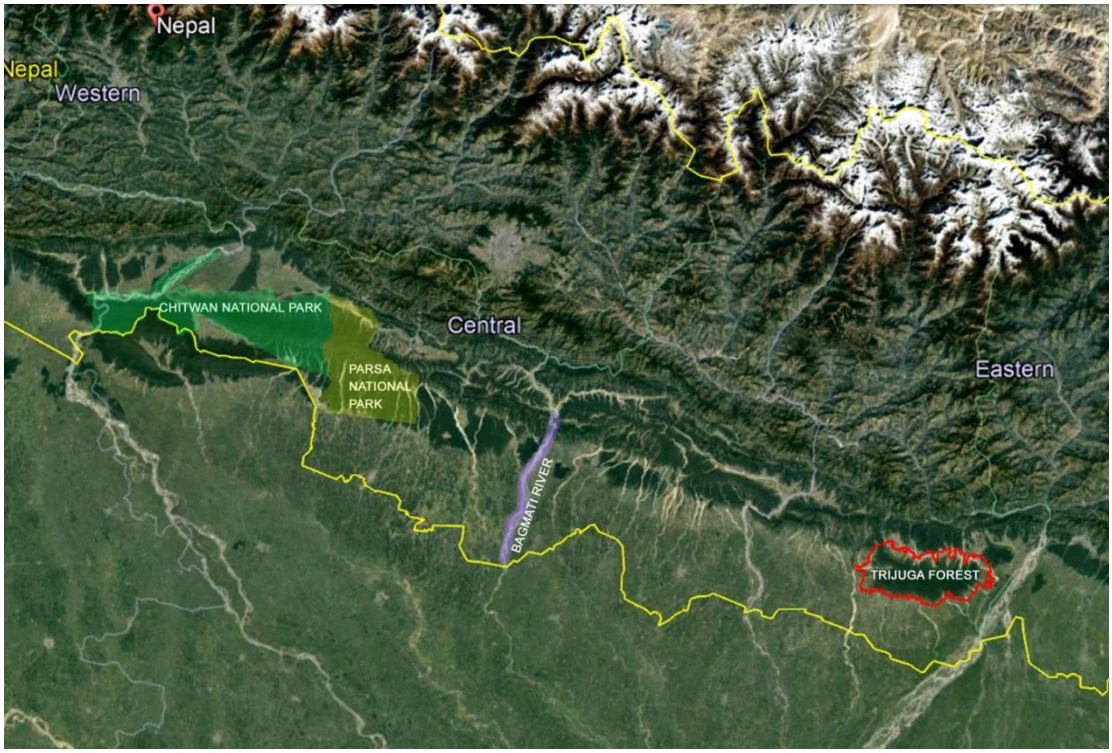

Fig 1. Position of Trijuga forest in relation to existing tiger population

Tigers have been recorded from as far as Bagmati River in the east in Nepal which is about 117 km (aerial distance) away from Trijuga forest. However, the source

population of the tigers wandering around the Bagmati River is Chitwan-Parsa National Parks which are only about 190 km apart from Trijuga forest. Literature support that tigers can occupy the area as far as 1000 km apart (Nowell and Jackson, 1996). Chitwan-Parsa Complex currently harbours highest population of wild tigers in Nepal. As the number of tiger in these protected areas is going up, the available habitat is becoming inadequate. Hence, it is possible that tigers from Chitwan-Parsa National Parks migrate and occupy Trijuga forest in future through natural migration using Siwalik forests as corridor. However, improvement in the Siwalik forest's quality is crucial so that tigers can use them as corridor. Another way of bringing tigers back to this forest is through translocation.

1.2. Objectives

With the tiger population increasing, the Government of Nepal is trying to establish new protected areas and/or expand existing ones to accommodate the species within protected areas. Establishment of Banke National Park, expansion of Parsa and Chitwan National Parks were some initial attempts; however, these areas alone are insufficient to support the increasing population, and other potential sites need to be explored for tigers to occupy naturally and/or through reintroduction in the future. Trijuga forest appeared to be one of the most promising sites for such an endeavor and as such, we planned to study habitat suitability of this forest for the tiger.

The major objective of this project is to carry out habitat assessment of Trijuga Forest, a key biodiversity area for potential tiger habitat. Specific objectives were to:

- Conduct vegetation survey; vegetation type, cover, status, etc.
- Conduct tiger prey base survey; species diversity and abundance.
- Determine threats to local biodiversity.
- Study drainage or water; source type and distance.
- Assess local people's dependency on the forest.
- Study the topography; aspect, slope, elevation, etc., of the area.
- Identify critical areas of improvement and recommend for future actions.
- Recommend Government of Nepal to designate Trijuga forest as protected area to accommodate the growing tiger population in Nepal.

1.3. Limitations

Grids located towards the center (top and ridges) of the forest couldn't be surveyed due to difficult terrain, inaccessibility and harsh weather condition during the study period. Hence, we were able to gather only limited information on prey base and other parameters from those locations.

Chapter 2: Methodology

2.1. Study area

Trijuga forest, the project area lies in Udayapur and Saptari districts, north-west of Koshi Tappu Wildlife Reserve (KTWR) in East Nepal (Fig 2). This forest falls within Eastern Chure-Terai Complex, one of three new landscapes proposed by the Government of Nepal, Ministry of Forest and Soil Conservation. Trijuga forest is the largest forest patch in Eastern Nepal with an area of about 442 km^2 touching Udayapurgadhi Rural Municipality, Triyuga Municipality and Chaudandigadhi Municipality of Udayapur district and Surunga Municipality, Khadak Municipality, Shambhunath Municipality, Rupani Rural Municipality, Agnisair Krishna Savaran Rural Municipality, Kanchanrup Municipality and Saptakoshi Municipality of Saptari district. It is a part of the Siwalik hills with thick forested vegetation. This forest is hanging from the main Siwalik hills and is contiguous to forests of the Siwalik hills in the north-western side with a narrow neck. The forests of main Siwalik hills touch the Bagmati River in the west, which is the eastern end of Terai Arc Landscapce (TAL). TAL is a high priority tiger conservation landscape.

The major vegetation includes *Shorea robusta*, *Terminalia tementosa*, *Dalbergia latifolia*, *Acacia catechu*, *Buchanania latifolia*, *Lagerstroemia parviflora*, *Semicarpous anacardium*, *Emblica officinalis*, *Aegle marmelos,* etc. among trees, *Phoenix humilis*, *Zizyphus mauritiana*, *Mimosa rubicaulis*, *Caesalpinia bonduc*, *Thespesia lampas*, *Calotropis procera*, *Calotropis gigantean*, *Senna tora*, *Dendrocalamus* sp. etc. among shrubs and *Curculigo orchioides*, *Chlorophytum arundinaceum*, *Imperata cylindrica*, *Cyperus difformis*, *Cyperus iria*, *Eclipta prostrata*, etc. among herbs. *Bauhinia vahlii*, *Ichnocarpus frutescens* etc. are common climbers.

Major mammalian fauna includes *Melursus ursinus*, *Elephas maximus*, *Bos gaurus*, *Boselaphus tragocamelus*, *Manis pentadactyla*, *Panthera pardus*, *Lepus nigricollis*, *Prionailurus bengalensis*, *Muntiacus vaginalis*, *Macaca mulata, Semnopithecus hector*, *Sus scrofa*, *Vulpes bengalensis*, *Petaurista petaurista*, etc. *Pavo cristatus*, *Gallus gallus*, *Lophura leucomelanos*, etc. are the major avian fauna and *Varanus bengalensis*, *Indotestudo elongata*, etc. are the major reptilian fauna of Trijuga Forest.

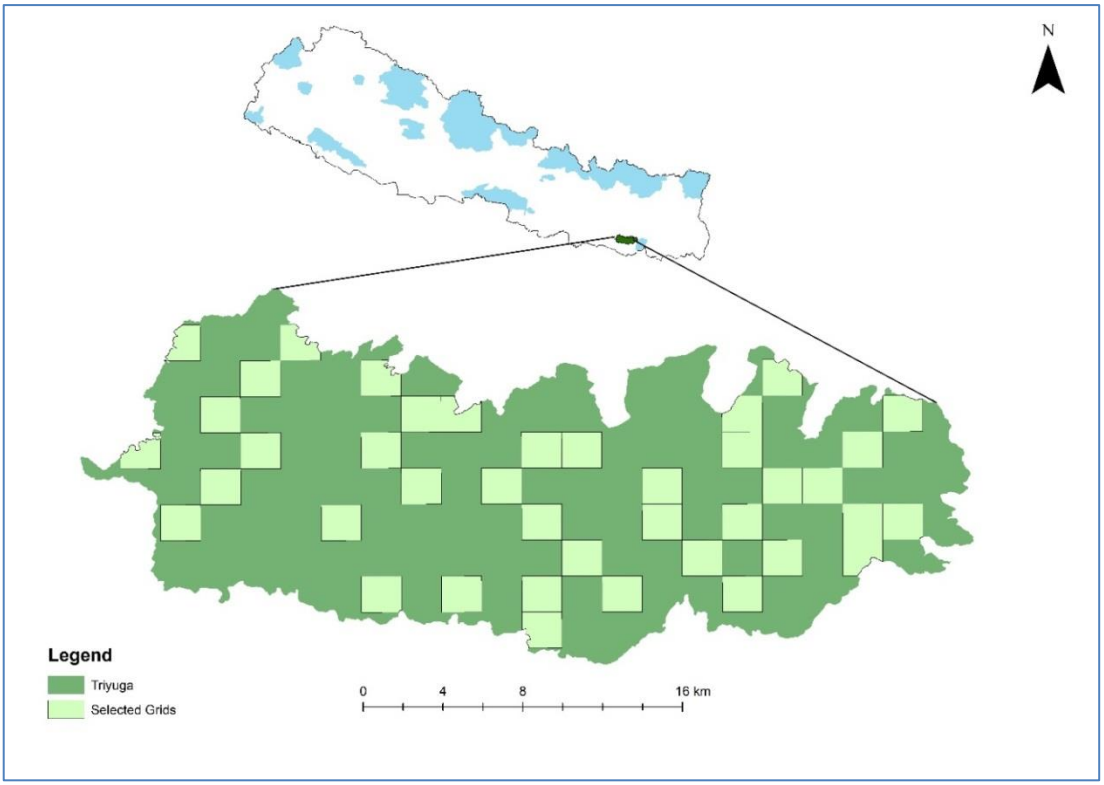

Fig 2. Map of the study area, Trijuga forest

2.2. Methods

In order to meet the objectives of the project, following methods were deployed:

2.2.1. Literature Review and Interaction

Prior to moving to the field, thorough review of published and unpublished literature and informal interactions with knowledgeable persons were carried out in Kathmandu.

2.2.2. Vegetation Survey

Biodiversity assessment methods and guidelines, as explained by various authors (CECI 1997; NSCEP 2001; and DoF 2012) were reviewed to design the field survey.

The altitude range of the study area varied from 107m to 380m only. Due to very low altitudinal gradient, no significant changes occur along the altitudinal gradient. Survey track was aligned along the length of the study area. Therefore for the survey, quadrates were laid down at an interval of 4km, and as many as 11 quadrates were surveyed along the length of the forest. The sample quadrates were of 20mx20m, 5mx5m and 1mx1m for trees, shrubs and herbs respectively.

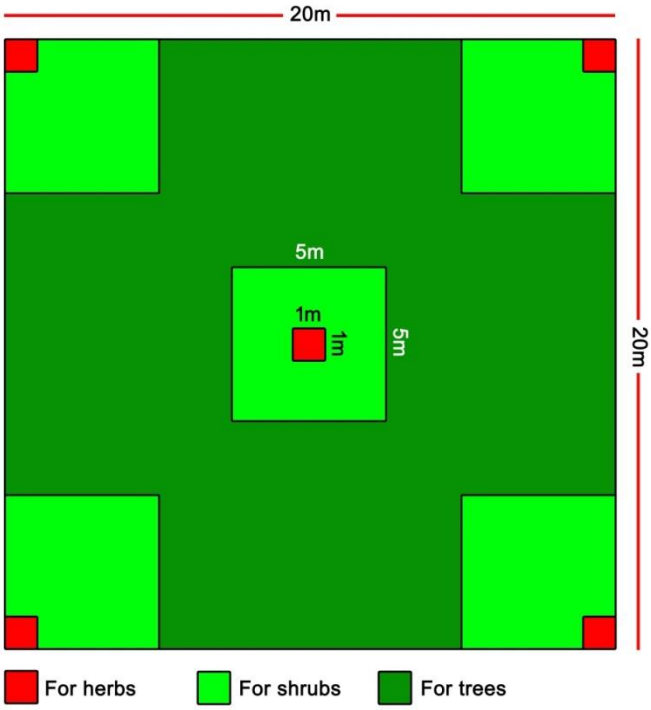

Fig 3. Pictorial representation of the vegetation survey design

Besides, different sites were randomly accessed across the breadth of the forest. The vegetation along walking trails and their surroundings were also surveyed casually by entering 2-3 km across their left and right flanks. All the information regarding the plant's morphological condition such as flower colour, fruits, bulbs etc. were recorded. Plant species which were not identified in the field were photographed, collected as herbarium specimens, dried and brought to Kathmandu for identification. These voucher specimens were identified using standard literature and deposited in the National Herbarium and Plant Laboratories (KATH), Godawari.

2.2.3. Species Occupancy Survey

Realizing the proposed Distance Sampling Method was unsuitable due to undulating terrain, high human disturbance, low prey abundance and poor visibility due to monsoonal weather condition and dense forest after our preliminary survey, we switched the method to Species Occupancy Survey. The total study area of 442km^2 was divided into 137 grids of 1.8km x 1.8km, of which 32 were omitted due to more than 50% of area lying outside the forest area. Out of remaining 105 grids, 40 random grids were initially targeted for the survey, however inaccessibility due to difficult terrain and challenging climatic condition, and potential threats from poachers and wild animals like Wild Elephant and Sloth Bear, despite our best efforts we were able to cover only 18 grids. A total of eight line transects of 600m each were laid in '2' or 'S' shape (Fig 6) and at least three line transects were covered during the survey to demonstrate spatial replication for species occupancy survey. Quadrats of 10m x 10m were fixed at starting point and after each 600m, making

nine quadrats in total. Direct observation of prey species, their foot prints, faecal matters, calls and other indirect signs were recorded walking through the line transects. Vegetation type, canopy cover, ground cover, and human disturbances seen within the quadrats were documented. The survey was carried out from 26 May to 24 June of 2018 on foot for having no road networks inside the forest.

