

Impact of habitat management practices, especially canopy manipulation and grassland restoration, on the habitat use pattern of herbivores and the herbivores-carrying capacity in Jaldapara NP, Gorumara NP and Mahananda WLS.



A FINAL REPORT

by



NATURE ENVIRONMENT & WILDLIFE SOCIETY

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“Impact of habitat management practices, especially canopy manipulation and grassland restoration, on the habitat use pattern of herbivores and the herbivores-carrying capacity in Jaldapara NP, Gorumara NP and Mahananda WLS.”

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ABBREVIATIONS

A	Abundance
AU	Animal Unit
AGB	Above Ground Biomass
AVG	Average
D/ha	Density/Hectare
DD	Data Deficient
DM	Dry matter
F	Frequency
GPS	Global positioning System
IUCN	International Union for Conservation of Nature
IVI	Importance Value Index
m	Meter
RA	Relative Abundance
RD	Relative Density
RF	Relative frequency
WL	Wildlife
MT	Metric Ton
NP	National Park
WLS	Wildlife Sanctuary
SDI	Simpson Diversity Index
JNP	Jaldapara National Park
GNP	Gorumara National Park
NI	Number of Individuals
O	Occurrence
Sq	Square
Km	Kilometer
Kg	Kilogram
Ha	Hectare

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Executive Summary

The West Bengal Forest Department envisaged the improvement of Wildlife Habitat in Protected Areas in North Bengal in its totality. To sustain the healthy populations of large herbivores, particularly rhinoceros, elephant and gaur, and reduce the possible man-animal conflict, the Forest Department has been conducting wildlife habitat management through the creation and restoration of grassland with/without planting bamboos, fruit trees and other fodder trees, which increase the food base for those animals. The methodology has been consolidated as a sort of guidelines and the plots for this scheme are confined to the Habitat Improvement Zone, contained in their management plans. It is an accepted management practice to thin out the overhead canopy by cutting down old plantation stock, such as Teak and Simul. After that, grass slips of desirable species are planted and the grassland is maintained by eradicating climbers/weeds and cutting/burning the old stalks during the fourth year after planting. The area is replanted with fresh grass slips mostly after the seventh year.

Towards this, initially grass, bamboo and fodder tree plantation were undertaken by the Forest Department in the Protected Areas of North Bengal. It is known that the plains of Gorumara NP and Jaldapara NP provide the suitable foraging ground for large herbivores. In these two protected areas, restoring the open grasslands is critically important to sustain the population of rhinoceros in particular.

Other than Jaldapara NP and Gorumara NP, the Mahananda WLS is located in a key area for elephant conservation. In Mahananda WLS after canopy-opening of plantation areas, bamboo seedlings and in some plots, fruit tree seedlings were planted.

Hence this study was undertaken to understand the impact of these management practices especially canopy manipulation and grassland restoration, on the habitat use pattern of herbivores and the herbivores-carrying capacity in Jaldapara NP, Gorumara NP and Mahananda WLS.

Therefore, this Research Project titled ***“Impact of habitat management practices, especially canopy manipulation and grassland restoration, on the habitat use pattern of herbivores and the herbivores-carrying capacity in Jaldapara NP, Gorumara NP and Mahananda WLS”*** was commissioned by West Bengal Forest and Biodiversity Conservation Project (WBFBCP). The financial assistance was provided by the Japan International Cooperation Agency (JICA) and awarded to Nature Environment & Wildlife Society (NEWS) for carrying out this research project for three years.

37 managed plots were chosen in Jaldapara NP, 33 in Gorumara NP and 35 in Mahananda WLS. For comparison, a few natural grassland sites were chosen 5 in Jaldapara NP and 3 in Gorumara NP and 4 Teak plantations in Mahananda WLS as it has no grasslands like the other two National Parks.

In all the selected sites of the three PAs, the size of the sampling quadrat was fixed at 10m X 10m (100 sq. m.) for collection of data on vegetation (species diversity and occupancy).

Special emphasis was given to record the presence/absence of the planted species and all weeds, to understand the correlation between their intrusion and growth of grass, fodder and sedge species.

For convenience all the plant species found in the quadrates they were grouped into 4 categories:

- Planted grass & fodder species (planted by Forest Department)
- Naturally occurring grass, fodder & sedge species (those not planted)
- Weed species
- Other species (excluding all the above species)

The documentation of plants from the different sites was tabulated and their Abundance, Frequency & Relative Frequency, Density & Relative Density were also calculated (Baxter, 2014). The Importance Value Index (IVI) was analyzed (Sukla & Chandel, 1980).

Habitat utilization of major herbivores like Rhino, Gaur, and Elephant were mapped with the animal sighting records from the respective forest departments. The data were represented and categorized in five major classes.

Feeding and foraging behaviour of herbivores (Rhino, Gaur, Elephant, Sambar and Spotted Deer and other deer species) was recorded by direct opportunistic observation in Jaldapara NP, Gorumara NP and Mahananda WLS. The plant species consumed were collected immediately from the field and later identified.

For Assessment for Above Ground Biomass (AGB), 3 nested subplots of 1m X 1m were randomly chosen, within the same quadrate in which the taxonomical studies for vegetation were carried out. The wet weight of all these plants was weighed in the field itself and tabulated plot wise and each species expressed as Kg/m². These plants which were collected from each plot were then placed in an open paper or cloth bag and brought back to Kolkata and sun dried. Once totally dried, each sample was weighed with a gram scale and the recorded dry weights were averaged (Voelkel *et al.*, 2018).

After determining annual forage production/ha (plant biomass), using Voelkel's estimation method, the total annual forage produced in the management area was calculated. This was used for determining the carrying capacity of the animals.

Jaldapara National Park

From the present study in the 33 management plots, it was seen that the Planted Fodder species by the Forest Department revealed a low occupancy percentage in all the Ranges varying from an average of 6% to 11% in pre-monsoon and 8% to 12% in post monsoon. These few occurrences of the Planted species may either be due to non-survival at the sapling stage or its immediate consumption by herbivores as soon as the fences were removed.

70% of the total sightings of the Hispid hare (both direct and indirect) was in the habitat managed plots of West and East Range of Jaldapara.

It was seen that the most utilised habitat zone for both the Rhino and Gaur was in the Sissamara and Malangi beats of the East Range. Both these large ungulate species showed a positive correlation between their sightings and the percentage of grassland area.

Poaceae family (Grass species) was the dominant family in terms of the fodders fed by both the Rhino and Gaur.

The maximum estimated Biomass (24,000 kg/ha) comprised of the Planted Fodder Species planted by the Forest Department in the management plots. The least Biomass (3,500 kg/ha) occurred among the Naturally occurring Fodder Species, which were not planted, in the management plots. In between was the Biomass (18,500 kg/ha) of the Fodder Species that occurred naturally in the Natural Grasslands (untouched/unmanaged).

The total Biomass (35,29,251 kg/year) as Available Fodder Species in management plots is approximately only 1/3rd of the Available Biomass of Fodder Species in Natural Grasslands (untouched/unmanaged).

On calculation of the carrying capacity, it was seen that if only the total grassland area (without trees) of Jaldapara NP can support 111 Rhinos, 248 Gaurs and 54 Elephants on the basis of dry season biomass available. 15% of this which is 17 Rhinos, 37 Gaurs and 8 Elephants was calculated to found in the managed plots when only the planted species biomass is considered. However, if the managed plots are taken into consideration as a whole, both the planted species as well as the natural occurring grass species then the carrying capacity is 27% amounting to 30 Rhinos, 68 Gaurs and 15 Elephants.

Gorumara National Park

It was noted that an increase in the percentage of Natural grass (*Saccharum spontaneum*, *Imperata cylindrica*, *Oplismenus burmannii* & *Axonopus compressus*) decreased the intrusion of Weeds (*Lantana camara*, *Mikania micrantha*, *Leea asiatica*, *Chromolaena odorata*, *Clerodendrum infortunatum*) and vice versa. On a total evaluation of vegetation in Gorumara NP the cover percentage for planted species is around 32.96%.

It was also seen that occupancy percentage of Weed species in North Range is higher than the South Range. Weed species occupied about 32% of area in North Range recording the highest among the four categories of plants.

Most utilized habitat zone for both the Rhino and Gaur was Budhram with Ramsai Ext followed by Gorumara Beat of the South Range which has most of the natural grasslands. Both the species showed a positive correlation between sightings and the percentage of grassland area.

A total of 22 species of plants was recorded as consumed by herbivores like Rhino, Gaur, Sambar, Elephant, Barking deer and Spotted deer. Poaceae family (Grass species) was the dominating family in terms of the fodders for all the herbivores like Rhino, Gaur, Elephant and all deer species.

The maximum estimated Biomass (19,000 kg/ha) comprised of the Fodder Species that occurred in the Natural Grasslands (untouched/unmanaged). The least Biomass (4,500 kg/ha)

occurred among the Naturally occurring Fodder Species, which were not planted, in the management plots. In between was the Biomass (13,100 kg/ha) of the Planted Fodder Species in management plots.

The total grassland area of Gorumara NP can support 38 Rhinos, 86 Gaurs and 19 Elephants on the basis of dry season biomass available. 18% of this which is 7 Rhinos, 17 Gaurs and 4 Elephants was calculated to found in the managed plots when only the planted species biomass was considered. However, if the managed plots are taken into consideration as a whole, both the planted species as well as the natural occurring grass species, then the carrying capacity is 23% amounting to 9 Rhinos, 21 Gaurs and 5 Elephants.

Mahananda Wildlife Sanctuary

Grass and bamboo fodder species diversity in canopy opened plots of Mahananda WLS was calculated to be 3% of the total plants recorded, while fruit fodder diversity is minimal in the sample plots. In comparison to the canopy opened plots, the teak plantation plots showed less grass fodder species as it recorded only 35%, while total grass and bamboo fodder density in whole of Mahananda was 57%.

Among the weeds *Chromolaena odorata*, *Mikania micrantha*, and *Clerodendrum infortunatum* were denser than others. The weed species density was calculated to be almost 10% in Teak plantation and 5% in the canopy opened plots.

Of the two major herbivores in Mahananda only Gaur shows a positive correlation between sightings and the percentage of grassland area.

A total of 7 plant species was recorded as consumed by the herbivores like the Elephant, Gaur, Barking deer and Spotted deer.

The maximum estimated mean Biomass (800kg/ha) comprised of the Planted Fodder Species planted by the Forest Department in the management plots. The least Biomass (540 kg/ha) occurred among the Naturally occurring Fodder Species, which were not planted, in the management plots. This trend was seen also in the total Biomass of the Fodder Species as well as in Consumable Biomass of Fodder Species.

The biomass of the planted species of grass fodder in the managed plots of Mahananda WLS was seen not to support any animal by its own, but with the naturally growing grass fodder species present in the managed plots it is seen to support 1 elephant and 2 gaurs on the basis of biomass in the dry season as per our findings.

Suggestions and recommendations

Grassland (Fodder species)

Cover and abundance were estimated for grasses, shrubs, herbs, and sedges. Data collection in grasslands was carried out in the pre- and post-monsoon season i.e. December, 2018 and October, 2019.

Our findings clearly indicate that Dhadda is not a good species to be planted in the management plots. This has also been reflected in the latest Management Plan of Jaldapara NP where they have suggested only 50% of Dhadda be considered for plantation. We would like to go a little further in that our suggestion would be to plant only 10% of Dhadda and over the next couple of years after a rapid analysis to remove the species from the plantation list. There is enough Dhadda available in the open unmanaged grasslands to be sustainable by itself. Moreover, over the years as per the plantation journals it is seen that the older plantations are left and mostly not tendered and in addition occupying space where other fodder can be planted or can grow on their own as is seen in the present study.

In addition, *Digitaria* sp. and other Bamboo sp. may be added in the list of species to be planted in Mahananda as both grass and bamboo fodder species accounted for nearly 60% of the fodder species in the canopy opened plots. Along with all these species only 10% of Dhadda may be considered for planting.

The fodder species suggested may be planted based on the grazing capacity of herbivores, in addition legumes which should be mixed together and sown as a mixed crop with a species mix ratio of 45%:20%:20%:15%.

Invasive Weeds

In the present study among the weed species recorded, *Mikania micrantha*, *Chromolaena odorata* and *Ageratum conyzoides* were the dominant and recorded only 20% as maximum. It is suggested that weeding of these species should be done just before the opening of the fences. While uprooting one has to be very specific about the weed species and the timing of its flowering and fruiting season.

Animal Sightings

During the study period, 70% of the total sightings of the Hispid hare (both direct and indirect) in JNP was documented from the managed plots of West and East Range. In those places where the Hispid hare was sighted, it was seen to choose tall, coarse and old Dhadda plantation beds for its nesting ground. In these areas to prevent natural succession Dhadda may be considered for planting, helping in maintaining the habitat of the Hispid hare.

Opportunistic Feeding Behaviour

It is seen from the feeding behavior that these herbivores feed on a variety of fodder species of plants. However, Dhadda and Chepti seem to form nearly 50% of their diet. It is suggested that there is a need to increase the naturally growing grass species as suggested by planting them in the management plots.

Fodder Biomass

It is seen that the estimated Biomass comprising of the Planted Fodder Species planted by the Forest Department in the management plots and the estimated Biomass of the Fodder Species that occurred naturally in the Natural Grasslands (untouched/unmanaged) were the maximum. In fact when the Available Biomass of Fodder Species was taken into consideration it is seen

that the Biomass in the Management Plots is approximately 1/3rd of the Biomass of Natural Grasslands (untouched/unmanaged).

This indicates that if this 1/3rd of Managed plots has helped in the steady growth of these large herbivores, it is suggested that 10 to 20% more management plots may be undertaken for plantation with the species identified above under Grassland as a general prescription. In fact this is true of Mahananda where the Biomass of Natural Grass species growing within the management plots seem to sustain the carrying capacity of the animals, because even though Dhadda was present the planted species did not have enough Biomass to sustain even one animal.

We recommend that in future for all Forage Biomass Estimations especially from management plots should be undertaken at least a couple of days before the fence are removed. Also Biomass estimations should be reflecting at least two seasons if not the ideal four seasons. This will go a long way in the calculation of the Carrying Capacity of not only the grassland ecosystem but also of the animals that depend on this ecosystem. In addition to regenerate more grassland areas it is recommended that canopy opening may be undertaken in old teak plantations and in monoculture plantations in the 3 Protected Areas.

Grazing

The timing of the removal of the fence from the management plots is very crucial both for the plants as well as for the grazers. We recommend a deferred and rotational grazing for long term sustenance of plant species and the animal species.

Carrying Capacity

The Carrying Capacity of the grasslands are adequate for the present species of animals. It is at a stage when the Carrying capacity of the Herbivores will overshoot beyond its sustenance. It is recommended to have 10% extra management plots in each Range. In addition it is useful to procure the adjacent tea gardens or at least portions of it that border the Protective Areas for future growth of the large ungulates.

The study revealed that the impact of managing the grasslands in these Protective Areas have shown in the turnover of the large herbivores which have had a logarithmic growth since the initiation of such management practices. In effect the study revealed that the past management intervention of grassland development and canopy opening has helped enhance the ecosystem and wildlife in all the 3 PAs of North Bengal. From our study we have suggested a few alterations for the betterment of the management practices and introduce regular monitoring and correction through adaptive management.

1. General Introduction:

This Research Project titled ***“Impact of habitat management practices, especially canopy manipulation and grassland restoration, on the habitat use pattern of herbivores and the herbivores-carrying capacity in Jaldapara NP, Gorumara NP and Mahananda WLS”*** was commissioned by West Bengal Forest and Biodiversity Conservation Project (WBFBCP). The financial assistance was provided by the Japan International Cooperation Agency (JICA) through them to Nature Environment & Wildlife Society (NEWS) for carrying out this research project for three years.

The West Bengal Forest Department envisaged the improvement of Wildlife Habitat in Protected Areas in North Bengal in its totality. To sustain the healthy populations of large herbivores, particularly rhinoceros, elephant and gaur, in the protected areas in the North Bengal and reduce the possible man-animal conflict, the Forest Department has been conducting wildlife habitat management through the creation and restoration of grassland with/without planting bamboos, fruit trees and other fodder trees, which increase the food basis for those animals. The methodology has been consolidated as a sort of guidelines and the plots for this scheme are confined to Habitat Improvement Zone in the protected areas, contained in their management plans. It is an accepted management practice to thin out the overhead canopy by cutting down old plantation stock, such as Teak and Simul, and by girdling (*i.e.* cutting up to phloem layer). After that, grass slips of desirable species are planted and the grassland is maintained by eradicating climbers/weeds and cutting/burning the old stalks in the fourth year after planting. In the seventh year, the old grasses are uprooted and the area is replanted with fresh grass slips.

Towards this initially grass and fodder tree plantation was undertaken by the West Bengal Forest Department in the Protected Areas located in the Plains of North Bengal. It is known that the plains of Gorumara NP and Jaldapara NP provide the suitable foraging ground for large herbivores. In these two protected areas, restoring the open grasslands is critically important to sustain the population of rhinoceros in particular. However, many such areas have been getting shrunk due to the natural succession with the rapid growth of colonising tree species. At the same time, the numbers of the threatened species have been increasing due to the success of conservation effort by the Forest Department for the past decade. Thus, the shortage of open grasslands has become more serious management issue for recent years. The grass species so far planted by the Forest Department are: Dhadda (*Saccharum narenga*), Chepti (*Themeda arundinacea*), Malsa (*Saccharum longisetosum*), Madhua (*Saccharum arundinaceum*), Ekra (*Saccharum longisetosum* var. *hookeri*), Nal (*Arundo donax*), Khagra (*Pharagmites karka*), Bhutta ghash (*Coix lachryma-jobi*), Banspati (*Setaria* sp.), Purundi (*Alpinia nigra*), etc. The tree species planted are: Sissoo (*Dalbergia sissoo*), Chapalish (*Artocarpus chaplasha*), Kumbhi (*Careya arborea*), Chalta (*Dillenia indica*), Jogdumur (*Ficus hispida*), etc. In addition, old grassland of over seven years old was revitalized by similar operation.

Other than Jaldapara NP and Gorumara NP, the Mahananda WLS is located in a key area for elephant conservation. Herds of elephant stay in the foothills longer than other areas along migration routes before crossing to Nepal and after coming back to West Bengal. During the

stay, they raid paddy fields or maize farms, damaging crops and house properties seriously. After canopy-opening of plantation areas, bamboo seedlings and in some plots, fruit tree seedlings will be planted by the Forest Department. The bamboo species used will all be indigenous species: Bhalu bans (*Dendrocalamus sikkimensis*), Choya bans (*Dendrocalamus hamiltonii*), Mala bans (*Bambusa nutans*), Kalaimakla (*Bambusa vulgaris*) and Mulibans (*Melocana baccifera*).

Towards achieving these goals, the respective Forest Department undertook management interventions of planting grass fodder during the past 30 years in open grasslands/areas after canopy opening as plantation sites. This led to an increase not only in the Rhino populations but also in other herbivores like the Elephant, Gaur, Sambar, Chital, Barking deer, Wild boar and Hog deer.

Hence this study was undertaken to understand the impact of these management practices especially canopy manipulation and grassland restoration, on the habitat use pattern of herbivores and the herbivores-carrying capacity in Jaldapara NP, Gorumara NP and Mahananda WLS.

However, due to the Covid-19 pandemic which led to a total shutdown of India including the State of West Bengal from March 2020 till August 2020 with the Protected Areas opening up only after September/October 2020 the project was brought down to a study period of only six months as all the field work had to be completed on or before the 31st of March, 2021. Therefore, many of objectives were not fully complied with, like for example the seasonal studies carried out in Jaldapara NP could not be undertaken in either Gorumara NP or in Mahananda WLS. The opportunistic foraging studies which had been kept for the last year of the project could not be carried out to our satisfaction. Only representative AGB (Above Ground Biomass) was collected for analysis as time was the biggest constraint.

The management plots undertaken in this study in the three Protected areas were chosen by the respective Forest Officials for the detailed study of vegetation and for AGB collections.

Protected Areas represent glimpses of awe-inspiring creativity of evolutionary processes, albeit somewhat edited by the human footprint on wilderness. These sacred lands are the only ones capable of providing us a kinship with wondrous wild creatures and plants, our fellow travelers on this planet. We need to ensure their persistence for posterity. Over the past three decades Protected Area Management in India has come to be driven by Scientific Wildlife Management plans, slowly at first, later as a mandatory process. Such conservation efforts cannot be sustained without long-term vision, direction and quality, based on Integration of modern scientific precepts.

Protected areas of West Bengal cover 4% of the state having 4692 sq.km. of forests under Protected Area (PA) network which is 39.50% of the State's recorded forest area. There are 6 national parks and 16 wildlife sanctuaries in West Bengal.

The geographical positioning of West Bengal is distinctive as it is the only state within the Indian region, which extends from the Himalayas in the North to the Bay of Bengal in the south, and

has many perennial rivers flowing through the state. Therefore, it enjoys an alpine as well as a sub-tropical climate.

Located in the eastern part of India, the State of West Bengal, occupies a geographical area of 88,752 sq km, (2.70% area of the country). The State lies between 21°29'N to 27°13'N latitude and 85°50'E to 89°52' E longitude. It shares the international borders with Bangladesh in the east, Nepal in the northwest and Bhutan in the northeast. With the rest of India, the State is bordered by Sikkim in the north, Assam in the east, Bihar and Jharkhand in the west and Odisha and the Bay of Bengal in the south. The North Himalayan and the south Alluvial Gangetic Plains are the two natural divisions of the State.

The state has a recorded forest land of 16,902 sq km, of which 3,018.52 sq km under Very Dense Forest (VDF), 4,160.26 sq km under Moderately Dense Forest (MDF) and 9,722.73 sq km under Open Forest (OF), thus constituting 19.04% of the geographical area of the state (FSI, 2019). The forests of West Bengal are classified into seven categories viz., Tropical Semi-Evergreen Forest, Tropical Moist Deciduous Forest, Tropical Dry Deciduous Forest, Littoral and Swampy Forest, Sub-Tropical Hill Forest, Eastern Himalayan Wet Temperate Forest and Alpine Forest.

The protected areas like National Parks, Wildlife Sanctuaries and Reserve Forests have attracted worldwide attention to study vegetation, floral diversity and other wildlife for their conservation, sustainable use and also for proper management of bio-resources. The three protected areas undertaken for the present study have a rich ecological habitat for the wild variety of animal and plants species. The natural vegetation of the areas is mainly contributed by forests of tall trees, grassland and wetland vegetation. The wood land provides food and shelter to a variety of animals and the grassland is the heaven for a variety of herbivores. One of most profound statements ever made was that Protected Area management plans, etc. would provide valuable lessons in launching the landscape approach in the country (Faizi, 2013).

The habitat of any organism is its immediate, physical and biological surroundings which supplies all the elements an animal needs for its survival. A healthy and sustainable wild habitat includes food, cover, water, and space as its basic elements. However, each animal varies in its requirement of these elements. Wildlife populations in forested habitats are dynamic because the forest is always changing. Habitat management is commonly used to maintain and enhance the biological interest of many areas of semi-natural habitat, where natural processes no longer create suitable conditions for desired species. Habitat restoration and creation is increasingly being used to increase the extent of ecologically important habitats in order to mitigate the impacts of overall human development. The modification of past management techniques and the introduction of new ones can provide additional benefits (Malcolm Ausden, 2007).

Habitat management is the key to supporting pre-historic wild animals like the rhino. Individuals or groups of wild animals never use the entire habitat homogeneously, but utilize selective zones of the habitat (Hazarika, 2007). Each species requires a particular habitat, food, shelter and other survival needs, to the extent that species are said to be a product of their habitat (Smith, 1974). This habitat selection could be determined by the availability of food resources, mate distribution as well as safety from predators (Fjellstad and Steinheim, 1996).

There are species-specific variations of habitat use patterns owing to distinct food choices of individual species, which may or may not be available in each habitat patch and home range area (Bell, 1971). The differences in food choice led to variations in habitat utilization patterns among different species; widely applicable among herbivorous animals. The seasonal variation of food availability, such as burning of grasslands and annual floods, affects the variation of habitat utilization pattern of herbivorous animals.

Management Planning is an ongoing process. Adaptive management is the key element. Good planning requires continuous monitoring and evaluation to test the effectiveness of the plan. Lessons learnt act as the feedback to review the appropriateness of management actions and policies and then used to either a) make adjustments to the original plan to keep it on the right track; or b) use the lessons to develop the next version of the plan.

If one has to understand the impact of grassland management some of the following aspects need to be looked into to get a truly holistic picture for future guideline.

Forage/Grasslands

Grasslands in the wider sense are among the largest ecosystems in the world; their area is estimated at 52.5 million sq km, or 40.5 percent of the terrestrial area excluding Greenland and Antarctica (World Resources Institute, 2000, based on IGBP data). In its narrow sense, “grassland” may be defined as ground covered by vegetation dominated by grasses, with little or no tree cover; UNESCO defines grassland as “land covered with herbaceous plants with less than 10 percent tree and shrub cover” and wooded grassland as 10-40 percent tree and shrub cover (White, 1983).

Globally, grasses are represented by 10,550 species belonging to 715 genera (Pathak, 2013) whereas, in India 1,200 species belonging to 268 genera are documented (Karthikeyan *et al.* 1989; Moulik, 1997). About 430 grass species are endemic to India, among them Indian peninsular region shows 55% endemism (Jain 1986). For a proper management of grasslands, it is necessary to know something about the Indian grasslands, its area of occurrence, production potential and management methods. Dabadghao and Shankaranarayan (1973) have grasslands classified into five types:

1. *Sehima* - *Dichanthium* grasslands are spread over the Central Indian plateau, Chota Nagpur plateau and Aravallis. The elevation ranges between 300 and 1200 m.
2. *Dichanthium* - *Cenchrus* - *Lasiurus* grasslands cover northern parts of Gujarat, Rajasthan, Aravalli ranges, southwestern Uttar Pradesh, Delhi and Punjab. The elevation ranges between 150 and 300 m.
3. *Phragmites* - *Saccharum* - *Imperata* grasslands are in the Gangetic plains, the Brahmaputra Valley and the plains of Punjab. The elevation ranges between 300 and 500 m.
4. *Themeda* - *Arundinella* grasslands are found in the States of Manipur, Assam, West Bengal, Uttar Pradesh, Himachal Pradesh and Jammu and Kashmir. The elevation ranges between 350 and 1200 m.

5. Temperate - Alpine grasslands are found above 2 100 m and include the temperate and cold arid areas of Jammu and Kashmir, Himachal Pradesh, Uttar Pradesh, West Bengal and the northeastern states.

These grasslands are major reserves of biodiversity, providing important wildlife habitat. Grasslands have a basic role in feeding herbivores and ruminants and provide important ecosystem services, including erosion control, water management and water purification. Grasslands are very diverse in terms of management, yield and biodiversity value. Determining the status of grassland community structure and long-term ecological studies on various grasslands will be fundamental in systematic planning and development of scientific grassland management regime (Rawat & Adhikari 2015).

The main objective in the management of grassland is to secure the maximum production of herbivores without any detrimental effect to the productivity of grass land. It is therefore essential to see that the grassland under consideration is kept at its peak level of productivity as long as possible. Depending on the respective management regime, these areas provide a wide range of ecosystem services that include carbon sequestration, water filtering, the provision of species-rich habitats or the provision of fodder (Zhao *et al.* 2020; Blair *et al.* 2014; Sala and Paruelo 1997).

Foraging/Grazing/Browsing

Grazing management plays a large role in the quality and extent of wildlife habitat. Practices like grazing too long, stocking too heavily, and applying too much grazing pressure especially in a single pasture system all negatively impact the natural variability of grasslands upon which wildlife populations depend. Over grazing deteriorates the grasslands. Just like human beings, grazing animals, too, have their likes and dislikes and certain grasses are preferred while certain others are avoided. On account of the relative grazing habit, desirable species tend to get depleted in grasslands much faster than other species that are not so palatable. Bison herds never stayed in one place for long, allowing grazed areas to recover. Their hooves churned the soil leaving bare areas for annual forbs and grasses to take hold, and animals like deer, dove, quail, and many others were attracted to these areas.

Since a smaller number of well-fed animals are always better than a large number of half-starved ones, the number of animals is the first principle of all grazing systems. In fixing the number of animals, the carrying capacity of the grassland should be taken into consideration. This is defined as the number of animals that can graze in a unit area without over grazing or under grazing in an average season. The greatest single factor which causes deterioration of grasslands is over-grazing on account of selective grazing habit of animals; desirable species tend to get depleted much faster than the less palatable species. To avoid this risk, grazing must be stopped at some stage or other i.e., in grassland terminology the grazing has to be deferred since it will seldom be possible to stop grazing over entire area, when no other alternative areas are available. The practical method is to defer grazing in a part of the grassland and to allow grazing in the other part in a 'rotational' system.

Forage Biomass

Biomass is defined as the total amount of living vegetation in e.g., a habitat or a sample (Chapin *et al.*, 2002) and is a measure of vegetative growth. Because all living things contain water (fresh mass) and the percentage of water can vary widely from species to species, biomass is calculated as a dry mass. Dry mass is the mass of life that is left after all the water is removed, much like squeezing out a sponge. Total biomass is found by summing the dry mass of all individuals in a given land area and then reported by naming the area of concern, e.g. biomass per plot, ecosystem, biome, classroom. To be able to compare biomass in different locations, biomass is standardized as per unit of area. Typical units of biomass are grams per meters squared (g/m^2), although it is also expressed as kg/m^2 , lb/ft^2 . The first requirement when developing a grazing management plan is setting a proper stocking rate that considers annual vegetation production (kg/m^2). A proper stocking rate matches animal demand with the annual forage production, and consists of three factors: the number of animals grazing, the area being grazed, and the amount of time a given area is grazed. Biomass of grassland vegetation refers to above-ground herbaceous flora, commonly referred to as 'dry matter (DM) yield.'

Plant biomass measurement is a fundamental procedure for grassland management and grassland field studies. The precision of herbaceous biomass estimation depends not only on the sample number (Iwasaki 1976), but also on the spatial heterogeneity of the biomass (Iwasaki 1976) and sampling procedures (Cobby *et al.* 1985). Research workers and managers of grassland vegetation are interested in this to determine the amount of available forage for animals or to measure the effects of management on the vegetation. Traditional biomass measurements are considered the most reliable method for determining aboveground biomass (AGB) (Desalew *et al.*, 2010). However, they are extremely labor demanding and time consuming; including cutting of biomass in field, followed by drying and weighing of biomass in laboratories.

Forage can be divided into botanical species, into groups of species (grasses, legumes, weeds or other species), or into standing green and dead material and litter. The quantity of vegetation present at any one given time can be used to calculate changes, such as herbage growth, utilization by grazing animals, or deterioration. Although the basic techniques of measuring the amount of vegetation present can be used for each of these purposes, the procedures and intensity of sampling will differ depending on the objectives of the measurements.

Vegetation also varies in quality according to their stage of growth and maturity. Plants are most nutritious during the early growing stages. Once mature the nutritive value of plants declines – especially for herbaceous plants (Desalew *et al.*, 2010). At the same time the plants' content of fibre, lignin and cellulose increase. These substances serve as protection from high temperatures and evapotranspiration. But they also reduce their nutritional content and digestibility, making them more indigestible to animals (Powell *et al.*, 1996). Therefore, the early growing stages are important for the animals.

Carrying Capacity

The number of animals a piece of land can support on a long-term basis without causing damage to the range resource is the carrying capacity (or grazing capacity) of the land. Thus,

carrying capacity is set by mother nature, through soil and climate characteristics; stocking rate is set by humans, through wildlife management. Large herbivore carrying capacity, that is, the maximum biomass of large herbivorous mammals that an ecosystem is able to sustain for the long term, is a key factor in ecosystems trophic dynamics.

In a mammalian community, the biomass of secondary consumers (carnivores) depends on the biomass of their prey, namely, the herbivores, and this biomass, in turn, depends on primary production (McNaughton *et al.*, 1989; Oesterheld *et al.*, 1992), which, in turn, is determined by climate (mainly temperature and rain fall) and soil fertility (Rosenzweig, 1968; Fritz and Duncan, 1994). Generally speaking, the total ungulate biomass is closer to estimated carrying capacity in open than in closed forest because of the different distribution of primary production, which results in different food availability for the large mammal herbivores.

The dynamics of a plant-herbivore system can be represented by three components (Caughley, 1979): 1) the functional response of the herbivore, which describes plant biomass intake by herbivores as a function of standing plant biomass, 2) the numerical response of the herbivore, which describes the rate of increase of herbivores as a function of standing plant biomass, and 3) the plant growth response, which describes the rate of increase of plant biomass as a function of plant density.

This present study has a direct application to the conservation of wildlife implicitly and will also serve as a primary input for planning management interventions for sustaining the phyto-diversity of the diverse grass/forest cover present in the area of study.

In this report we document a comprehensive inventory of all grass and tree species wherever present, both quantitatively and qualitatively with relevant statistical analysis in random quadrates from the selected management plots along with some natural plots in each of the three Protected areas. Also, Above Ground Biomass (AGB) estimations were undertaken in randomized nested subplots in the same plots from where the vegetation data was recorded. All these plots were chosen by the West Bengal Forest Department.

Data collected from the Forest Department on animal sightings in the three Protected areas have also been computed and analyzed. Along with this the foraging behavior of animals was documented by direct opportunistic observation of herbivores (Rhino, Gaur and Deer species) feeding pattern with the help of vehicles and departmental elephants. In addition, in Jaldapara NP, the habitat use by hispid hare was carried out by signs (pellets) and direct opportunistic observation.

All these have been explained through relevant statistical analysis with Tables and Pie diagrams. Based on the findings, relevant calculations have been made to enumerate the AGB and relate it to the Carrying Capacity of these Protected areas.

The final findings have been explained separately with particular reference to the impact of management for each of the Protected area along with recommendations for future management in these individual areas. A general conclusion and suggested recommendations as whole are also given to understand these areas holistically, to enable its inclusion in future adaptive management plans of these Protected areas of the West Bengal Forest Department.

2. Objectives:

- I. To finalise the methodology and selection of study sites in consultation with the client.
- II. To assess the impact of habitat management practices with emphasis on canopy manipulation and grassland management in Jaldapara NP, Gorumara NP, and Mahananda WL Sanctuary on the habitat use pattern of herbivores (especially all Deer species, Rhino, Elephant, Gaur and Hispid hare) and the Bengal Florican.
- III. To assess the Herbivore-carrying capacity of these PAs.
- IV. To identify the major weeds in the PAs, assess the occupancy percentage, evaluate the current practices for weed elimination and suggest measures for strengthening effective weed management.
- V. To develop habitat management plans for the three Protected Areas in relation to the herbivores, especially in regard to canopy manipulation and grassland management.
- VI. To incorporate the comments and suggestions of the Wildlife Wing and other field officers received through PMU office.

1. General Methodology

a) Discussion with forest officials and collection of plantation journals:

Discussions were carried out with the respective forest officials in all the three PAs.

Both old and new Plantation journals that were made available were collected from respective ranges of Jaldapara NP, Gorumara NP and Mahananda WLS. In addition, archival documents like previous Management Plan, Rhino Census Report (2013, 2015, and 2019), old and new cut back and burning records and Annual Report (2015-16) of Jaldapara NP were also collected. All these documents were photo copied for reference.



Figure 1: Discussion with the Forest Officials

b) Selection of sites:

I. For collection, identification & documentation of plants

Sites were selected by going through all the available archive journals/reports/ documents including repeated plantation sites and after discussion with the relevant Forest Officials. A ground survey was also conducted before the actual sites were selected, to understand different ecosystem, habitats and river pathways. The survey also examined the relationship between light availability and canopy type viz. open pasture, planted canopy, and secondary forest on understory grass biomass. The plots were so chosen that they were located in the different habitats like low land, high land etc, and near adjoining water bodies and salt licks. All these sites were chosen with the approval of the Forest Department.

II. For assessing vegetation in managed and natural sites

These sites were randomly selected with the help of the Respective Forest Departments, so that they are representative of all the beats and ranges in three Protected Areas. Based on these, 37 managed plots were chosen in Jaldapara NP, 33 in Gorumara NP and 35 in Mahananda WLS. Simultaneously for comparison, 5 sites of natural grassland in Jaldapara NP, 3 Sites in Gorumara NP and 4 Teak plantation in Mahananda WLS as it has no grasslands like the other two National Parks.

III. For assessing Above Ground Biomass (AGB)

Sites for the biomass assessment were selected randomly from the same sites where the taxonomical studies were carried out for the JNP, GNP and Mahananda. 10 sites from JNP, 16 sites from GNP and 10 sites from Mahananda were chosen for grass collection. The sites were so chosen that at least one plot from each beat was represented. Two natural plots were also randomly selected at Jaldapara North and East Ranges. Similarly, two natural plots were randomly selected in Gorumara South Range.

c) Assessment of flora in the selected sites:

In all the selected sites of the three PAs, the size of the sampling quadrature was fixed at 10m X 10m (100 sq. m.) for collection of the data on vegetation (Species diversity and occupancy).

Special emphasis was given to record the presence/absence of the planted species and all weeds, to understand the correlation between their intrusion and growth of grass, fodder and sedge species.

In Mahananda WLS vegetation occupancy method could not be done as most of the plots were under canopy openings and along with the grass fodder species tree species were also there.

I. Calculation methods for Vegetation occupancy:

For occupancy percentage calculation in this study, both *Saccharum narenga* and *Themeda arundinacea* were selected as standard species and given the score as 1 as these were the large planted grass species. A mature plant species generally occupied more or less same land area in different quadrates. As an example, one individual of either *Saccharum narenga* or *Themeda arundinacea* usually take up a land area of 9 sq ft, where 50 individuals of *Ageratum conyzoides* also occur in the same area. So, the score for *Ageratum conyzoides* is calculated as $1/50$ i.e. 0.02.

Such a scoring of all plant species found at Jaldapara and Gorumara were done first and then multiplied with the individual plant number which was encountered in each quadrature during survey. Occupancy percentage was calculated for all species (planted, natural grass and weeds) within the 100 sq. m. area. Summation of all species occupied is always 100. (Elzinga *et. al.*, 1998)

For convenience all the plant species found in the quadrates were grouped into 4 categories:

- Planted grass & fodder species (planted by Forest Department)
- Naturally occurring grass, fodder & sedge species (those not planted)
- Weed species
- Other species (excluding all the above species)

II. Statistical evaluation of the data:

The documentation of plants from the site was tabulated and their Abundance, Frequency & Relative Frequency, Density & Relative Density were also calculated (Baxter, 2014) Range wise and also total PA wise. The Importance value Index (IVI) was analysed by summing up the

values of Relative Density, Relative Frequency and Relative Abundance (Sukla & Chandel, 1980). The adopted formulas are as follows –

$$1. \text{Abundance}(A) = \frac{i}{n}$$

Where, i = total number of individuals of a species and n = number of quadrates in which the species has occurred.

$$2. \text{Frequency}(F) = \frac{n}{N}$$

$$3. \text{Frequency \%}(F\%) = F * 100$$

Where, n = number of quadrates in which the species has occurred and N = Total number of quadrates studied.

$$4. \text{Relative Frequency}(RF) = \frac{F}{f}$$

$$5. \text{Relative Frequency \%}(RF\%) = RF * 100$$

Where, F = frequency of a species and f = total plant frequency.

$$6. \text{Density}(D) = \frac{x}{c}$$

Where, x = total number of a species and c = area studied.

$$7. \text{Relative Density}(RD) = \frac{D}{d}$$

Where, D = density of a species and d = total plant density.

$$8. \text{IVI (Important Value Index)} = RA + RF + RD$$

Where, RA=Relative Abundance, RF= Relative Frequency and RD= Relative density

The species diversity was calculated by Simpson Diversity Index.

$$9. \text{Simpson Diversity Index (SDI)} = \sum \frac{ni(ni-1)}{N(N-1)}$$

Where, ni = number of individuals of a species and N = Total number of individuals of all species.

d) Habitat use by animals:

I. Hispid hare:

Habitat utilization of Hispid hare was analyzed by using photographs of the Hispid hare, and by collection of pellets in the sites identified by the Forest Department and by direct sightings. All the sites were tagged by GPS and micro habitat was noted during the study.

II. Other Herbivores:

Habitat utilization:

Habitat utilisation of major herbivores like Rhino, Gaur, and Elephant were mapped with the animal sighting records from the forest departments. The data were represented beat wise (in case of Mahananda it is range wise) and categorised in five major classes:

1. Most Preferable,
2. High Preferable,
3. Moderately Preferable,
4. Least Preferable and
5. Not Preferable

e) Herbivores feeding behaviour observation:

Feeding and foraging behaviour of herbivores (Rhino, Gaur, Elephant, Sambar and Spotted Deer and other deer species) was recorded by direct opportunistic observation in Jaldapara NP, Gorumara NP and Mahananda WLS. In Jaldapara the observations were made with the help of vehicle as well as on elephant back. In Gorumara and Mahananda observation were made mainly from the observation camps and watch towers. The plant species consumed were collected immediately from the field and later identified. Photographic evidence was also recorded and later used for identification of the preferable fodders. High zooming camera and binoculars were also used during observation. All observation points were tagged with GPS. Observing Sambar and other Deer species was difficult as they are very shy animals and run away when approached.

f) Assessment for Above Ground Biomass (AGB):

When developing a management plan for grazing herbivores, the first essential thing is setting a proper stocking rate that considers annual vegetation production (kg/ha). A proper stocking rate matches animal demand with the annual forage production, and consists of three factors: the number of animals grazing, the area being grazed, and the amount of time a given area is grazed. There are many methods of determining plant biomass, but perhaps the most common method used for rangeland and pasturelands is clipping and weighing.

For this technique, 3 nested subplots of 1m X 1m were randomly chosen, within the same quadrat in which the taxonomical studies for vegetation were carried out but only in the dry season. All the plants present within the subplot were clipped to within 2-3 cm of the soil surface. All clipped samples were further separated by species and also as per their height viz. small, medium and tall. The wet weight of all these plants was weighed in the field itself and tabulated plot wise and each species expressed as Kg/m⁻².

These plants which were collected from each plot were then placed in an open paper or cloth bag and brought back to Kolkata and sun dried. Once totally air-dried, each sample was weighed with a gram scale and the recorded weights were averaged (Voelkel *et al.*, 2018).

The AGB values were calculated as follows:

$$\text{Water Content} = \text{Fresh Weight} - \text{Dry Weight}$$

$$\text{Standing Biomass (forage production)} = \frac{\text{Dry Weight (of above ground tissue)}}{\text{Plot Area}}$$



Figure 2: Methods of AGB assessment (a= measuring of 1mX1m plot, b= collection of all the species from the plot, c= weighing the species in the field, d= weighing the species after fully air dried)

Calculating of forage:

After determining annual forage production/ha (plant biomass), using Voelkel's estimation method, the total annual forage produced in the management area must be calculated:

$$\text{Available area for grazing} \times \text{Forage production/ha} = \text{Total forage/year}$$

[NOTE: This methodology does not measure woody species biomass, so estimates of forage production in animals for which woody species was a significant part of their diet (e.g. Deers), is likely underestimates.]

According to Voelkel *et al.* 2018, only 25% of the total forage production is utilized by grazers. Therefore, consumable forage would be produced, as follows for the overall grassland available for grazing in Park:

$$\text{Total forage/year} \times 0.25 = \text{Consumable forage/year}$$

There are also areas in forest land that cattle do not graze such as heavy brush, weeds, roads, fire lines, other non fodder species etc. To reduce the risk of overgrazing, these areas were removed from the calculation. The available forage would be determined as follows:

$$\text{Consumable forage} \times \% \text{ Grazeable areas} = \text{Available forage kg /year}$$

g) Carrying capacity:

Ecological carrying capacity (K) is usually defined as the maximum number of animals a defined area can support in relation to available resources (McCullough, 2001), where K is primarily limited by forage.

As Rhino is the keystone species here the calculation of carrying capacity is based on the Rhino suitable grassland area in Jaldapara and Gorumara NP. Besides Rhino and Gaur, Elephant is also considered for this calculation as they preferred the same habitat in Jaldapara and Gorumara NP (Anon., 2018; Anon., 2007a) as all the animals preferred grass species as primary fodders in this region (Peden *et. al.*, 1974; Banerjee, 1993; Ghosh and Das, 2007; Roy, 2010; Lahkar *et. al.*, 2018). But in Mahananda the Elephant is the main species. And as elephants also prefer grassland for foraging so therefore the carrying capacity will be calculated again on the basis of vegetation of the grassland plantation on the canopy opening areas available in Mahananda WLS.

In this study a straight forward approach was taken to determine the Carrying Capacity (K). To find out the number of animals one Protected Area can support over a period of time one need to divide the total forage biomass available in the particular area by the total amount of forage consumed by the targeted animal during the grazing period (Workman & MacPherson, 1973). Here the unit of the Carrying Capacity (K) will be AU/ year). Carrying Capacity of the Protected Areas was measured by using following formula.

$$\text{Carrying Capacity (K)} = \frac{\text{Available forage kg}}{\text{Animal forage requirement kg/year}}$$

h) Collection of Soil samples:

- a. 35 soil samples have been collected from 11 beats (both flooded & non flooded zone of JNP during Pre monsoon & Post Monsoon season.
- b. All the soil samples were studied and analysis was done of all the soil samples on pH, Electrical conductivity, percentage of organic content and Nitrogen, Phosphorus, Potassium content (kg/ha).

[NOTE: The Soil study which was recommended to be undertaken in the present study was subsequently dropped as per PMU letter no. 558/WBFBCP/17-1/19 dtd.03.03.2020. Since then, no more soil analysis was carried out in this project.]

CHAPTER I

4. Jaldapara National Park:

4.1. Study Area:

One of the three Protected Areas undertaken for the present study is in the Jaldapara National Park. This National Park lying in the civil district of Alipurduar in North Bengal between the latitudes 25°58'' and 27°45''N and longitudes 89°08'' and 89°55''E, comprises of 216.51 km² area. Jaldapara National Park is the second largest home after the Kaziranga National Park in Assam, India for the Great Indian One-Horned Rhinoceros (*Rhinoceros unicornis* L.) and is one of the prestigious National Parks of West Bengal.

Initially it was a Wildlife Sanctuary, and in May, 2012 this was upgraded and designated as a National Park. The Park is located in the flood plains of the River Torsa and other small rivers, like Malangi, Buritorsa, Hollong, Sissamara, Kalijhora, Sanjoy, Sukti, Bhaluka etc.

The area of the Park is 216.51 sq.km comprising of 12 blocks, 45 compartments, 29 beats and 4 Camps under eight Territorial Ranges, one Eco-Tourism and one Elephant Squad Range (Anon. 2007, 2019).

The average day temperature varies from 10°C to 21°C from November to February, between 27°C to 37°C during May to September and between 24°C to 27°C during the rest of the year and is adequately humid throughout the year, ranging from 80 to 100%. The soil types are alluvial, with coarse gravel and sandy clay to loam. Annual rainfall exceeds 2000 mm and natural flooding from annual monsoons varies in frequency and magnitude.

The Great Indian One-Horned Rhinoceros is the key-stone species of the Park. The other associated herbivore species are Elephants, Gaur, different species of Deer (Sambar, Hog Deer, Barking Deer, and Spotted Deer), Hispid hare, Indian hare, Wild Boar. It also boasts of the presence of a large number of Avian species (246) and the Leopard and Lesser cats among the carnivores. It has been reported that Jaldapara NP has 33 species of carnivores & herbivores, 29 species of reptiles, 8 species of turtles, 54 species of fishes and a host of other micro fauna (Anon. 2007b, 2019).

The whole area is rich with biodiversity and has a mixture of natural and manmade forests with a great collection of rare and medicinal plants. Jaldapara NP is reported to contain a total of 585 identified plant species belonging to 111 families, 429 genera, including 91 grass species, 19 orchid species and 47 endangered plant species (29 genera) which are of conservation importance (Anon. 2007b, 2019).

The vegetation types present here as per the classification of Champion and Seth (1968) are (1) Evergreen Forests (*Northern tropical evergreen forest*); (2) Semi-Evergreen Forests (*Eastern sub-montane semi-evergreen forest*); (3) Hill Forests (*East Himalayan subtropical wet hill forest*); (4)

Wet Mixed Deciduous Forest (*Sub-Himalayan secondary wet mixed forest*); (5) Dry Mixed Forests (*East Himalayan moist mixed deciduous forest*); (6) Sal Forests (*Eastern Bhabar and Terai sal*); (7) Riverine Forests (*Northern dry deciduous forest*); (8) Savanna (*Moist sal savanna and low alluvium savannah woodland*); and (9) Grassland (*Eastern alluvial grassland*).

The riverine grass lands and savannah wood land occupy 45 percent of the total plant cover of the National Park, offering the best type of grazing ground for the herbivores of the park. This type of vegetation is found in JP-1, 2, 3, 4 & 5, Hasimara-1, 2, 3, 4, Malangi- 1, 2, 3, Torsa-1, 2, 3, Chilapata-1, 2, 3b, Jaigaon-1, 2, Dalsingpara-1, 2, 3, 4 and Titi-1, 2, 3 & 4 compartments confined in East, West, North, Jaigaon, Nilpara and Lankapara Range. However, herbivores are not found in Jaigaon-1, 2 & Dalsingpara-1, 2, 3, 4 Compartment of Jaigaon and Nilpara Range. In Titi block of Lankapara Range, only the deer, wild boar, gaur and elephant are distributed sparsely. Distribution of animals is highly concentrated in old National Park area *i.e.* East, West and North Range mostly (Anon. 2007b).

The vegetation found in Savanna woodland areas are Sal along with Kumbhi, Amloki, Sidha, Tanki associated with grasses in moist savanna Sal land and Simul, with Sirish, Khair, Pitali etc associated with grasses in the low alluvium savannah woodland and dominated by species like *Saccharum spp*, *Arundo donax*, *Phragmites karka*, *Imperata cylindrica* and *Themeda arundinacea* in eastern alluvial grasslands along with the bed of river Torsa and its tributaries in the Park. The grasses are very tall, dense, sometimes 4-5m high and are the principal dwelling places for one horned Rhinoceros.

Rhinoceros mostly occur with high concentration in East, West, North and part of Chilapata Ranges. New fodder plantations are highly grazed by Rhinoceros. Rhinoceros never found in Titi, Jaigaon and Dalsingpara block of Nilpara, Jaigaon and Lankapara Range, beyond National High Way 31A (Anon. 2007b, 2019).

As a keystone species of the Park, the Rhino along with the other herbivores occur mainly in the East, West and North Ranges of the Park; these habitats were undertaken for (Grassland) improvement by the Forest Department.

The present study was therefore confined to the main habitat improvement zone of the Park *i.e.* East, West and North Ranges to identify the impact of Grassland Management in these areas.

Location map of Jaldapara National Park

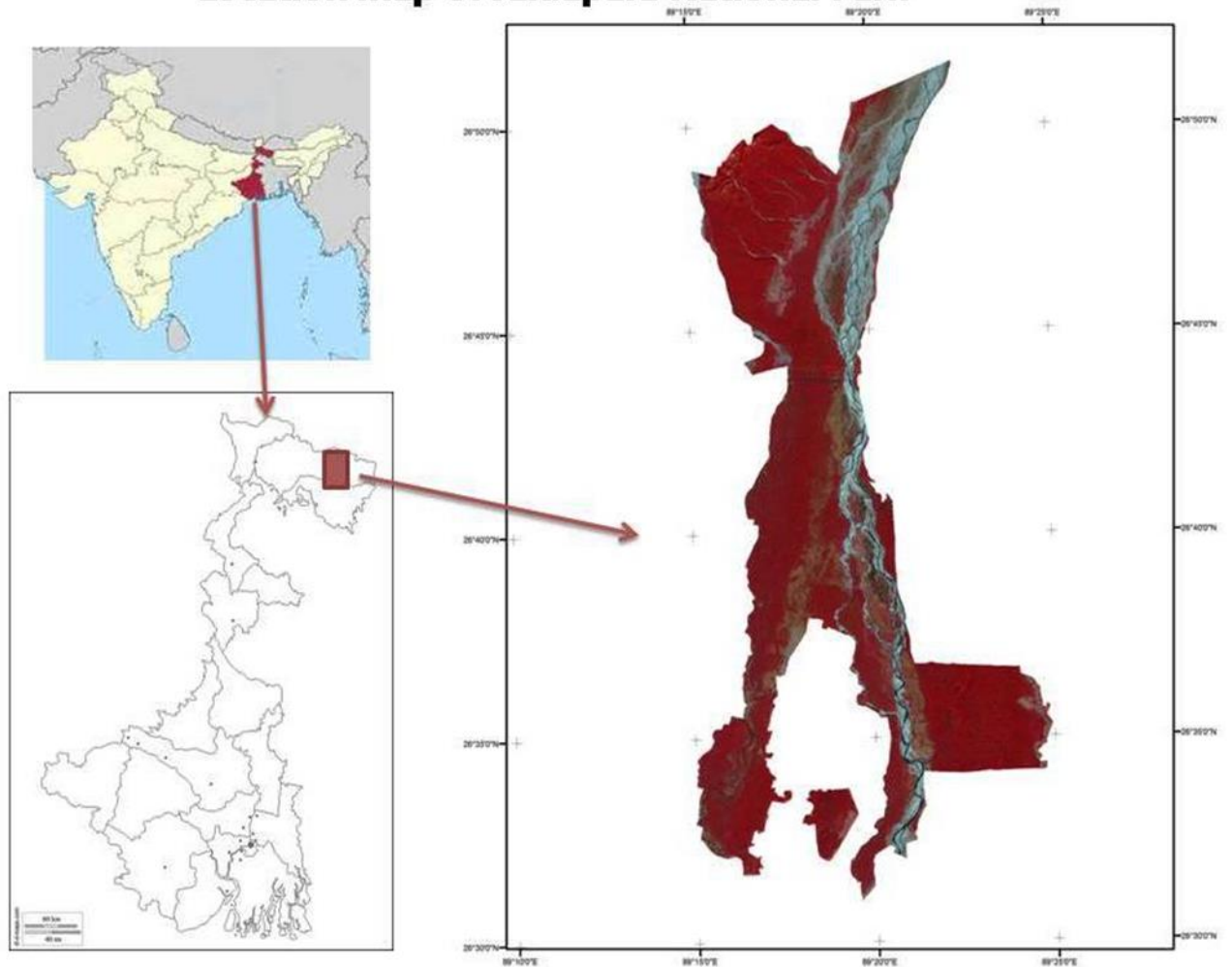


Figure 3: Jaldapara National Park

4.2. Discussion with forest officials and collection of plantation journals

Results:

Detailed discussions were carried out with the following officers of Jaldapara viz. Mr. Ujjal Ghosh, Former CCF, Wildlife, North Bengal; Mr. Kumar Vimal, DFO, Jaldapara NP; Mr. Bimal Debnath, Former AWLW; Mr. Debdarshan Roy, AWLW; Mr. Mukesh Sarkar, Ranger, Jaldapara West Range; Mr. Sibash Sarkar, Ranger, Jaldapara North Range; Mr. Swapan Majhi, Ranger Jaldapara East Range; Beat officers of East, West and North Ranges.

4.3. Archive literature review

Results:

After discussion with the forest officials the relevant archive literatures were collected from the respective Beats and Ranges of JNP 150 Plantation journals were made available by the forest officials of the respective forest Ranges and Beats of JNP. These journals were reviewed and tabulated beat wise with the main details like area, previous plantations, planted species, gap between the planted species, flood conditions, species before plantation etc were tabulated.

Table 1: Details of Plantation journals from Jaldapara NP

Range	Beat	Total journal collected	Repeated plantation /Chosen for study	Onetime plantation /Chosen for study	
West Range	<i>Bendaki Beat</i>	16	6/5	10/2	One journal not found
	<i>Hollong Beat</i>	23	6/2	17/4	
	<i>Mairadanga Beat</i>	17	6/1	11/1	
	<i>Kunjanagar Beat</i>	11	2/0	9/1	One journal not found
	<i>TEC Beat</i>	16	2/2	14/2	One journal not found
Total	5 Beats	83	22/10	61/10	
East Range	<i>Sissamara Beat</i>	7	4/2	3/0	
	<i>Jaldapara HQ Beat</i>	8	8/4	0/0	
	<i>Malangi Beat</i>	8	8/2	0/0	
Total	3 Beats	23	20/8	3/0	
North Range	<i>50 feet Beat</i>	13	2/2	11/0	
	<i>Hassimara Beat</i>	6	0/0	6/2	
	<i>NWC Beat</i>	6	2/0	4/0	
	<i>Siltorsa Beat</i>	11	2/2	9/0	
Total	4 Beats	36	6/4	30/2	
Kodalbasti Range	<i>CC line Beat</i>	5	0/0	5/0	
	<i>Kodalbasti Beat</i>	1	0/0	1/0	
	<i>Mantharam Beat</i>	1	0/0	1/0	
	<i>NEC Beat</i>	1	0/0	1/0	
Total	4 Beats	8	0/0	8/0	
GRAND TOTAL	16 Beats	150	48/22	102/12	3

4.4. Inventorization of Flora

Results:

A total of 37 managed plots were identified by the Forest Department and selected for the study in 11 beats of 3 Ranges *i.e.* Jaldapara West Range, East Range and North Range of Jaldapara NP. Of these 23 were repeated plantations and 14 were one-time plantations 41 quadrates [10 m X 10 m (100 sq. m.)) were randomly chosen in these 37 plots, for detailed documentation of all vegetation occupancy in two seasons *viz.* pre monsoon (December to April) and post monsoon (September to November). In addition, 5 natural grassland plots (unmanaged) were randomly chosen for a similar qualitative and quantitative documentation of all vegetation in these plots in Jaldapara NP.

