Biological Corridor 05: Connecting Royal Manas National Park and Jomotshangkha Wildlife Sanctuary Conservation Management Plan 2020-2029

Towards ensuring ecological connectivity and species persistence

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Towards ensuring ecological connectivity and species persistence

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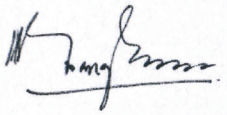
Royal Government Endorsement and Approval

Biological Corridor – 05
Conservation Management Plan Period: 1st January 2020 – 31st December 2029

In accordance to and as per the provisions of the Forests and Nature Conservation Act of Bhutan, 1995. This plan was examined by wide section of user groups and organizations. The final draft plan was verified and reviewed by the Chief Forestry Officer, NCD and the final version of the BC-05 Conservation Management Plan was reviewed and technically cleared by the TAC, Department of Forests and Park Services

Submitted by



Ugyen Wangchuk
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Recommendation for kind Approval:

Lobzang Dorji
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Approved by:

Rinzin Dorji
Hon'ble Secretary
Ministry of Agriculture and Forests

Executive summary

Biological Corridors system in Bhutan was started in 1999 as a "Gift to the Earth from the people of Bhutan" by Her Majesty Queen Mother Ashi Dorji Wangmo Wangchuck to ensure the continuous gene flow through uninterrupted wildlife movements and succession of habitats.

The Biological Corridor 05 is located in the south eastern part of the country and it lies within the administrative jurisdiction of Pema Gatshel and Samdrup Jongkhar Dzongkhags. Covering an area of 203.58 km^2 and 48 km (approx.) in length, corridor connects the Royal Manas National Park in the west and Jomotshangkha Wildlife Sanctuary in the east.

To prepare the management plan for BC 05, biodiversity and socio-economic survey was carried out in 2018-2019 by the Pema Gatshel Divisional Forest Office in collaborating with Samdrup Jongkhar Divisional Forest Office with technical guidance from Nature Conservation Division and Ugyen Wangchuck Institute for Environmental Studies and Research, Department of Forests and Park Services.

The biodiversity data was collected from 46 (2x2km^2) grids covering the entire corridor area. In each grid cell, animal signs were recorded in three transects of length 0.75-1.5 km^2 each. In addition, camera traps were also installed on animal trails in 20 random grids. A total of 24 mammal species were recorded from which 3 endangered and 5 vulnerable species under IUCN category of threatened species were identified. For birds, 139 species were recorded using MacKinnon's species listing. 1 endangered and 2 vulnerable species of birds were recorded as per the IUCN category. A total of 226 plant species from 77 families were recorded from 48 grids. This includes 174 species of trees and shrubs, 38 herbs and 14 climbers respectively. Six invasive plants were also recorded. For social data, a total of 100 households were interviewed covering four Gewogs namely Norbugang and Choekorling under Pema Gatshel Dzongkhag and Dewathang and Phuntshothang Gewog under Samdrup Jongkhar Dzongkhag. The result showed that 50.49% of the total respondents are having negative attitude towards wild boar among other wildlife species for conservation.

Threat assessment and rankings for the corridor has been done using Miradi-4.5.0 and Habitat degradation was ranked as highest threat in BC-5 followed by Habitat fragmentation. The other threats include Human Wildlife Conflict, drying up of small and perennial water sources, invasive/alien species and wildlife poaching.

To address aforementioned threats, the strategies such as restoring and managing critical habitats, strengthening trans-boundary conservation initiatives, ensuring scientific and sustainable utilization of resources, implementing integrated conservation development programs and zero poaching strategy were incorporated.

Forward

Biological Cooridor-05 which connects Royal Manas National Park and Jomotshangkha Wildlife Sanctuary plays a vital role in conserving biodiversity of southern foothills of eastern Himalaya. Arguable, it is home for many endangered species such as Tiger, Dhole, Asian Elephant, Great hornbill and Rufous necked hornbill.

I send my congratulation to the Division Forest Office, Pema Gatshel for coming up with conservation management plan, which is crucial at the moment according to the high conservation significances and with making biological corridor at par with Parks and Wildlife sanctuaries legally in FNCRR 2017.

It is very clear that the tremendous effort has been made by staff in the field to come up with this conservation management plan. It basically aim to maintain ecological connectivity between parks and enhance species persistence with reduce Human Wildlife Conflict through placing four key objectives, 1) Secure and improve wildlife habitat. 2) Reduce human wildlife conflict and enhance community livelihood. 3) Reduce poaching and illegal extraction of timber and forest produces. 4) Increase knowledge base on species and habitat

I would like to join the Division Forest Office, Pema Gatshel to thank Bhutan Trust Fund for Environmental Conservation for their generous financial support to come up with such conservation management plan and look forward same support in near future.

Finally, I remind field office to implement the plan successfully. I am confident that the impacts of implementing the plan will gear up towards achieving its over arching goals, which will benefit the nation at large towards achieving Gross National Happiness.

Director

Lobzang Dorji

Department of Forests and Park Services

Acknowledgement

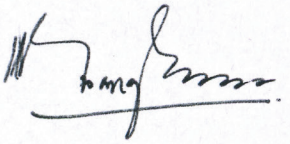
On behalf of Pema Gatshel Division Forest Office, I would like to sincerely thank His Excellency the Minister and the Hon'ble Secretary, Ministry of Agriculture and Forests, Hon'ble Director, Department of Forests and Park Services for their continuous guidance and kind support to come up with this conservation management plan without which, we would not be able to spearhead.

Similarly, We would also like to send thankful note to Dasho Dzongdag, Dzongkhag Administration, Pema Gatshel, Dasho Dungpa, Dungkhag Administration, Nganglam, Gup, Gewog Administration of four Gewogs and the communities residing around Biological Corridor No. 5 for their prompt response and support during preparation of management plan over the stretch of two years.

We like to thank the Chief Forestry Officer and staff of Nature Conservation Division for their support and guidance. We also like to thank the staff of JKSNR and UWICER for sparing staff as Resource Person during our staff training on biodiversity, socio economic survey and data collections.

We also like to give our sincere gratitude to Pema Gatshel Forest Division Staff, who have worked tirelessly and gave their enormous effort and full support during the survey and preparation of conservation management plan for Biological Corridor No. 5. We have high gratitude to Samdrup Jongkhar Division Forest Office and other offices who have supported us during preparation of this management plan.

Lastly, we would like to extend our immense appreciation and sincerely thank the Bhutan Trust Fund for Environmental Conservation (BTFEC) for their generous funding support. Without their funding support, we would have never able to come with this first Biological Corridor conservation management plan.



(Ugyen Wangchuk)
Chief Forestry Officer

Contents

List of Table

List of Figure

LIST OF COMMON ACRONYMS

B2C2	Bhutan Biological Conservation Computer
BC 05	Biological Corridor Number " 5 "
BC	Biological Corridors
BCCL	Bhutan Carbide and Chemicals Limited
BTFEC	Bhutan Trust Fund for Environmental Conservation
FMU	Forest Management Unit
FNCRR	Forest Nature Conservation Rules and Regulation
GBCL	Green Bhutan Cooperation Limited
GRF	Government Reserve Forests
HWC	Human Wildlife Conservation Division
IUCN	International Union for Conservation of Nature
LFMP	Local Forests Management Plan
LULU	Land Use Land Cover
Masl	Meter above sea level
QGS	Quantum Geographic Information System
SGI	Sustainable Green Infrastructure
SRF	State Reserve Forests
TAC	Technical Advisory Committee
UWICER	Ugyen Wangchuck Institute for Conservation and Environmental Research

Chapter 1 Introduction

1.1. History of Biological Corridors in Bhutan

Bhutan's corridor system known as Bhutan Biological Conservation Complex (B2C2) started as early as 1999 as a "Gift to the Earth from the people of Bhutan" by Her Majesty Ashi Dorji Wangmo Wangchuck. Bhutan has a total area of 38,343 km^2 from which 51% is set aside for conservation of rare, endemic and endangered species of flora and fauna. From this, 43% is contributed by National Parks, Wildlife Sanctuaries and a Strict Nature Reserve; and rest 9% by the biological corridors connecting different protected areas that constitutes to a total area of 3,640 km^2.

The significance of the B2C2 and its importance for Bhutan, including the commitment from the Royal Government, was underscored with the Bhutan Biological Corridor Rule (2007), which was endorsed as an addendum to the Forest and Nature Conservation Rules of Bhutan (2006). Under this rule, the management of biological corridors was to be vested within the Territorial Divisions with coordination from the centrally instituted Nature Conservation Division. Based on an executive order on management of Biological Corridors from the (then) Minister of Agriculture, the status of Biological Corridors was also set above Government Reserved Forests (GRF) or State Reserved Forests (SRF), but below that of Protected Areas.

In 2010, several regional consultation workshops recommended for biological corridors to be considered at par with the protected areas in status, rather than an intermediate status between a protected area and a State Reserved Forest. Following these recommendations, an amendment to the Forest and Nature Conservation Rules and Regulations of Bhutan (2017) now provides the Biological Corridors with equivalent legal protection status as any other protected areas.

To ensure continuous gene flow through uninterrupted wildlife movements and succession of habitats is the sole aim of establishing and managing the biological corridors in Bhutan. Linkage of protected areas through a network of corridors including areas of forests and low-level human disturbances will enable wildlife to move between reserves, protected areas and will greatly

increase the conservation values of these protected areas as well as in buffering against climate change.

1.2 Functions of Biological Corridors

Biological Corridor is defined as a geographically defined area which provides connectivity between landscapes, ecosystems and habitats, natural or modified, and ensures the maintenance of biodiversity and ecological and evolutionary processes. These are habitat linkages connecting protected areas to enable movement, dispersal and shift of species between the different protected areas.

Corridors are critical for the maintenance of ecological processes including allowing for the movement of animals and the continuation of viable populations. By providing landscape connections between larger areas of habitat, corridors enable migration, colonization and interbreeding of plants and animals. If protected areas become isolated within a landscape with increased anthropogenic pressures, wildlife populations tend to become isolated within these protected areas. Isolated populations are at greater risk from threats, ranging from poaching, disease outbreaks, genetic inbreeding and physiological changes that can affect reproductive success of all the populations.

Therefore, Biological Corridors will help in alleviating or mitigating these risks by allowing continued exchange of individuals among a previously connected population. Movement of individuals among subpopulations will reduce regional or local extinction rates by a number of mechanisms: by decreasing variability in birth and death rates (Beier 1993, Den Boer 1981), by increasing (re)colonization rates of unoccupied patches (Hanski and Gilpin 1991), by decreasing inbreeding depression (i.e., by increasing gene flow; Shonewald-Cox et. al. 1983), and by increasing potentially adaptive genetic variance for maintaining population fitness (Lande 1995). In addition to connecting isolated populations, corridors will also allow the movement of individuals within its home range. However, in Bhutan biological corridors are mainly established to connect the protected area network for efficient gene flow and to avoid the inbreeding of wild populations, so as to tackle genetic drift.

Therefore, in Bhutan, the functions of the Biological Corridors have been defined as:

- to provide conserved, secured habitats to facilitate dispersal or migration of species between core areas;
- to sustain ecological and environmental flows;
- to prevent genetic inbreeding and erosion of genetic variability; and,
- to provide supplementary feeding habitats for animals.

Bhutan's Biological Corridors are justified by the conservation requirements of 6 focal species including Tiger (Panthera tigris), Asian elephant (Elephas maximus), Snow leopard (Panthra uncia), Red panda (Ailurus fulgens), Golden langur (Trachypithecus geei) and Takin (Burdocus taxicolor whitii). These species are either wide-ranging, area-sensitive species such as tiger (Panthera tigris), Asian elephant (Elephas maximus), Snow leopard (Panthra uncia), or habitat specialists such as Red panda (Ailurus fulgens) or Golden langur (Trachypithecus geei), for which the corridors provide additional habitat, and could also serve as climate corridors. The north-south directed corridors also serve as migratory pathways for the suite of birds that undertake seasonal altitudinal migrations.

1.3. Information of Biological Corridor 05

Sprawling an area of 103.58 km^2 and 48 km (approx.) in length, biological corridor 05 connects the Royal Manas National Park and Jomotshangkha Wildlife Sanctuary and was declared as a corridor through satellite image and detailed land use maps accompanied with field verifications and survey works. It is situated approximately between 26°47'00"N and 26°52'30"N latitudes and 91°13'00"E and 91°43'00"E longitudes. Biological corridor 05 has an altitudinal variation from 127 to 1183 meters above mean sea level (masl). Tropical broad leaved forest is an main vegetation composition of the Biological corridor 05.

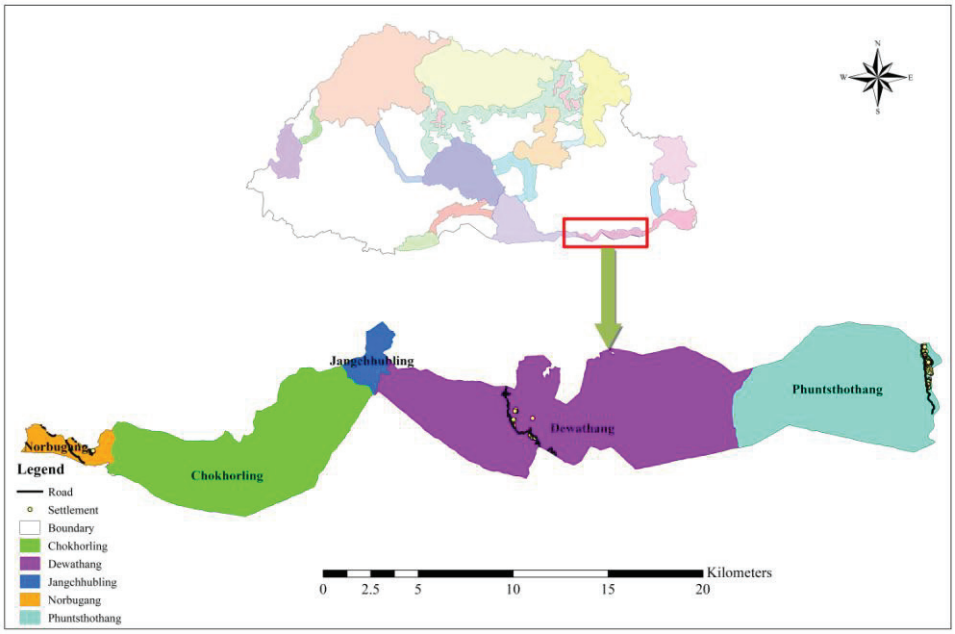


Figure 1: Location Map of BC 05

The corridor is located in the south eastern part of the country and it lies within the administrative jurisdiction of Pema Gatshel and Samdrup Jongkhar Districts. It covers Norbugang and Choekhorling Gewogs under Pema Gatshel District; and Dewathang, Orong, Phuntshothang Gewogs under Samdrup Jongkhar District.

Dzongkhag	Gewog	Area (km^2)	Percent
Pema Gatshel	Norbugang	5.50	2.70
	Choekhorling	55.02	27.03
	Phuntshothang	53.99	26.52
	Dewathang	84.14	41.33
Samdrup Jongkhar	Orong	4.93	2.42

Table 1: Area covered by various Gewogs under the two Dzongkhag

Chapter II: Current Status of Biological Corridor 05

2.1. Physical features of Biological Corridor 05

Physiographic involves the scientific study of natural features of the earth's surface, especially its current aspects, including land forms, climate, and distribution of flora and fauna. Within the context of the social sciences, the physical features of a place matter a great deal more than most people realize. Physical features are geography and climate of a place, and these have a bearing on the history, culture, and collective behavior of a people and followings are some of the elements that were included to describe BC 05

2.1.1. Topography and Slope

The general topography for this corridor is moderate to steep slope ranging from zero degrees to more than 35 degrees in which the slope classification was based on the standard adopted for developing Local Forest Management Plans (LFMP) in Bhutan. The slope was classified at an interval of 0 – 25 degrees, 25-35 degrees and more than 35 degrees corresponding to gentle slope, moderately steep slope and steep slope respectively. Gentle sloped areas were found distributed mostly towards the southern belts and areas adjoining the Indian international border and steep-sloped areas mostly occur along the ridges and at many parts were found inaccessible to people.