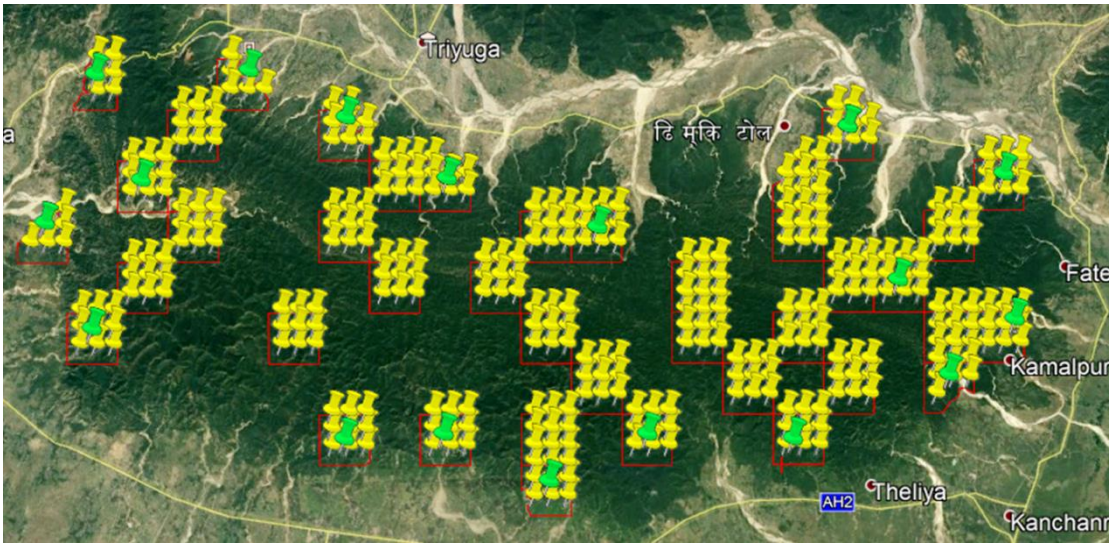

Fig 4. Red boxes: selected grids, yellow pins: quadrats and green pins: surveyed grids

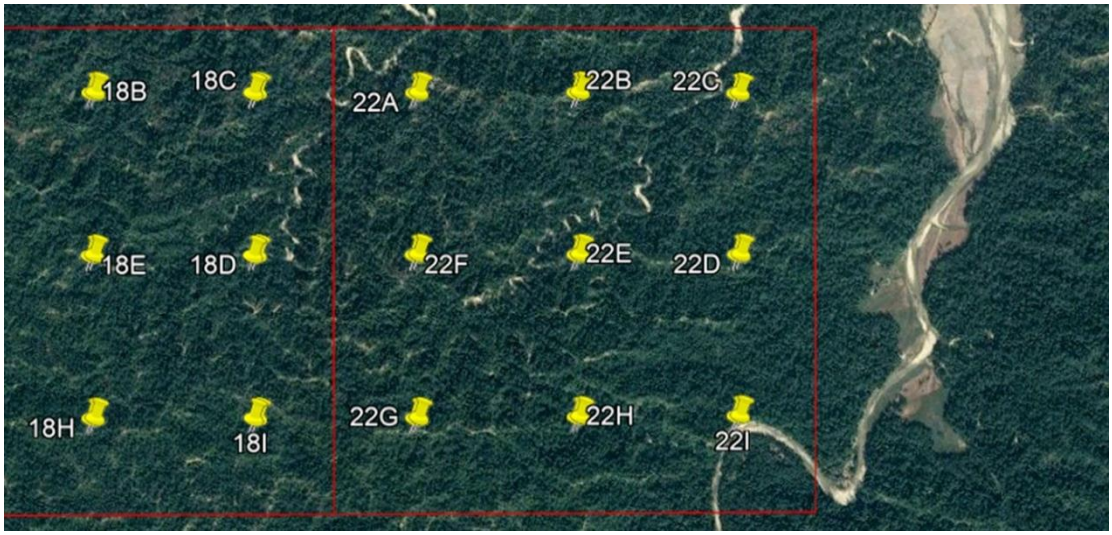

Fig 5. Survey design shown on Google map

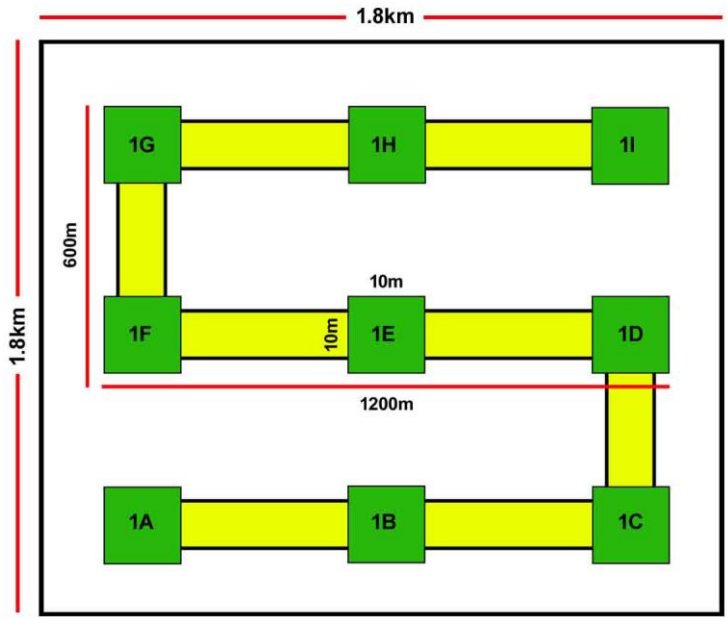

Fig 6. Pictorial representation of the survey design within a grid

2.2.4. Opportunistic Survey

Opportunistic surveys were carried out randomly, to record different prey species and other essential parameters.

2.2.5. Interactions/Questionnaire Survey

More than four dozens of informal interactions and questionnaire survey in 104 households were conducted in surrounding communities to collect information on basic natural resource use, wildlife sighting, poaching, people's perception on returning of tiger to the area, etc. In order to capture local people's perception on returning of tiger to the area in future which is vital as they are the pivot in conserving tiger, we prepared a series of questions related to human-wildlife conflict, its status and type, effectiveness of government's compensation scheme, local livelihood benefits due to presence of tiger, tiger's religious and cultural values in the area, potential tiger tourism, etc. Additionally, informal interactions made them feel easy to come up with their opinion on tiger returning. Informal interactions were also carried out with division forest officials and members of community forest user's group.

2.2.6. Occupancy Modeling

Occupancy modeling was done for Barking deer, Wild boar, Rhesus macaque and Terai Grey langur. Spotted deer was excluded due to lack of sufficient data. Occupancy modeling was carried out using standard occupancy modeling framework in unmarked package (Fiske & Chandler, 2011) in R software (R Core Team, 2018). Detection of signs of animals in the field was observed to be function of presence of Thakal (*Phoenix humilis*), thus was modeled as sampling covariates for analysis. Canopy cover, ground cover, distance to water and human settlements, coverage of Thakal along with human disturbance (fire, human presence, and fodder and

firewood collection) and grazing was taken as the habitat level covariates in the model. Series of model were built and the best model was selected using Akaike Information Criterion (AIC) (Burnham & Anderson, 2004).

2.2.7. Data Analysis

Data obtained from questionnaire survey were analyzed using MS Excel 2010.

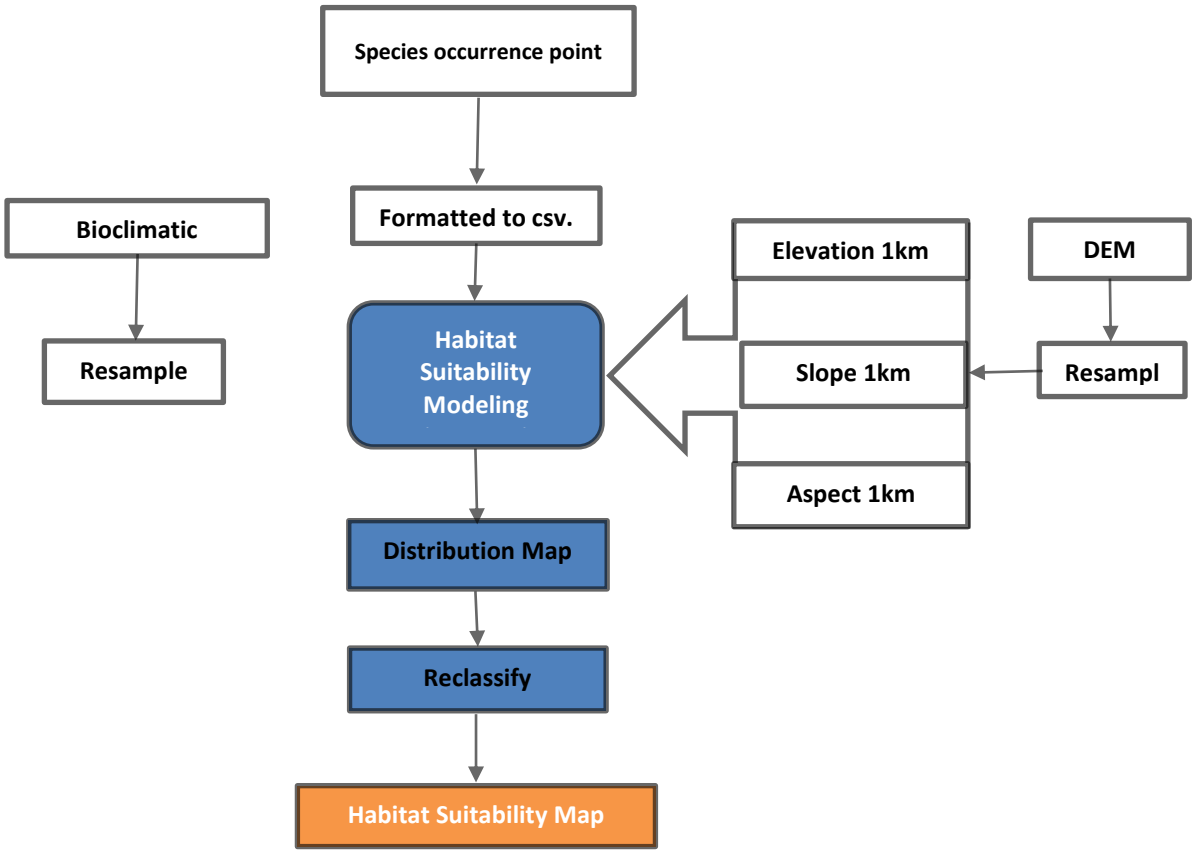

Fig 7. Process of Habitat Suitability Mapping

Chapter 3: Achievements and Opportunities

3.1. Achievements

Following achievements especially in relation to local biodiversity conservation has been observed in the area.

- The local community is helpful to the concerned government authorities for conserving the biodiversity. As a result wire fencing had been done in some parts of the forest.
- Livestock number has been decreased due to several reasons as a result livestock grazing pressure also decreased in some areas. This factor also reduced fuel wood consumption by local villagers.
- Nowadays, wildlife poaching and illegal felling of trees considerably reduced in some areas due to strong action taken by the local bodies. Many young people had moved out of the village to foreign countries for job purposes. This has also reduced biodiversity related crimes. Earlier this was rampant for earning money as many young people were jobless.
- In some areas (i.e. Rajaji CF) people started routinely monitoring their forest for checking illegal activities. If someone found doing illegal activity then he is captured and handed to District Forest Office for further action.
- A Peacock Conservation Center has been established in Sundarpur, Udayapur district.

3.2. Opportunities

The Trijuga forest provides following opportunities.

- The local NTFPs especially asparagus, bamboo, babiyo, amliso are plenty available and they can be used for income generation and improving local's livelihood.
- The area offers an excellent opportunity for biodiversity related study and researches, bird watching etc.
- The area's forests, wildlife, topography etc. offer great opportunities for nature based ecotourism, which can provide an extra source of income for local communities.
- The area also offers an excellent opportunity for reintroduction of locally extinct wildlife species including tiger and its principal prey species.
- The area harbours many huge wild mango trees, which provide food to various wildlife. However, these mango trees can also be utilized for income generation for local community.
- The area provides good opportunity for launching Home Stay programme.

Chapter 4: Results and Discussion

4.1. Topography

Trijuga forest lies in Siwalik hills. Siwalik hills belong to the tertiary deposits of the outer Himalayas (Chisholm, 1911). They are chiefly composed of sandstones and conglomerate rock formation, which are the solidified detritus of the Himalayas (Chisholm, 1911) to their north; poorly consolidated. The remnant magnetization of siltstones and sandstones indicates that they were deposited 16-5.2 million years ago. They are the southernmost and geologically youngest east-west mountain chain in the Himalayas. The fragile texture of soil along with high intensity of seasonal rainfall leads to severe erosion creating gullies that promotes landslides. The forest is basically elongated and extended in east-west direction. The elevation of the forest ranges from 107m to 380m and comprises some plain lands to steep slope of almost 90^0, especially in the ridges.

4.2. Vegetation

Altogether, 104 species of flowering plants were recorded from the forest during the field survey (Annex 3). Dominant species of tree based on highest percentage of occurrence were found to be as *Shorea robusta*, *Buchanania latifolia* and *Lagerstroemia parviflora* whereas the dominant shrub species were *Phoenix humilis*, *Chromolaena odorata* and *Caesalpinia bonduc*. Among the recorded shrubs, *Lantana camara* was found to be frequently occurring along the side of the walking trails. The dominant herbs of the area included *Curculigo orchioides*, *Chlorophytum arundinaceum*, and *Imperata cylindrica*.

The principal forest type was Sal (*Shorea robusta*) forest in most of the areas. It was replaced by tropical deciduous riverine forest in water edges and tropical evergreen forest in humid north facing slopes of outer foot hills. The common trees associated with Sal forest were *Terminalia bellerica*, *Terminalia chebula*, *Dillenia pentagyna*, *Lagerstroemia parviflora*, *Schleichera oleosa*, *Syzygium cumini*, *Semecarpus anacardium* and *Phyllanthus emblica*. The shrubs were *Zizyphus mauritiana*, *Mimosa rubicaulis*, *Caesalpinia bonduc*, *Thespesia lampas*, *Calotropis procera*, *Calotropis gigantea* and whereas the herbs included *Cyperus difformis*, *Cyperus iria*, *Eclipta prostrata* etc. *Bauhinia vahlii* and *Ichnocarpus fruitiscens* were common climbers of the area. *Butea minor* was occasionally found on the open slopes.

Sal (*Shorea robusta*) forest was replaced by tropical deciduous riverine forest in the stream sides which was dominated by Khair (*Acacia catechu*) and Siso (*Dalbergia sisoo*). The shrubs components of these areas consisted of *Pogostemon benghalensis*, *Clerodendron infortunatum*, *Justicia adhatoda*, *Colebrookea oppositifolia* and *Ardisia solanacea*. The riverside terrace was dominanted by *Bombax ceiba* with undergrowth of *Albizia procera*, *Syzygium cumini*, *Toona ciliata*, *Erhetia laevis*, *Murraya koengii* and *Butea monosperma*. The open areas of the riverside were densely occupied by

Saccharum spontaneum, *Saccharum benghalense* and *Imperata cylindrica*. *Mucuna pruriens* and *Martynia annua* were rarely found in the forest.

In the north facing slopes and outer foothills of the study site, the Sal forest was replaced by tropical evergreen forest which was dominated by *Michelia champaca* associated with Laurels such as *Litsea monopetala*, *Actinodaphne sikimensis*, *Phoebe lanceolata*, *Persea* sp. and *Murraya paniculata* and *Cycas pectinata* were the threatened species recorded in the forest.

The study area was distributed lengthwise in East-West direction so that there were peaks and ridges on the top. The ridges were fragile and almost barren due to loose geological structure. The north and south faces of the ridge were somewhat different in vegetation components. North face was dominated by *Shorea robusta* along with *Buchanania latifolia*, *Careya arborea* and *Phoenix humilis* as shrub. The West face was dominated by *Adina cordifolia*, *Lagerstroemia parviflora*, *Calicarpa arborea* and *Wendlandia tinctoria*. *Phoenix humilis*, *Chromolaena odorata* etc. were common shrubs. *Pogonantherum paniceum*, *Tridax procumbens* and *Evolvulus nummularius* were the frequently occurring herbs.

At least 38 species of plants were found to have NTFPs or medicinal values in the area (Table 1).