A total of 178 plant species were identified and recorded, documented and tabulated. Of these, 14 were the Planted species by the Forest Department, while 17 species belonged to Natural grass, fodder & sedge and 29 were Weed species. The remaining 121 species were Other species including ferns. Fern species have not been considered as weeds as they play an important role in maintaining the swampy habitat.

Analyzed data shows that *Imperata cylindrica* has highest IVI= 44.64 (in Pre-monsoon) and IVI=61.56 (in Post monsoon) followed by *Axonopus compressus* (IVI= 26.34 in Pre-monsoon-and IVI= 35.59 in Post monsoon) among all the species found in the managed plots of Jaldapara National Park.

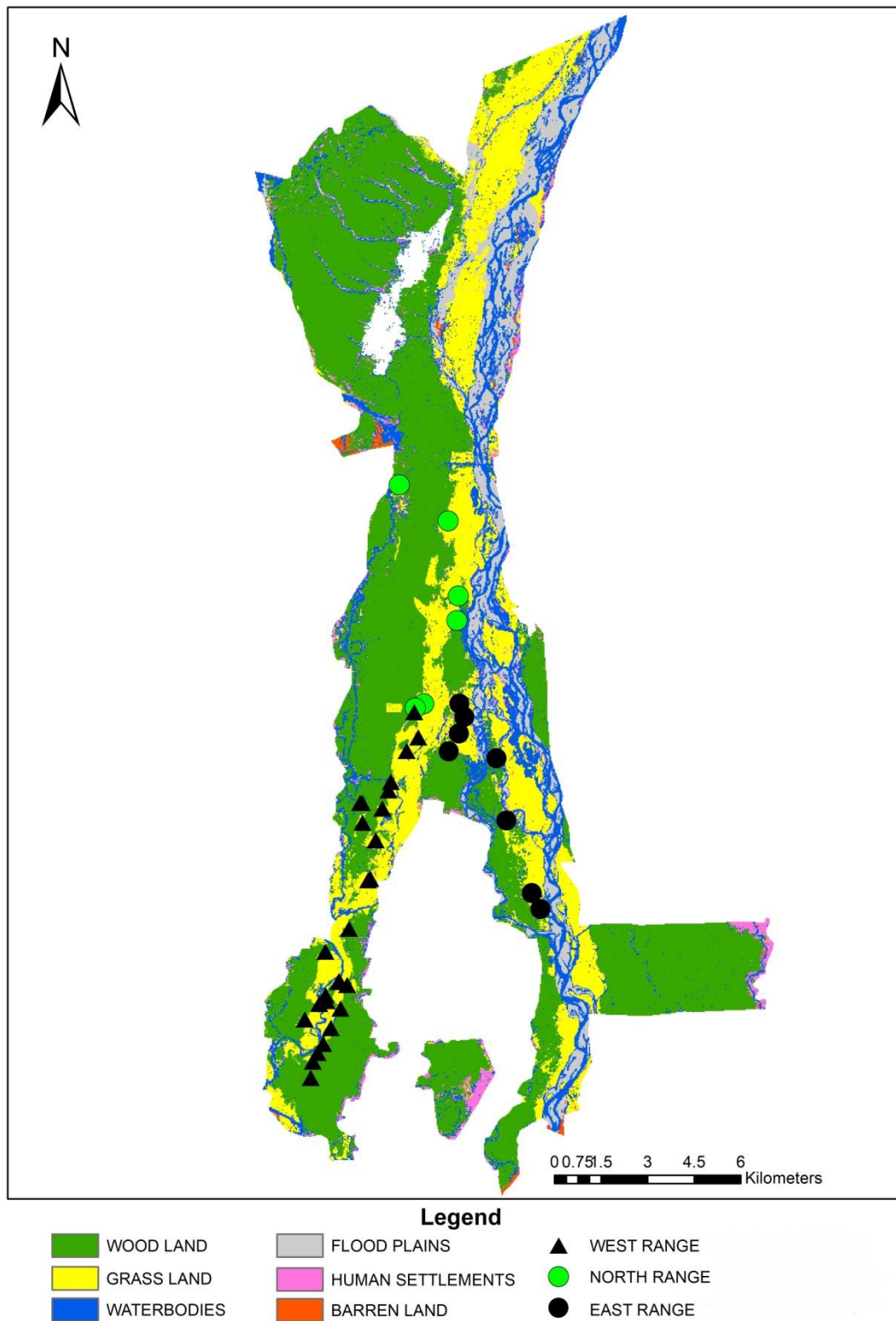


Figure 4: Jaldapara Land Use land cover map showing the managed plots undertaken for this study

Table 2: List of all species of plants recorded from managed plots with their IVI values season wise

Sl no	Family	Scientific name	IVI values	
			Post monsoon	Pre-monsoon
1	Fabaceae	<i>Acacia catechu</i> (L.f.) Willd.	0.16	
2	Lamiaceae	<i>Achyrospermum wallichianum</i> (Benth.) Benth. ex Hook.f.	0.52	
3	Asteraceae	<i>Acmella paniculata</i> (Wall. ex DC.) R. K. Jansen	1.50	1.45
4	Pteridaceae	<i>Adiantum</i> sp	2.82	
5	Asteraceae	<i>Ageratum conyzoides</i> (L.) L.	4.50	4.45
6	Asteraceae	<i>Ageratum houstonianum</i> Miller		0.13
7	Fabaceae	<i>Albizia lucidior</i> (Steud.) I.C. Nielsen	0.32	0.35
8	Fabaceae	<i>Albizia procera</i> (Roxburgh) Benth		0.56
9	Zingiberaceae	<i>Alpinia nigra</i> (Gaertn.) Burt	1.14	0.79
10	Amaranthaceae	<i>Alternanthera philoxeroides</i> (Mart.) Griseb.	0.16	
11	Amaranthaceae	<i>Amaranthus spinosus</i> L.		0.13
12	Amaranthaceae	<i>Amaranthus viridis</i> L.		0.31
13	Commelinaceae	<i>Amischotolype hookeri</i> (Hassk.) H. Hara	0.18	0.14
14	Lamiaceae	<i>Anisomeles indica</i> (L.) Kuntze	0.34	0.97
15	Convolvulaceae	<i>Argyreia roxburghii</i> (Wall.) Arn. ex Choisy	0.48	0.38
16	Aristolochiaceae	<i>Aristolochia saccata</i> Wall. indica L.	0.32	0.26
17	Poaceae	<i>Arundo donax</i> L.	0.36	0.27
18	Poaceae	<i>Axonopus compressus</i> (Sw.) P. Beauv.	26.34	35.59
19	Poaceae	<i>Bambusa</i> sp	0.23	0.32
20	Rhamnaceae	<i>Berchemia floribunda</i> (Wallich) Brongniart	0.17	0.14
21	Asteraceae	<i>Bidens pilosa</i> L.	0.38	0.35
22	Compositae	<i>Blumea lacera</i> (Burman f.) de Candolle		0.15
23	Urticaceae	<i>Boehmeria</i> sp	2.33	1.82
24	Malvaceae	<i>Bombax ceiba</i> L.	2.55	2.30
25	Phyllanthaceae	<i>Bridelia retusa</i> (L.) A. Juss.	1.97	2.30
26	Cyperaceae	<i>Bulbostylis densa</i> (Wallich) Handle-Mazzetti ex Karsten & Schenck		0.43
27	Lamiaceae	<i>Callicarpa tomentosa</i> (L.) L.	1.58	0.43
28	Apiaceae	<i>Centella asiatica</i> (L.) Urban		0.24
29	Costaceae	<i>Cheilocostus speciosus</i> (J. Koenig) C.D. Specht	0.64	0.81
30	Asteraceae	<i>Chromolaena odorata</i> (L.) R.M. King & H. Rob.	4.78	3.84
31	Menispermaceae	<i>Cissampelos pareira</i> L.		0.13
32	Cucurbitaceae	<i>Citrullus</i> sp	0.48	
33	Rutaceae	<i>Clausena excavata</i> Burm.f.	0.16	
34	Lamiaceae	<i>Clerodendrum infortunatum</i> L.	3.78	2.96
35	Fabaceae	<i>Codariocalyx motorius</i> (Houtt.) H. Ohashi		0.27
36	Rubiaceae	<i>Coffea benghalensis</i> B. Heyne ex Schult.	0.54	1.18
37	Poaceae	<i>Coix lacryma-jobi</i> L.		0.94
38	Araceae	<i>Colocasia esculenta</i> (L.) Schott	0.33	0.26

39	Commelinaceae	<i>Commelina benghalensis</i> L.		1.37
40	Commelinaceae	<i>Commelina suffruticosa</i> Blume	0.45	
41	Boraginaceae	<i>Cordia dichotoma</i> G. Forst.	0.47	
42	Asteraceae	<i>Crassocephalum crepidioides</i> (Benth) S. Moore		0.18
43	Fabaceae	<i>Crotalaria pallida</i> Aiton	0.36	
44	Fabaceae	<i>Crotalaria prostrata</i> Willd.	0.18	
45	Euphorbiaceae	<i>Croton caudatus</i> Geiseler	0.34	0.34
46	Apocynaceae	<i>Cryptolepis dubia</i> (Burm.f.) M.R. Almeida	0.16	
47	Lythraceae	<i>Cuphea procumbens</i> Ortega	0.16	0.22
48	Zingiberaceae	<i>Curcuma zedoaria</i> (Christm.) Roscoe	1.99	1.63
49	Zingiberaceae	<i>Curcuma aromatica</i> Salisb.	0.38	
50	Commelinaceae	<i>Cyanotis</i> sp	0.20	1.78
51	Asteraceae	<i>Cyanthillium cinereum</i> (L.) H. Rob.		0.27
52	Thelypteridaceae	<i>Cyclosorus</i> sp	1.92	2.97
53	Poaceae	<i>Cymbopogon flexuosus</i> (Nees ex Steud.) W. Watson	0.25	0.66
54	Poaceae	<i>Cynodon dactylon</i> (L.) Persoon	10.81	12.79
55	Cyperaceae	<i>Cyperus</i> sp	0.57	2.07
56	Fabaceae	<i>Dalbergia sissoo</i> DC.	0.16	0.76
57	Amaranthaceae	<i>Deeringia amaranthoides</i> (Lam.) Merr.	0.84	1.54
58	Fabaceae	<i>Desmodium cuspidatum</i> (Willd.) Loudon	0.19	0.92
59	Fabaceae	<i>Desmodium gangeticum</i> (L.) DC.	1.22	0.26
60	Fabaceae	<i>Desmodium laxiflorum</i> DC.	0.85	2.56
61	Acanthaceae	<i>Dicliptera bupleuroides</i> Nees	0.93	0.50
62	Poaceae	<i>Digitaria ciliaris</i> (Retz.) Koeler		0.39
63	Dilleniaceae	<i>Dillenia indica</i> L.		0.13
64	Dilleniaceae	<i>Dillenia pentagyna</i> Roxb.	0.16	0.37
65	Dioscoreaceae	<i>Dioscorea bulbifera</i> L.	0.98	1.95
66	Dioscoreaceae	<i>Dioscorea pentaphylla</i> L.	0.51	1.06
67	Dioscoreaceae	<i>Dioscorea</i> sp	0.66	
68	Athyriaceae	<i>Diplazium esculentum</i> (Retz.) Sw.	10.21	2.46
69	Apocynaceae	<i>Dregea volubilis</i> (L.f.) Benth. ex Hook.f.	0.48	0.28
70	Caryophyllaceae	<i>Drymaria cordata</i> subsp. <i>diandra</i> (Blume) J.A. Duke		0.75
71	Dryopteridaceae	<i>Dryopteris sparsa</i> (D. Don) Kuntze	1.84	4.82
72	Rosaceae	<i>Duchesnea indica</i> (Jacks.) Focke		1.59
73	Poaceae	<i>Echinochloa crus-galli</i> (L.) P. Beauv	35.83	2.35
74	Boraginaceae	<i>Ehretia acuminata</i> R.Br.	0.34	0.28
75	Poaceae	<i>Eleusine indica</i> (L.) Gaertn.	0.27	0.18
76	Lamiaceae	<i>Elsholtzia fruticosa</i> (D. Don) Rehder		0.52
77	Poaceae	<i>Eragrostis tenella</i> (L.) Beauverd ex Roemer et Schultes		0.27
78	Euphorbiaceae	<i>Euphorbia hirta</i> L.		1.09
79	Moraceae	<i>Ficus heterophylla</i> L.f.		0.14
80	Phyllanthaceae	<i>Flueggea virosa</i> (Roxb. ex Willd.) Royle	0.34	0.92
81	Malvaceae	<i>Grewia asiatica</i> L.	0.51	1.16

82	Malvaceae	<i>Helicteres isora</i> L.	1.03	1.33
83	Equisetaceae	<i>Hippochaete debilis</i> (Roxb. ex Vaucher) Ching	0.45	1.92
84	Lamiaceae	<i>Hyptis suaveolens</i> (L.) Poit.	1.23	1.29
85	Apocynaceae	<i>Ichnocarpus frutescens</i> (L.) W.T. Aiton	2.81	3.42
86	Poaceae	<i>Imperata cylindrica</i> (L.) Raeusch.	44.64	61.56
87	Convolvulaceae	<i>Ipomoea hederifolia</i> L.	0.34	1.29
88	Convolvulaceae	<i>Ipomoea nil</i> (L.) Roth	0.28	
89	Poaceae	<i>Kyllinga nemoralis</i> (J.R. Forst. & G. Forst.) Dandy ex Hutch. & Dalziel	0.22	1.96
90	Lythraceae	<i>Lagerstroemia parviflora</i> Roxb.	0.99	1.62
91	Lythraceae	<i>Lagerstroemia speciosa</i> (L.) Pers.	0.17	0.15
92	Verbenaceae	<i>Lantana camara</i> L.	2.22	1.53
93	Vitaceae	<i>Leea asiatica</i> (L.) Ridsdale	3.73	3.17
94	Lauraceae	<i>Litsea glutinosa</i> (Lour.) C.B. Rob.	0.50	0.43
95	Lauraceae	<i>Litsea monopetala</i> (Roxb.) Pers.	0.48	0.17
96	Lauraceae	<i>Litsea salicifolia</i> (J. Roxb. ex Nees) Hook. f.	0.34	
97	Onagraceae	<i>Ludwigia perennis</i> L.	0.33	0.28
98	Lygodiaceae	<i>Lygodium flexuosum</i> (L.) Sw.	0.81	0.62
99	Euphorbiaceae	<i>Macaranga denticulata</i> (Blume) Müll.Arg.	0.32	
100	Myrsinaceae	<i>Maesa indica</i> (Roxb.) A. DC.	0.65	1.30
101	Euphorbiaceae	<i>Mallotus philippensis</i> (Lam.) Müll.Arg.	0.33	0.13
102	Euphorbiaceae	<i>Mallotus polycarpus</i> (Benth.) Kulju & Welzen	1.59	1.75
103	Melastomataceae	<i>Melastoma malabathricum</i> L.		0.13
104	Meliaceae	<i>Melia azedarach</i> L.		0.13
105	Rubiaceae	<i>Meyna spinosa</i> Roxb.ex Link	0.49	0.43
106	Asteraceae	<i>Mikania micrantha</i> Kunth	6.47	4.13
107	Fabaceae	<i>Mimosa pudica</i> L.	2.06	1.94
108	Rubiaceae	<i>Mitracarpus hirtus</i> (L.) DC.	0.18	1.28
109	Cucurbitaceae	<i>Momordica charantia</i> L.	0.16	0.15
110	Pontederiaceae	<i>Monochoria vaginalis</i> (Burman f.) C. Presl		0.13
111	Rubiaceae	<i>Morinda angustifolia</i> Roxb.		0.13
112	Moraceae	<i>Morus indica</i> L.	0.32	0.14
113	Fabaceae	<i>Mucuna pruriens</i> (L.) DC.	0.16	
114	Cucurbitaceae	<i>Mukia maderaspatana</i> (L.) M. Roem.	0.48	0.98
115	Rutaceae	<i>Murraya koenigii</i> (L.) Sprengel	0.26	0.48
116	Ranunculaceae	<i>Naravelia zeylanica</i> (L.) DC.	0.35	0.27
117	Icacinaceae	<i>Natsiatum herpeticum</i> Buch. -Ham. ex Arn.	1.43	0.80
118	Acanthaceae	<i>Nelsonia canescens</i> (Lam.) Spreng.	0.22	0.92
119	Apiaceae	<i>Oenanthe javanica</i> (Blume) de Candolle	0.37	0.64
120	Poaceae	<i>Oplismenus burmanni</i> (Retz.) P. Beauv.	12.08	13.13
121	Oxalidaceae	<i>Oxalis corniculata</i> L.		2.07
122	Rubiaceae	<i>Paederia foetida</i> L.	0.52	0.85
123	Polygonaceae	<i>Persicaria chinensis</i> (L.) H. Gross		2.00

124	Polygonaceae	<i>Persicaria hydropiper</i> (L.) Delarbre		0.57
125	Fabaceae	<i>Phaseolus vulgaris</i> L.	0.42	
126	Acanthaceae	<i>Phaulopsis imbricata</i> (Forssk.) Sweet	0.63	0.73
127	Phyllanthaceae	<i>Phyllanthus emblica</i> L.	0.17	
128	Solanaceae	<i>Physalis minima</i> L.	0.34	0.26
129	Piperaceae	<i>Piper longum</i> L.	0.22	
130	Piperaceae	<i>Piper sp</i>	2.56	1.93
131	Piperaceae	<i>Piper sylvaticum</i> Roxb.	12.20	
132	Convolvulaceae	<i>Porana paniculata</i> Roxb.	0.83	0.81
133	Urticaceae	<i>Pouzolzia zeylanica</i> (L.) Benn.	0.25	3.50
134	Lamiaceae	<i>Premna bengalensis</i> C.B. Clarke	0.99	2.04
135	Lamiaceae	<i>Prunella vulgaris</i> L.	0.41	0.51
136	Fabaceae	<i>Pueraria phaseoloides</i> (Roxb.) Benth.	0.65	0.15
137	Amaranthaceae	<i>Pupalia lappacea</i> (L.) Juss.	1.59	2.41
138	Lamiaceae	<i>Rotheca serrata</i> (L.) Steane & Mabberley		0.13
139	Acanthaceae	<i>Rungia pectinata</i> (L.) Nees		0.88
140	Poaceae	<i>Saccharum arundinaceum</i> Retz.	1.70	0.61
141	Poaceae	<i>Saccharum longisetosum</i> (Andersson) V. Naray. ex Bor	0.40	0.41
142	Poaceae	<i>Saccharum longisetosum</i> var. <i>hookeri</i> (Hackel) Bor	0.16	
143	Poaceae	<i>Saccharum narenga</i> (Nees ex Steud.) Hack.	6.05	5.59
144	Poaceae	<i>Saccharum spontaneum</i> L.	24.78	16.63
145	Phyllanthaceae	<i>Sauropus quadrangularis</i> (Willd.) Müll.Arg.	0.22	0.15
146	Plantaginaceae	<i>Scoparia dulcis</i> L.		0.13
147	Fabaceae	<i>Cassia tora</i> (L.) Roxb. (L.) Roxb.	0.94	0.27
148	Poaceae	<i>Setaria palmifolia</i> (J. Koenig) Stapf	0.34	1.67
149	Malvaceae	<i>Sida cordifolia</i> L.		0.15
150	Malvaceae	<i>Sida acuta</i> Burm.f.	0.63	0.75
151	Malvaceae	<i>Sida cordata</i> (Burm.f.) Borss.Waalk.		0.18
152	Malvaceae	<i>Sida rhombifolia</i> L.	0.74	1.31
153	Smilacaceae	<i>Smilax perfoliata</i> Lour.		0.22
154	Solanaceae	<i>Solanum aculeatissimum</i> Jacq.	0.65	0.71
155	Solanaceae	<i>Solanum torvum</i> Sw.	0.33	0.15
156	Solanaceae	<i>Solanum americanum</i> Miller		0.15
157	Solanaceae	<i>Solanum indicum</i> L.		0.14
158	Rubiaceae	<i>Spermacoce alata</i> Aubl.		0.40
159	Caryophyllaceae	<i>Stellaria media</i> (L.) Vill.		1.16
160	Menispermaceae	<i>Stephania hernandiifolia</i> (Willd.) Walp.	1.97	2.41
161	Malvaceae	<i>Sterculia villosa</i> Roxb.	0.48	0.42
162	Moraceae	<i>Streblus asper</i> Lour.	0.34	1.29
163	Asteraceae	<i>Synedrella nodiflora</i> (L.) Gaertn.	1.42	
164	Myrtaceae	<i>Syzygium cumini</i> (L.) Skeels	0.16	0.56
165	Combretaceae	<i>Terminalia bellirica</i> (Gaertn.) Roxb.	0.16	
166	Vitaceae	<i>Tetrastigma bracteolatum</i> (Wall.) Planch.	0.45	0.83

167	Thelypteridaceae	<i>Thelypteris nudata</i> (Roxb.) C.V. Morton	4.31	1.66
168	Poaceae	<i>Themeda arundinacea</i> (Roxb.) A. Camus	5.19	4.14
169	Poaceae	<i>Thysanolaena latifolia</i> (Roxb. ex Hornem.) Honda	0.46	1.86
170	Meliaceae	<i>Toona ciliata</i> M. Roem.		0.28
171	Linderniaceae	<i>Torenia asiatica</i> L.	0.32	0.60
172	Malvaceae	<i>Triumfetta rhomboidea</i> Jacq.	2.88	2.64
173	Typhaceae	<i>Typha elephantina</i> Roxb.		0.18
174	Fabaceae	<i>Uraria picta</i> (Jacq.) DC.	0.18	
175	Malvaceae	<i>Urena lobata</i> L.	0.22	0.36
176	Asteraceae	<i>Youngia japonica</i> (L.) DC.		6.16
177	Cucurbitaceae	<i>Zehneria japonica</i> (Thunb.) H.Y. Liu	0.18	0.15
178	Rhamnaceae	<i>Ziziphus jujuba</i> Mill.	0.49	0.97

Table 3: List of planted species recorded from managed plots

SI no.	Family	Planted species	Also found naturally	Vernacular name
1	Zingiberaceae	<i>Alpinia nigra</i> (Gaertn.) Burt	✓	Purundi
2	Poaceae	<i>Arundo donax</i> L.	✓	Nol
3	Poaceae	<i>Bambusa sp</i>		Bamboo
4	Poaceae	<i>Cymbopogon flexuosus</i> (Nees ex Steud.) W. Watson		Lemon grass
5	Poaceae	<i>Imperata cylindrica</i> (L.) Raeusch.	✓	Thach
6	Poaceae	<i>Saccharum arundinaceum</i> Retz.		Madhua
7	Poaceae	<i>Saccharum longisetosum</i> (Andersson) V. Naray. ex Bor		Malsa
8	Poaceae	<i>Saccharum longisetosum</i> var. <i>hookeri</i> (Hackel) Bor		Ekra
9	Poaceae	<i>Saccharum narenga</i> (Nees ex Steud.) Hack.	✓	Dhadda
10	Poaceae	<i>Saccharum spontaneum</i> L.	✓	Kasia
11	Poaceae	<i>Setaria palmifolia</i> (J. Koenig) Stapf	✓	Banspati
12	Poaceae	<i>Themeda arundinacea</i> (Roxb.) A. Camus		Chepti
13	Poaceae	<i>Thysanolaena latifolia</i> (Roxb. ex Hornem.) Honda	✓	Jharu gach
14	Typhaceae	<i>Typha elephantina</i> Roxb.	✓	Hogla

Table 4: List of natural grasses, fodder and sedges recorded from managed plots

SL no	Family	Natural grasses and sedges	Also in the plantation list
1	Poaceae	<i>Arundo donax</i> L.	✓
2	Zingiberaceae	<i>Alpinia nigra</i> (Gaertn.) Burt	✓
3	Poaceae	<i>Axonopus compressus</i> (Sw.) P. Beauv.	
4	Cyperaceae	<i>Bulbostylis densa</i> (Wallich) Handle-Mazzetti ex Karsten & Schenck	
5	Poaceae	<i>Coix lacryma-jobi</i> L.	
6	Poaceae	<i>Cynodon dactylon</i> (L.) Persoon	
7	Cyperaceae	<i>Cyperus</i> sp	
8	Poaceae	<i>Digitaria ciliaris</i> (Retz.) Koeler	
9	Poaceae	<i>Echinochloa crus-galli</i> (L.) P. Beauv	
10	Poaceae	<i>Eleusine indica</i> (L.) Gaertn.	
11	Poaceae	<i>Eragrostis tenella</i> (L.) Beauverd ex Roemer et Schultes	
12	Poaceae	<i>Imperata cylindrica</i> (L.) Raeusch. <i>cylindrica</i> (L.) Raeusch.	✓
13	Cyperaceae	<i>Kyllinga nemoralis</i> (J.R. Forst. & G. Forst.) Dandy ex Hutch. & Dalziel	
14	Poaceae	<i>Oplismenus burmanni</i> (Retz.) P. Beauv.	
15	Poaceae	<i>Saccharum spontaneum</i> L.	✓
16	Poaceae	<i>Setaria palmifolia</i> (J. Koenig) Stapf	✓
17	Poaceae	<i>Thysanolaena latifolia</i> (Roxb. ex Hornem.) Honda	✓

Table 5: List of weed species recorded from managed plots

SI no.	Family	Harmful weeds
1	Asteraceae	<i>Ageratum conyzoides</i> (L.) L.
2	Asteraceae	<i>Ageratum houstonianum</i> Miller
3	Convolvulaceae	<i>Argyrea roxburghii</i> (Wall.) Arn. ex Choisy
4	Rhamnaceae	<i>Berchemia floribunda</i> (Wallich) Brongniart
5	Asteraceae	<i>Chromolaena odorata</i> (L.) R.M. King & H. Rob.
6	Lamiaceae	<i>Clerodendrum infortunatum</i> L.
7	Polypodiaceae	<i>Cyclosorus</i> sp
8	Amaranthaceae	<i>Deeringia amaranthoides</i> (Lam.) Merr.
9	Apocynaceae	<i>Dregea volubilis</i> (L.f.) Benth. ex Hook.f.
10	Convolvulaceae	<i>Ipomoea hederifolia</i> L.
11	Convolvulaceae	<i>Ipomoea nil</i> (L.) Roth
12	Lamiaceae	<i>Lantana camara</i> L.
13	Vitaceae	<i>Leea asiatica</i> (L.) Ridsdale
14	Lygodiaceae	<i>Lygodium flexuosum</i> (L.) Sw.
15	Fabaceae	<i>Mimosa pudica</i> L.
16	Asteraceae	<i>Mikania micrantha</i> Kunth
17	Cucurbitaceae	<i>Mukia maderaspatana</i> (L.) M. Roem.

18	Ranunculaceae	<i>Naravelia zeylanica</i> (L.) DC.
19	Icacinaceae	<i>Natsiatum herpeticum</i> Buch. -Ham. ex Arn.
20	Rubiaceae	<i>Paederia foetida</i> L.
21	Convolvulaceae	<i>Porana paniculata</i> Roxb.
22	Fabaceae	<i>Pueraria phaseoloides</i> (Roxb.) Benth.
23	Fabaceae	<i>Senna tora</i> (L.) Roxb. (<i>Cassia tora</i>)
24	Smilacaceae	<i>Smilax perfoliata</i> Lour.
25	Solanaceae	<i>Solanum torvum</i> Sw.
26	Menispermaceae	<i>Stephania hernandiifolia</i> (Willd.) Walp.
27	Vitaceae	<i>Tetrastigma bracteolatum</i> (Wall.) Planch.
28	Malvaceae	<i>Triumfetta rhomboidea</i> Jacq.
29	Rhamnaceae	<i>Ziziphus jujuba</i> Mill.

Table 6: List of other species recorded from managed plots

SI No.	Family	Other Species
1	Fabaceae	<i>Acacia catechu</i> (L.f.) Willd.
2	Lamiaceae	<i>Achyropermum wallichianum</i> (Benth.) Benth. ex Hook.f.
3	Asteraceae	<i>Acmella paniculata</i> (Wall. ex DC.) R.K. Jansen
4	Pteridaceae	<i>Adiantum</i> sp
5	Fabaceae	<i>Albizia lucidior</i> (Steud.) I.C. Nielsen
6	Fabaceae	<i>Albizia procera</i> (Roxburgh) Benth
7	Amaranthaceae	<i>Alternanthera philoxeroides</i> (Mart.) Griseb.
8	Amaranthaceae	<i>Amaranthus spinosus</i> L.
9	Amaranthaceae	<i>Amaranthus viridis</i> L.
10	Commelinaceae	<i>Amischotolype hookeri</i> (Hassk.) H. Hara
11	Lamiaceae	<i>Anisomeles indica</i> (L.) Kuntze
12	Aristolochiaceae	<i>Aristolochia saccata</i> Wall. indica L.
13	Asteraceae	<i>Bidens pilosa</i> L.
14	Compositae	<i>Blumea lacera</i> (Burman f.) de Candolle
15	Urticaceae	<i>Boehmeria</i> sp
16	Malvaceae	<i>Bombax ceiba</i> L.
17	Phyllanthaceae	<i>Bridelia retusa</i> (L.) A. Juss.
18	Lamiaceae	<i>Callicarpa tomentosa</i> (L.) L.
19	Apiaceae	<i>Centella asiatica</i> (L.) Urban
20	Costaceae	<i>Cheilocostus speciosus</i> (J. Koenig) C.D. Specht
21	Menispermaceae	<i>Cissampelos pareira</i> L.
22	Cucurbitaceae	<i>Citrullus</i> sp
23	Rutaceae	<i>Clausena excavata</i> Burm.f.
24	Fabaceae	<i>Codariocalyx motorius</i> (Houtt.) H. Ohashi
25	Rubiaceae	<i>Coffea benghalensis</i> B. Heyne ex Schult.
26	Araceae	<i>Colocasia esculenta</i> (L.) Schott
27	Commelinaceae	<i>Commelina benghalensis</i> L.

28	Commelinaceae	<i>Commelina suffruticosa</i> Blume
29	Boraginaceae	<i>Cordia dichotoma</i> G. Forst.
30	Asteraceae	<i>Crassocephalum crepidioides</i> (Benth) S. Moore
31	Fabaceae	<i>Crotalaria pallida</i> Aiton
32	Fabaceae	<i>Crotalaria prostrata</i> Willd.
33	Euphorbiaceae	<i>Croton caudatus</i> Geiseler
34	Apocynaceae	<i>Cryptolepis dubia</i> (Burm.f.) M.R. Almeida
35	Lythraceae	<i>Cuphea procumbens</i> Ortega
36	Zingiberaceae	<i>Curcuma zedoaria</i> (Christm.) Roscoe
37	Zingiberaceae	<i>Curcuma aromatica</i> Salisb.
38	Commelinaceae	<i>Cyanotis</i> sp
39	Asteraceae	<i>Cyanthillium cinereum</i> (L.) H. Rob.
40	Fabaceae	<i>Dalbergia sissoo</i> DC.
41	Fabaceae	<i>Desmodium cuspidatum</i> (Willd.) Loudon
42	Fabaceae	<i>Desmodium gangeticum</i> (L.) DC.
43	Fabaceae	<i>Desmodium laxiflorum</i> DC.
44	Acanthaceae	<i>Dicliptera bupleuroides</i> Nees
45	Dilleniaceae	<i>Dillenia indica</i> L.
46	Dilleniaceae	<i>Dillenia pentagyna</i> Roxb.
47	Dioscoreaceae	<i>Dioscorea bulbifera</i> L.
48	Dioscoreaceae	<i>Dioscorea pentaphylla</i> L.
49	Dioscoreaceae	<i>Dioscorea</i> sp
50	Athyriaceae	<i>Diplazium esculentum</i> (Retz.) Sw.
51	Caryophyllaceae	<i>Drymaria cordata</i> subsp. diandra (Blume) J.A. Duke
52	Dryopteridaceae	<i>Dryopteris sparsa</i> (D. Don) Kuntze
53	Rosaceae	<i>Duchesnea indica</i> (Jacks.) Focke
54	Boraginaceae	<i>Ehretia acuminata</i> R.Br.
55	Lamiaceae	<i>Elsholtzia fruticosa</i> (D. Don) Rehder
56	Euphorbiaceae	<i>Euphorbia hirta</i> L.
57	Moraceae	<i>Ficus heterophylla</i> L.f.
58	Phyllanthaceae	<i>Flueggea virosa</i> (Roxb. ex Willd.) Royle
59	Malvaceae	<i>Grewia asiatica</i> L.
60	Malvaceae	<i>Helicteres isora</i> L.
61	Equisetaceae	<i>Hippochaete debilis</i> (Roxb. ex Vaucher) Ching
62	Lamiaceae	<i>Hyptis suaveolens</i> (L.) Poit.
63	Apocynaceae	<i>Ichnocarpus frutescens</i> (L.) W.T. Aiton
64	Lythraceae	<i>Lagerstroemia parviflora</i> Roxb.
65	Lythraceae	<i>Lagerstroemia speciosa</i> (L.) Pers.
66	Lauraceae	<i>Litsea glutinosa</i> (Lour.) C.B. Rob.
67	Lauraceae	<i>Litsea monoptala</i> (Roxb.) Pers.
68	Lauraceae	<i>Litsea salicifolia</i> (J. Roxb. ex Nees) Hook. f.
69	Onagraceae	<i>Ludwigia perennis</i> L.
70	Euphorbiaceae	<i>Macaranga denticulata</i> (Blume) Müll.Arg.

71	Myrsinaceae	<i>Maesa indica</i> (Roxb.) A. DC.
72	Euphorbiaceae	<i>Mallotus philippensis</i> (Lam.) Müll.Arg.
73	Euphorbiaceae	<i>Mallotus polycarpus</i> (Benth.) Kulju & Welzen
74	Melastomataceae	<i>Melastoma malabathricum</i> L.
75	Meliaceae	<i>Melia azedarach</i> L.
76	Rubiaceae	<i>Meyna spinosa</i> Roxb.ex Link
77	Rubiaceae	<i>Mitracarpus hirtus</i> (L.) DC.
78	Cucurbitaceae	<i>Momordica charantia</i> L.
79	Pontederiaceae	<i>Monochoria vaginalis</i> (Burman f.) C. Presl
80	Rubiaceae	<i>Morinda angustifolia</i> Roxb.
81	Moraceae	<i>Morus indica</i> L.
82	Fabaceae	<i>Mucuna pruriens</i> (L.) DC.
83	Acanthaceae	<i>Nelsonia canescens</i> (Lam.) Spreng.
84	Apiaceae	<i>Oenanthe javanica</i> (Blume) de Candolle
85	Oxalidaceae	<i>Oxalis corniculata</i> L.
86	Polygonaceae	<i>Persicaria chinensis</i> (L.) H. Gross
87	Polygonaceae	<i>Persicaria hydropiper</i> (L.) Delarbre
88	Fabaceae	<i>Phaseolus vulgaris</i> L.
89	Acanthaceae	<i>Phaulopsis imbricata</i> (Forssk.) Sweet
90	Phyllanthaceae	<i>Phyllanthus emblica</i> L.
91	Solanaceae	<i>Physalis minima</i> L.
92	Piperaceae	<i>Piper longum</i> L.
93	Piperaceae	<i>Piper sp</i>
94	Piperaceae	<i>Piper sylvaticum</i> Roxb.
95	Urticaceae	<i>Pouzolzia zeylanica</i> (L.) Benn.
96	Lamiaceae	<i>Premna bengalensis</i> C.B. Clarke
97	Lamiaceae	<i>Prunella vulgaris</i> L.
98	Amaranthaceae	<i>Pupalia lappacea</i> (L.) Juss.
99	Lamiaceae	<i>Rothea serrata</i> (L.) Steane & Mabberley
100	Acanthaceae	<i>Rungia pectinata</i> (L.) Nees
101	Phyllanthaceae	<i>Sauropus quadrangularis</i> (Willd.) Müll.Arg.
102	Plantaginaceae	<i>Scoparia dulcis</i> L.
103	Malvaceae	<i>Sida cordifolia</i> L.
104	Malvaceae	<i>Sida cordata</i> (Burm.f.) Borss.Waalk.
105	Malvaceae	<i>Sida rhombifolia</i> L.
106	Solanaceae	<i>Solanum aculeatissimum</i> Jacq.
107	Solanaceae	<i>Solanum americanum</i> Miller
108	Solanaceae	<i>Solanum indicum</i> L.
109	Rubiaceae	<i>Spermacoce alata</i> Aubl.
110	Caryophyllaceae	<i>Stellaria media</i> (L.) Vill.
111	Malvaceae	<i>Sterculia villosa</i> Roxb.
112	Moraceae	<i>Streblus asper</i> Lour.
113	Asteraceae	<i>Synedrella nodiflora</i> (L.) Gaertn.

114	Myrtaceae	<i>Syzygium cumini</i> (L.) Skeels
115	Combretaceae	<i>Terminalia bellirica</i> (Gaertn.) Roxb.
116	Thelypteridaceae	<i>Thelypteris nudata</i> (Roxb.) C.V. Morton
117	Meliaceae	<i>Toona ciliata</i> M. Roem.
118	Linderniaceae	<i>Torenia asiatica</i> L.
119	Fabaceae	<i>Uraria picta</i> (Jacq.) DC.
120	Asteraceae	<i>Youngia japonica</i> (L.) DC.
121	Cucurbitaceae	<i>Zehneria japonica</i> (Thunb.) H.Y. Liu

a. Vegetation Occupancy:

Range wise result of vegetation occupancy in Jaldapara NP:

Range – East:

- Vegetation occupancy studies were carried out in eight quadrates in eight management plots, both in the pre & post monsoon.
- Among the study areas four were chosen from lower & flooded land (ESQ 1, ESQ 2, EMQ 7 and EMQ 8) and the other four were chosen from upper and non-flooded land (EJQ 3, EJQ 4, EJQ 5 and EJQ 6).
- Among the 6 Planted species viz. *Saccharum narenga*, *Themeda arundinacea*, *Alpinia nigra*, *Saccharum arundinaceum*, *Saccharum longisetosum* (Andersson) V. Naray. ex Bor) and *Setaria palmifolia* (Annexure:1), only four (*Saccharum narenga*, *Themeda arundinacea*, *Alpinia nigra*, *Saccharum arundinaceum*) of them were found in different quadrates, ranging from 0.4 % to 18.18 % in pre monsoon and 0.63 % to 24.45 % in post monsoon season
- The total area coverage by the planted species in this range was 6% in Pre-monsoon and 8% in post monsoon season. (Figure: 5)
- It was seen that the occupancy percentage of Natural grass, fodder & sedge plants ranged from 27.85% to 94.17% in pre & post monsoon season, occupying the maximum area of 61% and 66% within the Range in Pre and post monsoon seasons respectively. Of these, *Axonopus compressus* (Chota chepti) occupied more than 70% during the post monsoon season.
- Weeds varied from 4.24% to 38.04% and 4.03% to 41.23% in pre and post monsoon respectively.

Table 7: Occupancy percentage of Planted, Natural, Weeds and other species in East Range, Jaldapara NP

Beat-Sissamara											
Managed Plot No.	Quadrate No.	Year of plantation	Location	Season	Occupancy Percentage/ no of species	Planted Species	Natural grass, fodder, sedge species	Weeds	Other Species	Flood	Previous condition of the area as per the plantation journal
ESQ 1	1	2016	26°36'16.60"N, 89°20'14.82"E	Pre monsoon	Occupancy %	4.67	27.85	42.45	25.03	Flooded	old plantation
					No of species	3	5	17	12		
				Post monsoon	Occupancy %	4.24	63.06	21.32	11.38	"	
					No of species	3	3	9	7		
ESQ 2	2	2017	26°35'59.50"N, 89°20'24.50"E	Pre monsoon	Occupancy %	1.12	92.58	4.24	2.05	"	old plantation
					No of species	3	1	9	10		
				Post monsoon	Occupancy %	1.37	94.17	4.03	0.43	"	
					No of species	3	1	6	5		
Beat-Jaldapara HQ											
EJQ 3	3	2015	26°39'36.00"N, 89°18'54.61"E	Pre monsoon	Occupancy %	0.4	89.95	4.48	3.64	Non flooded	old plantation of 2007
					No of species	1	6	10	15		
				Post monsoon	Occupancy %	0.63	94.11	4.60	0.66	"	
					No of species	1	2	5	7		
EJQ 4	4	2016	26°39'22.10"N, 89°19'0.19"E	Pre monsoon	Occupancy %	13.33	29.22	19.99	37.46	"	old plantation of 2007
					No of species	2	3	4	3		
				Post monsoon	Occupancy %	18.01	43.99	25.85	12.15	"	
					No of species	2	2	4	2		
EJQ 5	5	2017	26°39'5.00"N, 89°18'53.50"E	Pre monsoon	Occupancy %	18.18	39.11	38.04	4.67	"	old plantation of 2006
					No of species	4	3	9	7		
				Post monsoon	Occupancy %	24.45	28.77	41.23	5.55	"	
					No of species	4	1	7	4		
EJQ 6	6	2017	26°38'46.40"N, 89°18'41.29"E	Pre monsoon	Occupancy %	4.62	76.6	13.54	5.25	"	old fodder plantation
					No of species	3	4	9	10		
				Post monsoon	Occupancy %	6.83	76.9	13.43	2.84	"	
					No of species	3	2	8	4		
Beat- Malangi											
EMQ 7	7	2017	26°38'38.30"N, 89°19'36.61"E	Pre monsoon	Occupancy %	1.17	69.02	12.29	17.52	Flooded	old degraded fodder plantation
					No of species	3	6	8	12		
				Post monsoon	Occupancy %	1.93	72.92	9.60	15.55	"	
					No of species	3	6	6	8		
EMQ 8	8	2017	26°37'32.90"N, 89°19'46.92"E	Pre monsoon	Occupancy %	3.37	63.69	23.17	9.77	"	old degraded fodder plantation
					No of species	2	3	7	10		
				Post monsoon	Occupancy %	6.22	49.98	6.22	32.54	"	
					No of species	2	3	7	7		

Range- West

- Twenty-seven quadrat studies in twenty-three management plots, were carried out both in the pre & post monsoon, mainly in upper & non- flooded land except two plots (WHQ 21, WHQ 22) occurring in Hollong which were flooded land.
- Among the 12 Planted species viz. *Saccharum narenga*, *Themeda arundinacea*, *Alpinia nigra*, *Saccharum arundinaceum*, *Saccharum longisetosum* var. *longisetosum*, *Bambusa sp*, *Phragmites karka*, *Typha elephantina*, *Arundo donax*, *Saccharum longisetosum* var. *hookeri* and *Setaria palmiflora* (Annexure:1) only six (*Saccharum narenga*, *Themeda arundinacea*, *Alpinia nigra*, *Saccharum arundinaceum*, *Bambusa sp* and *Saccharum longisetosum* var. *longisetosum*) were found in the different quadrates with a percentage ranging from 2.53% to 33.91% and 0.40% to 56.65% in pre and post monsoon respectively.
- Occupancy percentage in regard to Natural grass, fodder & sedge plants varied from 0% to 94.47% in pre monsoon and 0% to 99.36% in post monsoon represented by 13 species.
- In plots WBQ 9, WBQ 11 and WBQ 12, Natural grass, fodder and sedge species recorded nil in pre monsoon season while in post monsoon it rose up to 75.01% while in plot WBQ 14 *Saccharum spontaneum* alone occurred 99.36% in post monsoon.
- Percentage of Weed species varied from 0.39% to 72.48% in pre monsoon while in post monsoon it was ranged from 0% to 67.06%.

Table 8: Occupancy percentage of Planted, Natural, Weeds and other species in West Range, Jaldapara NP

Beat-Bendaki											
Managed Plot No.	Quadrat No.	Year of plantation	Location	Season	Occupancy Percentage/ no of species	Planted Species	Natural grass, fodder, sedge species	Weeds	Other Species	Flood	Previous condition of the area as per the plantation journal
WBQ 9	9	2014	N 26°33'07.4", E 089°15'53.6"	Pre monsoon	Occupancy %	8.47	0	61.91	29.62	Non flooded	Degraded high forest land
					No of species	1	0	8	10		
				Post monsoon	Occupancy %	2.4	40.04	49.57	7.98		
					No of species	1	1	7	10		
WBQ 10	10	2016	N 26°33'42.8", E 089°16'09.0"	Pre monsoon	Occupancy %	11.22	10.66	41.55	36.57	Non flooded	Natural high forest
					No of species	3	2	7	14		
				Post monsoon	Occupancy %	3.08	12.18	56.25	28.29		
					No of species	1	2	9	5		
WBQ 11	11	2016	N 26°33'33.5", E 089°16'02.2"	Pre monsoon	Occupancy %	16.76	0	23.15	60.09	Non flooded	Old plantation of 2011
					No of species	2	0	8	17		
				Post monsoon	Occupancy %	3.14	75.01	20.64	1.22		
					No of species	3	2	8	10		
WBQ12	12	2017	N 26°34'47.3", E 089°16'27.8"	Pre monsoon	Occupancy %	33.91	0	24.17	41.92	Non flooded	Old plantation of 2005
					No of species	2	0	4	12		
				Post monsoon	Occupancy %	38.27	0	46.50	15.23		
					No of species	2	0	4	6		
	13		N 26°33'59.24", E 089°16'17.9"	Pre monsoon	Occupancy %	25.74	0	52.22	22.04	Non flooded	
					No of species	2	0	8	14		
WBQ 13	14	2017	N 26°34'43.9", E 089°16'37.8"	Pre monsoon	Occupancy %	25.53	4.93	34.83	34.70	Non flooded	Old plantation of 2002
					No of species	2	2	7	14		
				Post monsoon	Occupancy %	6.23	82.25	6.34	5.18		
					No of species	4	3	7	8		

WBQ14	15	2018	26°34'33.42"N, 89°16'12.54"E	Pre	Occupancy %	10.1	65.16	6.19	18.55	Non flooded	Old plantation of 2004				
				monsoon	No of species	1	1	1	7						
				Post	Occupancy %	0.4	99.36	0	0.24						
				monsoon	No of species	2	1	0	7						
WBQ 15	16	2018	N 26°34'27.6", E 089°16'13.7"	Pre	Occupancy %	11.11	71.69	11.11	6.27	Non flooded	Old plantation of 2004				
				monsoon	No of species	1	1	1	7						
				Post	Occupancy %	7.69	84.58	2.54	5.19						
				monsoon	No of species	3	2	3	7						
WBQ 16	17	2017	N 26°34'19.5", E 089°16'29.6"	Pre	Occupancy %	29.85	17.11	45.14	7.89	Non flooded					
				monsoon	No of species	3	3	7	5						
				Post	Occupancy %	12.59	67.45	14.28	5.69						
				monsoon	No of species	6	1	9	6						
Beat- Hollong															
WHQ17	18	2016	N 26°38.263', E 089°17.550'	Pre	Occupancy %	4.51	4.84	8.84	81.81	Non flooded	Old plantation of 2010-2011				
				monsoon	No of species	2	2	6	10						
				Post	Occupancy %	2.62	36.57	8.78	52.03						
	19			N 26°38'07.0", E 089°17'30.2"	monsoon	No of species	2	2	7	14		Non flooded			
					Pre	Occupancy %	19.37	0.15	37.85	42.64					
					monsoon	No of species	2	1	3	14					
WHQ 18	20	2014	N 26°38'47.9", E 089°17'52.2"	Post	Occupancy %	12.64	2.87	25.42	59.08	Non flooded	Degraded Dhadda plantation				
				monsoon	No of species	3	2	4	10						
				Pre	Occupancy %	4.71	84.36	4.67	6.23						
	21			N 26°38'47.9", E 089°17'52.2"	monsoon	No of species	2	3	5	8		Non flooded			
					Post	Occupancy %	14.43	72.16	10.29	3.12					
					monsoon	No of species	1	1	5	4					
WHQ19	21	2014	N 26°37'54.2", E 089°16'56.8"	Pre	Occupancy %	5.8	88.17	3.91	2.11	Non flooded	Natural Grassland				
				monsoon	No of species	3	4	5	13						
				Post	Occupancy %	1.85	0	53.70	44.44						
	22			N 26°37'54.2", E 089°16'59.1"	monsoon	No of species	2	0	7	9		Non flooded			
					Pre	Occupancy %	7.36	60.54	4.40	27.71					
					monsoon	No of species	2	5	5	12					
	23	26°37'33.37"N 89°16'59.23"E	Post	Occupancy %	2.92	10.53	9.24	76.42	Non flooded						
			monsoon	No of species	2	1	3	6							
			Pre	Occupancy %	17.54	26.58	2.55	53.33							
	WHQ 20	24	2016	N 26°37'48.0", E 089°17'22.5"	monsoon	No of species	2	1	6	14	Non flooded	Natural blank			
					Post	Occupancy %	32.34	0	67.06	0.61					
					monsoon	No of species	2	0	3	5					
25		2017			26°39'1.79"N, 89°18'5.94"E	Pre	Occupancy %	6.6	15.06	24.96	53.03		Non flooded		
						monsoon	No of species	2	2	6	12				
						Post	Occupancy %	3.93	0	46.77	49.30				
WHQ 21	25	2017	26°39'1.79"N, 89°18'5.94"E	monsoon	No of species	2	0	7	8	Flooded	No information				
				Pre	Occupancy %	16.98	58.55	15.51	9.16						
				monsoon	No of species	2	2	6	11						
	26			2018	N 26°39'08.0", E 089°17'46.7"	Post	Occupancy %	1.21	96.75	1.45		0.59	Flooded		
						monsoon	No of species	1	4	6		4			
						Pre	Occupancy %	6.46	65.56	20.11		7.88			
WHQ 22	26	2018	N 26°39'08.0", E 089°17'46.7"	monsoon	No of species	3	5	11	13	Flooded	Canopy opening area				
				Post	Occupancy %	8.65	63.28	19.17	8.90						
				monsoon	No of species	3	3	9	12						
	Beat- TEC														
	WTQ 23			27	2016	N 26°34'48.0", E 089°16'29.0"	Pre	Occupancy %	2.53	45.81		25.86	25.81	Non flooded	Natural blank
							monsoon	No of species	1	3		7	9		
Post		Occupancy %	2.81				84.4	11.70	1.08						
28	2018	N 26°36'34.7", E 089°17'07.1"	monsoon	No of species	1	1	5	7	Non flooded						
			Pre	Occupancy %	4.92	94.38	0.39	0.31							
			monsoon	No of species	3	3	1	2							
WTQ 24	28	2018	N 26°36'34.7", E 089°17'07.1"	Post	Occupancy %	3.61	96.39	0	0	Non flooded					
				monsoon	No of species	3	2	0	0						
WTQ 25	29	2018	N 26°35'42.8", E 089°16'41.2"	Pre	Occupancy %	20.28	15.26	34.55	29.91	Non flooded	Old plantation of 2002				
				monsoon	No of species	2	4	13	9						

				Post monsoon	Occupancy % No of species	8.35 2	10.85 1	54.87 6	25.94 8		
WTQ 26	30	2015	N 26°37'14.9", E 089°17'14.2"	Pre monsoon	Occupancy %	4.56	3.97	72.48	52.45	Non flooded	Old plantation of 2010
					No of species	2	5	11	19		
				Post monsoon	Occupancy %	7.92	0	22.77	69.31		
					No of species	1	0	6	5		
WTQ 27	31	2017	N 26°36'33.3", E 089°17'04.5"	Pre monsoon	Occupancy %	4.09	94.47	0.44	1	Non flooded	
					No of species	2	4	1	3		
				Post monsoon	Occupancy %	3.44	96.56	0	0		
					No of species	1	2	0	0		
Beat- Kunjanagar											
WKQ 28	32	2018	N 26°34'05.4", E 089°15'44.3"	Pre monsoon	Occupancy %	8.42	61.77	20.51	9.29	Non flooded	Fodder plantation of 2010
					No of species	2	4	7	12		
				Post monsoon	Occupancy %	37.55	0	56.31	6.14		
					No of species	2	0	11	4		
WKQ 29	33	2017	N 26°33'24.5", E 089°15'56.4"	Pre monsoon	Occupancy %	13.1	43.76	32.91	10.22	Non flooded	
					No of species	2	4	7	12		
				Post monsoon	Occupancy %	0.72	4.48	4.31	90.50		
					No of species	2	1	4	9		
Beat- Mairadanga											
WMQ 30	34	2017	N 26°35'19.4", E 089°16'13.2"	Pre monsoon	Occupancy %	3.23	24.33	3.61	69.68	Non flooded	
					No of species	2	4	4	9		
				Post monsoon	Occupancy %	17.36	39.9	23.83	18.91		
					No of species	3	2	10	12		
WMQ 31	35	2018	26°34'24.86"N , 89°16'5.05"E	Pre monsoon	Occupancy %	5.75	66.14	18.51	9.60	Non flooded	Fodder plantation of 2004
					No of species	2	5	6	12		
				Post monsoon	Occupancy %	56.65	29.15	12.13	2.06		
					No of species	2	1	7	1		

Range-North

- Six quadrat studies in six management plots, in upper & non- flooded areas, were conducted both in the pre & post monsoon.
- *Saccharum narenga*, and *Themeda arundinacea* were found out of 5 planted species (Annexure: 1) in different plots with a cover percentage ranging from 0.54% to 20.31 % in pre monsoon and 0.71% to 19.56 % in post monsoon season.
- Occupancy percentage of Natural grass, fodder & sedge plants ranged from 5.72 % to 93.90% in pre monsoon and 0% to 97.09% in post monsoon.
- Occupancy percentage of Weed species ranged from 1.37 % to 62.63% in pre monsoon season and 1.63% to 54.67 % in post monsoon season.