Slope	Category	Area (km^2)	Percent
>35	Steep Slope	22	10.80
25-35	Moderately Steep Slope	48	23.58
0-25	Gentle Slope	133.58	65.62

Table 2: Topography and slope of BC 05

A total of 133.58 km^2 corresponding to 65.62% of the total corridor area have gentle slope and 22.85% (48 km^2) have moderately steep slope and most of these areas are accessible to humans. The least area of the total inside this corridor (10.80%) have slopes more than 35 degrees and some

areas along the ridges are found inaccessible to human but have a good potential as wildlife habitats.

2.1.2. Climate

Meteorological data has been derived from station records of Dewathang, Class A & Nganglam Class A, from the Meteorology Section, Department of Hydro-met Services, Ministry of Economic Affairs, Thimphu.

Weather data from the past 10 years showed that highest average maximum temperature of 30 ^{o} C (2013) and lowest average minimum temperature of 8 ^{o} C (2015) was recorded for Nganglam meteorological station. Similarly, highest average temperature of 26 ^{o} C was recorded in 2016 and 2017; and lowest average minimum temperature of 15 ^{o} C was recorded in 2015 for Dewathang meteorological station.

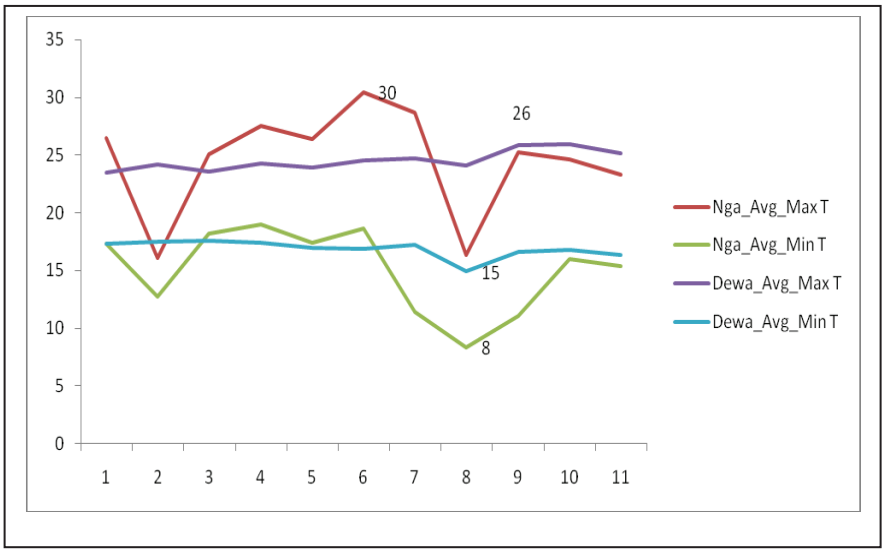


Figure 2: Average max. and min. temperatures for 10 years (2009 - 2018)

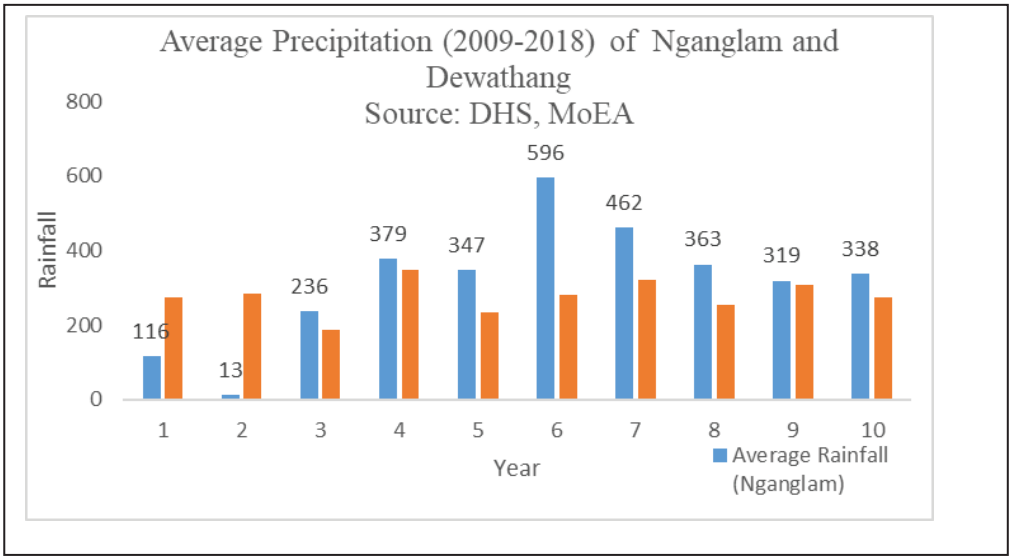


Figure 3: Average max. and min. temperatures for 10 years (2009 - 2018)

Data from last 10 years (2009 – 2019) revealed that the highest average precipitation that Nganglam received was 596 mm in 2014 and lowest of 13 mm in 2010. Similarly, for Dewathang station, a highest average precipitation amount of 349 mm was received in the year 2012 and lowest in 2011 amounting to 188 mm.

2.1.3. Hydrology

There are numerous streams and water bodies falling within the boundary of corridor connecting Royal Manas National Park and Jomotshangkha Wildlife Sanctuary among which there are seven prominent and major streams. The Bodpapam and Khala Tsho streams falls under Choekhorling Gewog, Pema Gatshel Dzongkhag; and Deu Ri, Dewathang and Martang streams falls under Dewathang Gewog, Samdrup Jongkhar Dzongkhag. These streams ultimately drain into Brahmaputra river. And the most prominent stream inside the corridor called Agurung ri drains into one of the major river systems of the country, Nyera Ama Chhu and it also ultimately drains into Brahmaputra river in Indian state of Assam.

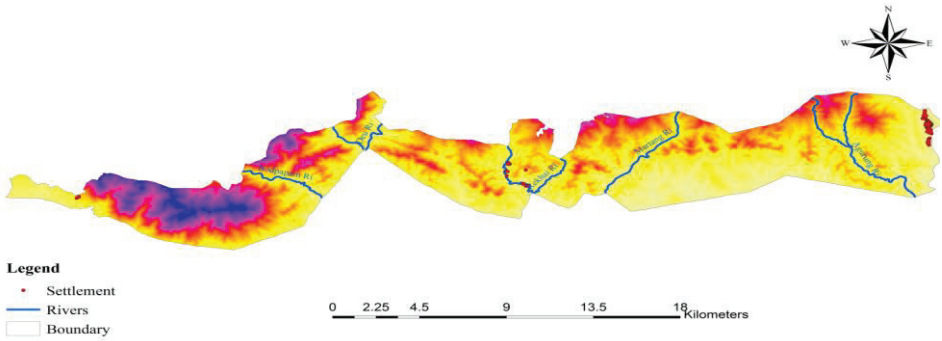


Figure 4: Drainage of BC 05

There are also many wetlands and seasonal ponds making it a very potential habitat for wildlife populations and also forms small catchment areas for the downstream communities.

2.1.4. Aspect

Aspect refers to the direction that slopes face. This will govern how much solar radiation it receives, which in turn impacts upon temperature and shading thus, affecting the local microclimate of the site. This corridor has maximum of south and south east aspect in most of the areas meaning that there is plenty of sun light available for the growth. A minimal aspect of north and west facing slopes were also recorded in some areas behind the ridges.

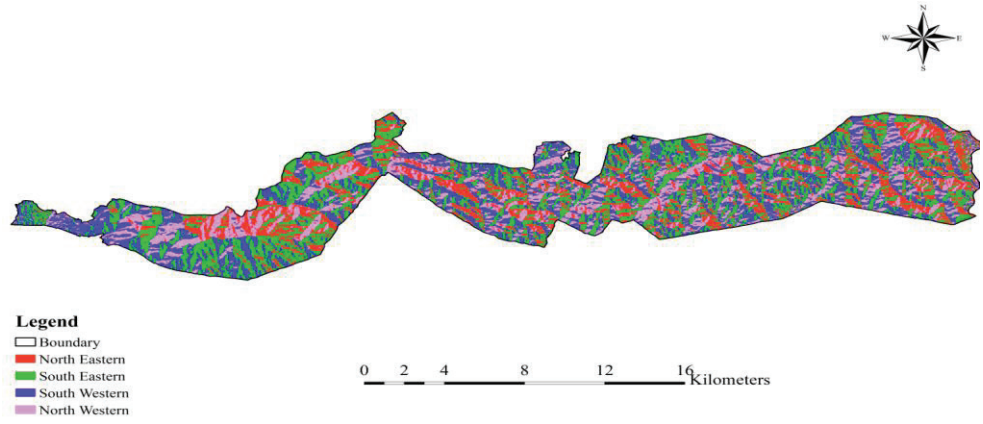


Figure 5: Aspects of BC 05

2.2. Biological Features

2.2.1. Survey Design and Methodology

The entire corridor area was divided into 2x2km^2 using QGIS. In each grid, separate plots were laid out for vegetation, mammal presence and their evidences and avifaunal diversities. There were 52 grids laid out initially covering the entire corridor area, from which only 46 were able to enumerate. A total of 6 grids were left mainly due to inaccessible topographical terrains and security reasons as it falls very near to the Indian international border.

Methodologies used for data collection with regard to different group of biological entities like vegetation, mammals and avifauna are being discussed under their respective headings.

2.2.2. Vegetation and Forest Types

This biological corridor has over 95% of the land covered under broad-leafed forests comprising of different layers of shrubs (3.07%) and meadows (0.03%). The disturbances due to natural landslides are minimal and only 0.28% of the total corridor area is under landslide affected. The small portion of the land also falls under agriculture (0.81%) and built-up areas (0.02%). The rivers, streams and water bodies contribute to about 0.63% of the total corridor area.

Land use/Cover	Area (Sq.km)	Percent (%)
Rivers	1.19	0.58
Shrubs	4.82	2.17
Cultivated Area	1.07	0.53
Landslides	0.53	0.26
Broad Leafed Forests	195.90	96.23
Built up	0.01	0.01
Meadows	0.06	0.03

Table 3: Land use and land cover categories in BC 05 (Source: LULC 2016)

2.2.2.1. Floral Diversity

From the predetermined grid of 2x2km^2, a quadrat measuring 20x20 m^2 were laid out for the enumeration of trees and shrubs. In the center of the 20x20m^2 grid, another quadrat measuring 2x2m^2 was laid out for enumerating the herbs and regenerations. A total of 48 grids out of 52 were enumerated for vegetation survey.

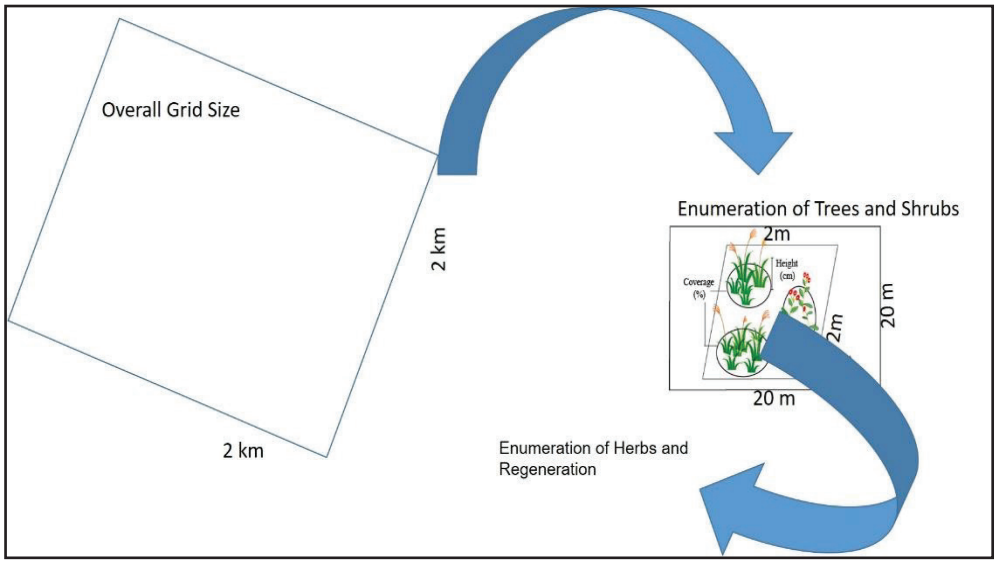


Figure 6: Vegetation Survey Methodology

2.2.2.2. Data analysis

The preliminary data were processed using pivot-table of the Microsoft Excel 2010. Species basal area (BA) was calculated from DBH data of all the tree individuals with a height greater than 1.3 m and calculated the relative proportion of each species' basal area in percent (RBA). Further, DBH data was used to analyze the DBH class distribution in each stand and similarly the height class was analyzed by using height data of each species.

Species diversity was measured using Shannon & Wiener equation
$H' = \Sigma PiLnPi$

Where, P is the proportion (n/N) of individuals of one particular species found (n) divide by the total number of individuals found (N). Ln is the natural log and Σ is the sum of the calculations.

The dominance of tree species was determined through dominance formula

$$d = 1/N \{\Sigma_{i \in T} (\chi_i - \chi')^2 + \Sigma_{j \in U} \chi_j^2\}$$

Where χ_i is the actual percent share (relative basal area is adopted here) of the top species (T), i.e., in the top dominant in the one-dominant model, or the two top dominants in the two-dominant model and so on; χ' is the ideal percent share based on the model as mentioned above and χ_j is the percent share of the remaining species (U). N is total number of species.

Cluster analysis was performed using PC-ORD version 5.1. using distance measure of relative Sorensen (Bray-Curtis method) and group average as linkage method (McCune et al., 2002,). Flexible sorting at 0.20 was used arbitrarily for grouping different forest types. Canonical correspondence analysis was carried out to see the relation between vegetation data and environmental variables. Mean annual temperature, annual precipitations were computed in Microsoft Excel using equation of Dorji et al. (2015). Similarly, evapotranspiration and water balance were calculated using equation of Dorji et al. (2016).

2.2.2.3. Floral diversity

2.2.2.3.1. Floristic composition of major life forms

A total of 226 plant species from 77 families were recorded from 48 grids (Annexure I). This includes 174 species of trees and shrubs, 38 herbs and 14 climbers respectively. Further, six invasive plants namely Chromolaena odorata, Lantana camara, Ageratum conyzoides, Mikania micrantha, Ageratina adenophora, and Sida acuta occurred in the area.

Shannon Diversity (H') ranged from 1.52 to 3.84 after combining 2 grids. Similarly, tree and shrub richness ranged from 8 to 29 inside the 20 x 20 plot and herb richness ranged from 1 to 14 inside the 2 x 2 m plot. The composite plot was generated from the relative basal area, which shows that the overall corridor is dominated by evergreen trees in all five Gewogs, followed by deciduous trees and other shrubs (Fig 7 and 8).

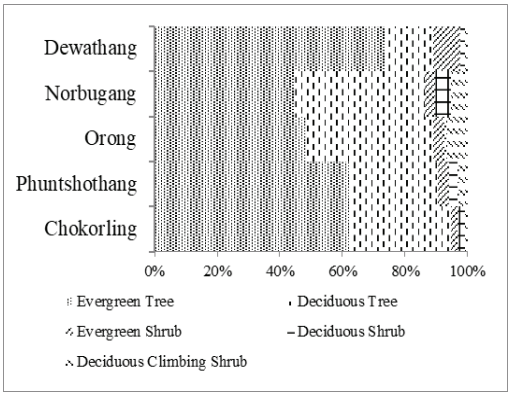


Figure 7: Gewog wise tree and shrub composition

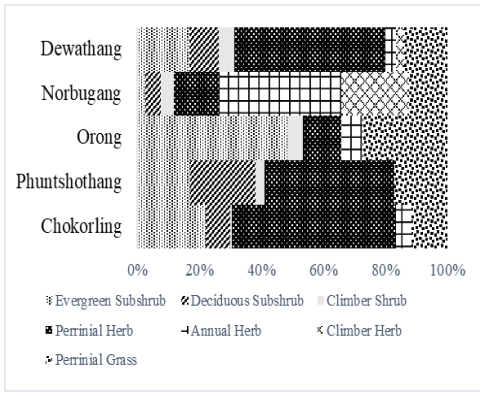


Figure 8: Gewog wise sub shrub and Herb composition

2.2.2.3.2. Forest type classification and environmental variables

According to LULC (2016), only broad-leafed forest is known to occur in the corridor. The relative basal area and the species gathered from 48 plots were further clubbed into 27 altitudinal class with interval of 50 meters for cluster analysis. Five distinct clusters were grouped as Type I, II, III, IV and V as shown in the cluster dendrogram based on the similarity index (%) threshold at 20 % scale.