Table 1: List of potential NTFPs and medicinal plants found in Trijuga forest

SN	Botanical Name	Family	Common name	Remarks
1.	*Acacia catechu* (L.f.) Willd.	Fabaceae	Khayar	Medicinal
2.	*Aegle marmelos* (L.) Correa	Rutaceae	Bel	Medicinal
3.	*Alstonia neriifolia* D.Don	Apocynaceae	Chhatiwan	Medicinal
4.	*Anogeissus latifolius* (Roxb.ex DC.) Bedd.	Anacardiaceae	Hade	Fodder
5.	*Anthocephallus chinensis* (Lam.) A. Rich. exWalp.	Rubiaceae	Kadam	Fruit edible
6.	*Antidesma acidum* Retz.	Euphorbiaceae	Archal	Medicinal
7.	*Asparagus racemosus* Willd.	Liliaceae	Kurilo	Roots medicinal, Shoots edible
8.	*Bauhinia purpurea* Linn.	Fabaceae	Tanki	Fodder
9.	*Bauhinia vahlii* Wight &Arn.	Fabaceae	Bhorla	Fodder
10.	*Boerhavia diffusa* Linn.	Nyctaginaceae	Punarwa	Medicinal
11.	*Bombax ceiba* Linn.	Bombacaceae	Simal	Medicinal
12.	*Bridelia retusa* (L.) Spreng.	Euphorbiaceae	Gayo	Fodder, Fruits edible
13.	*Cassia fistula* Linn.	Fabaceae	Rajbriksha	Medicinal
14.	*Desmostachya bipinnata* (L.) Stapf.	Poaceae	Kush	Religious
15.	*Dillenia indica* Linn.	Dileniaceae	Chanchari	Fruit edible

16.	*Dioscorea bulbifera* Linn.	Dioscoreaceae	Vyakur	Edible, Medicinal
17.	*Elephantopus scaber* Linn.	Asteraceae	Sahasra buti	Roots used for making local wine
18.	*Engelhardia spicata* Lesch. ex Blume	Juglandaceae	Mahuwa	Flowers used for making local wine
19.	*Ficus semicordata* Buch.-Ham. ex Sm.	Moraceae	Khanayo	Fodder
20.	*Ficus subincisa* Buch.-Ham. ex Sm.	Moraceae	Bedulo	Fodder
21.	*Murraya koenigii* (L.) Spreng.	Rutaceae	Mithanim	Edible
22.	*Osbeckia rostrata* D.Don.	Melastomataceae	Ghayeri	Fruits edible
23.	*Phoenix humilis* Royle	Palmae	Thakal	Fruits edible
24.	*Phyllanthus emblica* Linn.	Euphorbiaceae	Amala	Medicinal
25.	*Pithecellobium heterophyllum* (Roxb.) Macbride	Fabaceae	Jilebi	Fruits edible
26.	*Rauvolfia serpentine* (L.) Benth. Ex Kurz.	Apocynaceae	Sarpagandha	Medicinal
27.	*Rhynchostylis retusa* (L.) Blume	Orchidaceae	Sunakhari	Ornamental
28.	*Sapium baccatum* Roxb.	Euphorbiaceae	Khirro	Fish poison
29.	*Sesbania grandiflora* L. Poir.	Fabaceae	Dhaicha	Manure
30.	*Sida acuta* Burm.f.	Malvaceae	Bala	Medicinal
31.	*Terminalia bellirica* (Gaertn.) Roxb.	Combretaceae	Barro	Medicinal
32.	*Terminalia chebula* Retz.	Combretaceae	Harro	Medicinal
33.	*Thysanolaena maxima* (Roxb.) Kuntze	Poaceae	Amliso	Broom
34.	*Trewia nudiflora* Linn.	Euphorbiaceae	Bhellar	Edible
35.	*Vanda teres* Lindl.	Orchidaceae	Sunakhari	Ornamental
36.	*Vitex negundo* Linn.	Verbenaceae	Simali	Medicinal
37.	*Wudfordia fruiticosa*	Lythraceae	Dhairo	Medicinal
38.	*Xeromphis uliginosa*	Rubiaceae	Pidar	Edible

4.3. Canopy and ground coverage

Covers were recorded within 90 quadrats of 10x10m along transects. The canopy cover was found to be 60% and ground cover 75%. The higher ground cover was contributed by Thakal (*Phoenix humilis*); especially in northern side of the forest where it was so thick that the ground was almost 100% covered in some places. Lower canopy cover was also because some grids fell in such places where there was no canopy cover at all; i.e. either the grid fell on barren land or with no trees. As we

move up, towards the top and ridges of the forest, both canopy and ground cover decrease due to high soil erosion and thinner vegetation.

4.4. Faunal diversity and tiger prey base

As many as 86 species of vertebrates including 37 mammals (Annex 2), 31 birds, 10 reptiles and 8 amphibians were found to occur in Trijuga forest. Among them, 14 species (Indian hare, Spotted deer, Gaur, Blue bull, Wild water buffalo, Barking deer, Himalayan serow, Wild boar, Terai Grey langur, Rhesus macaque, Indian crested porcupine, Indian pangolin, Chinese pangolin and Indian peafowl) were prominent ad occasional prey species. However, prominent, occasional and potential tiger prey base comprised of 26 species. Based on tiger's prey species mentioned by Prater (1971) and other literature, potential prey species of tiger recorded in the area are: *Felis chaus* (Jungle cat), *Prionailurus bengalensis* (Leopard cat), *Neofelis nebulosa* (Clouded leopard), *Panthera pardus* (Common leopard), *Vulpes bengalensis* (Bengal fox), *Canis aureus* (Asiatic golden jackal), *Hyaena hyaena* (Striped hyena), *Melursus ursinus* (Sloth bear), *Elephas maximus* (Asian wild elephant), *Varanus bengalensis* (Bengal monitor lizard), *Varanus flavescens* (Golden monitor lizard) and *Python bivittatus* (Burmese rock python).

Table 2: Prominent and occasional prey species of tiger recorded in the area

SN	Scientific name	Common Name
1.	*Lepus nigricollis*	Indian hare
2.	*Axis axis*	Spotted deer
3.	*Bos gaurus*	Gaur
4.	*Boselaphus tragocamelus*	Blue bull
5.	*Bubalus arnee*	Wild water buffalo
6.	*Muntiacus vaginalis*	Barking deer
7.	*Capricornis thar*	Himalayan serow
8.	*Sus scrofa*	Wild boar
9.	*Semnopithecus schistaceus*	Terai Grey langur
10.	*Macaca mulatta*	Rhesus macaque
11.	*Hystrix indica*	Indian crested porcupine
12.	*Manis crassicaudata*	Indian pangolin
13.	*Manis pentadactyla*	Chinese pangolin
14.	*Pavo cristatus*	Peafowl

Mammals recorded from the study area were found to have most common to endangered conservation status. Among them, 22 are listed in the different threat categories of Nepal government's NPWC Act, 1973 (2029 BS), the National Red list, IUCN Red List and CITES appendices (Table 3).

Table 3. List of protected species of mammal recorded in the area

SN	Scientific Name	NPWC, Act, 1973	National Red List Status	IUCN	CITES
1.	*Manis crassicaudata*	P	EN	NT	I
2.	*Manis pentadactyla*	P	EN	EN	I
3.	*Viverra zibetha*		NT	NT	
4.	*Felis bengalensis*	P	VU	LC	I
5.	*Felis chaus*		LC	LC	II
6.	*Neofelis nebulosa*	P	EN		I
7.	*Panthera pardus*		VU		I
8.	*Herpestes urva*		VU	LC	
9.	*Vulpes bengalensis*		VU	LC	
10.	*Hyaena hyaena*		EN	NT	
11.	*Melursus ursinus*		EN	VU	I
12.	*Lutra perspicillata*		EN	VU	II
13.	*Semnopithecus hector*		LC	NT	I
14.	*Macaca mulatta*		LC	LC	II
15.	*Muntiacus vaginalis*		VU	LC	
16.	*Axix axis*		VU	LC	
17.	*Boselaphus tragocamelus*		VU	LC	
18.	*Capricornis thar*		DD	NT	I
19.	*Elephas maximus*	P	EN	EN	
20.	*Bos gaurus*	P	VU	VU	I
21.	*Bubalus arnee*	P	EN	EN	III

Legend: P= Protected by NPWC, Act, 1973; IUCN Red List of Threatened Species: CR= Critically Endangered, EN= Endangered, VU= Vulnerable, DD= Data Deficient, NT= Near Threatened, LC= Least Concern; I & II= CITES Appendices

The Wild water buffalo (arna) enter into Trijuga forest during rainy season. It may be due to high flood in the Koshi Tappu area. They move upwards following the streams. They cross Kanchanrup-Beltar road and enter into the Siwalik. The species seems to be occasional visitor in the area when flooding occurs in the Koshi Tappu area. Recently, some people had seen arna in Jorpokhari area of Udayapur (Mr. Narayan Thapa, pers comm.). Till 8-10 years ago, arnas were found in Chakakhola (Hari Narayan Chaudhary, pers comm.).

Till late 70s, gaurs were plenty in the area (Dhirendra Prashad Singh, DFO Saptari, pers comm.) but poaching and habitat degradation critically reduced their population. Ten years ago, a gaur injured a person from Mauli, Saptari district (Jugeswar Chaudhari, Maina village, pers comm.). Mr. Krishna Bhakta Chaudhary, Chairman, Amaha CFUG saw Gaur's tracks close to his village 7-8 days before we reached the area. Five years ago, Bhupendra Chaudhary and Puhuplal Chaudhary of Maina village saw a herd of gaur consisting of more than 15 individuals in the Maulikhola area. Nowadays, Gaur and their signs (Gaur has sunken tracks) are only spotted by local

bamboo sprout collectors. Gaur basically dwells around the upper catchment area of Siwai Khola, Sundari Khola, and Gauri/Mahuli Khola.

4.5. Locally extinct mammals

Based on the literature review and interaction with locals, at least four large mammals (Royal Bengal tiger, Wild dog/Dhole, Sambar and Goral antelope) are found to be locally extinct from Trijuga forest (Table 4). Some people still believe that Sambar Deer occur in Damauti area. About 40 years before, it was killed in Kalayanpur and eaten during a wedding feast. Tiger killed a calf 15-20 years ago in Bhavanipur (Mahesh Prasad Chaudhary, pers comm.).

According to locals, tigers were common in the area some 40-50 years ago, even a local village (i.e. Baghaahaa: meaning tiger in Nepali) is named after tiger. About 15 years before, a tiger was killed in Mahuli, Saptari (Jugeswar Chaudhary, Maina village, pers comm.). A cow was killed by a tiger some 30-40 years before in Khoriyaa village, Udayapur. The carcass was poisoned as a result the tiger was also killed (Raghu Nandan Chaudhary, pers comm.).

Table 4: Checklist of mammal once present but now extinct from the area

SN	Scientific name	Common Name	Means of verification
1.	*Panthera tigris*	Royal Bengal tiger	Interview/literature
2.	*Cuan alpinus*	Wild dog/Dhole	Interview
3.	*Rusa unicolor*	Sambar deer	Interview/literature
4.	*Naemorhedus goral*	Goral antelope	Interview

4.6. Other significant wild animals of the area:

Presence of Bengal Monitor Lizard, Golden Monitor Lizard, Burmese Python, King Cobra, Elongated Tortoise and Indian peafowl has been confirmed from the area (Table 5).

Table 5: Checklist of other large vertebrates recorded from the area

SN	Scientific name	Common Name	Means of verification
1.	*Indotestudo elongata*	Elongated tortoise	Tracks/interview
2.	*Varanus flavescens*	Golden monitor lizard	Observation
3.	*Varanus bengalensis*	Bengal monitor lizard	Observation
4.	*Python bivittatus*	Burmese python	Interview
5.	*Ophiophagus hannah*	King cobra	Interview
6.	*Pavo cristatus*	Indian peafowl	Observation

4.7. Water

Since Trijuga forest lies in Siwalik hills, it is mostly dry. The streams except during monsoon period as shown in the map (Fig 8) are also mostly dry. Only a few streams had springs upstream and were found flowing, others were dry and drain water

during rainfall only. There were some ponds at lower elevation generally towards the edges of the forest, which were found to be used by wild animals. However, some of them were drained for irrigation. Many water springs were also found channeled to nearby villages through pipes for human consumption and other uses. Therefore, new waterholes should be created and drainage of water from ponds and springs should be stopped to avoid water shortage to wildlife in the forest.

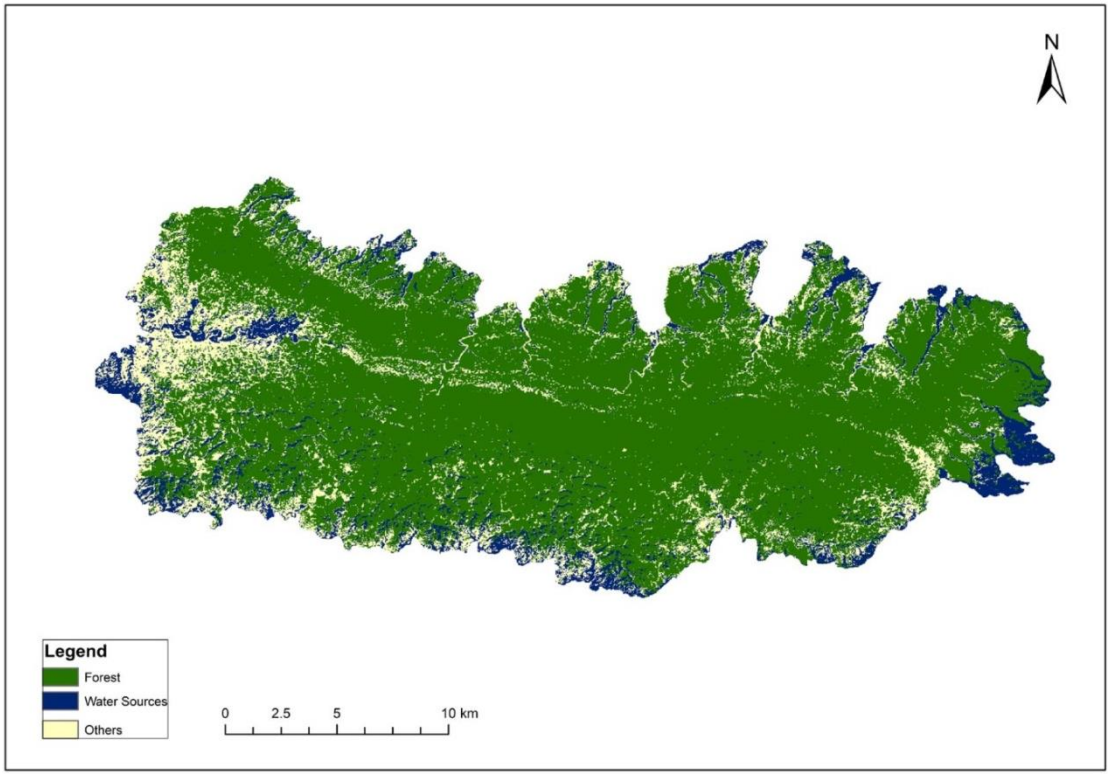

Fig 8. Availability of water sources in Trijuga forest

4.8. Community's dependency on forest resources

Local people make utmost use of various resources of Trijuga forest. People collect vegetables and other medicinal plants like niguro (fiddleheads), kurilo (Asparagus), kukurdino (*Smilax macrophylla*), *Cycas* shoot, *Cinnamomum*, etc. from the forest. They also collect leaves of different plants for various purposes like *Shorea robusta* and *Bauhinia vahlii* for making plates and *Phoenix humilis* for making mats. At many places, people were seen collecting fodder, firewood, stones, soil, sand and gravel. CFUGs harvest dead and fallen trees which are of timber quality and distribute among users. Excess timber is sold to furniture factories. Fruits of *Phyllanthus emblica*, *Aegle marmelos*, *Ziziphus mauritiana*, *Mangifera indica*, *Syzygium cumini*, *Phoenix humilis,* etc. are also directly eaten or used for making pickles. *Imperata cylindrica* and other shorter grasses are used for thatching the roof. Leaf litters are collected to be used as bedding for livestock in the sheds or on farmlands for making manure. Hence, communities living around the Trijuga forest were highly dependent upon the forest resources.

4.9. Ethno-zoology

The local wildlife has economic, religious and cultural importance (Table 6). Some are pest on agriculture and livestock hence cause economic loss. Some wildlife are used as food and in the preparation of traditional medicines. Bats sometimes get electrocuted and die which are consumed by Mushahar (a marginalized dalit people of low land Nepal) people. Porcupine's gut is used for treating chronic fever, gout, arthritis, asthma etc. and it is said that in old days, the quills were used as writing pen. The quills also used as needles. Leopard's canine teeth are carried by the hunters in the belief that it will make them to kill their targeted wildlife species.

Table 6. Economic, cultural and religious importance of wildlife in the area.

Name	Pest		Uses			
	Livestock	Agriculture	Food	Medicine	Culture	Others
House rat		X			X	
Shrew					X	
Crested Indian porcupine		X	X	X	X	X
Indian hare		X	X			X
Large Indian civet		X	X			
Masked palm civet		X	X			
Indian pangolin			X	X	X	
Chinese pangolin			X	X	X	
Jungle cat	X					
Leopard cat	X					
Common leopard	X			X	X	X
Golden jackal	X	X	X	X	X	
Sloath bear	X	X		X	X	X
Yellow throated martin	X	X			X	X
Nepal Tarai gray langur		X			X	
Rhesus macaque		X			X	
Wild boar		X	X	X	X	
Barking deer		X	X		X	X
Blue bull		X	X		X	
Himalayan serow			X		X	X
Elephant		X		X	X	X
Wild water buffalo		X				

Meat of local wildlife such as Barking deer, Masked Palm Civet, Pheasants etc. is eaten. Some people also eat meat of both species of monkey and jackal. Rai (Indigenous people, basically dwell hills of eastern Nepal) ethnic people of Maina village illegally hunt and eat meat of Monitor Lizards. Flying fox is eaten by Mushahar tribesmen. The Flying fox are killed by the Mushahar like other tribesmen *Chidimar* (i.e. birdkiller) kill the birds. Some people eat bear's meat as well.

