

Comparative Study in Habitat Suitability Analysis of Wild Water Buffalo (*Bubalus arnee*) in Two Flood Plains of Chitwan National Park (CNP), Nepal

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Abstract: Globally endangered species, Wild Water Buffaloes are restricted to some extent of South and Southeast Asia. Its only population in Nepal survive on the flood plains of Koshi River inside Koshi Tappu Wildlife Reserve (KTWR). They prefer alluvial grasslands and are heavily dependent on water. In KTWR, they face high anthropogenic pressure ranging from habitat deterioration to hybridization with domestic buffaloes. Hence, 15 of them have been translocated to CNP which are to be released in the wild soon from the open closure. However, the suitability analysis of potential habitat within CNP has not been done until now. Consequently, this research is carried out to find the appropriate habitat of water buffalo within Chitwan National Park for their release as well as for further translocation. Two potential habitats namely eastern sector grassland and western sector grassland were identified, analyzed and compared to determine the habitat suitability for wild water buffalo. Vegetation composition, slope, elevation, proximity to the water source and human settlement were the parameters that were selected to assess the suitability. The results showed that *Saccharum arundinaceum* was the dominant tall grass species in the both sites (IVI in eastern grassland=105.34, IVI of western grassland= 102.49) followed by *Saccharum spontenium* and *Imperata cylindrical*. Similarly, *Bombax ceiba* was the dominant tree species (IVI=12.57) followed by *Trewia nudiflora* and others in eastern sector whilst *Syzygium cumini* was the dominant tree species (IVI=68.11) followed by *Bombax ceiba* and *Trewia nudiflora* in western sector. The integration of all factors has shown that both sites possess suitable habitat for water buffalo but comparatively western sector (65.74%) was more preferable than the eastern sector (52.77%). Accordingly, western sector grassland can be considered as the new worthy site for further translocation of wild water buffalo in CNP.

Keywords: Translocation, Habitat Suitability. Geospatial. Open Enclosure

Abbreviations: CNP-Chitwan National Park, ACAP-Annapurna Conservation Area Project, KTWR-Koshi-Tappu Wildlife Reserve, IVI-Important Value Index, IUCN-International Union for Conservation of Nature, CITES-Convention on International Trade in Endangered Species, GPS-Global Positioning System, LULC-Land Use Land Cover, RD-Relative Density, RC-Relative Cover, GIS-Geographical Information System, DNPWC-Department of National Park and Wildlife Conservation, NTNC-National Trust for Nature Conservation.

1. INTRODUCTION

Wild Wild Water Buffaloes (*Bubalus arnee*) are the second largest members of the family Bovidae under the order Artiodactyla. They weigh between 800-1200 kg, and are a massive, powerful animal with the widest horn span of any bovid i.e. more than 2 m [1]. Their home range size ranges from 1.7 sq. km to 10 sq. km [15] and the gestation period is of about 300-340 days and give birth to a single calf at a time. The maximum life span of *B. arnee* is 25 years in the wild [15]. They are highly social animals and females remain in the groups in which they are born. Adult males live either as resident bulls in mixed herds comprised of females and their dependent off-spring, or as bachelors, either singly or in herds [8]. All population of *B. arnee* are considered to be endangered to critically-endangered for many reasons [9] and have probably been in decline for at least a century [7, 4]. They are listed as 'Endangered' on the IUCN Red List of Threatened Species since 1986, and appear under Appendix III

of CITES, also, legally protected in Nepal, India, Bhutan and Thailand. The global population of *B. arnee* has been estimated at 3,400 individuals of which 91% live in India, mostly Assam [5]. *B. arnee*'s main diet is grasses and leafy aquatic vegetation so they prefer low lying alluvial grasslands and their surroundings. They are heavily dependent on water and spend much considerable time wallowing in rivers or mud holes and are more frequently encountered in riverine forests and grasslands, marshes and swamps. They are chiefly grazer, feeding in the morning and evening and lying up in dense cover or wallowing in mid-day heat, to keep themselves cool, and to remove skin parasites, biting flies, and other pests. They are sometimes completely submerged while wallowing, with only showing the nostrils and where there is a substantial human disturbance, they mainly adapt being nocturnal. The important factors determining the choice of habitat for *B. arnee* appears to be food and water rather than protection against predators and environmental factors like heat stress [4].

In Nepal, Koshi Tappu Wildlife Reserve (KWTR) is the only habitat that supports the last surviving population of 441 Wild water buffaloes (KTWR, 2018), until some of them were translocated to Chitwan National Park (CNP) in January 2017. *B. arnee* of KTWR are seriously threatened [10] and the most serious existing threats are interbreeding with feral and domestic buffaloes, followed by hunting, poaching, habitat loss/degradation, diseases and parasites and inter-specific competition for food and water [12]. In addition, the entire reserve is prone to flooding during monsoon as it lies within the embankments of the Koshi River [19], which apparently results in high calf mortality when the flood is underway [6, 8]. This single isolated population within the country has no possibility of immigration and emigration, hence, there is a strong need to shift some of the population into other suitable habitats for establishing sub-populations.