Type I distance matrix ordination was mainly due to the significant height of the Pterospermum acerifolium species measuring the height over 30 meters in grid 38. The nearest two cluster, that is grid 38 and grid 49 are combined at similarity index 60 %. The dominant herbs are Poa sp; Strobilanthes sp, and Chromolaena odoratum.

Type II distance matrix ordination was mainly due to the significant DBH of the Chukrasia tabularis species measuring DBH 162 cm in grid 35 and Bombax ceiba measuring DBH 280 cm in grid 14. The nearest two cluster,

that is grid 14 and grid 35 are combined at similarity index 30 %. Other dominant tree species in this Type includes Schima wallichii, Mesua ferrea, Castanopsis indica, Gynocardia odorata, Albezia procera, Talauma hodgsonii, and Daubanga grandiflora. The herb layer is dominated by Alpinia malaccensis, Hedychium sp, Dracena angustifolia, Elatostema platyphyllum, Piper longum, Elatostema sessile, Dymaria cordata, Ageratum conyzoides.

Type III distance matrix ordination was mainly due to the wide range of DBH of Macaranga denticulate ranging from 2.5 to 29 in grid 13 and 30, Syzygium cumini from 2.5 to 61.8 in grid 23, Dillenia indica from 3.1 to 43 in grid 3, and Beilschmiedia dalzellii from 6.5 to 18.5 in grid 27 and Mangifera sylvatica from 28 to 103 in grid 1 respectively. However, Terminalia myriocarpa measuring the DBH 198 cm and height 35 m in grid 46 was a outlier in type III. The dominant understorey species includes Chromolaena odoratum, Thysanolaena latifolia, Elatostema platyphyllum, Kyllingia brevifolia, Paspalum dilatatum, and Piper hamiltonii.

Type IV The average height of Syzygium cumini measured 7m in grid 25, however Ficus elastica measuring DBH 150 cm height 20 m was a outlier in type IV. The nearest two cluster of grid 25, grid 32 is separated from grid 51 at similarity index 55%. The dominant understory species in this group is Paspallum conjugatum.

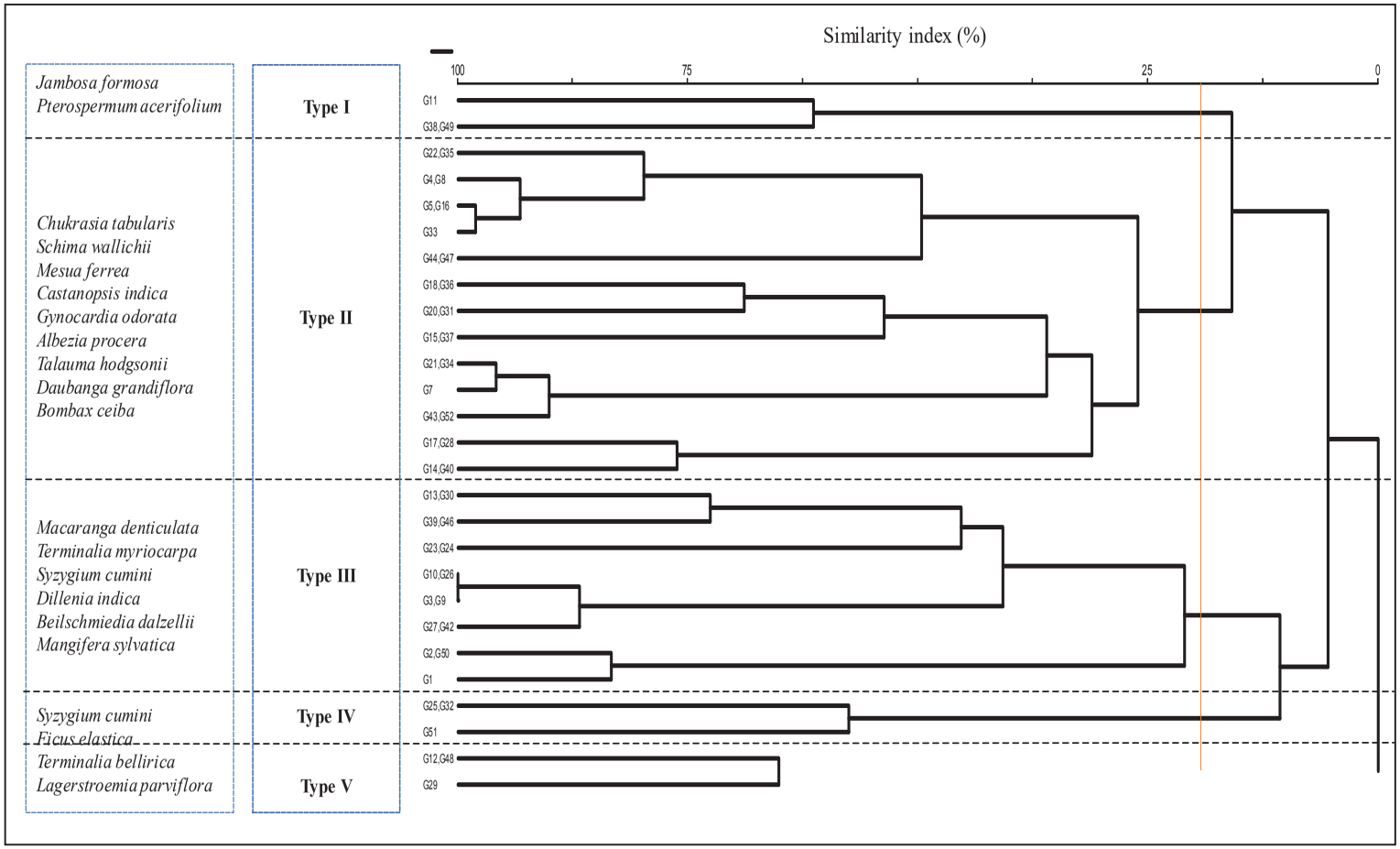


Figure 9: Forest type in BC 05 through similarity index

Type V distance matrix ordination was mainly due to the top 2 dominant RBA% shared by Terminalia bellirica and Lagerstroemia parviflora in grid 12 and 29 respectively. The nearest two cluster of grid 12 is separated from grid 29 at similarity index 65 %. The domaninant species in the understory layer are Kyllingia brevifolia, Boehmeria macrophylla, and Chromolaena odorata.

2.2.3. Faunal Diversity

2.2.3.1. Mammal diversity

Mammal sign survey was conducted in 46 square grids of each 2x2 km2. The small grid size of 2x2 km2 was chosen to ensure the gird cells adequately overlap with home range of large and medium sized mammals. Within each grid cell, animal signs were recorded in three transects of length 0.75-1.5 km2 each. Camera traps were installed on animal trails in 20 random grid cells (one camera in each grid).

Figure 10: Mammals captured in the camera trap: Asian elephant and Gaur

Figure 11:Mammals captured in the camera trap: Dhole and Himalayan black bear

A total of 24 mammal species (mostly large and medium sized mammals: Table 4 and Fig 12) were recorded through the sign and camera trap survey. Specific survey of small mammals and bats were not taken up during the mammal survey. Many globally threatened species and species which are listed under Schedule I of Forest and Nature Conservation Act 1995 were recorded.

Mammals were found to be distributed within elevation range of 130-1026 m (Fig 12) and slope of 1-57 degrees (Fig 12). However, within the elevation and slope range, most of the species were recorded at lower elevation and gentle slopes.

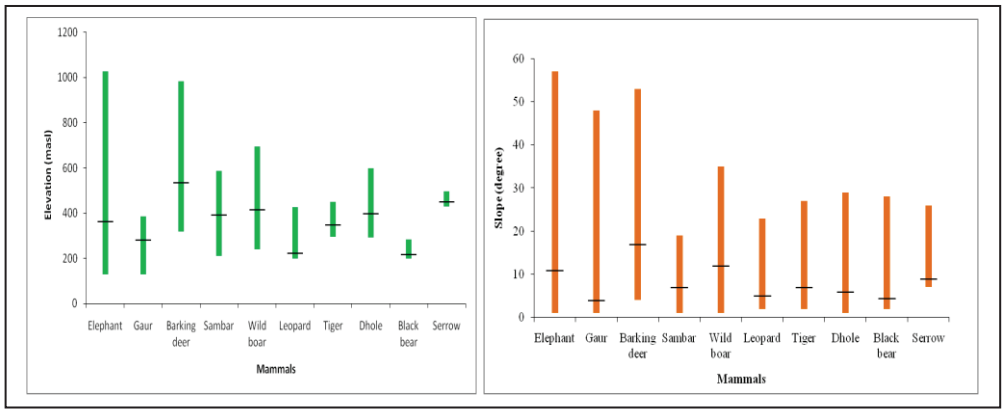


Figure 12: Mammal distribution along different elevation gradient and slope degrees

The survey recorded the presence of five felid species viz., Tiger (Panthera tigris), Common leopard (Panthera pardus), Asiatic golden cat (Catopuma temminckii), Marbled cat (Pardofelis marmorata) and Leopard cat (Prionailurus bengalensis).

Besides being important habitat for other felid species, BC 05 as corridor is very crucial for the dispersing Tiger population from RMNP to JWS and other nearby areas as recent report indicated increase of Tiger population in RMNP (RMNP, 2017). A Tiger habitat use and suitability model also indicated high probability of use in the areas of the corridor adjoining RMNP and also areas closer to JWS (NCD, 2019)

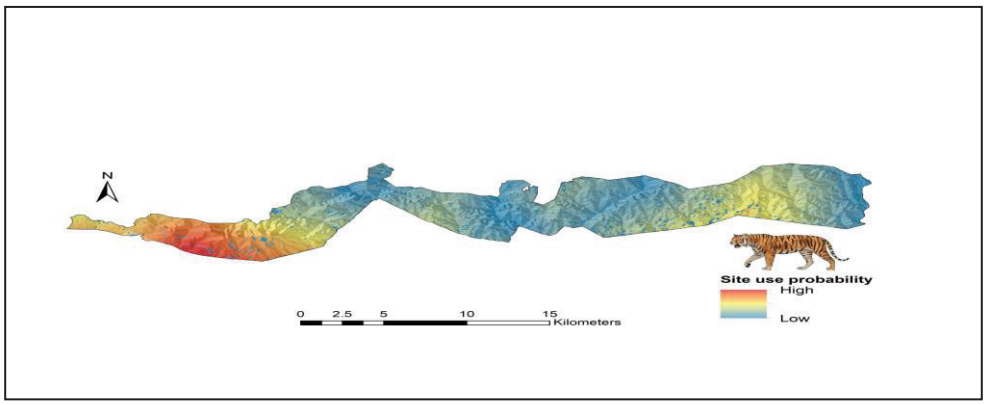


Figure 13: Site use probability for Tiger in BC 05

Although Clouded leopard was not recorded during this survey, the nation-wide site-use probability for Clouded leopard (Neofelis nebulosa) in Bhutan indicated high probability of occurrence of the species in BC 05 (Penjor et al, 2018). The endangered Dhole (Cuon alpinus) which is one of the top predators was also recorded.

Elephant evidences were recorded in 40 of 46 girds surveyed which accounts for a naïve occupancy of 87%. The site use probability analysis for elephants by NCD, 2018 estimates at least 80% of the potential habitat excluding the human habitation within BC 05 are used by elephants.

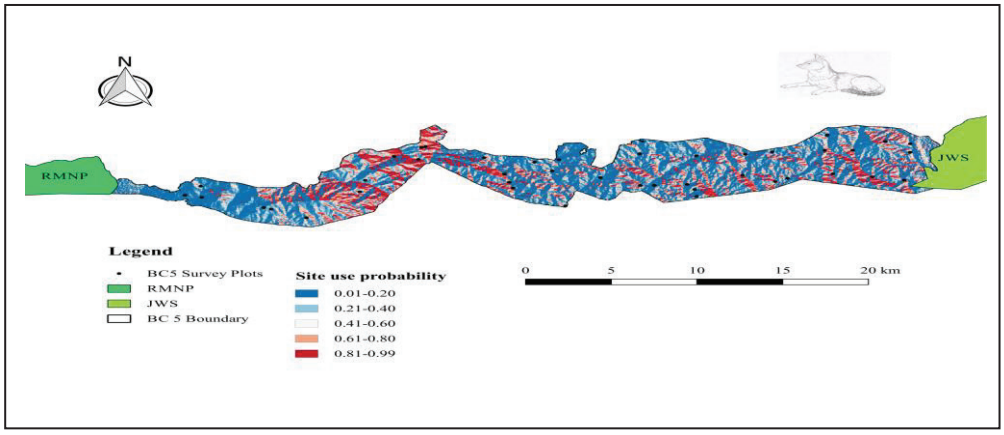


Figure 14: Site use probability for Dhole and Elephant in BC 05

The BC 05 was declared as an important corridor for movement of Elephant, Tiger and Gaur between RMNP and JWS (MacKinnon, 1999) in addition to being home to many other key species. The findings from the survey reconfirm the significance of the corridor for Elephant movement.

Major prey species like Gaur (Bos gaurus), Sambar deer (Rusa unicolor), Barking deer (Muntiacus muntjak) and Wild boar (Sus scrofa) were found to be widely distributed in the corridor. Evidences of Himalayan serow (Capricornis thar) and Himalayan goral (Naemorhedus goral) were recorded from few locations

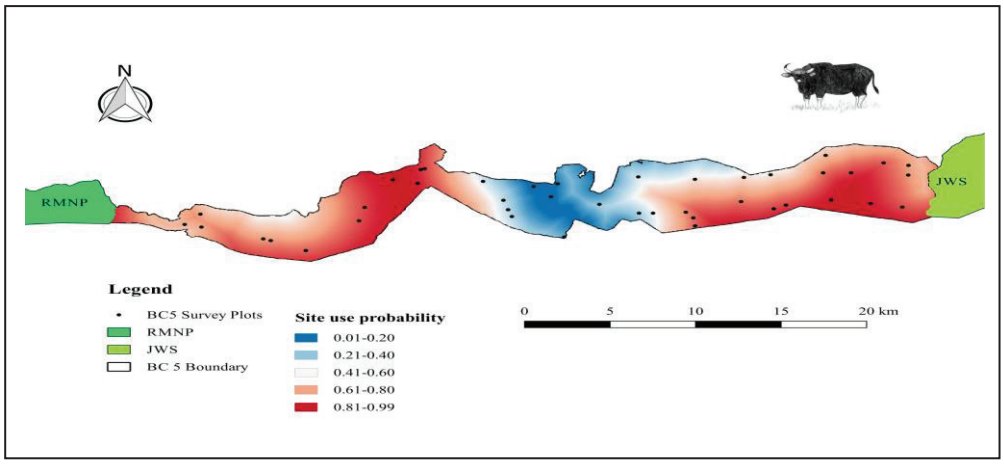


Figure 15: Site use probability of Gaur in BC 05

2.2.3.2. Avifaunal Diversity

Birds are perhaps the most valued and actively appreciated component of Bhutan's biological diversity. Currently 742 species of birds inhabit Bhutan (Kuensel, 2019). 139 species of birds were recorded from the entire corridor area (BC 05) during the survey, which is carried out in the month of November-December, 2018.

The method used during the avifaunal survey was MacKinnon's species listing. This was carried out in every grid covering entire corridor. The inference drawn from the data analysis revealed that a total of 139 species were recorded in three different habitat types, viz: Subtropical broadleafed forest-SBF, Wet river bed-WRB, and Open woodland-OWL.