Some wildlife related traditional beliefs among locals were as follows:

- Keeping porcupine's quills in the house creates quarrel and restlessness.

- Porcupine shoots its quills like a projectile to fell down 'githa' (*Dioscoria sp.*) fruits.
- Locals believe that Wild boar is dangerous than Leopard if confronted.
- Tiger's whiskers are kept with the body while gambling in the belief that it makes them winning.
- Pangolin scales are used to detect poison in the foods and drinks.
- Pangolin's real scale cannot be swept downstream by the water.
- When local deity is unhappy it sends tiger in the village. As a punishment the tiger depredate on villager's livestock.

In present situation, local community's dependency on Trijuga forest's resource is very high. Therefore, it seems very important to provide them with alternative.

4.10. Human-Wildlife Conflict

Human and wildlife both are the components of natural environment. They have co-existed with considerable competition since time immemorial. Humans have modified their habitat drastically and are expanding into new areas. In recent years, the competition for survival has turned into conflict and has threatened to destroy the natural balance and right of wildlife to co-exist in many areas of Nepal (Giri and Shah, 1992). The Trijuga area of eastern Nepal is no exception, where growing human population has encroached upon natural wildlife habitats and compelled them to interfere into human affairs by depredation of crops and livestock.

Based on our questionnaire survey, out of 104 respondents, 62 said that human-wildlife conflict is minimum in Trijuga forest, 28 said there is extreme conflict, however, 14 said that there is only moderate conflict (Fig 9).

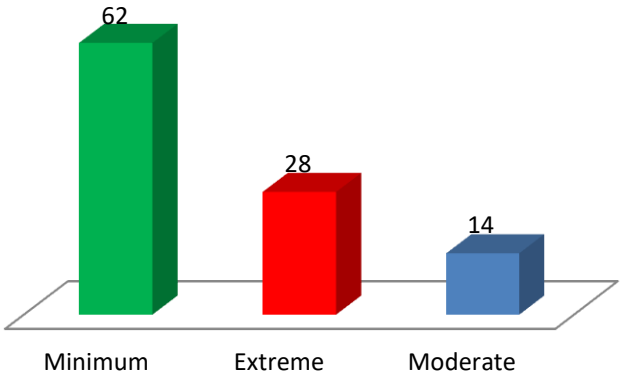

Fig 9. Extent of human-wildlife conflict (based on questionnaire survey)

As observed during the study period, major conflicts instigated by wildlife against human in the area are:

4.10.1. Crop damage by feeding and trampling

Crop damage by wildlife is a significant problem in some areas. The crops are raided by porcupine (potato), monkeys (tomato), wild elephant (paddy), Wild boar (corn), Sloth Bear (mango), Blue bull (mustard; hence also called *Torigadhaa/Tori Jarayo* i.e.

Mustard Donkey/Mustard Sambar) and jackal (corn, paddy, etc.). Otters are pest of fish farms. Peafowl are also said to raid crops basically at the time of sowing and harvesting. Arna also damage crops during rainy season in Saptari, adjacent to Koshi Tappu Wildlife Reserve (KTWR). Sloth Bear is agriculture and orchard pest as well.

4.10.2. Livestock depredation by killing and eating, by killing and leaving behind and by injuring

Mostly livestock are left in the forest unattended. They are killed by wild predators. Leopard, other small cats, jackal, fox, mongoose and python were found responsibly for preying upon livestock and poultry. Wild elephants occasionally attack on livestock and harm them. Six months before jackals killed four goats in Mohanpur. In Kalyanpur, a goat was swallowed by a python which was 10-15 ft. long (65-70 kg in weight). Villagers of Bhavanipur killed another python which was also swallowing a goat. In Mahuli, a buffalo and an ox were killed by wild elephant.

4.10.3. By killing, injuring, disturbing and terrorizing humans

The wild animals, especially wild elephant and Sloth Bear were responsible for loss of human lives. Every year some human casualties occur and many people get injured from wild elephant and bear attack in the area. They also create disturbance to human settlements and their normal activities by mauling, by terrorizing through their presence and by creating obstructions. These two species of wildlife create much more serious threat especially when villagers are guarding their mango, paddy and maize crops ready to harvest.

Wild elephants (6-8 individuals) from Koshi Tappu Wildlife Reserve visit the area at least three times a year. Sometimes they kill, injure people and damage their property including the houses. Two years ago a woman was killed by wild elephant in Saptari. Bear killed a person in Bhavanipur 10-15 years ago and injured recently. Many people were injured by Sloth Bear, 10-15 years ago, a person from Chaudhary tole of Khoriya village was killed by a bear while collecting fodder. A Rupani villager got injured by a bear 7-8 years ago. A mother bear having small cubs recently attacked a woman from Fattepur while collecting fodder. When we visited the area, locals informed us that she was still medicating in a hospital in Kathmandu.

4.10.4. The major conflicts instigated by humans against the wildlife in the area

- Encroachment of wildlife habitats by extending agricultural land, felling trees and removing vegetation from the forest.
- Burning of forests/pastures to renew pastures, to create new agricultural land and to drive wildlife during hunting.
- Killing wildlife for economic gain, to obtain bush meat and fur.
- Capturing and rearing wild animals like Wild boar, Barking deer, Porcupine, Indian peafowl, etc.
- Livestock grazing in prime wildlife habitats.
- Disturbances simply due to their presence.

The major problem confronted by wildlife in the area is encroachment of their habitat by humans through several activities. Livestock grazing has tremendous negative impacts directly on the wildlife and their habitats throughout the Trijuga area. Livestock not only compete with wild herbivores for food but also interfere in their normal biological activities. Sharing of common habitats may spread some contagious diseases to them. In some places, forests were burnt by hunters to drive targeted wildlife species.

Dogs were found to be used for killing porcupines. A hyaena was killed by poisoning carcass few years ago in Maina village (Mr. Krishna Bhakta Chaudhary, pers comm.). In Rupani, 7-8 years before a villager was highly injured by a bear. The bear then entered into the settlements and it was killed by the villagers. About 5-6 years ago local people killed an injured Blue bull in Rupani and its meat was eaten. Three tigers (mother and two cubs) were killed in Kalayanpur 20-25 years ago by poisoning the carcass. Five years ago 10-12 ft. long python (65-70 kg of weight) was killed by villagers of Bhavanipur, it was swallowing a goat. Last year a python was killed in Khaijanpur village. Probably, all large predators in some areas are killed by poisoning.

Results of our questionnaire survey (Fig 10) also indicated that crop raiding is the foremost reason for conflict between human and wildlife, followed by injuring people, killing people, deterring people and livestock depredation. Two percent of people didn't see any conflict at all. Crop raiding and deterring people by their presence might have been well reflected here but injuring/killing people and livestock depredation is not very intense. Actually, when people see or hear about physical attack by wildlife on human and livestock, they become emotional and try to exaggerate the fact. This may be the reason why questionnaire result shows their high values.

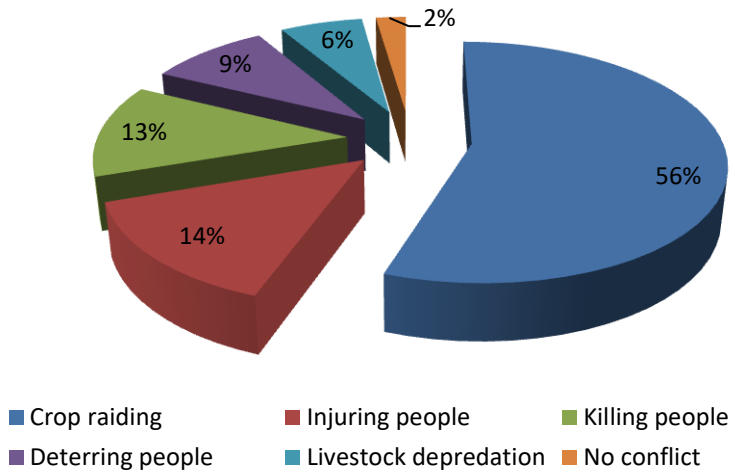

Fig 10. Types and extent of human-wildlife conflict (based on questionnaire survey)

Therefore, there exist conflict between human and wildlife but the intensity is not very high. Most of the conflicts are prompted by people and definitely a few from the other side.

4.11. Threats to Local Biodiversity

Based on the field observations, interactions with local government authorities and local people, following biodiversity related threats were documented in the area:

4.11.1. Water scarcity

Scarcity of water during dry seasons (mostly winter and spring) is a significant problem in the area especially in the upper parts of the Siwalik. Because of this reason some wild animals descend to the lower parts close to the settlements in search of water and are easily targeted by the poachers.

4.11.2. Illegal hunting

Poaching of wildlife for household consumption and for commercial purpose is a major problem in the area. Illegal hunting has significant impact on the survival of many common to endangered species of wild fauna. Though the hunting practice is common all around the Trijuga forest, according to local respondents, some people of Damauti, Udayapur are said to be notorious wildlife poachers. Last year illegal hunters from Damauti killed an adult Gaur (Prem Bahadur Magar, pers comm.). Five years before a Gaur calf was captured by local hunters in Gauri-Maulikhola area. Nets are used for capturing while musket and explosive are used for killing the wildlife. Local Danuwar (a marginalized indigenous community) tribesmen of Udayapur are also highly involved in wildlife poaching; mostly they use nets for trapping wildlife. Some hunters are said to enter the forest disguised as firewood or grass collectors.

One of our local assistants from Madhupatti told us that the hunters from Damauti had killed a Barking deer two days before we reach the area for survey. They were in the jungle for hunting for last two days. They killed two Barking deer. The assistant said that, he was also shared the meat as the hunters were distant relatives of him.

Two hunting parties consisting of 5 and 9 individuals with guns and logistics for camping were confronted in the forest near Maina village. They were said to be hunting Wild boar. They were said to live in the forest for 4-5 days and visit up to top of Maulikhola.

4.11.2.1. Frequency and trend of wildlife sightings

Based on our questionnaire survey with 104 households, these days frequency of wildlife sighting in Trijuga forest is very low than the past. Sixty two respondents said that they have sighted wildlife rarely, 24 respondents saw wildlife occasionally and only 18 respondents saw wildlife very often (Fig: 11). Similarly, the trend of wildlife sighting in Trijuga forest has also been found declining. Forty eight respondents said that wildlife is declining. Those who saw wildlife stable or didn't have any idea whether increasing or decreasing were 11 each. However, 34 respondents thought that wildlife is increasing (Fig 12).

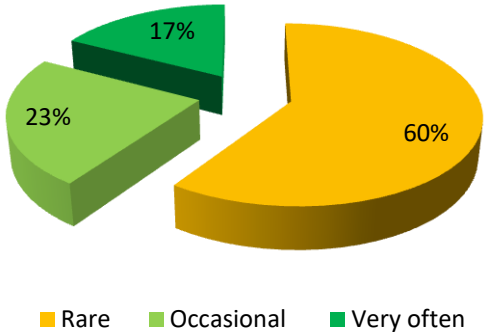

Fig 11. Frequency of wildlife sighting .

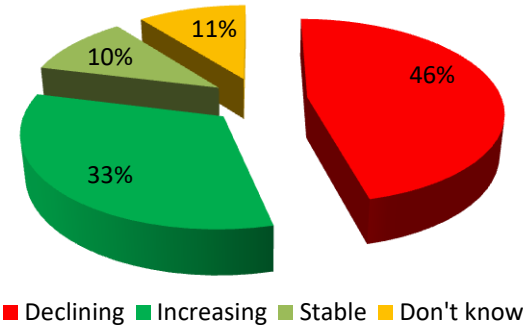

Fig 12. Trend of wildlife sighting

People also said that they observed animals like Rhesus macaque, Blue bull, Wild Elephant, Barking deer, Wild boar and Indian peafowl increasing in the forest. However, these animals were also found to be very low during our survey. This means community forestry has helped reviving these animals which were once lesser in number than now but are still far more less than they used to be decades back.

4.11.3. Overexploitation of the natural resources

The local forest resources are being overexploited at an alarming rate for household and commercial purposes. Illegal timber collectors use mobile nexus to communicate. Excess illegal timber felling took place at the time of fuel blockade by India; the timbers were finally smuggled to India. Mostly Mushahar tribesmen were found engaged in timber smuggling business. Sometimes, a group of 50-60 individuals used to be seen doing timber smuggling to India (Dhirendra Pd. Singh, pers comm.). The forest is said to have faced extreme exploitation (basically timber) during Maoist revolution when the government agencies were almost non-functional and community forest user groups were paralyzed. Locals of Saptari district told us that most of the old Sal forests were cleared at that time. The local NTFPs are haphazardly collected. High exploitation of bamboo shoot takes place in Saptari area of the forest. During the peak season it is so high that in Bhavanipur area, a family in average earns NPR 65,000/- (about US $ 590.0) per year by selling the bamboo shoots (Mahesh Pd. Chaudhary, pers comm.). Firewood collection in some area was so intense that people were even felling large trees. Firewood is collected for household as well as commercial purpose. Good quality firewood is sold to roadside hotels and restaurants. Extraction of soil, sand and stones were also observed. The intensity of the extraction was not found very high. However, in long run it can put significant negative impact to the area by accelerating soil erosion. Human presence always disturbs wildlife and the extractors may get involved in illegal hunting at any time.

4.11.4. Illegal raising of wildlife

In some area, locals were found to capture and rear wild animals. Two Wild boars and one Indian crested porcupine were found being raised in Maina village, Udayapur.

One porcupine was said to be already killed and eaten. Wild boar's young are raised in houses and a year later they fetch NPR 20,000 to 30,000 (i.e. US$ 200-300.). According to family members of the same house where Wild boars were being raised, they found a Chinese pangolin washed away by flash flood. They captured it and reared for some days and later released back into the jungle. However, we are doubtful on whether they released it.

4.11.5. Haphazard use of pesticides

Pesticides are used for fishing. Their haphazard uses kill non-targeted species as well as pollute the environment.

4.11.6. Forest encroachment

Encroachment had occurred at few places mostly for agriculture purpose.

4.11.7. Free grazing

More or less free grazing occurs everywhere in the area. Local livestock are left unattended in the forests, uncontrolled grazing always puts negative impact on the wildlife habitats. In Lohaale Khola area of Udayapur, herders were found with built sheds and other logistics like foods and beddings; they stay there with their hundreds of livestock till the arrival of crop cultivation season.

4.11.8. Retaliatory Killing

Crop raiding and livestock depredation do not seem to be severe in the area, however even its slight occurrence causes high wildlife mortality due to retaliatory killing. Carcass poisoning is one of the common ideas to kill the predators.

4.11.9. Soil erosion

Due to loose geological structure of Siwalik hills, the area is highly prone to soil erosion. The ridges and peaks in many areas are almost barren because of loss of top fertile soil. The forest receives maximum rainfall during monsoon season. Heavy rainfall in a short period of time accelerates erosion of loose soil through gullies and streams. Even small streams wash away huge quantity of debris and deposit them in the downstream. This nature of flood widens the stream exposing both wildlife and people into risk which sometimes proves to be devastating.

4.11.10. Wildlife mortality due to flooding

Flooding is common in the area due aforementioned reasons. The seasonal floods wash away many wild animals each year; some of them get seriously injured and some are killed. Injured ones are easy target for the feral as well as domestic dogs. They are also killed and eaten by people. Last year only a Chinese Pangolin was brought by a flood which was captured by local family and reared for few days. According to local people, sighting of wild animals dead due to sweeping by river flood is common.

4.11.11. Jackal and mongoose killers

Syaalamaaraa (i.e. jackal killers, a tribe of nomads from India) regularly visit the area. They not only target jackals but also kill whatever wildlife they encounter with. They are said to use explosive to kill the wildlife. Elsewhere in Nepal they have already been found involved in international smuggling of wildlife trophy including tiger body parts and are under surveillance of CIB. Mongoose killer also visit the area especially in November and December. They are said to emit mongoose call (both normal and distress) as a result mongooses come out of their burrows and get killed.