Additionally, CNP is considered as one of the most likely habitats for translocation of *B. arnee*: it possesses several required factors like better protection, qualitative habitat, extensive riverine habitat adjacent to upland forests for flood refuge [10]. *B. arnee* were known to occur in Chitwan until the 1960's [18]. Keeping this in mind, 15 *B. arnee* have already been translocated to CNP but some of them were died and suffering from the parasitic diseases and even Tiger attacked [20] and [21]. However, the habitat suitability analysis of CNP specifically for *B. arnee* has not been done till now. Hence, this study is an attempt to use geospatial solutions, satellite data and field data along with vegetation survey in the field for the analysis of habitat suitability of two different potential sites and determine the better site as the habitat of *B. arnee* which is supposed to aid further translocation and release of translocated buffaloes in suitable area within CNP.

2. MATERIALS AND METHODS

2.1. Locations

The study was conducted in Chitwan National Park, which is the first National Park, established in 1973 and enlisted in the world heritage site in 1984. It is situated in the southern part of Central Nepal. The study was conducted in Chitwan National Park (CNP), which is the first National Park of Nepal, established in 1973 and enlisted in the UNESCO world heritage site in 1984 [22]. The CNP is situated in the southern part of Central Nepal, in the Subtropical low lands of the inner terai of Chitwan, Makwanpur, Parsa and Nawalparasi district lying in between 27.282–27.703 °N & 83.839 – 84.773 °E surrounded by an additional 750 sq.Km. buffer [23] and the park covers an area of 952.63 sq. k.m., and about 70% of the area is covered by Sal forest [2]. Three major rivers; Narayani, Rapti and Reu and their flood plains and several other lakes and pools are the major water sources of this park. A total of 68 species of mammals, 54 species of birds, 56 species of herpetofauna and 126 species of fish have been recorded. The park is particularly famous for endangered fauna like One-horned rhinoceros (*Rhinoceros unicornis*), Gaur (*Bos Gaurus*), Royal Bengal Tiger (*Panthera tigris*), Wild elephant (*Elephas maximus*) and many more [24]. Two large patches of floodplains i.e. eastern sector grassland and western sector grassland were selected as our study site for further analysis after consultation with the Park authorities as they are the most potential site for translocation of wild water buffalo. The eastern sector grassland falls under the Suaraha sector of CNP adjacent to Rapti River while the western sector grassland falls under Meghauri sector and Kasara sector of CNP adjacent to Rapti River and Reu River. These two grasslands are the important grasslands of CNP for the wild water buffaloes.