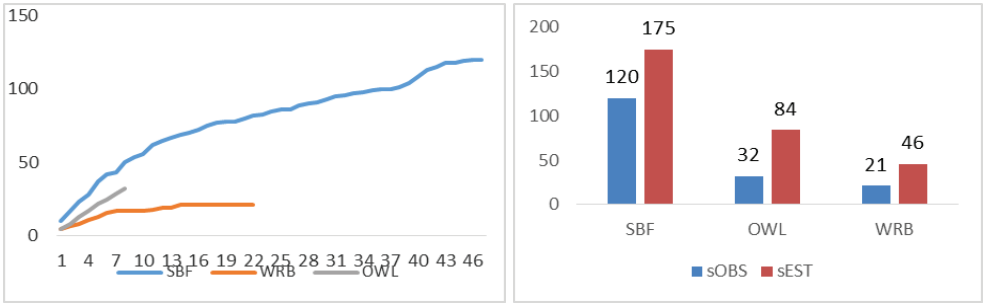


Figure 16: Species Richness using MacKinnon's listing and Chao1

The combined species richness graph (Figure 1) for SBF and OWL shows increasing trend in the observed number of bird species, indicating the record is not completed. However, for WRD, the graph flattens at certain point indicating the species record for the habitat is relatively complete. Chao 1 estimator was used to determine whether or not the listing was completed at given period. It indicated that species detected in all these habitats are below estimation. The estimated species based on Chao1 estimation in SBF, OWL and WRD are sEST= 175, sEST=84 and sEST=46 respectively, but the observed species are sOBS=120 (SBF), sOBS= 32 (OWL) and sOBS=21 (WRD) indicating that there is possibility of detecting more species with increased survey effort.

The Shannon Wiener index shows greater species diversity in SBF (H'=1.74)) compared to OWL (H'=1.24) and WRB (H'=1.07) due to more sampling units falling within SBF habitat.Of 139 bird species recorded in BC 5, the relative abundance graph shows Red-vented bulbul are in abundance followed by Black-crested bulbul and Streaked-spider hunter. Birds of International concern like Rufous-necked Hornbill (Vulnerable), Great Hornbill (Vulnerable) and River Lapwing (Near-Threatened) were also recorded.

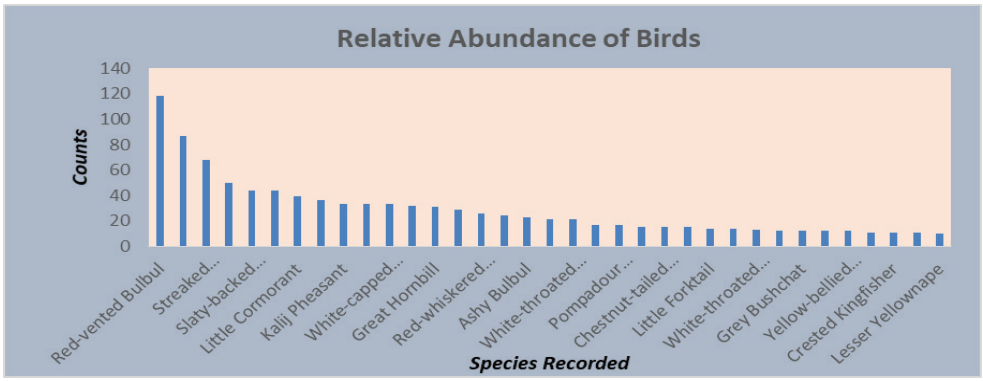


Figure 17: Relative abundance of birds in BC 05

These birds are of great importance to ecosystem in many ways, and their stability of the population is at stake in future due to loss, modification, degradation and fragmentation of habitat. Therefore, the study related to these species' conservation such as dietary analysis, habitat ecology and migration patterns needs to be carried out for effective conservation.

2.2.4. Socio-economic characteristics

2.2.4.1 Social information

Khameythang Chiwog under Phuntshothang Gewog, Samdrup Jongkhar Dzongkhag, and Zalashing Juk village under Dezama Chiwog of Choekorling Gewog, Pema Gatshel Dzongkhag falls within the biological corridor. 101 households that resides along the periphery of the Biological corridor were interviewed ensuring representation from all 4 Gewogs and different level of age class (Figure 18). Of the various age class the maximum number of respondents was in young group, 26-36 age class and

the minimum were in old age group, 70-80 age class. The mean age of the respondents was 42 and the median age was 37. Respondent comprises of 71 % male and 29 % were female (Figure 18) which means the male participation was double than the female during social survey.

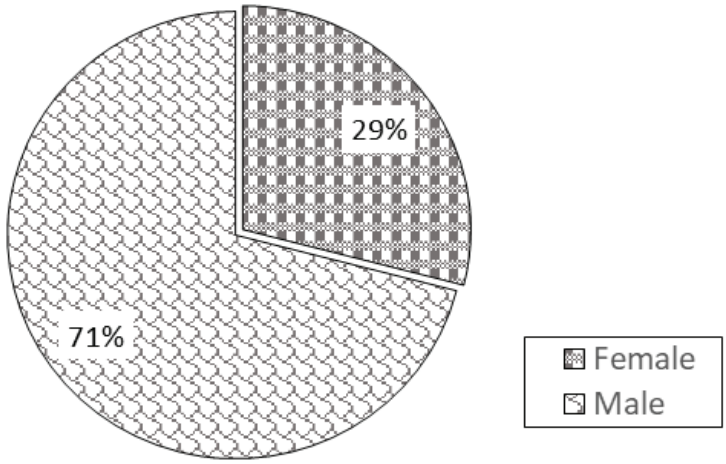


Figure 18:Percentages of respondents based on gender

2.2.4.2 Social economics information

Among various income source, as per the assessment based on the interviewees' respondents (Fig 19), Agriculture farming was the main income source of the communities followed by livestock farming. Rest of the income source were all ranked as least by all the respondents. However, we can foresee the income generation opportunities from remaining sources such as Eco tourism, Horticulture and other wood base industries in future. The communities residing within the Biological Corridor rear livestock. Cattle is the main livestock reared mostly by the communities and on an average every household rear three heads of cattle. Besides cattle the communities also rear horse, poultry, goats and pigs.

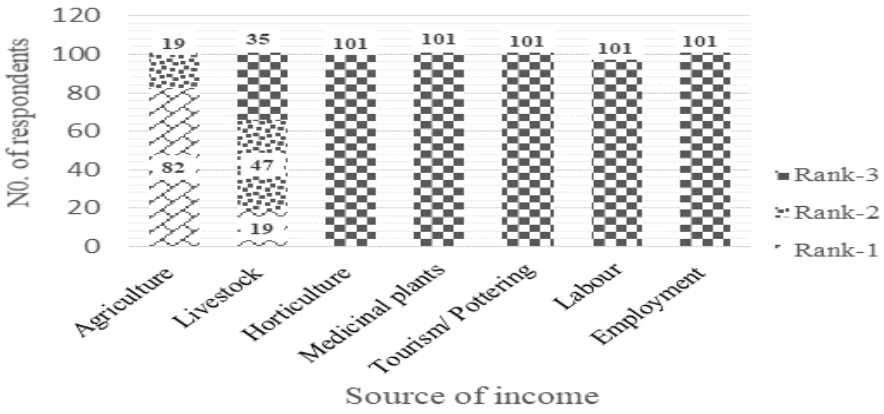


Figure 19: Source of income and ranking

The people in the communities were from various occupational group and based on the sampling enumeration, the occupational group was classified under five categories (Table 5) of which the maximum respondents was under the category (Farmer-79 %) and the least was in the category (Employed-3 %). This indicates that the majority of the respondents were agriculturist.

Occupation of respondents	Business	Employed	Farmer	Student	Monk	Total
Nos. of respondents	3	5	80	6	7	101
Categories in %	3	5	79	6	7	100

Table 4 - Occupation of respondents

2.2.4.3 Human wildlife conflict

The Human Wildlife Conflict (HWC) assessment was conducted categorizing the conflict into four different categories (Table-2). The HWC conflict and their severity assessment was conducted in respective Gewog as the nature of conflict and severity depends on various environmental aspects, distance between settlement areas and SRF land, ecological range, forest type and condition, cropping pattern and season. However as per the assessment result, it was revealed that in all Gewogs there were maximum HWC issues in relation to crop damaged by wild animals comparing to other conflict category.

Gewog	Phuntshothang				Dewathang				Choekhorling				Norbugang			
Category	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
Severe	19	0	0	0	13	0	0	0	8	0	0	0	12	0	0	0
Moderate	2	0	3	2	0	0	3	0	1	0	0	0	5	2	1	0
Minor	4	3	0	5	4	3	0	0	6	0	0	0	3	0	1	1
None	1	23	23	19	8	22	25	25	10	25	25	25	5	23	23	24
Index: Crop damaged- 1 Livestock predation- 2 Property damaged-3 Attack to human- 4																

Table 5- Gewog wise category of HWC and their severity

2.2.4.4 People's attitude and feelings towards wildlife conservation

Gewog	Attitude	Wildlife										
		Bear	**Boar**	**Deer**	**Elephant**	**Gaur**	**Monkey**	**Porcupine**	**Sambar**	**Tiger**	**Wild cats**	**Wild dog**
P/thang	Dislike	0	18	2	9	1	10	1	0	0	0	2
	Like	0	0	6	3	0	1	0	3	0	0	0
	Neutral	26	8	18	14	25	15	25	23	26	26	24
D/thang	Dislike	1	11	3	6	0	0	1	1	0	0	0
	Like	0	3	4	1	0	1	0	1	0	0	0
	Neutral	24	11	18	18	25	24	24	23	25	25	25
C/ling	Dislike	3	8	2	2	0	1	2	0	0	0	0
	Like	0	1	7	1	0	0	2	2	0	1	0
	Neutral	22	16	16	22	25	24	21	23	25	24	25
N/gang	Dislike	0	14	5	0	0	5	4	2	0	0	0
	Like	0	2	8	4	1	1	0	2	0	0	0
	Neutral	25	9	12	21	24	19	21	21	25	25	25
BC-5	Dislike	4	51	12	17	1	16	8	3	0	0	2
	Like	0	6	25	9	1	3	2	8	0	1	0
	Neutral	97	44	64	75	99	82	91	90	101	100	99

Table 6: People's attitude and feelings towards wildlife conservation

The study assessed community's attitudes toward wildlife conservation to understand the feelings of local communities towards wildlife conservation. The result showed that 50.49% (n = 51) of the total respondents are having negative attitude towards Wild boar among other wildlife species. However, 43.56% (n = 44) of the respondents reported that they have neutral attitude towards Wild boar conservation. It was followed by 16.83% (n=17) and 15.84% (n=16) of the respondents who have disliking attitude towards Elephant and Monkey respectively for conservation. However, one of the most liked wildlife for conservation was Deer with 24.75% (n=25) of respondents. Among the respondents who expressed their personal feelings on wildlife conservation, 84.78% of them neither dislike nor like the wildlife conservation. Hence, wildlife conservation within this BC 05 area will need extensive awareness programs towards wildlife conservation.

As per the report generated based on the wildlife population trend (Fig 20), 22% (n=22) respondents felt that there is decrease in general population trend of wildlife population under BC-5. 77% (n=22) respondent feels that the construction of electric fencing around the agricultural field is the main factor contributing for wildlife population decrease followed by 18% (n=22) of the respondent feels it is due to wildlife poaching. Developmental activities within the BC-5 area also contributed for declining of wildlife population as per 5% (n=22) respondents. However, 56.44% (n=57) respondents suggested that there is increase in general wildlife population. As per the respondents, the main factor helping in increase of wildlife population were less poachers/predation, increased conservation measures and good forest conditions (42%, 23% and 12% respectively).

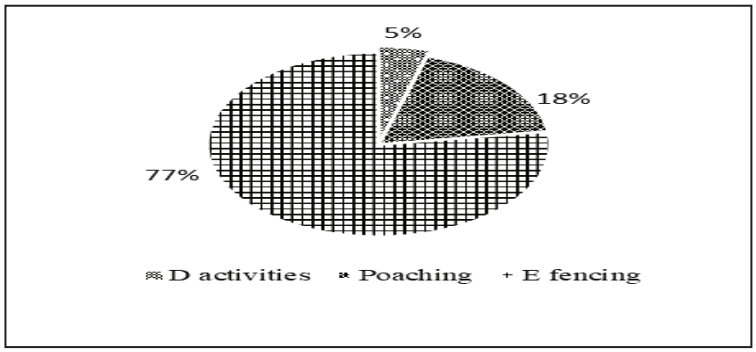


Figure 20: Respondent's reason for wildlife population change over the years

2.2.4.5 Seasonal Activity Calendar

Major agricultural activities carried out by local communities within BC 05 are growing of Maize, Ginger, Paddy and Chili (Fig 21). However, Choekhorling Gewog does not engage in growing paddy mainly due to HWC with Elephants and other wild animals. Off farm activities such as constructions of building, road, water supply etc. with contractors makes major financial income to support the families. Cardamom is grown as one of the main cash crops under Norbugang unlike other Gewogs, where they mostly depend on Potato and Ginger as cash crops

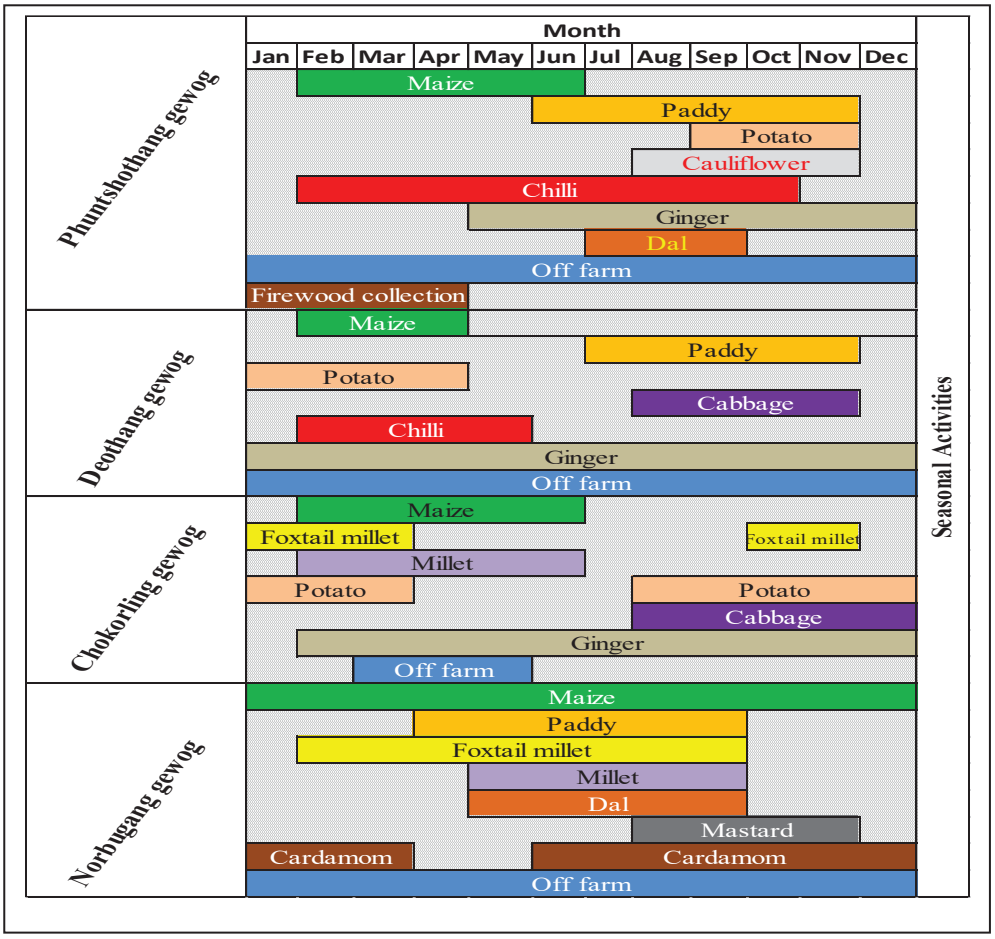
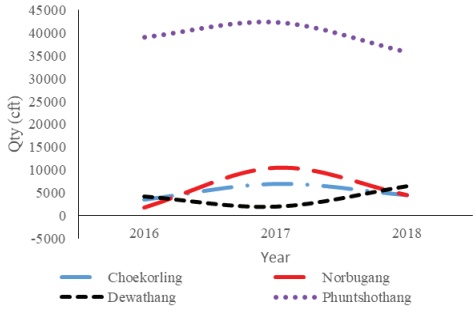