4.11.12. Low conservation awareness among local people

It is obvious that lack of conservation awareness seen among many locals. This has caused poaching of wildlife and overexploitation of other biological resources in an unsustainable manner. In addition to this, the existing rules and regulations concerning to natural resource conservation are also not followed by the local people.

4.12. Human disturbances

From our survey data obtained from 90 quadrats of 10x10m, eight different anthropogenic disturbances were recorded in Trijuga forest. Out of which; grazing (38), fire (30), fodder collection (18) and firewood collection (18) were the major disturbances (Fig 13). Human's sign, wood cutting, tractor trails and bamboo shoot collection were among other disturbing factors documented. Firewood collection, wood cutting and bamboo shoot collection were comparatively higher in Saptari area of the forest than that of Udayapur.

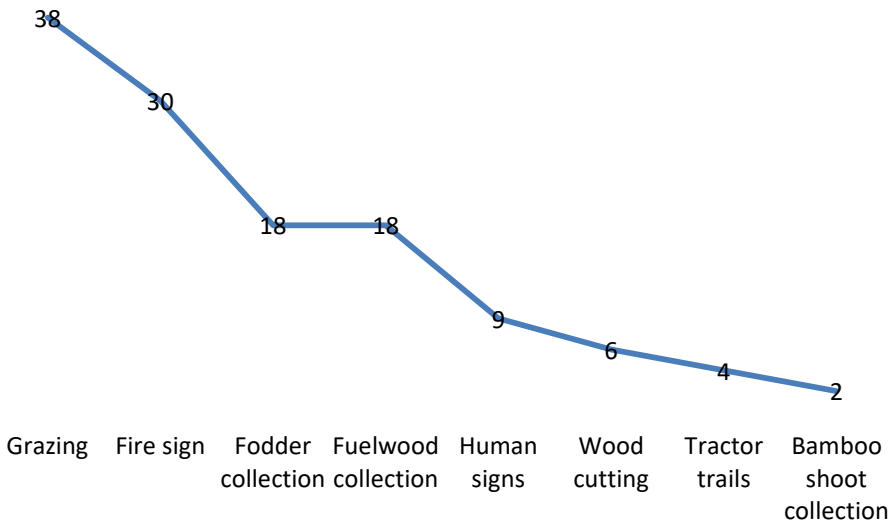

Fig 13. Human disturbance present in Trijuga forest

The threats mentioned and discussed above clealy indicate that the biodiversity of Trijuga forest is under extreme stress mainly due to anthropenic activities. Thus,

immediate actions are needed to be put forward by concerned government authorities and non-government agencies.

4.13. Impact of community forestry in Trijuga forest

The peripheral area of Trijuga forest has been divided into several community forests. Only the deep forests consisting of top and ridges are national forest. Community people have formed Community Forest User's Groups (CFUGs) that are responsible for conservation of forests and sustainable harvesting of forest products. After the introduction of community forestry programme in Nepal, many positive impacts have been observed in forest conservation. As such, some CFUGs in Trijuga area are very active and have brought about remarkable changes; the forests are rejuvenating. Some of them have appointed forest guards (*ban heraalu*); however, some CFUGs have managed to patrol their forests on rotation basis among the members. Few of them have established nurseries and allocated plots to users for fodder plantation so that their members don't need to go deep into the forest for fodder collection thereby, reducing human-wildlife conflict. They have also prohibited open grazing, fodder collection and firewood collection in their CFs. Water holes have been created at some places. The users have been encouraged to plant bamboo in their personal property that has stopped people from going into the forest for bamboo shoot collection. Moreover, they are also making some money by selling bamboo shoot. Each year they get firewood and timber through CFUG. Community forestry have increased social bonding, enhanced leadership quality, women empowerment and got opportunities to go on exposure visits. Therefore, community participation for forest and wildlife conservation should be strongly encouraged.

4.14. Perception on wildlife and tiger returning

Our observations, interactions during field visit and questionnaire survey indicated that the local people basically have positive views towards the wildlife. All methodologies of our effort to know the perception of local people revealed that they admire the presence of wild animals in Trijuga forest. Out of members of 104 households we surveyed, 80 respondents (77%) expressed their fascination towards wildlife (Fig 14). Most of the people, who exhibited aversion, actually had faced loss at some point of time due to wild animals like livestock depredation or crop raiding or attack on themselves or their family members. Wild Elephant, Sloth Bear, Leopard and Rhesus macaque were mainly responsible for this aversion.

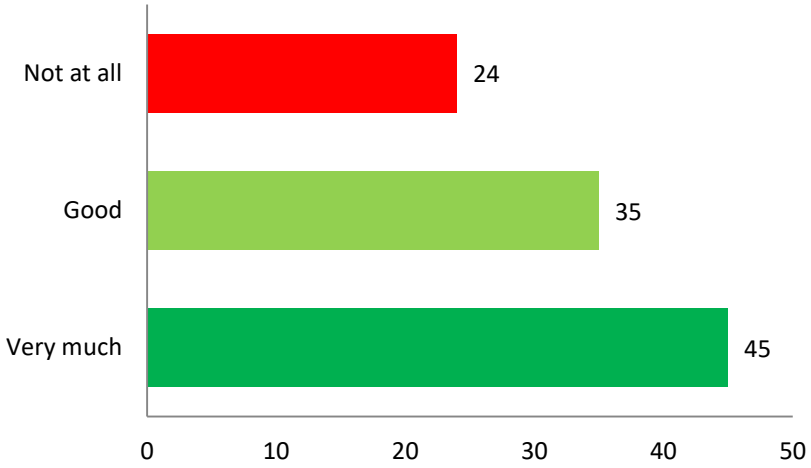

Fig 14. Fascination of local people towards wild animals

In our attempt to understand the people's thoughts on returning of tiger to Trijuga forest, we interacted with people of various levels and occupations. Most of the locals were positive. Their logic behind there should be tiger in Trijuga forest were: a) tiger will safeguard the forest from poachers and smugglers so they won't need to go for patrolling, b) tiger is the king of the forest c) tiger's presence adds to beauty of forest d) It will discourage free grazing of livestock. However, the result of our questionnaire survey revealed that only 39 (38%) respondents had welcomed the view, 15 (14%) were neutral and 50 (48%) were negative (Fig 15). This negative feeling is mainly due to lack of awareness and loss of property and life they have faced as results of conflict with wild animals in the past. Moreover, Nepal Government's Wildlife Damage Relief Scheme because of people's ignorance and its tedious process; is ineffective in this part of the country.

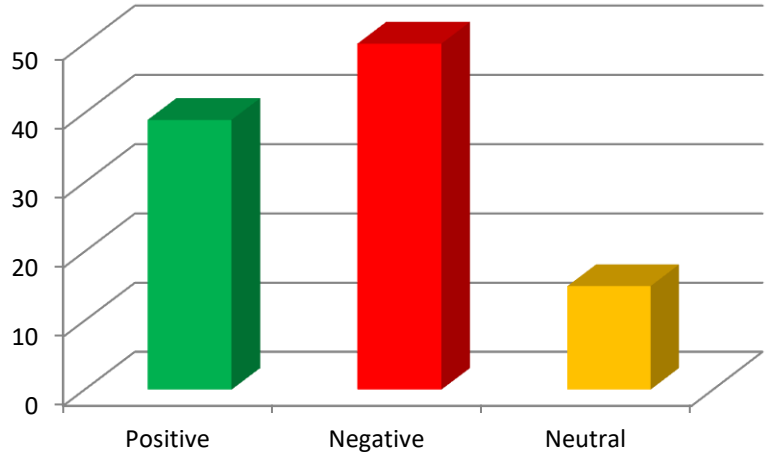

Fig 15. People's verdict on tiger returning to Trijuga forest (based on questionnaire survey)

4.15. Occupancy Modeling

Detection of signs of Barking deer was found to be influenced by the presence of Thakal (*Phoenix humilis)* at the sampling location and distance to the water source which is followed by the presence of Thakal at the sampling location, distance to water and settlements as shown in the table 3.

Table 7. Detection model (Barking deer) arranged in descending order of magnitude

Model	No. of parameters	AIC	delta	AICwt	cumltvWt
p(thakals+dtw)psi(.)	4	86.03	0	0.2605	0.26
p(thakals+dtw+dts)psi(.)	5	86.72	0.69	0.1847	0.45
p(thakals+dts)psi(.)	4	87.09	1.05	0.1539	0.6
p(thakas)psi(.)	3	87.9	1.87	0.1023	0.7
p(thakals+dts+fire)psi()	6	88.07	2.04	0.094	0.8
p(thakals+dtw+dts+canopy)psi(.)	6	88.23	2.2	0.0868	0.88
p(thakals+canopy)psi(.)	4	89.38	3.35	0.0489	0.93
p(thakals+fod)psi()	5	89.83	3.8	0.0389	0.97
p(thakals+dtw+dts+human)psi(.)	5	91.26	5.23	0.0191	0.99
p(dtw+dts)psi(.)	4	93.23	7.2	0.0071	1
p(.)psi(.)	2	94.47	8.44	0.0038	1

Site level occupancy of Barking deer was found to be the function of ground coverage, fire, distance to human settlement and canopy coverage as shown by the top models in table below:

Table 8. Model used for averaging the beta coefficient (Barking deer)

Model	nPars	AIC	Delta	AICwt	Cumltv Wt
p(thakals+dtw)psi(ground+fire)	7	74.68	0	4.30E-01	0.43
p(thakals+dtw)psi(ground+fire+dts)	8	76.51	1.83	1.70E-01	0.6
p(thakals+dtw)psi(canopy+ground+fire)	8	76.53	1.85	1.70E-01	0.76
p(thakals+dtw)psi(ground+fire+dtw)	8	76.62	1.94	1.60E-01	0.92

Fit of top model was assessed by using MacKenzie and Bailey goodness-of-fit for single-season occupancy model (MacKenzie & Bailey, 2004).

Table 9. Pearson chi-square table

Chi square test for Barking deer				
Detection history	**Cohort**	**Observed**	**Expected**	**Chi-square**
0000	0	8	8.75	0.06
0001	0	3	1.3	2.24

0010	0	1	0.91	0.01
0011	0	1	0.52	0.46
0110	0	1	0.52	0.46
1000	0	1	1.13	0.02
1001	0	1	0.81	0.05
1010	0	1	0.44	0.71
1100	0	1	0.81	0.05
1101	0	1	0.49	0.53
1111	0	1	1.19	0.03

Chi-square statistic = 7.7415
Number of bootstrap samples = 1000
P-value = 0.904
c-hat = 0.6

As shown above p value is greater than 0.05 indicating the fitness of the model.

Table 10. Beta coefficient of occupancy of Barking deer

Parameter	**Estimate**	**SE**	**95% unconditional confidence interval**	
Intercept	-36.71	34.67	-104.67	31.25
Distance to settlement	2.44	6.81	-10.9	15.79
Distance to Water source	-0.02	3.24	-6.36	6.33
Canopy Coverage	-0.87	5.03	-10.73	8.99
Ground coverage	-26.31	26.07	-77.4	24.79
Fire low	50.14	46.69	-41.36	141.65
Fire medium	77.8	74.1	-67.44	223.04

Detection of signs of Primate was influenced by the presence of canopy at the sampling location which is followed by combine model distance to water and canopy coverage.

Table 11. Detection model (Primates) arranged in descending order of magnitude

Model	**nPars**	**AIC**	**delta**	**AICwt**	**cumltvWt**
p(canopy)psi()	3	90.14	0	0.2919	0.29
p(dtw+canopy)psi()	4	90.26	0.12	0.2746	0.57
p(dts+canopy)psi()	4	91.91	1.78	0.12	0.69
p(canopy+thakals)psi()	4	92.04	1.91	0.1126	0.8
p()psi()	2	92.29	2.15	0.0995	0.9
p(thakals)psi()	3	94.18	4.05	0.0386	0.94
p(thakals+dts)psi()	4	95.27	5.13	0.0224	0.96
p(thakals+dtw)psi()	4	95.51	5.37	0.0199	0.98
p(thakals+fire)psi()	5	96.28	6.15	0.0135	0.99

p(thakals+fod)psi()	5	97.57	7.44	0.0071	1

4.15.1. Occupancy

The naive occupancy estimate was found to be 0.6. The null model psi(.), p(.) performed poorly as can't be seen in the top seven models ranked according to AIC value. The model p(canopy)psi(canopy+ground+dts+I(dts^2)+dtw+I(dtw^2) +dtw:human had the highest level of support (ΔQAICc = <2.0) with highest weight (wi) which suggests that it was the best model in the set. Similarly, p(canopy)psi(canopy+ground+dts+I(dts^2)+dtw +I(dtw^2)+thk) and p(canopy)psi(ground+dts+dtw) were also found to be strong candidates models (ΔAIC = <2.0) (Table 12).

Table 12. Occupancy Model (Primates) arranged in descending order of magnitude

Model	nPars	AIC	delta	AICwt	CumltvWt
p(canopy)psi(canopy+ground+dts+I(dts^2)+dtw+I(dtw^2)+dtw:human)	11	86.41	0	0.12825	0.13
p(canopy)psi(canopy+ground+dts+I(dts^2)+dtw+I(dtw^2)+thk)	11	86.41	0.0049	0.12794	0.26
p(canopy)psi(ground+dts+dtw)	6	87.75	1.3397	0.06564	0.32
p(canopy)psi(canopy+thakals:canopy ~canopy+ground+dts+I(dts^2)+dt+I (dtw^2)+dtw:human)	12	87.97	1.5642	0.05867	0.38
p(canopy)psi(canopy+dts+I(dts^2)+ dtw+I(dtw^2)+thk)	10	88	1.596	0.05774	0.44
p(canopy)psi(dts+dtw+I(dts^2)+I(dt w^2)+ground+thk)	10	88.01	1.5984	0.05767	0.5

Table 13. Beta coefficient of occupancy of Primate

Parameter	estimate
Intercept	39.49
Distance to settlement	30.93
Distance to Water source	-12.34
Canopy Coverage	19.98
Ground coverage	-19.67
Thakal medium	31.21

Naïve occupancy for Barking deer = 0.6 (12 of 20 grids selected occupied)
Naïve occupancy for Primates = 0.6 (12 of 20 grids selected occupied)

4.15.2. Land covers classification (forest classification)

To classify Trijuga, based on forest, water source and others (farmland, degraded land, settlements etc.), Remap: An online remote sensing application for land cover classification and monitoring was used (Murray, 2018). Remap requires only georeferenced training points that identify different map classes, which most often

represents ecosystems or land cover classes. Each training point then samples a range of satellite datasets (predictors) to train a random forest classifier. Once the random forest is trained, remap classifies all of the pixels present in a focal region into the map classes defined by the training set. The output raster file was then reclassified using QGIS. Total area of Trijuga forest was 442.98 km^2.