Table 9: Occupancy percentage of Planted, Natural, Weeds and other species in North Range, Jaldapara NP

Beat- 50 Feet											
Managed Plot No.	Quadrat No.	Year of plantation	Location	Season	Occupancy Percentage/ no of species	Planted Species	Natural grass, fodder, sedge species	Weeds	Other Species	Flood	Previous condition of the area as per the plantation journal
N50Q 32	36	2016	N26°39'36.8", E089°18'13.1"	Pre monsoon	Occupancy %	15.81	68.9	10.10	6.07	Non flooded	Degraded area
					No of species	3	2	11	10		
				Post monsoon	Occupancy %	16.09	66.68	12.53	4.70	"	
					No of species	3	2	9	7		
N50Q 33	37	2018	N26°39'32.5", E089°18'02.9"	Pre monsoon	Occupancy %	0.54	93.9	1.37	4.19	"	Degraded area
					No of species	3	2	6	12		
				Post monsoon	Occupancy %	0.71	97.09	1.16	1.04	"	
					No of species	3	2	6	7		
Beat-Hassimara											
NHQ 34	38	2014	26°43'26.35"N, 89°17'48.84"E	Pre monsoon	Occupancy %	4.84	5.72	62.63	26.82	Non flooded	Torsa river bed area with succession species
					No of species	2	1	8	7		
				Post monsoon	Occupancy %	11.52	0	54.67	33.80	"	
					No of species	2	0	8	3		
NHQ 37	39	2017	26°42'47.48"N, 89°18'45.07"E	Pre monsoon	Occupancy %	20.31	49.88	19.42	10.39	"	High forest area
					No of species	2	2	5	8		
				Post monsoon	Occupancy %	19.56	51.48	21.45	7.52	"	
					No of species	2	2	5	6		
Beat- Siltorsa											
NSQ 35	40	2014	26°41'3.20"N, 89°18'53.29"E	Pre monsoon	Occupancy %	5.04	75.38	8.47	11.11	Non flooded	Degraded area
					No of species	2	3	6	15		
				Post monsoon	Occupancy %	5.57	71.5	6.82	16.12	"	
					No of species	2	3	5	11		
NSQ 36	41	2016	N26°41'28.9", E089°18'55.4"	Pre monsoon	Occupancy %	11.61	71.55	10.49	6.35	"	Degraded area
					No of species	2	4	9	14		
				Post monsoon	Occupancy %	11.07	72.1	11.81	5.02	"	
					No of species	2	3	7	9		

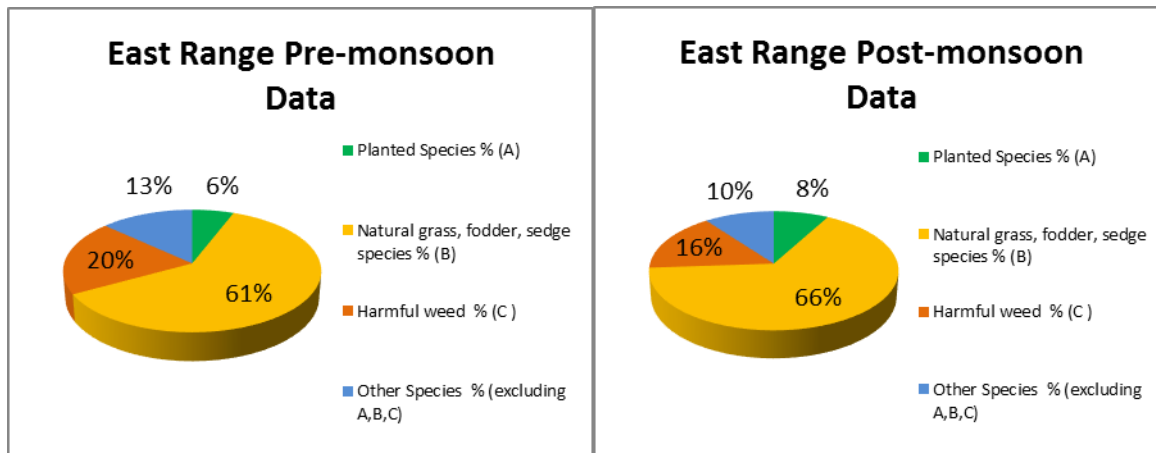


Figure 5: Pre and Post monsoon season Occupancy Percentage of East Range, Jaldapara NP

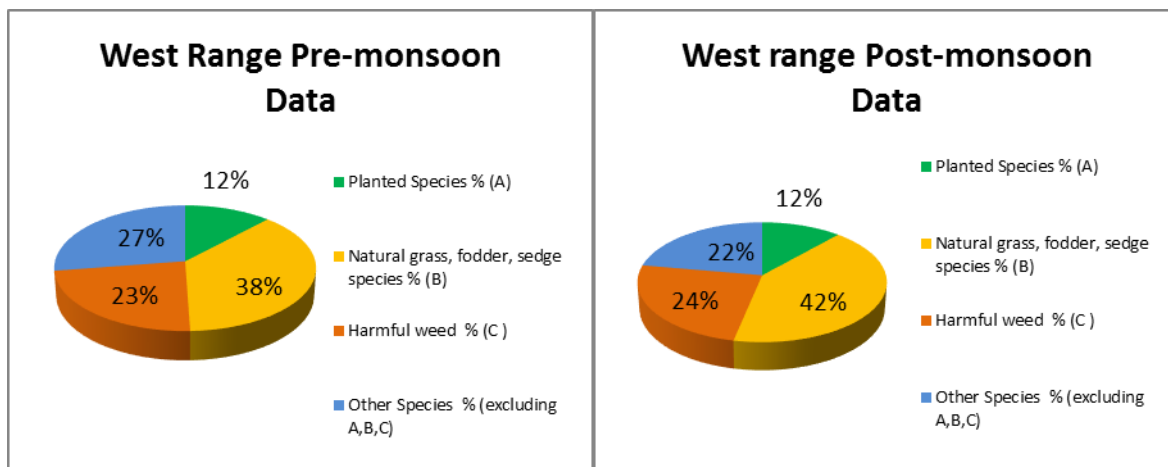


Figure 6: Pre and Post monsoon season Occupancy Percentage of West Range, Jaldapara NP

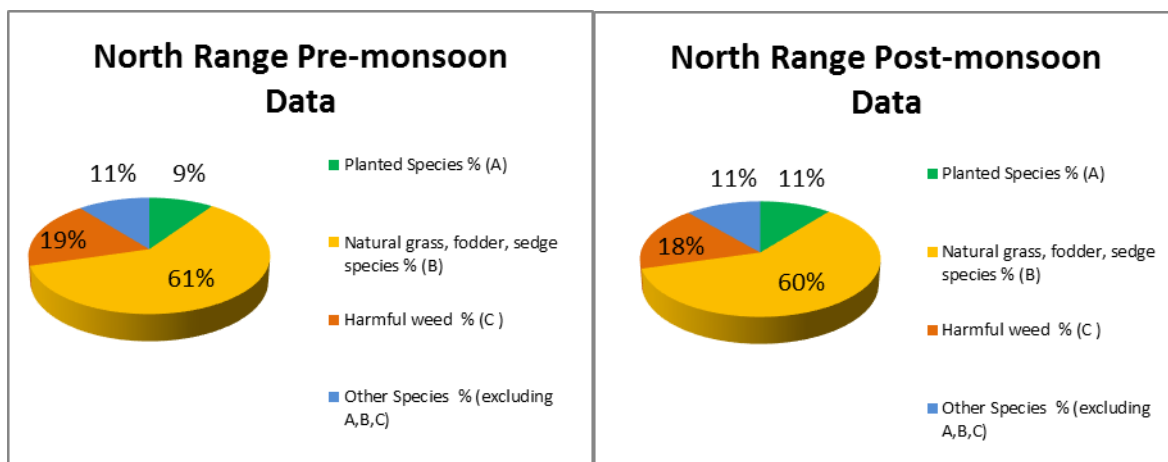


Figure 7: Pre and Post monsoon season Occupancy Percentage of North Range, Jaldapara NP

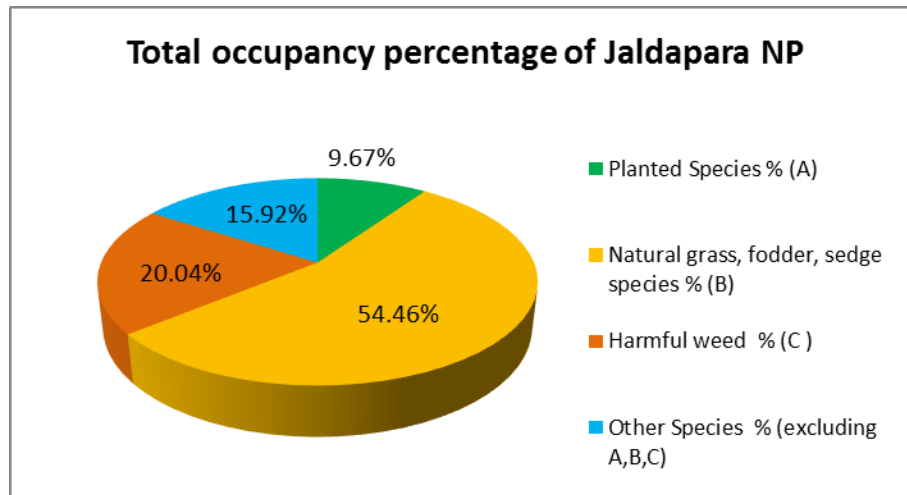


Figure 8: Total occupancy Percentage of 3 Ranges in Jaldapara National Park

b. Statistical evaluation:

i) Analysis of the vegetation data of management plots:

East Range:

A total of 77 and 58 plant species were recorded from this range in pre and post monsoon season respectively. Grass fodder and sedge species from this eastern zone were found to be 14 in Pre monsoon and 13 in Post monsoon season respectively, of which 5 from both the season were planted by Forest Department.

Statistical analysis of all the species shows that highest IVI was recorded by *Axonopus compressus* (IVI= 85.59 and IVI= 107.24 in Premonsoon and in Postmonsoon season respectively) followed by *Cynodon dactylon* (IVI= 32.63 in Pre monsoon and IVI= 32.84 in Postmonsoon season respectively). Both the species are naturally grown grass fodder.

Among the planted species *Saccharum narenga* possesses the highest IVI values (4.37 in Premonsoon and 6.21 in Post monsoon) in both the seasons followed by *Themeda arundinacea* (4.12 and 5.98 in pre and post monsoon respectively).

Among the weed species *Cyclosorus sp* recorded the highest IVI value of 5.75 followed by *Mikania micrantha* (IVI= 4.70) in pre monsoon and *Mikania micrantha* (IVI=6.73) followed by *Cyclosorus sp* (IVI= 5.31) in post monsoon season.

The population density of the grass species (both planted and natural) was 82% in pre-monsoon and 91% in post monsoon season, whereas the population density of the weed species varied from 6-7% both in pre and post monsoon season.

Simpson Diversity Index for Species diversity was calculated to be 0.69 in Premonsoon and 0.59 in post monsoon for all plant species found in East Range of Jaldapara NP.

Table 10: Statistical analysis of all plant species recorded in pre monsoon reason East Range

Sl. No.		Species	NI	O	F %	RF %	D/sq.m.	RD %	A	RA %	IVI	SDI
1	Planted Species	<i>Saccharum narenga</i> (Nees ex Steud.) Hack.	192	7	87.5	3.43	0.24	0.58	27.43	0.36	4.37	0.69
2		<i>Themeda arundinacea</i> (Roxb.) A. Camus	141	7	87.5	3.43	0.18	0.42	20.14	0.26	4.12	
3		<i>Saccharum arundinaceum</i> Retz.	39	4	50	1.96	0.05	0.12	9.75	0.13	2.21	
4		<i>Arundo donax</i> L.	12	1	12.5	0.49	0.02	0.04	12.00	0.16	0.68	
5		<i>Alpinia nigra</i> (Gaertn.) Burt	2	1	12.5	0.49	0.00	0.01	2.00	0.03	0.52	
6	Natural Grass, fodder and Sedge	<i>Axonopus compressus</i> (Sw.) P. Beauv.	17631	8	100	3.92	22.04	52.85	2203.88	28.81	85.59	
7		<i>Cynodon dactylon</i> (L.) Persoon	2000	1	12.5	0.49	2.50	6.00	2000.00	26.15	32.63	
8		<i>Imperata cylindrica</i> (L.) Raeusch.	5206	7	87.5	3.43	6.51	15.61	743.71	9.72	28.76	
9		<i>Oplismenus burmanni</i> (Retz.) P. Beauv.	2071	4	50	1.96	2.59	6.21	517.75	6.77	14.94	
10		<i>Cyperus</i> sp	116	6	75	2.94	0.15	0.35	19.33	0.25	3.54	
11		<i>Kyllinga nemoralis</i> (J.R. Forst. & G. Forst.) Dandy ex Hutch. & Dalziel	54	3	37.5	1.47	0.07	0.16	18.00	0.24	1.87	
12		<i>Setaria palmifolia</i> (J. Koenig) Stapf	12	1	12.5	0.49	0.02	0.04	12.00	0.16	0.68	
13		<i>Eragrostis tenella</i> (L.) Beauverd ex Roemer et Schultes	12	1	12.5	0.49	0.02	0.04	12.00	0.16	0.68	
14		<i>Eleusine indica</i> (L.) Gaertn.	5	1	12.5	0.49	0.01	0.01	5.00	0.07	0.57	
15	harmful Weeds	<i>Cyclosorus</i> sp	500	2	25	0.98	0.63	1.50	250.00	3.27	5.75	
16		<i>Mikania micrantha</i> Kunth	261	7	87.5	3.43	0.33	0.78	37.29	0.49	4.70	
17		<i>Ageratum conyzoides</i> (L.) L.	296	5	62.5	2.45	0.37	0.89	59.20	0.77	4.11	
18		<i>Chromolaena odorata</i> (L.) R.M. King & H. Rob.	251	5	62.5	2.45	0.31	0.75	50.20	0.66	3.86	
19		<i>Clerodendrum infortunatum</i> L.	173	5	62.5	2.45	0.22	0.52	34.60	0.45	3.42	
20		<i>Stephania hernandiifolia</i> (Willd.) Walp.	150	5	62.5	2.45	0.19	0.45	30.00	0.39	3.29	
21		<i>Triumfetta rhomboidea</i> Jacq.	120	4	50	1.96	0.15	0.36	30.00	0.39	2.71	
22		<i>Natsiatum herpeticum</i> Buch. -Ham. ex Arn.	93	3	37.5	1.47	0.12	0.28	31.00	0.41	2.15	
23		<i>Mukia maderaspatana</i> (L.) M. Roem.	16	4	50	1.96	0.02	0.05	4.00	0.05	2.06	
24		<i>Ipomoea hederifolia</i> L.	77	3	37.5	1.47	0.10	0.23	25.67	0.34	2.04	
25		<i>Tetrastigma bracteolatum</i> (Wall.) Planch.	40	3	37.5	1.47	0.05	0.12	13.33	0.17	1.76	
26		<i>Mimosa pudica</i> L.	39	3	37.5	1.47	0.05	0.12	13.00	0.17	1.76	
27		<i>Leea asiatica</i> (L.) Ridsdale	69	2	25	0.98	0.09	0.21	34.50	0.45	1.64	
28		<i>Lantana camara</i> L.	54	2	25	0.98	0.07	0.16	27.00	0.35	1.50	
29		<i>Ziziphus jujuba</i> Mill.	16	2	25	0.98	0.02	0.05	8.00	0.10	1.13	
30		<i>Porana paniculata</i> Roxb.	38	1	12.5	0.49	0.05	0.11	38.00	0.50	1.10	
31		<i>Paederia foetida</i> L.	7	1	12.5	0.49	0.01	0.02	7.00	0.09	0.60	
32		<i>Lygodium flexuosum</i> (L.) Sw.	3	1	12.5	0.49	0.00	0.01	3.00	0.04	0.54	
33		<i>Solanum torvum</i> Sw.	3	1	12.5	0.49	0.00	0.01	3.00	0.04	0.54	
34		<i>Deeringia amaranthoides</i> (Lam.) Merr.	2	1	12.5	0.49	0.00	0.01	2.00	0.03	0.52	
35		<i>Dregea volubilis</i> (L.f.) Benth. ex Hook.f.	1	1	12.5	0.49	0.00	0.00	1.00	0.01	0.51	
36	Other Species	<i>Pouzolzia zeylanica</i> (L.) Benn.	799	4	50	1.96	1.00	2.40	199.75	2.61	6.97	
37		<i>Dryopteris sparsa</i> (D. Don) Kuntze	429	3	37.5	1.47	0.54	1.29	143.00	1.87	4.63	
38		<i>Pupalia lappacea</i> (L.) Juss.	329	4	50	1.96	0.41	0.99	82.25	1.08	4.02	
39		<i>Ichnocarpus frutescens</i> (L.) W.T. Aiton	193	6	75	2.94	0.24	0.58	32.17	0.42	3.94	
40		<i>Helicteres isora</i> L.	222	3	37.5	1.47	0.28	0.67	74.00	0.97	3.10	

41	<i>Piper sp</i>	105	5	62.5	2.45	0.13	0.31	21.00	0.27	3.04
42	<i>Acmella paniculata</i> (Wall. ex DC.) R.K. Jansen	146	4	50	1.96	0.18	0.44	36.50	0.48	2.88
43	<i>Duchesnea indica</i> (Jacks.) Focke	193	2	25	0.98	0.24	0.58	96.50	1.26	2.82
44	<i>Oxalis corniculata</i> L.	172	3	37.5	1.47	0.22	0.52	57.33	0.75	2.74
45	<i>Sida rhombifolia</i> L.	72	4	50	1.96	0.09	0.22	18.00	0.24	2.41
46	<i>Cyanotis sp</i>	112	3	37.5	1.47	0.14	0.34	37.33	0.49	2.29
47	<i>Desmodium laxiflorum</i> DC.	112	3	37.5	1.47	0.14	0.34	37.33	0.49	2.29
48	<i>Mallotus polycarpus</i> (Benth.) Kulju & Welzen	27	4	50	1.96	0.03	0.08	6.75	0.09	2.13
49	<i>Boehmeria sp</i>	85	3	37.5	1.47	0.11	0.25	28.33	0.37	2.10
50	<i>Bombax ceiba</i> L.	17	4	50	1.96	0.02	0.05	4.25	0.06	2.07
51	<i>Diplazium esculentum</i> (Retz.) Sw.	96	2	25	0.98	0.12	0.29	48.00	0.63	1.90
52	<i>Euphorbia hirta</i> L.	94	2	25	0.98	0.12	0.28	47.00	0.61	1.88
53	<i>Rungia pectinata</i> (L.) Nees	94	2	25	0.98	0.12	0.28	47.00	0.61	1.88
54	<i>Dioscorea bulbifera</i> L.	18	3	37.5	1.47	0.02	0.05	6.00	0.08	1.60
55	<i>Mitracarpus hirtus</i> (L.) DC.	63	1	12.5	0.49	0.08	0.19	63.00	0.82	1.50
56	<i>Nelsonia canescens</i> (Lam.) Spreng.	63	1	12.5	0.49	0.08	0.19	63.00	0.82	1.50
57	<i>Drymaria cordata subsp. diandra</i> (Blume) J.A. Duke	50	1	12.5	0.49	0.06	0.15	50.00	0.65	1.29
58	<i>Coffea benghalensis</i> B. Heyne ex Schult.	42	1	12.5	0.49	0.05	0.13	42.00	0.55	1.17
59	<i>Premna bengalensis</i> C.B. Clarke	18	2	25	0.98	0.02	0.05	9.00	0.12	1.15
60	<i>Lagerstroemia parviflora</i> Roxb.	8	2	25	0.98	0.01	0.02	4.00	0.05	1.06
61	<i>Ehretia acuminata</i> R.Br.	7	2	25	0.98	0.01	0.02	3.50	0.05	1.05
62	<i>Physalis minima</i> L.	5	2	25	0.98	0.01	0.01	2.50	0.03	1.03
63	<i>Spermocoe alata</i> Aubl.	22	1	12.5	0.49	0.03	0.07	22.00	0.29	0.84
64	<i>Cyanthillium cinereum</i> (L.) H. Rob.	12	1	12.5	0.49	0.02	0.04	12.00	0.16	0.68
65	<i>Solanum aculeatissimum</i> Jacq.	9	1	12.5	0.49	0.01	0.03	9.00	0.12	0.63
66	<i>Oenanthe javanica</i> (Blume) de Candolle	7	1	12.5	0.49	0.01	0.02	7.00	0.09	0.60
67	<i>Curcuma zedoaria</i> (Christm.) Roscoe	5	1	12.5	0.49	0.01	0.01	5.00	0.07	0.57
68	<i>Hippochaete debilis</i> (Roxb. ex Vaucher) Ching	5	1	12.5	0.49	0.01	0.01	5.00	0.07	0.57
69	<i>Dioscorea pentaphylla</i> L.	4	1	12.5	0.49	0.01	0.01	4.00	0.05	0.55
70	<i>Litsea monopetala</i> (Roxb.) Pers.	4	1	12.5	0.49	0.01	0.01	4.00	0.05	0.55
71	<i>Anisomeles indica</i> (L.) Kuntze	3	1	12.5	0.49	0.00	0.01	3.00	0.04	0.54
72	<i>Flueggea virosa</i> (Roxb. ex Willd.) Royle	3	1	12.5	0.49	0.00	0.01	3.00	0.04	0.54
73	<i>Meyna spinosa</i> Roxb.ex Link	3	1	12.5	0.49	0.00	0.01	3.00	0.04	0.54
74	<i>Momordica charantia</i> L.	3	1	12.5	0.49	0.00	0.01	3.00	0.04	0.54
75	<i>Sterculia villosa</i> Roxb.	2	1	12.5	0.49	0.00	0.01	2.00	0.03	0.52
76	<i>Youngia japonica</i> (L.) DC.	2	1	12.5	0.49	0.00	0.01	2.00	0.03	0.52
77	<i>Sida acuta</i> Burm.f.	1	1	12.5	0.49	0.00	0.00	1.00	0.01	0.51

NI= Number of Individuals, O= Occurance, F= Frequency, RF=Relative Frequency, D/sq m=Density per sq meter, RD=Relative Density, A=Abundance, RA= Relative Abundance, IVI= Importance Value Index, SDI= Simpson's Diversity Index

Table 11: Statistical analysis of all plant species recorded in post monsoon season East Range

Sl. No		Species	NI	O	F %	RF %	D/sq. m.	RD %	A	RA %	IVI	SDI
1	Planted Species	<i>Saccharum narenga</i> (Nees ex Steud.) Hack.	220	7	87.5	5.11	0.28	0.70	31.43	0.40	6.21	0.59
2		<i>Themeda arundinacea</i> (Roxb.) A. Camus	174	7	87.5	5.11	0.22	0.55	24.86	0.32	5.98	
3		<i>Saccharum arundinaceum</i> Retz.	64	4	50	2.92	0.08	0.20	16.00	0.21	3.33	
4		<i>Arundo donax</i> L.	14	1	12.5	0.73	0.02	0.04	14.00	0.18	0.95	
5		<i>Alpinia nigra</i> (Gaertn.) Burt	12	1	12.5	0.73	0.02	0.04	12.00	0.15	0.92	
6	Natural Grass, fodder and Sedge	<i>Axonopus compressus</i> (Sw.) P. Beauv.	19300	6	75	4.38	24.13	61.46	3216.67	41.40	107.24	
7		<i>Cynodon dactylon</i> (L.) Persoon	2000	1	12.5	0.73	2.50	6.37	2000.00	25.74	32.84	
8		<i>Imperata cylindrica</i> (L.) Raeusch.	5412	7	87.5	5.11	6.77	17.24	773.14	9.95	32.30	
9		<i>Opismenus burmanni</i> (Retz.) P. Beauv.	1184	3	37.5	2.19	1.48	3.77	394.67	5.08	11.04	
10		<i>Setaria palmifolia</i> (J. Koenig) Stapf	34	1	12.5	0.73	0.04	0.11	34.00	0.44	1.28	
11		<i>Cyperus</i> sp	24	1	12.5	0.73	0.03	0.08	24.00	0.31	1.12	
12		<i>Eleusine indica</i> (L.) Gaertn.	22	1	12.5	0.73	0.03	0.07	22.00	0.28	1.08	
13		<i>Kyllinga nemoralis</i> (J.R. Forst. & G. Forst.) Dandy ex Hutch. & Dalziel	12	1	12.5	0.73	0.02	0.04	12.00	0.15	0.92	
14	harmful Weeds	<i>Mikania micrantha</i> Kunth	322	7	87.5	5.11	0.40	1.03	46.00	0.59	6.73	
15		<i>Cyclosorus</i> sp	400	2	25	1.46	0.50	1.27	200.00	2.57	5.31	
16		<i>Chromolaena odorata</i> (L.) R.M. King & H. Rob.	245	5	62.5	3.65	0.31	0.78	49.00	0.63	5.06	
17		<i>Clerodendrum infortunatum</i> L.	150	5	62.5	3.65	0.19	0.48	30.00	0.39	4.51	
18		<i>Stephania hernandiifolia</i> (Willd.) Walp.	87	5	62.5	3.65	0.11	0.28	17.40	0.22	4.15	
19		<i>Ageratum conyzoides</i> (L.) L.	124	3	37.5	2.19	0.16	0.39	41.33	0.53	3.12	
20		<i>Triumfetta rhomboidea</i> Jacq.	68	3	37.5	2.19	0.09	0.22	22.67	0.29	2.70	
21		<i>Leea asiatica</i> (L.) Ridsdale	90	2	25	1.46	0.11	0.29	45.00	0.58	2.33	
22		<i>Lantana camara</i> L.	68	2	25	1.46	0.09	0.22	34.00	0.44	2.11	
23		<i>Tetragia bracteolata</i> (Wall.) Planch.	47	2	25	1.46	0.06	0.15	23.50	0.30	1.91	
24		<i>Mimosa pudica</i> L.	35	2	25	1.46	0.04	0.11	17.50	0.23	1.80	
25		<i>Ziziphus jujuba</i> Mill.	10	2	25	1.46	0.01	0.03	5.00	0.06	1.56	
26		<i>Nastium herpeticum</i> Buch. -Ham. ex Arn.	45	1	12.5	0.73	0.06	0.14	45.00	0.58	1.45	
27		<i>Porana paniculata</i> Roxb.	8	1	12.5	0.73	0.01	0.03	8.00	0.10	0.86	
28		<i>Solanum torvum</i> Sw.	5	1	12.5	0.73	0.01	0.02	5.00	0.06	0.81	
29		<i>Dregea volubilis</i> (L.f.) Benth. ex Hook.f.	3	1	12.5	0.73	0.00	0.01	3.00	0.04	0.78	
30	Other Species	<i>Ichnocarpus frutescens</i> (L.) W.T. Aiton	194	6	75	4.38	0.24	0.62	32.33	0.42	5.41	
31		<i>Dryopteris sparsa</i> (D. Don) Kuntze	392	3	37.5	2.19	0.49	1.25	130.67	1.68	5.12	
32		<i>Mallotus polycarpus</i> (Benth.) Kulju & Welzen	19	4	50	2.92	0.02	0.06	4.75	0.06	3.04	
33		<i>Boehmeria</i> sp	112	3	37.5	2.19	0.14	0.36	37.33	0.48	3.03	
34		<i>Bombax ceiba</i> L.	15	4	50	2.92	0.02	0.05	3.75	0.05	3.02	
35		<i>Sida rhombifolia</i> L.	47	3	37.5	2.19	0.06	0.15	15.67	0.20	2.54	
36		<i>Acmella paniculata</i> (Wall. ex DC.) R.K. Jansen	68	2	25	1.46	0.09	0.22	34.00	0.44	2.11	
37		<i>Diplazium esculentum</i> (Retz.) Sw.	82	1	12.5	0.73	0.10	0.26	82.00	1.06	2.05	
38		<i>Coffea benghalensis</i> B. Heyne ex Schult.	72	1	12.5	0.73	0.09	0.23	72.00	0.93	1.89	
39		<i>Desmodium laxiflorum</i> DC.	20	2	25	1.46	0.03	0.06	10.00	0.13	1.65	
40		<i>Premna bengalensis</i> C.B. Clarke	16	2	25	1.46	0.02	0.05	8.00	0.10	1.61	

41	<i>Physalis minima</i> L.	11	2	25	1.46	0.01	0.04	5.50	0.07	1.57
42	<i>Ehretia acuminata</i> R.Br.	9	2	25	1.46	0.01	0.03	4.50	0.06	1.55
43	<i>Lagerstroemia parviflora</i> Roxb.	7	2	25	1.46	0.01	0.02	3.50	0.05	1.53
44	<i>Helicteres isora</i> L.	48	1	12.5	0.73	0.06	0.15	48.00	0.62	1.50
45	<i>Piper sp</i>	21	1	12.5	0.73	0.03	0.07	21.00	0.27	1.07
46	<i>Pouzolzia zeylanica</i> (L.) Benn.	18	1	12.5	0.73	0.02	0.06	18.00	0.23	1.02
47	<i>Hippochaete debilis</i> (Roxb. ex Vaucher) Ching	12	1	12.5	0.73	0.02	0.04	12.00	0.15	0.92
48	<i>Oenanthe javanica</i> (Blume) de Candolle	12	1	12.5	0.73	0.02	0.04	12.00	0.15	0.92
49	<i>Sida acuta</i> Burm.f.	12	1	12.5	0.73	0.02	0.04	12.00	0.15	0.92
50	<i>Dioscorea bulbifera</i> L.	8	1	12.5	0.73	0.01	0.03	8.00	0.10	0.86
51	<i>Solanum aculeatissimum</i> Jacq.	8	1	12.5	0.73	0.01	0.03	8.00	0.10	0.86
52	<i>Anisomeles indica</i> (L.) Kuntze	7	1	12.5	0.73	0.01	0.02	7.00	0.09	0.84
53	<i>Curcuma zedoaria</i> (Christm.) Roscoe	3	1	12.5	0.73	0.00	0.01	3.00	0.04	0.78
54	<i>Sterculia villosa</i> Roxb.	3	1	12.5	0.73	0.00	0.01	3.00	0.04	0.78
55	<i>Dioscorea pentaphylla</i> L.	2	1	12.5	0.73	0.00	0.01	2.00	0.03	0.76
56	<i>Litsea monopetala</i> (Roxb.) Pers.	2	1	12.5	0.73	0.00	0.01	2.00	0.03	0.76
57	<i>Meyna spinosa</i> Roxb.ex Link	2	1	12.5	0.73	0.00	0.01	2.00	0.03	0.76
58	<i>Momordica charantia</i> L.	1	1	12.5	0.73	0.00	0.00	1.00	0.01	0.75

NI= Number of Individuals, O= Occurance, F= Frequency, RF=Relative Frequency, D/sq m=Density per sq meter, RD=Relative Density, A=Abundance, RA= Relative Abundance, IVI= Importance Value Index, SDI= Simpson's Diversity Index

West range:

A total 123 and 114 plant species were recorded from this range during pre and post monsoon season. Grass fodder and sedge species in the Western zone were 20 in number in Pre monsoon and 15 in Post monsoon season respectively, out of which 8 species from pre-monsoon and 9 species from post monsoon were planted by Forest Department.

Statistical analysis of all the species found in both the seasons in the zone shows that highest IVI was recorded by *Imperata cylindrica* in both the seasons (IVI= 93.19 and IVI= 52.37 in Pre-monsoon and in Post-monsoon season respectively) followed by *Axonopus compressus* (IVI= 13.24) in Pre monsoon and *Echinochloa crus-galli* (IVI= 41.56) in Postmonsoon season. Both the species are naturally growing grass fodder.

Among the planted species *Saccharum narenga* possesses the highest IVI values (6.07 in Pre-monsoon and 5.82 in Post-monsoon) followed by *Themeda arundinacea* (4.53 and 5.27 in pre and post monsoon respectively).

Among the the weed species *Ageratum conyzoides* recorded the highest IVI value of 5.38 followed by *Chromolaena odorata* (IVI= 4.50) in pre-monsoon and *Mikania micrantha* (IVI=6.65) followed by *Chromolaena odorata* (IVI= 5.36) in post-monsoon season.

Population density of total grass species was 75% in premonsoon season while only the planted grasses were 3%. Similarly, total grass species population density was 77% in post monsoon

season but only the planted species was 2%. Population density of weeds was 8% and 7% in pre monsoon and post monsoon period respectively.

Simpson Diversity Index for Species diversity was calculated to be 0.71 in pre-monsoon and 0.83 in post monsoon for all plant species found in West Range of Jaldapara NP.

Table 12: Statistical analysis of all plant species recorded in pre monsoon season West Range

Sl. No.		Species	NI	O	F %	RF %	D/sq. m.	RD %	A	RA %	IVI	SDI
1	Planted Species	<i>Saccharum narenga</i> (Nees ex Steud.) Hack.	760	22	95.65	4.14	0.33	1.48	34.55	0.45	6.07	0.71
2		<i>Themeda arundinacea</i> (Roxb.) A. Camus	551	16	69.57	3.01	0.24	1.07	34.44	0.45	4.53	
3		<i>Alpinia nigra</i> (Gaertn.) Burt	89	2	8.70	0.38	0.04	0.17	44.50	0.58	1.13	
4		<i>Cymbopogon flexuosus</i> (Nees ex Steud.) W. Watson	65	3	13.04	0.56	0.03	0.13	21.67	0.28	0.98	
5		<i>Saccharum longisetosum</i> (Andersson) V. Naray. ex Bor	14	3	13.04	0.56	0.01	0.03	4.67	0.06	0.65	
6		<i>Bambusa</i> sp	16	1	4.35	0.19	0.01	0.03	16.00	0.21	0.43	
7		<i>Typha elephantina</i> Roxb.	5	1	4.35	0.19	0.00	0.01	5.00	0.07	0.26	
8	Natural Grass, fodder and Sedge	<i>Imperata cylindrica</i> (L.) Raeusch.	26833	9	39.13	1.69	11.67	52.34	2981.44	39.15	93.19	
9		<i>Axonopus compressus</i> (Sw.) P. Beauv.	3607	12	52.17	2.26	1.57	7.04	300.58	3.95	13.24	
10		<i>Oplismenus burmanni</i> (Retz.) P. Beauv.	2577	12	52.17	2.26	1.12	5.03	214.75	2.82	10.10	
11		<i>Saccharum spontaneum</i> L.	1833	7	30.43	1.32	0.80	3.58	261.86	3.44	8.33	
12		<i>Cynodon dactylon</i> (L.) Persoon	530	2	8.70	0.38	0.23	1.03	265.00	3.48	4.89	
13		<i>Echinochloa crus-galli</i> (L.) P. Beauv	407	3	13.04	0.56	0.18	0.79	135.67	1.78	3.14	
14		<i>Thysanolaena latifolia</i> (Roxb. ex Hornem.) Honda	306	2	8.70	0.38	0.13	0.60	153.00	2.01	2.98	
15		<i>Kyllinga nemoralis</i> (J.R. Forst. & G. Forst.) Dandy ex Hutch. & Dalziel	350	6	26.09	1.13	0.15	0.68	58.33	0.77	2.58	
16		<i>Setaria palmifolia</i> (J. Koenig) Stapf	312	6	26.09	1.13	0.14	0.61	52.00	0.68	2.42	
17		<i>Cyperus</i> sp	162	6	26.09	1.13	0.07	0.32	27.00	0.35	1.80	
18		<i>Coix lacryma-jobi</i> L.	65	1	4.35	0.19	0.03	0.13	65.00	0.85	1.17	
19		<i>Bulbostylis densa</i> (Wallich) Handle-Mazzetti ex Karsten & Schenck	25	1	4.35	0.19	0.01	0.05	25.00	0.33	0.57	
20		<i>Digitaria ciliaris</i> (Retz.) Koeler	4	1	4.35	0.19	0.00	0.01	4.00	0.05	0.25	
21	harmful Weeds	<i>Ageratum conyzoides</i> (L.) L.	1081	9	39.13	1.69	0.47	2.11	120.11	1.58	5.38	
22		<i>Chromolaena odorata</i> (L.) R.M. King & H. Rob.	538	16	69.57	3.01	0.23	1.05	33.63	0.44	4.50	
23		<i>Leea asiatica</i> (L.) Ridsdale	413	15	65.22	2.82	0.18	0.81	27.53	0.36	3.99	
24		<i>Mikania micrantha</i> Kunth	447	14	60.87	2.63	0.19	0.87	31.93	0.42	3.92	
25		<i>Clerodendrum infortunatum</i> L.	328	11	47.83	2.07	0.14	0.64	29.82	0.39	3.10	
26		<i>Triumfetta rhomboidea</i> Jacq.	109	11	47.83	2.07	0.05	0.21	9.91	0.13	2.41	
27		<i>Stephania hernandiifolia</i> (Willd.) Walp.	255	6	26.09	1.13	0.11	0.50	42.50	0.56	2.18	
28		<i>Mimosa pudica</i> L.	118	9	39.13	1.69	0.05	0.23	13.11	0.17	2.09	
29		<i>Deeringia amaranthoides</i> (Lam.) Merr.	68	9	39.13	1.69	0.03	0.13	7.56	0.10	1.92	
30		<i>Ipomoea hederifolia</i> L.	104	4	17.39	0.75	0.05	0.20	26.00	0.34	1.30	
31		<i>Ziziphus jujuba</i> Mill.	47	5	21.74	0.94	0.02	0.09	9.40	0.12	1.15	
32		<i>Lantana camara</i> L.	54	4	17.39	0.75	0.02	0.11	13.50	0.18	1.03	

33		<i>Lygodium flexuosum</i> (L.) Sw.	36	2	8.70	0.38	0.02	0.07	18.00	0.24	0.68
34		<i>Tetrastigma bracteolatum</i> (Wall.) Planch.	7	3	13.04	0.56	0.00	0.01	2.33	0.03	0.61
35		<i>Mukia maderaspatana</i> (L.) M. Roem.	6	3	13.04	0.56	0.00	0.01	2.00	0.03	0.60
36		<i>Porana paniculata</i> Roxb.	12	2	8.70	0.38	0.01	0.02	6.00	0.08	0.48
37		<i>Paederia foetida</i> L.	8	2	8.70	0.38	0.00	0.02	4.00	0.05	0.44
38		<i>Argyreia roxburghii</i> (Wall.) Arn. ex Choisy	3	2	8.70	0.38	0.00	0.01	1.50	0.02	0.40
39		<i>Senna tora</i> (L.) Roxb.	12	1	4.35	0.19	0.01	0.02	12.00	0.16	0.37
40		<i>Smilax perfoliata</i> Lour.	8	1	4.35	0.19	0.00	0.02	8.00	0.11	0.31
41		<i>Dregea volubilis</i> (L.f.) Benth. ex Hook.f.	6	1	4.35	0.19	0.00	0.01	6.00	0.08	0.28
42		<i>Naravelia zeylanica</i> (L.) DC.	1	1	4.35	0.19	0.00	0.00	1.00	0.01	0.20
43		<i>Ageratum houstonianum</i> Miller	1	1	4.35	0.19	0.00	0.00	1.00	0.01	0.20
44	Other Species	<i>Youngia japonica</i> (L.) DC.	1445	3	13.04	0.56	0.63	2.82	481.67	6.32	9.71
45		<i>Dryopteris sparsa</i> (D. Don) Kuntze	1263	7	30.43	1.32	0.55	2.46	180.43	2.37	6.15
46		<i>Ichnocarpus frutescens</i> (L.) W.T. Aiton	466	12	52.17	2.26	0.20	0.91	38.83	0.51	3.67
47		<i>Diplazium esculentum</i> (Retz.) Sw.	493	6	26.09	1.13	0.21	0.96	82.17	1.08	3.17
48		<i>Hippochaete debilis</i> (Roxb. ex Vaucher) Ching	315	2	8.70	0.38	0.14	0.61	157.50	2.07	3.06
49		<i>Bridelia retusa</i> (L.) A. Juss.	315	11	47.83	2.07	0.14	0.61	28.64	0.38	3.06
50		<i>Desmodium laxiflorum</i> DC.	264	10	43.48	1.88	0.11	0.51	26.40	0.35	2.74
51		<i>Persicaria chinensis</i> (L.) H. Gross	336	3	13.04	0.56	0.15	0.66	112.00	1.47	2.69
52		<i>Bombax ceiba</i> L.	124	12	52.17	2.26	0.05	0.24	10.33	0.14	2.63
53		<i>Boehmeria sp</i>	263	2	8.70	0.38	0.11	0.51	131.50	1.73	2.62
54		<i>Oxalis corniculata</i> L.	294	3	13.04	0.56	0.13	0.57	98.00	1.29	2.42
55		<i>Curcuma zedoaria</i> (Christm.) Roscoe	312	4	17.39	0.75	0.14	0.61	78.00	1.02	2.38
56		<i>Pouzolzia zeylanica</i> (L.) Benn.	285	6	26.09	1.13	0.12	0.56	47.50	0.62	2.31
57		<i>Premna bengalensis</i> C.B. Clarke	63	11	47.83	2.07	0.03	0.12	5.73	0.08	2.27
58		<i>Dioscorea bulbifera</i> L.	96	10	43.48	1.88	0.04	0.19	9.60	0.13	2.19
59		<i>Commelina benghalensis</i> L.	213	7	30.43	1.32	0.09	0.42	30.43	0.40	2.13
60		<i>Lagerstroemia parviflora</i> Roxb.	56	10	43.48	1.88	0.02	0.11	5.60	0.07	2.06
61		<i>Pupalia lappacea</i> (L.) Juss.	179	7	30.43	1.32	0.08	0.35	25.57	0.34	2.00
62		<i>Maesa indica</i> (Roxb.) A. DC.	68	9	39.13	1.69	0.03	0.13	7.56	0.10	1.92
63		<i>Hyptis suaveolens</i> (L.) Poit.	211	4	17.39	0.75	0.09	0.41	52.75	0.69	1.86
64		<i>Piper sp</i>	164	6	26.09	1.13	0.07	0.32	27.33	0.36	1.81
65		<i>Streblus asper</i> Lour.	52	8	34.78	1.50	0.02	0.10	6.50	0.09	1.69
66		<i>Mallotus polycarpus</i> (Benth.) Kulju & Welzen	45	8	34.78	1.50	0.02	0.09	5.63	0.07	1.67
67		<i>Mitracarpus hirtus</i> (L.) DC.	90	1	4.35	0.19	0.04	0.18	90.00	1.18	1.55
68		<i>Cyanotis sp</i>	125	5	21.74	0.94	0.05	0.24	25.00	0.33	1.51
69		<i>Stellaria media</i> (L.) Vill.	82	1	4.35	0.19	0.04	0.16	82.00	1.08	1.42
70		<i>Grewia asiatica</i> L.	65	6	26.09	1.13	0.03	0.13	10.83	0.14	1.40
71		<i>Anisomeles indica</i> (L.) Kuntze	60	6	26.09	1.13	0.03	0.12	10.00	0.13	1.38
72		<i>Desmodium cuspidatum</i> (Willd.) Loudon	112	2	8.70	0.38	0.05	0.22	56.00	0.74	1.33
73		<i>Coffea benghalensis</i> B. Heyne ex Schult.	110	4	17.39	0.75	0.05	0.21	27.50	0.36	1.33
74		<i>Duchesnea indica</i> (Jacks.) Focke	112	3	13.04	0.56	0.05	0.22	37.33	0.49	1.27
75		<i>Sida rhombifolia</i> L.	89	4	17.39	0.75	0.04	0.17	22.25	0.29	1.22

76	<i>Dioscorea pentaphylla</i> L.	42	5	21.74	0.94	0.02	0.08	8.40	0.11	1.13
77	<i>Acmella paniculata</i> (Wall. ex DC.) R.K. Jansen	71	4	17.39	0.75	0.03	0.14	17.75	0.23	1.12
78	<i>Cheilocostus speciosus</i> (J. Koenig) C.D. Specht	39	5	21.74	0.94	0.02	0.08	7.80	0.10	1.12
79	<i>Euphorbia hirta</i> L.	66	2	8.70	0.38	0.03	0.13	33.00	0.43	0.94
80	<i>Flueggea virosa</i> (Roxb. ex Willd.) Royle	32	4	17.39	0.75	0.01	0.06	8.00	0.11	0.92
81	<i>Solanum aculeatissimum</i> Jacq.	56	3	13.04	0.56	0.02	0.11	18.67	0.25	0.92
82	<i>Albizia procera</i> (Roxburgh) Benth	26	4	17.39	0.75	0.01	0.05	6.50	0.09	0.89
83	<i>Syzygium cumini</i> (L.) Skeels	26	4	17.39	0.75	0.01	0.05	6.50	0.09	0.89
84	<i>Dalbergia sissoo</i> DC.	22	4	17.39	0.75	0.01	0.04	5.50	0.07	0.87
85	<i>Thelypteris nudata</i> (Roxb.) C.V. Morton	43	1	4.35	0.19	0.02	0.08	43.00	0.56	0.84
86	<i>Sida acuta</i> Burm.f.	53	2	8.70	0.38	0.02	0.10	26.50	0.35	0.83
87	<i>Persicaria hydropiper</i> (L.) Delarb	50	2	8.70	0.38	0.02	0.10	25.00	0.33	0.80
88	<i>Torenia asiatica</i> L.	38	1	4.35	0.19	0.02	0.07	38.00	0.50	0.76
89	<i>Elsholtzia fruticosa</i> (D. Don) Rehder	43	2	8.70	0.38	0.02	0.08	21.50	0.28	0.74
90	<i>Oenanthe javanica</i> (Blume) de Candolle	39	2	8.70	0.38	0.02	0.08	19.50	0.26	0.71
91	<i>Murraya koenigii</i> (L.) Sprengel	36	2	8.70	0.38	0.02	0.07	18.00	0.24	0.68
92	<i>Litsea glutinosa</i> (Lour.) C.B. Rob.	17	3	13.04	0.56	0.01	0.03	5.67	0.07	0.67
93	<i>Dicliptera bupleuroides</i> Nees	30	1	4.35	0.19	0.01	0.06	30.00	0.39	0.64
94	<i>Prunella vulgaris</i> L.	31	2	8.70	0.38	0.01	0.06	15.50	0.20	0.64
95	<i>Urena lobata</i> L.	19	2	8.70	0.38	0.01	0.04	9.50	0.12	0.54
96	<i>Albizia lucidior</i> (Steud.) I.C. Nielsen	18	2	8.70	0.38	0.01	0.04	9.00	0.12	0.53
97	<i>Meyna spinosa</i> Roxb.ex Link	14	2	8.70	0.38	0.01	0.03	7.00	0.09	0.50
98	<i>Sterculia villosa</i> Roxb.	14	2	8.70	0.38	0.01	0.03	7.00	0.09	0.50
99	<i>Codariocalyx motorius</i> (Houtt.) H. Ohashi	6	2	8.70	0.38	0.00	0.01	3.00	0.04	0.43
100	<i>Colocasia esculenta</i> (L.) Schott	5	2	8.70	0.38	0.00	0.01	2.50	0.03	0.42
101	<i>Amaranthus viridis</i> L.	15	1	4.35	0.19	0.01	0.03	15.00	0.20	0.41
102	<i>Aristolochia saccata</i> Wall.	4	2	8.70	0.38	0.00	0.01	2.00	0.03	0.41
103	<i>Desmodium gangeticum</i> (L.) DC.	4	2	8.70	0.38	0.00	0.01	2.00	0.03	0.41
104	<i>Dillenia pentagyna</i> Roxb.	4	2	8.70	0.38	0.00	0.01	2.00	0.03	0.41
105	<i>Centella asiatica</i> (L.) Urban	10	1	4.35	0.19	0.00	0.02	10.00	0.13	0.34
106	<i>Cuphea procumbens</i> Ortega	8	1	4.35	0.19	0.00	0.02	8.00	0.11	0.31
107	<i>Toona ciliata</i> M. Roem.	6	1	4.35	0.19	0.00	0.01	6.00	0.08	0.28
108	<i>Crassocephalum crepidioides</i> (Benth) S. Moore	5	1	4.35	0.19	0.00	0.01	5.00	0.07	0.26
109	<i>Ludwigia perennis</i> L.	5	1	4.35	0.19	0.00	0.01	5.00	0.07	0.26
110	<i>Sida cordata</i> (Burm.f.) Borss.Waalk.	5	1	4.35	0.19	0.00	0.01	5.00	0.07	0.26
111	<i>Blumea lacera</i> (Burman f.) de Candolle	3	1	4.35	0.19	0.00	0.01	3.00	0.04	0.23
112	<i>Lagerstroemia speciosa</i> (L.) Pers.	3	1	4.35	0.19	0.00	0.01	3.00	0.04	0.23
113	<i>Solanum americanum</i> Miller	3	1	4.35	0.19	0.00	0.01	3.00	0.04	0.23
114	<i>Ficus heterophylla</i> L.f.	2	1	4.35	0.19	0.00	0.00	2.00	0.03	0.22
115	<i>Solanum indicum</i> L.	2	1	4.35	0.19	0.00	0.00	2.00	0.03	0.22
116	<i>Amaranthus spinosus</i> L.	1	1	4.35	0.19	0.00	0.00	1.00	0.01	0.20
117	<i>Callicarpa tomentosa</i> (L.) L.	1	1	4.35	0.19	0.00	0.00	1.00	0.01	0.20
118	<i>Cissampelos pareira</i> L.	1	1	4.35	0.19	0.00	0.00	1.00	0.01	0.20

119	<i>Helicteres isora</i> L.	1	1	4.35	0.19	0.00	0.00	1.00	0.01	0.20
120	<i>Melastoma malabathricum</i> L.	1	1	4.35	0.19	0.00	0.00	1.00	0.01	0.20
121	<i>Monochoria vaginalis</i> (Burman f.) C. Presl	1	1	4.35	0.19	0.00	0.00	1.00	0.01	0.20
122	<i>Rotheca serrata</i> (L.) Steane & Mabberley	1	1	4.35	0.19	0.00	0.00	1.00	0.01	0.20
123	<i>Scoparia dulcis</i> L.	1	1	4.35	0.19	0.00	0.00	1.00	0.01	0.20
NI= Number of Individuals, O= Occurance, F= Frequency, RF=Relative Frequency, D/sq m=Density per sq meter, RD=Relative Density, A=Abundance, RA= Relative Abundance, IVI= Importance Value Index, SDI= Simpson's Diversity Index										

Table 13: Statistical analysis of all plant species recorded in post monsoon season West range

Sl. No.		Species	NI	O	F %	RF %	D/sq.m.	RD %	A	RA %	IVI	SDI
1	Planted Species	<i>Saccharum narenga</i> (Nees ex Steud.) Hack.	1052	19	82.61	4.73	0.46	0.83	55.37	0.27	5.82	0.83
2		<i>Themeda arundinacea</i> (Roxb.) A. Camus	747	18	78.26	4.48	0.32	0.59	41.50	0.20	5.27	
3		<i>Saccharum arundinaceum</i> Retz.	82	6	26.09	1.49	0.04	0.06	13.67	0.07	1.62	
4		<i>Alpinia nigra</i> (Gaertn.) Burt	228	4	17.39	1.00	0.10	0.18	57.00	0.27	1.45	
5		<i>Saccharum longisetosum</i> (Andersson) V. Naray. ex Bor	30	2	8.70	0.50	0.01	0.02	15.00	0.07	0.59	
6		<i>Cymbopogon flexuosus</i> (Nees ex Steud.) W. Watson	18	1	4.35	0.25	0.01	0.01	18.00	0.09	0.35	
7		<i>Bambusa</i> sp	15	1	4.35	0.25	0.01	0.01	15.00	0.07	0.33	
8		<i>Arundo donax</i> L.	2	1	4.35	0.25	0.00	0.00	2.00	0.01	0.26	
9		<i>Saccharum longisetosum</i> var. <i>hookeri</i> (Hackel) Bor	2	1	4.35	0.25	0.00	0.00	2.00	0.01	0.26	
10	Natural Grass, fodder and Sedge	<i>Imperata cylindrica</i> (L.) Raeusch.	40405	11	47.83	2.74	17.57	31.97	3673.18	17.67	52.37	
11		<i>Echinochloa crus-galli</i> (L.) P. Beauv.	23000	5	21.74	1.24	10.00	18.20	4600.00	22.12	41.56	
12		<i>Saccharum spontaneum</i> L.	18110	7	30.43	1.74	7.87	14.33	2587.14	12.44	28.51	
13		<i>Oplismenus burmanni</i> (Retz.) P. Beauv.	6817	5	21.74	1.24	2.96	5.39	1363.40	6.56	13.19	
14		<i>Axonopus compressus</i> (Sw.) P. Beauv.	6508	6	26.09	1.49	2.83	5.15	1084.67	5.22	11.86	
15		<i>Cyperus</i> sp	4	1	4.35	0.25	0.00	0.00	4.00	0.02	0.27	
16	harmful Weeds	<i>Mikania micrantha</i> Kunth	2257	17	73.91	4.23	0.98	1.79	132.76	0.64	6.65	
17		<i>Chromolaena odorata</i> (L.) R.M. King & H. Rob.	1657	14	60.87	3.48	0.72	1.31	118.36	0.57	5.36	
18		<i>Ageratum conyzoides</i> (L.) L.	1817	11	47.83	2.74	0.79	1.44	165.18	0.79	4.97	
19		<i>Leea asiatica</i> (L.) Ridsdale	655	15	65.22	3.73	0.28	0.52	43.67	0.21	4.46	
20		<i>Clerodendrum infortunatum</i> L.	839	12	52.17	2.99	0.36	0.66	69.92	0.34	3.99	
21		<i>Triumfetta rhomboidea</i> Jacq.	494	8	34.78	1.99	0.21	0.39	61.75	0.30	2.68	
22		<i>Mimosa pudica</i> L.	306	7	30.43	1.74	0.13	0.24	43.71	0.21	2.19	
23		<i>Natsiatum herpeticum</i> Buch. -Ham. ex Arn.	123	7	30.43	1.74	0.05	0.10	17.57	0.08	1.92	
24		<i>Lantana camara</i> L.	74	7	30.43	1.74	0.03	0.06	10.57	0.05	1.85	
25		<i>Stephania hernandiifolia</i> (Willd.) Walp.	32	6	26.09	1.49	0.01	0.03	5.33	0.03	1.54	
26		<i>Cyclosorus</i> sp	287	3	13.04	0.75	0.12	0.23	95.67	0.46	1.43	
27		<i>Lygodium flexuosum</i> (L.) Sw.	26	5	21.74	1.24	0.01	0.02	5.20	0.03	1.29	
28		<i>Senna tora</i> (L.) Roxb.	219	3	13.04	0.75	0.10	0.17	73.00	0.35	1.27	
29		<i>Deeringia amaranthoides</i> (Lam.) Merr.	36	4	17.39	1.00	0.02	0.03	9.00	0.04	1.07	
30		<i>Pueraria phaseoloides</i> (Roxb.) Benth.	13	3	13.04	0.75	0.01	0.01	4.33	0.02	0.78	
31		<i>Ipomoea hederifolia</i> L.	11	2	8.70	0.50	0.00	0.01	5.50	0.03	0.53	
32		<i>Porana paniculata</i> Roxb.	9	2	8.70	0.50	0.00	0.01	4.50	0.02	0.53	

33		<i>Argyreia roxburghii</i> (Wall.) Arn. ex Choisy	5	2	8.70	0.50	0.00	0.00	2.50	0.01	0.51
34		<i>Dregea volubilis</i> (L.f.) Benth. ex Hook.f.	3	2	8.70	0.50	0.00	0.00	1.50	0.01	0.51
35		<i>Mukia maderaspatana</i> (L.) M. Roem.	3	2	8.70	0.50	0.00	0.00	1.50	0.01	0.51
36		<i>Ipomoea nil</i> (L.) Roth	23	1	4.35	0.25	0.01	0.02	23.00	0.11	0.38
37		<i>Naravelia zeylanica</i> (L.) DC.	5	1	4.35	0.25	0.00	0.00	5.00	0.02	0.28
38		<i>Ziziphus jujuba</i> Mill.	2	1	4.35	0.25	0.00	0.00	2.00	0.01	0.26
39		<i>Mucuna pruriens</i> (L.) DC.	1	1	4.35	0.25	0.00	0.00	1.00	0.00	0.25
40		<i>Paederia foetida</i> L.	1	1	4.35	0.25	0.00	0.00	1.00	0.00	0.25
41		<i>Solanum torvum</i> Sw.	1	1	4.35	0.25	0.00	0.00	1.00	0.00	0.25
42	Other Species	<i>Diplazium esculentum</i> (Retz.) Sw.	8094	7	30.43	1.74	3.52	6.40	1156.29	5.56	13.71
43		<i>Piper sylvaticum</i> Roxb.	4030	2	8.70	0.50	1.75	3.19	2015.00	9.69	13.38
44		<i>Thelypteris nudata</i> (Roxb.) C.V. Morton	2242	4	17.39	1.00	0.97	1.77	560.50	2.70	5.46
45		<i>Piper sp</i>	1082	3	13.04	0.75	0.47	0.86	360.67	1.73	3.34
46		<i>Adiantum sp</i>	500	1	4.35	0.25	0.22	0.40	500.00	2.40	3.05
47		<i>Curcuma zedoaria</i> (Christm.) Roscoe	720	6	26.09	1.49	0.31	0.57	120.00	0.58	2.64
48		<i>Bridelia retusa</i> (L.) A. Juss.	92	10	43.48	2.49	0.04	0.07	9.20	0.04	2.60
49		<i>Bombax ceiba</i> L.	73	10	43.48	2.49	0.03	0.06	7.30	0.04	2.58
50		<i>Boehmeria sp</i>	364	7	30.43	1.74	0.16	0.29	52.00	0.25	2.28
51		<i>Ichnocarpus frutescens</i> (L.) W.T. Aiton	123	8	34.78	1.99	0.05	0.10	15.38	0.07	2.16
52		<i>Callicarpa tomentosa</i> (L.) L.	19	8	34.78	1.99	0.01	0.02	2.38	0.01	2.02
53		<i>Pupalia lappacea</i> (L.) Juss.	524	3	13.04	0.75	0.23	0.41	174.67	0.84	2.00
54		<i>Synedrella nodiflora</i> (L.) Gaertn.	442	3	13.04	0.75	0.19	0.35	147.33	0.71	1.80
55		<i>Acmella paniculata</i> (Wall. ex DC.) R.K. Jansen	410	3	13.04	0.75	0.18	0.32	136.67	0.66	1.73
56		<i>Hyptis suaveolens</i> (L.) Poit.	312	2	8.70	0.50	0.14	0.25	156.00	0.75	1.49
57		<i>Dryopteris sparsa</i> (D. Don) Kuntze	276	3	13.04	0.75	0.12	0.22	92.00	0.44	1.41
58		<i>Desmodium gangeticum</i> (L.) DC.	200	1	4.35	0.25	0.09	0.16	200.00	0.96	1.37
59		<i>Helicteres isora</i> L.	30	5	21.74	1.24	0.01	0.02	6.00	0.03	1.30
60		<i>Mallotus polycarpus</i> (Benth.) Kulju & Welzen	23	5	21.74	1.24	0.01	0.02	4.60	0.02	1.28
61		<i>Dicliptera bupleuroides</i> Nees	218	3	13.04	0.75	0.09	0.17	72.67	0.35	1.27
62		<i>Dioscorea sp</i>	24	4	17.39	1.00	0.01	0.02	6.00	0.03	1.04
63		<i>Lagerstroemia parviflora</i> Roxb.	35	3	13.04	0.75	0.02	0.03	11.67	0.06	0.83
64		<i>Litsea glutinosa</i> (Lour.) C.B. Rob.	15	3	13.04	0.75	0.01	0.01	5.00	0.02	0.78
65		<i>Dioscorea bulbifera</i> L.	12	3	13.04	0.75	0.01	0.01	4.00	0.02	0.77
66		<i>Maesa indica</i> (Roxb.) A. DC.	8	3	13.04	0.75	0.00	0.01	2.67	0.01	0.77
67		<i>Solanum aculeatissimum</i> Jacq.	8	3	13.04	0.75	0.00	0.01	2.67	0.01	0.77
68		<i>Citrullus sp</i>	7	3	13.04	0.75	0.00	0.01	2.33	0.01	0.76
69		<i>Cheilocostus speciosus</i> (J. Koenig) C.D. Specht	6	3	13.04	0.75	0.00	0.00	2.00	0.01	0.76
70		<i>Cordia dichotoma</i> G. Forst.	4	3	13.04	0.75	0.00	0.00	1.33	0.01	0.76
71		<i>Achyroserpnum wallichianum</i> (Benth.) Benth. ex Hook.f.	68	1	4.35	0.25	0.03	0.05	68.00	0.33	0.63
72		<i>Phaseolus vulgaris</i> L.	37	2	8.70	0.50	0.02	0.03	18.50	0.09	0.62
73		<i>Commelina suffruticosa</i> Blume	55	1	4.35	0.25	0.02	0.04	55.00	0.26	0.56
74		<i>Crotalaria pallida</i> Aiton	16	2	8.70	0.50	0.01	0.01	8.00	0.04	0.55
75		<i>Desmodium laxiflorum</i> DC.	12	2	8.70	0.50	0.01	0.01	6.00	0.03	0.54

76	<i>Meyna spinosa</i> Roxb.ex Link	9	2	8.70	0.50	0.00	0.01	4.50	0.02	0.53
77	<i>Colocasia esculenta</i> (L.) Schott	8	2	8.70	0.50	0.00	0.01	4.00	0.02	0.52
78	<i>Albizia lucidior</i> (Steud.) I.C. Nielsen	5	2	8.70	0.50	0.00	0.00	2.50	0.01	0.51
79	<i>Macaranga denticulata</i> (Blume) Müll.Arg.	5	2	8.70	0.50	0.00	0.00	2.50	0.01	0.51
80	<i>Aristolochia saccata</i> Wall.	4	2	8.70	0.50	0.00	0.00	2.00	0.01	0.51
81	<i>Litsea monopetala</i> (Roxb.) Pers.	4	2	8.70	0.50	0.00	0.00	2.00	0.01	0.51
82	<i>Sterculia villosa</i> Roxb.	3	2	8.70	0.50	0.00	0.00	1.50	0.01	0.51
83	<i>Sida acuta</i> Burm.f.	45	1	4.35	0.25	0.02	0.04	45.00	0.22	0.50
84	<i>Curcuma aromatica</i> Salisb.	43	1	4.35	0.25	0.02	0.03	43.00	0.21	0.49
85	<i>Hippochaete debilis</i> (Roxb. ex Vaucher) Ching	35	1	4.35	0.25	0.02	0.03	35.00	0.17	0.44
86	<i>Litsea salicifolia</i> (J. Roxb. ex Nees) Hook. f.	35	1	4.35	0.25	0.02	0.03	35.00	0.17	0.44
87	<i>Torenia asiatica</i> L.	32	1	4.35	0.25	0.01	0.03	32.00	0.15	0.43
88	<i>Sida rhombifolia</i> L.	21	1	4.35	0.25	0.01	0.02	21.00	0.10	0.37
89	<i>Murraya koenigii</i> (L.) Sprengel	20	1	4.35	0.25	0.01	0.02	20.00	0.10	0.36
90	<i>Dioscorea pentaphylla</i> L.	18	1	4.35	0.25	0.01	0.01	18.00	0.09	0.35
91	<i>Nelsonia canescens</i> (Lam.) Spreng.	12	1	4.35	0.25	0.01	0.01	12.00	0.06	0.32
92	<i>Piper longum</i> L.	12	1	4.35	0.25	0.01	0.01	12.00	0.06	0.32
93	<i>Urena lobata</i> L.	12	1	4.35	0.25	0.01	0.01	12.00	0.06	0.32
94	<i>Cyanotis</i> sp	9	1	4.35	0.25	0.00	0.01	9.00	0.04	0.30
95	<i>Premna bengalensis</i> C.B. Clarke	8	1	4.35	0.25	0.00	0.01	8.00	0.04	0.29
96	<i>Anisomelis indica</i>	5	1	4.35	0.25	0.00	0.00	5.00	0.02	0.28
97	<i>Crotalaria prostrata</i> Willd.	5	1	4.35	0.25	0.00	0.00	5.00	0.02	0.28
98	<i>Mitracarpus hirtus</i> (L.) DC.	5	1	4.35	0.25	0.00	0.00	5.00	0.02	0.28
99	<i>Grewia asiatica</i> L.	4	1	4.35	0.25	0.00	0.00	4.00	0.02	0.27
100	<i>Ludwigia perennis</i> L.	4	1	4.35	0.25	0.00	0.00	4.00	0.02	0.27
101	<i>Mallotus philippensis</i> (Lam.) Müll.Arg.	4	1	4.35	0.25	0.00	0.00	4.00	0.02	0.27
102	<i>Uraria picta</i> (Jacq.) DC.	4	1	4.35	0.25	0.00	0.00	4.00	0.02	0.27
103	<i>Lagerstroemia speciosa</i> (L.) Pers.	3	1	4.35	0.25	0.00	0.00	3.00	0.01	0.27
104	<i>Phyllanthus emblica</i> L.	3	1	4.35	0.25	0.00	0.00	3.00	0.01	0.27
105	<i>Alternanthera philoxeroides</i> (Mart.) Griseb.	2	1	4.35	0.25	0.00	0.00	2.00	0.01	0.26
106	<i>Clausena excavata</i> Burm.f.	2	1	4.35	0.25	0.00	0.00	2.00	0.01	0.26
107	<i>Cryptolepis dubia</i> (Burm.f.) M.R. Almeida	2	1	4.35	0.25	0.00	0.00	2.00	0.01	0.26
108	<i>Cuphea procumbens</i> Ortega	2	1	4.35	0.25	0.00	0.00	2.00	0.01	0.26
109	<i>Dillenia pentagyna</i> Roxb.	2	1	4.35	0.25	0.00	0.00	2.00	0.01	0.26
110	<i>Morus indica</i> L.	2	1	4.35	0.25	0.00	0.00	2.00	0.01	0.26
111	<i>Acacia catechu</i> (L.f.) Willd.	1	1	4.35	0.25	0.00	0.00	1.00	0.00	0.25
112	<i>Streblus asper</i> Lour.	1	1	4.35	0.25	0.00	0.00	1.00	0.00	0.25
113	<i>Syzygium cumini</i> (L.) Skeels	1	1	4.35	0.25	0.00	0.00	1.00	0.00	0.25
114	<i>Terminalia bellirica</i> (Gaertn.) Roxb.	1	1	4.35	0.25	0.00	0.00	1.00	0.00	0.25

NI= Number of Individuals, O= Occurance, F= Frequency, RF=Relative Frequency, D/sq m=Density per sq meter, RD=Relative Density, A=Abundance, RA= Relative Abundance, IVI= Importance Value Index, SDI= Simpson's Diversity Index

North Range:

A total of 71 and 58 species were recorded from this range in pre and post monsoon season. Total grass fodder and sedge species recorded from Northern zone were recorded as 9 in Pre monsoon and 8 in Post monsoon season respectively, out of which 2 species in both the seasons were planted by Forest Department.