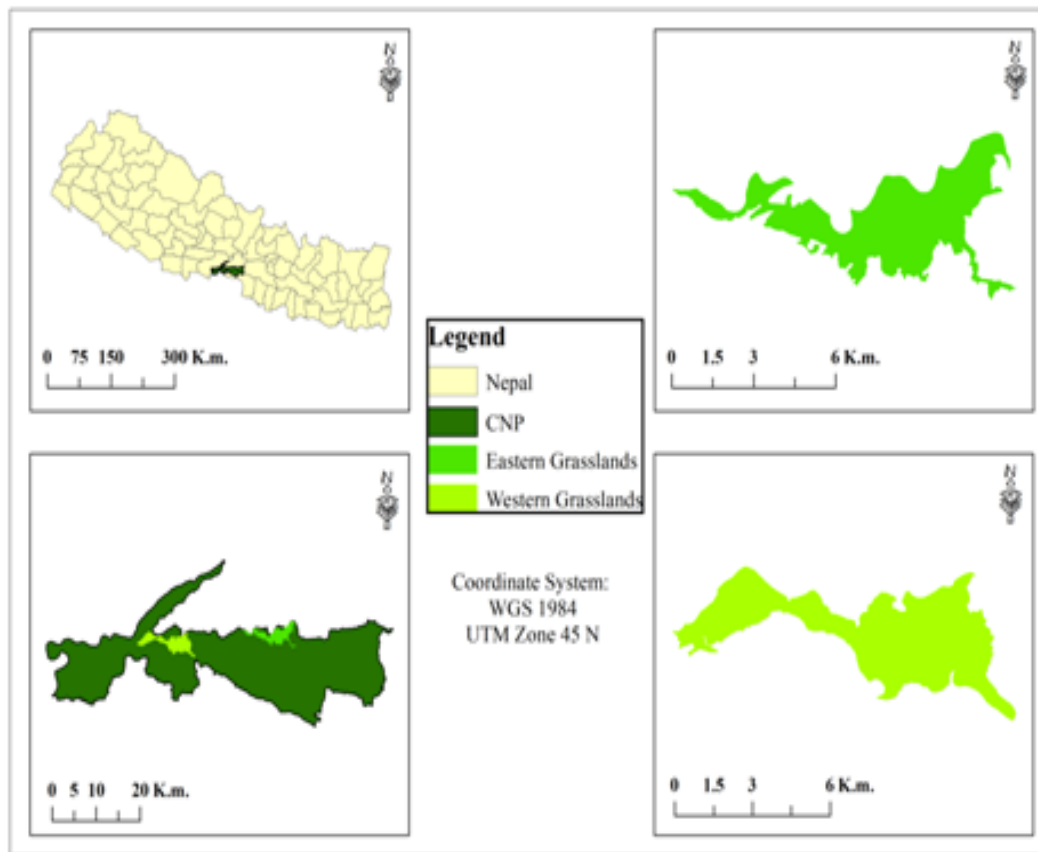


Figure1. Study Area

2.2. Data Collection

Two patches of floodplain (the study sites), the eastern and western grasslands, were digitized by using Google Earth Pro 7.3.2.5776 and 1km x 1km grids were overlaid through fishnet tool in ArcGIS 10.5 and systematic sample plots were laid on both study areas. The coordinates of center points of grids were extracted and uploaded in GPS. During the field survey, each grid was navigated and three sample plots in each grid; one at the center and two other plots 250 m away on either side of the center point were surveyed for the vegetation analysis. The quadrat size of 25m x 20m was taken for trees, 10m x 10m for poles and 1m x 1m was taken for grasses. Species composition, frequency and coverage of grasses along with GPS coordinates were recorded from each plot.

2.3. Habitat Suitability Analysis

Potential sites for the habitat of *B. arnee* were found out based on the preferred suitable habitat criteria. Suitability criteria of *B. arnee* were prepared by reviewing available literature, consultations and discussions with wildlife experts and officials of KTWR including holders. Various criteria were listed and the potential range of threshold values was set from less preferred to highly preferred. Habitat suitability criteria of *B. arnee* was classified into different suitability categories based on resource selection functions of the species and sensitivity to the physical attributes and human activities. The determining factors of habitat suitability were vegetation type/land use, distance from the water source, distance from settlement, slope and elevation [23]. With the use of Rapid Eye Image of 2011 for Land Use Land Cover (LULC) Mapping vegetation type/land use (Forest type/grassland type) were determined; vegetation analysis computed from the data collected from field; proximity to water sources/holes, settlement and slope were calculated using Aster DEM satellite Image and remaining two factors distance from water and the settlement was defined by using water and settlement thematic maps. Habitat values were assigned by putting the habitat quality ranking (HQR) using a common scale, so the criteria can be compared (Table 1). Regarding the common scale, it helps to produce worth values after combining all criteria together. At last, putting together gives the values from higher to lower level i.e. higher values resulting a map which represent the preferable habitat locations.

Table1. Criteria for Habitat Suitability for wild water buffalo

Habitat Suitability	Vegetation/Land Use Type	Distance from water/river (m)	Distance from Settlement (m)	Slope (Degree)
Highly Suitable (4)	River bed/ Bushes/Shrubs	Within 500	Greater than 2000 m	
Suitable (3)	Grassland/ Waterbodies	500 to 1000	1000 to 2000	<7°
Moderately Suitable (2)	Riverine Forest	1000 to 2000	500 to 1000	>7°
Least Suitable (1)	Sal Forest	Greater than 2000	Less than 500	

2.4. Vegetation Analysis

The vegetation data collected from field was used to calculate species richness, density, relative density, frequency, and relative frequency of the trees and by using the following relation:

Density of species A = Total No. of individuals of species A / Total No. of areas surveyed x Area of plot

Relative density of species A = Total No. of individual of species A / Total number of individuals of all species

Frequency of species A = (Number of plots in which species A occurs x 100) / Total number of plot samples

Relative Frequency of species A = (Frequency value of species A x 100) / Total frequency value of all species

Relative dominance of species A = Total basal area of species A x 100) / Total basal area of all species

2.5. Important Value index (IVI)

For Grasses IVI= Relative Density (RD) + Relative Frequency (RF) + Relative Cover (RC)

For Trees IVI = Relative Density (RD) + Relative Frequency (RF) + Relative Basal Area