Figure 21: Seasonal calendar

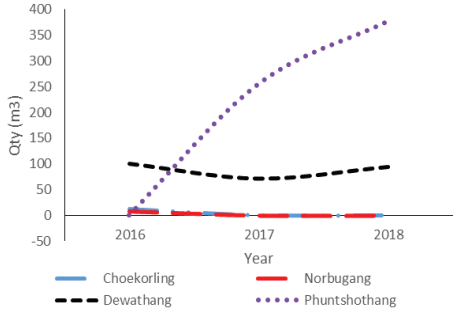
This study shows that local communities are entirely engaged in the months of August and September with 13 different farm activities followed by 11 and 10 different farm activities in the month of October and November respectively. Villagers are relaxed in the month of December with only 6 types of farm works followed by 7 type of farm works in January and March. Therefore, any kind of works related to BC 05 management activities shall be carried out in relax months for better participation from public

2.2.4.6 Resources extraction by communities of four Gewog

The total of 1, 61,835 cft of subsidized rural house building timber were allotted over three year (2016, 2017 & 2018) to the four Gewogs under BC 05. Phuntshothang Gewog communities availed the highest timber volume with 71.48 % and 68.91% availing for firewood amongst the four Gewog. However, only 9.28% of timber volumes were allotted to Choekhorling Gewog communities and 8.00% of the firewood was allotted to the Norbugang Gewog communities.



a. Rural house building Timber allotment



b. Rural firewood distribution

Figure 22: Forest resources allotted to the rural community through subsidized allotment

Khameythang Chiwog under Phuntshothang Gewog entirely falls inside BC 05 unlike other villages where only few household falls inside the jurisdiction. Community of Khameythang Chiwog with 68 households has utilized 8700 cft and 84 m^3 of timber and firewood respectively over last three years. It is projected that this Chiwog's demand will be 2900 cft timber and 28 m^3 firewood annually. However, the site of extraction was outside the BC area (between Phuntshothang and Samrang Gewog). It is mainly due to

shortage of timber nearby as the area of more than 100 acres above the Chiwog is leased to BCCL (Currently planted teak saplings). Another 100 acres next to BCCL plantation site is currently afforested by GBCL and the nearby grass land around 86 acres were leased for rubber tree plantation. In fact meeting the timber demand over the coming years will be a challenging task for BC 05 managers. Therefore, to maintain the sustainable utilization of forest produce and to meet BC 05 goals, private forest development should be encouraged.

2.2.5 Present land use status

Biological Corridor 05 covers an area of 203.58 km^2 from which 95.15% is completely under tree cover followed by shrubs covering 3.07 %. Water bodies with a percent share of 0.63 % is the third highest land use in the corridor (LULC 2016). The small portion of the area also falls under agriculture (0.81%). Samdrup Jongkhar-Tashigang national highway also cuts through BC 05. Few settlements such as zalashing juk under Choekorling Gewog and Khameythang village under Phuntshothang Gewog, Samdrup Jongkhar also falls under the BC 05. All these built up areas contribute to about 0.02% (0.05km2) of the total corridor area. There are no Forest Management Units (FMUs), Community Forests (CF), transmission lines and other major infrastructures inside the corridor boundary currently.

Land use Types	Area (Sq.km)	Percent (%)
Water bodies	1.34	0.63
Shrubs	6.51	3.07
Cultivated Agriculture	1.71	0.81
Landslides	0.60	0.28
Forests	201.34	95.15
Built up	0.05	0.02
Meadows	0.06	0.03

Table 7: Land Use of BC No: 05

2.2.6. Future Plan for Developmental Activities

As stated in the current status, there is very minimal infrastructures and built up areas falling inside the corridor amounting to about 0.02% of the total area. Nonetheless, there are several plans in the pipeline including development of regional-hub at Nganglam town, construction of Dewathang-Nganglam national highway, Nyera Ama Chu Hydro-Power plant construction and development of Phuntshothang Town-C (Yenlag Thromde). Though, all these developmental activities won't fall inside the corridor area, certain potential impacts would be foreseen to the adjacent and buffering areas. The impacts can be mainly in the form of resource extraction, pollutions from road leakages, vehicle emissions, diverting of water heads and anthropogenic disturbances to wildlife and other natural resources.

Chapter III: Threat Analysis

Threat analysis encompasses the assessment of threats in conservation planning and management in setting conservation goals, identifying priority strategies and determining the effectiveness of strategies. It forms the integral part of conservation planning and management. Threat assessment and rankings for this corridor have been done using Miradi-4.5.0. The following threats have been discussed and ranked for coming up with the relevant strategies and interventions for monitoring the effectiveness of the corridor.

3.1. Habitat Degradation

Habitat degradation is the decline in species-specific habitat quality that leads to reduced survival and/or reproductive success in a population e.g. related to changes in food availability cover or climate (International Union for Conservation of Nature (IUCN) 2006). Habitat loss and degradation around the world is being triggered mainly due to the expansion of agriculture and other anthropogenic pressures including development of infrastructures through intensive garnering of natural resources.

Within this corridor (BC 05), the main drivers for habitat degradation are intensive harvesting of timber illegally, cattle grazing and sometimes forest fires. The area becomes more susceptible to over-exploitation as it bonds

with porous international border with India. Cattle grazing and forest fires also seems a huge potential threat in future as cattle from across the border can easily get into the corridor. Some incidences of intentional fires were also seen during the field surveys, which were predicted to be set by the people from across the border.

Colonization by invasive and unpalatable plant species is also a potential foreseen threat in the corridor. Some species like Chromolaena odorata, Ageratina adenophora and Micania micrantha are some of the plants susceptible to grow in such kind of topographies and weather conditions. Therefore, proper monitoring and management works are deemed essential for maintaining the proper functionality of the corridor's habitat.

3.2. Habitat Fragmentation

Habitat fragmentation is a prominent issue in the western part of the corridor. The new Nganglam town planning and construction of new integrated check gate has reduced the corridor width to less than 750m, thereby, forming a bottle neck. Other infrastructure development works like industrial area expansion, road construction and power transmission lines are additional drivers to habitat fragmentation in the corridor.

The formation of bottle neck will have biggest hindrance to the movement of Elephants between RMNP and JWS. In addition, dispersing species like Tigers and other carnivores from RMNP will not be able to navigate to other habitats through the corridor.

However, as the forest on the Indian side is still intact without human habitation, an initiation of transboundary conservation initiative can minimize the impact on species movement.

3.3. Human Wildlife Conflict

Unlike in the national parks and protected areas elsewhere, BC 05 has number of people living inside the BC. It is impossible to relocate human settlements out of the BC. The issue of Human Wildlife Conflict has become serious with increase in human population encroaching to forested land

causing fragmentation and disruption of wild animal's habitat in recent years. The agricultural lands and settlements being situated very close to forests, wild animals often venture into the crop fields and settlements for predictable and easy food. Interaction with local communities during the socio-economic survey in November-December 2019 recorded considerate livestock and crop depredation cases from BC 05. It recorded four different conflict categories namely; attack on human and property by Elephants, livestock predation by top carnivores such as Tiger, Common leopard and Dholes and crop depredation by Elephant, Wild boar, Monkey and Deer. The conflict analysis in BC 05 shows that:

- Livestock depredation impacts the people's livelihoods, resulting in retaliatory killing of targeted carnivores and ungulates. Livestock depredation also damages people's attitude towards conservation.
- Low wild prey density results in increased depredation of livestock and reduced food for carnivores.
- Spatial distribution of prey is higher near human settlements and results in bringing prey closer to settlements, thereby increases attacks on livestock.
- Potential threats to human life could result in fear and retaliatory killing of target species such as elephants and top carnivores.

The major causes of conflict in BC 05 are:

- Unattended free-ranging cattle without herders (especially for Tiger depredation).
- Wild prey is out competed and displaced by livestock.
- Poor habitat quality.
- Forest fires in Indian areas resulting in translocation of wild animals to Bhutan side, hence imbalance exist.
- Habitat loss and fragmentation due to industrialization and development of towns.
- Many houses are being built close to the forests. This is possibly a reason why more cats predate on livestock.
- People's capacity of income generation increased more than ever, so there are now more livestock.

Due to high nature of conflict, its adverse effect on human livelihood is huge:

- Livestock loss to carnivores causes food shortages and insecurity.
- Loans are taken from the Government to buy livestock and when they are killed due to HWC, it causes farmers to suffer huge losses.
- Elephants are a threat to humans as they usually come close to settlements and often damage attack people and damage property.
- Depredation of crops and livestock by other animals, such as Wild dogs and Wild boar are not considered under the compensation scheme.
- Cash compensation is not a long-term solution. Programs similar to ICDPs need to be implemented.

Due to the highly scattered nature of settlements inside the BC, the issue of habitat fragmentation and degradation will keep surfacing every year and conflicts between farmers and wild animals will inevitably continue. The forest division however needs prepare and face the challenge of allowing socio-economic developments inside the BC while maintaining viable animal populations and protecting critical ecosystems and their services.

3.4. Drying up of small and perennial water sources

Drying up of small and perennial water sources is one of the serious issues across the country despite having abundance of 109,000 cubic meters per capita per annum of water resources (Wangchen, 2019). Factors causing drying up of water sources in the country seems:

- ✓ Catchment degradation
- ✓ Change in the land use pattern
- ✓ Deforestation
- ✓ Overuse of the forest
- ✓ Increasing population and households

Also, climate change effects such as long dry seasons, erratic rain fall and geological vulnerability of Himalayan region is believed to be the most likely cause for the drying up of water sources.

Threats of drying small and perennial water sources have been vividly noticed inside the corridor currently and are likely to face severe in near future. Factors contributing to this are:

- Catchment degradation through illicit extraction of timber and other resources due to porous entrance from international boundary.
- Trapping of water source for drinking and agriculture purpose without proper water budgeting and ecological flow, due to increase number of population and household in the periphery of corridor.
- Sporadic developmental activities in buffer and adjoining areas such as farm roads, transmission lines and others lead to change the land use pattern, which could alter the biophysical features of catchment areas.
- Erratic rainfall and temperature pattern over last 10 years from 2009-2018 indicates the effect of climate change. Also flash flood, land slide and small but numerous erosions are some of the geological vulnerabilities contributing to change the hydro-geological cycle in the catchment areas.

3.5. Invasive species

Invasive/alien species are a major cause of decline in native biodiversity in both terrestrial and aquatic ecosystems (Kopp, 2010). Towards the end of the 20th century, 12 species of fish were introduced in Bhutan (D.B.Gurung, 2018) and in the last decade, invasive plant species such as Lantana camera, Viscum album, Chromolaena odoratum and Ageratina adeniphora have invaded forest surpassing palatable and native species.

These invasive plants including Lantana camara, Chromolaena odoratum, Micania micrantha, Ageratina adeniphora and Ageratum adenophora were recorded in BC 05. Not just plants, certain faunal species like Barking Deer, Wild Pig and Indian Crestless Porcupine were considered invasive by the local communities residing within and adjacent areas of BC 05.

Moreover, not much study on the invasive species has been done. A recently recorded fish species, Notopterus notopterus and many more which are not native to BC 05 needs to be documented. These species could possibly interact with indigenous organisms and may disrupt the functionality of the entire ecosystem in the BC. Besides ecological impacts, invasive species can also cause socio economic and livelihood implications as this may lead to reduced yields due to invasive plants; and crop damage by non-native animals. There are also risk of disease introduction to fishes in water bodies and to the native wild diversities.

3.6. Poaching

Wildlife poaching has grave consequences for targeted species and their habitats. Besides, it has clear environmental implications, as this illegal activity negatively affects ecosystems and prosperity of local communities. Similarly, in Bhutan owing to the rich wildlife diversity and porous international borders, the wildlife poaching and its illegal trades are also being reported which would bring both unforseen environmental and social impact in the long run.

The whole stretch of Biological Corridor 05 falls near to the Indian state of Assam, there were many incidences of both illegal resource extraction and wildlife poaching evidenced during the data collection works.Poaching, therefore, has been bserved as one of the most prominent and potential threat to the overall management of the biological corridor.This corridor is serving as a habitat for various significant species such as Asian Elephant (Elephas maximus), Guar (Bos guarus) and numerous felid species forming the target to poachers for easy economic gains. Moreover, other wild life species like Wild Boar (Sus scrofa), Barking Deer (Muntiacus muntjak) and Sambar (Rusa unicolor) may be hunted for meat illegally.