Statistical analysis of all the species found in both the seasons in the zone shows that highest IVI was recorded by *Imperata cylindrica* in both the seasons (IVI= 70.89 and IVI= 77.35 in Premonsoon and in Post monsoon season respectively) followed by *Saccharum spontaneum* (IVI= 69.92 and 65.00) in both the season. Both the species are naturally growing grass fodder.

Among planted species *Saccharum narenga* possesses the highest IVI values (6.90 in Premonsoon and 8.04 in Post monsoon) followed by *Themeda arundinacea* (3.37 and 4.29 in pre and post monsoon respectively). These were the only two species which were planted in this Range.

Among the weeds *Mikania micrantha* recorded the highest IVI value in both the seasons (IVI= 4.64 in Premonsoon and IVI=5.86 in post monsoon) followed by *Ageratum conyzoides*, both in the seasons with IVI= 3.78 in Premonsoon and IVI=5.05 in Post monsoon.

The total grass species including planted and natural growing species density was 90% and 92% in pre and post monsoon. For only planted species the density was 2% in both the seasons. Weed species have a density of 4% and 5% in pre and post monsoon respectively.

Simpson Diversity Index for Species diversity was calculated to be 0.71 in Premonsoon and 0.69 in post monsoon for all plant species found in North Range of Jaldapara NP.

Table 14: Statistical analysis of all plant species recorded in Premonsoon season North Range

Sl. No.		Species	NI	O	F %	RF %	D/sq.m.	RD %	A	RA %	IVI	SDI
1	Planted Species	<i>Saccharum narenga</i> (Nees ex Steud.) Hack.	238	6	100.00	4.35	0.40	1.54	39.67	1.01	6.90	0.71
2		<i>Themeda arundinacea</i> (Roxb.) A. Camus	37	4	66.67	2.90	0.06	0.24	9.25	0.24	3.37	
3	Natural Grass, fodder and Sedge	<i>Imperata cylindrica</i> (L.) Raeusch.	5300	4	66.67	2.90	8.83	34.30	1325.00	33.69	70.89	
4		<i>Saccharum spontaneum</i> L.	6122	6	100.00	4.35	10.20	39.62	1020.33	25.94	69.92	
5		<i>Oplismenus burmanni</i> (Retz.) P. Beauv.	2125	3	50.00	2.17	3.54	13.75	708.33	18.01	33.94	
6		<i>Thysanolaena latifolia</i> (Roxb. ex Hornem.) Honda	49	2	33.33	1.45	0.08	0.32	24.50	0.62	2.39	
7		<i>Axonopus compressus</i> (Sw.) P. Beauv.	48	1	16.67	0.72	0.08	0.31	48.00	1.22	2.26	
8		<i>Cyperus sp</i>	28	1	16.67	0.72	0.05	0.18	28.00	0.71	1.62	
9		<i>Digitaria ciliaris</i> (Retz.) Koeler	20	1	16.67	0.72	0.03	0.13	20.00	0.51	1.36	
10	harmful Weeds	<i>Mikania micrantha</i> Kunth	88	5	83.33	3.62	0.15	0.57	17.60	0.45	4.64	
11		<i>Ageratum conyzoides</i> (L.) L.	69	4	66.67	2.90	0.12	0.45	17.25	0.44	3.78	
12		<i>Lantana camara</i> L.	68	4	66.67	2.90	0.11	0.44	17.00	0.43	3.77	

13		<i>Triumfetta rhomboidea</i> Jacq.	62	4	66.67	2.90	0.10	0.40	15.50	0.39	3.69
14		<i>Leea asiatica</i> (L.) Ridsdale	72	3	50.00	2.17	0.12	0.47	24.00	0.61	3.25
15		<i>Paederia foetida</i> L.	39	3	50.00	2.17	0.07	0.25	13.00	0.33	2.76
16		<i>Stephania hernandiifolia</i> (Willd.) Walp.	33	3	50.00	2.17	0.06	0.21	11.00	0.28	2.67
17		<i>Clerodendrum infortunatum</i> L.	42	2	33.33	1.45	0.07	0.27	21.00	0.53	2.26
18		<i>Mimosa pudica</i> L.	26	2	33.33	1.45	0.04	0.17	13.00	0.33	1.95
19		<i>Porana paniculata</i> Roxb.	21	2	33.33	1.45	0.04	0.14	10.50	0.27	1.85
20		<i>Cyclosorus</i> sp	35	1	16.67	0.72	0.06	0.23	35.00	0.89	1.84
21		<i>Deeringia amaranthoides</i> (Lam.) Merr.	15	2	33.33	1.45	0.03	0.10	7.50	0.19	1.74
22		<i>Chromolaena odorata</i> (L.) R.M. King & H. Rob.	13	2	33.33	1.45	0.02	0.08	6.50	0.17	1.70
23		<i>Argyrea roxburghii</i> (Wall.) Arn. ex Choisy	5	1	16.67	0.72	0.01	0.03	5.00	0.13	0.88
24		<i>Naravelia zeylanica</i> (L.) DC.	5	1	16.67	0.72	0.01	0.03	5.00	0.13	0.88
25		<i>Mukia maderaspatana</i> (L.) M. Roem.	3	1	16.67	0.72	0.01	0.02	3.00	0.08	0.82
26		<i>Pueraria phaseoloides</i> (Roxb.) Benth.	3	1	16.67	0.72	0.01	0.02	3.00	0.08	0.82
27		<i>Berchemia floribunda</i> (Wallich) Brongniart	2	1	16.67	0.72	0.00	0.01	2.00	0.05	0.79
28		<i>Lygodium flexuosum</i> (L.) Sw.	1	1	16.67	0.72	0.00	0.01	1.00	0.03	0.76
29	Other Species	<i>Thelypteris nudata</i> (Roxb.) C.V. Morton	262	3	50.00	2.17	0.44	1.70	87.33	2.22	6.09
30		<i>Cyanotis</i> sp	90	1	16.67	0.72	0.15	0.58	90.00	2.29	3.60
31		<i>Bridelia retusa</i> (L.) A. Juss.	15	4	66.67	2.90	0.03	0.10	3.75	0.10	3.09
32		<i>Desmodium laxiflorum</i> DC.	47	3	50.00	2.17	0.08	0.30	15.67	0.40	2.88
33		<i>Phaulopsis imbricata</i> (Forssk.) Sweet	73	2	33.33	1.45	0.12	0.47	36.50	0.93	2.85
34		<i>Premna bengalensis</i> C.B. Clarke	40	3	50.00	2.17	0.07	0.26	13.33	0.34	2.77
35		<i>Ichnocarpus frutescens</i> (L.) W.T. Aiton	55	2	33.33	1.45	0.09	0.36	27.50	0.70	2.50
36		<i>Boehmeria</i> sp	18	3	50.00	2.17	0.03	0.12	6.00	0.15	2.44
37		<i>Grewia asiatica</i> L.	34	2	33.33	1.45	0.06	0.22	17.00	0.43	2.10
38		<i>Bidens pilosa</i> L.	18	2	33.33	1.45	0.03	0.12	9.00	0.23	1.79
39		<i>Diplazium esculentum</i> (Retz.) Sw.	17	2	33.33	1.45	0.03	0.11	8.50	0.22	1.78
40		<i>Callicarpa tomentosa</i> (L.) L.	16	2	33.33	1.45	0.03	0.10	8.00	0.20	1.76
41		<i>Dioscorea bulbifera</i> L.	16	2	33.33	1.45	0.03	0.10	8.00	0.20	1.76
42		<i>Dioscorea pentaphylla</i> L.	14	2	33.33	1.45	0.02	0.09	7.00	0.18	1.72
43		<i>Streblus asper</i> Lour.	13	2	33.33	1.45	0.02	0.08	6.50	0.17	1.70
44		<i>Flueggea virosa</i> (Roxb. ex Willd.) Royle	8	2	33.33	1.45	0.01	0.05	4.00	0.10	1.60
45		<i>Mallotus polycarpus</i> (Benth.) Kulju & Welzen	7	2	33.33	1.45	0.01	0.05	3.50	0.09	1.58
46		<i>Bombax ceiba</i> L.	6	2	33.33	1.45	0.01	0.04	3.00	0.08	1.56
47		<i>Dalbergia sissoo</i> DC.	3	2	33.33	1.45	0.01	0.02	1.50	0.04	1.51
48		<i>Sida acuta</i> Burm.f.	21	1	16.67	0.72	0.04	0.14	21.00	0.53	1.39
49		<i>Croton caudatus</i> Geiseler	18	1	16.67	0.72	0.03	0.12	18.00	0.46	1.30
50		<i>Pupalia lappacea</i> (L.) Juss.	18	1	16.67	0.72	0.03	0.12	18.00	0.46	1.30
51		<i>Coffea benghalensis</i> B. Heyne ex Schult.	14	1	16.67	0.72	0.02	0.09	14.00	0.36	1.17
52		<i>Piper</i> sp	12	1	16.67	0.72	0.02	0.08	12.00	0.31	1.11
53		<i>Desmodium cuspidatum</i> (Willd.) Loudon	6	1	16.67	0.72	0.01	0.04	6.00	0.15	0.92
54		<i>Lagerstroemia parviflora</i> Roxb.	4	1	16.67	0.72	0.01	0.03	4.00	0.10	0.85
55		<i>Cheilocostus speciosus</i> (J. Koenig) C.D. Specht	3	1	16.67	0.72	0.01	0.02	3.00	0.08	0.82

56	<i>Helicteres isora</i> L.	3	1	16.67	0.72	0.01	0.02	3.00	0.08	0.82
57	<i>Prunella vulgaris</i> L.	3	1	16.67	0.72	0.01	0.02	3.00	0.08	0.82
58	<i>Sauropus quadrangularis</i> (Willd.) Müll.Arg.	3	1	16.67	0.72	0.01	0.02	3.00	0.08	0.82
59	<i>Sida cordifolia</i> L.	3	1	16.67	0.72	0.01	0.02	3.00	0.08	0.82
60	<i>Zehneria japonica</i> (Thunb.) H.Y. Liu	3	1	16.67	0.72	0.01	0.02	3.00	0.08	0.82
61	<i>Amischotolype hookeri</i> (Hassk.) H. Hara	2	1	16.67	0.72	0.00	0.01	2.00	0.05	0.79
62	<i>Ludwigia perennis</i> L.	2	1	16.67	0.72	0.00	0.01	2.00	0.05	0.79
63	<i>Maesa indica</i> (Roxb.) A. DC.	2	1	16.67	0.72	0.00	0.01	2.00	0.05	0.79
64	<i>Morus indica</i> L.	2	1	16.67	0.72	0.00	0.01	2.00	0.05	0.79
65	<i>Dillenia indica</i> L.	1	1	16.67	0.72	0.00	0.01	1.00	0.03	0.76
66	<i>Dillenia pentagyna</i> Roxb.	1	1	16.67	0.72	0.00	0.01	1.00	0.03	0.76
67	<i>Mallotus philippensis</i> (Lam.) Müll.Arg.	1	1	16.67	0.72	0.00	0.01	1.00	0.03	0.76
68	<i>Melia azedarach</i> L.	1	1	16.67	0.72	0.00	0.01	1.00	0.03	0.76
69	<i>Morinda angustifolia</i> Roxb.	1	1	16.67	0.72	0.00	0.01	1.00	0.03	0.76
70	<i>Oenanthe javanica</i> (Blume) de Candolle	1	1	16.67	0.72	0.00	0.01	1.00	0.03	0.76
71	<i>Toona ciliata</i> M. Roem. a	1	1	16.67	0.72	0.00	0.01	1.00	0.03	0.76
NI= Number of Individuals, O= Occurance, F= Frequency, RF=Relative Frequency, D/sq m=Density per sq meter, RD=Relative Density, A=Abundance, RA= Relative Abundance, IVI= Importance Value Index, SDI= Simpson's Diversity Index										

Table 15: Statistical analysis of all plant species recorded in postmonsoon season North Range

Sl. No.		Species	NI	O	F %	RF %	D/sq.m.	RD %	A	RA %	IVI	SDI
1	Planted Species	<i>Saccharum narenga</i> (Nees ex Steud.) Hack.	261	6	100.00	5.50	0.44	1.59	43.50	0.95	8.04	0.69
2		<i>Themeda arundinacea</i> (Roxb.) A. Camus	54	4	66.67	3.67	0.09	0.33	13.50	0.29	4.29	
3	Natural Grass, fodder and Sedge	<i>Imperata cylindrica</i> (L.) Raeusch.	6400	4	66.67	3.67	10.67	38.92	1600.00	34.77	77.35	
4		<i>Saccharum spontaneum</i> L.	6132	6	100.00	5.50	10.22	37.29	1022.00	22.21	65.00	
5		<i>Oplismenus burmanni</i> (Retz.) P. Beauv.	2045	2	33.33	1.83	3.41	12.43	1022.50	22.22	36.49	
6		<i>Axonopus compressus</i> (Sw.) P. Beauv.	100	1	16.67	0.92	0.17	0.61	100.00	2.17	3.70	
7		<i>Thysanolaena latifolia</i> (Roxb. ex Hornem.) Honda	50	2	33.33	1.83	0.08	0.30	25.00	0.54	2.68	
8		<i>Cyperus sp</i>	22	1	16.67	0.92	0.04	0.13	22.00	0.48	1.53	
9	harmful Weeds	<i>Mikania micrantha</i> Kunth	122	5	83.33	4.59	0.20	0.74	24.40	0.53	5.86	
10		<i>Ageratum conyzoides</i> (L.) L.	120	4	66.67	3.67	0.20	0.73	30.00	0.65	5.05	
11		<i>Lantana camara</i> L.	84	4	66.67	3.67	0.14	0.51	21.00	0.46	4.64	
12		<i>Triumfetta rhomboidea</i> Jacq.	75	4	66.67	3.67	0.13	0.46	18.75	0.41	4.53	
13		<i>Leea asiatica</i> (L.) Ridsdale	52	3	50.00	2.75	0.09	0.32	17.33	0.38	3.45	
14		<i>Clerodendrum infortunatum</i> L.	45	2	33.33	1.83	0.08	0.27	22.50	0.49	2.60	
15		<i>Paederia foetida</i> L.	27	2	33.33	1.83	0.05	0.16	13.50	0.29	2.29	
16		<i>Chromolaena odorata</i> (L.) R.M. King & H. Rob.	24	2	33.33	1.83	0.04	0.15	12.00	0.26	2.24	
17		<i>Mimosa pudica</i> L.	24	2	33.33	1.83	0.04	0.15	12.00	0.26	2.24	
18		<i>Porana paniculata</i> Roxb.	20	2	33.33	1.83	0.03	0.12	10.00	0.22	2.17	
19		<i>Cyclosorus sp</i>	44	1	16.67	0.92	0.07	0.27	44.00	0.96	2.14	
20		<i>Deeringia amaranthoides</i> (Lam.) Merr.	12	1	16.67	0.92	0.02	0.07	12.00	0.26	1.25	
21		<i>Naravelia zeylanica</i> (L.) DC.	8	1	16.67	0.92	0.01	0.05	8.00	0.17	1.14	
22		<i>Stephania hernandiifolia</i> (Willd.) Walp.	7	1	16.67	0.92	0.01	0.04	7.00	0.15	1.11	
23		<i>Mukia maderaspatana</i> (L.) M. Roem.	5	1	16.67	0.92	0.01	0.03	5.00	0.11	1.06	
24		<i>Argyreia roxburghii</i> (Wall.) Arn. ex Choisy	3	1	16.67	0.92	0.01	0.02	3.00	0.07	1.00	
25		<i>Berchemia floribunda</i> (Wallich) Brongniart	3	1	16.67	0.92	0.01	0.02	3.00	0.07	1.00	
26		<i>Pueraria phaseoloides</i> (Roxb.) Benth.	3	1	16.67	0.92	0.01	0.02	3.00	0.07	1.00	
27	Other Species	<i>Phaulopsis imbricata</i> (Forssk.) Sweet	110	2	33.33	1.83	0.18	0.67	55.00	1.20	3.70	
28		<i>Diplazium esculentum</i> (Retz.) Sw.	82	2	33.33	1.83	0.14	0.50	41.00	0.89	3.22	
29		<i>Thelypteris nudata</i> (Roxb.) C.V. Morton	78	1	16.67	0.92	0.13	0.47	78.00	1.69	3.09	
30		<i>Premna bengalensis</i> C.B. Clarke	24	3	50.00	2.75	0.04	0.15	8.00	0.17	3.07	
31		<i>Ichnocarpus frutescens</i> (L.) W.T. Aiton	70	2	33.33	1.83	0.12	0.43	35.00	0.76	3.02	
32		<i>Bridelia retusa</i> (L.) A. Juss.	34	2	33.33	1.83	0.06	0.21	17.00	0.37	2.41	
33		<i>Prunella vulgaris</i> L.	48	1	16.67	0.92	0.08	0.29	48.00	1.04	2.25	
34		<i>Bidens pilosa</i> L.	24	2	33.33	1.83	0.04	0.15	12.00	0.26	2.24	
35		<i>Grewia asiatica</i> L.	20	2	33.33	1.83	0.03	0.12	10.00	0.22	2.17	
36		<i>Dioscorea bulbifera</i> L.	16	2	33.33	1.83	0.03	0.10	8.00	0.17	2.11	
37		<i>Boehmeria sp</i>	14	2	33.33	1.83	0.02	0.09	7.00	0.15	2.07	
38		<i>Callicarpa tomentosa</i> (L.) L.	12	2	33.33	1.83	0.02	0.07	6.00	0.13	2.04	
39		<i>Flueggea virosa</i> (Roxb. ex Willd.) Royle	12	2	33.33	1.83	0.02	0.07	6.00	0.13	2.04	

40	<i>Bombax ceiba</i> L.	4	2	33.33	1.83	0.01	0.02	2.00	0.04	1.90
41	<i>Croton caudatus</i> Geiseler	34	1	16.67	0.92	0.06	0.21	34.00	0.74	1.86
42	<i>Desmodium laxiflorum</i> DC.	22	1	16.67	0.92	0.04	0.13	22.00	0.48	1.53
43	<i>Sida acuta</i> Burm.f.	20	1	16.67	0.92	0.03	0.12	20.00	0.43	1.47
44	<i>Sauropus quadrangularis</i> (Willd.) Müll.Arg.	12	1	16.67	0.92	0.02	0.07	12.00	0.26	1.25
45	<i>Streblus asper</i> Lour.	10	1	16.67	0.92	0.02	0.06	10.00	0.22	1.20
46	<i>Cheilocostus speciosus</i> (J. Koenig) C.D. Specht	8	1	16.67	0.92	0.01	0.05	8.00	0.17	1.14
47	<i>Maesa indica</i> (Roxb.) A. DC.	8	1	16.67	0.92	0.01	0.05	8.00	0.17	1.14
48	<i>Oenanthe javanica</i> (Blume) de Candolle	8	1	16.67	0.92	0.01	0.05	8.00	0.17	1.14
49	<i>Desmodium cuspidatum</i> (Willd.) Loudon	6	1	16.67	0.92	0.01	0.04	6.00	0.13	1.08
50	<i>Amischotolype hookeri</i> (Hassk.) H. Hara	4	1	16.67	0.92	0.01	0.02	4.00	0.09	1.03
51	<i>Lagerstroemia parviflora</i> Roxb.	4	1	16.67	0.92	0.01	0.02	4.00	0.09	1.03
52	<i>Ludwigia perennis</i> L.	4	1	16.67	0.92	0.01	0.02	4.00	0.09	1.03
53	<i>Zehneria japonica</i> (Thunb.) H.Y. Liu	4	1	16.67	0.92	0.01	0.02	4.00	0.09	1.03
54	<i>Dioscorea pentaphylla</i> L.	3	1	16.67	0.92	0.01	0.02	3.00	0.07	1.00
55	<i>Mallotus philippensis</i> (Lam.) Müll.Arg.	2	1	16.67	0.92	0.00	0.01	2.00	0.04	0.97
56	<i>Mallotus polycarpus</i> (Benth.) Kulju & Welzen	2	1	16.67	0.92	0.00	0.01	2.00	0.04	0.97
57	<i>Morus indica</i> L.	2	1	16.67	0.92	0.00	0.01	2.00	0.04	0.97
58	<i>Dalbergia sissoo</i> DC.	1	1	16.67	0.92	0.00	0.01	1.00	0.02	0.95

NI= Number of Individuals, O= Occurance, F= Frequency, RF=Relative Frequency, D/sq m=Density per sq meter, RD=Relative Density, A=Abundance, RA= Relative Abundance, IVI= Importance Value Index, SDI= Simpson's Diversity Index

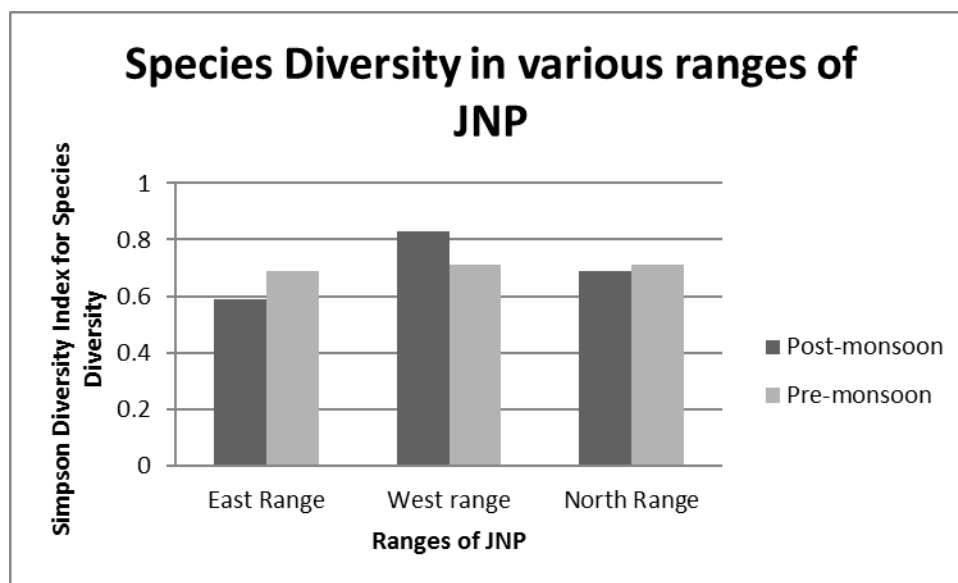


Figure 9: Comparison of species diversity in different Ranges and seasons in JNP

ii) Analysis of the vegetation data of natural grassland plots:

In Jaldapara NP, vegetation data was also recorded from 5 quadrates in 5 natural unmanaged grasslands occurring in 5 different beats. These data were further statistically analyzed and arranged in separate groups like grass fodders, weeds and other species. A total of 58 species were found from the 5 quadrates out of which 12 belong to grass fodders and sedge species, 12 to weeds and rest of the plants to other species.

The highest IVI value was recorded in *Marsilea minuta* (IVI=128.51) which belongs to the category of other species. *Imperata cylindrica* was recorded with highest IVI value of 23.38 in grass fodders followed by *Saccharum spontaneum* (IVI=15.40). In the weed species highest IVI value was observed in *Chromolaena odorata* (IVI= 3.77) followed by *Mikania micrantha* (IVI=3.71).

The density of the grass species was calculated to be 38% whereas the density of the weeds was around 1%.

Simpson Diversity Index for Species diversity was calculated to be 0.65 in Natural Grassland in Jaldapara NP.

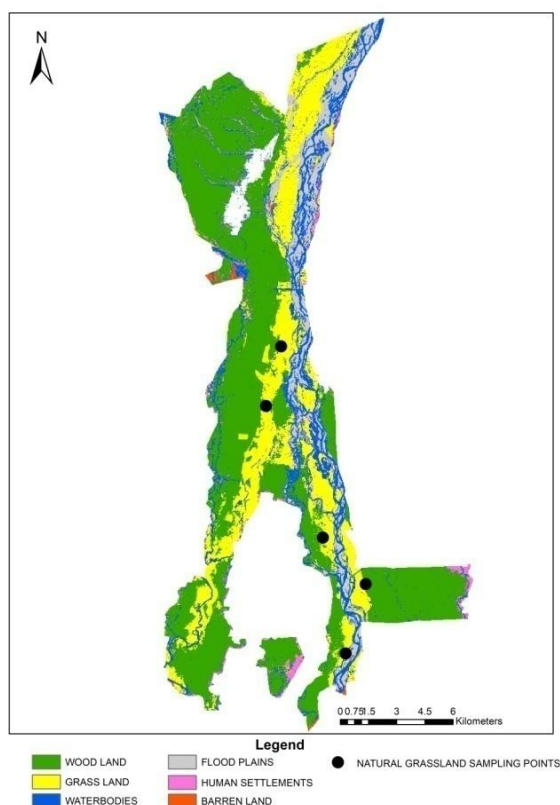


Figure 10: Natural Grassland Quadrates in Jaldapara NP

Table 16: Statistical analysis of all plant species recorded in Natural Grass land in Jaldapara NP

Sl No	Class	Name of the species	Family	NI	O	F %	RF %	D/ sq.m.	RD %	A	RA %	IVI	SDI
1	Grass fodders	<i>Imperata cylindrica</i> (L.) Raeusch.	Poaceae	2290	2	40	2.35	458.00	12.89	1145.00	8.14	23.38	0.65
2		<i>Saccharum spontaneum</i> L.	Poaceae	1444	4	80	4.71	288.80	8.13	361.00	2.57	15.40	
3		<i>Cynodon dactylon</i> (L.) Pers.	Poaceae	1000	1	20	1.18	200.00	5.63	1000.00	7.11	13.91	
4		<i>Axonopus compressus</i> (Sw.) P. Beauv.	Poaceae	1012	2	40	2.35	202.40	5.70	506.00	3.60	11.64	
5		<i>Alpinia nigra</i> (Gaertn.) Burt	Zingiberaceae	588	3	60	3.53	117.60	3.31	196.00	1.39	8.23	
6		<i>Saccharum narenga</i> (Nees ex Steud.) Hack.	Poaceae	65	4	80	4.71	13.00	0.37	16.25	0.12	5.19	
7		<i>Typha elephantina</i> Roxb.	Cyperaceae	203	2	40	2.35	40.60	1.14	101.50	0.72	4.22	
8		<i>Arundo donax</i> L.	Poaceae	128	2	40	2.35	25.60	0.72	64.00	0.45	3.53	
9		<i>Oplismenus burmanni</i> (Retz.) P. Beauv.	Poaceae	22	1	20	1.18	4.40	0.12	22.00	0.16	1.46	
10		<i>Cyperus</i> sp	Cyperaceae	13	1	20	1.18	2.60	0.07	13.00	0.09	1.34	
11		<i>Dactyloctenium aegyptium</i> (L.) Willd.	Poaceae	7	1	20	1.18	1.40	0.04	7.00	0.05	1.27	
12		<i>Cymbopogon flexuosus</i> (Nees ex Steud.) W. Watson	Poaceae	1	1	20	1.18	0.20	0.01	1.00	0.01	1.19	
13	Weeds	<i>Chromolaena odorata</i> (L.) R.M. King & H. Rob.	Asteraceae	30	3	60	3.53	6.00	0.17	10.00	0.07	3.77	
14		<i>Mikania micrantha</i> Kunth	Asteraceae	22	3	60	3.53	4.40	0.12	7.33	0.05	3.71	
15		<i>Ageratum conyzoides</i> (L.) L.	Asteraceae	54	2	40	2.35	10.80	0.30	27.00	0.19	2.85	
16		<i>Paederia foetida</i> L.	Rubiaceae	19	2	40	2.35	3.80	0.11	9.50	0.07	2.53	
17		<i>Triumfetta rhomboidea</i> Jacq.	Malvaceae	3	2	40	2.35	0.60	0.02	1.50	0.01	2.38	
18		<i>Stephania hernandiifolia</i> (Willd.) Walp.	Menispermaceae	2	2	40	2.35	0.40	0.01	1.00	0.01	2.37	
19		<i>Ziziphus jujuba</i> Mill.	Rhamnaceae	8	1	20	1.18	1.60	0.05	8.00	0.06	1.28	
20		<i>Argyrea roxburghii</i> (Wall.) Arn. ex Choisy	Convolvulaceae	7	1	20	1.18	1.40	0.04	7.00	0.05	1.27	
21		<i>Clerodendrum infortunatum</i> L.	Lamiaceae	4	1	20	1.18	0.80	0.02	4.00	0.03	1.23	
22		<i>Lantana camara</i> L.	Lamiaceae	4	1	20	1.18	0.80	0.02	4.00	0.03	1.23	
23		<i>Leea asiatica</i> (L.) Ridsdale	Vitaceae	3	1	20	1.18	0.60	0.02	3.00	0.02	1.21	
24		<i>Mimosa pudica</i> L.	Fabaceae	1	1	20	1.18	0.20	0.01	1.00	0.01	1.19	
25	Other Species	<i>Marsilea minuta</i> L.	Marsileaceae	10000	1	20	1.18	2000.00	56.28	10000.00	71.06	128.51	
26		<i>Hippochaete debilis</i> (Roxb. ex Vaucher) Ching	Equisetaceae	186	3	60	3.53	37.20	1.05	62.00	0.44	5.02	
27		<i>Thelypteris</i> sp	Thelypteridaceae	118	2	40	2.35	23.60	0.66	59.00	0.42	3.44	
28		<i>Asplenium</i> sp	Aspleniaceae	101	2	40	2.35	20.20	0.57	50.50	0.36	3.28	
29		<i>Diplazium esculentum</i> (Retz.) Sw.	Athyriaceae	89	2	40	2.35	17.80	0.50	44.50	0.32	3.17	
30		<i>Gnaphalium purpureum</i> L.	Asteraceae	99	1	20	1.18	19.80	0.56	99.00	0.70	2.44	
31		<i>Syzygium cumini</i> (L.) Skeels	Myrtaceae	4	2	40	2.35	0.80	0.02	2.00	0.01	2.39	
32		<i>Porana paniculata</i> Roxb.	Convolvulaceae	3	2	40	2.35	0.60	0.02	1.50	0.01	2.38	
33		<i>Dalbergia sissoo</i> DC.	Fabaceae	72	1	20	1.18	14.40	0.41	72.00	0.51	2.09	
34		<i>Duchesnea indica</i> (Jacks.) Focke	Rosaceae	37	1	20	1.18	7.40	0.21	37.00	0.26	1.65	
35		<i>Persicaria hydropiper</i> (L.) Delarb	Polygonaceae	31	1	20	1.18	6.20	0.17	31.00	0.22	1.57	
36		<i>Oenanthe benghalensis</i> Benth. & Hook. f.	Apiaceae	17	1	20	1.18	3.40	0.10	17.00	0.12	1.39	
37		<i>Bridelia retusa</i> (L.) A. Juss.	Phyllanthaceae	12	1	20	1.18	2.40	0.07	12.00	0.09	1.33	

38	<i>Ludwigia adscendens</i> (L.) H. Hara	Onagraceae	12	1	20	1.18	2.40	0.07	12.00	0.09	1.33
39	<i>Ludwigia perennis</i> L.	Onagraceae	9	1	20	1.18	1.80	0.05	9.00	0.06	1.29
40	<i>Anisomeles indica</i> (L.) Kuntze	Lamiaceae	7	1	20	1.18	1.40	0.04	7.00	0.05	1.27
41	<i>Tetrastigma sp</i>	Vitaceae	7	1	20	1.18	1.40	0.04	7.00	0.05	1.27
42	<i>Hydrocotyle sibthorpioides</i> Lam.	Araliaceae	5	1	20	1.18	1.00	0.03	5.00	0.04	1.24
43	<i>Litsea monopetala</i> (Roxb.) Pers.	Lauraceae	4	1	20	1.18	0.80	0.02	4.00	0.03	1.23
44	<i>Desmodium gangeticum</i> (L.) DC.	Fabaceae	3	1	20	1.18	0.60	0.02	3.00	0.02	1.21
45	<i>Desmodium laxiflorum</i> DC.	Fabaceae	3	1	20	1.18	0.60	0.02	3.00	0.02	1.21
46	<i>Hyptis suaveolens</i> (L.) Poit.	Lamiaceae	3	1	20	1.18	0.60	0.02	3.00	0.02	1.21
47	<i>Lagerstroemia parviflora</i> Roxb.	Lythraceae	3	1	20	1.18	0.60	0.02	3.00	0.02	1.21
48	<i>Bischofia javanica</i> Blume	Bischofiaceae	2	1	20	1.18	0.40	0.01	2.00	0.01	1.20
49	<i>Bombax ceiba</i> L.	Malvaceae	2	1	20	1.18	0.40	0.01	2.00	0.01	1.20
50	<i>Tetrastigma dubium</i> (Lawson) Planch.	Vitaceae	2	1	20	1.18	0.40	0.01	2.00	0.01	1.20
51	<i>Callicarpa tomentosa</i> (L.) L.	Lamiaceae	1	1	20	1.18	0.20	0.01	1.00	0.01	1.19
52	<i>Dioscorea bulbifera</i> L.	Dioscoreaceae	1	1	20	1.18	0.20	0.01	1.00	0.01	1.19
53	<i>Ficus hispida</i> L.f.	Moraceae	1	1	20	1.18	0.20	0.01	1.00	0.01	1.19
54	<i>Maesa macrophylla</i> Wall.	Primulaceae	1	1	20	1.18	0.20	0.01	1.00	0.01	1.19
55	<i>Pupalia lappacea</i> (L.) Juss.	Amaranthaceae	1	1	20	1.18	0.20	0.01	1.00	0.01	1.19
56	<i>Streblus asper</i> Lour.	Moraceae	1	1	20	1.18	0.20	0.01	1.00	0.01	1.19
57	<i>Uraria picta</i> (Jacq.) DC.	Fabaceae	1	1	20	1.18	0.20	0.01	1.00	0.01	1.19
58	<i>Ziziphus oenopolia</i> (L.) Mill.	Rhamnaceae	1	1	20	1.18	0.20	0.01	1.00	0.01	1.19

NI= Number of Individuals, O= Occurance, F= Frequency, RF=Relative Frequency, D/sq m=Density per sq metre, RD=Relative Density, A=Abundance, RA= Relative Abundance, IVI= Importance Value Index, SDI= Simpson's Diversity Index

Findings:

In the 37 management plots identified in consultation with the Forest Department, a total of 41 quadrates were sampled twice, one in pre monsoon and the other in post monsoon. It was seen from the data of the vegetation collected, that there was no overall significant impact range wise due to seasonal change either in the pre or post monsoon season. However, the three beats Bendaki, Hollong and Kunjanagar recorded a significant impact between the two seasons, in that whenever the Natural grass species were higher the Weeds were recorded low and *vice versa*.

It is interesting to note that as per our study in all the management plots, the Planted species revealed a low occupancy percentage Range wise, which varied from an average of 6% to 11% in pre-monsoon and 8% to 12% in post monsoon season. It is obvious that fewer occurrences of Planted species may be due to non-survival at the sapling stage or its consumption by herbivores as soon as the fences are removed.

As per plantation journals the Forest Department had identified and chosen 14 species of fodder grasses (Annexure: 1) for plantation in the different management plots. However, in the field it was observed a maximum of 9 species and a minimum of 2 species of the 14 species have been planted in the different managed plots.

It was observed that in almost all the managed plots where Dhadda and Chepti were planted they were found to be also present in our present collections. However, Purundi, Malsa and Madhua which were planted in 22 to 29 managed plots as per plantation journals, but their occurrence was found only in 4 to 9 plots respectively in our study.

In the quadrates where 4-6 species were planted as per the record, only 50% of them were found in actual field during this study. However, wherever only 2-3 species were planted all of them were also found in our collections. This phenomenon was seen both in pre and post monsoon seasons.

On a comparison between Weeds and Planted species it was seen that there was very little impact/conflict on Planted species by Weeds. However, this trend was not observed in Mairadanga beat where higher the Planted species lower the occurrence of Weeds and *vice versa*.

It was seen that occupancy percentage of Weed species in non-flooded areas was more in comparison to flooded areas.

On a total evaluation of the managed plots in Jaldapara NP the **cover percentage** for planted species is 9.67%; natural grass, fodder & sedge species – 54.46%; harmful weeds – 20.04% and other species occupies 15.92% of the area. (Figure: 8)

Natural Grass species shows high IVI values in both the seasons in all the Ranges. Among natural grasses *Imperata cylindrica*, *Axonopus compressus* and *Saccharum spontaneum* were the naturally occurring grass species with high IVI in most cases.

Among the weed species, *Mikania micrantha*, *Chromolaena odorata* and *Ageratum conyzoides* were denser than the other weed species.

Species diversity was highest in West range in post monsoon season with SDI= 0.83 while East range shows the lowest diversity.

It is seen that in natural grassland the effects of weeds are minimum as the **population density** of the weeds in natural grassland quadrates were only 1% where as in the managed grassland the density varied from 4% to 8%.

Interestingly it was also seen that the population density of grass species in natural grassland was less (only 38%) than the managed plots in various ranges (75% to 92%).

4.5. Habitat use by animals

Results:

a. Hispid hare:

Actual sighting of Hispid Hare occurrence was observed twice during the study period in Jaldapara NP. With the help of photographs that was shown to the forest guards, a total of 11 locations were identified during the study. Out of these, in 8 locations, Hispid Hare pellets were found, in one location forest guards confirmed their sightings and in 2 locations direct sightings were documented (Table: 17). Out of these 11 locations, 8 (*i.e.* 73%) were from the management zone and only 3 were from non-management area (Figure: 12). One nest was seen built in Dhadda (*Saccharum narenga*) grass with one leveret found in managed area (Figure: 11). All direct sightings of hispid hare were observed to be only in habitat management zones. Based on the report of the Forest Guards it was observed that Hispid Hare occurrences matched in all the locations except in one (Hassimara).

Table 17: Hispid Hare Occurrence in Jaldapara NP

Sl no.	Range	Beat	Block/Compartment	Lat	Long	Pellet Found	Report From Forest Guards	Remarks
						Yes/No		
1	Jaldapara East	Malangi	Chilapata 2	N26°36'46.5"	E89°19'31.2"	Yes	Yes	Pellets collected near Kodalbasti Tower (East Side) in Natural grassland
2	Jaldapara East	Sissamara	Chilapata 3b	N26°33'41.9"	E89°20'50.6"	Yes	Yes	Pellets collected in managed grassland
3	Jaldapara East	Sissamara	Chilapata 3b	N26°33'14.9"	E89°20'48.0"	Yes	Yes	Pellets collected beside the managed grassland. Few Rhinos and Sambar observed
4	West Range	Hollong	JP5	N26°39'08.0"	E89°17'46.7"	Yes	Yes	Pellets collected in managed grassland. Hispid Hares sighted by forest guard eating the young shoots.
5	North Range	Hassimara	Hassimara 3a	N26°42'39.0"	E89°18'46.3"	No	Yes	Rare sightings of Hispid hare in managed grassland. Pellets not found
6	West Range	TEC	Torsa 1	26°36'33.83"N	89°17'4.97"E	Yes	Yes	Pellets collected in managed grassland
7	West Range	TEC	Torsa 1	26°37'34.20"N	89°18'2.78"E	Yes	Yes	Pellets collected in managed grassland
8	West Range	Bendaki	Torsa 2	26°34'28.50"N	89°16'33.84"E	Yes	Yes	Pellets collected in managed grassland
9	Jaldapara East	Malangi	MLG 1	26°39'25.00"N	89°19'15.10"E	Yes	Yes	Pellets collected in natural riverine Grassland
10	Jaldapara East	Malangi	MLG 2	26°38'40.7"N	89°19'11.1"E	Direct sighting	Yes	In managed grassland, crossing the road
11	Jaldapara East	Jaldapara HQ	JP3	26°39'16.6"N	89°18'35.2"E	Leveret sighted in nest	Yes	Nest in Dhadda grass, in managed grassland

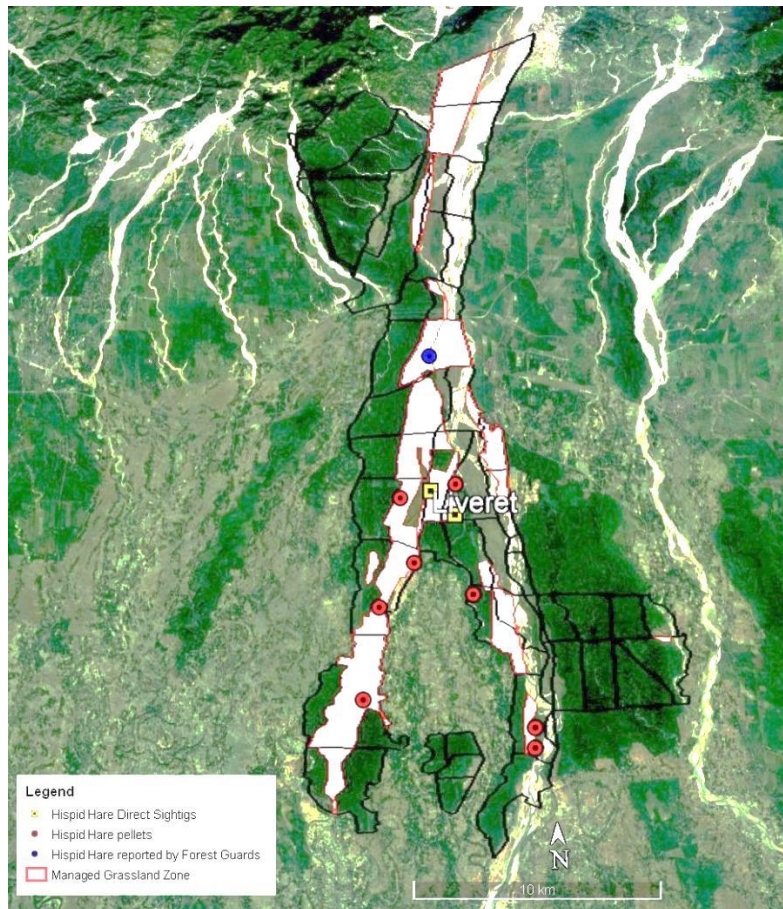


Figure 11: Hispid hare occurrence in management and non-management zone in Jaldapara NP



Figure 12: Hispid Hare leveret with its nest in *Saccharum narenga*

b. Other herbivores habitat utilisation:

- *Rhino:*

In the latest Rhino census of 2019, it was reported that there are 237 Rhinos available in the Park. Through this year Rhinos were sighted 37315 times in different habitats by the Forest Department staff. The highest number of sightings took place in Sissamara Beat (20.94%) followed by Malangi Beat (18.07%) of East Range of the Park. The main reason the rhinos concentrated in these beats were the availability of fodder, as these beats has a good amount of natural wet alluvial grasslands (Table: 18)

Rhino sightings and grassland percentage (Figure: 14) in each beat shows a positive correlation ($R = 0.555$).

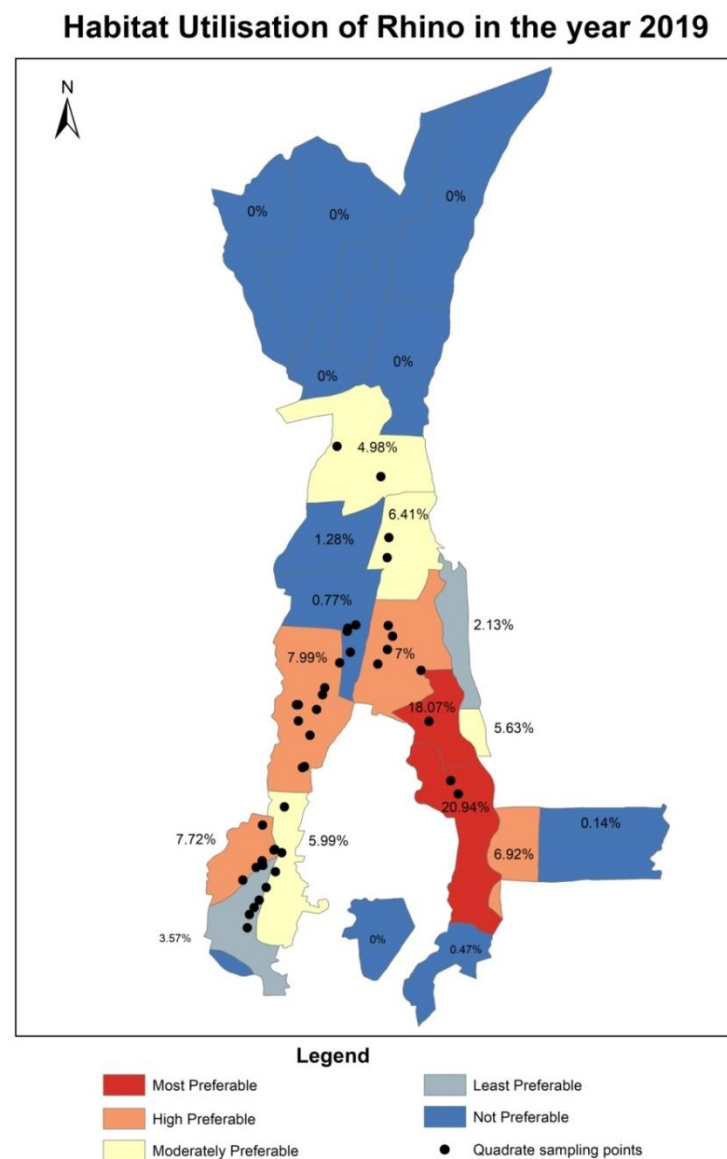


Figure 13: Habitat Utilisation map of Rhino during 2019

Table 18: Beat wise Rhino sighting with percentage of grassland in the beat

Sl. no.	Beats	Sightings (%)	Grasslands (%)
1	50 Feet	0.77	33.29
2	Bania	0.14	0.13
3	Bendaki & TEC	5.99	14.40
4	CC line	5.63	34.53
5	Chilapata	6.92	26.78
6	Dalsingpara	0.00	39.59
7	Dhaidhaighat	0.47	14.22
8	Hassimara	4.98	16.45
9	Hollapara	0.00	12.61
10	Hollong	7.99	34.64
11	Jaldapara HQ	7.00	32.26
12	Kunjanagar	3.57	27.00
13	Lankapara	0.00	1.09
14	Mairadanga	7.72	25.13
15	Malangi	18.07	53.18
16	NEC	2.13	8.39
17	Nilpara	0.00	31.05
18	NWC	1.28	12.15
19	Salkumar	0.00	7.50
20	Siltorsa	6.41	39.97
21	Sissamara	20.94	27.79
22	Titi	0.00	0.82

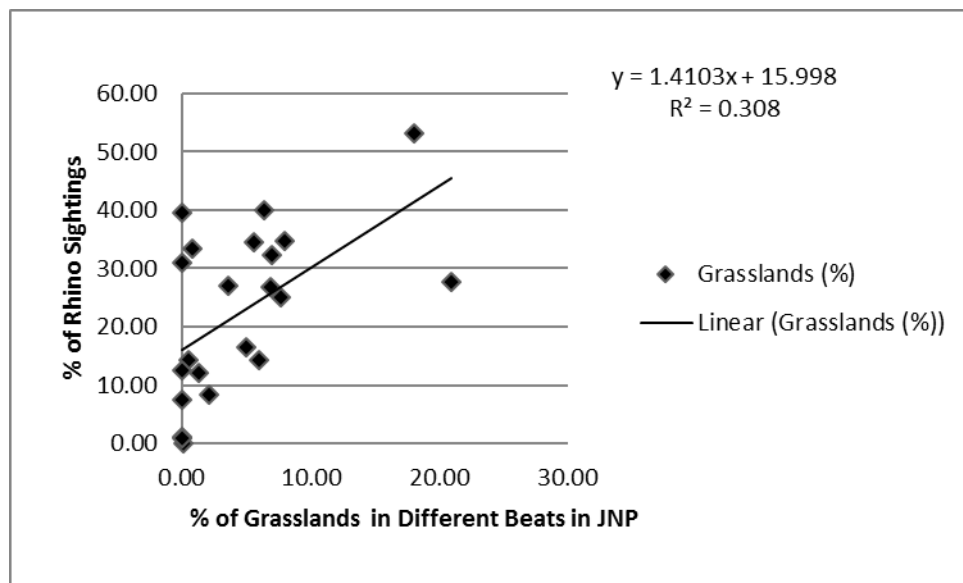


Figure 14: Correlation between grassland and rhino sightings

- *Gaur:*

Similarly, gaur was sighted in 2019 by the Department Staff 194908 times in different habitats throughout the Park. But some Beats do not maintain records for Gaur sightings and hence taken as Data deficient (DD). Data provided by the Forest department shows that the 15.18% and 12.79% Gaur sightings were from Sissamara and Malangi Beat of East Range respectively. But other Ranges like West and North also have good number of sightings varied from 4.09% to 9.57% (Table: 19).

The correlation between Gaur sightings and grassland percentage (Figure: 16) in the Beats where sighting records were maintained shows a very positive result ($R = 0.648$).