Table 14. Table showing land cover

Land cover	**Area (km^2)**	**Percentage (%)**
Forest	326.3107	74.08987
Water Sources	46.47167	10.55154
Others (Farmland, degraded land, settlements, etc.)	67.64315	15.35859

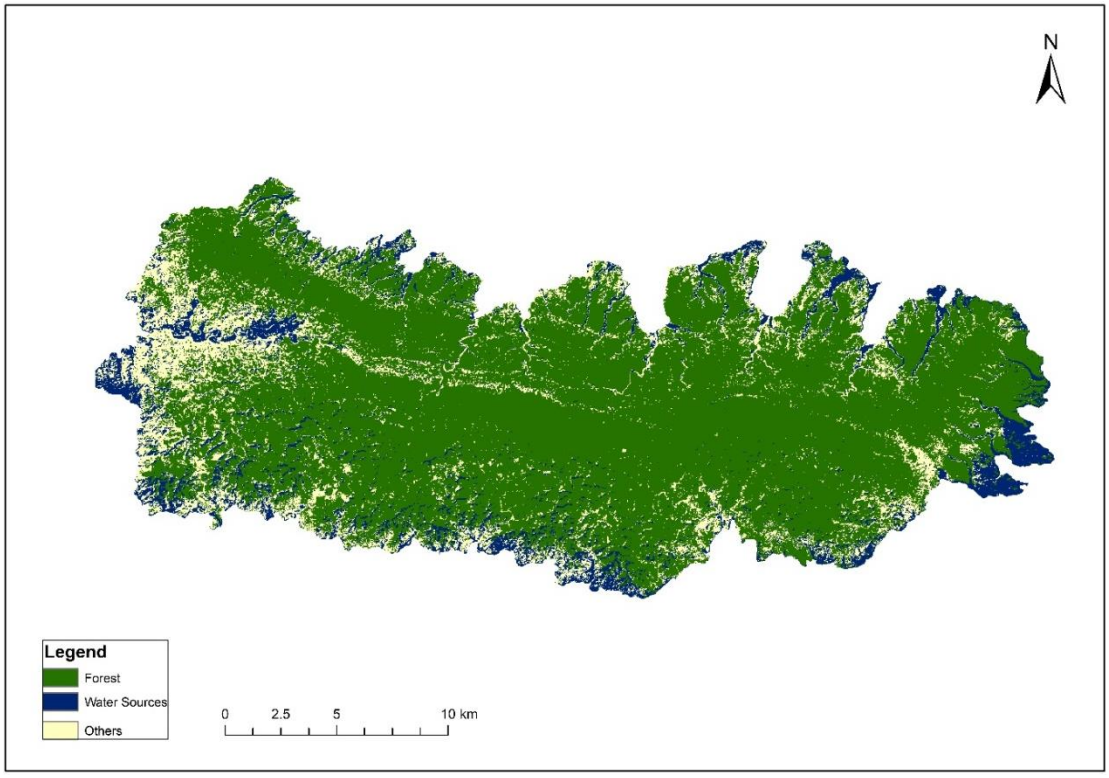

Fig 16. Map showing forest and water covers

Land covers classification revealed that the forest covers 326.3 km^2 (74%), water covers 46.5 km^2 (10.5%) and others (farmland, degraded land, settlements, etc.) cover 67.6 km^2 (15.5%) of total area (Table 14; Fig 16). This means, though the forest covers one-third of the area, still the significant area is covered by farmland, degraded land and human settlements. Settlement covers as shown in the western part of the Trijuga forest by the classified map is contributed by the settlements of Damauti area.

4.15.3. Recorded location of prey species of tiger

Nine prey species (major and occasional) of tiger were recorded in Trijuga forest through direct sighting or their signs (Table 15). Wild water buffalo was confirmed

to visit the forest during flooding in KTWR but couldn't be recorded during our survey. Barking deer was found most abundant among the prey species followed by primates (Blue bull and Rhesus macaque), Wild boar, Indian peafowl, Indian hare, Blue bull, Porcupine, Spotted deer and Gaur (Fig 17). Presence of Wild boar and Gaur was confirmed through foot prints and Spotted deer through foot prints and pellets only.

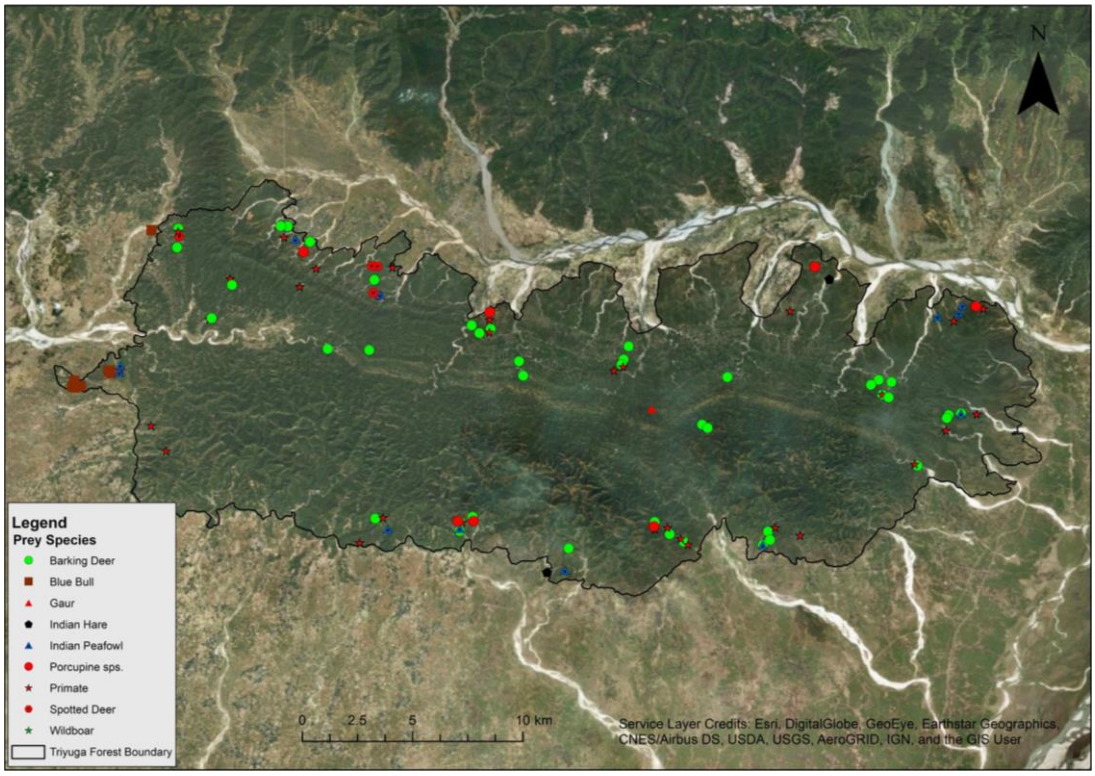

Fig 17. Map showing recorded location of tiger prey species in Trijuga Forest

Table 15. Table showing prey species recorded and number of their sighting

SN	Prey Species	No. of Sighting
1.	Barking deer	49
2.	Primate (Blue bull and Rhesus macaque)	31
3.	Wild boar	26
4.	Indian peafowl	13
5.	Indian hare	13
6.	Blue bull	10
7.	Porcupine	7
8.	Spotted deer	6
9.	Gaur	1

4.15.4. Habitat suitability of prey species

All the prey species occurrence records were collected within Trijuga forest (Annex 4). Occurrence locations were based on presence data obtained from field survey. Direct sightings, foot prints and pellets were indicator of the species presence. To

model potential distribution, 19 bioclimatic raster layers were obtained from WorldClim (www.worldclim.com) which were (~1km) in spatial resolution (Hijmans, Cameron, Parra, Jones, & Jarvis, 2005). Among 19 bio-climatic layers, eight climatic layers (BIO1, BIO3, BIO4, BIO11, BIO12, BIO14, BIO15 and BIO17) after clicking the collinearity to remove the highly correlated variables and maximize model performance (Quinn & Keough, 2002). Additionally, aspect and slope were derived from elevation data of WorldClim, which have similar resolution with climate variables. All the layers were masked with Trijuga Forest boundary and then formatted by ArcGIS 10 to prepare the ASCII format which is readable by the Maximum Entropy Modeling. The prey species geo-referenced points were converted into comma separated values (.csv) file type as required by the software. All the data were finally imported to MaxEnt to predict the habitat. The model was then run using default auto setting. Finally, the result was analyzed using QGIS 3.4.1. The output MaxEnt was reclassified into three classes of habitat suitability, low (0.22–0.50 probability of occurrence), moderate (0.50–0.75 probability of occurrence), and high (<0.75 probability of occurrence), by omitting the values below the threshold as unsuitable habitat (Shrestha & Bawa, 2014).

Altogether nine species (Barking deer, Spotted deer, Primate (Blue bull and Rhesus macaque), Wild boar, Gaur, Blue bull, Indian peafowl, Porcupine sp. and Indian hare were used to predict the habitat suitability of prey species. Occurrence locations consisted of 130 presence records.

Bioclimatic variables

BIO1 = Annual Mean Temperature
BIO3 = Isothermality (BIO2/BIO7) (* 100)
BIO4 = Temperature Seasonality (standard deviation *100)
BIO11 = Mean Temperature of Coldest Quarter
BIO12 = Annual Precipitation
BIO14 = Precipitation of Driest Month
BIO15 = Precipitation Seasonality (Coefficient of Variation)
BIO17 = Precipitation of Driest Quarter

4.15.5. Results of occupancy modeling

Among the total forest area of Trijuga, 62.55 km^2 (14.12%) was found to have high suitability (>0.70 threshold) for the prey species, 129.98 km^2 (29.34%) was moderate suitable (0.50-0.70 threshold) and 250.54 km^2 (56.56%) was found to be low suitable for the prey species (Fig 18).

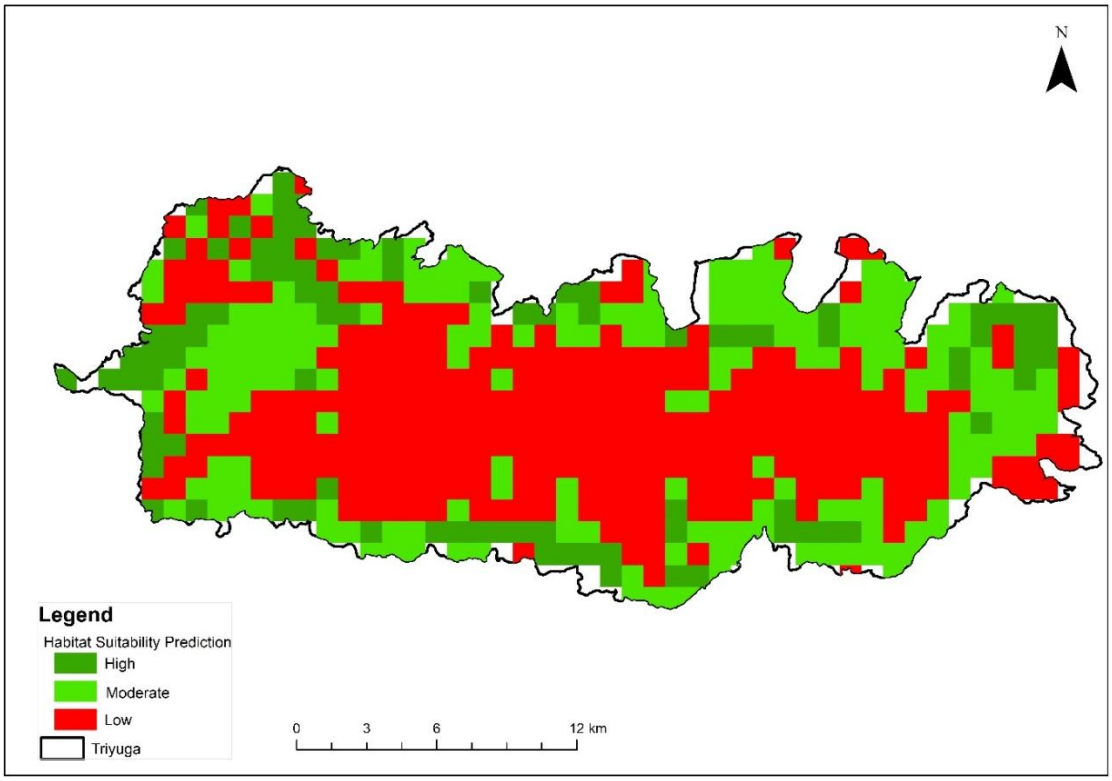

Fig 18. Map showing habitat suitability prediction for tiger prey base in Trijuga Forest

4.15.6. Habitat suitability prediction for Barking deer

Altogether, 50 GPS co-ordinates were available for modeling. The highly suitable habitat (> 0.70 threshold) for Barking deer was predicted to be 70.91 km^2 (16%) of total area. Similarly, 104.27 km^2 of area was predicted as moderate suitable (23.53%). Most of these areas lied in the north-east and south-east corner of Trijuga Forest. Most of the unsuitable areas were in western part of Trijuga covering 267 km^2 (60.45%) (Fig 19).

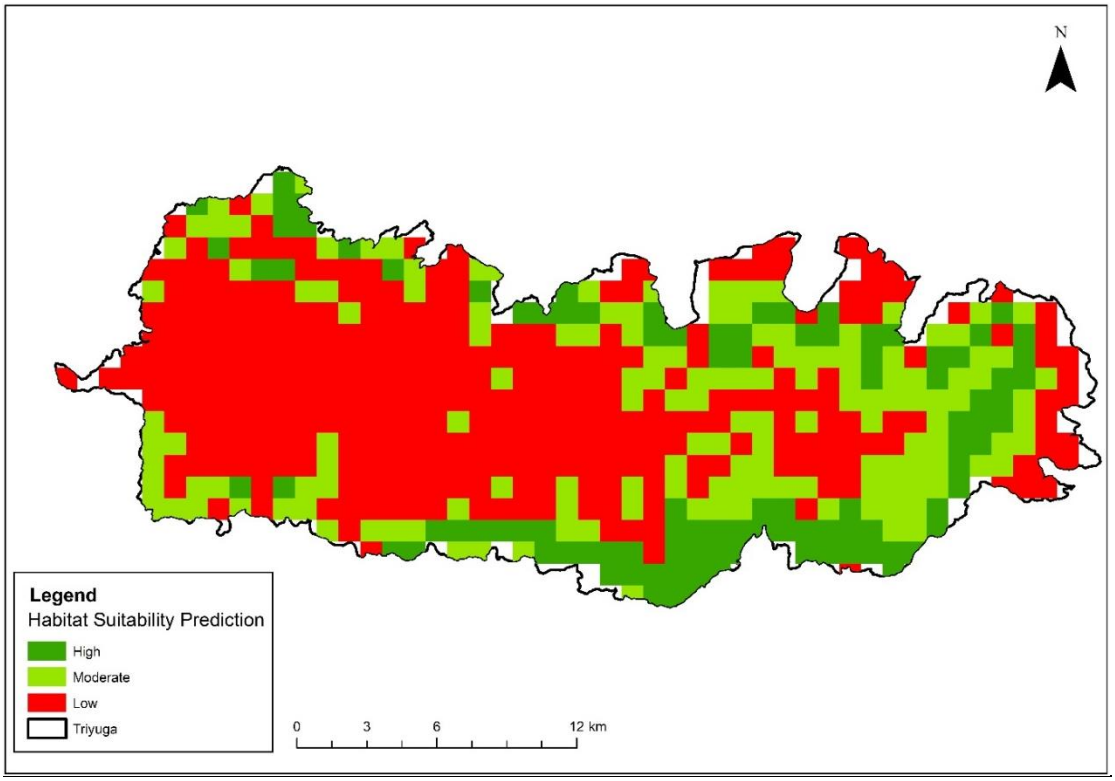

Fig 19. Map showing predicted suitable habitat for Barking deer in Trijuga Forest

4.15.7. Habitat suitability prediction for primates

Highly potential areas for primates (Blue bull and Rhesus macaque) were found scattered around the forest fringes of Trijuga (Fig 20). Highly suitable habitat predicted for primates was 117.96 km^2 (26.63%) and 148 km^2 (33.48%) area was moderately suitable. Similarly, an area of 176 km^2 (40%) was unsuitable for primates in Trijuga.