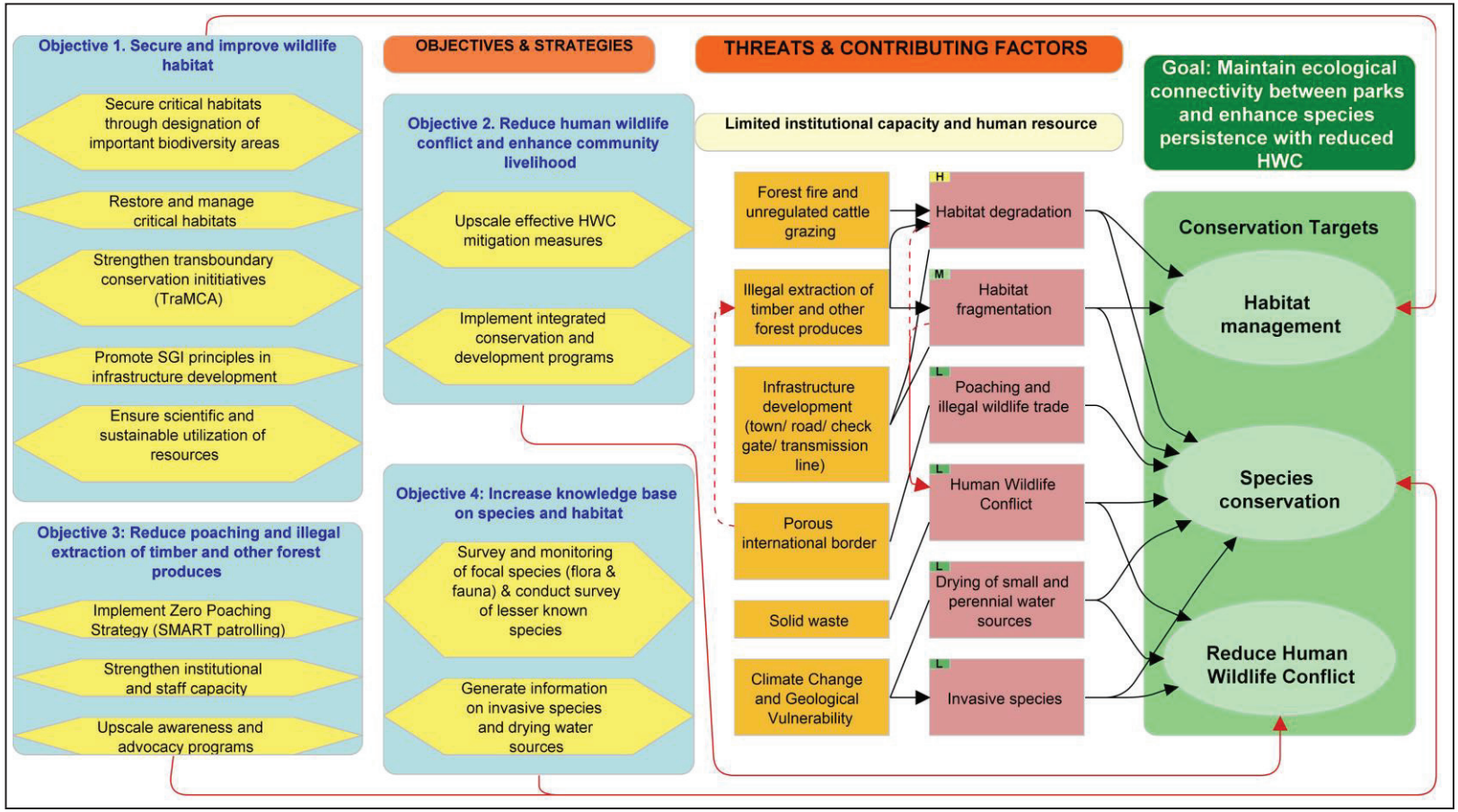


Figure 23: BC 05 Plan Conceptual Model

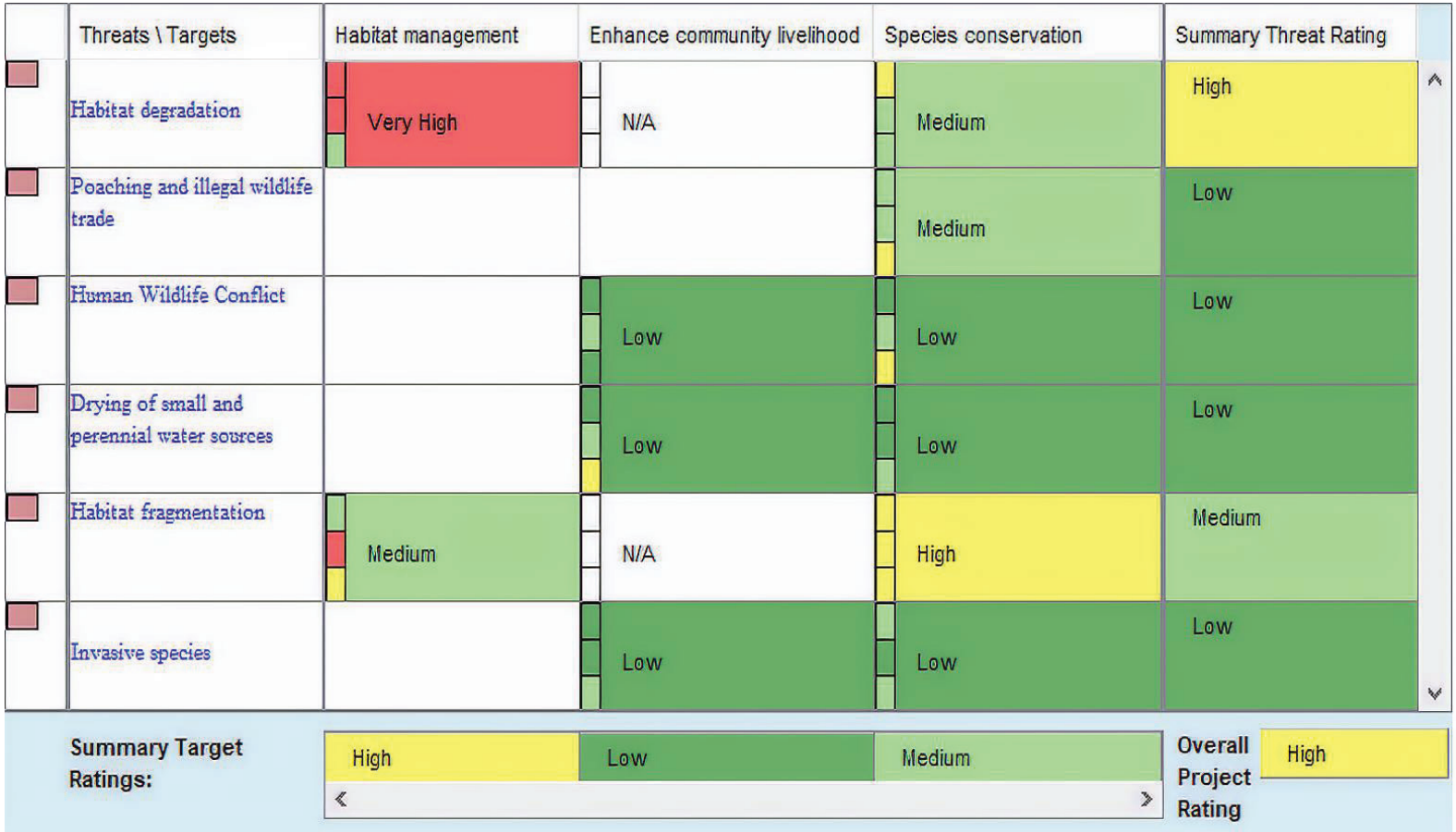


Table 8: Threat Rankings for BC 05 developed using MIRADI software based on the conceptual model

Chapter IV: Management Interventions

Having analyzed and ranked the threats in chapter III, the conservation goals and strategies along with the actions and guidelines are being devised. This being the first management plan for BC 05, the plan should be dynamic to adapt to any unforeseen circumstances. This plan also takes stock for coordination and participatory participation from the local communities. In the era of changing world, development of any infrastructures should not pose stake to nature. Thus, it is necessary to adopt the principle of Smart and Green Infrastructures (SGI).

Strategies and actions are defined based on the overall goal of the plan to achieve and maintain proper habitat, species conservation and enhanced social livelihood. These strategic actions will to solve problems or overcome the barriers that prevent us from achieving the objectives and subsequently the goals.

4.1. Objective 1: Secure and improve wildlife habitat

4.1.1. Strategy 1: Secure critical habitats through designation of important biodiversity areas

Action 4.1.1.1. Mapping of salt licks, water holes and other important biodiversity area

Action 4.1.1.2. Control invasive species

Action 4.1.1.3. Improve and enrich wildlife habitats

4.1.2. Strategy 2: Restore and manage critical habitats (most frequently used as well as most disturbed)

Action 4.1.2.1. Identify and map critical wildlife habitats and assess severity of disturbances.

Action 4.1.2.2. Restore critical habitat through conservation and protection actions

4.1.3. Strategy 3: Strengthen transboundary conservation initiatives (TraMCA)

Action 4.1.3.1.Strengthen transboundary collaborations and cooperation

Action 4.1.3.2. Conduct synchronized patrolling and wildlife surveys

4.1.4. Strategy 4: Integrate SGI principles in infrastructure development

Action 4.1.4.1. Promote SGI principles in any developmental works impacting connectivity of landscape.

Strategy 5: Ensure scientific and sustainable utilization of resources

Action 4.1.5.1. Ensure allocation of resources to be scientific and sustainable with effective service delivery

Action 4.1.5.2. Regulate the sustainable collection of NWFP

4.2. Objective 2: Reduce human wildlife conflict and enhance community livelihood

4.2.1. Strategy: Upscale effective HWC mitigation measures

Action 4.2.1.1: Analyze and study the impacts of HWC using available data from relevant sectors

Action 4.2.1.2: Study the extent of lax livestock herding practices and its underlying causes

Action 4.2.1.3: Facilitate and collaborate with relevant stakeholders for the installation of electric fences in conflict areas

Action 4.2.1.4: Educate students and local communities on natural heritage and human-wildlife conflicts.

Action 4.2.1.5: Integrate conservation program through development of Agro-Silvo-Pastoral

Action 4.2.1.6: Train field staff in managing conflicts

4.2.2. Strategy : Implement Integrated Conservation Development Programs

Action 4.2.2.1: Facilitate crop and livestock compensation to protect crops and livestock from wildlife damages

Action 4.2.2.2: Identify and promote enterprise development

Action 4.2.2.3: Educate communities through exposure trips

Action 4.2.2.4: Support in development of biogas plant in collaboration with Department of Livestock and Local Government.

4.3. Objective 3: Reduce poaching and illegal extraction of timber and forest produces

4.3.1. Strategy: Implement Zero Poaching Strategy

Action 4.3.1.1. Assess current poaching trends and enforcement operations in the corridor

Action 4.3.1.2. Procure SMART patrol tools and technology (phone, radio communication, laptop, camera & lens, GPS, Printer)

Action 4.3.1.3. Conduct/attend SMART patrol training and refresher courses

Action 4.3.1.4. Conduct SMART patrolling on regular basis and generate monthly and annual patrol reports

Action 4.3.1.5. Conduct/ engage in coordination meeting with line agencies (Army, Police, Customs, Judiciary, BAFRA, DoA, DoL, LG, etc)

4.3.2. Strategy: Strengthen institutional and staff capacity for conservation and management

Action 4.3.2.1. Conduct rangers training on tactical enforcement including patrolling, intelligence gathering, surveillance, search and raid, evidence collection, prosecution)

Action 4.3.2.2. Conduct/ attend trainings on corridor management (biodiversity survey and monitoring, wildlife rescue and rehabilitation, study design and data analysis, HWC management)

Action 4.3.2.3. Establish/ maintain infrastructure (office, staff quarter, furniture and office equipment, field gear and equipment, mobility, communication equipment)

4.3.3. Strategy: Upscale conservation awareness and advocacy program

Action 4.3.3.1. Conduct awareness campaigns among communities on ills of wildlife poaching and need for conservation

Action 4.3.3.2. Celebrate important days like Wildlife Day, Elephant Day, Tiger Day, etc., with schools and institutions nearby

Action 4.3.3.3. Identify and support nature club in schools as ambassador of conservation and promote the corridor as living classroom

Action 4.3.3.3. Organize religious discourses on the spiritual linkage of conservation and human wellbeing

4.4. Objective 4: Increase knowledge base on species and habitat

4.4.1. Strategy 1: Population status of focal species (elephant, Guar, Tiger, Hornbill, Dhole) and lesser known species determined through survey and research conduction.

Action 4.4.1.1. Population survey of focal species (Elephant, Dhole, Hornbill, Guar, Tiger)

Action 4.4.1.2. Habitat modeling for focal and other species in BC

Action 4.4.1.3. Conduct survey on lesser known species (fishes, bats, small mammals, herpetofauna and butterflies)

Action 4.4.1.4. Publication of pamplets and technical reports

4.4.2. Strategy 2: Generate information on invasive species and dying water sources

Invasive species and drying water sources are considered as threats in the corridor for human and wildlife in many aspects. Invasive species which is on the rise if left unchecked would interact with indigenous species and may disrupt the functioning of entire ecosystems. Drying of water sources will displace wildlife from their natural habitat in search for other sources. Therefore, it is crucial to intervene with sound management prescription which can be achieved through proper study.

Action 4.4.2.1. Conduct field survey on distribution of invasive species in collaboration with NBC.

Action 4.4.2.2. Identify and manage degraded watershed in collaboration WMD (Formation of water user groups).

Action 4.4.2.3. Data compilation, report write shop and publication.

Chapter V: Implementation Schedule and Budget

5.1. Implementing Agency

As per the Biological Corridors Regulations of Bhutan, 2018, Department of Forests and Park Services (DoFPS) is bestowed with the responsibility in managing the protected area and biological corridors in Bhutan. The DoFPS will discharge this responsibility to one or more territorial divisions. The Chief Forestry Officers of Pema Gatshel and Samdrup Divisions are responsible for the implementation of this Management Plan in which technical backstopping agency will be Nature Conservation Division (NCD), Thimphu. Field level management of the corridor may require to create a dedicated BC Unit office for increased efficacy.

5.2. Implementation Schedule

The activities listed under this heading is proposed to be carried out within the ten-year time period. These activities are derived from the current information and knowledge gaps, infrastructure deficits and analyzed threats.

Implementation Schedule for BC 05											
Strategic Actions	**Y1 Budget**	**Y2 Budget**	**Y3 Budget**	**Y4 Budget**	**Y5 Budget**	**Y6 Budget**	**Y7 Budget**	**Y8 Budget**	**Y9 Budget**	**Y10 Budget**	**Total**
Objective 1: Secure and improve wildlife habitat											
Strategy 1: Secure critical habitats through designation of important biodiversity areas											
Action 1. Mapping of salt licks, water holes and other IBA	0.52										0.52
Action 2. Control noxious weeds and non-native invasive species			0.1		0.1		0.1				0.3
Action 3. Improve and enrich wildlife habitats	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	4
Strategy 2: Restore and manage critical habitats (most frequently used as well as most disturbed)											0
Action 1. Identify and map critical wildlife habitats and assess severity of disturbances.		0.25	0.25								0.5
Action 2. Restore critical habitat through conservation and protection actions			0.1	0.1	0.1	0.1	0.1	0.1			0.6
Strategy 3: Strengthen transboundary conservation initiatives (TraMCA)											0
Action 1. Strengthen transboundary collaborations and cooperation			0.05		0.05		0.05		0.05		0.2
Action 2. Conduct synchronized patrolling and wildlife surveys			0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.4
Strategy 4: Integrate SGI principles in infrastructure development											0
Action 1. Promote SGI principles in any developmental works impacting connectivity of landscape.	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.3

Strategy 5: Ensure scientific and sustainable utilization of resources											0
Action 1. Ensure allocation of any resources to be scientific and sustainable with effective service delivery.											0
Action 2. Regulate the sustainable collection of NWFP		0.03	0.1		0.03		0.03		0.03		0.22
Objective 2: Reduce human wildlife conflict and enhance community livelihood											0
Strategy 1. Upscale effective HWC mitigation measures											0
Action 1. Analyze and study the impacts of HWC using available data from relevant sectors				0.25	0.25						0.5
Action 2. Study the extent of lax livestock herding practices and its underlying causes			0.08								0.08
Action 3. Facilitate and collaborate with relevant stakeholders for the installation of electric fences in conflict areas			0.08								0.08
Action 4. Educate students and local communities on natural heritage and human-wildlife conflicts.			0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.24
Action 5. Integrate conservation program through development of Agro-Silvo-Pastoral		0.3			0.3			0.3			0.9
Action 6: Train field staff in managing conflicts		0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.27
Strategy 2. Implement Integrated Conservation Development Programs											0

Action 1. Facilitate crop and livestock compensation to protect crops and livestock from wildlife damages					0.1	0.1					0.2
Action 2. Identify and promote enterprise development								0.5			0.5
Action 3. Educate communities through exposure trips						0.35	0.35				0.7
Action 4. Support in development of biogas plant in collaboration with DoL and LG.				0.25	0.25						0.5
Objective 3: Reduce poaching and illegal extraction of timber and forest produces											0
Strategy 1. Implement Zero Poaching Strategy											0
Action 1. Assess current poaching trends and enforcement operations in the corridor		0.4									0.4
Action 2. Procure SMART patrol tools and technology (phone, radio communication, laptop, camera & lens, GPS, Printer)	1.35										1.35
Action 3. Conduct/attend SMART patrol training and refresher courses	0.3		0.3								0.6
Action 4. Conduct SMART patrolling on regular basis and generate monthly and annual patrol reports	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	1.5
Action 5. Conduct/ engage in coordination meeting with line agencies (Army, Police, Customs, Judiciary, BAFRA, DoA, DoL, LG, etc)	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.5

Strategy 2. Strengthen institutional and staff capacity for conservation and management											0
Action 1. Conduct rangers training on tactical enforcement including patrolling, intelligence gathering, surveillance, search and raid, evidence collection, prosecution)		0.7				0.7					1.4
Action 2. Conduct/ attend trainings on corridor management (biodiversity survey and monitoring, wildlife rescue and rehabilitation, study design and data analysis, HWC management)	0.6		0.6		0.4		0.2		0.2		2
Action 3. Establish/ maintain infrastructure (office, staff quarter, furniture and office equipment, field gear and equipment, mobility, communication equipment)	6.5	5	0.5	0.5	0.5						13
Strategy 3. Upscale conservation awareness and advocacy program											0
Action 1. Conduct awareness campaigns among communities on ills of wildlife poaching and need for conservation	0.1		0.1		0.1		0.1		0.1		0.5
Action 2. Celebrate important days like Wildlife Day, Elephant Day, Tiger Day, etc., with schools and institutions nearby	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	1
Action 3. Identify and support nature club in schools as ambassador of conservation and promote the corridor as living classroom	0.05		0.05		0.05		0.05		0.05		0.25
Action 4. Organize religious discourses on			0.2			0.2			0.2		0.6

the spiritual linkage of conservation and human wellbeing											
Objective 4: Increase knowledge base on species and habitat											0
Strategy 1: Population status of focal species (Elephant, Guar, Tiger, Hornbill, Dhole) and lesser known species determined through survey and research conduction											0
Action 1. Population survey of focal species (Elephant, Dhole, Hornbill, Guar, Tiger)	0.7		0.7		0.7						2.1
Action 2. Habitat modelling for focal and other species in BC			0.05								0.05
Action 3. Conduct survey on lesser known species (fishes, bats, small mammals, herpetofauna and butterflies)		0.7		0.7							1.4
Action 4. Publication of pamphlets and technical reports					0.3						0.3
Strategy 2: Generate information on invasive species and dying water sources											0
Action 1. Conduct field survey on distribution of invasive species in collaboration with NBC.		0.3	0.3								0.6
Action 2. Identify, assess and manage degraded watershed in collaboration WMD (Formation of water user groups).		0.3	0.3								0.6
Action 3. Data compilation, report write shop					0.6						0.6
				Grand total							**39.76**