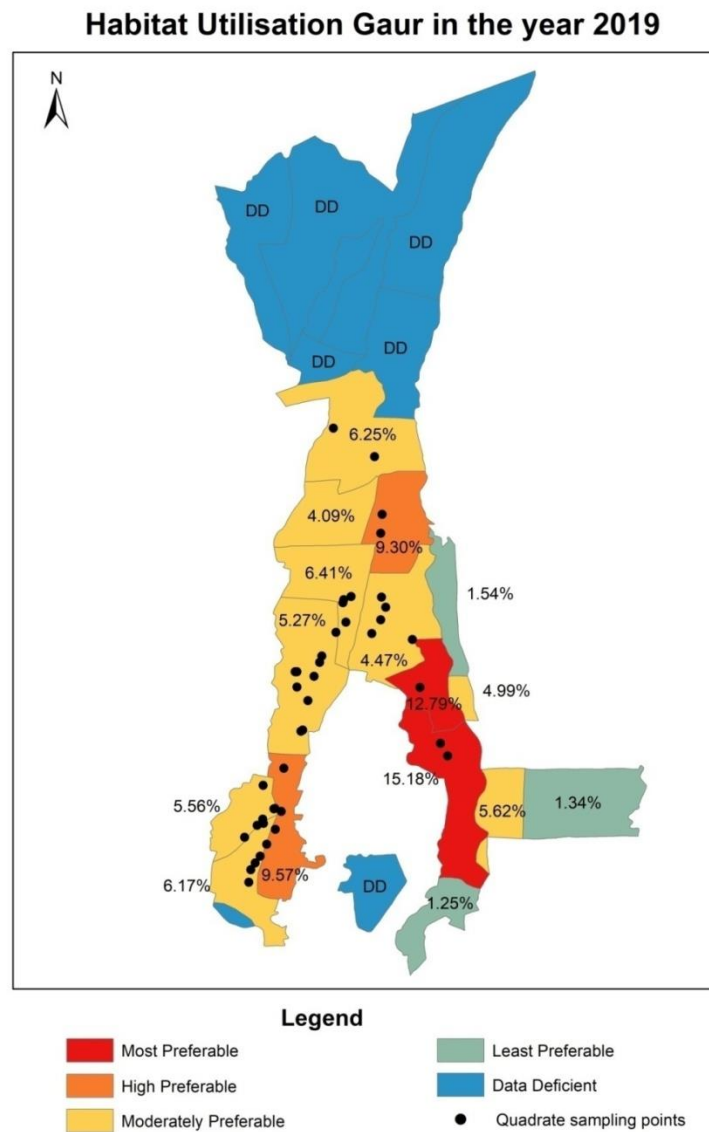


Figure 15: Habitat utilisation map of Gaur during 2019

Table 19: Beat wise Gaur sighting with percentage of grassland in the beat

Sl. no.	Beats	Sightings (%)	Grasslands (%)
1	50 Feet	6.41	33.29
2	Bania	1.34	0.13
3	Bendaki & TEC	9.57	14.40
4	CC line	4.99	34.53
5	Chilapata	5.62	26.78
6	Dalsingpara	DD	39.59
7	Dhaidhaighat	1.25	14.22
8	Hassimara	6.25	16.45
9	Hollapara	DD	12.61
10	Hollong	5.27	34.64
11	Jaldapara HQ	4.47	32.26
12	Kunjanagar	5.56	27.00
13	Lankapara	DD	1.09
14	Mairadanga	6.17	25.13
15	Malangi	12.79	53.18
16	NEC	1.54	8.39
17	Nilpara	DD	31.05
18	NWC	4.09	12.15
19	Salkumar	DD	7.50
20	Siltorsa	9.30	39.97
21	Sissamara	15.18	27.79
22	Titi	DD	0.82

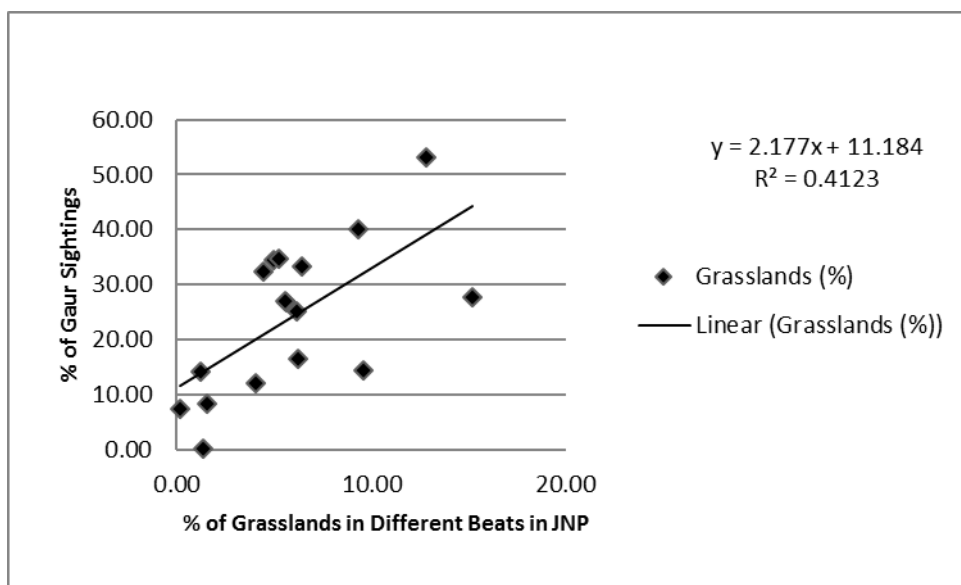


Figure 16: Correlation between grassland and Gaur sightings

Findings:

70% of the total sightings Hispid hare (both direct and indirect) in JNP during the study period was in the habitat managed plots of West and East Range of Jaldapara. Both the direct sightings were from Jaldapara HQ Beat.

It was observed that Hispid hare choose tall, coarse and old Dhadda bed for its nesting ground during the month of March-April.

Most utilised habitat zone for both the Rhino and Gaur was Sissamara and Malangi beat of the East Range.

In 2019 above 20% and 18% of the total Rhino sightings were recorded in Sissamara and Malangi Beats, while Hollong (8%) and Mairadanga (7.72%) recorded maximum from West Range. Jaldapara HQ from East Range and Chilapata Beat recorded 7% to 8% of the total Rhino sightings in the Park.

Similarly, above 15% and 12% of total Gaur sightings during 2019 was recorded in Sissamara and Malangi Beats. Bendaki & TEC Beats from West Range and Siltorsa Beat from North Range recorded 9% - 10% of the total sightings.

Both the large ungulate species show a positive correlation between sightings and the percentage of grassland area.

The analysis reveals that habitat utilization pattern of both the Rhino and Gaur changes according to the availability of the grassland area (Table 18 and Table 19).

4.6. Herbivores feeding behaviour observation

Results:

The feeding and foraging observations were carried out for around 60 hours mainly in the East Range, West Range and North Range in Jaldapara NP, as most of the herbivore population resides in these areas (Figure: 17). On direct observation a total of 38 plant species was observed to be eaten by the Rhino, Gaur, Sambar, other Deer species and Elephant. Out of these, 23 species were consumed by Rhino, 25 species by Gaur and 8 species by Sambar, 2 species by Elephant and only one species by Spotted deer (Table:21).

Table 20: Beat wise animal encountered

Animals	East Range			West Range		North Range		
	Jaldapara HQ	Malangi	Sissamara	Bendaki	Hollong	50 feet	Hassimara	Siltorsa
Rhino	12	6	1	1				2
Gaur	8	1		1	2	1		
Sambar	5	1	1		1			1
Elephant					1		1	
Spotted Deer				1				1

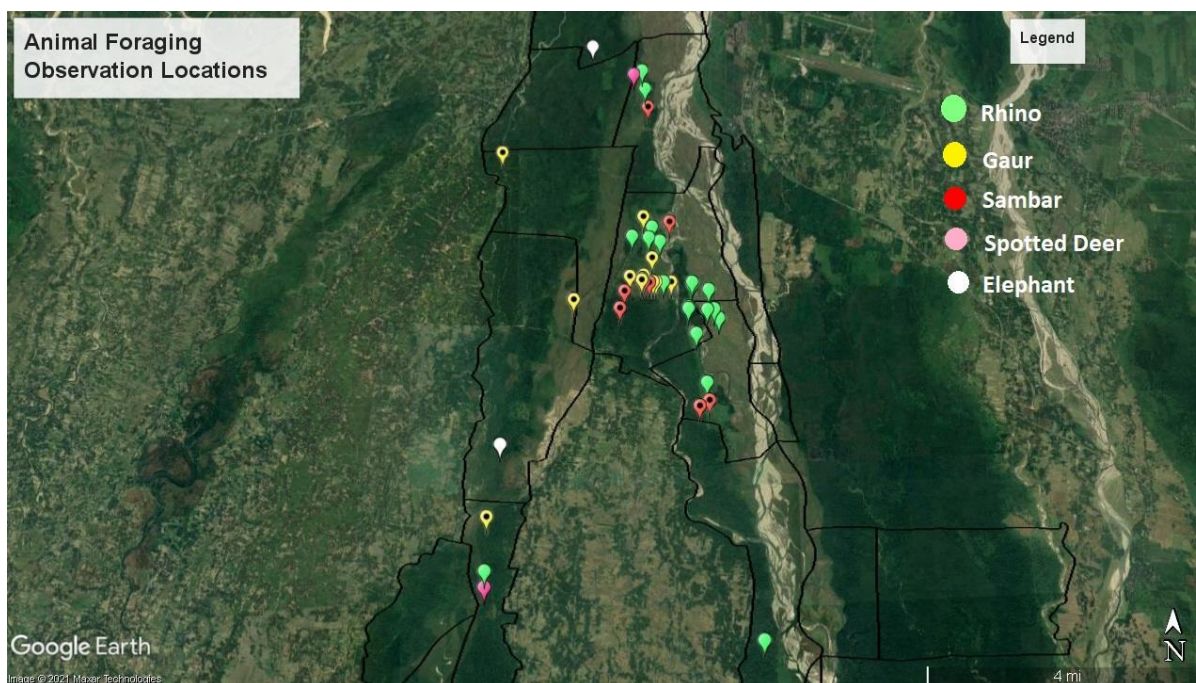


Figure 17: Animal encountered sites in Jaldapara NP

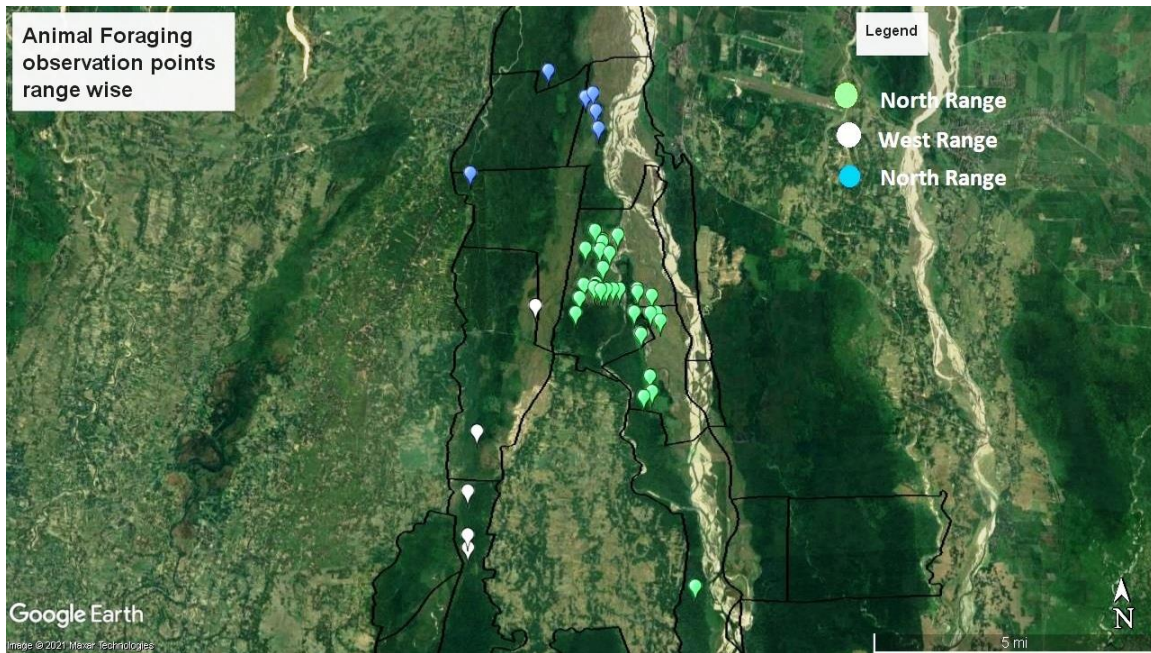


Figure 18: Range wise Herbivores foraging observation points

Table 21: Plant species consumed by herbivores in JNP

Sl no.	Scientific Names	Family	Local Name	Eaten by			
				Rhino	Gaur	Sambar, Spotted Deer	Elephant
1	<i>Albizia lucidior</i>	Leguminosae		Rhino			
2	<i>Alpina nigra</i>	Zingiberaceae	Purundi	Rhino			
3	<i>Arundinella bengalensis</i>	Poaceae	Bindi ghas/ Chhoto jharu		Gaur		
4	<i>Arundo donax</i>	Poaceae	Nol	Rhino	Gaur		
5	<i>Axonopus compresus</i>	Poaceae	Chapta Ghas/ Chhoto chepti	Rhino	Gaur		
6	<i>Bischofia javanica</i> Blume	Phyllanthaceae	Kanjil Leaves		Gaur		
7	<i>Bombax ceiba</i> (Bark and flower)	Malvaceae	Simul		Gaur	Sambar	Elephant
8	<i>Bridelia retusa</i>	Euphorbiaceae	Datan	Rhino	Gaur	Sambar	
9	<i>Christella sp.</i>	Thelypteridaceae		Rhino			
10	<i>Coffea bengalensis</i>	Rubiaceae				Sambar	
11	<i>Cynodon dactylon</i>	Poaceae	Durba	Rhino	Gaur		
12	<i>Dalbergia sissoo</i>	Fabaceae	Sisso Leaves		Gaur		
13	<i>Digitaria ciliaris</i>	Poaceae		Rhino	Gaur		
14	<i>Diplazium esculentum</i>	Athyriaceae	Dhekia	Rhino	Gaur		
15	<i>Gmelina arborea</i>	Lamiaceae	Gamari leaves		Gaur		
16	<i>Ichnocarpus frutiscens</i>	Apocynaceae					Elephant
17	<i>Imperata cylindrica</i>	Poaceae	Shon	Rhino	Gaur		
18	<i>Isachne sp</i>	Poaceae		Rhino	Gaur		
19	<i>Lantana camara</i>	Verbenaceae	Putus	Rhino	Gaur		
20	<i>Litsea monopelata</i>	Lauraceae	Bonkathal		Gaur		

21	<i>Litsea sp</i>	Lauraceae				Sambar	
22	<i>Mallotus polycarpus</i>	Euphorbiaceae	Pithali Leaves		Gaur		
23	<i>Mikania micrantha</i>	Asteraceae	Larong, Mekani	Rhino	Gaur		
24	<i>Morinda sp.</i>	Rubiaceae	Dalchhari			Sambar	
25	<i>Phragmites sp.</i>	Poaceae	Khagri		Gaur		
26	<i>Piper sp</i>	Piperaceae				Sambar	
27	<i>Porana paniculata</i>	Convolvulaceae		Rhino	Gaur		
28	<i>Saccharum longisetosum</i>	Poaceae	Malsa		Gaur		
29	<i>Saccharum narenga</i>	Poaceae	Dhadda	Rhino	Gaur		
30	<i>Saccharum sp.</i>	Poaceae	Elua	Rhino	Gaur		
31	<i>Saccharum spontaneum</i>	Poaceae	Kasia	Rhino			
32	<i>Sterblus asper</i>	Moraceae		Rhino	Gaur	Sambar	
33	<i>Tetrastigma dubia</i>	Vitaceae	Larong	Rhino			
34	<i>Tetrastigma serrulata</i>	Vitaceae	Tok ghas	Rhino			
35	<i>Themeda arundinacea</i>	Poaceae	Chepti	Rhino	Gaur	Sambar, Spotted deer	
36	<i>Toona ciliata</i>	Meliaceae	Tun Leaves		Gaur		
37	<i>Typha angustifolia</i>	Typhaceae	Hogla	Rhino			
38			Lepra ghas	Rhino			

- *Rhino:*

During our study period, the feeding of Rhino was encountered 23 times (considered only when it was consuming) in which 10 times they were seen feeding on Dhadda (*Saccharum narenga*) specially the new shoots and 8 times Chepti grass (*Themeda arundinacea*). Very interestingly *Mikania micrantha* and *Lantana camara* were seen to be consumed 5 and 2 times respectively (Figure:19). From the direct observation it was noticed that the Rhinos prefer grasses in general, as out of 23 encounters, 59% of encounters were with the plants from Poaceae family and the remaining 41% were from other families (Figure:20).

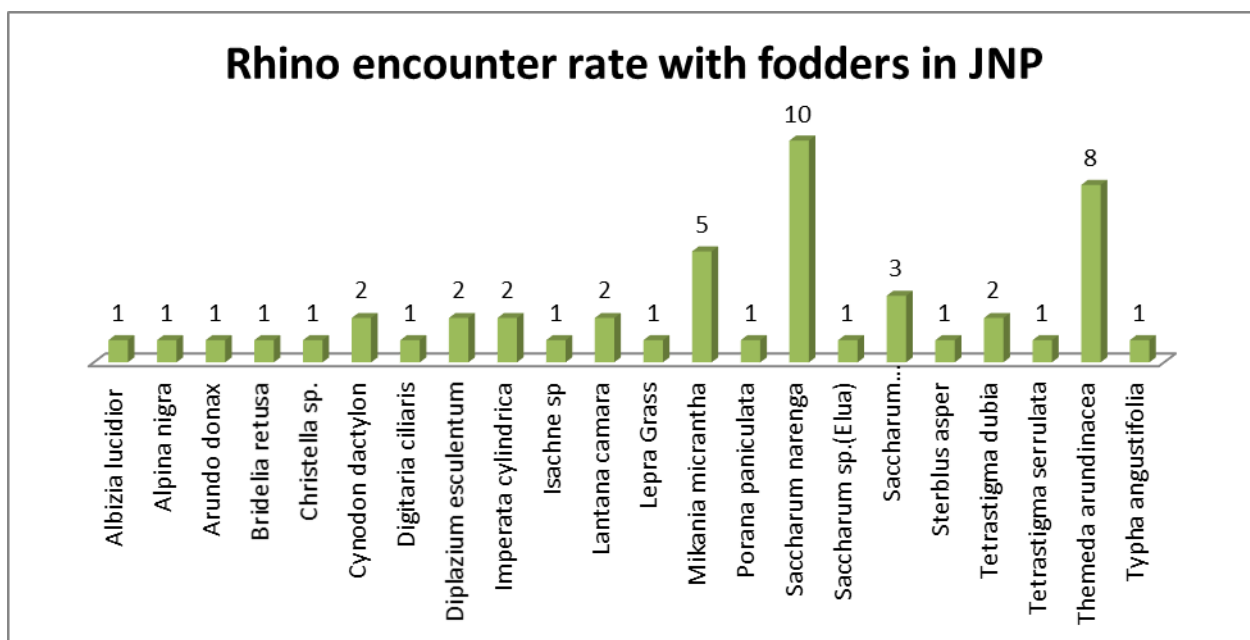


Figure 19: Rhino encounter rate with fodders in JNP

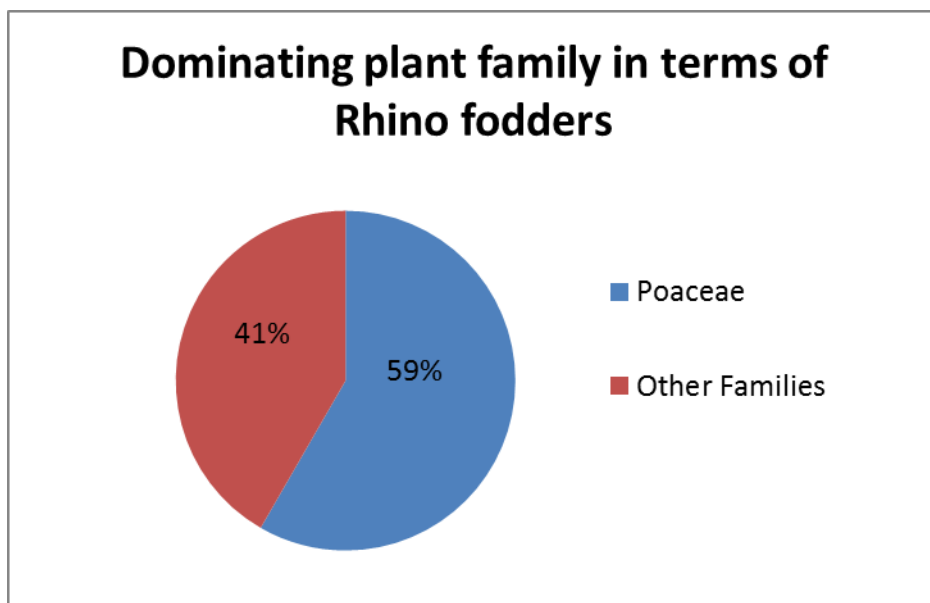


Figure 20: Grasses are dominating in terms of Rhino fodders in JNP

Table 22: Families of Rhino-fodders and their numerical representation at the species

SL no.	Families	Number of Plants
1	Poaceae	10
2	Zingiberaceae	1
3	Typhaceae	1

4	Asteraceae	1
5	Athyriaceae	1
6	Convolvulaceae	1
7	Euphorbiaceae	1
8	Leguminosae	1
9	Moraceae	1
10	Thelypteridaceae	1
11	Verbenaceae	1
12	Vitaceae	2
13	Unknown	1
TOTAL		23

- *Gaur*:

Similarly, Gaur was encountered while feeding 13 times, in which 8 times they were seen consuming *Saccharum narenga* specially the new shoots and 4 times *Themeda arundinacea* and *Saccharum spontaneum* (Kasia). They also were seen grazing *Mikania micrantha* and *Lantana camara* once or twice only (Figure: 21). From the direct observation it was noticed that the Gaur also prefer grasses in general like Rhinos and out of 13 encounters, 67% of encounters were with the plants from Poaceae family and the remaining 33% were from other families (Figure: 22).

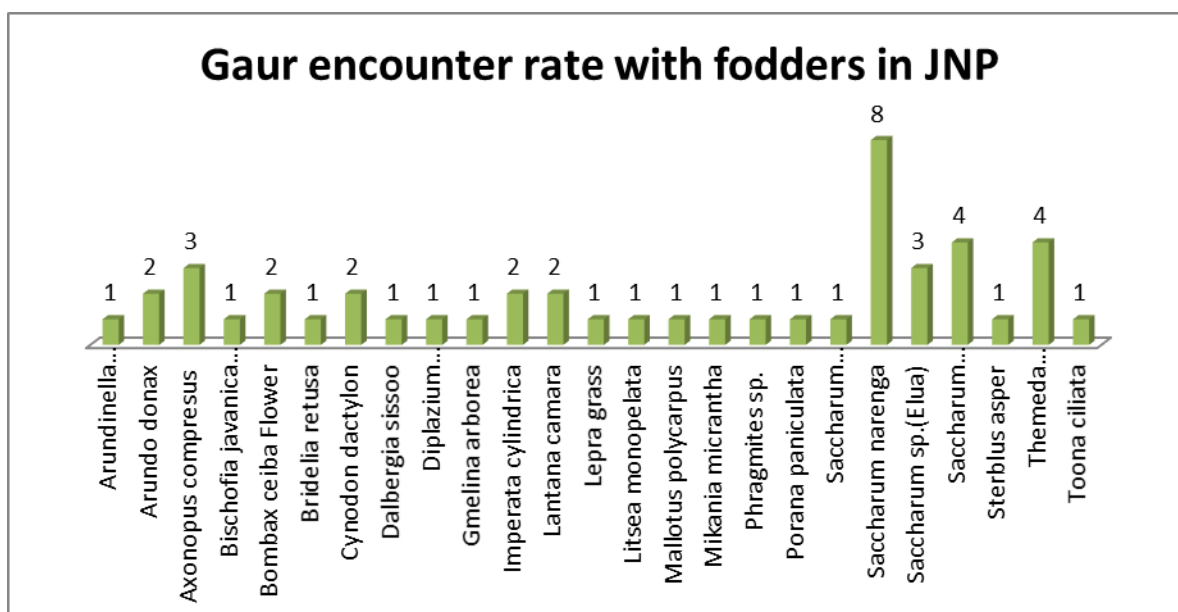


Figure 21: Gaur encounter rate with fodders in JNP

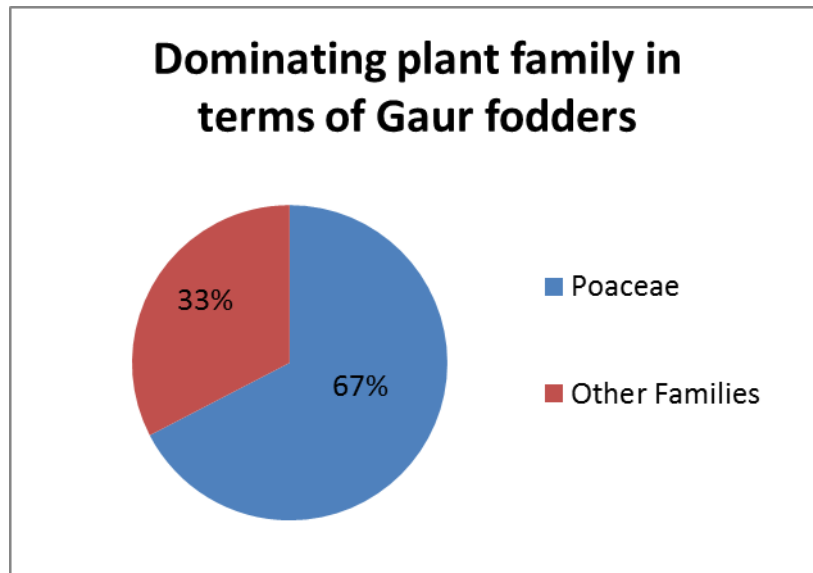


Figure 22: Grasses are dominating in terms of Gaur fodders in JNP

Table 23: Families of Gaur-fodders and their numerical representation at the species

Sl no	Families	Number of Plants
1	Poaceae	12
2	Euphorbiaceae	2
3	Asteraceae	1
4	Athyriaceae	1
5	Convolvulaceae	1
6	Fabaceae	1
7	Lamiaceae	1
8	Lauraceae	1
9	Malvaceae	1
10	Meliaceae	1
11	Moraceae	1
12	Phyllanthaceae	1
13	Verbenaceae	1
	TOTAL	25

- *Other herbivores:*

In JNP other herbivores like Sambar, Spotted deer, Elephant has also been observed.

In a same manner, Sambar was encountered 9 times in which 2 times they were seen consuming the new shoots of *Themeda arundinacea*.

Elephant was encountered 2 times with bark of *Bombax ceiba* and *Ichnocarpus frutiscens* each time.

Similarly, Spotted deer was encountered 2 times consuming new shoots of Chepti (*Themeda arundinacea*).

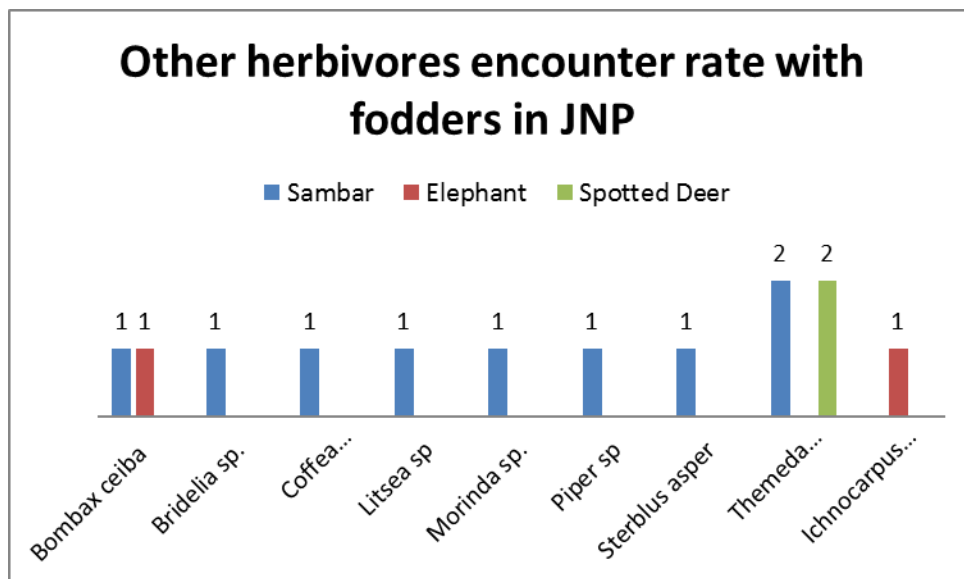


Figure 23: Encounter rate of other key herbivores with fodders in JNP

Findings:

Total 38 species of plants were recorded consumed by the herbivores like Rhino, Gaur, Sambar, Elephant and Spotted deer.

Rhino was observed to consume 23 species, Gaur 25 species, Sambar 8 species, Elephant 2 species and Spotted deer only one species.

Poaceae family (Grass species) was the dominating family in terms of the fodders in both the Rhino and Gaur.

Mikania micrantha, which is a commonly available weed in Jaldapra, was observed to be consumed both by Rhino and Gaur in the winter season.

First time in Jaldapara NP *Lantana camara* was recorded to be browsed by Rhino after Ram (2008), in Chitwan National Park, Nepal and Hazarika and Saikia (2012) in Rajiv Gandhi Orang National Park, Assam, India.

4.7. Assessment of Above Ground Biomass (AGB):

Results:

10 nested sites in randomly chosen management plots from JNP were chosen for collection for Assessment of Above Ground Biomass (AGB). The sites were so chosen that at least one plot from each beat was represented. Two natural plots were also randomly selected at Jaldapara North and East Ranges (Figure: 24).

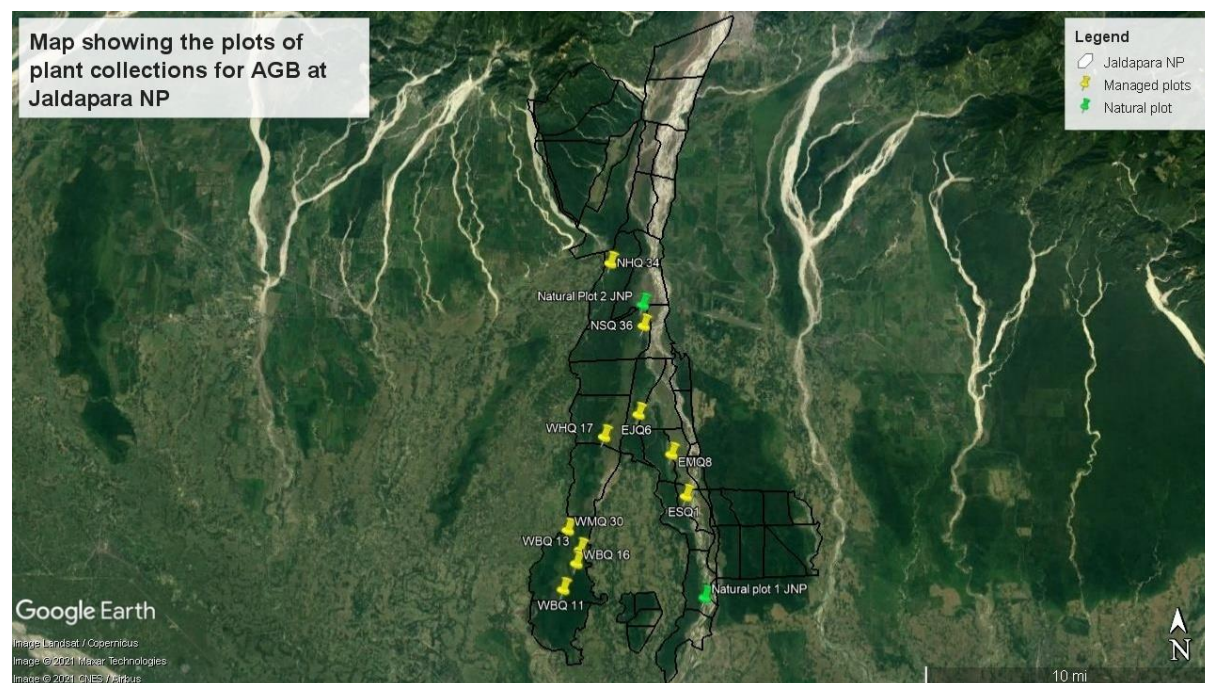


Figure 24: AGB collection points in Jaldapara NP

a. For Planted Species:

Table 24: Above Ground Biomass values of planted species in at Jaldapara NP

Jaldapara managed plots planted species	Dhadda (<i>Sacchrum narenga</i>) (kg/m ²)	Chepti (<i>Themeda arundinacea</i>) (kg/m ²)	Purundi (<i>Alpinia nigra</i>) (kg/m ²)	Malsa (<i>Saccharum longisetosum</i> var. <i>longisetosum</i>) (kg/m ²)	Madhua (<i>Saccharum arundinaceum</i>) (kg/m ²)	Plot wise biomass value (kg/m ²)	Mean value (kg/m ²)
ESQ1	3.128	0.497	0.000	0.000	0.210	3.835	0.383
EJC6	3.267	1.244	0.000	0.073	0.000	4.585	0.459
EMQ8	1.421	0.291	0.257	0.000	0.000	1.969	0.197
WBQ11	0.000	0.453	0.203	0.000	0.277	0.933	0.093
WBQ13	3.366	1.278	0.745	0.000	0.000	5.390	0.539
WBQ16	1.400	0.648	0.000	0.000	0.249	2.298	0.230
WHQ17	1.103	0.000	0.239	0.000	0.000	1.342	0.134
WMQ30	0.000	0.524	0.000	0.000	0.258	0.781	0.078
NHQ34	0.946	0.000	0.000	0.000	0.000	0.946	0.095
NSQ36	1.333	0.563	0.000	0.000	0.000	1.896	0.190

Species wise Biomass value	15.966	5.499	1.444	0.073	0.994	23.975	
Mean Value	1.597	0.550	0.144	0.007	0.099		2.3975

Estimated Biomass for planted species = 2.3975 kg/m² or 23975 kg/ha ≈ 24000kg/ha

Calculating of forage:

After determining annual forage production/ha (plant biomass) of planted species, using Voelkel's estimation method, the total annual forage produced by planted species in the management area must be calculated by following formula:

$$\text{Available area for grazing} \times \text{Forage production/ha} = \text{Total forage/year}$$

The total grassland management area in Jaldapara is 3366 ha (Anon, 2018; in heading no. 6.2.2.5 Grass land management, under subheading Category of grass land, page no 119-120).

So,

Total forage in the management plot for the planted species for the year would be:

$$3366 \times 24000 \text{ kg/ha} = 80784000 \text{ kg/year}$$

According to Voelkel *et al.* 2018, only 25% of the total forage production is utilized by grazers. Therefore, consumable forage would be produced, as follows for the managed grassland available for grazing in Park:

$$\text{Total forage/year} \times 0.25 = \text{Consumable forage/year}$$

$$80784000 \times 0.25 = 20196000 \text{ kg/ year}$$

There are also areas in forest land that herbivores do not graze, such as heavy brush, weeds, other non-fodder species etc. To reduce the risk of overgrazing, these areas were removed from the calculation. In this case, from our vegetation occupancy percentage value it was estimated that planted species occupy only 9.24% in premonsoon season and 10.10% in postmonsoon season for managed area. Therefore, the average value of the above-mentioned seasons we have taken consideration for this calculation which is 9.67% (Figure: 8) only for planted species in Jaldapara NP.

Therefore, the available forage would be determined as follows:

$$\text{Consumable forage} \times \% \text{ Grazeable areas} = \text{Available forage kg /year}$$

$$20196000 \text{ kg/ year} \times 0.09 = 1938816 \text{ Kg/year}$$

b. For Naturally growing grass fodder species in managed plots:

Table 25: Above Ground Biomass values of naturally growing fodder grass species in managed plots at Jaldapara NP

Jaldapara managed plots natural growing species	Thach/ Son (<i>Imperata cylindrica</i>) (kg/m ²)	Kasia (<i>Saccharum spontaneum</i>) (kg/m ²)	Choto chepti/ Chapti (<i>Axonopus compressus</i>) (kg/m ²)	Nol (<i>Arundo Donax</i>) (kg/m ²)	Plot wise biomass value (kg/m ²)	Mean value (kg/m ²)
ESQ1	0.055	0.000	0.000	0.774	0.829	0.083
EJQ6	0.040	0.648	0.000	0.000	0.688	0.069
EMQ8	0.038	0.000	0.000	0.585	0.622	0.062
WBQ11	0.057	0.000	0.000	0.000	0.057	0.006
WBQ13	0.053	0.000	0.000	0.000	0.053	0.005
WBQ16	0.054	0.537	0.000	0.000	0.591	0.059
WHQ17	0.042	0.000	0.000	0.000	0.042	0.004
WMQ30	0.000	0.000	0.021	0.000	0.021	0.002
NHQ34	0.000	0.516	0.000	0.000	0.516	0.052
NSQ36	0.048	0.000	0.028	0.000	0.076	0.008
Species wise Biomass value	0.387	1.701	0.049	1.359	3.496	
Mean Value	0.039	0.170	0.005	0.136		0.3496

Estimated Biomass for naturally growing fodder grass species in managed plots = 0.3496 kg/m² or 3496 kg/ha ≈ 3500 kg/ha

Calculating of forage:

After determining annual forage production/ha (plant biomass) of natural grass species in managed area, using Voelkel's estimation method, the total annual forage produced by natural grass species in the management area must be calculated by following formula:

$$\text{Available area for grazing} \times \text{Forage production/ha} = \text{Total forage/year}$$

The total grassland management area in Jaldapara is 3366 ha (Anon, 2018).

So,

Total forage in the management plot for the natural grass species for the year would be:

$$3366 \times 3500 \text{ kg/ha} = 11781000 \text{ kg/year}$$

If only 25% of the total forage production of natural grass species in managed plots is utilized by grazers, consumable forage would be produced, as follows for the managed grassland available for grazing in Park:

$$\text{Total forage/year} \times 0.25 = \text{Consumable forage/year}$$

$$11781000 \times 0.25 = 2945250 \text{ kg/ year}$$

There are also areas in forest land that herbivores do not graze such as heavy brush, weeds, other non fodder species etc. To reduce the risk of overgrazing, these areas were removed from the calculation. In this case, from our vegetation occupancy percentage value it was estimated that natural grass fodder and sedge species occupy only 53.26% in premonsoon season and 55.65% in postmonsoon season only in managed area. Therefore, the average value of the above-mentioned seasons we have taken consideration for this calculation which is 54.46% (Figure: 8) only for naturally growing grass fodder and sedge species in Jaldapara NP.

Therefore, the available forage would be determined as follows:

Consumable forage X % Grazeable areas = Available forage kg /year

2945250 kg/ year X 0.54= 1590435 Kg/year

c. For natural grasslands:

Table 26: Above Ground Biomass values of natural species in natural grassland plots at Jaldapara NP

Jaldapara Natural plots	Dhadda (<i>Sachhrum narenga</i>) (kg/m ⁻²)	Thach/ Son (<i>Imperata cylindrica</i>) (kg/m ⁻²)	Kasia (<i>Saccharum spontaneum</i>) (kg/m ⁻²)	Nol (<i>Arundo Donax</i>) (kg/m ⁻²)	Plot wise biomass value (kg/m ⁻²)	Mean value (kg/m ⁻²)
Natural plot 1(JNP1)	1.086	0.036	0.454	0.686	2.262	1.131
Natural plot 2(JNP2)	0.793	0.052	0.630	0.000	1.475	0.737
Species wise Biomass value	1.879	0.088	1.084	0.686	3.737	
Mean Value	0.940	0.044	0.542	0.343		1.8685

Estimated Biomass for grass species in natural grasslands = 1.8685 kg/m⁻² or 18685 kg/ha ≈ 18500 kg/ha

Calculating of forage:

After determining annual forage production/ha (plant biomass) of natural grass land area, using Voelkel's estimation method, the total annual forage produced in the natural grassland area must be calculated by following formula:

Available area for grazing X Forage production/ha = Total forage/year

The total natural grassland area (active flood zone and riverine natural grassland) in Jaldapara is 3662.99 ha+1670.52ha or say, 5333 ha approximately (Anon, 2018; heading no. 6.2.2.5 Grass land management, under subheading Category of grass land, page no 119-120).

So,

Total forage in the natural grasslands for the year would be:

5333 X 18500 kg/ha = 98660500 kg/year

If only 25% of the total forage production of grass species is utilized by grazers, consumable forage would be produced, as follows for the natural grassland available for grazing in Park:

$$\text{Total forage/year} \times 0.25 = \text{Consumable forage/year}$$

$$98660500 \times 0.25 = 24665125 \text{ kg/ year}$$

There are also areas in forest land that herbivores do not graze such as heavy brush, weeds, other non-fodder species etc. To reduce the risk of overgrazing, these areas were removed from the calculation. In this case, from our statistical analysis data of plant species found in natural grasslands in Jaldapara, it was estimated that grass species density is 38% among all the species found within the sample plots (Table: 16).

Therefore, the available forage would be determined as follows:

$$\text{Consumable forage} \times \% \text{ Grazeable areas} = \text{Available forage kg /year}$$

$$24665125 \text{ kg/ year} \times 0.38 = 9372747.5 \text{ Kg/year}$$

Table 27: Estimated Biomass of Fodder species in Jaldapara National Park at a glance

	Mean of Fodder species	Total Fodder Species	Consumable Fodder Species	Available Fodder Species
Planted fodder species in management plots	2.3975 kg/m ⁻² or 24,000kg/ha	3,366 X 24000 kg/ha = 8,07,84,000 kg/year	8,07,84,000 X 0.25= 2,01,96,000 kg/ year	2,01,96,000 kg/ year X 0.09= 19,38,816 kg/year
Naturally occurring fodder species in management plots	0.3496 kg/m ⁻² or 3,500 kg/ha	3,366 X 3500 kg/ha = 1,17,81,000 kg/year	1,17,81,000 X 0.25= 29,45,250 kg/ year	29,45,250 kg/ year X 0.54= 15,90,435 kg/year
Fodder species in natural grasslands (unmanaged)	1.8685 kg/m ⁻² or 18,500 kg/ha	5,333 X 18500 kg/ha = 9,86,60,500 kg/year	9,86,60,500 X 0.25= 2,46,65,125 kg/ year	2,46,65,125 kg/ year X 0.38= 93,72,748kg/year

Findings:

Dhadda (*Sachhrum narenga*) shows the highest productivity of 1.597 kg/sq m or 15970 kg/ ha in Managed plots as well as in natural grassland (0.940kg/sq m or 9400kg/ ha), whereas the naturally growing grasses (not planted) within the managed plots Kasia (*Saccharum spontaneum*) revealed the highest productivity of 0.170 kg/ sq m or 1700kg/ha.

The maximum estimated Biomass (24,000 kg/ha) comprised of the Planted Fodder Species planted by the Forest Department in the management plots. The least Biomass (3,500 kg/ha)

occurred among the Naturally occurring Fodder Species, which were not planted, growing simultaneously along with planted species in the management plots. In between was the Biomass (18,500 kg/ha) of the Fodder Species that occurred naturally in the Natural Grasslands (untouched/unmanaged).

However, when the Biomass of the total Fodder Species was calculated as per the available area to each of them, revealed that the Biomass of the Fodder Species in Natural Grasslands (unmanaged) was the highest (9,86,60,500 kg/year), while the next highest Biomass (8,07,84,000 kg/year) was seen to be in Planted Fodder Species in management plots and the least Biomass (1,17,81,000 kg/year) in the Naturally occurring Fodder Species in management plots.

Interestingly, if the total Biomass of Fodder Species (both Planted and Naturally occurring) in the management plots were taken together, it is seen that the Biomass is more or less the same Biomass (9,25,65,000 kg/year) as in the Natural Grasslands.

This trend was seen to be the same when the Biomass of Consumable Fodder Species were tabulated, as only 25% was estimated to be utilized in each case, and irrespective of wherever they occurred.

Finally when the percentage of the Fodder Species as recorded in the quantitative and qualitative sampling results in each case were tabulated with the Biomass of the Consumable Fodder Species to obtain the Biomass of the Available Fodder Species it was seen that the highest Biomass of 93,72,748 kg/year occurred in Fodder Species in Natural Grasslands (untouched/unmanaged), followed by the Biomass (19,38,816 kg/year) of Planted Fodder Species in management plots and least by the Biomass (15,90,435 kg/year) of Naturally occurring Fodder Species in management plots.

In fact, if both the Available Biomass of the Planted Fodder Species and the Naturally occurring Fodder Species in management plots were added together, the total Biomass (35,29,251 kg/year) Available as Fodder Species in management plots is approximately only 1/3rd of the Available Biomass of Fodder Species in Natural Grasslands (untouched/unmanaged).

4.8. Carrying Capacity

As Rhino is the keystone species here the calculation of carrying capacity is based on the Rhino suitable grassland area. Besides Rhino and Gaur, Elephant is also considered for this calculation as they preferred the same habitat in Jaldapara NP (Anon., 2018) as both the animals preferred grass species as primary fodders in this region (Peden *et. al.*, 1974; Banerjee, 1993; Ghosh and Das, 2007; Roy, 2010; Lahkar *et. al.*, 2018).

An adult rhino eats between 60–80 kg a day fresh weight and spends most of its time browsing or grazing (Dinerstein, 2003). In addition, the food primarily consists of *Saccharum* species and other grass species. According to Coombs & Vlitos (1978) estimation, the standing biomass of sugarcane is 100 MT/ha fresh weight or 35 MT/ha dry weight, which gives a fresh/dry ratio of 100/35. So, if one rhino eats approximately 21–28 kg/day of dry weight, assuming the mid value of this range, 24.5 kg/day, the annual food requirement of one Rhino is 24.5 kg/day x 365 day/year = 8.9 Tons/year ≈ 9 tons/year or 9000 Kg/year.

Likewise for Asian Elephant it is assuming that they consume about 1.5–2.5% of its body weight of dry fodder (Sukumar, 2003) every day. Therefore, the middle value was taken consideration for this study. For the other ruminant herbivores, the consume rate is around 2% of their body weight (Murray, 1995). On the basis of their body weight the approximate DM intake value/year are following (Table: 28).

Table 28: Body weight and Dry matter intake value

Sl. No	Common Name	Scientific Name	Average Body Weight (Kg.)	DM intake per day (Kg)	Total DM requirement/year (Kg)
1	One Horned Rhino	<i>Rhinoceros unicornis</i>	1600 [©]	24.5	8900 ≈ 9000
2	Indian bison or Gaur	<i>Bos gaurus</i>	600 ⁺	12	4380 ≈ 4000
3	Asian Elephant	<i>Elephas maximus</i>	2500 [*]	50	18250
Total DM requirement for Rhino, Gaur and Elephant					31250

(*Mathur; 1991, *Roy 2010, ©Macdonald 2001)

Multiple grazing species has been considered in this case, so, to determine the total animal forage requirement, all the considered animals' annual requirement has been added up and applied to the main formula of carrying capacity (Table: 28).

$$\text{Carrying Capacity (K)} = \frac{\text{Available forage kg}}{\text{Animal forage requirement kg/year}}$$

Therefore, only for available forage in planted species in Jaldapara,

$$\begin{aligned}
\text{Carrying Capacity (K) or AU} &= 1938816 / (9000+4000+18250) \\
&= 1938816^* / 31250 \\
&= 62.04 \text{ AU} \approx 62 \text{ AU/year}
\end{aligned}$$

*The Available forage only calculated for planted species

62 AU/Year means, the planted species of Managed area can hold a total of 62 animals (Rhino+ gaur+ elephant) per year if the forage available, per day consumption rate for individual animals and the other environmental conditions are constant.

The intake capacities of the herbivores are different as per their body weight and one gaur cannot consume the same amount as Rhino or elephant.

Therefore, as per their consumption rate (Table: 28) it can be assumed that one rhino can consume fodders same as 2.3 numbers of gaur and half of an elephant.

Hence, using this logic, the planted species of grass fodder managed plot in Jaldapara NP can support 17 Rhinos, 37 Gaurs and 8 elephants at a time.

[Note: The biomass study was done in the dry season of the year 2020 and could not be collected data in the wet seasons as the nationwide lockdown was imposed for Covid 19 Pandemic and the situation gets better only after the wet season. So, the carrying capacity is calculated here only basis for the dry season biomass availability]

For, only for forage available for natural grass species in managed plot in Jaldapara NP

$$\begin{aligned}
\text{Carrying Capacity (K) or AU} &= 1590435 / (9000+4000+18250) \\
&= 1590435^* / 31250 \\
&= 50.89 \text{ AU} \approx 51 \text{ AU/year}
\end{aligned}$$

*The Available forage only calculated for naturally occurring grass species within managed plots

In the same manner, the carrying capacity of the natural occurring species in managed plot of Jaldapara is 14 Rhinos, 31 Gaurs and 7 elephants at a time.

For, only for forage available in natural grass lands of in Jaldapara NP

$$\begin{aligned}
\text{Carrying Capacity (K) or AU} &= 9372747.5 / (9000+4000+18250) \\
&= 9372747.5^* / 31250 \\
&= 299.93 \text{ AU} \approx 300 \text{ AU/year}
\end{aligned}$$

*The Available forage only calculated for grass fodder species within natural grassland

The natural grasslands of Jaldapara can support 80 Rhinos, 180 Gaurs and 40 elephants at a time.

Table 29: Estimated Carrying Capacity of Large Herbivores in Jaldapara National Park at a glance

	Available Forage Biomass (AB)	Animal Forage Requirement (AD)	Carrying Capacity (K) or Animal Unit (AU) = (AB/AD)
Planted fodder species in management plots	1938816 kg/year	One Horned Rhino - 9000	19,38,816/9,000 = 215.42
		Indian Bison or Gaur – 4000	19,38,816/4,000 = 484.70
		Asian Elephant- 18250	19,38,816/18,250 = 106.24
		Total - 31250	19,38,816/31,250 = 62.04
		17 Rhinos, 37 Gaurs and 8 Elephants	
Naturally occurring fodder species in management plots	1590435 kg/year	One Horned Rhino - 9000	15,90,435/9,000 = 176.72
		Indian Bison or Gaur – 4000	15,90,435/4,000 = 397.61
		Asian Elephant - 18250	15,90,435/18,250 = 87.15
		Total - 31250	15,90,435/31,250 = 50.89
		14 Rhinos, 31 Gaurs and 7 Elephants	
Fodder species in natural grasslands (unmanaged)	9372748 kg/year	One Horned Rhino - 9000	93,72,748/9,000 = 1041.42
		Indian Bison or Gaur – 4000	93,72,748/4,000 = 2343.19
		Asian Elephant - 18250	93,72,748/18,250 = 513.58
		Total - 31250	93,72,748/31,250 = 299.93
		80 Rhinos, 180 Gaurs and 40 Elephants	
Planted fodder species + Naturally occurring fodder species in management plots	19,38,816 kg/year + 15,90,435 kg/year = 35,29,251kg/year	One Horned Rhino - 9,000	35,29,251/9,000 = 392.14
		Indian Bison or Gaur – 4,000	35,29,251/4,000 = 882.31
		Asian Elephant - 18,250	35,29,251/18,250 = 193.38
		Total - 31,250	35,29,251/31,250 = 112.94
		30 Rhinos, 68 Gaurs and 15 Elephants	
Planted fodder species + Naturally occurring fodder species in management plots + Fodder species in natural grasslands (unmanaged)	19,38,816 kg/year + 15,90,435 kg/year + 93,72,748 kg/year = 1,29,01,999kg/year	One Horned Rhino - 9,000	1,29,01,999/9,000 = 1433.56
		Indian Bison or Gaur – 4,000	1,29,01,999/4,000 = 3225.50
		Asian Elephant - 18,250	1,29,01,999/18,250 = 706.96
		Total - 31,250	1,29,01,999/31,250 = 412.86
		111 Rhinos, 248 Gaurs and 54 Elephants	

So, the grassland management plots without the support of natural grassland can support 30 Rhinos, 68 Gaurs and 15 Elephants, while the total grassland area of Jaldapara NP can support 111 Rhinos, 248 Gaurs and 54 Elephants in the basis for dry season biomass availability.

4.9. Discussion:

From the present study in the 33 management plots, it was seen that the Planted Fodder species by the Forest Department revealed a low occupancy percentage in all the Ranges varying from on an average of 6% to 11% in pre-monsoon and 8% to 12% in post monsoon. These few occurrences of the Planted species may either be due to non-survival at the sapling stage or its immediate consumption by herbivores as soon as the fences were removed.

These low percentages mostly comprised of Dhadda and Chepti in almost all the management plots where they were planted. However, Purundi, Malsa and Madhua which were also planted in 22 to 29 managed plots along with Dhadda and Chepti as per plantation journals, their occurrence was found only in 4 to 9 plots. Do we then infer that Dhadda and Chepti were not the most favorable fodder species? Yes, they were not as favourable as Malsa and Madhua.

On a total evaluation of the managed plots in Jaldapara NP the **cover percentage** for planted species was 9.67%; natural grass, fodder & sedge species – 54.46%; harmful weeds – 20.04% and other species occupied 15.92% of the area.

Among the weed species recorded, *Mikania micrantha*, *Chromolaena odorata* and *Ageratum conyzoides* were denser than the other weed species.

Among natural grasses *Imperata cylindrica*, *Axonopus compressus* and *Saccharum spontaneum* were the naturally occurring grass species with high IVI in most cases.

It is seen that in natural grassland the effects of weeds are minimum as the **population density** of the weeds in natural grassland quadrates were only 1% where as in the managed grassland the density varied from 4% to 8%.

Interestingly it was also seen that the population density of grass species in natural grassland was less (only 38%) than the managed plots in various ranges (75% to 92%).

70% of the total sightings of the Hispid hare (both direct and indirect) in JNP during the study period was in the habitat managed plots of West and East Range of Jaldapara. Both the direct sightings were from Jaldapara HQ Beat. It was observed that Hispid hare choose tall, coarse and old Dhadda bed for its nesting ground during the months of March-April.

It was seen that the most utilised habitat zone for both the Rhino and Gaur was in the Sissamara and Malangi beats of the East Range. Both these large ungulate species showed a positive correlation between their sightings and the percentage of grassland area.

Poaceae family (Grass species) was the dominant family in terms of the fodders in both the Rhino and Gaur. *Mikania micrantha*, which is a commonly available weed in Jaldapara, was observed to be consumed both by Rhino and Gaur in the winter season. For the first time in Jaldapara NP *Lantana camara* was recorded to be browsed by Rhinos. Two other records in

other places were after Ram (2008), in Chitwan National Park, Nepal and Hazarika and Saikia (2012) in Rajiv Gandhi Orang National Park, Assam, India.

Dhadda (*Sachhrrum narenga*) shows the highest productivity of 1.597 kg/sq m or 15970 kg/ ha in Managed plots as well as in natural grassland (0.940kg/sq m or 9400kg/ ha), whereas the naturally growing grasses (not planted) within the managed plots Kasia (*Saccharum spontaneum*) revealed the highest productivity of 0.170 kg/ sq m or 1700kg/ha.

The maximum estimated Biomass (24,000 kg/ha) comprised of the Planted Fodder Species planted by the Forest Department in the management plots. The least Biomass (3,500 kg/ha) occurred among the Naturally occurring Fodder Species, which were not planted, in the management plots. In between was the Biomass (18,500 kg/ha) of the Fodder Species that occurred naturally in the Natural Grasslands (untouched/unmanaged).

Finally when the percentage of the Fodder Species as recorded in the quantitative and qualitative sampling results in each case were tabulated with the Biomass of the Consumable Fodder Species to obtain the Biomass of the Available Fodder Species it was seen that the highest Biomass of 93,72,748 kg/year occurred in Fodder Species in Natural Grasslands (untouched/unmanaged), followed by the Biomass (19,38,816 kg/year) of Planted Fodder Species in management plots and least by the Biomass (15,90,435 kg/year) of Naturally occurring Fodder Species in management plots.

In fact, if both the Available Biomass of the Planted Fodder Species and the Naturally occurring Fodder Species in management plots were added together, the total Biomass (35,29,251 kg/year) Available as Fodder Species in management plots is approximately only 1/3rd of the Available Biomass of Fodder Species in Natural Grasslands (untouched/unmanaged).

The total grassland area of Jaldapara NP can support 111 Rhinos, 248 Gaurs and 54 Elephants on the basis of dry season biomass available as per our findings. 15% of this which is 17 Rhinos, 37 Gaurs and 8 Elephants was calculated to found in the managed plots when only the planted species biomass is considered. However, if the managed plots are taken into consideration as a whole, both the planted species as well as the natural occurring grass species then the carrying capacity is 27% amounting to 30 Rhinos, 68 Gaurs and 15 Elephants.

CHAPTER II

5. Gorumara National Park:

5.1. Study Area:

Since 1895, the present Gorumara National Park was a reserve forest, with an area of 7 sq. km. In 1949 this was extended to an area of 8.61 sq. km. when it was declared as the Gorumara Game Sanctuary. Nearly 27 years later a notification dated 24th June, 1976 was issued under the Wildlife (Protection) Act 1972, declaring it as Gorumara Wildlife Sanctuary. Finally in 1994, nearly two decades later the Wildlife Sanctuary was upgraded to a National Park, with a major extension comprising a total area of over 90 sq km (Mukherjee *et al.*, 2019). The Gorumara National Park today is situated between latitude 26°47'12.5"N to 26°43'25.6"N and longitude 88°52'4.2"E to 88°47'7.3"E in Jalpaiguri district of North Bengal, India. The Park currently has two territorial ranges, four squad ranges, six beats and 7 camps.