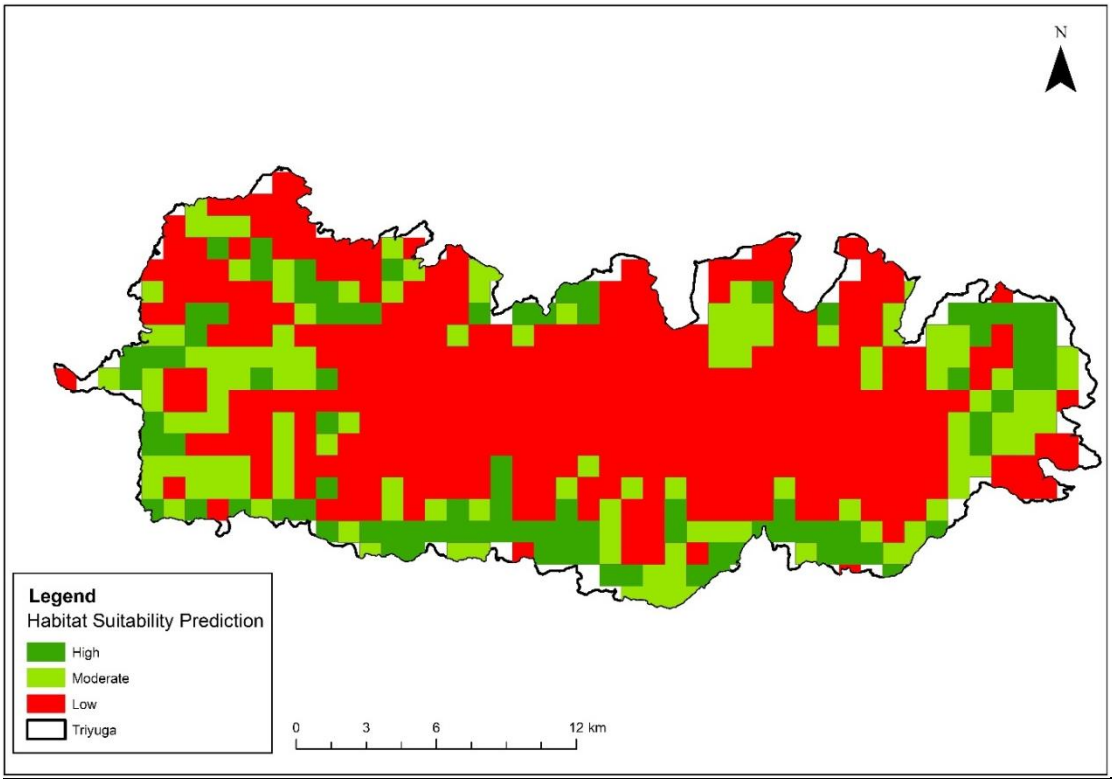

Fig 20. Map showing predicted suitable habitat for primates in Trijuga Forest

4.15.8. Habitat Suitability for tiger

Based on the habitat prediction of Barking deer and primate species, high and moderate suitable area was taken into consideration for tiger. Firstly, suitable area for both the species was overlaid and intersection (suitable for both species) was calculated.

Based on the analysis, 97.88 km^2 of area in Triyuga forest is currently suitable habitat for the tiger (Fig 21). These areas are scattered around the fringes of Trijuga forest. It is because survey couldn't be done towards the center (top and ridges) of the forest due to difficult terrain, inaccessibility and harsh weather condition during the survey period. Those areas are very dry and not much suitable for many animals. However, some prey species would have been definitely dwelling the area. Therefore, the habitat prediction map produced as a result of our survey do not represent complete study area and we believe inclusion of those areas in the future would give comprehensive tiger habitat suitability mapping.

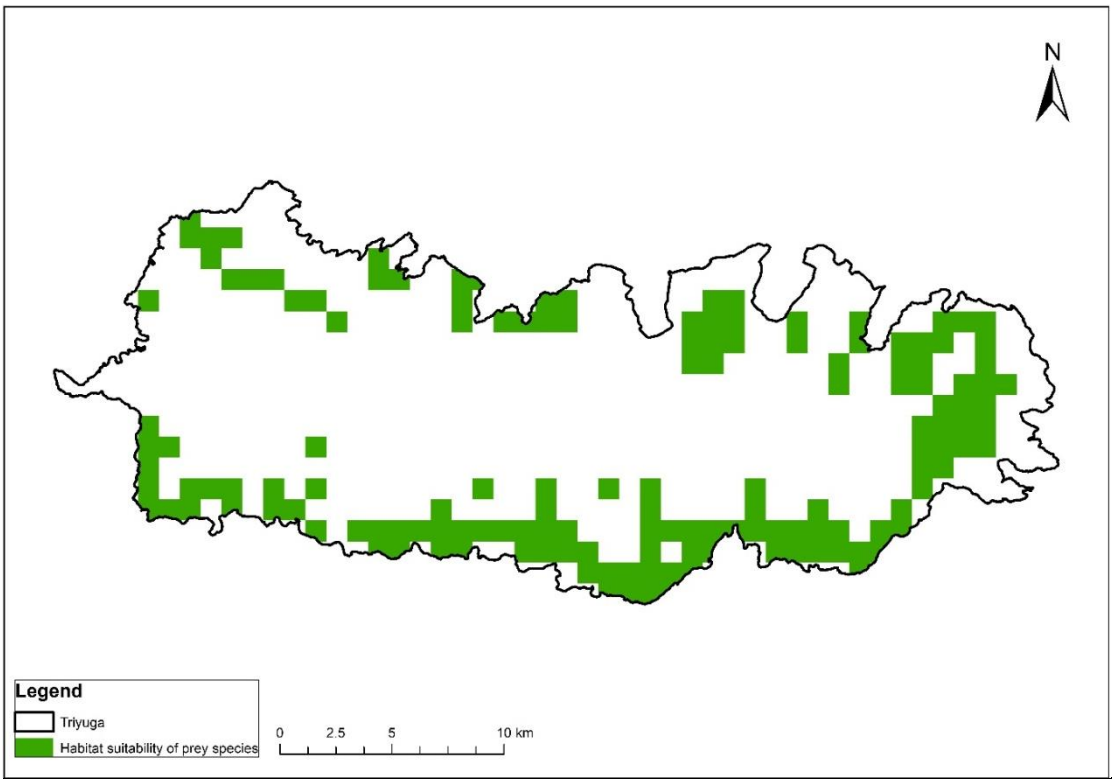

Fig 21. Predicted highly suitable habitat for Barking deer and primates in Trijuga Forest

4.15.9. Assessment of potentiality of tiger reintroduction in Trijuga forest

According to *Guidelines for reintroduction and other conservation translocations* (IUCN/SSC, 2013), biological feasibility, social feasibility, regulatory compliance and resources availability are the four major criteria for reintroduction and translocation. In this study, biological and social feasibility have been assessed and other two criteria have not been assessed.

4.15.9.1. Biological feasibility

Habitat suitability of prey species (Barking deer and primates) indicates that only 65.35 km^2 of area is currently highly suitable for the tiger. Increasing the number of major prey species recorded in Trijuga like Gaur, Blue bull, Spotted deer, Wild boar and Barking deer along with occasional prey base like porcupine, Indian hare and Indian peafowl would increase the habitat suitability for tiger. Moreover, reintroduction of large ungulate like Sambar deer would add to the potential of tiger reintroduction in the forest. Appropriate management and restoration of grasslands and forest, and elimination of human disturbance would offer more areas for the tiger.

4.15.9.2. Social feasibility

As already mentioned in the perception section, most of the local people are very much supportive to the idea of bringing back the tiger in Trijuga forest. Local people's belief that the tiger would guard the forest from smugglers and poachers is

a very positive indication. Few who exhibited aversion to having tiger in the forest because of loss from other wild animals can be made aware of Nepal Government's Wildlife Damage Relief Scheme and importance of tiger.

Chapter 5: Conclusion and Recommendations

Conclusion

Fourteen prominent and occasional species and 12 potential prey species of tiger were recorded from Trijuga forest. Barking deer was the most abundant prey species by distribution; however, primates were recorded as having higher number. Barking deer and primate (Terai grey langur and Rhesus macaque) were used for habitat modeling. An area of 192 km^2 was found to be suitable for these prey species and 98 km^2 for the tiger. Covers, water and disturbance were the affecting factors. Poaching and other human disturbances were found to be very high. Therefore, with the same prey base and other conditions reintroduction of tiger in the area seems to be not feasible. Long term and detailed study of habitat suitability is must requirement for the area. Improvement of the forests and corridors with source population (Chitwan-Parsa National Park) and KTWR, Beltar and Dharan forests, increasing population of existing prey species, introduction of large ungulates like Sambar deer and mitigation of poaching and other human disturbance are basic requirements for reintroduction of tiger.

Although majority of local people were found positive on returning of tiger to the area, some people mostly those who had faced conflict with the wildlife had opined negatively. Carrying out awareness campaign and effective implementation of Nepal Government's Wildlife Damage Relief Scheme would help in alleviating their negative attitude.

Recommendations

Based on our field observation and interaction with local people following recommendations are suggested for overall wellbeing of the area:

- Keep at least one Forest Guard (*ban heraalu*) in every community forests.
- Introduce active relief system against wildlife damage.
- Construct permanent water holes in the areas where water scarcity occur in winter and summer months. This will reduce wildlife mortality due to illegal hunting.
- Cover entire Trijuga area by proper wire fencing, this will also reduce human-wildlife conflict.
- Conduct tree plantation in the areas where local forest is highly degraded.
- Establish alert system at different strategic locations to inform local villagers about presence of wild elephant in their areas.
- Launch nature conservation, existing wildlife conservation rules and regulations related awareness programs in the areas.
- Give responsibility of community forestry officials/position holders to the timber smugglers and illegal hunters (this is already seen successful in few areas).

- Conduct a detail study including status, population, density, threats, etc. of flora and fauna of the area.
- Conduct detail study for reintroducing locally extinct (tiger and its principal prey species) wildlife of the area.
- Make paddy and sugarcane artificially available for wild elephant in their natural habitat. It is presumed that this will control their movement and also leaving of their original natural habitat in eastern Nepal.
- Designate Trijuga forest as protected area especially to accommodate the growing tiger population in the country.

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Annexes

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Annex 2: Checklist of mammals recorded from Trijuga forest

SN	Scientific name	Common Name (Local Name)	Means of verification
1.	*Lepus nigricollis*	Indian hare	observation
2.	*Funambulus pennantii*	Five Striped Palm Squirrel	observation
3.	*Callosclurus pygerythrus*	Irrawaddy squirrel	interview
4.	*Petaurista petaurista*	Red giant flying squirrel	observation
5.	*Rattus rattus*	House Rat	observation
6.	*Hystrix indica*	Indian Crested Porcupine	observation
7.	*Manis crassicaudata*	Indian pangolin	interview
8.	*Manis pentadactyla*	Chinese pangolin	scales observed
9.	*Paguma larvata*	Masked palm civet	scats/Interview
10.	*Viverra zibetha*	Large Indian civet	observation
11.	*Paradoxurus hermaphroditus*	Asian palm civet	Interview
12.	*Felis chaus*	Jungle cat	pugmarks/Interview
13.	*Prionailurus bengalensis*	Leopard cat	Observation/pugmarks/Interview
14.	*Neofelis nebulosa*	Clouded leopard	Interview
15.	*Panthera pardus*	Common leopard	pugmarks/interview
16.	*Herpestes auropunctatus*	Small Indian mongoose	interview
17.	*Herpestes edwardsii*	Indian Grey mongoose	interview
18.	*Herpestes urva*	Crab-eating mongoose	interview
19.	*Vulpes bengalensis*	Bengal fox (Khir khire)	observation
20.	*Canis aureus*	Asiatic Golden Jackal	Observation/Signs/Interview
21.	*Hyaena hyaena*	Striped hyena	pugmarks/interview
22.	*Melursus ursinus*	Sloth bear	observation
23.	*Lutrogale perspicillata*	Smooth-coated Otter	interview
24.	*Martes flavigula*	Yellow-throated Marten	observation
25.	*Shrew sp.*	Shrew	interview
26.	*Pteropus giganteus*	Indian flying fox	observation
27.	*Bat spp.*	Bats	observation
28.	*Semnopithecus schistaceus*	Blue bull	observation
29.	*Macaca mulatta*	Rhesus macaque	observation
30.	*Sus scrofa*	Wild boar	observation
31.	*Muntiacus vaginalis*	Barking deer	observation
32.	*Axis axis*	Chital	signs/Interview
33.	*Boselaphus tragocamelus*	(Tori gadhaa/tori jarayo)	observation

SN	Scientific name	Common Name (Local Name)	Means of verification
34.	*Capricornis thar*	Himalayan serow	interview
35.	*Elephas maximus*	Asian Wild elephant	signs/Interview
36.	*Bos gaurus*	Gaur (Liligaai)	tracks/interview
37.	*Bubalus arnee*	Wild water buffalo	interview

Annex 3: List of plant species recorded from Trijuga forest

SN	Botanical Name	Family	Common Name
1.	*Acacia catechu* (L.f.) Willd.	Fabaceae	Khayar
2.	*Adina cordifolia* Benth. & Hook. f. ex Brandis	Rubiaceae	
3.	*Aegle marmelos* (L.) Correa	Rutaceae	Bel
4.	*Alstonia neriifolia* D.Don	Apocynaceae	Chhatiwan
5.	*Anogeissus latifolius (Roxb.ex DC.) Bedd.*		
6.	*Anthocephallus chinensis* (Lam.) A. Rich. ex Walp.	Rubiaceae	Kadam
7.	*Antidesma acidum* Retz.	Euphorbiaceae	
8.	*Ardisia solanacea* Roxb.	Myrsinaceae	
9.	*Argemone mexicana* L.	Papaveraceae	
10.	*Asparagus racemosus* Willd.	Liliaceae	Kurilo
11.	*Barleria cristata* Linn.	Acanthaceae	
12.	*Bauhinia purpurea* Linn.	Fabaceae	Tanki
13.	*Bauhinia vahlii* Wight & Arn.	Fabaceae	Bhorla
14.	*Boerhavia diffusa* Linn.	Nyctaginaceae	Punarwa
15.	*Bombax ceiba* Linn.	Bombacaceae	Simal
16.	*Boreria articularis* (L. f.) F. N. Williams	Rubiaceae	
17.	*Breynia vitis-idaea* Fischer	Euphorbiaceae	
18.	*Bridelia retusa* (L.) Spreng.	Euphorbiaceae	Gayo
19.	*Buchanania latifolia* Roxb.	Anacardiaceae	Pyar
20.	*Butea minor* Buch.-Ham.	Fabaceae	Bhujetro
21.	*Butea monosperma* (Lam.) Kuntze	Fabaceae	Palas
22.	*Capparis zelanica* Linn.	Capparidaceae	
23.	*Casearia graveolens* Dalz.	Flacourtaceae	
24.	*Cassia fistula* Linn.	Fabaceae	Rajbriksha
25.	*Chlorophytum arundinaceum* Baker	Liliaceae	Seto Musali
26.	*Chromolaena odorata* (L.) King & H. Rob.	Asteraceae	Banmara
27.	*Chrysopogon aciculatus* (Retz.) Trin.	Poaceae	
28.	*Clerodendrum infortunatum* L.	Verbenaceae	
29.	*Colebrookea oppositifolia* Sm.	Verbenaceae	Dhusure
30.	*Cordia dichotoma* Forster	Boraginaceae	
31.	*Crotolaria alata* Buch.-Ham.	Fabaceae	
32.	*Crotolaria pallid* Ait.	Fabaceae	
33.	*Curculigo orchioides* Gaertn.	Hypoxidaceae	Kalo Musali
34.	*Curcuma angustifolia* Roxb.	Zingiberaceae	
35.	*Dalbergia latifolia* Roxb.	Fabaceae	
36.	*Dalbergia sisoo* Roxb.	Fabaceae	Sisoo
37.	*Desmodium oojeinense* (Roxb.) Ohashi	Fabaceae	