2.6. Framework of GIS Analysis

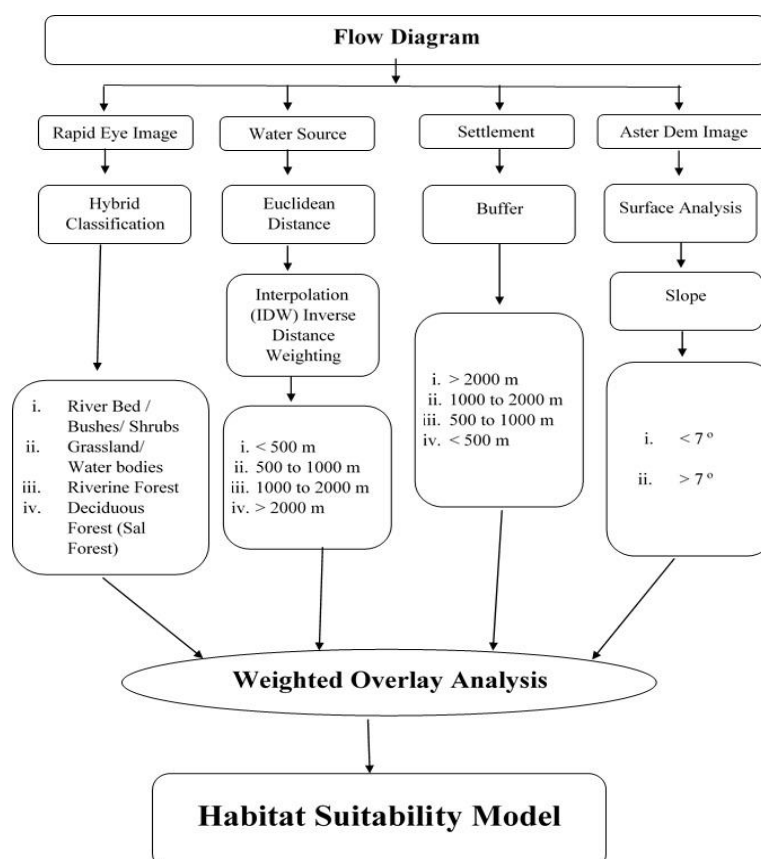


Figure2. Methodological Flow Diagram

3. RESULTS

3.1. IVI of Grass Species

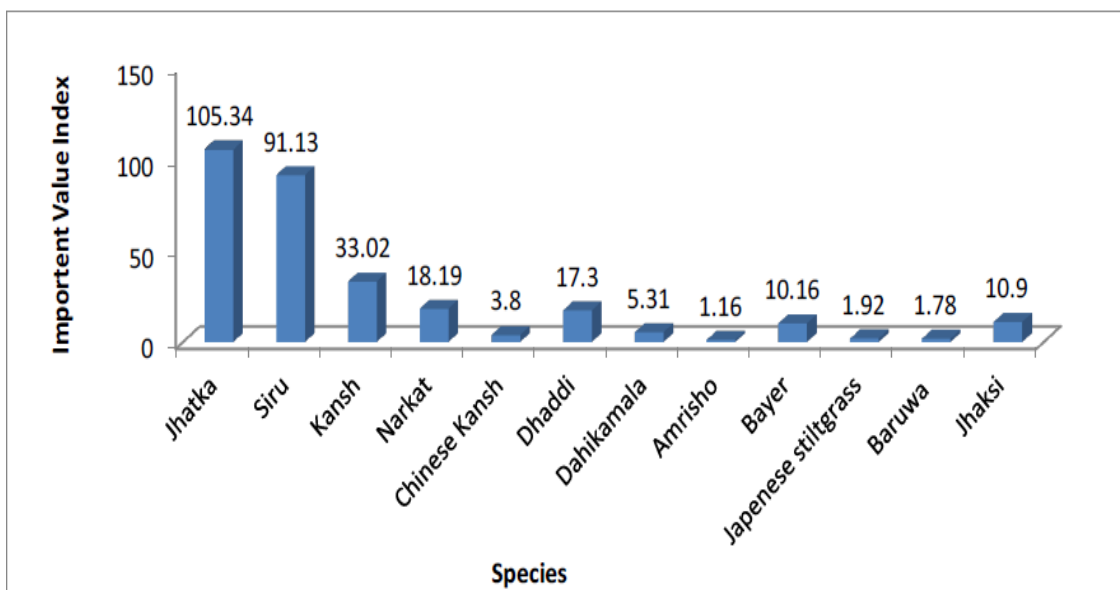


Figure3. IVI of Grass Species in Eastern Sector

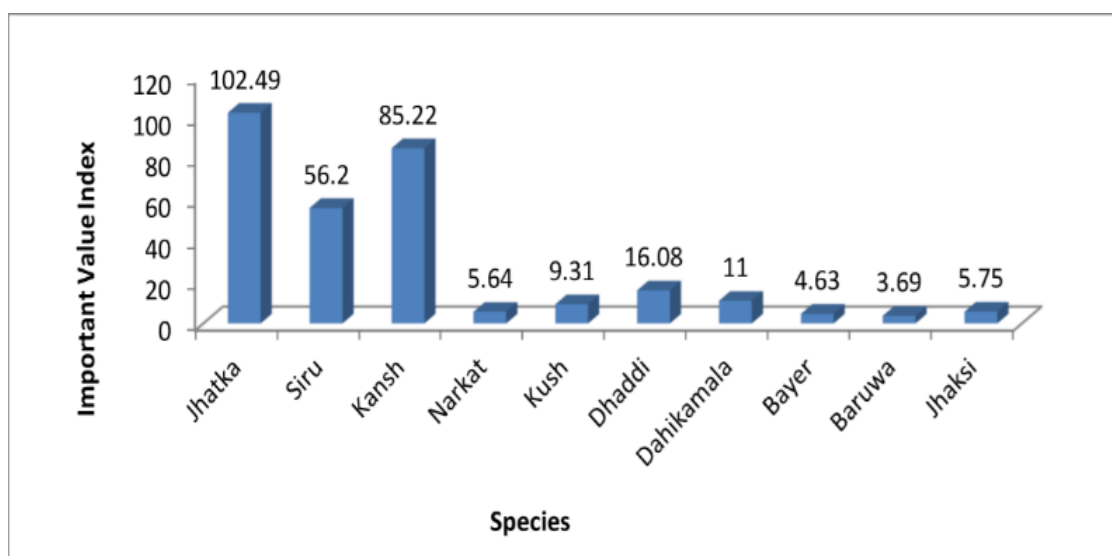


Figure4. IVI of Grass Species in Western Sector

All total 12 species of tall grasses were recorded out of which the dominant grass species recorded in the eastern sector grassland was Jhatka (*Saccharum arundinacium*) with IVI of 105.34 followed by Siru (*Imperata cylindrical*) with IVI of 91.13 and Kansh (*Saccharum spontaenum*) with IVI of 33.02 as the second and third most dominant species respectively. The Relative Density of Jhatka, Siru and Kansh were 17.24%, 60.39% and 10.89% respectively and the relative coverage were 59.30%, 17.94%, and 7.73% respectively.

Likewise, in the western sector grassland consists of 10 different species of tall grasses. Out of which, dominant species was same Jhatka (*Saccharum arundinacium*) with IVI value of 102.49 followed by Kansh (*Saccharum spontaenum*) in this site with its IVI value of 85.22 and Siru (*Imperata cylindrical*) with IVI of 56.20 as the second and third most dominant species respectively. The relative density of Jhatka, Kansh and Siru were found to be 17.63%, 31.37% and 37.10% respectively and the relative coverage were found to be 48.35%, 32.98%, and 8.66% respectively.

In addition, among the small species found in the eastern sector, Fern (*Dryopteris sps.*) was found to be dominant with Relative coverage of 24.57% followed by Unyu with Relative coverage of 17.24% and

Dicanthium annulatum with relative coverage of 9.48%. Accompanying, there was presence of species like *Cynodon dactylon* and *Cyperus dichome* in eastern sector grassland. Likewise, the small grasses of western grassland consists of Bansa (*Digitaria ciligara*) as dominant one with the relative coverage of 38.47% followed by Niuro (*Dryopteris cochleata*) with relative coverage of 12.46% and *Cynodon dactylon* with relative coverage of 7.96%. In addition to this, there was presence of *Dichanthium annulatum* and Kuro (*Desmodiuml axiflorum*) in the western sector grassland.