The terrain of Gorumara National Park is differentiated into a distinct plateau and a plain area. The soil profile of the area is of alluvial and bhabar formations.

Three main rivers flow within Gorumara NP viz. the Murti, Indong and Garati. These rivers merge with each other and finally meet the Jaldhaka River that forms the boundary of the National Park in the eastern side. Water bodies like Hatidoba, Shealdoba, Gairadoba, Bandiabil, Chukchukie are the other perennial sources of water for the National Park. There are also rivulets and streams passing through the Park which are seasonal in nature, like the Bamni jhora, Saraswati jhora, Mukaddam nala, Neora jhora, Amba khola and Chang khola, carrying water only during rainy season and remaining dry the rest of the year.

Maximum recorded temperature is 37°C (in summer) and a minimum of 4°C (in winter). South-west monsoon is the main source of rainfall. Maximum precipitation occurs from mid-June to September, with a peak in July and August. The average annual rainfall is about 382 cm.

Gorumara National Park is famous for one of the last small pockets in Eastern India harbouring natural population of Great Indian one horned Rhinoceros, along with other mega herbivores. The National Park has immense significance in view of it being situated in the middle of the elephant migratory route between the rivers Tista and Torsa in North Bengal.

The Tondou, Selka, Gorumara, Barohati, Medla, Dhupjhora, Jaldhaka, Panjhora and Indong Blocks of Gorumara NP serve as a major habitat for elephant population and with development of fodder cover and water resources, the elephant depredation problem can be substantially reduced. The same is true for the ever-increasing population of gaurs in the area. However, in spite of having a good habitat for large carnivores, with plenty of food, water and cover, not having tigers which it once had, and though still to-day it is quite rich in leopard population the predator-prey relationship is not ideal.

As the Park is situated in the foothills of Eastern Himalayas, the areas boast a rich biological diversity. This Protected Area is famous for one of the few habitats in Eastern India that

harbours natural population of Greater One-horned Rhinoceros (*Rhinoceros unicornis*), along with other mega-herbivores like Asian Elephant (*Elephas maximus*), Gaur (*Bos gaurus*) and other Deer species along with carnivores like Leopard, lesser cats etc. Gorumara National Park has 48 species of mammals (carnivores and herbivores), approximately 195 species of birds, 22 species of reptiles including 7 species of turtles, 40 species of fishes and other macro and micro fauna (Anon, 2007a).

Gorumara National Park has 326 recorded plant species till now (trees 158, herbs - 35, shrubs - 77, grasses - 32, climbers - 15 and orchids - 9) (Anon, 2007a). The entire forest cover of Gorumara National Park comes under the North Indian Moist Tropical Forest (Champion & Seth, 1968) and can be classified into four distinct types 1. North Dry Deciduous Seral Sal-Khair-Sissoo Association, 2. Sal forests - Eastern Bhabar Sal and Eastern Terai Sal, 3. Wet Mixed forests – Sub-Himalayan Secondary Wet Mixed Forests and 4. Savannah Forests & Lower Alluvial Savannah - Sal Savannah (Anon, 2007a).

There are three distinct types of savannah forests as per the classification of Champion and Seth, 1968 in this region -

a) Moist Sal Savannah (3c/DS1)-Characterized by the presence of scattered Sal along with Kumbhi, Amlaki, Sidha, Tanki etc. The predominant grasses are *Sacchanum sp.*, *Arundo donax*, *Phragmites karka*, *Imperata cylindrica* and *Themeda arundinacea*.

b) Low alluvium savannah woodland (3/1S1) -This is characterized by *Bombax* - *Albizia* association. This type is met in the riverine flats that tend to be flooded during the rainy season but dry out during rest of the year. Trees include Simul, Siris and other important species like Khair, Kainjal and Pitali appear here. Grasses are very dense, sometimes 4-5 mt. high and consist of *Saccharum procerum*, *S. spontaneum*, *Phragmites karka*, *Arundo donax*, *Themeda arundinacea*, *Imperata spp.* etc.

c) Eastern alluvial grassland (4D/252) -This is found in patches inside the National Park where the tract is deeply flooded during monsoon and becomes completely dry in summer months and soil becomes hard. The alteration of moisture conditions seems to inhibit any tree growth and has resulted in the pure grassland on the banks of the river Jaldhaka, Murti. The grasses are very tall and are the principal dwelling place for one horned rhinoceros. The grass species found here are *Saccharum spontaneum*, *S. Procerum*, *Erianthus arundinacea*, *Phragmites karka*, *Arundo donax*, Malsa and *Setaria species*. This area provides the main fodder base for the herbivores.

Natural Savannah is present mostly in Jaldhaka-1b, Dhupjhora-1a, 1b, 1c blocks mainly of Gorumara NP.

A limiting factor for conservation of Rhinoceros in Gorumara National Park is the serious limitation of suitable grassland habitat for the species (Anon, 2007a). This severe restriction of grazing area automatically limits the scope of population growth and sustainability of a larger population of these large herbivores.

Moreover, succession of tree species is another most important factor for change in the grassland composition. In the natural process, depending on the climatic conditions fertile soil and underground moisture regime, the grasslands are colonized by tree species like Khair,

Sissoo, Simul, Siris as a riverine succession which gradually is converting the grassland into woodland ultimately leading to the degeneration of ideal herbivore habitat. Further the invasion of weeds like *Leea spp.*, *Eupatorium spp.*, *Lantana camara* etc. into the grassland add to this habitat degeneration process.

The Forest Department therefore set aside a Habitat Improvement Zone for active managerial intervention, including habitat manipulation, for development of the forest area as ideal rhino and other wildlife habitat. These zones have been identified in parts of compartments of Dhupjhora-I (b), South Indong-I, Jaldhaka-Ib, Selkapara-I (part), Selkapara-II, Tondou-I, II, III,

Gorumara-II and Ramsai Extension mostly under Gorumara South Range and North Range (Anon, 2007a).

The present study was therefore confined to the main habitat improvement zone of the Park i.e. Dhupjhora-I(b), South Indong-I, Jaldhaka-Ib, Ramsai Extension, Gorumara-II of South and Tondou-II, III of North Ranges to identify the impact of Grassland Management in these areas.

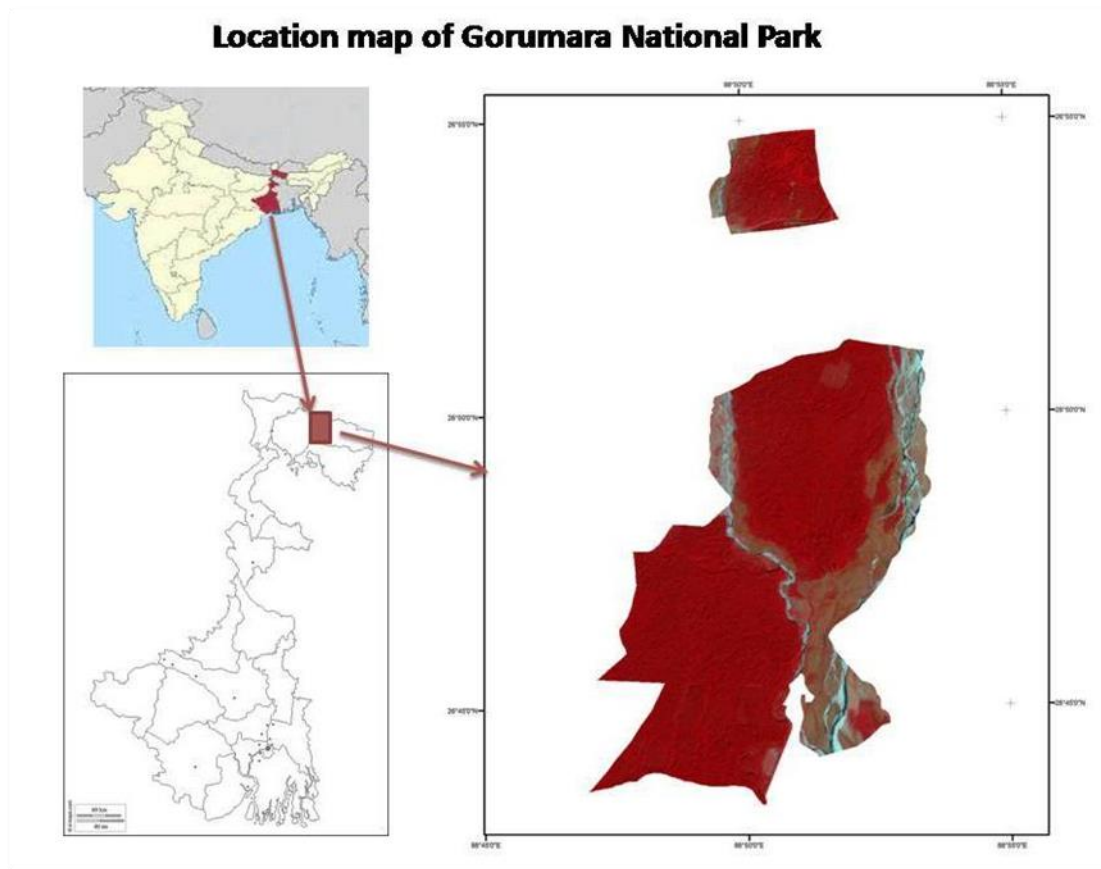


Figure 25: Gorumara National Park

5.2. Discussion with forest officials and collection of plantation journals

Results:

In Gorumara NP discussions with the following officials were held viz. Ms. Nisha Goswami, DFO; Ms. Rhea Ganguli, ADFO; Mr. Ayan Chakraborty, Ranger, Gorumara South Range; Mr. Sarad Mani Chetri, Ranger, Gorumara North Range. Ms. Smriti Rai, Beat Officer, Dhupjhora Beat; Mr. Bhupati Singh, Beat officer, Budhram Beat; Mr. Jibon Biswakarma, Beat Officer, Gorumara Beat; Mr. Kinu Sarkar, Beat Officer, Khunia Beat and Mr. Roshan Roy Beat Officer, Murti Beat.

5.3. Archive literature review

Results:

After discussed with the forest officials the relevant archive literatures were collected and reviewed from the respective Beats and Ranges of GNP. Total 74 Plantation journals were collected from the respective forest ranges and beats of Gorumara NP. The journals were reviewed and tabulated beat wise with the main details in a single page. Plantation details like area, previous plantations, planted species, gap between the planted species, flood condition, species before plantation etc were tabulated in a particular proforma.

Table 30: Plantation journals collected from GNP

Range	Beat	Total journal collected	Repeated plantation/ Chosen for study	One time plantation/ Chosen for study	Canopy opening/ Chosen for study	No Information/ Chosen for study
Gorumara North Range	Khunia Beat	10	6/4	4/0		
	Chapramari Beat	6	4/0	2/0		
	Murti Beat	2	1/1	0/0		1/1
Total	3 Beats	18	11/5	6/0		1/1
Gorumara South Range	Budhram Beat	16	5/3	5/3	4/2	2/0
	Dhupjhora Beat	21	12/5	8/2		1/0
	Gorumara Beat	19	8/6	10/3		1/1
Total	3 Beats	56	25/14	23/8	4/2	4/1
GRAND TOTAL	6 Beats	74	36/19	29/8	4/2	5/2

5.4. Inventorization of Flora

Results:

In GNP a total of 31 managed plots (19 repeated plantations, 8 one-time plantations, 2 canopy opening plantations and 2 without any information) were chosen for this study falling in 5 beats viz. Gorumara, Budhram, Dhupjhora, Khunia and Murti. Vegetation occupancy data were collected in 33 quadrates in these 31 plots in post monsoon season only. More over to compare the studied plots 3 natural grassland plots were also studied in GNP.

The size of the sampling quadrature was fixed at 10 m X 10 m (100 sq. m.) in all the quadrature.

Studies were carried out in all the 33 quadrates in 31 managed plots but only once in post monsoon season. During these studies a total of 104 plant species were recorded, identified,

documented and tabulated. Of these, 8 were the Planted species, while 14 species belonged to Natural occurring grass, fodder & sedge, 21 were Weed species and 61 were Other species including ferns. Fern species were not considered as weed as it plays an important role in maintaining the swampy habitat.

Analyzed data shows that *Axonopus compressus* have highest IVI (41.77) followed by *Imperata cylindrica* (IVI= 22.27) among all species found in studied managed plots of Gorumara National Park.

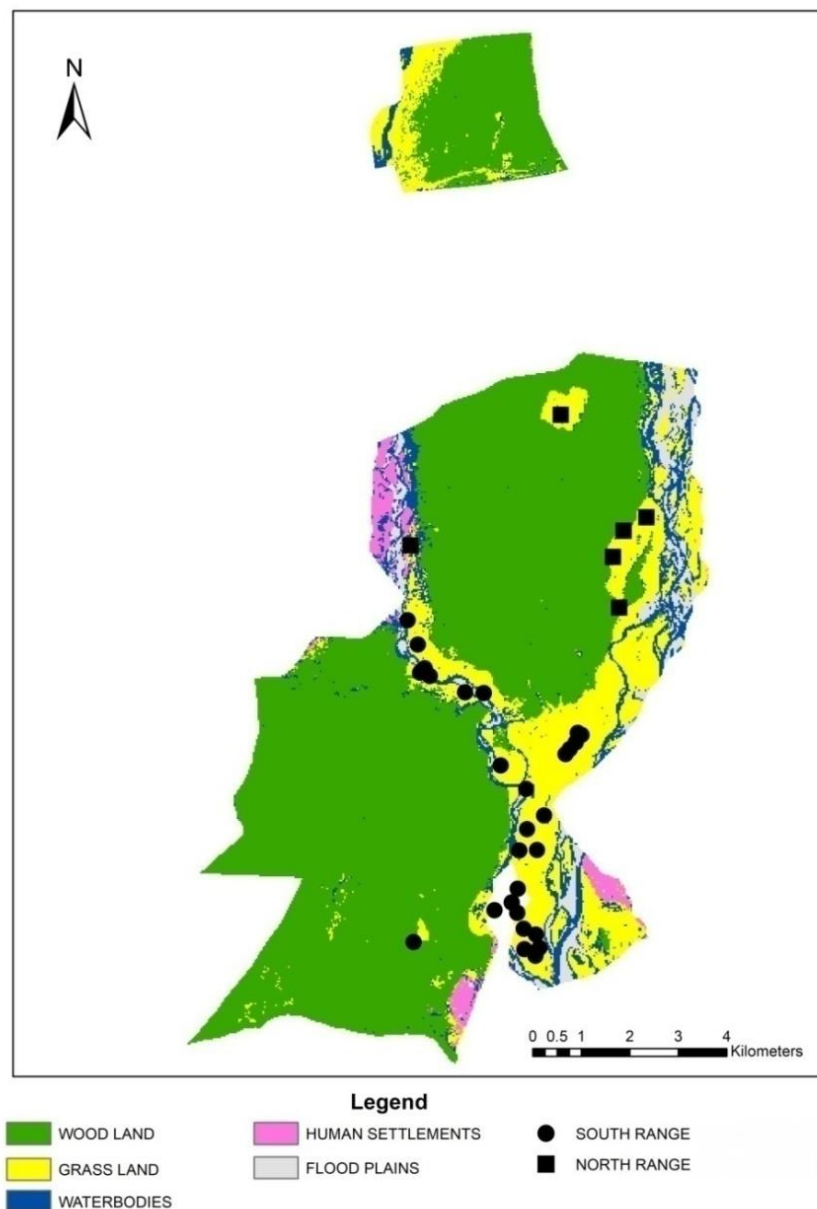


Figure 26: Gorumara Land Use land cover map showing the managed plots undertaken for this study

Table 31: List of all species of plants recorded in managed plots

Sl no.	Family	Scientific name	IVI Values
1	Asteraceae	<i>Acmella uliginosa</i>	3.46
2	Asteraceae	<i>Ageratum conyzoides</i>	10.76
3	Zingiberaceae	<i>Alpinia nigra</i>	2.32
4	Apocynaceae	<i>Alstonia scholaris</i>	0.24
5	Lamiaceae	<i>Anisomelis sp</i>	0.66
6	Poaceae	<i>Arundo donax</i> L.	2.67
7	Poaceae	<i>Axonopus compressus</i>	41.77
8	Poaceae	<i>Bambusa sp</i>	0.47
9	Asteraceae	<i>Bidens pilosa</i>	2.11
10	Malvaceae	<i>Bombax ceiba</i>	1.26
11	Rubiaceae	<i>Borreria alata</i>	13.65
12	Phyllanthaceae	<i>Bridelia sp</i>	1.32
13	Lamiaceae	<i>Callicarpa sp</i>	0.25
14	Fabaceae	<i>Cassia occidentalis</i>	0.50
15	Fabaceae	<i>Cassia tora</i>	2.20
16	Poaceae	<i>Cenchrus setiger</i>	0.79
17	Asteraceae	<i>Chromolaena odorata</i>	9.43
18	Cucurbitaceae	<i>Citrullus sp</i>	0.31
19	Lamiaceae	<i>Clerodendrum infortunatum</i>	2.39
20	Rubiaceae	<i>Coffea benghalensis</i>	0.25
21	Lamiaceae	<i>Colebrookea oppositifolia</i>	0.27
22	Lamiaceae	<i>Colebrookea sp</i>	0.66
23	Commelinaceae	<i>Commelina sp</i>	1.64
24	Fabaceae	<i>Crotalaria pallida</i>	0.75
25	Fabaceae	<i>Crotalaria sp</i>	0.61
26	Lythraceae	<i>Cuphea procumbens</i>	0.43
27	Zingiberaceae	<i>Curcuma sp</i>	0.90

28	Commelinaceae	<i>Cyanotis sp</i>	0.43
29	Cyperaceae	<i>Cyperus sp</i>	4.89
30	Fabaceae	<i>Desmodium sp</i>	1.75
31	Dilleniaceae	<i>Dillenia pentagyna</i>	0.24
32	Dioscoreaceae	<i>Dioscorea sp</i>	0.53
33	Athyriaceae	<i>Diplazium esculentum</i>	5.15
34	Dryopteridaceae	<i>Dryopteris sp</i>	1.70
35	Poaceae	<i>Echynocloa crassgali</i>	12.53
36	Poaceae	<i>Eragrostis amabilis</i>	7.61
37	Fabaceae	<i>Flemingia strobilifera</i>	1.63
38	Boraginaceae	<i>Heliotropium indicum</i>	0.24
39	Lamiaceae	<i>Hyptis capitata</i>	0.40
40	Lamiaceae	<i>Hyptis suaveolens</i>	4.73
41	Apocynaceae	<i>Ichnocarpus frutiscens</i>	0.43
42	Poaceae	<i>Imperata cylindrica</i>	22.27
43	Convolvulaceae	<i>Ipoemia sp</i>	0.62
44	Convolvulaceae	<i>Ipomoea nil</i>	1.00
45	Poaceae	<i>Ishachne sp</i>	8.64
46	Cyperaceae	<i>Kylinga nemoralis</i>	9.14
47	Lythraceae	<i>Lagerstroemia hirsuta</i>	0.25
48	Lythraceae	<i>Lagerstroemia speciosa</i>	1.07
49	Verbenaceae	<i>Lantana camara</i>	1.36
50	Vitaceae	<i>Leea asiatica</i>	0.58
51	Acanthaceae	<i>Lepidagathis incurva</i>	0.43
52	Verbenaceae	<i>Lippia javanica</i>	1.24
53	Lauraceae	<i>Litsea glutinosa</i>	0.61
54	Lauraceae	<i>Litsea monopetala</i>	0.29
55	Onagraceae	<i>Ludwigia sp</i>	2.34
56	Lygodiaceae	<i>Lygodium flexuosum</i>	0.32
57	Melastomataceae	<i>Melastoma malabathricum</i>	0.59

58	Malvaceae	<i>Melochia corchorifolia</i>	0.40
59	Malvaceae	<i>Melochia sp</i>	0.67
60	Asteraceae	<i>Mikania micrantha</i>	7.85
61	Fabaceae	<i>Mimosa invisa</i>	0.25
62	Fabaceae	<i>Mimosa pudica</i>	7.38
63	Rubiaceae	<i>Mitracarpus hirsuta</i>	1.13
64	Cucurbitaceae	<i>Momordica charantia</i>	0.25
65	Rubiaceae	<i>Morinda angustifolia</i>	0.25
66	Cucurbitaceae	<i>Mukia maderaspatana</i>	0.27
67	Poaceae	<i>Oplismenus burmannii</i>	17.73
68	Rubiaceae	<i>Paedaria foetida</i>	1.15
69	Poaceae	<i>Panicum sp</i>	0.72
70	Poaceae	<i>Penisetum sp</i>	0.29
71	Polygonaceae	<i>Persicaria hydropiper</i>	0.25
72	Polygonaceae	<i>Persicaria sp</i>	0.99
73	Poaceae	<i>Phragmites sp</i>	0.43
74	Phyllanthaceae	<i>Phyllanthus sp</i>	1.46
75	Lamiaceae	<i>Premna bengalensis</i>	0.24
76	Lamiaceae	<i>Premna sp</i>	0.46
77	Fabaceae	<i>Pueraria sp</i>	0.61
78	Amaranthaceae	<i>Pupalia lappacea</i>	1.78
79	Acanthaceae	<i>Rungia pectinata</i>	1.65
80	Poaceae	<i>Saccharum arundinaceum</i>	3.84
81	Poaceae	<i>Saccharum longisetosum</i> (Andersson) V. Naray. ex Bor	3.87
82	Poaceae	<i>Saccharum narenga</i>	12.62
83	Poaceae	<i>Saccharum spontaneum</i>	6.85
84	Phyllanthaceae	<i>Sauropus sp</i>	0.45
85	Theaceae	<i>Schima wallichii</i>	0.29
86	Plantaginaceae	<i>Scoparia dulcis</i>	0.31
88	Poaceae	<i>Setaria palmifolia</i>	2.70

89	Dipterocarpaceae	<i>Shorea robusta</i>	0.27
90	Malvaceae	<i>Sida acuta</i>	4.94
91	Malvaceae	<i>Sida rhomboidea</i>	0.43
92	Solanaceae	<i>Solanum torvum</i>	0.95
93	Rubiaceae	<i>Spermacoce alata</i>	2.49
94	Verbenaceae	<i>Stachytarpheta indica</i>	1.03
95	Menispermaceae	<i>Stephania hernandifolia</i>	1.90
96	Moraceae	<i>Streblus asper</i>	0.27
97	Combretaceae	<i>Terminalia myriocarpa</i>	0.24
98	Poaceae	<i>Themeda arundinacea</i>	8.42
99	Poaceae	<i>Thysanolena maxima</i>	0.61
100	Commelinaceae	<i>Tradiscantia sp</i>	0.31
101	Malvaceae	<i>Triumfetta rhomboidea</i>	2.31
102	Malvaceae	<i>Urena lobata</i>	1.89
103	Zingiberaceae	<i>Zingiber zerumbet</i>	1.24
104	Rhamnaceae	<i>Ziziphus sp</i>	0.50

Table 32: List of planted species recorded in managed plots

Sl no	Family	Planted species	Vernacular name
1	Zingiberaceae	<i>Alpinia nigra</i>	Purundi
2	Poaceae	<i>Arundo donax</i> L.	Nol
3	Poaceae	<i>Bambusa sp</i>	Bansh
4	Poaceae	<i>Cenchrus setiger</i>	Dhabon
5	Poaceae	<i>Saccharum arundinaceum</i> Retzius	Madhua
6	Poaceae	<i>Saccharum longisetosum</i> (Andersson) V. Naray. ex Bor	Malsa
7	Poaceae	<i>Saccharum narenga</i> (Nees ex Steud.) Hack.	Dhadda
8	Poaceae	<i>Themeda arundinacea</i> (Roxburgh) Ridley	Chepti

Table 33: List of natural grasses, fodder and sedges recorded in managed plots

Sl no	Family	Natural grass fodders species	Also in the plantation list
1	Poaceae	<i>Arundo donax</i> L.	√
2	Poaceae	<i>Axonopus compressus</i> (Sw.) P. Beauv.	
3	Cyperaceae	<i>Cyperus</i> sp	
4	Poaceae	<i>Echinochloa crus galli</i>	
5	Poaceae	<i>Eragrostis amabilis</i> (L.) Wight & Arn.	
6	Poaceae	<i>Imperata cylindrica</i> (L.) Raeusch.	
7	Poaceae	<i>Issachne</i> sp	
8	Cyperaceae	<i>Kylinga nemoralis</i>	
9	Poaceae	<i>Oplismenus burmannii</i>	
10	Poaceae	<i>Panicum</i> sp	
11	Poaceae	<i>Penisetum</i> sp	
12	Poaceae	<i>Saccharum spontaneum</i> L.	
13	Poaceae	<i>Setaria palmifolia</i> (J. Koenig) Stapf	
14	Poaceae	<i>Phragmites</i> sp	
15	Poaceae	<i>Thysanolenia maxima</i>	

Table 34: List of weed species recorded in managed plots

Sl no	Family	Species name
1	Asteraceae	<i>Ageratum conyzoides</i> (L.) L.
2	Fabaceae	<i>Cassia tora</i>
3	Asteraceae	<i>Chromolaena odorata</i> (L.) R.M. King & H. Rob.
4	Lamiaceae	<i>Clerodendrum infortunatum</i> L.
5	Lamiaceae	<i>Colebrookea oppositifolia</i> Sm.
6	Convolvulaceae	<i>Ipomoea nil</i> (L.) Roth
7	Verbenaceae	<i>Lantana camara</i> L.
8	Vitaceae	<i>Leea asiatica</i> (L.) Ridsdale
9	Lygodiaceae	<i>Lygodium flexuosum</i> (L.) Sw.
10	Malvaceae	<i>Melochia corchorifolia</i> L.

11	Asteraceae	<i>Mikania micrantha</i> Kunth
12	Fabaceae	<i>Mimosa invisa</i> Colla
13	Fabaceae	<i>Mimosa pudica</i> L.
14	Cucurbitaceae	<i>Mukia maderaspatana</i>
15	Rubiaceae	<i>Paederia foetida</i>
16	Fabaceae	<i>Pueraria</i> sp
17	Fabaceae	<i>Senna occidentalis</i> (L.) Link
18	Solanaceae	<i>Solanum torvum</i> Sw.
19	Verbenaceae	<i>Stachytarpheta indica</i> (L.) Vahl
20	Menispermaceae	<i>Stephania hernandifolia</i>
21	Malvaceae	<i>Triumfetta rhomboidea</i> Jacq.

Table 35: List of other species recorded in managed plots

Sl no	Family	Species name
1	Asteraceae	<i>Acmella uliginosa</i> (Sw.) Cass
2	Apocynaceae	<i>Alstonia scholaris</i> (L.) R. Br.
3	Lamiaceae	<i>Anisomelis</i> sp
4	Asteraceae	<i>Bidens pilosa</i>
6	Malvaceae	<i>Bombax ceiba</i> L.
7	Rubiaceae	<i>Borreria alata</i>
8	Phyllanthaceae	<i>Bridelia</i> sp
9	Lamiaceae	<i>Calycarpa</i> sp
10	Cucurbitaceae	<i>Citrulus</i> sp
11	Rubiaceae	<i>Coffea benghalensis</i> B. Heyne ex Schult.
12	Lamiaceae	<i>Colebrookea</i> sp
13	Commelinaceae	<i>Commelina</i> sp
14	Fabaceae	<i>Crotalaria pallida</i> Aiton
15	Fabaceae	<i>Crotalaria</i> sp
16	Lythraceae	<i>Cuphea procumbens</i>
17	Zingiberaceae	<i>Curcuma</i> sp

18	Commelinaceae	<i>Cyanotis sp</i>
19	Fabaceae	<i>Desmodium sp</i>
20	Dilleniaceae	<i>Dillenia pentagyna</i>
21	Dioscoreaceae	<i>Dioscorea sp</i>
22	Athyriaceae	<i>Diplazium esculentum</i> (Retz.) Sw.
23	Dryopteridaceae	<i>Dryopteris sp</i>
24	Fabaceae	<i>Flemingia strobilifera</i> (L.) W.T. Aiton
25	Boraginaceae	<i>Heliotropium indicum</i> L.
26	Lamiaceae	<i>Hyptis capitata</i> Jacq.
27	Lamiaceae	<i>Hyptis suaveolens</i> (L.) Poit.
28	Apocynaceae	<i>Ichnocarpus frutescens</i>
29	Convolvulaceae	<i>Ipoemia sp</i>
30	Lythraceae	<i>Lagerstroemia hirsuta</i>
31	Lythraceae	<i>Lagerstroemia speciosa</i> (L.) Pers.
32	Acanthaceae	<i>Lepidagathis incurva</i> Buch. -Ham. ex D. Don
33	Verbenaceae	<i>Lippia javanica</i> (Burm.f.) Spreng.
34	Lauraceae	<i>Litsea glutinosa</i> (Lour.) C.B. Rob.
35	Lauraceae	<i>Litsea monopetala</i>
36	Onagraceae	<i>Ludwigia sp</i>
37	Melastomataceae	<i>Melastoma malabathricum</i> L.
38	Malvaceae	<i>Melochia sp</i>
39	Rubiaceae	<i>Mitracarpus hirsuta</i>
40	Cucurbitaceae	<i>Momordica charantia</i>
41	Rubiaceae	<i>Morinda angustifolia</i> Roxb.
42	Polygonaceae	<i>Persicaria hydropiper</i> (L.) Delarbre
43	Polygonaceae	<i>Persicaria sp</i>
44	Phyllanthaceae	<i>Phyllanthus sp</i>
45	Lamiaceae	<i>Premna bengalensis</i>
46	Lamiaceae	<i>Premna sp</i>
47	Amaranthaceae	<i>Pupalia lappacea</i> (L.) Juss.

48	Acanthaceae	<i>Rungia pectinata</i> (L.) Nees
49	Phyllanthaceae	<i>Sauropus sp</i>
50	Theaceae	<i>Schima wallichii</i> Choisy
51	Plantaginaceae	<i>Scoparia dulcis</i> L.
52	Dipterocarpaceae	<i>Shorea robusta</i> Gaertn.
53	Malvaceae	<i>Sida acuta</i> Burm.f.
54	Malvaceae	<i>Sida rhomboidea</i>
55	Rubiaceae	<i>Spermacoce alata</i> Aubl.
56	Moraceae	<i>Streblus asper</i>
57	Combretaceae	<i>Terminalia myriocarpa</i> Van Heurck & Müll. Arg.
58	Commelinaceae	<i>Tradiscantia sp</i>
59	Malvaceae	<i>Urena lobata</i> L.
60	Zingiberaceae	<i>Zingiber zerumbet</i> (L.) Roscoe ex Sm.
61	Rhamnaceae	<i>Zizyphus sp</i>

a. Vegetation Occupancy:

Range wise result of vegetation occupancy in Gorumara NP:

Range-North

- A total of six quadrates were chosen in the six identified managed plots, where seven species of fodder plants were planted by the Forest Department viz. *Alpinia nigra*, *Saccharum narenga*, *S. arundinaceum*, *S. longisetosum*, *Themeda arundinacea*, *Phragmites karka* and *Arundo donax*.
- Of the seven species planted by forest department only five of these species were recorded during the present study (Annexure: 2).
- Occupancy percentage of these species ranged from 7.98% to 55.10% and occupied about 29% of area in this Range after weeds.
- *Oplismenus burmannii*, *Imperata cylindrica*, *Kylinga nemoralis*, *Saccharum spontaneum* and *Cyperus sp.* occurred naturally and ranges from 0 to 56.01% occupying about 18% of area in this Range.
- Weed species like *Chromolaena odorata*, *Clerodendrum infortunatum*, *Cassia tora*, *Mikania micrantha*, *Ageratum conyzoides*, *Mimosa pudica* ranged from 18.87% to 45.51% and occupied about 32% of area in this Range recording the highest among the four categories of plants (Figure 27).

Table 36: Occupancy percentage of Planted, Natural, Weeds and other species in North Range, Gorumara NP

Khunia Beat										
Managed Plot No.	Quadrate No.	Year of plantation	Locations	Occupancy Percentage/ no of species	Planted species %	Natural Grass, Fodder & Sedge %	Harmful weeds %	Other Species %	Flood	Previous condition of the area as per the plantation journal
GNKQ1	1	2018	26° 49.252'N, 88° 52.493'E	Occupancy %	36.02	23.49	18.87	21.62	Low	Older plantation
				No of species	2	1	6	6		
GNKQ2	2	2017	26° 48.395'N, 88° 52.424'E	Occupancy %	51.07	0.67	39.13	9.14	NIL	Older plantation
				No of species	4	1	6	3		
GNKQ3	3	2017	26° 49.400'N, 88° 52.779'E	Occupancy %	7.98	56.01	25.09	10.93	NIL	Older plantation
				No of species	3	3	5	5		
GNKQ5	4	2016	26° 48.963'N, 88° 52.357'E	Occupancy %	14.00	25.54	38.89	21.57	NIL	Older plantation
				No of species	3	3	9	9		
Murti Beat										
Managed Plot No.	Quadrate No.	Year of plantation	Locations	Occupancy Percentage/ no of species	Planted species %	Natural Grass, Fodder & Sedge %	Harmful weeds %	Other Species %	Flood	Previous condition of the area as per the plantation journal
GNMQ3	5	2016	26° 49.126'N, 88° 49.838'E	Occupancy %	9.38	2.92	45.51	42.19	NIL	
				No of species	1	2	6	5		
GNMQ4	6	2018	26° 50.561'N, 88° 51.730'E	Occupancy %	55.10	0.00	22.86	22.04	NIL	Older plantation
				No of species	4	0	6	8		

Range-South

- Twenty-seven quadrature studies were done in twenty-five different management plots of this Range. Of these two quadrates viz. GSBQ2 and GSBQ12 were in canopy opening sites.
- Among seventeen species planted by the forest department (Annexure: 1), altogether Seven planted grass species namely *Saccharum narenga*, *S. arundinaceum*, *S. longisetosum* (Andersson) V. Naray. ex Bor, *Themeda arundinacea*, *Arundo donax*, *Bambusa sp* and *Cenchrus setiger* were recorded whose occupancy percentage ranged from 5.48% to 70.88 % in different plots, occupying approximately 37% area of this range.
- *Axonopus compressus*, *Imperata cylindrica*, *Eragrostis amabilis*, *Ishachne sp*, *Oplismenus burmannii*, *Setaria palmifolia*, *Penisetum sp*, *Saccharum spontaneum*, *Phragmites sp*, *Panicum sp*, *Cyperus sp*, *Echinocloa crassgali* were the natural growing grass fodders and sedge species found in this Range with 0.59% to 57.43% occupancy rate, covering almost 30% area of the Range.
- Weed species like *Chromolaena odorata*, *Clerodendrum infortunatum*, *Cassia tora*, *Mikania micrantha*, *Ageratum conyzoides*, *Lygodium flexuosum*, *Mimosa pudica* ranged from 4.44% to 37.34%.
- The total area covering by the weed species was 21% approximately (Figure: 28).

Table 37: Occupancy percentage of Planted, Natural, Weeds and other species in South Range, Gorumara NP

Budhram beat										
Managed Plot No.	Quadrat e No.	Year of plantation	Locations	Occupancy Percentage/ no of species	Planted species %	Natural Grass, Fodder & Sedge %	Harmful weeds %	Other Species %	Flood	Previous condition of the area as per the plantation journal
GSBQ2	7	2004	26° 44.691'N, 88° 49.805'E	Occupancy % No of species	5.48 1	0.59 1	23.72 4	70.20 10		Canopy opening
GSBQ8	8	2011	26° 44.754'N, 88° 51.329'E	Occupancy % No of species	35.70 3	25.45 6	35.13 5	3.73 2	Very high	Natural blank
GSBQ9	9	2014	26° 44.593'N, 88° 51.181'E	Occupancy % No of species	55.76 4	19.08 1	13.13 4	12.03 4	Moderate	Natural blank
	10	2014	26° 44.518'N, 88° 51.319'E	Occupancy % No of species	45.38 3	29.59 3	17.20 3	7.83 3	Moderate	Natural blank
GSBQ10	11	2015	26° 44.821'N, 88° 51.178'E	Occupancy % No of species	41.58 3	11.30 2	23.83 3	23.30 8	Low	Grass Plantation
GSBQ11	12	2017	26° 44.607'N, 88° 51.370'E	Occupancy % No of species	45.76 2	9.44 2	34.83 6	9.97 4	High	Natural blank
	13	2017	26° 45.001'N, 88° 51.099'E	Occupancy % No of species	25.11 3	34.38 4	23.28 3	17.23 3	High	Natural blank
GSBQ12	14	2018	26° 45.034'N, 88° 50.816'E	Occupancy % No of species	29.61 3	57.43 2	9.50 4	3.46 4	Low	Canopy opening
GSBQ13	15	2018	26° 45.269'N, 88° 51.109'E	Occupancy % No of species	59.41 3	7.68 2	27.97 4	4.94 2	Low	Grass Plantation
GSBQ14	16	2018	26° 45.118'N, 88° 51.032'E	Occupancy % No of species	39.86 2	44.68 2	14.05 4	1.41 1	Moderate	Grass Plantation
Gorumara Beat										
Managed Plot No.	Quadrat e No.	Year of plantation	Locations	Occupancy Percentage/ no of species	Planted species %	Natural Grass, Fodder & Sedge %	Harmful weeds %	Other Species %	Flood	Previous condition of the area as per the plantation journal
GSGQ40	17	2009	26° 45.701'N, 88° 51.356'E	Occupancy % No of species	64.38 3	19.93 2	6.76 3	8.94 3	High	Over grazed fodder plantation
GSGQ41	18	2014	26° 45.935'N, 88° 51.236'E	Occupancy % No of species	39.64 2	20.33 1	33.39 6	6.65 3	Moderate	Natural Blank
GSGQ42	19	2015	26° 46.384'N, 88° 51.232'E	Occupancy % No of species	5.5 2	89.4 3	4.9 6	0.2 1	Very High	
GSGQ43	20	2016	26° 46.980'N, 88° 51.933'E	Occupancy % No of species	41.67 2	30.10 2	19.55 3	8.68 3		Older Plantation
GSGQ44	21	2016	26° 46.651'N, 88° 50.921'E	Occupancy % No of species	31.44 3	34.62 1	24.73 3	9.22 4	Moderate	Degraded Forest
GSGQ45	22	2016	26° 46.767'N, 88° 51.730'E	Occupancy % No of species	15.33 3	74.32 2	4.44 4	5.91 2	Moderate	Older Plantation
GSGQ46	23	2017	26° 47.002'N, 88° 51.885'E	Occupancy % No of species	37.15 4	31.83 3	25.14 5	5.88 4	High	Natural
GSGQ47	24	2018	26° 46.822'N, 88° 51.782'E	Occupancy % No of species	70.88 3	3.00 1	13.48 2	12.65 3	High	Older Plantation
GSGQ48	25	2018	26° 45.699'N, 88° 51.136'E	Occupancy % No of species	42.83 3	26.14 2	26.66 4	4.37 3	High	Older Plantation
GSGQ49	26	2019	26° 46.084'N, 88° 51.451'E	Occupancy % No of species	56.36 4	22.04 1	14.44 3	7.16 3	High	Older Plantation
Dhupjhora Beat										
Managed Plot No.	Quadrat e No.	Year of plantation	Locations	Occupancy Percentage/ no of species	Planted species %	Natural Grass, Fodder & Sedge %	Harmful weeds %	Other Species %	Flood	Previous condition of the area as per the plantation journal
GSDQ29	27	2015	26° 47.474'N,	Occupancy %	9.16	25.96	37.34	28.45	High	Older plantation

			88° 50.490'E	No of species	4	3	5	8		
GSDQ30	28	2017	26° 47.750'N, 88° 49.992'E	Occupancy %	49.37	32.91	10.04	7.68	High	Degraded Forest
				No of species	4	1	4	2		
GSDQ31	29	2018	26° 47.462'N, 88° 50.723'E	Occupancy %	30.23	19.19	36.56	14.03	Low	Failure Plantation
				No of species	3	1	6	9		
GSDQ32	30	2018	26° 48.016'N, 88° 49.911'E	Occupancy %	44.92	24.95	26.01	4.12	Moderate	Failure Plantation
				No of species	4	1	5	4		
GSDQ50	31	2019	26° 47.700'N, 88° 49.933'E	Occupancy %	31.17	12.99	31.33	24.51	NIL	Failure Plantation
				No of species	4	2	5	8		
GSDQ51	32	2019	26° 47.661'N, 88° 50.054'E	Occupancy %	19.17	63.71	13.58	3.54	Moderate	Natural blank
				No of species	4	2	4	2		
GSDQ52	33	2019	26° 48.288'N, 88° 49.789'E	Occupancy %	26.31	36.54	18.89	18.25	Low	Bamboo Plantation
				No of species	4	1	8	6		

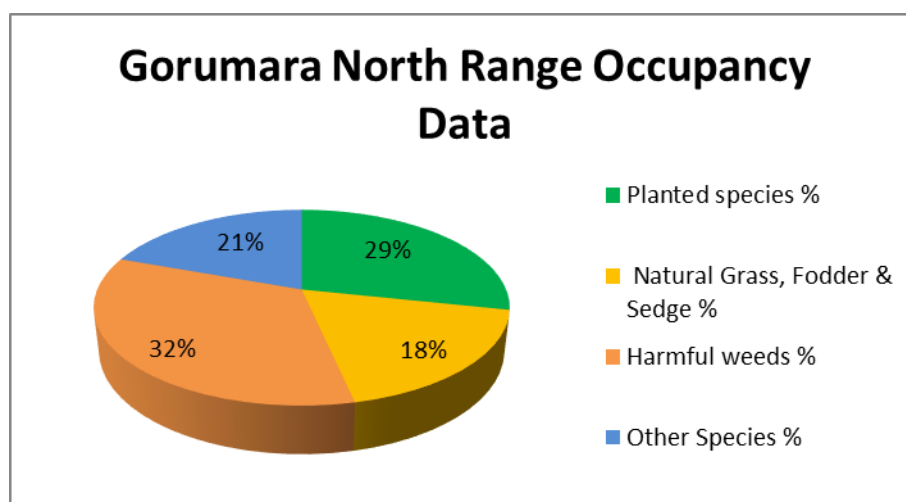


Figure 27: Occupancy percentage of North Range, Gorumara NP

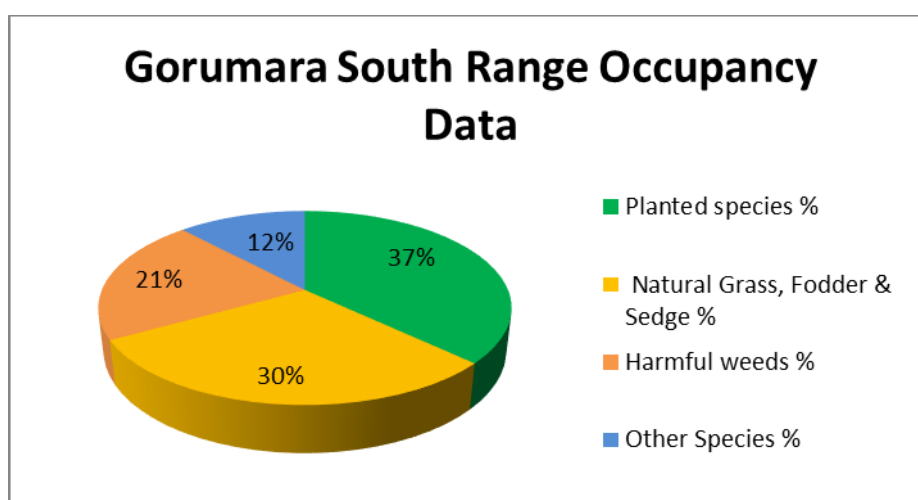


Figure 28: Occupancy percentage of South Range, Gorumara NP

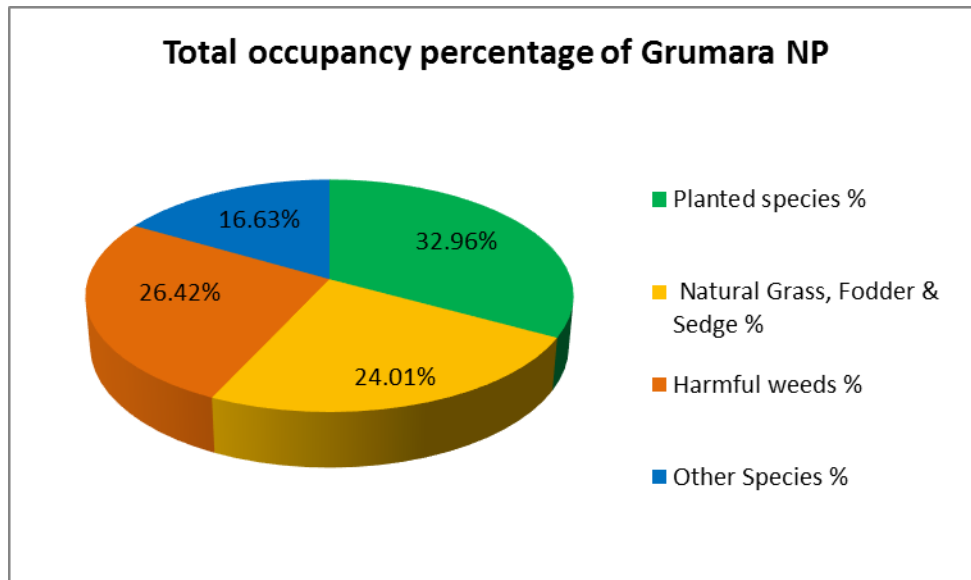


Figure 29: Occupancy percentage of South Range, Gorumara NP

b. Statistical evaluation:

i) Analysis of the vegetation data of management plots:

North Range:

Total 44 species were recorded from this range in post monsoon season only. Total numbers of grass fodder and sedge species from this zone were recorded were 11, out of which 5 species were planted by Forest Department.

Statistical analysis of all the species found in the zone shows that highest IVI was recorded by *Borreria alata* (IVI= 52.12) followed by *Oplismenus burmannii* (IVI= 37.02). The earlier mentioned species belonged to the other species and the later one is naturally grown grass fodder.

In planted species *Saccharum narenga* possesses the highest IVI values (9.84) followed by *Themeda arundinacea* (5.41).

In weed species *Mimosa pudica* recorded the highest IVI value of 12.77 followed by *Ageratum conyzoides* (IVI= 11.75).

The population density of the grass species (both planted and natural) was 43%. Whereas, the population density of the weed species was 17% in this Range.

Simpson Diversity Index (SDI) for Species diversity was calculated to be 0.87 for all plant species found in North Range of GNP.

Table 38: Statistical analysis of all plant species recorded in North Range of GNP

Sl. No.		Species	NI	O	F %	RF %	D/sq.m.	RD %	A	RA %	IVI	SDI
1	Planted Species	<i>Saccharum narenga</i> (Nees ex Steud.) Hack.	219	6	100.00	6.00	0.37	2.71	36.50	1.13	9.84	0.87
2		<i>Themeda arundinacea</i> (Roxburgh) Ridley	70	4	66.67	4.00	0.12	0.87	17.50	0.54	5.41	
3		<i>Alpinia nigra</i>	118	2	33.33	2.00	0.20	1.46	59.00	1.82	5.28	
4		<i>Saccharum longisetosum</i> (Andersson) V. Naray. ex Bor	14	3	50.00	3.00	0.02	0.17	4.67	0.14	3.32	
5		<i>Saccharum arundinaceum</i> Retzius	48	1	16.67	1.00	0.08	0.59	48.00	1.48	3.08	
6	Natural Grass fodder & sedge	<i>Oplismenus burmannii</i>	1500	3	50.00	3.00	2.50	18.56	500.00	15.46	37.02	
7		<i>Kylinga nemoralis</i>	500	1	16.67	1.00	0.83	6.19	500.00	15.46	22.65	
8		<i>Cyperus sp</i>	578	2	33.33	2.00	0.96	7.15	289.00	8.94	18.09	
9		<i>Saccharum spontaneum</i> L.	322	2	33.33	2.00	0.54	3.98	161.00	4.98	10.96	
10		<i>Imperata cylindrica</i> (L.) Raeusch.	44	2	33.33	2.00	0.07	0.54	22.00	0.68	3.22	
11		<i>Thysanolenia maxima</i>	22	1	16.67	1.00	0.04	0.27	22.00	0.68	1.95	
12	harmful weeds	<i>Mimosa pudica</i>	386	6	100.00	6.00	0.64	4.78	64.33	1.99	12.77	
13		<i>Ageratum conyzoides</i> (L.) L.	364	5	83.33	5.00	0.61	4.50	72.80	2.25	11.75	
14		<i>Chromolaena odorata</i> (L.) R.M. King & H. Rob.	268	6	100.00	6.00	0.45	3.32	44.67	1.38	10.70	
15		<i>Mikania micrantha</i> Kunth	184	6	100.00	6.00	0.31	2.28	30.67	0.95	9.22	
17		<i>Cassia tora</i>	41	3	50.00	3.00	0.07	0.51	13.67	0.42	3.93	
18		<i>Stephania hernandifolia</i>	12	3	50.00	3.00	0.02	0.15	4.00	0.12	3.27	
19		<i>Ipomoea nil</i> (L.) Roth	40	2	33.33	2.00	0.07	0.49	20.00	0.62	3.11	
20		<i>Clerodendrum infortunatum</i>	39	2	33.33	2.00	0.07	0.48	19.50	0.60	3.09	
21		<i>Triumfetta rhomboidea</i> Jacq.	30	2	33.33	2.00	0.05	0.37	15.00	0.46	2.83	
22		<i>Lantana camara</i> L.	22	1	16.67	1.00	0.04	0.27	22.00	0.68	1.95	
23		<i>Cassia occidentalis</i>	5	1	16.67	1.00	0.01	0.06	5.00	0.15	1.22	
24		<i>Stachytarpheta indica</i>	3	1	16.67	1.00	0.01	0.04	3.00	0.09	1.13	
25	Other Species	<i>Borreria alata</i>	2166	3	50.00	3.00	3.61	26.80	722.00	22.32	52.12	
26		<i>Acmela uliginosa</i>	298	2	33.33	2.00	0.50	3.69	149.00	4.61	10.29	
27		<i>Hyptis suaveolens</i>	148	5	83.33	5.00	0.25	1.83	29.60	0.92	7.75	
		<i>Diplazium esculentum</i> (Retz.) Sw.	185	3	50.00	3.00	0.31	2.29	61.67	1.91	7.20	
28		<i>Bidens pilosa</i>	124	3	50.00	3.00	0.21	1.53	41.33	1.28	5.81	
29		<i>Commelina sp</i>	90	2	33.33	2.00	0.15	1.11	45.00	1.39	4.50	
30		<i>Urena lobata</i> L.	39	2	33.33	2.00	0.07	0.48	19.50	0.60	3.09	
31		<i>Sida acuta</i>	43	1	16.67	1.00	0.07	0.53	43.00	1.33	2.86	
32		<i>Desmodium sp</i>	38	1	16.67	1.00	0.06	0.47	38.00	1.17	2.65	
33		<i>Ipoemia sp</i>	18	2	33.33	2.00	0.03	0.22	9.00	0.28	2.50	
34		<i>Crotalaria sp</i>	22	1	16.67	1.00	0.04	0.27	22.00	0.68	1.95	
35		<i>Persicaria sp</i>	22	1	16.67	1.00	0.04	0.27	22.00	0.68	1.95	
36		<i>Cyanotis sp</i>	12	1	16.67	1.00	0.02	0.15	12.00	0.37	1.52	
37		<i>Melastoma malabathricum</i> L.	12	1	16.67	1.00	0.02	0.15	12.00	0.37	1.52	
38		<i>Sida rhomboidea</i>	12	1	16.67	1.00	0.02	0.15	12.00	0.37	1.52	
39		<i>Bridelia sp</i>	7	1	16.67	1.00	0.01	0.09	7.00	0.22	1.30	
40		<i>Tradiscantia sp</i>	5	1	16.67	1.00	0.01	0.06	5.00	0.15	1.22	

41	<i>Zizyphus sp</i>	5	1	16.67	1.00	0.01	0.06	5.00	0.15	1.22
42	<i>Calycarpa sp</i>	2	1	16.67	1.00	0.00	0.02	2.00	0.06	1.09
43	<i>Momordica charantia</i>	2	1	16.67	1.00	0.00	0.02	2.00	0.06	1.09
44	<i>Dillenia pentagyna</i>	1	1	16.67	1.00	0.00	0.01	1.00	0.03	1.04

NI= Number of Individuals, O= Occurance, F= Frequency, RF=Relative Frequency, D/sq m=Density per sq metre, RD=Relative Density, A=Abundance, RA= Relative Abundance, IVI= Importance Value Index, SDI= Simpson's Diversity Index

South Range:

Total 92 species were recorded from this range in post monsoon season only. Total numbers of grass fodder and sedge species from this zone were recorded were 19, out of which 7 species were planted by Forest Department.

Statistical analysis of all the species found in the zone shows that highest IVI was recorded by *Axonopus compressus* (IVI= 51.61) followed by *Imperata cylindrica* (IVI= 27.81). Both the species belonged to naturally grown grass fodder.

In planted species *Saccharum narenga* possesses the highest IVI values (13.71) followed by *Themeda arundinacea* (9.39).

In weed species *Ageratum conyzoides* recorded the highest IVI value of 10.96 followed by *Chromolaena odorata* (IVI= 9.37).

Population density of total grass species was analyzed 75%, out of which only planted grasses was 10%. Population density of weeds was calculated to be 13% in this Range.

Simpson Diversity Index (SDI) for Species diversity was calculated same as North Range 0.87 for all plant species found in South Range of GNP.