5.3. Monitoring and Evaluation

Strategic Action	Target	Indicators	Baseline	Monitoring Frequency	Source of Verification
Objective 1: Secure and improve wildlife habitat					
Strategy 1: Secure critical habitats through designation of important biodiversity areas					
Action 1. Mapping of salt licks, water holes and other important biodiversity area	Managed 10 salt licks, 3 water holes and 2 IBAs	No. of salt licks, water holes and IBAs mapped and managed	6 salt licks managed.	Annually	Reports and physical verification
Action 2. Control noxious weeds and non-native invasive species	2 species controlled (Species)	No. of species controlled	NA	3 times starting 3rd year	Reports
Action 3. Improve and enrich wildlife habitats	20 hectares	Area coverage	NA	Annually	Physical verification and plantation journal
Strategy 2: Restore and manage critical habitats (most frequently used as well as most disturbed)					
Action 1. Identify and map critical wildlife habitats and assess severity of disturbances.	2 critical habitats (Hornbill and Elephant)	No. of critical habitats identified	NA	Two times	Report/map
Action 2. Restore critical habitat through conservation and protection actions	Partnered with 3 communities	No. of communities	NA	One time at the end of the plan period	Physical verification and report

Strategic Action	Target	Indicators	Baseline	Monitoring Frequency	Source of Verification
Strategy 3: Strengthen transboundary conservation initiatives (TraMCA)					
Action 1. Strengthen transboundary collaborations and cooperation	Initiated and processed	Efforts and initiatives	0	2 times	Minutes of the meetings, Official correspondences
Action 2. Conduct synchronized patrolling and wildlife surveys	Initiated and processed	Efforts and initiatives	0	Annually	Minutes of the meetings, Official correspondences
Strategy 4: Integrate SGI principles in infrastructure development					
Action 1. Promote SGI principles in any developmental works impacting connectivity of landscape.	Applied to every relevant developmental activity	No. of SGI implemented and monitored	0	Annually	Forestry clearance, physical verification, monitoring report
Strategy 5: Ensure scientific and sustainable utilization of resources					
Action 1. Ensure allocation of any resources to be scientific and sustainable with effective service delivery.	At par with G2C	Turn around time		Annually	FIRMS report/feedback from clients
Action 3. Regulate the sustainable collection of NWFP	Form 1 NWFP user group	No. of groups formed	Zero	One time	NWFP Plan
Objective 2: Reduce human wildlife conflict and enhance community livelihood					

Strategic Action	Target	Indicators	Baseline	Monitoring Frequency	Source of Verification
Strategy 1. Upscale effective HWC mitigation measures					
Action 1. Analyze and study the impacts of HWC using available data from relevant sectors	1	Study conducted	0	One time	Technical report
Action 2. Study the extent of lax livestock herding practices and its underlying causes	1	Study conducted	0	One time	Technical report
Action 3. Facilitate and collaborate with relevant stakeholders for the installation of electric fences in conflict areas	10 km	Distance covered (km)	0	Two times	Materials supplied, Physical verification
Action 4. Educate students and local communities on natural heritage and human-wildlife conflicts.	3 school and 2 NFI	Adopted natural heritage	NA	2 times	Physical verification
Action 5. Integrate conservation program through development of Agro-Silvo-Pastoral	5 hectares of pastures	Area developed	NA	4 times	Physical verification, seeds and seedlings supplied
Action 6. Train field staff in managing conflicts	60 staffs	Staffs trained	0	One time	Training report

Strategic Action	Target	Indicators	Baseline	Monitoring Frequency	Source of Verification
Strategy 3. Implement Integrated Conservation Development Programs					
Action1. Facilitate crop and livestock compensation to protect crops and livestock from wildlife damages	Every case	Attendance percent		Annually	Compensation receipt
Action 2. Identify and promote enterprise development	2 products	Product enterprises developed		Annually from 2nd year	Physical verification and marketing plan
Action 3. Educate communities through exposure trips	15 heads	No. of people availed		One time	Trip report
Action 4. Support in development of biogas plant in collaboration with DoL and LG.	20 households	No. of households with biogas plants	0	Annually from 3rd year	Physical verification and materials supplied
Objective 3: Reduce poaching and illegal extraction of timber and forest produces					
Strategy 1. Implement Zero Poaching Strategy					
Action 1. Assess current poaching trends and enforcement operations in the corridor	1	No of assessment reports	0	One time	Assessment report

Strategic Action	Target	Indicators	Baseline	Monitoring Frequency	Source of Verification
Action 2. Procure SMART patrol tools and technology (phone, radio communication, laptop, camera & lens, GPS, Printer)	10 each (Phones, GPS, and Handset), 4 laptops, 2 camera and lens, 2 printers	No. and type of equipment procured	Nil	One time	Payment receipt, stock register
Action 3. Conduct/attend SMART patrol training and refresher courses	5 times	No. trainings conducted or attended	2 focal staff trained	Annually	Training report
Action 4. Conduct SMART patrolling on regular basis and generate monthly and annual patrol reports	60 reports	No. of patrols conducted and reports generated		Monthly and Annually	SMART reports
Action 5. Conduct/ engage in coordination meeting with line agencies (Army, Police, Customs, Judiciary, BAFRA, DoA, DoL, LG, etc)	5	No of meetings conducted or attended		Annually	Minutes of the meetings, Official correspondences
Strategy 2. Strengthen institutional and staff capacity for conservation and management					
Action 1. Conduct rangers training on tactical enforcement including	60 staff	No. of persons trained		One time	Training report

Strategic Action	Target	Indicators	Baseline	Monitoring Frequency	Source of Verification
patrolling, intelligence gathering, surveillance, search and raid, evidence collection, prosecution)					
Action 2. Conduct/ attend trainings on corridor management (biodiversity survey and monitoring, wildlife rescue and rehabilitation, study design and data analysis, HWC management)	30 staff	Number of persons trained; type of training conducted	15 staffs trained on biodiversity assessment, 10 staff trained on wildlife rescue and rehabilitation	Annually	Training report
Action 3. Establish/ maintain infrastructure (office, staff quarter, furniture and office equipment, field gear and equipment, mobility, communication equipment)	1 office and staff quarter with office furniture and equipment	Infrastructures developed or procured		Annually	Physical verification and stock register
Strategy 3. Upscale conservation awareness and advocacy program					
Action 1. Conduct awareness campaigns among communities on ills of wildlife poaching and need for conservation	5 times	No. of trainings and participants		Annually	Training report

Strategic Action	Target	Indicators	Baseline	Monitoring Frequency	Source of Verification
Action 2. Celebrate important days like Wildlife Day, Elephant Day, Tiger Day, etc., with schools and institutions nearby	5 times each for Wildlife day, Elephant day and Tiger day	No. of celebrations		Annually	Event report, press reports
Action 3. Identify and support nature club in schools as ambassador of conservation and promote the corridor as living classroom	Partner with 2 schools	No. of schools partnered; type of activities carried out		Annually	Official correspondences and MoU with schools
Action 4. Organize religious discourses on the spiritual linkage of conservation and human wellbeing	2	No. of religious discourses made	0	2 times	Field Report
Objective 4: Increase knowledge base on species and habitat					
Strategy 1: Population status of focal species (elephant, Guar, Tiger, Hornbill, Dhole) and lesser known species determined through survey and research conduction					
Action 1. Population survey of focal species (Elephant, Dhole, Hornbill, Guar, Tiger)	2 surveys	No. of surveys conducted and species covered, Area covered		2 times	Evidence survey report, camera trap report and technical report
Action 2. Habitat modelling for focal and other species in BC	1 time	Habitat modelling done		1 time	Modelling map
Action 3. Conduct survey on lesser	1 time	Surveys done		1 time	Survey report

Strategic Action	Target	Indicators	Baseline	Monitoring Frequency	Source of Verification
known species (fishes, bats, small mammals, herpetofauna and butterflies)					
Action 4. Publication of pamphlets and technical reports	1 pamphlet and 1 technical report	No. of reports and pamphlets published	0	1 time at the end of the plan	Publications
Strategy 2: Generate information on invasive species and dying water sources					
Action 1. Conduct field survey on distribution of invasive species in collaboration with NBC.	1 survey	Surveys done	0	1 time	Invasive species report
Action 2. Identify, assess and manage degraded watershed in collaboration WMD (Formation of water user groups).	1 survey and 1 water user group	Surveys done; Group formed	0	1 time	Field report, User group guidelines
Action 3. Data compilation, reports write shop and publication.	1 write shop	write shop conducted	1 write shop on BC plan development	1 time	Publications

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Annexure I. Species list of plants

20 x 20 m plot	Family	Chokorling	Phuntshothang	Orong	Norbugang	Dewathang
Evergreen Tree		**RBA (%)**	**RBA (%)**	**RBA (%)**	**RBA (%)**	**RBA (%)**
Schimawallichii	Theaceae	8.89	0.14		0.46	0.98
Duabanga grandiflora	Sonneratiaceae	7.37		26.86		2.32
Talaumahodgsonii	Magnoliaceae	6.47	4.24		0.00	6.19
Phoebe lanceolata	Lauraceae	5.10	1.50	0.84	0.51	3.55
Castanopsis indica	Fagaceae	3.40				3.83
Dillenia indica	Dilleniaceae	3.25	1.28			4.74
Mangiferasylvatica	Anacardiaceae	2.96	0.03			0.04
Ostodespaniculata	Euphorbiaceae	2.68	1.59	0.92		0.94
Pterospermumacerifolium	Sterculiaceae	2.32	0.61	0.54	11.49	4.73
Celtistetranda	Ulmaceae	2.04				0.02
Ailanthus paniculata	Simaroubaceae	1.72				
Altingiaexcelsa	Hamamelidaceae	1.70				2.80
Syzygiumcumini	Myrtaceae	1.70	5.28			4.56
Litseaglutinosa	Lauraceae	1.52	1.16		0.20	1.77
Elaeocarpussp	Elaeocarpaceae	1.28				
Helicianilagirica	Proteaceae	0.87	5.01			2.68
Boehmerianivea	Urticaceae	0.70			0.43	
Toonaciliata	Meliaceae	0.70				

Macropanaxdispermus	Araliaceae	0.67				
Ailanthus grandis	Simaroubaceae	0.65	0.13	0.00	0.03	0.24
Terminaliamyriocarpa	Combretaceae	0.59	5.90	1.21		3.30
Macropanaxundulatus	Araliaceae	0.57				
Ficusvirens	Moraceae	0.56			0.02	
Cinnamomumglaucescens	Lauraceae	0.55				0.50
Jambosaformosa	Bignoniaceae	0.54	1.86		0.04	2.20
Species	**Family**	**RBA (%)**	**RBA (%)**	**RBA (%)**	**RBA (%)**	**RBA (%)**
*Syzygium*sp	Myrtaceae	0.47			3.46	2.08
Aphanamixispolystachya	Meliaceae	0.38	0.39	7.32		1.92
Litseamonopetala	Lauraceae	0.34	0.07			0.13
Engelhardiaspicata	Juglandaceae	0.34			0.04	1.81
Mitrephoraharai	Annonaceae	0.29		0.74	2.52	0.00
Phoebe golparaensis	Lauraceae	0.28				0.20
Mallotusphilippensis	Euphorbiaceae	0.28	0.29	0.11	1.14	0.34
Symplocossp	Symplocaceae	0.26				0.22
Actinodaphneobovata	Lauraceae	0.24	0.36		2.25	1.19
Gynocardia odorata	Flacourtiaceae	0.24	2.87	0.01		0.01
Cinnamomumbejolghota	Lauraceae	0.23	0.03			0.30
Ficusauriculata	Moraceae	0.17				
Ailanthus integrifolia	Simaroubaceae	0.11				
Mesuaferrea	Guttiferae	0.03	4.24			0.75

Castanopsishystrix	Fagaceae	0.03			3.08	0.39
Phoebe attenuata	Lauraceae	0.02	0.09		7.58	0.12
Perseafructifera	Lauraceae	0.01	4.59			2.33
Ficuscunia	Moraceae	0.00				
Aquilariamalaccensis	Thymelaeaceae	0.00				
Boehmeriarugulosa	Urticaceae	0.00	0.01			
Lagerstroemia parviflora	Lythraceae		4.52			0.47
Sarcospermaarboreum	Sarcospermataceae		3.23			1.44
Oreocniderubescens	Urticaceae		2.71			0.62
Casearіagraveolens	Flacourtiaceae		2.41			
Elaeocarpuslanceifolius	Elaeocarpaceae		1.58			
Terminaliabellirica	Combretaceae		1.47			2.88
Elaeocarpusvaruna	Elaeocarpaceae		1.32			1.73
Boehmeriamacrophylla	Urticaceae		1.12			
Species	**Family**	**RBA (%)**	**RBA (%)**	**RBA (%)**	**RBA (%)**	**RBA (%)**
Miliusamarcrocarpa	Annonaceae		0.59			
Baccaurearamiflora	Euphorbiaceae		0.43			
Strobilanthesechinata	Acanthaceae		0.37			
Cassia fistula	Leguminosae		0.26			
Bamboo sp	Euphorbiaceae		0.21			1.66
Acacia gageana	Leguminosae		0.20			0.00
Terminaliachebula	Combretaceae		0.16			

Aesandrabutyracea	Sapotaceae		0.13			0.59
Eriobotryapetiolata	Rosaceae		0.09			0.28
Echinocarpusdecicarpus	Meliaceae		0.08			
Walsuratubulata	Arecaceae(Palmae)		0.07		0.28	0.32
Bauhinia purpurea	Leguminosae		0.07		9.14	
Choerospondiasaxillaris	Anacardiaceae		0.06		0.22	0.01
Buteabuteiformis	Leguminosae		0.03			0.08
Plumeriarubra	Apocynaceae		0.02			0.03
Holmskioldiasanguinea	Verbenaceae		0.01			
Alstoniascholaris	Apocynaceae		0.01			1.54
Vitex heterophylla	Verbenaceae		0.00			1.04
Anthocephaluscadamba	Polygonaceae			9.86		
Magnolia pterocarpa	Rubiaceae			0.27		0.31
Tectonagrandis	Verbenaceae				1.57	
Alangiumalpinum	Alangiaceae				0.19	
Spondiaspinnata	Anacardiaceae				0.03	
Boehmeriasp	Urticaceae					0.00
Persia fructifera	Lauraceae					0.02
Euryacavinervis	Theaceae					0.04
Ficuscrytophyla	Moraceae					0.05
Ficussemicordata	Moraceae					0.06
Species	**Family**	**RBA (%)**	**RBA (%)**	**RBA (%)**	**RBA (%)**	**RBA (%)**

Dilleniapentagyna	Dilleniaceae					0.14
Macarangapustula	Euphorbiaceae					0.14
Aglaia lawii	Meliaceae					0.26
Cinnamomumsp	Lauraceae					0.28
Ficusneriifolia	Moraceae					0.35
Mangifera indica	Anacardiaceae					0.51
Glochidionthomsonii	Euphorbiaceae					0.61
Beilschmidiaroxburghiana	Begoniaceae					0.74
Subtotal		62.53	62.78	48.69	44.67	73.42
Deciduous Tree						
Chukrasiatabularis	Meliaceae	8.57	0.23	33.09		0.03
Kydiacalycina	Malvaceae	4.79	0.15			2.24
Tetramelesnudiflora	Datiscaceae	3.07	1.57			
Sterculiavillosa	Sterculiaceae	2.85	0.58		3.96	0.76
Stereospermumcolais	Bignoniaceae	2.79	2.59		6.19	2.06
Bombaxceiba	Bombacaceae	2.17			11.85	
Albiziaprocera	Leguminosae	1.59	0.57	5.13	15.49	
Callicarpaarborea	Verbenaceae	1.03			0.56	0.39
Bischofiajavanica	Bischofiaceae	0.95				0.04
Gmelinaarborea	Verbenaceae	0.95	0.52			0.02
Alangiumchinense	Alangiaceae	0.79			0.32	
Macarangadenticulata	Euphorbiaceae	0.69	3.00	0.39		3.79