3.2. IVI of Trees Species

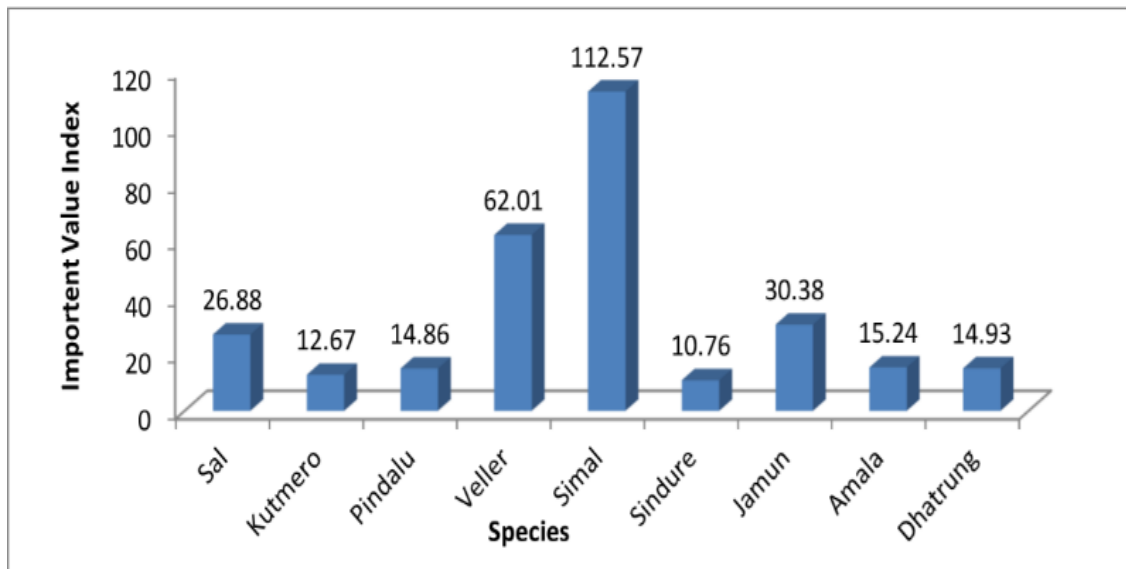


Figure5. IVI of Tree Species in Eastern Sector

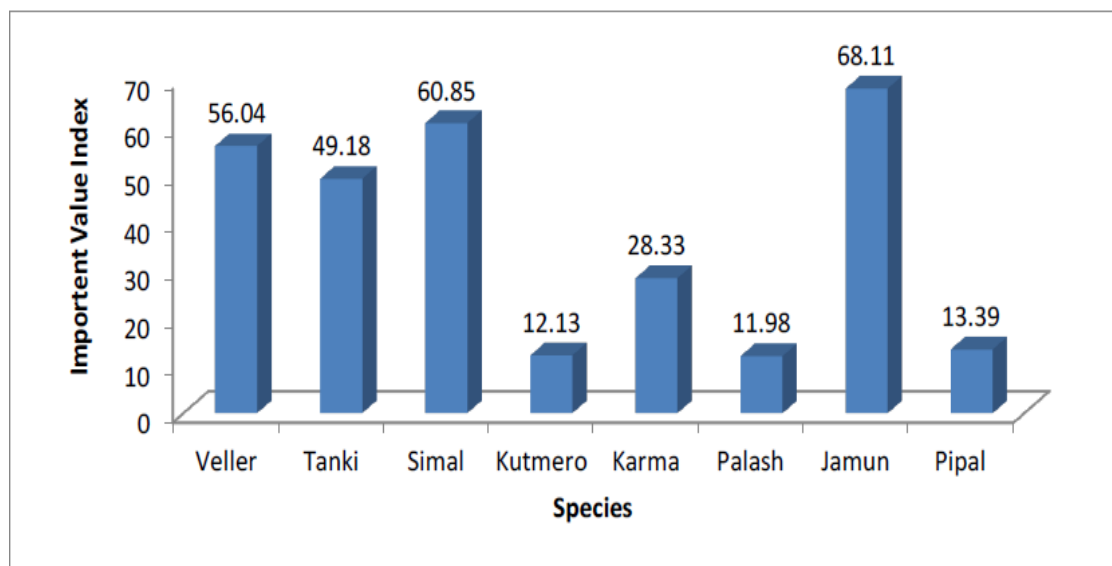


Figure6. IVI of Tree Species in Western Sector

In parallel to grass species, total of 9 species of trees were recorded in eastern sector grassland. The most dominant tree species was Simal (*Bombax ceiba*) with IVI of 112.57 and Relative Density and Relative Basal Area was 29.17%, and 54.0% respectively. The second dominant species was Veller (*Trewia nudiflora*) with its IVI value 62.01 and Relative Density and Relative Basal Area as 29.16% and 15.19%.

Likewise, the grassland of western sector consists of Jamun (*Syzigium cumini*) as dominant species with IVI value 68.11 which is followed by Simal (*Bombax ceiba*) with IVI value 60.84. The third dominant species was Veller (*Trewia nudiflora*) with IVI value 56.08 and the 4th dominant species was Tanki (*Baunia purpuria*) with IVI value of 49.18. The relative density of Jamun, Simal, Veller and Tanki were 27.27%, 22.73%, 13.64% and 18.18% respectively.