Table 39: Statistical analysis of all plant species recorded in South Range of GNP

Sl. No.	Species	NI	O	F %	RF %	D/sq. m.	RD %	A	RA %	IVI	SDI
1	Planted Species	<i>Saccharum narenga</i> (Nees ex Steud.) Hack.	1650	25	100.00	6.96	0.66	5.560	66.00	1.18	13.71
2		<i>Themeda arundinacea</i> (Roxburgh) Ridley	719	23	92.00	6.41	0.29	2.423	31.26	0.56	9.39
3		<i>Saccharum arundinaceum</i> Retzius	215	12	48.00	3.34	0.09	0.725	17.92	0.32	4.39
4		<i>Saccharum longisetosum</i> (Andersson) V. Naray. ex Bor	205	11	44.00	3.06	0.08	0.691	18.64	0.33	4.09
5		<i>Arundo donax</i> L.	203	8	32.00	2.23	0.08	0.684	25.38	0.46	3.37
6		<i>Cenchrus setiger</i>	35	2	8.00	0.56	0.01	0.118	17.50	0.31	0.99
7		<i>Bambusa sp</i>	14	1	4.00	0.28	0.01	0.047	14.00	0.25	0.58
8	Natural Grass fodder & sedge	<i>Axonopus compressus</i> (Sw.) P. Beauv.	8800	8	32.00	2.23	3.52	29.655	1100.00	19.72	51.61
9		<i>Imperata cylindrica</i> (L.) Raeusch.	5214	17	68.00	4.74	2.09	17.570	306.71	5.50	27.81
10		<i>Opilismenus burmannii</i>	1862	4	16.00	1.11	0.74	6.275	465.50	8.35	15.74
11		<i>Echynocloa crassgali</i>	690	1	4.00	0.28	0.28	2.325	690.00	12.37	14.98
12		<i>Ishachne sp</i>	800	2	8.00	0.56	0.32	2.696	400.00	7.17	10.43
13		<i>Eragrostis amabilis</i> (L.) Wight & Arn.	700	2	8.00	0.56	0.28	2.359	350.00	6.28	9.19
14		<i>Saccharum spontaneum</i> L.	761	10	40.00	2.79	0.30	2.564	76.10	1.36	6.71

15		<i>Setaria palmifolia</i> (J. Koenig) Stapf	265	3	12.00	0.84	0.11	0.893	88.33	1.58	3.31
16		<i>Cyperus sp</i>	90	3	12.00	0.84	0.04	0.303	30.00	0.54	1.68
17		<i>Panicum sp</i>	28	1	4.00	0.28	0.01	0.094	28.00	0.50	0.87
18		<i>Phragmites sp</i>	12	1	4.00	0.28	0.00	0.040	12.00	0.22	0.53
19		<i>Penisetum sp</i>	4	1	4.00	0.28	0.00	0.013	4.00	0.07	0.36
20	harmful weeds	<i>Ageratum conyzoides</i> (L.) L.	1211	21	84.00	5.85	0.48	4.081	57.67	1.03	10.96
21		<i>Chromolaena odorata</i> (L.) R.M. King & H. Rob.	774	22	88.00	6.13	0.31	2.608	35.18	0.63	9.37
22		<i>Mikania micrantha</i> Kunth	614	18	72.00	5.01	0.25	2.069	34.11	0.61	7.69
23		<i>Mimosa pudica</i> L.	500	14	56.00	3.90	0.20	1.685	35.71	0.64	6.23
24		<i>Triumfetta rhomboidea</i> Jacq.	163	4	16.00	1.11	0.07	0.549	40.75	0.73	2.39
25		<i>Clerodendrum infortunatum</i> L.	140	5	20.00	1.39	0.06	0.472	28.00	0.50	2.37
26		<i>Cassia tora</i>	100	4	16.00	1.11	0.04	0.337	25.00	0.45	1.90
27		<i>Stephania hernandifolia</i>	65	4	16.00	1.11	0.03	0.219	16.25	0.29	1.62
28		<i>Paedaria foetida</i>	70	2	8.00	0.56	0.03	0.236	35.00	0.63	1.42
29		<i>Lantana camara</i> L.	53	3	12.00	0.84	0.02	0.179	17.67	0.32	1.33
30		<i>Solanum torvum</i> Sw.	12	4	16.00	1.11	0.00	0.040	3.00	0.05	1.21
31		<i>Stachytarpheta indica</i> (L.) Vahl	22	3	12.00	0.84	0.01	0.074	7.33	0.13	1.04
32		<i>Pueraria sp</i>	22	1	4.00	0.28	0.01	0.074	22.00	0.39	0.75
33		<i>Leea asiatica</i> (L.) Ridsdale	14	2	8.00	0.56	0.01	0.047	7.00	0.13	0.73
34		<i>Melochia corchorifolia</i> L.	10	1	4.00	0.28	0.00	0.034	10.00	0.18	0.49
35		<i>Lygodium flexuosum</i> (L.) Sw.	6	1	4.00	0.28	0.00	0.020	6.00	0.11	0.41
36		<i>Ipomoea nil</i> (L.) Roth	5	1	4.00	0.28	0.00	0.017	5.00	0.09	0.39
37		<i>Mukia maderaspatana</i>	3	1	4.00	0.28	0.00	0.010	3.00	0.05	0.34
38		<i>Colebrookea oppositifolia</i> Sm.	3	1	4.00	0.28	0.00	0.010	3.00	0.05	0.34
39		<i>Mimosa invisa</i> Colla	2	1	4.00	0.28	0.00	0.007	2.00	0.04	0.32
40		<i>Senna occidentalis</i> (L.) Link	1	1	4.00	0.28	0.00	0.003	1.00	0.02	0.30
41	Other Species	<i>Sida acuta</i> Burm.f.	512	2	8.00	0.56	0.20	1.725	256.00	4.59	6.87
42		<i>Diplazium esculentum</i> (Retz.) Sw.	462	9	36.00	2.51	0.18	1.557	51.33	0.92	4.98
43		<i>Borreria alata</i>	451	5	20.00	1.39	0.18	1.520	90.20	1.62	4.53
44		<i>Hyptis suaveolens</i> (L.) Poit.	250	10	40.00	2.79	0.10	0.842	25.00	0.45	4.08
45		<i>Spermacoce alata</i> Aubl.	200	2	8.00	0.56	0.08	0.674	100.00	1.79	3.02
46		<i>Ludwigia sp</i>	219	5	20.00	1.39	0.09	0.738	43.80	0.79	2.92
47		<i>Pupalia lappacea</i> (L.) Juss.	146	3	12.00	0.84	0.06	0.492	48.67	0.87	2.20
48		<i>Dryopteris sp</i>	123	2	8.00	0.56	0.05	0.414	61.50	1.10	2.07
49		<i>Flemingia strobilifera</i> (L.) W.T. Aiton	118	4	16.00	1.11	0.05	0.398	29.50	0.53	2.04
50		<i>Rungia pectinata</i> (L.) Nees	80	1	4.00	0.28	0.03	0.270	80.00	1.43	1.98
51		<i>Acmeilla uliginosa</i> (Sw.) Cass	118	3	12.00	0.84	0.05	0.398	39.33	0.71	1.94
52		<i>Desmodium sp</i>	104	2	8.00	0.56	0.04	0.350	52.00	0.93	1.84
53		<i>Phyllanthus sp</i>	100	2	8.00	0.56	0.04	0.337	50.00	0.90	1.79
54		<i>Urena lobata</i> L.	37	5	20.00	1.39	0.01	0.125	7.40	0.13	1.65
55		<i>Bombax ceiba</i> L.	30	5	20.00	1.39	0.01	0.101	6.00	0.11	1.60

56	<i>Lippia javanica</i> (Burm.f.) Spreng.	57	4	16.00	1.11	0.02	0.192	14.25	0.26	1.56
57	<i>Zingiber zerumbet</i> (L.) Roscoe ex Sm.	78	2	8.00	0.56	0.03	0.263	39.00	0.70	1.52
58	<i>Bidens pilosa</i>	56	1	4.00	0.28	0.02	0.189	56.00	1.00	1.47
59	<i>Mitracarpus hirsuta</i>	68	2	8.00	0.56	0.03	0.229	34.00	0.61	1.40
60	<i>Bridelia</i> sp	34	4	16.00	1.11	0.01	0.115	8.50	0.15	1.38
61	<i>Lagerstroemia speciosa</i> (L.) Pers.	48	1	4.00	0.28	0.02	0.162	48.00	0.86	1.30
62	<i>Commelina</i> sp	38	1	4.00	0.28	0.02	0.128	38.00	0.68	1.09
63	<i>Curcuma</i> sp	38	1	4.00	0.28	0.02	0.128	38.00	0.68	1.09
64	<i>Persicaria</i> sp	32	1	4.00	0.28	0.01	0.108	32.00	0.57	0.96
65	<i>Crotalaria pallida</i> Aiton	13	3	12.00	0.84	0.01	0.044	4.33	0.08	0.96
66	<i>Melochia</i> sp	23	2	8.00	0.56	0.01	0.078	11.50	0.21	0.84
67	<i>Anisomelis</i> sp	25	1	4.00	0.28	0.01	0.084	25.00	0.45	0.81
68	<i>Colebrookea</i> sp	25	1	4.00	0.28	0.01	0.084	25.00	0.45	0.81
69	<i>Litsea glutinosa</i> (Lour.) C.B. Rob.	22	1	4.00	0.28	0.01	0.074	22.00	0.39	0.75
70	<i>Dioscorea</i> sp	9	2	8.00	0.56	0.00	0.030	4.50	0.08	0.67
71	<i>Premna</i> sp	2	2	8.00	0.56	0.00	0.007	1.00	0.02	0.58
72	<i>Sauropus</i> sp	13	1	4.00	0.28	0.01	0.044	13.00	0.23	0.56
73	<i>Cuphea procumbens</i>	12	1	4.00	0.28	0.00	0.040	12.00	0.22	0.53
74	<i>Lepidagathis incurva</i>	12	1	4.00	0.28	0.00	0.040	12.00	0.22	0.53
75	<i>Ichnocarpus frutiscens</i>	12	1	4.00	0.28	0.00	0.040	12.00	0.22	0.53
76	<i>Hyptis capitata</i> Jacq.	10	1	4.00	0.28	0.00	0.034	10.00	0.18	0.49
77	<i>Citrus</i> sp	5	1	4.00	0.28	0.00	0.017	5.00	0.09	0.39
78	<i>Scoparia dulcis</i> L.	5	1	4.00	0.28	0.00	0.017	5.00	0.09	0.39
79	<i>Litsea monopetala</i>	4	1	4.00	0.28	0.00	0.013	4.00	0.07	0.36
80	<i>Schima wallichii</i> Choisy	4	1	4.00	0.28	0.00	0.013	4.00	0.07	0.36
81	<i>Melastoma malabathricum</i> L.	3	1	4.00	0.28	0.00	0.010	3.00	0.05	0.34
82	<i>Shorea robusta</i> Gaertn.	3	1	4.00	0.28	0.00	0.010	3.00	0.05	0.34
83	<i>Streblus asper</i>	3	1	4.00	0.28	0.00	0.010	3.00	0.05	0.34
84	<i>Coffea benghalensis</i> B. Heyne ex Schult.	2	1	4.00	0.28	0.00	0.007	2.00	0.04	0.32
85	<i>Lagerstroemia hirsuta</i>	2	1	4.00	0.28	0.00	0.007	2.00	0.04	0.32
86	<i>Morinda angustifolia</i> Roxb.	2	1	4.00	0.28	0.00	0.007	2.00	0.04	0.32
87	<i>Persicaria hydropiper</i> (L.) Delarbre	2	1	4.00	0.28	0.00	0.007	2.00	0.04	0.32
88	<i>Alstonia scholaris</i> (L.) R. Br.	1	1	4.00	0.28	0.00	0.003	1.00	0.02	0.30
89	<i>Heliotropium indicum</i> L.	1	1	4.00	0.28	0.00	0.003	1.00	0.02	0.30
90	<i>Premna bengalensis</i>	1	1	4.00	0.28	0.00	0.003	1.00	0.02	0.30
91	<i>Terminalia myriocarpa</i> Van Heurck & Müll. Arg.	1	1	4.00	0.28	0.00	0.003	1.00	0.02	0.30
92	<i>Zizyphus</i> sp	1	1	4.00	0.28	0.00	0.003	1.00	0.02	0.30
NI= Number of Individuals, O= Occurance, F= Frequency, RF=Relative Frequency, D/sq m=Density per sq metre, RD=Relative Density, A=Abundance, RA= Relative Abundance, IVI= Importance Value Index, SDI= Simpson's Diversity Index										

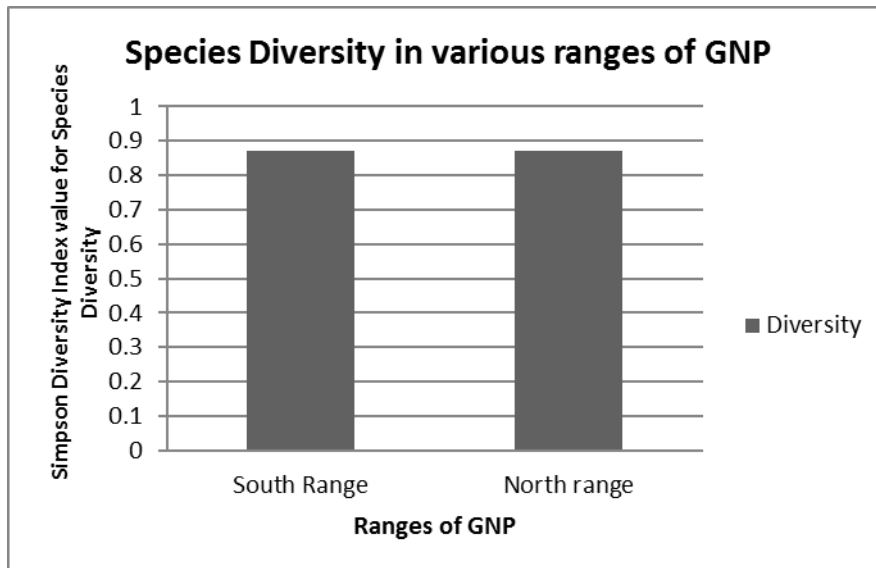


Figure 30: Comparison of species diversity in different Ranges in GNP

ii) Analysis of the vegetation data of Natural Grassland plots:

In Gorumara NP, vegetation data also collected in 3 natural grasslands in 2 different Ranges. These data were further statistically analysis and arranged in separate groups like grass fodders, weeds and other species. Total 27 species found from the 3 quadrates out of which 8 species belongs to grass fodders and sedge species, 7 species to weeds and rest of the plants in other species.

The highest IVI value (97.89) was recorded in *Axonopus compressus* which belongs to the grass species followed by *Imperata cylindrica* with IVI value of 62.65.

The density of the grass species was calculated to be 88% whereas the density of the weeds was around 4%.

Among the weed species highest IVI value observed in *Mimosa pudica* (IVI= 8.75) followed by *Chromolaena odorata* (IVI=8.52).

Simpson Diversity Index for Species diversity was calculated to be 0.68 in Natural Grassland in Gorumara NP.

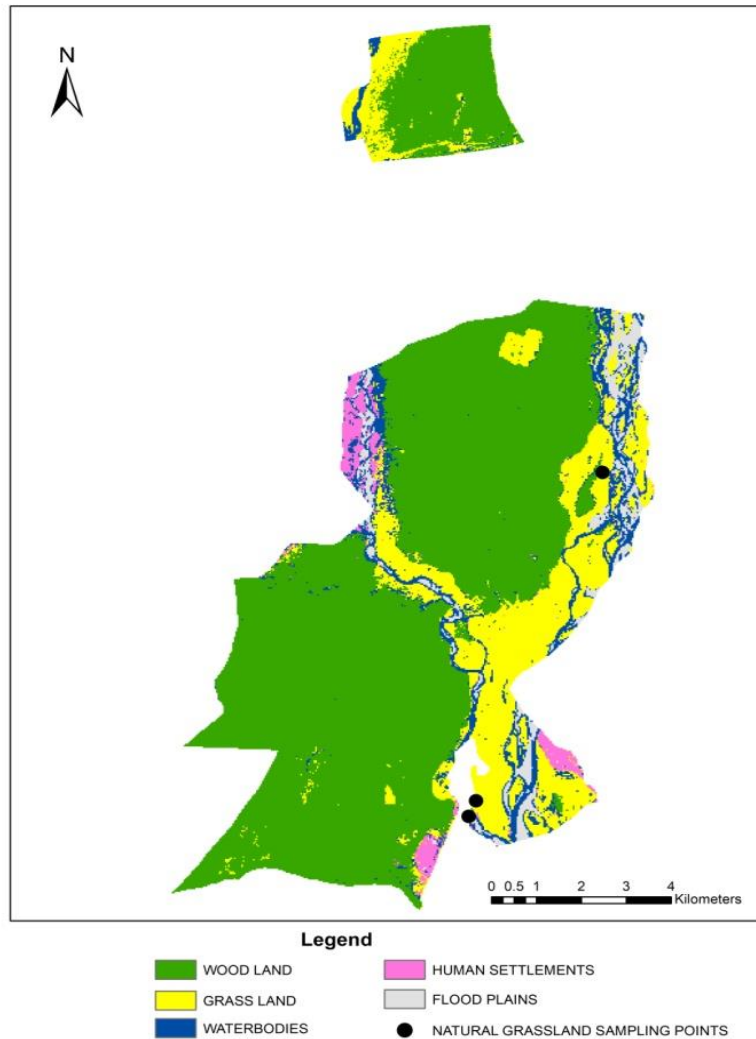


Figure 31: Natural Grassland Quadrates in Gorumara NP

Table 40: Statistical analysis of all plant species recorded in Natural Grass land in Gorumara NP

Sl. No.	Class	Species	Family	NI	O	F %	RF %	D/sq.m.	RD %	A	RA %	IVI	SDI
1	Grass fodders	<i>Axonopus compressus</i> (Sw.) P. Beauv.	Poaceae	6060	2	66.67	4.65	20.20	45.24	3030.00	48.00	97.89	0.68
2		<i>Imperata cylindrica</i> (L.) Raeusch.	Poaceae	4368	3	100.00	6.98	14.56	32.61	1456.00	23.07	62.65	
3		<i>Saccharum spontaneum</i> L.	Poaceae	685	3	100.00	6.98	2.28	5.11	228.33	3.62	15.71	
4		<i>Saccharum sp</i>	Poaceae	500	1	33.33	2.33	1.67	3.73	500.00	7.92	13.98	
5		<i>Cyperus sp</i>	Cyperaceae	130	1	33.33	2.33	0.43	0.97	130.00	2.06	5.36	
6		<i>Arundo donax</i> L.	Poaceae	39	2	66.67	4.65	0.13	0.29	19.50	0.31	5.25	
7		<i>Themeda arundinacea</i> (Roxburgh) Ridley	Poaceae	5	1	33.33	2.33	0.02	0.04	5.00	0.08	2.44	
8		<i>Saccharum narenga</i> (Nees ex Steud.) Hack.	Poaceae	1	1	33.33	2.33	0.00	0.01	1.00	0.02	2.35	
9	Weeds	<i>Mimosa pudica</i> L.	Fabaceae	139	3	100.00	6.98	0.46	1.04	46.33	0.73	8.75	8.52
10		<i>Chromolaena odorata</i> (L.) R.M. King & H. Rob.	Asteraceae	121	3	100.00	6.98	0.40	0.90	40.33	0.64	8.52	

11		<i>Triumfetta rhomboidea</i> Jacq.	Malvaceae	95	3	100.00	6.98	0.32	0.71	31.67	0.50	8.19
12		<i>Ageratum conyzoides</i> (L.) L.	Asteraceae	114	2	66.67	4.65	0.38	0.85	57.00	0.90	6.41
13		<i>Cassia occidentalis</i>	Fabaceae	68	1	33.33	2.33	0.23	0.51	68.00	1.08	3.91
14		<i>Ziziphus jujuba</i> Mill.	Rhamnaceae	15	1	33.33	2.33	0.05	0.11	15.00	0.24	2.68
15		<i>Leea asiatica</i>	Vitaceae	12	1	33.33	2.33	0.04	0.09	12.00	0.19	2.61
16	Other species	<i>Borreria alata</i>	Rubiaceae	501	3	100.00	6.98	1.67	3.74	167.00	2.65	13.36
17		<i>Hyptis suaveolens</i>	Lamiaceae	72	2	66.67	4.65	0.24	0.54	36.00	0.57	5.76
18		<i>Leguminoase Stylosanthes</i>	Fabaceae	93	1	33.33	2.33	0.31	0.69	93.00	1.47	4.49
19		<i>Acmela uliginosa</i>	Asteraceae	83	1	33.33	2.33	0.28	0.62	83.00	1.31	4.26
20		<i>Stylosanthes sp</i>	Fabaceae	69	1	33.33	2.33	0.23	0.52	69.00	1.09	3.93
21		<i>Phyllanthus sp</i>	Phyllanthaceae	62	1	33.33	2.33	0.21	0.46	62.00	0.98	3.77
22		<i>Ludwigia sp</i>	Onagraceae	49	1	33.33	2.33	0.16	0.37	49.00	0.78	3.47
23		<i>Cuphea procumbens</i>	Lythraceae	38	1	33.33	2.33	0.13	0.28	38.00	0.60	3.21
24		<i>Desmodium laxiflorum</i> DC.	Fabaceae	30	1	33.33	2.33	0.10	0.22	30.00	0.48	3.02
25		<i>Hyptis capitata</i>	Lamiaceae	22	1	33.33	2.33	0.07	0.16	22.00	0.35	2.84
26		<i>Ludwigia perennis</i> L.	Onagraceae	20	1	33.33	2.33	0.07	0.15	20.00	0.32	2.79
27		<i>Mallotus nudiflorus</i>	Euphorbiaceae	3	1	33.33	2.33	0.01	0.02	3.00	0.05	2.40

NI= Number of Individuals, O= Occurance, F= Frequency, RF=Relative Frequency, D/sq m=Density per sq metre, RD=Relative Density, A=Abundance, RA= Relative Abundance, IVI= Importance Value Index, SDI= Simpson's Diversity Index

Findings:

In Gorumara NP, studies were carried out in 33 quadrates in 31 management plots of the Forest Department in post monsoon season only.

As per plantation journals the Forest Department had identified and chosen 17 species of fodder grasses (Annexure: 1) for plantation in the management plots. However, in field it was observed a maximum of 4 species and a minimum of 1 species in the different managed plots.

It was observed that in almost all the managed plots where Dhadda and Chepti were planted they were recorded to be also present in our documentation. However, Madhua and Malsa which were planted in 18 to 26 managed plots, their occurrence was found only in 13 to 12 plots respectively in our study.

It was also noted that increase in the percentage of Natural grass (*Saccharum spontaneum*, *Imperata cylindrica*, *Oplismenus burmannii* & *Axonopus compressus*) decreased the intrusion of Weeds (*Lantana camara*, *Mikania micrantha*, *Leea asiatica*, *Chromolaena odorata*, *Clerodendrum infortunatum*) and vice versa.

Occupancy percentage of Planted species was high in Gorumara South range (37%) than Gorumara North Range (29%). In fact, the planted species percentage is the highest among the four categories in South Range.

It was seen that occupancy percentage of Weed species in North Range is higher than the South Range. Weed species occupied about 32% of area in North Range recording the highest among the four categories of plants.

In a total evaluation in Gorumara NP the cover percentage for planted species is around 32.96%; natural grass, fodder & sedge species – 24.01%; harmful weeds – 26.42% and other species occupies 16.63% of the area (Figure: 29).

Natural Grass species shows high IVI values in all the Ranges. Among natural grasses *Oplismenus burmannii*, *Imperata cylindrica* and *Axonopus compressus* were the grass species with high IVI in most cases.

Among the weed species, *Mikania micrantha*, *Chromolaena odorata*, *Ageratum conyzoides* and *Mimosa pudica* were denser than the other weed species.

Species diversity for the managed plots were same in both the ranges with SDI= 0.87, while in natural grassland it was calculated to be 0.68.

It is seen that in natural grassland the effects of weeds are minimum as the population density of the weeds in natural grassland quadrates were only 4.24% where as in the managed grassland the density varied from 12.77% to 17.25%.

It was seen that the population density of grass species in natural grassland was higher (88%) than the managed plots in various ranges (42% to 75%).

5.5. Habitat use by animals

Results:

Herbivores habitat utilisation:

- *Rhino:*

The latest Rhino census of 2019 revealed, there are 50 Rhinos available in the Park. Through this year Rhinos were sighted 11791 times in different habitats by the Forest Department staffs. The highest number of sightings took place in Budhram Beat followed by Gorumara Beat of South Range of the Park. The main reason the rhinos concentrated in these beats were the availability of fodder, as these beats has a good amount of natural as well as wet alluvial grasslands (Table: 41)

In the correlation graph between rhino sightings and grassland percentage (Figure: 33) in each beat shows a quite positive result ($R = 0.170$).

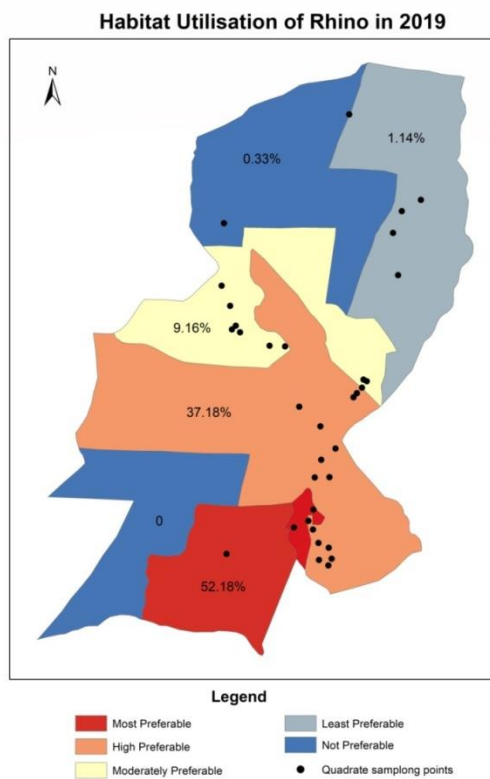


Figure 32: Habitat Utilisation map of Rhino during 2019

Table 41: Beat wise Rhino sighting with percentage of grassland in the beat

Sl no.	Beats	Sightings (%)	Grasslands (%)
1	Bichabhanga	0	0.94
2	Budhram with Ramsai Ext	52.18	11.46
3	Dhupjhora	9.16	21.40
4	Gorumara	37.18	27.32
5	Khunia	1.14	32.10
6	Murti	0.33	2.48

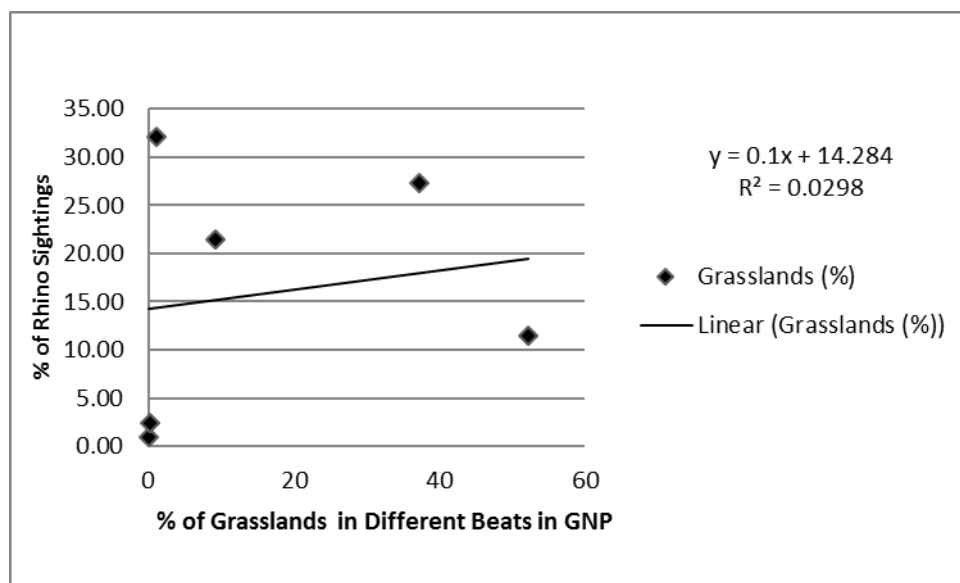


Figure 33: Correlation between grassland and rhino sightings

- *Gaur:*

Similarly, gaur was sighted in 2019 by the Department Staffs 32236 times in different habitat throughout the Park. Data provided by the Forest department shows that the above 42% and 30% Gaur sightings were from Budhram and Gorumara Beat of South Range respectively (Table: 42).

The correlation graph between Gaur sightings and grassland percentage (Figure: 35) in each beat also shows a positive result ($R = 0.216$).

Habitat Utilisation of Gaur in 2019

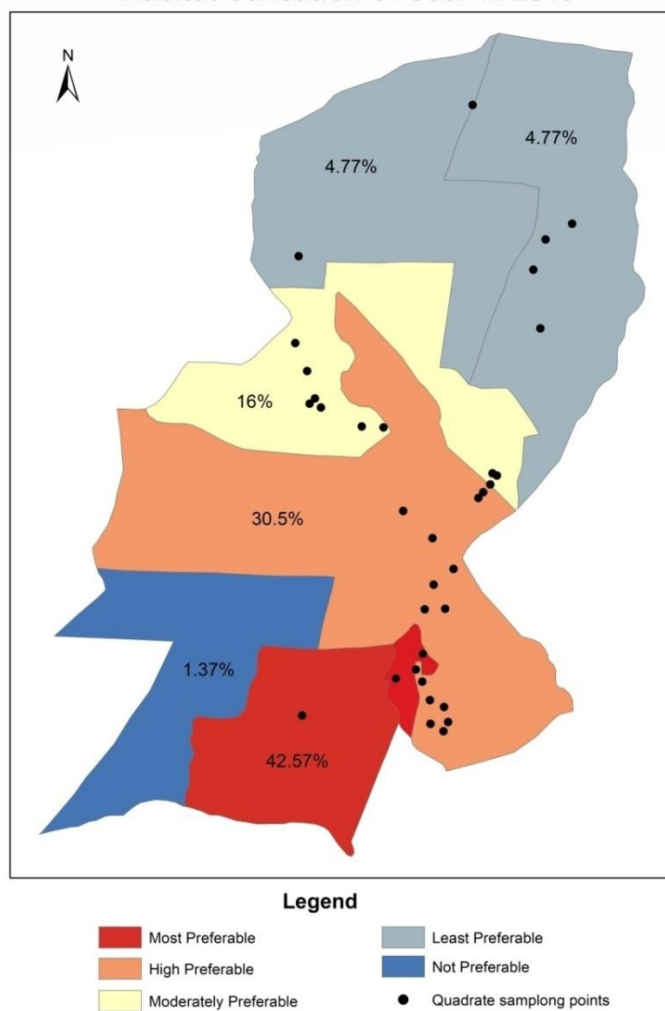


Figure 34: Habitat Utilisation map of Gaur during 2019

Table 42: Beat wise Gaur sighting with percentage of grassland in the beat

Sl no.	Beats	Sightings (%)	Grasslands (%)
1	Bichabhanga	1.37	0.94
2	Budhram with Ramsai Ext	42.58	11.46
3	Dhupjhora	16.00	21.40
4	Gorumara	30.50	27.32
5	Khunia	4.77	32.10
6	Murti	4.77	2.48

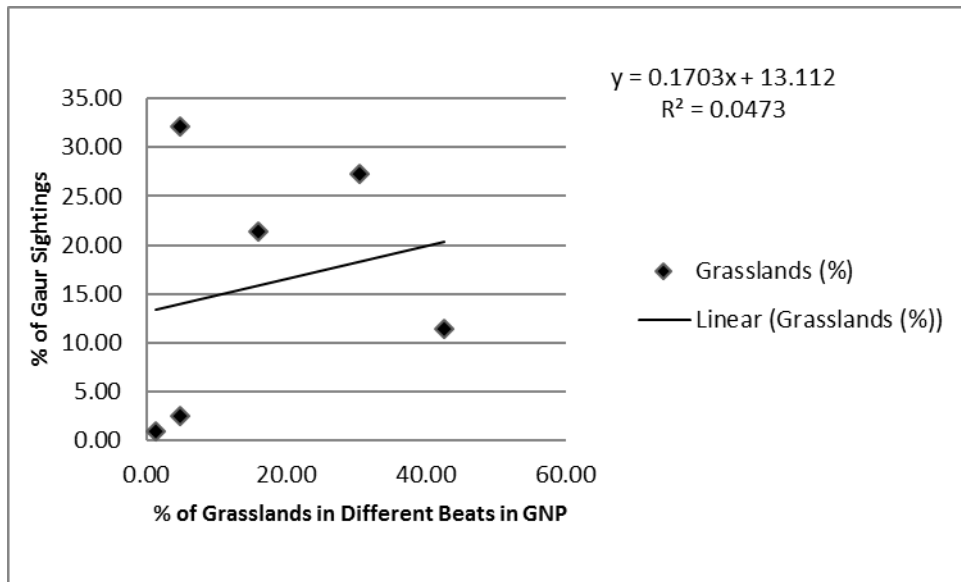


Figure 35: Correlation between grassland and Gaur sightings

Findings:

Most utilized habitat zone for both the Rhino and Gaur was Budhram with Ramsai Ext followed by Gorumara Beat of the South Range.

Almost 90% of the total Rhino sightings and 70% of total Gaur sightings in 2019 were recorded from these two beats.

Both the species shows a positive correlation between sightings and the percentage of grassland area.

The analysis reveals that habitat utilization pattern of both the Rhino and Gaur varies according to the availability of the grassland area within the Park.

5.6. Herbivores feeding behaviour observations

Results:

The feeding and foraging observations were carried out for around 59 hours mainly in the North Range and South range in Gorumara NP, mostly from the watchtowers and by car and elephants back also (Figure: 36). On direct observation a total of 22 plant species was observed to be eaten by the Rhino, Gaur, Sambar, Spotted Deer, other deer species and Elephant. Out of these 7 species were consumed by Rhino, 10 species by Gaur, 12 species by Elephant and 9 species by Spotted deer and only one species each by Sambar and Barking deer (Table: 43). These 22 plant species were recorded during the present study out of more than 50 plant species recorded earlier.

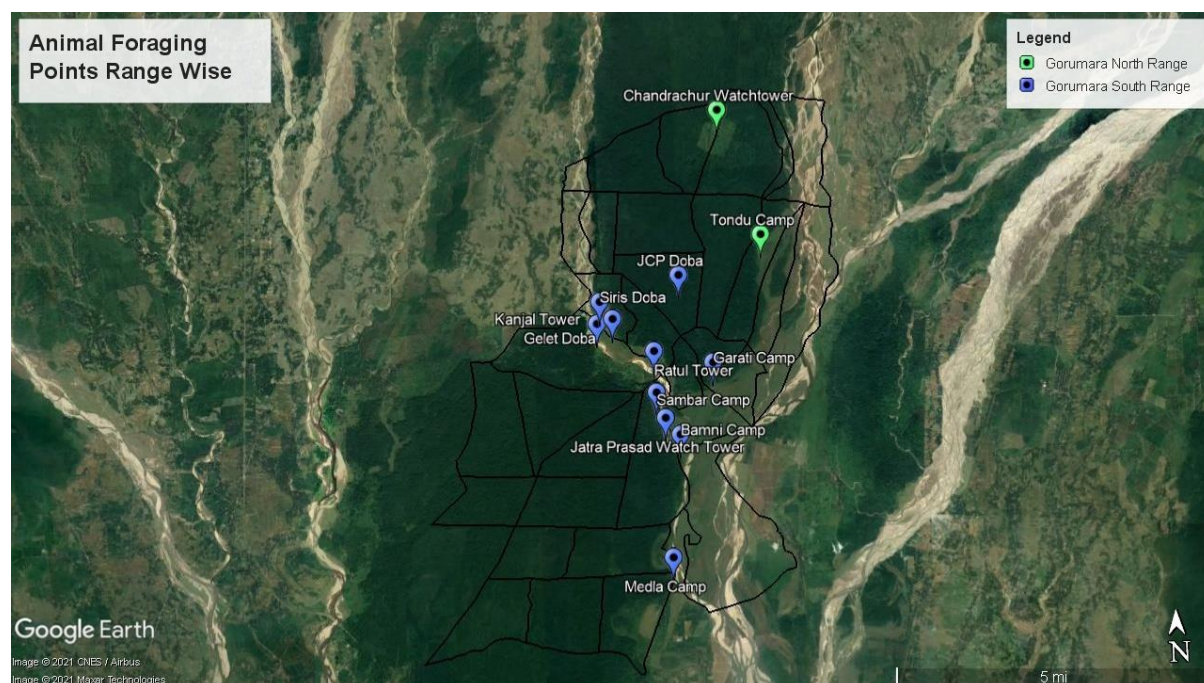


Figure 36: Range wise Herbivores foraging observation points

Table 43: Plant species observed consumed by herbivores in GNP

Sl no.	Scientific Names	Family	Local Name	Eaten by					
				Rhino	Gaur	Sambar	Spotted deer	Barking deer	Elephant
1	<i>Alpina nigra</i>	Zingiberaceae	Purundi		Gaur				Elephant
2	<i>Axonopus compresus</i>	Poaceae	Chapta Ghas/ Chhoto chepti	Rhino	Gaur		Spotted deer		

3	<i>Lantana camara</i>	Verbenaceae	Putus						Elephant
4	<i>Mikania micrantha</i>	Asteraceae	Larong, Mekani		Gaur		Spotted deer		Elephant
5	<i>Saccharum narenga</i>	Poaceae	Dhadda	Rhino	Gaur				Elephant
6	<i>Saccharum spontaneum</i>	Poaceae	Kasia						Elephant
7	<i>Themeda arundinacea</i>	Poaceae	Chepti	Rhino	Gaur				Elephant
8	<i>Saccharum longisetosum</i>	Poaceae	Malsa	Rhino	Gaur	Sambar	Spotted deer		Elephant
9	<i>Mallotus polycarpus</i>	Euphorbiaceae	Pithali Fruits					Barking deer	
10	<i>Saccharum arundinaceum</i>	Poaceae	Madhua		Gaur				Elephant
11	<i>Bambusa sp</i>	Poaceae	Bamboo						Elephant
12	<i>Echinocloa crass galli</i>	Poaceae			Gaur				Elephant
13			Siru ghass						Elephant
14	<i>Eragrostis tenella</i>	Poaceae					Spotted deer		
15	<i>Eleusine indica</i>	Poaceae			Gaur		Spotted deer		
16	<i>Dactyloctenium sp.</i>	Poaceae					Spotted deer		
17	<i>Mitracarpus hirtus</i>	Rubiaceae					Spotted deer		
18	<i>Cuphea sp.</i>	Lythraceae			Gaur		Spotted deer		
19	<i>Ipomea sp.</i>	Convolvulaceae		Rhino			Spotted deer		
20	<i>Flemingia sp.</i>	Fabaceae							Elephant
21	<i>Chromolaena odorata</i>	Asteraceae		Rhino					
22	<i>Spermacoce alata</i>	Rubiaceae		Rhino					

- *Rhino:*

During our study period, the feeding of Rhino was encountered 16 times (considered only when it was consuming) in which 7 times they were seen feeding on Choto chepti (*Axonopus compresus*) specially the new shoots and 5 times Chepti grass (*Themeda arundinacea*) and 4 times Dhadda (*Saccharum narenga*). Very interestingly *Chromolaena odorata* were seen to be fed upon 3 times (Figure: 37). From the direct observation it was noticed that the Rhinos prefer grasses in general, as out of 16 encounters, 74% of encounters were with the plants from Poaceae family and the remaining 26% were from other families (Figure: 38).

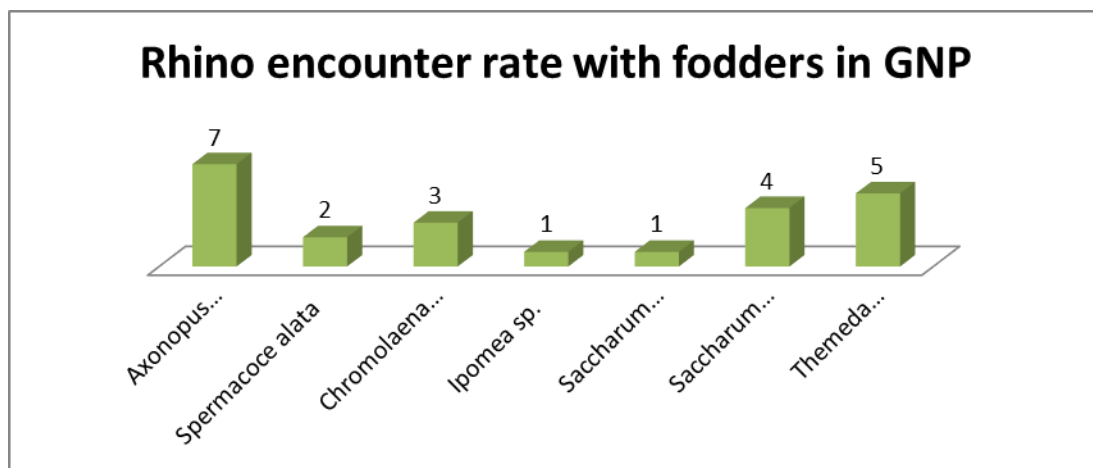


Figure 37: Rhino encounter rate with fodders in GNP

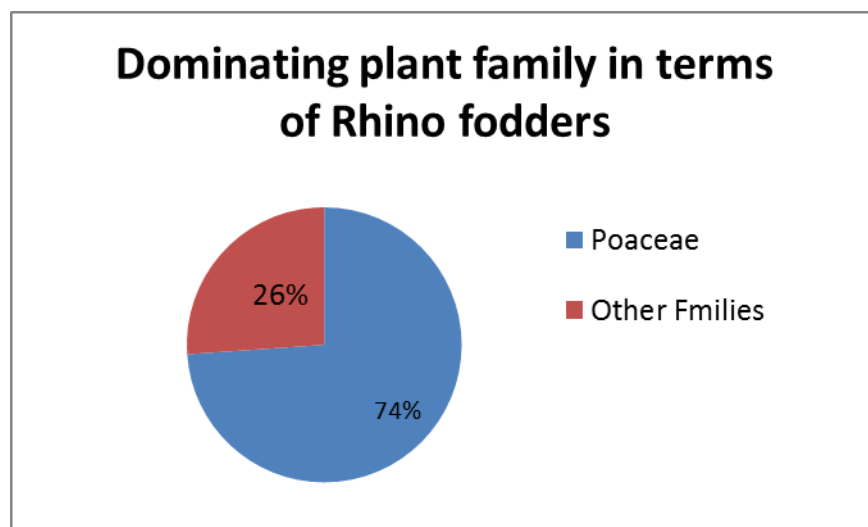


Figure 38: Grasses are dominating in terms of Rhino fodders in GNP

Table 44: Families of Rhino-fodders and their numerical representation at the species

SL no.	Families	Number of Plants
1	Asteraceae	1
2	Convolvulaceae	1
3	Poaceae	4
4	Rubiaceae	1
	TOTAL	7

- *Gaur*:

Similarly, Gaur was encountered while feeding 36 times, in which 17 times they were seen eating *Themeda arundinacea* (Chepti) specially the new shoots and followed by *Axonopus compresus* (Choto chepti), *Saccharum narenga* (Dhadda) and *Saccharum longisetosum* 12, 10 and 9 times respectively. They also were seen eating *Mikania micrantha* 7 times (Figure: 39). From the direct observation it was noticed that the Gaur also prefer grasses in general like Rhinos and out of 36 encounters, 84% of encounters were with the plants from Poaceae family and the remaining 16% were from other families (Figure: 40).

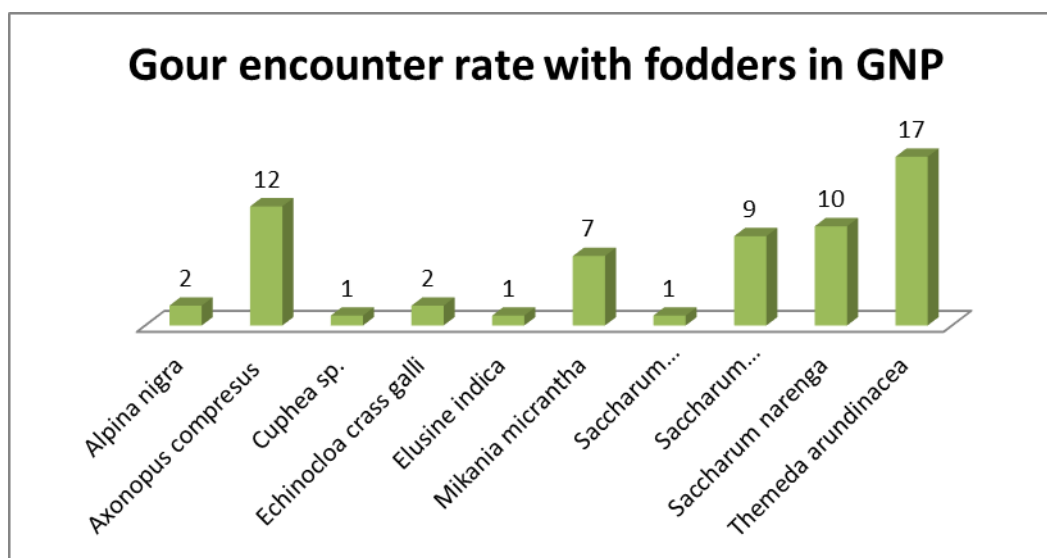


Figure 39: Gour encounter rate with fodders in GNP

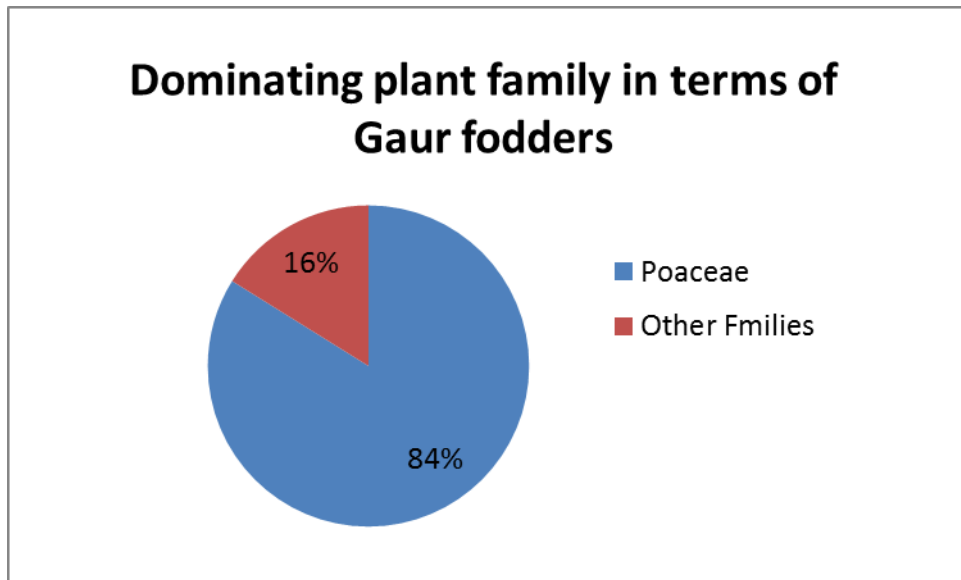


Figure 40: Grasses are dominating in terms of Gaur fodders in GNP

Table 45: Families of Gaur-fodders and their numerical representation at the species

SL no.	Families	Number of Plants
1	Poaceae	7
2	Asteraceae	1
3	Lythraceae	1
4	Zingiberaceae	1
	TOTAL	10

- *Elephant:*

Elephant was encountered 11 times in which 7 times they were seen eating *Saccharum narenga* (Dhadda) followed by *Themeda arundinacea* (Chepti) 4 times. They also were seen eating *Mikania micrantha* and *Lantana camara* once or twice only (Figure: 41). Just like the other mega herbivores in GNP, Elephants were also seen here to prefer grasses than other species. Like Rhinos and Gaur, out of 11 encounters, 75% of encounters were with the plants from Poaceae family and the remaining 25% were from other families (Figure: 42).

Elephant encounter rate with fodders in GNP

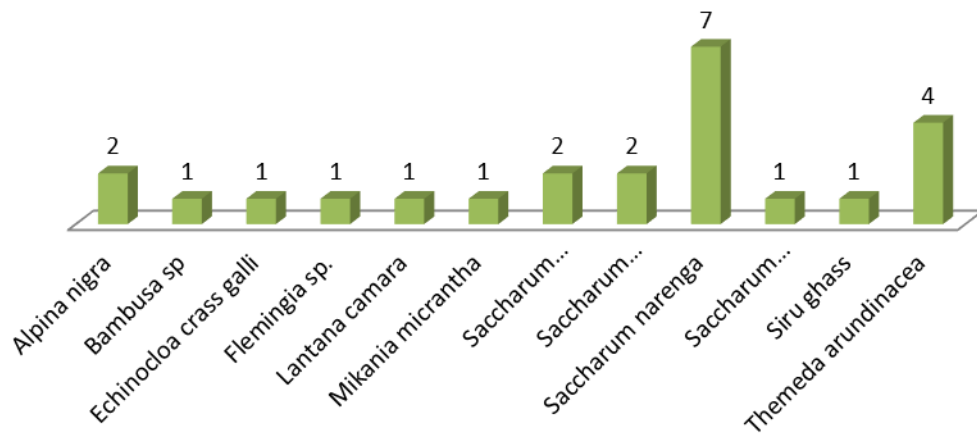


Figure 41: Elephant encounter rate with fodders in GNP

Dominating plant family in terms of Elephant fodders

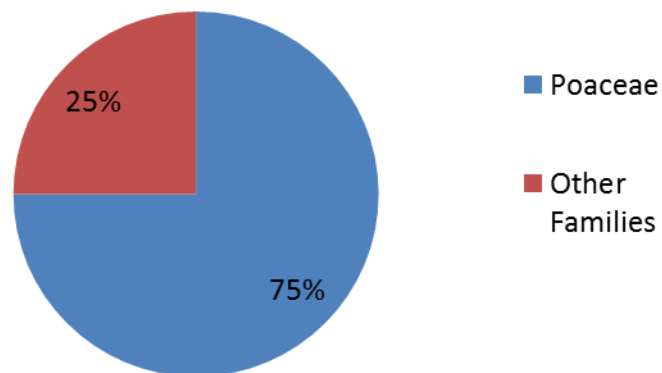


Figure 42: Grasses are dominating in terms of Elephant fodders in GNP

Table 46: Families of Elephant-fodders and their numerical representation at the species and variety level

SL no.	Families	Number of Plants
1	Poaceae	7
2	Asteraceae	1
3	Fabaceae	1
4	Verbenaceae	1
5	Zingiberaceae	1
6	Unknown	1
	TOTAL	12

- *Deer species:*

Spotted deer was encountered 16 times in which 11 times they were seen eating the new shoots of *Themeda arundinacea*. They also were recorded eating *Mikania micrantha* twice. Sambar and barking deer encountered one time each.

In same manner it was observed that Poaceae occupied 68% out of 18 encountered of different Deer species.

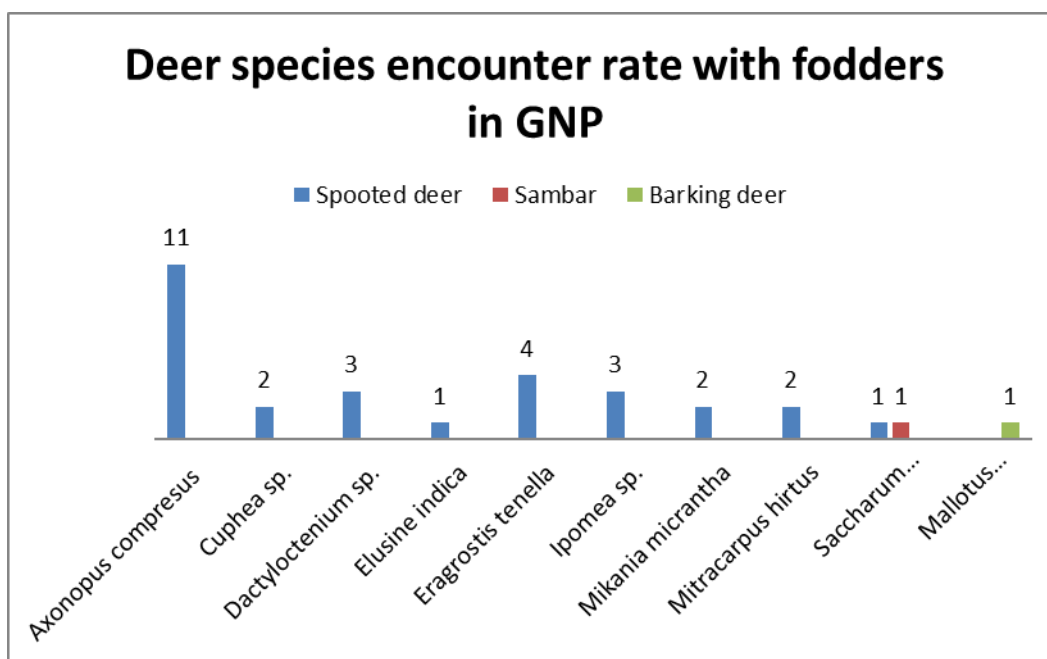


Figure 43: Encounter rate of different Deer species with fodders in GNP

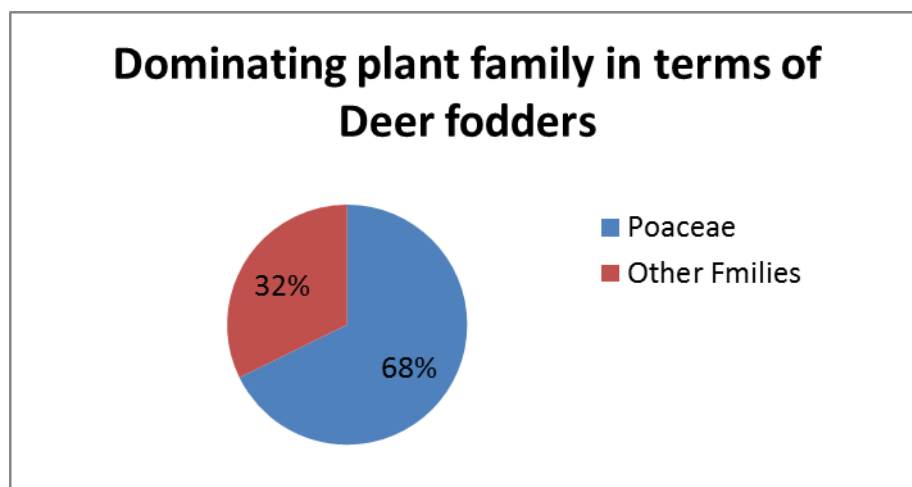


Figure 44: Grasses are dominating in terms of Deer fodders in GNP

Table 47: Families of Deer-fodders and their numerical representation at the species and variety level

SL no.	Families	Number of Plants
1	Poaceae	5
2	Convolvulaceae	1
3	Lythraceae	1
4	Asteraceae	1
5	Rubiaceae	1
6	Euphorbiaceae	1
	TOTAL	10

Findings:

Total 22 species was recorded while consumed by the herbivores like Rhino, Gaur, Sambar, Elephant, Barking deer and Spotted deer.

Out of these 22 species Rhino was observed to consume 7 species, Gaur 10 species, Elephant 12 species and all the deer species consumed 10 plant species.

Poaceae family (Grass species) was the dominating family in terms of the fodders for all the herbivores like Rhino, Gaur, Elephant and all deer species.

Mikania micrantha, which is considered as a weed, was observed to be consuming by Gaur, Elephant and Spotted deer. Surprisingly, *Lantana camara* was also observed browsing by elephant.

5.7. Assessment of Above Ground Biomass (AGB)

Results:

16 sites from GNP were chosen for grass collection. The sites were so chosen that at least one plot from each beat was represented. Two natural plots were randomly selected each in Gorumara South and North Range (Figure: 45).

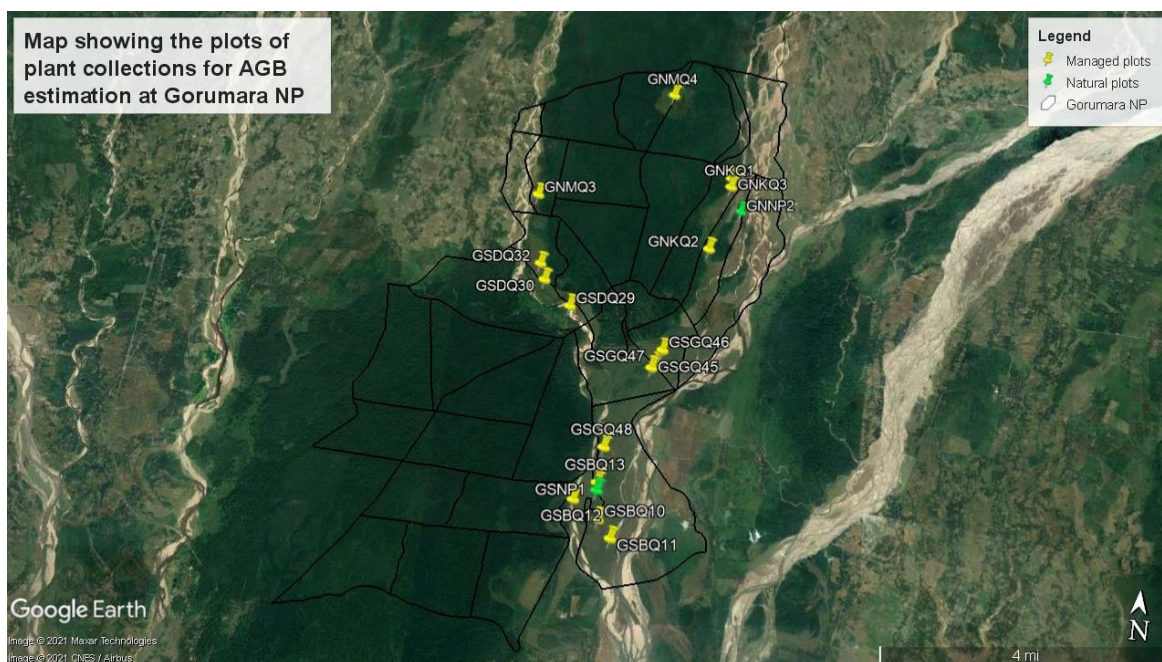


Figure 45: AGB collection points in Gorumara NP

a. For Planted Species:

Table 48: Above Ground Biomass values of planted species in at Gorumara NP

Gorumara Managed Plots panted species	Dhadda (<i>Sachhrum narenga</i>) (kg/m ²)	Chepti (<i>Themeda arundinacea</i>) (kg/m ²)	Malsa (<i>Saccharum longisetosum var. longisetosum</i>) (kg/m ²)	Madhua (<i>Saccharum arundinaceum</i>) (kg/m ²)	Purundi (<i>Alpinia nigra</i>) (kg/m ²)	Plot wise biomass value (kg/m ²)	Mean value (kg/m ²)
GSBQ11	1.231	0.548	0.000	0.305	0.000	2.083	0.130
GSBQ13	1.547	1.206	0.000	0.000	0.000	2.753	0.172
GSDQ30	0.000	0.324	0.000	0.000	0.000	0.324	0.020
GSDQ32	2.000	0.000	0.083	0.281	0.000	2.365	0.148
GSGQ45	0.000	0.697	0.000	0.124	0.000	0.821	0.051

GSGQ46	1.451	0.404	0.000	0.178	0.000	2.033	0.127
GSGQ48	1.910	0.826	0.000	0.000	0.000	2.736	0.171
GNKQ1	1.333	0.359	0.000	0.000	0.000	1.693	0.106
GNKQ2	1.333	0.567	0.042	0.000	0.000	1.943	0.121
GNMQ3	1.030	0.635	0.000	0.168	0.000	1.833	0.115
GNKQ3	0.000	0.009	0.000	0.000	0.000	0.009	0.001
GSGQ47	0.022	0.000	0.000	0.000	0.000	0.022	0.001
GSDQ29	0.000	0.000	0.176	0.000	0.000	0.176	0.011
GSBQ10	1.734	0.000	0.000	0.000	0.000	1.734	0.108
GNMQ4	0.000	0.000	0.000	0.000	0.06	0.060	0.004
GSBQ12	0.376	0.000	0.000	0.000	0.000	0.376	0.024
Species wise biomass value	13.967	5.576	0.302	1.055	0.060	20.960	
Mean Value	0.873	0.349	0.019	0.066	0.004		1.3100

Estimated Biomass for planted species = 1.31 kg/m⁻² or 13100 kg/ha

Calculating of forage:

After determining annual forage production/ha (plant biomass) of planted species, using Voelkel's estimation method, the total annual forage produced by planted species in the management area must be calculated by following formula:

$$\text{Available area for grazing} \times \text{Forage production/ha} = \text{Total forage/year}$$

Total grassland area available in Gorumara is around 10sq km (Anon, 2007a; page 54) out of which around 700 ha is managed (data acquired from plantation journals area records after 2013, as the regeneration of fodder plantation can be done after 5-6 years in a degraded land in Gorumara.