38.	*Desmodium velutinum* (Willd.) DC.	Fabaceae	
39.	*Desmostachya bipinnata* (L.) Stapf	Poaceae	
40.	*Dillenia indica* Linn.	Dileniaceae	Chanchari
41.	*Dioscorea bulbifera* Linn.	Dioscoreaceae	Vyakur
42.	*Elephantopus scaber* Linn.	Asteraceae	
43.	*Engelhardia spicata* Lesch. ex Blume	Juglandaceae	Mahuwa
44.	*Evolvulus nummularius* Linn.	Convolvulaceae	
45.	*Ficus semicordata* Buch.-Ham. ex Sm.	Moraceae	Khanayo
46.	*Ficus subincisa* Buch.-Ham. ex Sm.	Moraceae	
47.	*Grewia sp*	Tiliaceae	
48.	*Hiptage benghalensis* (L.) Kurz	Malpighiaceae	
49.	*Holarrheana pubescens* G.Don.	Apocynaceae	Indrajau
50.	*Hyptianthera stricta* Wight & Arn.	Rubiaceae	
51.	*Hyptis suaveolens* (L.) Poit.	Lamiaceae	Ganaune tulasi
52.	*Ichnocarpus frutiscens* (L.) R.Br.	Apocynaceae	
53.	*Imperata cylindrical* (L.) Beauvois	Poaceae	Dari
54.	*Indopiptadanea oudhensis (Brandis)Brenan*	Fabaceae	
55.	*Ipomoea aquitica* Forssk.	Convolvulaceae	Besarma
56.	*Ipomoea quamoclit* Linn.	Convolvulaceae	
57.	*Lagerstroemia parviflora* Roxb.	Lythraceae	
58.	*Lantana camara* Linn..	Verbenaceae	
59.	*Leea crispa* Royen ex Linn.	Vitaceae	
60.	*Leea macrophylla* Roxb. ex Hornem.	Vitaceae	Goleni
61.	*Leucas indica* (L.) R. Br. ex Vatke	Lamiaceae	
62.	*Mallotus philippensis* (Lam.) Müll. Arg.	Euphorbiaceae	Sindur
63.	*Mangifera indica* Linn.	Anacardiaceae	Aamp
64.	*Mikania micrantha* Kunth	Asteraceae	Lahare Banmara
65.	*Mitragyna parviflora* (Roxb.) Korth.	Rubiaceae	
66.	*Morus australis* Poir.	Moraceae	Kimbu
67.	*Murraya koenigii* (L.) Spreng.	Rutaceae	Mithanim
68.	*Osbeckia rostrata D.Don.*	Melastomataceae	Ghayeri
69.	*Phoenix humilis* Royle	Palmae	Thakal
70.	*Phyllanthus emblica* Linn.	Euphorbiaceae	Amala
71.	*Pithecellobium heterophyllum* (Roxb.) Macbride	Fabaceae	Jilebi
72.	*Pogostemon benghalensis* (Burm.f.) Kuntze	Labiatae	
73.	*Polygala sibirica* Linn.	Polygalaceae	
74.	*Pueraria tuberosa* DC.	Fabaceae	
75.	*Randia fasciculata* (Roxb.) DC.	Rubiaceae	
76.	*Randia Sikkimensis* Hook.f.	Rubiaceae	
77.	*Rauvolfia serpentine* (L.) Benth. ex Kurz.	Apocynaceae	Sarpagandha

78.	*Rhynchostylis retusa* (L.) Blume	Orchidaceae	
79.	*Saccharum spontaneum* Linn.	Poaceae	Kans
80.	*Sapium baccatum* Roxb.	Euphorbiaceae	Khirro
81.	*Schleichera oleosa* (Lour.) Oken	Sapindaceae	Kusum
82.	*Scoparia dulcis* Linn.	Scrophulariaceae	Mithajhar
83.	*Semecarpus anacardium* L. f.	Anacardiaceae	Valayo
84.	*Sesbania grandiflora* L. Poir.	Fabaceae	Dhaicha
85.	*Senna tora* Linn.	Fabaceae	
86.	*Shorea robusta* Gaertn.	Dipterocarpaceae	Sal
87.	*Sida acuta* Burm.f.	Malvaceae	
88.	*Smilax ovalifolia* Roxb.	Smilacaceae	Kukurdainu
89.	*Spermadictyon suaveolens* Roxb.	Rubiaceae	
90.	*Terminalia bellirica* (Gaertn.) Roxb.	Combretaceae	Barro
91.	*Terminalia chebula* Retz.	Combretaceae	Harro
92.	*Terminalia alata* Heyne ex Roth	Combretaceae	Saj
93.	*Thespesia lampas* (Cav.) Dalz. & Gibs	Malvaceae	Bankapas
94.	*Thysanolaena maxima* (Roxb.) Kuntze	Poaceae	Amliso
95.	*Trewia nudiflora* Linn.	Euphorbiaceae	
96.	*Tridax procumbens* Linn.	Asteraceae	
97.	*Uraria lagopodioides* (L.) Desv.	Fabaceae	
98.	*Vanda cristata* Lindl.	Orchidaceae	
99.	*Vanda teres* Lindl.	Orchidaceae	
100.	*Vitex negundo* Linn.	Verbenaceae	Simali
101.	*Wendlandia coriacea* (Wall.) DC.	Rubiaceae	
102.	*Wenlandia tinctoria* (Roxb.)DC.	Rubiaceae	
103.	*Wudfordia fruiticosa*	Lythraceae	Dhairo
104.	*Xerophis uliginosa*	Rubiaceae	

Annex 4: GPS coordinates of tiger prey base recorded in Trijuga forest

Species	Lon	Lat
Barking deer	86.66607	26.66435
Barking deer	86.87662	26.71998
Barking deer	86.87287	26.71486
Barking deer	86.87287	26.71486
Barking deer	86.87149	26.72092
Barking deer	86.86830	26.71886
Barking deer	86.71317	26.74163
Barking deer	86.70857	26.73998
Barking deer	86.70539	26.74309
Barking deer	86.74499	26.65217
Barking deer	86.70049	26.65932
Barking deer	86.70081	26.66297
Barking deer	86.70581	26.66513
Barking deer	86.70621	26.66334
Barking deer	86.79192	26.65497
Barking deer	86.78617	26.65801
Barking deer	86.78007	26.66297
Barking deer	86.78007	26.66298
Barking deer	86.88732	26.68588
Barking deer	86.76942	26.73454
Barking deer	86.76942	26.73454
Barking deer	86.76942	26.73454
Barking deer	86.76738	26.72919
Barking deer	86.76738	26.72919
Barking deer	86.76653	26.72709
Barking deer	86.76653	26.72709
Barking deer	86.82415	26.65362
Barking deer	86.82633	26.65908
Barking deer	86.82708	26.65569
Barking deer	86.80975	26.72204
Barking deer	86.63036	26.78349
Barking deer	86.62748	26.78357
Barking deer	86.63943	26.77716
Barking deer	86.66569	26.76165
Barking deer	86.58573	26.78260
Barking deer	86.58520	26.77483
Barking deer	86.58520	26.77483
Barking deer	86.90508	26.70722
Barking deer	86.89999	26.70653
Barking deer	86.89927	26.70531
Spotted deer	86.66701	26.76716
Spotted deer	86.66464	26.76732
Spotted deer	86.66522	26.75638
Spotted deer	86.66731	26.75528
Spotted deer	86.58612	26.77932
Primate	86.65968	26.65439
Primate	86.66920	26.66460
Primate	86.56192	26.72484
Primate	86.87287	26.71486
Primate	86.71270	26.74535
Primate	86.71260	26.74025
Primate	86.57464	26.70213
Primate	86.58070	26.69190
Primate	86.70160	26.66272
Primate	86.69977	26.66333
Primate	86.79369	26.65366
Primate	86.79072	26.65609
Primate	86.78526	26.66059
Primate	86.78023	26.65994
Primate	86.88615	26.68649
Primate	86.76719	26.72613
Primate	86.76344	26.72460
Primate	86.82918	26.66063
Primate	86.83938	26.65739
Primate	86.83532	26.74887
Primate	86.62881	26.77883
Primate	86.67308	26.76664
Primate	86.58568	26.78131
Primate	86.91413	26.74976
Primate	86.90209	26.74480
Primate	86.91150	26.70682
Primate	86.89888	26.70018
Primate	86.63530	26.75880
Primate	86.64194	26.76617
Wild boar	86.55832	26.72362
Wild boar	86.55732	26.72427
Wild boar	86.55790	26.72455
Wild boar	86.55783	26.72465
Wild boar	86.54241	26.71814
Wild boar	86.54339	26.71811
Wild boar	86.54361	26.71771
Wild boar	86.54336	26.72052
Wild boar	86.54589	26.71827
Wild boar	86.57477	26.78187
Gaur	86.77883	26.70894

Primate	86.59848	26.74562
Primate	86.60685	26.76201
Barking deer	86.60758	26.75956
Barking deer	86.87553	26.71372
Barking deer	86.79942	26.70263
Barking deer	86.64667	26.73350
Barking deer	86.72644	26.72260
Barking deer	86.80170	26.70129
Barking deer	86.72471	26.72845
Barking deer	86.66356	26.73305
Barking deer	86.59932	26.74602
Blue bull	86.55832	26.72362
Blue bull	86.55732	26.72427
Blue bull	86.55790	26.72455
Blue bull	86.55783	26.72465
Blue bull	86.54241	26.71814
Blue bull	86.54339	26.71811
Blue bull	86.54361	26.71771
Blue bull	86.54336	26.72052
Blue bull	86.54589	26.71827
Blue bull	86.57477	26.78187
Indian peafowl	86.67125	26.66007
Indian peafowl	86.56206	26.72684
Indian peafowl	86.56163	26.72387
Indian peafowl	86.56163	26.72387
Indian peafowl	86.74346	26.64326
Indian peafowl	86.70056	26.66024
Indian peafowl	86.82415	26.65362
Indian peafowl	86.89551	26.74671
Indian peafowl	86.63348	26.77820
Indian peafowl	86.66806	26.75545
Indian peafowl	86.90566	26.75125
Indian peafowl	86.90411	26.74819
Indian peafowl	86.90508	26.70722
Porcupine sp.	86.71286	26.74851
Porcupine sp.	86.69977	26.66333
Porcupine sp.	86.70621	26.66334
Porcupine sp.	86.77981	26.66114
Porcupine sp.	86.84548	26.76694
Porcupine sp.	86.63674	26.77304
Porcupine sp.	86.91114	26.75085
Indian hare	86.73618	26.64244
Indian hare	86.85131	26.76188
Indian hare	86.85131	26.76188

Annex 5: Datasheets

Datasheet: Human Disturbance Survey

Observer's name:						**Location name:**				**Date:**
Start time:		**Grid ID:**	**Start GPS location** Easting: Northing:			**End GPS location** Easting: Northing:				
End time:										
Quadrate ID	Wood cutting (No. of trees cut)	Lopping (No. of trees lopped)	Tree felling (Stump count)	Presence of temporary construction (Y/N) No.	Presence of human/livestock /tractor trails (Y/N)	People seen	Livestock seen/grazing (No.)	Presence of permanent construction (Y/N) No.	Others	Remarks

Note:

Temporary construction (huts, poacher's camp, hunting machan, illegal settlers, logging camps, picnic camps)

Other: Gun shot heard, snares found, fishing, poisoning

Datasheet: Species Occupancy Survey

Observer's Name:_____ **Location Name:**_____ **Date:**_____

Start time:_____ **End time:**_____ **Grid ID:**_____

Start GPS location **End GPS location**

Easting:_____ **Easting:**_____

Northing:_____ **Northing:**_____

Transect ID	GPS location	Species	Sign type/Direct sighting (No.)	Habitat type	Canopy cover	Ground cover	Terrain type	Slope	Aspect	Remarks
	E: N:									
	E: N:									
	E: N:									
	E: N:									
	E: N:									
	E: N:									
	E: N:									
	E: N:									
	E: N:									
	E: N:									

Note:

Carnivore species: Tiger, Leopard, Sloth Bear, Hyena, Wild Dog, Jackals, Wild Cat, Civets, Mongoose, Other cat species

Ungulates species: Chittal, Hog Deer, Swamp Deer, Gaur, Sambar, Wild Boar, Barking Deer, Hare, Four-horned Antelope, Rhesus Macaque, Langur, Porcupine, Elephant, Cattle, Unid

Sign types: Scats/Faecal matter, Dung, Pellet, Pugmark/Footprint, Scrape marks, Kills, Body parts

Forest types: Sal Forest/Mixed Forest/Riverine Forest/Grassland (short/tall)

Terrain types: Flat terrain/Foot hills/Churia/River bed

Datasheet: Line Transect Survey

Observer's Name:_____ **Grid ID:**_____ **Transect No.:**_____

Location Name:_____ **Weather:**_____ **Habitat Type:**_____

Start GPS: E:_____ **N:**_____

End GPS E:_____ **N:**_____

Date:_____ **Start time:**_____ **End time:**_____

SN	Time	Species	M	F	Y	UnId	Total No.	Animal Bearing	Angular Sighting Distance	Habitat Type* (Two major species)	GPS location
1											N: E:
2											N: E:
3											N: E:
4											N: E:
5											N: E:
6											N: E:
7											N: E:
8											N: E:
9											N: E:
10											N: E:
11											N: E:
12											N: E:
13											N: E:
14											N: E:
15											N: E:

***Habitat Type:** SF - Sal Forest, MF - Mixed Forest, RF - Riverine Forest, TG - Tall Grassland, SG - Short Grassland, W - Wetland, S - Streamed

Annex 6: Questionnaire form

Habitat Suitability Assessment for Tiger in Trijuga Forest, East Nepal

Questionnaire Form

Respondent's Information Box **Date:**_____

Name:_____ **Age:**_____ **Sex:**_____

Address:_____ **Occupation:**_____

Associated Community Forest:_____

General questions:

1. Do you know what wild animals stand for?

   Yes No

2. How much are you fascinated by wild animals?

   Very much Good Not at all

3. Are there any wild animals seen in Trijuga Forest?

   Yes No

4. If yes, how often are they seen?

   Very often Occasional Rare

5. Name the types of wild animals seen in Trijuga Forest.

   i._____ ii._____ iii._____ iv._____

   v._____ vi._____ vii._____ Viii._____

6. Which part/s of the forest do they dwell the most?

   Deep forest Forest edge Everywhere Don't know

7. What is your observation, are the number of wild animals increasing or declining than the past?

   Increasing Declining Stable Don't know

8. Give the name of wild animals which are declining based on you observation?

   i._____ ii._____ iii._____ iv._____

   v._____ vi._____ vii._____ Viii._____

9. Give the name of wild animals which are increasing based on you observation?

   i._____ ii._____ iii._____ iv._____

   v._____ vi._____ vii._____ Viii._____

Conflict:

10. Is there any conflict between wild animals and villagers around Trijuga forest?

    a) Yes b) No c) Don't know

11. If yes, what type of conflict is there?

    a) Crop raiding b) Livestock depredation c) Injuring people d) Killing people

    e) Deterring people

12. What is the extent of conflict in the area?

    a) Extreme b) Moderate c) Minimum

13. Which wild animals are responsible for the conflict?

    i)_____ ii)_____ iii)_____ iv)_____

    v)_____ vi)_____ vii)_____ viii)_____

14. Has the prevalence of conflict led to negative perception towards wild animals among local people?

    a) Yes b) No c) Don't know

15. Has any initiation been made to resolve/reduce the conflict?

    a) Yes b) No c) Don't know

16. If yes, who and what type of initiation has been made?

    i)_____ ii)_____

    iii)_____ iv)_____

17. Have you locally adopted any measures to reduce the conflict with wild animals?

    a) Yes b) No c) Planning to adopt

18. If yes, give the measures you have adopted or planning to adopt.

    i)_____ ii)_____

    iii)_____ iv)_____

19. What are conflicts instigated by local villagers against the wildlife?

    a) Killing b) Mauling c) General disturbances

    d) Food scarcity e) Habitat degradation f) Others

Threats:

20. Is there poaching of wild animals in Trijuga Forest?

    a) Yes b) No

21. If yes, what are the wild animals mostly poached and who are involved in it?

i)_____ ii)_____

iii)_____ iv)_____

v)_____ vi)_____

22. Are animals poached for consumption or trade?

a) Consumption b) Trade c) Both d) Don't know

23. What do you think the causes of wild animals decline in Trijuga forest? Mention orderly, top cause first.

a) Habitat destruction b) Poaching c) Wild fire d) Human disturbances

24. How wild animals are disturbed in Trijuga forest?

a) Vehicles b) Firewood/fodder collection c) NTFP/timber collection d) Livestock grazing

e) Extraction of natural resources like stones, sand, soil, drainage of water, collection of thatch grass, leaves, tree felling, picnic etc.

Perception:

25. What is your opinion about wild animal's presence in Trijuga forest?

a) Positive b) Negative c) Neutral

26. Do you know that Trijuga forest is a historical habitat of Bengal Tiger?

a) Yes b) No

27. If yes, from where did you come to know?

i)_____ ii)_____

iii)_____ iv)_____

28. Are you aware of tiger's contribution in the nature? If yes, please mention.

i)_____ ii)_____

iii)_____ iv)_____

29. Is there any cultural/religious significance of tiger in your area? If yes, mention its importance.

a) Yes, _____

b) No

30. What is your view on returning of the tiger in Trijuga forest?

a) Positive b) Negative c) Neutral

Annex 7: Vegetation survey datasheet

Vegetation Survey Data Sheet

Name of the forest:_____ Forest category:_____ Altitude:_____

Long/Lat:_____ Plot No_____/_____ Plot Size:_____ Aspect:_____

Plot Data:_____

S. N.	Name of the plant species	No. of Individuals	Habit & Size	Crown Coverage	Remarks

Annex 8: Images taken during the study period




















b










C