3.3. Habitat Suitability

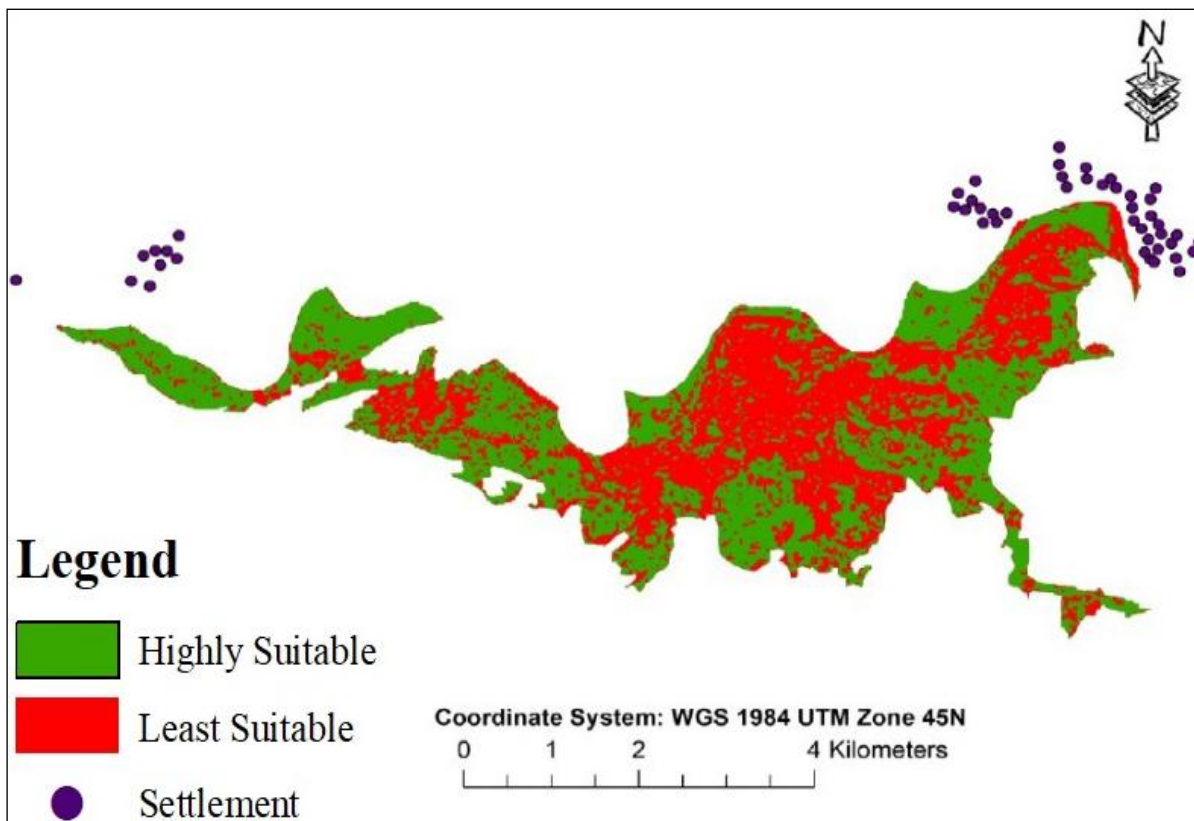


Figure7. *Habitat Suitability Map of Eastern Flood Plain*

In total, eastern sector grassland covers 1943.88 ha out of which 1025.85 ha (52.77%) was predicted as highly suitable habitat while 918.03 ha (49.79%) was least suitable. In figure 7 and 8 the green color represents the highly suitable area while red color least suitable area.

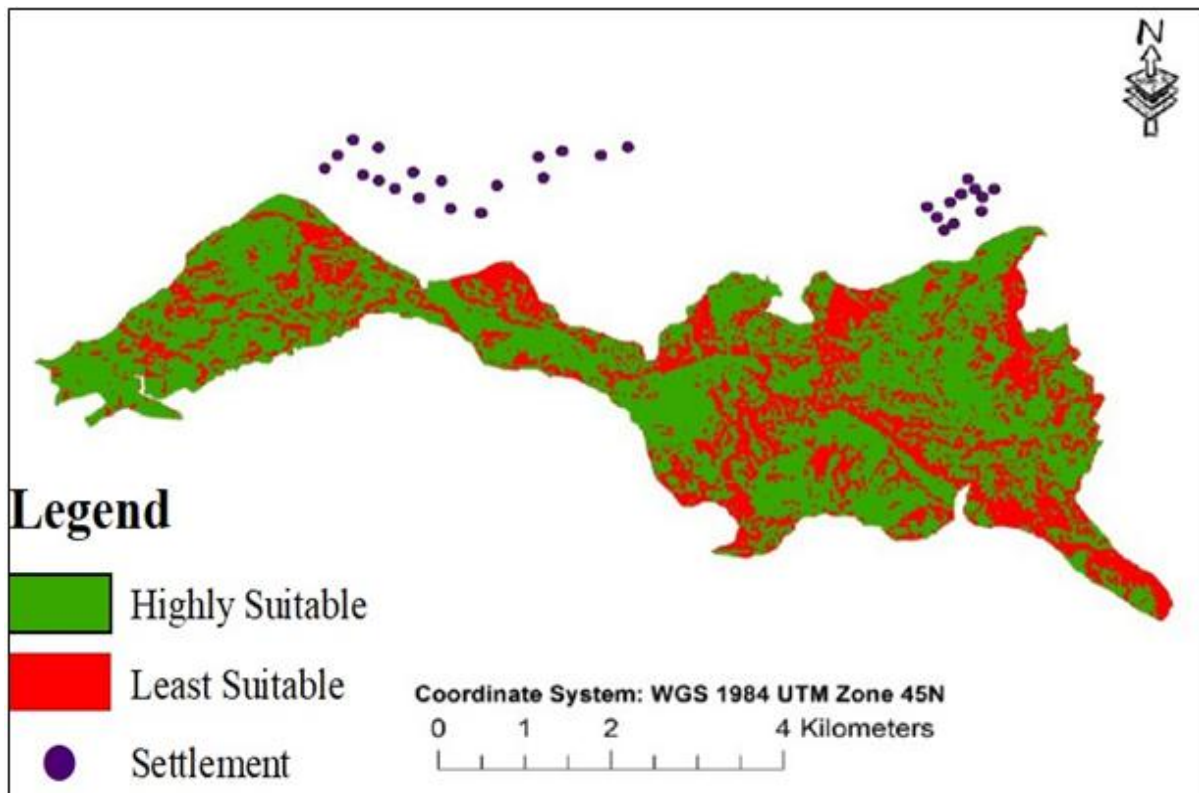


Figure8. *Habitat Suitability Map of Western Flood Plain*

Similarly, in the western sector grassland, out of 2422.67 ha analyzed, the highly suitable area predicted for the habitat of water buffalo was found 1593.57 ha (65.78%) and the least suitable area was 829.1 ha (34%).