Erythrinaarboresens	Leguminosae	0.60		0.94		
Sapium insigne	Euphorbiaceae	0.34	1.08			0.76
Brideliaretusa	Euphorbiaceae	0.33	0.46	0.72		2.68
Oroxylumindicum	Bignoniaceae	0.24	0.41	0.07		0.28
Bauhinia variegata	Leguminosae	0.17				
Brideliapubescens	Euphorbiaceae	0.17				
Species	**Family**	**RBA (%)**	**RBA (%)**	**RBA (%)**	**RBA (%)**	**RBA (%)**
Acerthomsonii	Aceraceae	0.02				
Cordiaobliqua	Boraginaceae	0.01				0.01
Ficuselastica	Moraceae		5.25			
Trevianudiflora	Araliaceae		3.82			0.83
Adina cordifolia	Compositae		2.49			
Haldinacordifolia	Gramineae		1.70			
Micheliacathcartii	Rubiaceae		1.60			
Tetradiumfraxinifolium	Rutaceae		0.73			
Cinnamomumtamala	Lauraceae		0.50			0.36
Neocinnamomumcaudatum	Lauraceae		0.33			
Phyllanthusemblica	Euphorbiaceae		0.06			0.32
Acronychiapedunculata	Rutaceae		0.00			
Boehmeriaglomerulifera	Urticaceae		0.00			0.02
Daphniphyllumchartaceum	Daphniphyllaceae				2.18	0.09
Eriobotrya bengalensis	Compositae				1.17	

Ficusmacrophylla	Moraceae				0.08	
Desmosdumosus	Annonaceae				0.01	
Clerodendrumsp	Verbenaceae				0.01	0.07
Rhushookeri	Anacardiaceae					0.65
Sapindusrarak	Sapindaceae					0.06
Brassaiopsismitis	Araliaceae					0.02
Brassaiopsisglomerulata	Araliaceae					0.00
Subtotal		32.11	27.65	40.33	41.82	15.50
Evergreen Shrub						
Tecomastans	Bignoniaceae	1.26		0.86	1.93	0.06
Maesachisia	Myrsinaceae	0.24	0.40	0.02		0.04
Tabernaemontanadivaricata	Apocynaceae	0.24		1.47	0.38	0.07
Tremaorientalis	Umbelliferae	0.09				0.60
Species	**Family**	**RBA (%)**	**RBA (%)**	**RBA (%)**	**RBA (%)**	**RBA (%)**
Phlogacanthusthyrsiformis	Acanthaceae	0.07	0.02		0.71	0.21
Macluracochinchinensis	Moraceae	0.06				0.02
Justiciaadhatoda	Acanthaceae	0.03		0.71		
Euryaacuminata	Theaceae	0.02	0.35	0.60		1.12
Maesa indica	Myrsinaceae	0.01				
Aralia foliolosa	Araliaceae	0.01				0.01
Wrightiaarborea	Apocynaceae		2.23			0.28
Beilschmiediadalzellii	Lauraceae		0.20			5.42

Catunaregamlongispina	Rubiaceae					0.00
Subtotal		2.03	3.20	3.66	3.02	7.84
Deciduous Shrub						
Dendrocnidesinuta	Urticaceae	0.83				0.00
Rhus succedanea	Anacardiaceae	0.70				
Dendrocnidesinuata	Urticaceae	0.02	0.18		0.11	0.49
Flueggeavirosa	Euphorbiaceae	0.01		0.27		0.00
Lantana camara	Verbenaceae	0.00				
Debregeasialongifolia	Urticaceae	0.00			0.03	0.00
Amooralawii	Zingiberaceae		0.02			
Myricaesculenta	Myricaceae		0.03			0.02
Garugapinnata	Burseraceae				5.16	0.45
Rhuschinensis	Anacardiaceae					0.02
Clerodendrumbracteatum	Verbenaceae					0.02
Hydrangea heteromalla	Hydrangeaceae					0.01
Subtotal		1.57	0.23	0.27	5.30	1.01
Deciduous Climbing Shrub						
Cissusjavana	Vitaceae	0.67		6.86		
Entadarheedii	Leguminosae	0.01	0.02			
Climber		0.01	0.10			0.08
Species	**Family**	**RBA (%)**	**RBA (%)**	**RBA (%)**	**RBA (%)**	**RBA (%)**

Albezialebbeck	Alangiaceae				4.30	
Tetrastigmarumicispermum	Vitaceae				0.89	
Aglaia spectabilis	Meliaceae		3.12			0.64
Derris microptera	Leguminosae					0.13
Caesalpiniacucullata	Leguminosae					0.06
Actinidiastrigosa	Actinidiaceae					0.00
Toddaliaasiatica	Rutaceae					0.00
Subtotal		0.69	3.24	6.86	5.19	0.91
Deciduous Subshrub						
Vernoniasaligna	Compositae	1.08		0.20		
Lithocarpuselegans	Fagaceae		2.35			0.26
Melastomanormale	Melastomataceae					0.22
Subtotal		1.08	2.35	0.20		0.48
Evergreen Subshrub						
Piper sp	Piperaceae		0.29			
Litseaalbescens	Lauraceae		0.25			0.84
Ardisiamacrocarpa	Myrsinaceae					0.01
Piper longum	Piperaceae					0.00
Subtotal			0.54			0.85
Perennial Bamboo						
Neyraudiaarundinacea	Graminae	0.01				
Subtotal		0.01				

2 x 2 m		RD (%)	RD (%)	RD (%)	RD (%)	RD (%)
Evergreen Subshrub						
Piper sp	Piperaceae	9.52	0.10	4.38	2.61	3.81
Piper pedicellatum	Piperaceae	4.24				
Strobilanthessp	Acanthaceae	3.92		36.80		3.42
Species	**Family**	**RD (%)**	**RD (%)**	**RD (%)**	**RD (%)**	**RD (%)**
Wallichiadensiflora	Arecaceae(Palmae)	1.81				0.96
Acanthus sp	Acanthaceae	1.07		7.20		0.11
Piper longum	Piperaceae	0.74	8.57			
Aconogononmolle	Polygonaceae	0.43	2.39			3.30
Triumfetta annua	Tiliaceae	0.29				0.41
Ardisiamacrocarpa	Myrsinaceae		5.08			
Piper hamiltonii	Piperaceae		0.91			4.89
Sub Total		22.02	17.05	48.38	2.61	16.92
Deciduous Subshrub						
Chromolaena odoratum	Compositae	7.97	16.49			5.85
Boehmeriamacrophylla	Urticaceae		4.53			
Desmodiumsp	Leguminosae				3.04	0.31
Sidaacuta	Malvaceae				1.97	
Clerodendrumsp	Verbenaceae					1.87
Osbeckiastellata	Melastomataceae					0.82

Helwingiahimalaica	Cornaceae					0.46
Helwingiasp	Cornaceae					0.20
Sub Total		7.97	21.02		5.01	9.51
Climber Shrub						
Smilax perfoliata	Smilacaceae	0.25				0.13
Parthenocissussp	Vitaceae	0.19		5.10	4.12	2.59
Tetrastigmaserrulatum	Vitaceae		2.95			
Smilax sp	Smilacaceae					1.06
Climber						0.56
Smilax orthoptera	Smilacaceae					0.49
Sub Total		0.44	2.95	5.10	4.12	4.83

Species	**Family**	**RD (%)**	**RD (%)**	**RD (%)**	**RD (%)**	**RD (%)**
Perrinial Herb						
Elatostema sessile	Urticaceae	24.94				0.58
Hedychiumsp	Zingiberaceae	7.27		1.29		0.10
Dracaena angustifolia	Dracaenaceae	6.87				
Achyranthesbidentata	Amaranthaceae	5.13				
Mikania micrantha	Compositae	2.89			2.90	1.17
Hedychiumthyrsiforme	Zingiberaceae	2.01				1.91
Persicariasp	Polygonaceae	1.45				

Fern		1.21	26.34	6.33		28.32
Colocasiaesculenta	Araceae	0.64				0.34
Commelinasp	Commelinaceae	0.49			1.60	
Elatostemaplatyphyllum	Urticaceae		15.47			5.60
Achyranthessp	Amaranthaceae			4.81		
Molineriacapitulata	Hypoxidaceae				9.42	0.04
Commelinadiffusa	Commelinaceae				0.82	
Cerastiumsp	Caryophyllaceae				0.21	
Alpiniamalaccensis	Zingiberaceae					5.52
Drymariacordata	Caryophyllaceae					3.76
Zingibersp	Zingiberaceae					1.16
Begonia sp	Begoniaceae					0.31
Sub Total		52.91	41.82	12.43	14.94	48.82
Annual Herb						
Ageratum conyzoides	Compositae	1.81			23.94	0.35
Bidens pilosa	Compositae	1.54			9.10	
Ecliptaprostrata	Compositae	1.38		6.68		0.26
Solanumviarum	Solanaceae	0.40				0.20
Argeratum conyzoides	Compositae				3.72	
Pouzolziasp	Urticaceae				1.52	
Species	**Family**	**RD (%)**	**RD (%)**	**RD (%)**	**RD (%)**	**RD (%)**

Galinsoga parviflora	Compositae		0.21		0.96	
Impatiens sp	Balsaminaceae					2.12
Sigesbeckiaorientalis	Compositae					0.42
Sub Total		5.13	0.21	6.68	39.23	3.35
Climber Herb						
Argyreiavenusta	Convolvulaceae				18.12	
Herpetospermumsp	Cucurbitaceae				3.71	
Raphidophoraglauca	Araliaceae					2.26
Raphidophorasp	Cruciferae					0.34
Stephania japonica	Menispermaceae					0.04
Sub Total					21.82	2.64
Perrinial Grass						
Poa sp	Gramineae	10.50		27.41	11.32	2.46
Grass	Gramineae	1.02	8.50		0.96	1.01
Thysanolaenalatifolia	Poaceae		8.19			1.09
Paspalum dilatatum	Gramineae		0.18			6.12
Kyllinga brevifolia	Cyperaceae		0.09			2.97
Digitaria ciliaris	Gramineae					0.28
Sub Total		11.52	16.96	27.41	12.27	13.92

Annexure II. Species list of birds

Common Species

Ashy Bulbul
Ashy Drongo
Ashy Woodswallow
Asian Fairy Bluebird
Asian Pied Starling
Bay Woodpecker
Black Bulbul
Black Crested Bulbul
Black Drongo
Black Eagle
Black-crested Bulbul
Black-hooded Oriole
Black-naped Monarch
Black-throated Sunbird
Blue Rock Thrush
Blue Whistling Thrush
Blue-bearded Bee-eater
Blue-throated Barbet
Blyth's Leaf Warbler
Blyth's Reed Warbler
Bronzed Drongo
Brown Dipper
Brown Shrike
Brownish-flanked Bush Warbler
Chestnut-bellied Nuthatch
Chestnut-crowned Warbler
Chestnut-headed Bee-eater
Chestnut-tailed Starling
Collared Falconet
Collared Scops Owl
Common Green Magpie
Common Iora
Common Kestrel
Common Kingfisher
Common Myna
Common Tailorbird
Crested Kingfisher
Crested Serpent Eagle
Crimson Sunbird
Dusky Warbler
Emerald Dove
Golden-fronted Leafbird
Golden-spectacled Warbler
Golden-throated Barbet
Great Barbet
Great Cormorant
Great Hornbill
Greater Flameback
Greater Racket-tailed Drongo
Greater Yellownape
Green Sandpiper
Green-billed Malkoha
Grey Bushchat
Grey Treepie
Grey Wagtail
Grey-backed Shrike
Grey-bellied Cuckoo
Grey-capped Pygmy Woodpecker
Grey-headed Canary Flycatcher
Grey-sided Bush Warbler
Hill Myna
Hill Partridge
Himalayan Bulbul
Himalayan Flameback
Indian Pond Heron
Indian Roller
Jungle Myna

Rufous Woodpecker
Rufous-bellied Niltava
Rufous-necked Hornbill
Rufous-throated Partridge
Rusty-cheeked Scimitar Babbler
Scaly-breasted Munia
Scarlet Minivet
Short-billed Minivet
Silver-breasted Broadbill
Silver-eared Mesia
Slaty-backed Forktail
Small Niltava
Spangled Drongo
Spotted Dove
Spotted Forktail
Steppe Eagle
Streaked Spiderhunter
Striped Tit Babbler
Sultan Tit
Verditer Flycatcher
Wallcreeper
White-bellied Yuhina
White-browed Scimitar Babbler
White-browed Wagtail
White-capped Water Redstart
White-crested Laughingthrush
White-rumped Shama
White-throated Bulbul
White-throated Fantail
White-throated Kingfisher
White-throated Laughingthrush
White-throated Redstart
Yellow-bellied Fantail
Yellow-bellied Warbler
Yellow-throated Fulvetta
Yellow-vented Flowerpecker
Kalij Pheasant
Lesser Racket-tailed Drongo
Lesser Yellownape
Lineated Barbet
Little Cormorant
Little Egret
Little Forktail
Little Heron
Little Pied Flycatcher
Little Spiderhunter
Long-tailed Broadbill
Long-tailed Minivet
Maroon Oriole
Mountain Imperial Pigeon
Olive-backed Pipit
Orange-bellied Leafbird
Oriental Magpie Robin
Oriental Pied Hornbill
Oriental Turtle Dove
Oriental White-eye
Osprey
Paddyfield Pipit
Pale-headed Woodpecker
Pin-tailed Green Pigeon
Plain Flowerpecker
Plumbeous Water Redstart
Pompadour Green Pigeon
Pygmy Wren Babbler
Red Junglefowl
Red-headed Trogon
Red-vented Bulbul
Red-wattled Lapwing
Red-whiskered Bulbul
River Lapwing
Ruddy-breasted Crake
Rufous Treepie

Annexure III. Species list of Mammals

Sl. No	Order	Family	Scientific Name	Common Name	IUCN	FNCA 1995
1	Carnivora	Canidae	Cuon alpinus	**Dhole**	**EN**	
2		Felidae	Catopuma temminckii	Asiatic Golden Cat	NT	
3			**Panthera pardus**	**Common Leopard**	**VU**	**Schedule I**
4			**Panthera tigris tigris**	**Tiger**	**EN**	**Schedule I**
5			Pardofelis marmorata	Marbled Cat	NT	
6			Prionailurus bengalensis	Leopard Cat	LC	
7		Herpestidae	Herpestes urva	Crab-eating Mongoose	LC	
8		Mustelidae	Lutra lutra	Common Otter	NT	
9		Mustelidae	Melogale spp.	Ferret Badger	LC	
10		Mustelidae	Martes falvigula	Yellow-throated Marten	LC	
11		Ursidae	**Ursus thibetanus**	**Asiatic Black Bear**	**VU**	**Schedule I**
12		Viverridae	Paguma larvata	Masked Indian Civet	LC	
13	Cetartiodactyla	Bovidae	**Bos gaurus**	**Gaur**	**VU**	**Schedule I**
14			**Capricornis thar**	**Himalayan Serow**	**NT**	**Schedule I**
15			Naemorhedus goral	Himalayan Goral	NT	
16		Cervidae	Muntiacus muntjak	Barking Deer	LC	
17			Rusa unicolor	Sambar	VU	
18		Suidae	Sus scrofa	Wild Boar	LC	
19	Primates	Cercopithecidae	Macaca assamensis	Assamese Macaque	NT	
20			Trachypithecus pileatus	Capped Langur	VU	
21	Proboscidae	**Elephantidae**	**Elephas maximus**	**Asian elephant**	**EN**	**Schedule I**
22	Rodentia	Hystricidae	Hystrix indica	Indian Crested Porcupine	LC	
23		Sciuridae	Ratufa bicolor	Black/Malayan Giant Squirrel	NT	
24		Sciuridae	Dremomys lokriah	Orange-bellied Himalayan Squirrel	LC