Comparing the habitat components of water buffalo in the study sites, the results showed that both eastern and western sector possess dominant vegetations preferred by *B. arnee*. The composition of tall grass in both sites was almost the same though the second dominant and third dominant species were Siru (*I. cylindrical*) and Kansh (*S. spontenium*) in the eastern sector and Kansh (*S. spontenium*) and Siru (*I. cylindrical*) in western sector. Despite of all, dominant species are the preferred food of water buffalo. Similarly, while comparing the small grasses composition, more small grasses preferred by *B. arnee* were found in the western sector than eastern sector grassland. At the same time, while comparing the tree species of two sites the dominance of deciduous species was more in eastern sector i.e. Simal (*Bombax ceiba*) and Veller (*Trewia nudiflora*) while in western sector result showed the presence of evergreen species i.e. Jamun (*Syzygium cumini*) as dominant species. Hence, we can say that both areas are suitable as habitat of water buffalo on the basis of vegetation analysis.

Similarly, while comparing the results of geospatial analysis both areas are suitable as the habitat of wild water buffalo on the basis of distance from the settlement, slope and elevation as a huge portion of study area possess slope below 7°, elevation less than 300m and almost all area is far from settlement. While comparing the water body there is the presence of flowing water body in both study sites while more amount of water body is present in the western sector than the eastern sector. Hence, as water buffalo need more water and sand body as its habitat it can be concluded that western sector grassland is more suitable for water buffalo on the basis of geospatial analysis.

4. DISCUSSIONS

According to [13], both *S. spontaneum* and *I. cylindrical* are the most preferred species of *B. arnee*. Similarly, [2] have agreed on *Arundo donax*, *Saccharum arundinaceum* and *S. spontaneum* as the most preferred foods of *B. arnee* in Thailand. Thus, regarding the study areas both possesses the similar species preferred by *B. arnee* as a dominant species as shown by IVI, resulted the both of areas have suitable habitat based on the availability of preferred foods. In addition, the vegetation analysis also revealed that other grass species like Narket (*Phragmite karka*), Baruwa (*S. bengalensis*), Dubo (*Cynodon dactylon*), Mother (*Cyperus dichtome*), *Dichanthium annulatum* and Kuro (*Desmodium laxiflorum*) were also present which are consumed by wild water buffalo [13]. Similarly, [14] has also agreed on the presence of these species in study area, which makes these areas more suitable for *B. arnee*. Additionally, the most preferred habitat of *B. arnee* consist of *Bombax ceiba*, *Dalbergia sissoo* and *Acacia catechu* [16]. In KTWR, the major forest type used by *B. arnee* is *Acacia-Dalbergia* forest [17]. The IVI index of trees in the study sites indicate the dominant species as *Bombax ceiba* followed by *Trewia nudiflora* and *Syzygium cumini*. Thus, the presence of the forest type preferred by *B. arnee* makes it more suitable for the translocation program.

The geo-spatial analysis of the study area shows that the studied sites are far from all kinds of human influences, hence there are numerous chances of interbreeding with domestic buffalo, but such problem is prevalent in KTWR. The elevation analysis of study sites shows that all area studied is below 330m, hence these criteria were not used for further analysis. According to [11], CNP consists of a mosaic of tall grasslands, short grasslands, riverine forests and Sal forest as well as plenty of wetlands and waterholes created by natural or artificial oxbow lakes and water flowing from Churia which is quite similar to KTWR flood plain [12]. *B. arnee* uses two types of wallows i.e. mud wallow and bath wallow. The geospatial analysis has shown more suitable water bodies in the western sector because of presence of two big flowing water bodies i.e. Rapti and Reu River in comparison to single flowing Rapti River in the eastern sector.

5. CONCLUSION

This habitat suitability analysis of Wild Water Buffalo (*Bubalus arnee*) in the CNP under the environment of geospatial solutions following the weighted overlay analysis concluded that, in eastern flood plain out of 1943.88 ha. only 1025.85 (52.77%) ha was found highly suitable whereas in western flood plain out of 2422.67 ha only 1593.57 (65.77%) ha was found highly suitable as fitted habitat for wild water buffaloes. The study sites are located in core area away from the human influence and have

perennial water sources of Rapti River and Reu River. There were plenty of foods available for the wild water buffalo in the both sites; sufficient availability preferred grass species Jhatka (*Saccharum arundinacium*), Siru (*Imperata cylindrical*), Kansh (*Saccharum spontaenum*) and others. Finally, revealed that both study areas possess worth coverage of suitable area which is more than 50% of total area for wild water buffalo. Comparatively, more suitable area falls under the western sector than eastern sector regarding the analysis of each parameter used in the study. Similarly, western sector floodplain is more suitable based on vegetation analysis, away from the human influence as well as the presence of water bodies. But, the area is far from the central office of the park and very fewer management activities have been done hence; habitat management activity should be done taking wild water buffalo in consideration to make it as the best habitat for wild water buffaloes in the long run.

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