So, total forage in the management plot for the planted species for the year would be:

$$800 \times 13100 \text{ kg/ha} = 10480000 \text{ kg/year}$$

According to Voelkel *et al.*, 2018, only 25% of the total forage production is utilized by grazers. Therefore, consumable forage would be produced, as follows for the managed grassland available for grazing in Park:

$$\text{Total forage/year} \times 0.25 = \text{Consumable forage/year}$$

$$10480000 \times 0.25 = 2620000 \text{ kg/ year}$$

There are also areas in forest land that herbivores do not graze, such as heavy brush, weeds, other non-fodder species etc. To reduce the risk of overgrazing, these areas were removed from the calculation. In this case, from our vegetation occupancy percentage value it was estimated that planted species occupy 32.96% or say 33% area for managed area. Therefore, we have taken consideration for this calculation which is 33% (Figure: 29) only for planted species in Gorumara NP.

Therefore, the available forage would be determined as follows:

$$\text{Consumable forage} \times \% \text{ Grazeable areas} = \text{Available forage kg /year}$$

$$2620000 \text{ kg/ year} \times 0.33 = 864600 \text{ Kg/year}$$

b. For Naturally growing grass fodder species in managed plots:

Table 49: Above Ground Biomass values of naturally growing fodder grass species in managed plots at Gorumara NP

Gorumara Managed Plots natural growing species	Thach/ Shon (<i>Imperata cylindrica</i>) (kg/m ²)	Nol (<i>Arundo donax</i>) (kg/m ²)	Choto chepti/ Chapta (<i>Axonopus compresus</i>) (kg/m ²)	<i>Echinochloa colona</i> (kg/m ²)	Kasia (<i>Saccharum spontaneum</i>) (kg/m ²)	<i>Echinochloa crus galli</i> (kg/m ²)	<i>Eragrostis sp.</i> (kg/m ²)	Plot wise biomass value (kg/m ²)	Mean value (kg/m ²)
GSBQ11	0.000	1.105	0	0	0	0	0	1.105	0.069
GSBQ13	0.055	1.227	0	0	0	0	0	1.282	0.080
GSDQ30	0.036	0.549	0	0	0	0	0	0.585	0.037
GSDQ32	0.000	0.650	0	0	0	0	0	0.650	0.041
GSGQ45	0.000	0.927	0	0	0	0	0	0.927	0.058
GSGQ46	0.037	0.000	0	0	0	0	0	0.037	0.002
GSGQ48	0.048	0.837	0	0	0	0	0	0.885	0.055
GNKQ1	0.036	0.471	0	0	0	0	0	0.507	0.032
GNKQ2	0.048	0.720	0	0	0	0	0	0.767	0.048
GNMQ3	0.042	0.000	0	0	0	0	0	0.042	0.003
GNKQ3	0.005	0.000	0.010	0	0	0	0	0.015	0.001
GSGQ47	0.008	0.000	0	0.046	0.002	0	0	0.056	0.004
GSDQ29	0.000	0.000	0.026	0	0	0.02	0.018	0.064	0.004

GSBQ10	0.018	0.000	0	0	0	0.008	0	0.026	0.002
GNMQ4	0.000	0.000	0.014	0	0	0.16	0	0.174	0.011
GSBQ12	0.006	0.000	0	0	0	0.056	0	0.062	0.004
Species wise biomass value	0.339	6.486	0.05029	0.046	0.002	0.244	0.018	7.186	
Mean Value	0.021	0.405	0.003	0.003	0.000	0.015	0.001		0.44910

Estimated Biomass for naturally growing fodder grass species in managed plots = 0.4491 kg/m^{-2}
or $4491 \text{ kg/ha} \approx 4500 \text{ kg/ha}$

Calculating of forage:

After determining annual forage production/ha (plant biomass) of natural grass species in managed area, using Voelkel's estimation method, the total annual forage produced by natural grass species in the management area must be calculated by following formula:

$$\text{Available area for grazing} \times \text{Forage production/ha} = \text{Total forage/year}$$

Similarly, this area will be also 800 ha as this is the calculation for natural grass species occurring in managed zone.

So, total forage in the management plot for the natural grass species for the year would be:

$$800 \times 4500 \text{ kg/ha} = 3600000 \text{ kg/year}$$

If only 25% of the total forage production of natural grass species in managed plots is utilized by grazers, consumable forage would be produced, as follows for the managed grassland available for grazing in Park:

$$\text{Total forage/year} \times 0.25 = \text{Consumable forage/year}$$

$$3600000 \times 0.25 = 900000 \text{ kg/ year}$$

There are also areas in forest land that herbivores do not graze such as heavy brush, weeds, other non-fodder species etc. To reduce the risk of overgrazing, these areas were removed from the calculation. In this case, from our vegetation occupancy percentage value it was estimated that natural grass fodder and sedge species occupy only 24.01% only in managed area. Therefore, we have taken consideration for this calculation which is 24% (Figure: 29) only for naturally growing grass fodder and sedge species in Gorumara NP.

Therefore, the available forage would be determined as follows:

$$\text{Consumable forage} \times \% \text{ Grazeable areas} = \text{Available forage kg /year}$$

$$900000 \text{ kg/ year} \times 0.24 = 216000 \text{ Kg/year}$$

c. For natural grasslands:

Table 50: Above Ground Biomass values of natural species in natural grassland plots at Jaldapara NP

Gorumara Natural plots	Dhadda (<i>Sachhrum narenga</i>) (kg/m ⁻²)	Thach/ Shon (<i>Imperata cylindrica</i>) (kg/m ⁻²)	Nol (<i>Arundo donax</i>) (kg/m ⁻²)	Plot wise Biomass (kg/m ⁻²)	Mean Value (kg/m ⁻²)
Natural plot 1 (GSP1)	2.722	0.047	1.014	3.784	1.892
Natural plot 2 (GSP2)	0	0	0	0	0
Species wise biomass value	2.722	0.047	1.014	3.784	
Mean Value	1.361	0.024	0.507		1.892

Estimated Biomass for grass species in natural grasslands = 1.892 kg/m⁻² or 18920 kg/ha ≈ 19000 kg/ha

Calculating of forage:

After determining annual forage production/ha (plant biomass) of natural grass land area, using Voelkel's estimation method, the total annual forage produced in the natural grassland area must be calculated by following formula:

$$\text{Available area for grazing} \times \text{Forage production/ha} = \text{Total forage/year}$$

If the total natural grassland area in Gorumara is 10% sq km of the total area (Anon, 2007a) approximately and the natural grassland area will be 811 ha approximately.

So, total forage in the natural grasslands for the year would be:

$$811 \times 19000 \text{ kg/ha} = 15409000 \text{ kg/year}$$

If only 25% of the total forage production of grass species is utilized by grazers, consumable forage would be produced, as follows for the natural grassland available for grazing in Park:

$$\text{Total forage/year} \times 0.25 = \text{Consumable forage/year}$$

$$15409000 \times 0.25 = 3852250 \text{ kg/ year}$$

There are also areas in forest land that herbivores do not graze such as heavy brush, weeds, other non-fodder species etc. To reduce the risk of overgrazing, these areas were removed from the calculation. In this case, from our statistical analysis data of plant species found in natural grasslands in Gorumara, it was estimated that grass species density is 88% among all the species found within the sample plots (Table: 40).

Therefore, the available forage would be determined as follows:

Consumable forage X % Grazeable areas = Available forage kg /year

3852250 kg/ year X 0.88= 3389980 Kg/year

Table 51: Estimated Biomass of Fodder species in Gorumara National Park at a glance

	Mean Biomass of Fodder species	Total Biomass Fodder Species	Consumable Biomass Fodder Species	Available Biomass Fodder Species
Planted fodder species in management plots	1.31 kg/m ² Or 13,100 kg/ha	800 X 13100 kg/ha = 1,04,80,000 kg/year	1,04,80,000 X 0.25= 26,20,000 kg/ year	26,20,000 kg/ year X 0.33= 8,64,600 Kg/year
Naturally occurring fodder species in management plots	0.449 kg/m ² Or 4,500 kg/ha	800 X 4500 kg/ha= 36,00,000 kg/year	36,00,000 X 0.25 = 9,00,000 kg/ year	9,00,000 kg/ year X 0.24 = 2,16,000 Kg/year
Fodder species in natural grasslands (unmanaged)	1.892 kg/m ² or 19,000 kg/ha	811 X 19000 kg/ha = 1,54,09,000 kg/year	1,54,09,000 X 0.25= 38,52,250 kg/ year	38,52,250 kg/ year X 0.88= 33,89,980 Kg/year

Findings

Dhadda (*Sachhrum narenga*) revealed the highest productivity of 0.837 kg/sq m or 8370 kg/ ha in Managed plots as well as in natural grassland (1.361kg/sq m or 13610 kg/ ha), whereas the naturally growing grasses (not planted) within the managed plots Nol (*Arundo donax*) revealed the highest productivity of 0.405 kg/ sq m or 4050kg/ha.

The maximum estimated Biomass (19,000 kg/ha) comprised of the Fodder Species that occurred in the Natural Grasslands (untouched/unmanaged). The least Biomass (4,500 kg/ha) occurred among the Naturally occurring Fodder Species, which were not planted, in the management plots. In between was the Biomass (13,100 kg/ha) of the Planted Fodder Species in management plots.

However, when the Biomass of the total Fodder Species was calculated as per the available area to each of them, revealed that the Biomass of the Fodder Species in Natural Grasslands (unmanaged) was the highest (1,54,09,000 kg/year), while the next highest Biomass (1,04,80,000 kg/year) was seen to be in Planted Fodder Species in management plots and the

least Biomass (36,00,000 kg/year) in the Naturally occurring Fodder Species in management plots.

Interestingly, if the total Biomass of Fodder Species (both Planted and Naturally occurring) in the management plots were taken together, it is seen that the Biomass is more or less the same Biomass (1,40,80,000 kg/year) as in the Natural Grasslands.

This trend was seen to be the same when the Biomass of Consumable Fodder Species were tabulated, as only 25% was estimated to be utilized in each case, and irrespective of wherever they occurred.

Finally when the percentage of the Fodder Species as recorded in the quantitative and qualitative sampling results in each case were tabulated with the Biomass of the Consumable Fodder Species to obtain the Biomass of the Available Fodder Species it was seen that the highest Biomass of 33,89,980 kg/year occurred in Fodder Species in Natural Grasslands (untouched/unmanaged), followed by the Biomass (8,64,600 kg/year) of Planted Fodder Species in management plots and least by the Biomass (2,16,000 kg/year) of Naturally occurring Fodder Species in management plots.

In fact, if both the Available Biomass of the Planted Fodder Species and the Naturally occurring Fodder Species in management plots were added together, the total Biomass (10,80,600 kg/year) Available as Fodder Species in management plots is approximately only 1/3rd of the Available Biomass (33,89,980 kg/year) of Fodder Species in Natural Grasslands (untouched/unmanaged).

5.8. Carrying Capacity

As Rhino is the keystone species in this National Park the calculation of carrying capacity is based on the Rhino suitable grassland area just like the Jaldapara NP. Besides Rhino and Gaur, Elephant is also considered for this calculation as they preferred the same habitat in Gorumara NP (Anon., 2007a) as both the animals preferred grass species as primary fodders in this region (Peden *et. al.*, 1974; Banerjee, 1993; Ghosh and Das, 2007; Roy, 2010; Lahkar *et. al.*, 2018).

An adult rhino eats between 60–80 kg a day fresh weight and spends most of its time browsing or grazing (Dinerstein, 2003). In addition, the food primarily consists of *Saccharum* species and other grass species. According to Coombs & Vlitos (1978) estimation, the standing biomass of sugarcane is 100 MT/ha fresh weight or 35 MT/ha dry weight, which gives a fresh/dry ratio of 100/35. So, if one rhino eats approximately 21–28 kg/day of dry weight, assuming the mid value of this range, 24.5 kg/day, the annual food requirement of one Rhino is 24.5 kg/day x 365 day/year = 8.9 Tons/year ≈ 9 tons/year or 9000 Kg/year.

Likewise for Asian Elephant it is assuming that they consume about 1.5–2.5% of its body weight of dry fodder (Sukumar, 2003) every day. Therefore, the middle value was taken consideration for this study. For the other ruminant herbivores, the consume rate is around 2% of their body weight (Murray, 1995). On the basis of their body weight the approximate DM intake value/year are following (Table: 52).

Table 52: Body weight and Dry matter intake value

Sl. No	Common Name	Scientific Name	Average Body Weight (Kg.)	DM intake per day (Kg)	Total DM requirement/year (Kg)
1	One Horned Rhino	<i>Rhinoceros unicornis</i>	1600 [©]	24.5	8900 ≈ 9000
2	Indian bison or Gaur	<i>Bos gaurus</i>	600 ⁺	12	4380 ≈ 4000
3	Asian Elephant	<i>Elephas maximus</i>	2500 [*]	50	18250
Total DM requirement for Rhino, Gaur and Elephant					31250

(*Mathur; 1991, *Roy 2010, ©Macdonald 2001)

Multiple grazing species has been considered in this case, so, to determine the total animal forage requirement, all the considered animals' annual requirement has been added up and applied to the main formula of carrying capacity (Table: 52).

$$\text{Carrying Capacity (K)} = \frac{\text{Available forage kg}}{\text{Animal forage requirement kg/year}}$$

Therefore, only for available forage in planted species in Gorumara,

$$\begin{aligned} \text{Carrying Capacity (K) or AU} &= 864600 / (9000+4000+18250) \\ &= 864600^*/31250 \\ &= 27.67 \text{ AU} \approx 28 \text{ AU/year} \end{aligned}$$

*The Available forage only calculated for planted species

28 AU/Year means, the planted species of Managed area can hold a total of 28 animals (Rhino+ gaur+ elephant) per year if the forage available, per day consumption rate for individual animals and the other environmental conditions are constant.

The intake capacities of the herbivores are different as per their body weight and one gaur cannot consume the same amount as Rhino or elephant.

Therefore, as per their consumption rate (Table: 52) it can be assumed that one rhino can consume fodders same as 2.3 numbers of gaur and half of an elephant.

Hence, using this logic, the planted species of grass fodder managed plot in Gorumara NP can support 7 Rhinos, 17 Gaurs and 4 elephants at a time.

[Note: The biomass study was done in the dry season of the year 2020 and could not be collected data in the wet seasons as the nationwide lockdown was imposed for Covid 19 Pandemic and the situation gets better only after the wet season. So, the carrying capacity is calculated here only basis for the dry season biomass availability]

For, only for forage available for natural grass species in managed plot in Gorumara NP

$$\begin{aligned}\text{Carrying Capacity (K) or AU} &= 216000 / (9000+4000+18250) \\ &= 216000 / 31250 \\ &= 6.91 \text{ AU} \approx 7 \text{ AU/year}\end{aligned}$$

*The Available forage only calculated for naturally occurring grass species within managed plots

In the same manner, the natural occurring species in managed plot in Gorumara NP can support 2 Rhinos, 4 Gaurs and 1 elephant at a time.

For, only for forage available in natural grass lands of in Gorumara NP

$$\begin{aligned}\text{Carrying Capacity (K) or AU} &= 3389980 / (9000+4000+18250) \\ &= 3389980 / 31250 \\ &= 108.47 \text{ AU} \approx 109 \text{ AU/year}\end{aligned}$$

*The Available forage only calculated for grass fodder species within natural grassland

The natural grasslands of Gorumara can support 29 Rhinos, 65 Gaurs and 14 elephants at a time.

Table 53: Estimated Carrying Capacity of Large Herbivores in Gorumara National Park at a glance

	Available Forage Biomass (AB)	Animal Forage Requirement (AD)	Carrying Capacity (K) or Animal Unit (AU) = (AB/AD)
Planted fodder species in management plots	8,64,600kg/year	One Horned Rhino - 9,000	8,64,600/9,000 = 96.07
		Indian Bison or Gaur – 4,000	8,64,600/4,000 = 216.15
		Asian Elephant- 18,250	8,64,600/18,250 = 47.38

		Total	- 31,250	8,64,600/31,250 = 27.67
		7 Rhinos, 17 Gaurs and 4 Elephants		
Naturally occurring fodder species in management plots	2,16,000kg/year	One Horned Rhino	- 9,000	2,16,000/9,000 = 24.00
		Indian Bison or Gaur	- 4,000	2,16,000/4,000 = 54.00
		Asian Elephant	- 18,250	2,16,000/18,250 = 11.84
		Total	- 31,250	2,16,000/31,250 = 6.91
		2 Rhinos, 4 Gaurs and 1 Elephant		
Fodder species in natural grasslands (unmanaged)	33,89,980kg/year	One Horned Rhino	- 9,000	33,89,980/9,000 = 376.66
		Indian Bison or Gaur	- 4,000	33,89,980/4,000 = 847.50
		Asian Elephant	- 18,250	33,89,980/18,250 = 185.75
		Total	- 31,250	33,89,980/31,250 = 108.48
		29 Rhinos, 65 Gaurs and 14 Elephants		
Planted fodder species + Naturally occurring fodder species in management plots	8,64,600 kg/year + 2,16,000 kg/year = 10,80,600kg/year	One Horned Rhino	- 9,000	10,80,600 /9,000 = 120.07
		Indian Bison or Gaur	- 4,000	10,80,600 /4,000 = 270.15
		Asian Elephant	- 18,250	10,80,600 /18,250 = 59.21
		Total	- 31,250	10,80,600/31,250 = 34.58
		9 Rhinos, 21 Gaurs and 5 Elephants		
Planted fodder species + Naturally occurring fodder species in management plots + Fodder species in natural grasslands (unmanaged)	8,64,600 kg/year + 2,16,000 kg/year + 33,89,980 kg/year = 44,70,580 kg/year	One Horned Rhino	- 9,000	44,70,580 /9,000 = 496.73
		Indian Bison or Gaur	- 4,000	44,70,580 /4,000 = 1117.65
		Asian Elephant	- 18,250	44,70,580/18,250 = 244.96
		Total	- 31,250	44,70,580/31,250 = 143.06
		38 Rhinos, 86 Gaurs and 19 Elephants		

So, the grassland management plots in total can support 9 rhinos, 21 gaur and 5 elephants, while at a totality of grassland area can support 38 rhinos, 86 Gaurs and 19 elephants in the basis of dry season biomass available as per our findings.

5.9. Discussion:

It was noted that an increase in the percentage of Natural grass (*Saccharum spontaneum*, *Imperata cylindrica*, *Oplismenus burmannii* & *Axonopus compressus*) decreased the intrusion of Weeds (*Lantana camara*, *Mikania micrantha*, *Leea asiatica*, *Chromolaena odorata*, *Clerodendrum infortunatum*) and vice versa. On a total evaluation of vegetation in Gorumara NP the cover percentage for planted species is around 32.96%; natural grass, fodder & sedge species – 24.01%; harmful weeds – 26.42% and other species occupies 16.63% of the area. It was seen that the population density of grass species in natural grassland was higher (88%) than the managed plots in various ranges (42% to 75%).

It was seen that occupancy percentage of Weed species in North Range is higher than the South Range. Weed species occupied about 32% of area in North Range recording the highest among the four categories of plants. Among the weed species, *Mikania micrantha*, *Chromolaena odorata*, *Ageratum conyzoides* and *Mimosa pudica* were denser than the other weed species. It is seen that in natural grassland the effects of weeds are minimum as the population density of the weeds in natural grassland quadrates were only 4.24% where as in the managed grassland the density varied from 12.77% to 17.25%.

Most utilized habitat zone for both the Rhino and Gaur was Budhram with Ramsai Ext followed by Gorumara Beat of the South Range which has most of the natural grasslands. Both the species shows a positive correlation between sightings and the percentage of grassland area.

A total of 22 species of plants was recorded as consumed by herbivores like Rhino, Gaur, Sambar, Elephant, Barking deer and Spotted deer. Poaceae family (Grass species) was the dominating family in terms of the fodders for all the herbivores like Rhino, Gaur, Elephant and all deer species. *Mikania micrantha*, which is considered as a weed, was observed to be consuming by Gaur, Elephant and Spotted deer. Surprisingly, *Lantana camara* was also observed browsing by elephant.

Dhadda (*Sachhrum narenga*) shows the highest productivity in both of natural grasslands (1.361kg/sq m or 13610 kg/ ha) as well as in Managed plots) 0.837 kg/sq m or 8370 kg/ ha) respectively, whereas among the naturally growing grasses (not planted) within the managed plots, Nol (*Arundo donax*) revealed the highest productivity of 0.405 kg/ sq m or 4050kg/ha.

The total grassland area of Gorumara NP can support 38 Rhinos, 86 Gaurs and 19 Elephants on the basis of dry season biomass available. 18% of this which is 7 Rhinos, 17 Gaurs and 4 Elephants was calculated to found in the managed plots when only the planted species biomass was considered. However, if the managed plots are taken into consideration as a whole, both the planted species as well as the natural occurring grass species, then the carrying capacity is 23% amounting to 9 Rhinos, 21 Gaurs and 5 Elephants.

CHAPTER III

6. Mahananda Wildlife Sanctuary:

6.1. Study Area:

The Mahananda Wildlife Sanctuary (MWLS) is situated on the West bank of the River Tista in the Terai region of Darjeeling district that forms a part of the Eastern Himalaya, and located between latitudes 26°55'33" N and 26°47'54" N and longitude 88°33'31" E and 88°23'36"E. The notified area of the sanctuary is 161.17 sq. km. (Anon, 2012).

It was first designated as a protected area during 1949. "Protection" at that time however was only to restrict the hunting of wild animals. Subsequently, in June, 1976, the reserve forest in the lower catchment of Mahananda River was declared as a Wildlife Sanctuary. All the notified blocks of MWLS have been placed under the direct management of Wildlife Wing on Reorganization of Forest Directorate in September, 1995 (Singhal and Chowdhury, 1996).

The total area is divided into 34 forest blocks under four ranges viz. East, West, North and South ranges (Anon, 2012).

The Sanctuary is situated between the elevations of 150 m to 1300 m above sea level. The soils are sandy and generally poorly developed. Along the banks of Tista, silts and silty loams predominate. Alluvial debris, boulders, gravel and alluvium predominate in the Bhabar and Terai belt south of the hilly terrain.

Mahanadi and Gulma khola the two spring-fed water courses play a major role in the ecological functioning of the Sanctuary. The other water courses of significance in the area are Nandi khola, Choklong khola, Ghoramara and Panchenai khola, all of which are seasonal and are of spring-origin. Except Mahanadi, which originates in Kurseong hills, north of the Sanctuary limits, all other courses in the Sanctuary have their catchments within the confines of the Sanctuary.

The climate varies from tropical to subtropical with the rise of elevation. The highest temperature of about 36°C occurs in the lower reaches in the months of May and June. December and January are the coldest months, with night temperatures falling down to 2°C in the higher altitudes. The annual rainfall in the region is 3500 mm. Monthly average being highest in July of (900 mm) and lowest in December (40 mm). Gulma block receives maximum rainfall. Fog in the hilly areas occurs mostly during the rainy months. The humidity level is fairly high.

The area of MWLS comprises of 60% of the forest in hilly region in the foot hills of the Himalayas and 40% in the plains, characterized by moderate, steep to precipitous mountain slopes and high ridges towards the north and then sloping to almost flat stretch of the Terai and alluvial plains towards the south. There are two broad ecological subdivisions, the Hill tract and the Bhabar tract. Conversion of the higher hills into tea estates and Cinchona plantations has fragmented the ecological boundary in the north. River Tista in the east forms a physical barrier

against movement of terrestrial wild lives of the Bhabar tract which is gently sloping and covered with sal forests. The river and khola belts act as valuable biotope for wildlife (Singhal and Chowdhury, 1996).

The forests can be classified into 10 distinct types namely 1. Khair-Sisoo Forest, 2. Eastern Bhabar Sal, 3. Eastern Terai Sal, 4. Dry mixed forest, 5. Wet mixed forest, 6. Lower Hill Sal Forest, 7. Lower Hill Dry mixed forest, 8. Lower Hill Wet mixed forest, 9. Middle Hill Forest and 10. Pure Sal forest. Monoculture of teak are common in the plains zone of Mahananda Wildlife Sanctuary and are distributed over the following blocks, namely- Jogijhora, Punding, Upper Champasari, Gulma, Lower Ghoramara, North Sevoke, East Sevoke, Singimari, Silivita West Sevoke, and Laltong block.

A total 113 tree species, 78 herbs and shrubs, and 10 climbers have been recorded so far from this sanctuary (Anon, 2012). Due to the diversity of elevation and vegetation, the range of species found in the Sanctuary is rich and varied. Considering the extent of the tract, however, the number of individuals in each of the species is very limited.

Mahananda Wildlife Sanctuary is an extremely important habitat of the wild elephants (*Elephas maximas indicus*) which is the key-stone species of the sanctuary. Earlier, the elephants did not stay in the Sanctuary permanently but used to pass through. However, during the last decade or so, elephants are staying within the Sanctuary for periods ranging up to several months. The reason may be the effect of canopy opening of teak plantation and planting up such areas with fodder & bamboo/ fruit trees.

The other associated species of the sanctuary are gaur, different species of deer, wild boar and a large number of birds, reptiles, amphibians and insects. From the available records it is seen that this Wildlife Sanctuary has 71 species of mammals, 253 species of birds, 29 species of butterflies, 6 amphibian species, 11 reptile species including 2 species of turtles (Singhal and Chowdhury, 1996; Anon, 2012).

The presence of large, relatively undisturbed semi-evergreen or moist deciduous forest tracts where there is abundance of forage in terms of coarse grass, bamboos, shrubs and trees found in central and eastern portions of the Sanctuary comprising of Gulma valley, Choklong, Silibhita and lower Ghoramara are the preferred habitats of the Gaur or Indian Bison (*Bos gaurus gaurus*), as they are primarily grazers, and their diet is largely composed of grasses (Peden *et.al.* 1974; Lahkar *et. al.* 2018). Similarly, elephants are known to exploit a large variety of species, yet the dominance of grasses in their diet was documented (Roy, 2010). As the elephants and the Gaurs are increasing day by day in this WLS, the need for the forage ground is also increasing.

Moreover, Mahananda WLS does not have as much natural grassland area like Jaldapara NP and Gorumara NP. In view of this the Forest Department has developed suitable habitats for management in the blocks of Koklong, Kyananuka, Adalpur, Chamta, Sukna, Punding, Panchnai, Hatisar, Mohurgong, Jogijhora, Lower Champasari, Gulma, Singhimari, Lower Ghoramara,

North/West/East Sevoke, Laltong 1 to 5, 9 to 10 of West, Sukna, South and North Range by opening the canopy followed by planting fodder species.

The present study was therefore confined to the main habitat improvement zone of the Park to identify the impact of habitat management especially canopy opening in these areas.

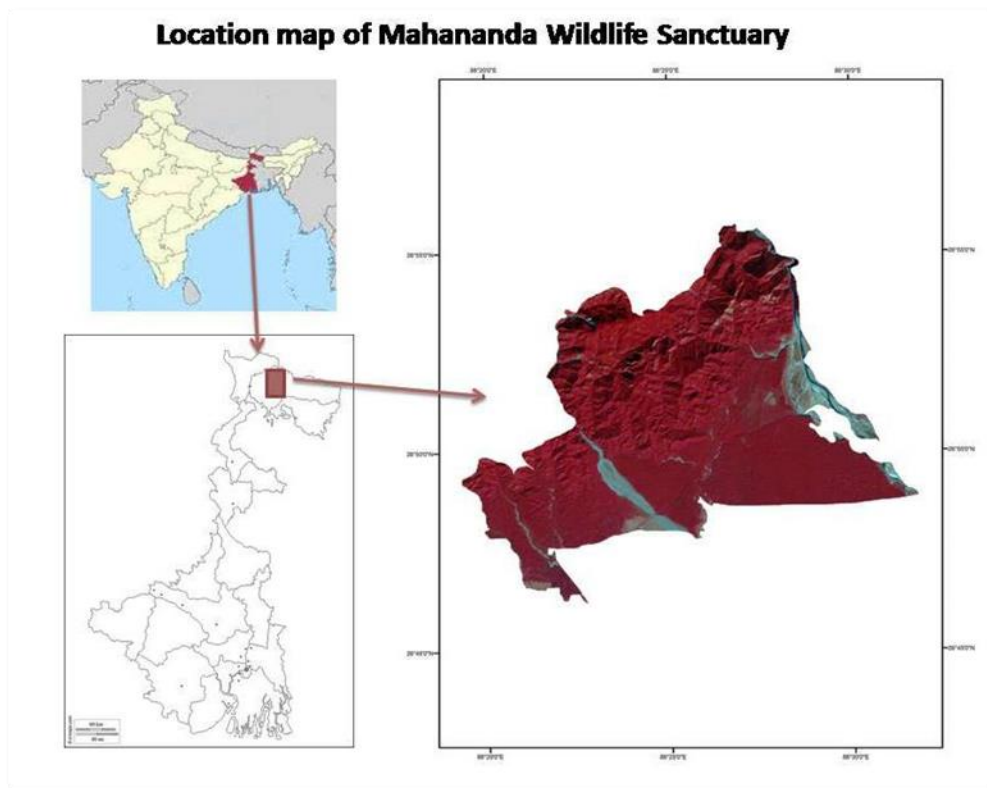


Figure 46: Mahananda Wildlife Sanctuary

6.2. Discussion with forest officials and collection of plantation journals

Results:

In Mahananda Wildlife Sanctuary discussions with the following officials were held viz. Mr. Jayanta Mandal, Former AWLW; Mr. Bimal Debnath, AWLW; Mr. Tapas Kundu, Ranger, West Range; Mr. Mriganka Maity, Ranger, Sukna Range; Mr. Kaji Chetri, Ranger, South Range and Mr. Nawin Mani Pradhan.

6.3. Archive literature review

Results:

After discussed with the forest officials the relevant archive literatures were collected and reviewed from the respective Ranges of MWLS. Total 56 Plantation journals were collected from the respective forest ranges and beats of Mahananda WLS. The journals were reviewed and tabulated beat wise with the main details in a single page. Plantation details like area,

previous plantations, planted species, gap between the planted species, flood condition, species before plantation etc were tabulated in a particular proforma.

Table 54: Plantation journals collected from MWLS

Range	Beat	Total journal collected	Repeated plantation /Chosen for study	Onetime plantation /Chosen for study	Canopy opening/ Chosen for study	No Information/ Chosen for study
West Range	<i>Gulma Beat</i>	7	1/1	3/2	3/3	
	<i>Punding Beat</i>	6			4/1	2/2
	<i>Sukna Beat</i>	3		1/0	2/2	
Total	3 Beats	16	1/1	4/2	9/6	2/2
Sukna Range	Chamta Beat	3		1/0	2/1	
	Mahanadi Beat	8		3/1		5/4
	Koklong Beat	2	2/1			
Total	3 Beats	13	2/1	4/1	2/1	5/4
North Range	<i>Sevoke Beat</i>	8		4/2	4/3	
	<i>Latpanchor Beat</i>	6		5/2		1/1
	<i>Kalijhora Beat</i>	3				3/3
Total	3 Beats	17		9/4	4/3	4/4
South Range	<i>Toribari Beat</i>	5	2/1	1/0	2/2	
	<i>7th mile beat</i>	5			2/1	3/2
Total	2 Beats	10	2/1	1/0	4/3	3/2
GRAND TOTAL	11 Beats	56	5/3	18/7	19/13	14/12

6.4. Inventorization of Flora

Results:

In Mahananda a total of 35 managed plots (13 canopy opening plantation, 7 one-time plantations, 3 repeated plantations and 12 without any information were chosen for this study falling in 11 beats viz. Gulma, Punding, Sukna, Chamta, Mahanadi, Koklong, Sevoke, Latpanchor, Kalijhora, Toribari and 7th mile beat. Vegetation data were collected in 38 quadrates [10 m X 10 m (100 sq. m.)] in these 35 plots in pre monsoon season only. More over to compare the studied plots 4 Teak plantation plots were randomly chosen for a similar qualitative and quantitative documentation of all vegetation in these plots in MWLS.

During these studies a total of 191 plant species were recorded, identified, documented and tabulated. Of these, 14 were the Planted species, while 13 species belonged to Natural occurring grass, fodder & sedge, 18 were Weed species and 146 were Other species. In these 191 species some of the species have both the mature and juvenile forms. So, while analysis the data the mature form and the juvenile form of the species calculated separately.

Analyzed data shows that *Eragrostis spp* has highest IVI (31.00) followed by *Drymaria cordata* (IVI= 30.12) within all species found in Mahananda WLS (Table: 55).

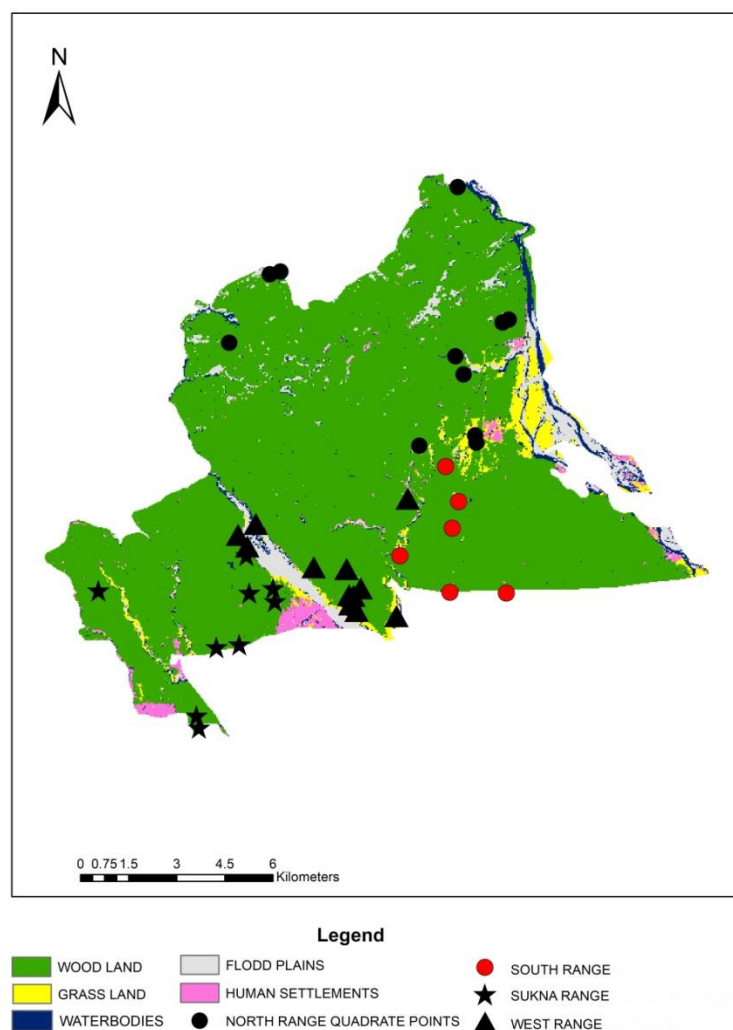


Figure 47: Mahananda Land Use land cover map along with the quadrature points

Table 55: List of all species of plants recorded during the study in managed plots with their IVI values

Sl No.	Family	Scientific name	IVI Values
1	Amaranthaceae	<i>Achyranthes bidentata</i> Blume	0.32
2	Lamiaceae	<i>Achyrosperrum wallichianum</i> (Benth.) Benth. ex Hook.f.	1.26
3	Asteraceae	<i>Acmella uliginosa</i> (Sw.) Cass.	0.44
4	Lauraceae	<i>Actinodaphne obovata</i>	0.31
5	Amaranthaceae	<i>Aerva lanata</i>	0.23
6	Asteraceae	<i>Ageratum conyzoides</i> (L.) L.	2.05
7	Asteraceae	<i>Ageratum houstonianum</i> Mill.	2.45
8	Meliaceae	<i>Aglaia spectabilis</i> (Miq.) S.S. Jain & S. Bennet	0.44
9	Simaroubaceae	<i>Ailanthus excelsa</i> Roxb.	0.15

10	Cornaceae	<i>Alangium chinense</i> (Lour.) Harms	1.00
11	Fabaceae	<i>Albizia procera</i>	0.33
12	Fabaceae	<i>Albizia procera</i> mature	0.15
13	Zingiberaceae	<i>Alpinia nigra</i>	1.10
14	Zingiberaceae	<i>Alpinia galanga</i>	0.40
15	Apocynaceae	<i>Alstonia scholaris</i>	0.15
16	Amaranthaceae	<i>Alternanthera pungens</i> Kunth	0.55
17	Commelinaceae	<i>Amischotolype hookeri</i> (Hassk.) H. Hara	3.00
18	Vitaceae	<i>Ampelocissus sikkimensis</i> (M.A. Lawson) Planch.	0.31
19	Lamiaceae	<i>Anisomeles indica</i> (L.) Kuntze	0.32
20	Phyllanthaceae	<i>Aporosa octandra</i> (Buch. -Ham. ex D. Don) Vickery mature	0.30
21	Myrsinaceae	<i>Ardisia solanacea</i> (Poir.) Roxb.	0.48
22	Convolvulaceae	<i>Argyreia roxburghii</i> (Wall.) Arn. ex Choisy	0.21
23	Moraceae	<i>Artocarpus chaplasi</i>	0.16
24	Poaceae	<i>Axonopus compressus</i> (Sw.) P. Beauv.	22.36
25	Poaceae	<i>Bambusa</i> sp (non-Thorny bamboo)	0.17
26	Poaceae	<i>Bambusa</i> spp	3.81
27	Poaceae	<i>Bambusa tulda</i>	0.65
28	Acanthaceae	<i>Barleria cristata</i>	2.20
29	Acanthaceae	<i>Barleria strigosa</i> Willd.	1.68
30	Fabaceae	<i>Bauhinia vahlii</i> Wight & Arn.	0.48
31	Rhamnaceae	<i>Berchemia floribunda</i> (Wall.) Brongn.	0.15
32	Blechnaceae	<i>Blechnum</i> sp	0.16
33	Asteraceae	<i>Blumia lacera</i>	0.22
34	Urticaceae	<i>Boehmeria hamiltoniana</i> Wedd.	1.16
35	Malvaceae	<i>Bombax ceiba</i>	0.15
36	Rubiaceae	<i>Borreria alata</i>	1.00
37	Phyllanthaceae	<i>Bridelia</i> sp	0.18
38	Caesalpiniaceae	<i>Caesalpinia cuculata</i>	0.26
39	Arecaceae	<i>Calamus</i> sp	0.16
40	Lamiaceae	<i>Callicarpa</i> sp	0.15
41	Capparaceae	<i>Capparis zeylanica</i> L.	0.32
42	Cyperaceae	<i>Carex</i> sp	4.03
43	Lecythidaceae	<i>Careya arborea</i> Roxb.	0.43
44	Fabaceae	<i>Cassia pinnata</i> Voigt	0.63
45	Fabaceae	<i>Cassia</i> sp	0.17
46	Fagaceae	<i>Castanopsis indica</i>	0.26
47	Meliaceae	<i>Chisocheton cumingianus</i> (C.DC.) Harms Mature	1.51
48	Meliaceae	<i>Chisocheton cumingianus</i> (C.DC.) Harms	0.46
49	Chloranthaceae	<i>Chloranthus elatior</i> Link	0.40
50	Asteraceae	<i>Chromolaena odorata</i> (L.) R.M. King & H. Rob.	4.08
51	Meliaceae	<i>Chukrasia tabularis</i> A. Juss.	0.29

52	Meliaceae	<i>Chukrasia tabularis</i> A. Juss. Mature	0.16
53	Lauraceae	<i>Cinamomum zeylacum</i>	0.19
54	Rutaceae	<i>Clausena excavata</i> Burm.f.	0.97
55	Lamiaceae	<i>Clerodendrum infortunatum</i> L.	3.21
56	Cucurbitaceae	<i>Coccinia grandis</i> (L.) Voigt	0.29
57	Rubiaceae	<i>Coffea benghalensis</i> B. Heyne ex Schult.	4.73
58	Poaceae	<i>Coix lacryma-jobi</i> L.	0.17
59	Araceae	<i>Colocasia esculenta</i> (L.) Schott	0.22
60	Combretaceae	<i>Combretum</i> sp	1.42
61	Commelinaceae	<i>Commelina paludosa</i> Blume	2.04
62	Commelinaceae	<i>Commelina suffruticosa</i> Blume	1.39
63	Capparaceae	<i>Crateva religiosa</i> G. Forst.	0.18
64	Amaryllidaceae	<i>Crinum amoenum</i> Ker Gawl. ex Roxb.	0.22
65	Euphorbiaceae	<i>Croton caudatus</i> Geiseler	0.31
66	Hypoxidaceae	<i>Curculigo recurvata</i>	0.18
67	Zingiberaceae	<i>Curcuma amada</i> Roxb.	0.16
68	Poaceae	<i>Cynodon dactylon</i> (L.) Pers.	2.20
69	Cyperaceae	<i>Cyperus</i> sp	1.53
70	Poaceae	<i>Dactyloctenium aegyptium</i>	0.26
71	Fabaceae	<i>Dalbergia stipulacea</i> Roxb.	0.30
72	Amaranthaceae	<i>Deeringia</i> sp	0.17
73	Urticaceae	<i>Dendrocnide sinuata</i>	0.19
74	Fabaceae	<i>Desmodium heterocarpum</i>	0.31
75	Annonaceae	<i>Desmos dumosus</i>	0.17
76	Acanthaceae	<i>Dicliptera bupleuroides</i> Nees	2.56
77	Poaceae	<i>Digitaria</i> sp	2.54
78	Dilleniaceae	<i>Dillenia indica</i> L.	1.03
79	Dilleniaceae	<i>Dillenia indica</i> L. mature	0.17
80	Dilleniaceae	<i>Dillenia pentagyna</i> Mature	0.30
81	Dioscoreaceae	<i>Dioscorea</i> sp	0.15
82	Athyriaceae	<i>Diplazium esculentum</i> (Retz.) Sw.	1.88
83	Apocynaceae	<i>Dregea volubilis</i> (L.f.) Benth. ex Hook.f.	0.30
84	Caryophyllaceae	<i>Drymaria cordata</i> (L.) Willd. ex Schult.	30.12
85	Dryopteridaceae	<i>Dryopteris sparsa</i> (D. Don) Kuntze	2.94
86	Lythraceae	<i>Duabanga grandiflora</i> (DC.) Walp.	0.15
87	Asteraceae	<i>Elephantopus scaber</i> L.	0.87
88	Asteraceae	<i>Eleutheranthera ruderalis</i> (Sw.) Sch.Bip.	0.27
89	Poaceae	<i>Eragrostis</i> spp	31.00
90	Acanthaceae	<i>Eranthemum griffithii</i> (T. Anderson) Bremek. & Nann.-Bremek.	1.60
91	Asteraceae	<i>Eupatorium adenophorum</i>	0.36
92	Salicaceae	<i>Flacourtia indica</i> (Burm.f.) Merr.	0.15
93	Fabaceae	<i>Flemingia strobilifera</i> (L.) W.T. Aiton	0.16

94	Burseraceae	<i>Garuga floribunda</i> Decne.	0.15
95	Zingiberaceae	<i>Globba racemosa</i> Sm.	0.44
96	Acanthaceae	<i>Hygrophila phlomoides</i> Nees	0.36
97	Lamiaceae	<i>Hyptis suaveolens</i> (L.) Poit.	0.19
98	Apocynaceae	<i>Ichnocarpus frutescens</i> (L.) W.T. Aiton	1.37
99	Balsaminaceae	<i>Impatiens tricolor</i> Ridl.	0.17
100	Poaceae	<i>Imperata cylindrica</i>	4.27
101	Convolvulaceae	<i>Ipoemia</i> sp	0.18
102	Convolvulaceae	<i>Ipomoea nil</i> (L.) Roth	0.66
103	Oleaceae	<i>Jasminum</i> sp	0.40
104	Acanthaceae	<i>Justicia hypoluca</i>	6.33
105	Cyperaceae	<i>Kylinga nemoralis</i>	0.23
106	Lythraceae	<i>Lagerstroemia parviflora</i> Roxb.	0.77
107	Lythraceae	<i>Lagerstroemia parviflora</i> Roxb. Mature	0.16
108	Lythraceae	<i>Lagerstroemia speciosa</i> (L.) Pers.	2.10
109	Lythraceae	<i>Lagerstroemia speciosa</i> (L.) Pers. Mature	0.77
110	Verbenaceae	<i>Lantana camara</i> L.	0.61
111	Vitaceae	<i>Leea asiatica</i> (L.) Ridsdale	0.32
112	Vitaceae	<i>Leea guineensis</i> G. Don	0.15
113	Acanthaceae	<i>Lepidagathis incurva</i> Buch. -Ham. ex D. Don	1.96
114	Lamiaceae	<i>Leucas aspera</i>	0.48
115	Lauraceae	<i>Litsea glutinosa</i> (Lour.) C.B. Rob.	1.11
116	Lauraceae	<i>Litsea glutinosa</i> (Lour.) C.B. Rob. Mature	0.16
117	Lauraceae	<i>Litsea monopetala</i> (Roxb.) Pers.	0.74
118	Lauraceae	<i>Litsea</i> spp	1.96
119	Onagraceae	<i>Ludwigia</i> sp	0.37
120	Cucurbitaceae	<i>Luffa acutangula</i> (L.) Roxb.	0.15
121	Schizaeaceae	<i>Lygodium flexuosum</i>	0.55
122	Euphorbiaceae	<i>Macaranga denticulata</i>	0.86
123	Primulaceae	<i>Maesa indica</i> (Roxb.) A. DC.	1.78
124	Magnoliaceae	<i>Magnolia champaca</i>	0.16
125	Euphorbiaceae	<i>Mallotus philippensis</i> (Lam.) Müll.Arg.	1.21
126	Anacardiaceae	<i>Mangifera sylvatica</i>	0.15
127	Melastomataceae	<i>Melastoma malabathricum</i> L.	0.97
128	Sabiaceae	<i>Meliosma simplicifolia</i> (Roxb.) Walp	0.29
129	Convolvulaceae	<i>Merremia vitifolia</i> (Burm. f.) Hallier f.	1.23
130	Rubiaceae	<i>Meyna spinosa</i> Roxb. ex Link	0.66
131	Dennstaedtiaceae	<i>Microlepia</i> sp	0.75
132	Asteraceae	<i>Mikania micrantha</i> Kunth	3.28
133	Rubiaceae	<i>Mitracarpus vertisilaster</i>	2.20
134	Rubiaceae	<i>Morinda angustifolia</i> Roxb.	1.07
135	Cucurbitaceae	<i>Mukia maderaspatana</i> (L.) M. Roem.	0.15
136	Rutaceae	<i>Murraya koenigii</i> (L.) Spreng.	0.15

137	Ranunculaceae	<i>Naravelia zeylanica</i> (L.) DC.	0.45
138	Icacinaeae	<i>Natsiatum herpeticum</i> Buch. -Ham. ex Arn.	0.60
139	Acanthaceae	<i>Nelsonia canescens</i> (Lam.) Spreng.	3.31
140	Rubiaceae	<i>Neolamarckia camamba</i> (Roxb.) Bosser Mature	0.15
141	Nephrolepidaceae	<i>Nephrolepis auriculata</i>	10.30
142	Poaceae	<i>Oplismenus burmanni</i> (Retz.) P. Beauv.	23.40
143	Oxalidaceae	<i>Oxalis debilis</i> var. <i>corymbosa</i> (DC.) Lourteig	0.17
144	Rubiaceae	<i>Paederia foetida</i> L.	0.96
145	Pandanaceae	<i>Pandanus</i> sp	0.16
146	Polygonaceae	<i>Persicaria chinensis</i> (L.) H. Gross	0.80
147	Polygonaceae	<i>Persicaria</i> sp	0.53
148	Acanthaceae	<i>Phaulopsis imbricata</i> (Forssk.) Sweet	3.30
149	Acanthaceae	<i>Phlogacanthus thyrsoifloras</i>	0.36
150	Urticaceae	<i>Pilea</i> sp	2.39
151	Piperaceae	<i>Piper longum</i> L.	0.25
152	Piperaceae	<i>Piper</i> spp	2.93
153	Piperaceae	<i>Piper sylvestre</i>	6.33
154	Myrtaceae	<i>Psidium guajava</i> L.	0.15
155	Pteridaceae	<i>Pteris biaurita</i> L.	0.87
156	Malvaceae	<i>Pterospermum acerifolium</i>	0.17
157	Amaranthaceae	<i>Pupalia lappacea</i> (L.) Juss.	4.29
158	Acanthaceae	<i>Rungia pectinata</i> (L.) Nees	1.08
159	Poaceae	<i>Saccharum narenga</i>	0.77
160	Poaceae	<i>Saccharum spontaneum</i>	2.87
161	Phyllanthaceae	<i>Sauropus compressus</i> Müll.Arg.	1.01
162	Theaceae	<i>Schima wallichii</i>	0.48
163	Poaceae	<i>Setaria palmifolia</i> (J. Koenig) Stapf	1.71
164	Dipterocarpaceae	<i>Shorea robusta</i> Gaertn.	1.33
165	Dipterocarpaceae	<i>Shorea robusta</i> Gaertn. Mature	0.57
166	Malvaceae	<i>Sida acuta</i> Burm.f.	0.93
167	Malvaceae	<i>Sida rhombifolia</i> L.	0.30
168	Smilacaceae	<i>Smilax perfoliata</i> Lour.	0.67
169	Menispermaceae	<i>Stephania glabra</i> (Roxb.) Miers	0.16
170	Menispermaceae	<i>Stephania hernandiifolia</i> (Willd.) Walp.	1.32
171	Malvaceae	<i>Sterculia villosa</i> Roxb.	0.15
172	Bignoniaceae	<i>Stereospermum tetragonum</i> DC.	0.30
173	Moraceae	<i>Streblus asper</i> Lour.	0.29
174	Acanthaceae	<i>Strobilanthes</i> sp	3.64
175	Myrtaceae	<i>Syzygium</i> spp	1.04
176	Apocynaceae	<i>Tabernaemontana divericata</i> (L.) R. Br. Ex Roem. & Schult.	0.49
177	Lamiaceae	<i>Tectona grandis</i> L.f.	0.92
178	Lamiaceae	<i>Tectona grandis</i> L.f. Mature	0.86

179	Combretaceae	<i>Terminalia bellirica</i> (Gaertn.) Roxb.	0.29
180	Combretaceae	<i>Terminalia myriocarpa</i> Van Heurck & Müll. Arg.	0.43
181	Dilleniaceae	<i>Tetracera sarmentosa</i> (L.) Vahl	0.15
182	Vitaceae	<i>Tetrastigma dubium</i> (Lawson) Planch.	0.38
183	Vitaceae	<i>Tetrastigma planicaule</i> (Hook. f.) Gagnep.	0.32
184	Vitaceae	<i>Tetrastigma serrulatum</i> (Roxb.) Planch.	0.74
185	Vitaceae	<i>Tetrastigma sp</i>	0.33
186	Thelypteridaceae	<i>Thelypteris sp</i>	0.53
187	Poaceae	<i>Themeda arundinacea</i>	0.71
188	Poaceae	<i>Themeda sp</i>	0.63
189	Acanthaceae	<i>Thunbergia fragrans</i>	0.33
190	Acanthaceae	<i>Thunbergia grandiflora</i> (Roxb. ex Rottl.) Roxb.	0.46
191	Poaceae	<i>Thysanolenia maxima</i>	2.76
192	Euphorbiaceae	<i>Trewia nudiflora</i> var. polycarpa (Benth.) Susila & N.P. Balakr.	0.84
193	Euphorbiaceae	<i>Trewia nudiflora</i> var. polycarpa (Benth.) Susila & N.P. Balakr. Mature	0.43
194	Malvaceae	<i>Triumfetta rhomboidea</i> Jacq.	1.23
195	Malvaceae	<i>Urena lobata</i> L.	1.17
196	Annonaceae	<i>Uvaria sp</i>	0.68
197	Asteraceae	<i>Vernonia ceneria</i>	0.26
198	Apocynaceae	<i>Wrightia pubescens</i> R.Br.	0.83
199	Cucurbitaceae	<i>Zanonia indica</i> L.	0.15
200	Rutaceae	<i>Zanthoxylum sp</i>	0.29
201	Rhamnaceae	<i>Zizyphus rugosus</i>	0.18

Table 56: List of planted species recorded during the study in managed plots

Sl no	Family	Scientific name	Vernacular name	Remarks
1	Zingiberaceae	<i>Alpina nigra</i>	Purundi	
2	Poaceae	<i>Bambusa sp</i> (non-Thorny bamboo)	Bans	
3	Poaceae	<i>Bambusa spp</i>	Bans	
4	Poaceae	<i>Bambusa tulda</i>	Bans	
5	Poaceae	<i>Coix lacryma-jobi</i> L.		
6	Hypoxidaceae	<i>Curculigo recurvata</i>	Dhotisara	
7	Dilleniaceae	<i>Dillenia indica</i> L.	Chalta	Tree fodder, also found naturally
8	Euphorbiaceae	<i>Mallotus philippensis</i> (Lam.) Müll.Arg.	Sindure	Tree fodder, also found naturally
9	Poaceae	<i>Saccharum narenga</i>	Dhadda	
10	Poaceae	<i>Setaria palmifolia</i> (J. Koenig) Stapf	Bhutta grass	
11	Combretaceae	<i>Terminalia bellirica</i> (Gaertn.) Roxb.	Bohera	Tree fodder, also found naturally
12	Combretaceae	<i>Terminalia myriocarpa</i> Van Heurck & Müll. Arg.	Panisal	Tree fodder, also found naturally
13	Poaceae	<i>Themeda arundinacea</i>	Chepti	
14	Poaceae	<i>Thysanolenia maxima</i>	Amliso	

Table 57: List of natural grasses, fodder and sedges recorded during the study in managed plots

Sl no	Family	Scientific name
1	Zingiberaceae	<i>Alpinia galanga</i>
2	Poaceae	<i>Axonopus compressus</i> (Sw.) P. Beauv.
3	Cyperaceae	<i>Carex sp</i>
4	Poaceae	<i>Cynodon dactylon</i> (L.) Pers.
5	Cyperaceae	<i>Cyperus sp</i>
6	Poaceae	<i>Dactyloctenium aegypticum</i>
7	Poaceae	<i>Digitaria sp</i>
8	Poaceae	<i>Eragrostis spp</i>
9	Poaceae	<i>Imperata cylindrica</i>
10	Cyperaceae	<i>Kylinga nemoralis</i>
11	Poaceae	<i>Oplismenus burmanni</i> (Retz.) P. Beauv.
12	Poaceae	<i>Saccharum spontaneum</i>
13	Poaceae	<i>Themeda sp</i>

Table 58: List of weed species recorded during the study in managed plots

Sl no	Family	Scientific name
1	Asteraceae	<i>Ageratum conyzoides</i> (L.) L.
2	Asteraceae	<i>Ageratum houstonianum</i> Mill.
3	Fabaceae	<i>Cassia pinnata</i> Voigt
4	Asteraceae	<i>Chromolaena odorata</i> (L.) R.M. King & H. Rob.
5	Lamiaceae	<i>Clerodendrum infortunatum</i> L.
6	Asteraceae	<i>Eupatorium adenophorum</i>
7	Convolvulaceae	<i>Ipomoea nil</i> (L.) Roth
8	Verbenaceae	<i>Lantana camara</i> L.
9	Vitaceae	<i>Leea asiatica</i> (L.) Ridsdale
10	Vitaceae	<i>Leea guineensis</i> G. Don
11	Schizaeaceae	<i>Lygodium flexuosum</i>
12	Asteraceae	<i>Mikania micrantha</i> Kunth
13	Cucurbitaceae	<i>Mukia maderaspatana</i> (L.) M. Roem.
14	Rubiaceae	<i>Paederia foetida</i> L.
17	Menispermaceae	<i>Stephania hernandiifolia</i> (Willd.) Walp.
18	Moraceae	<i>Streblus asper</i> Lour.
19	Malvaceae	<i>Triumfetta rhomboidea</i> Jacq.
20	Asteraceae	<i>Vernonia ceneria</i>

Table 59: List of other species recorded in managed plots

Sl no.	Family	Species name
1	Amaranthaceae	<i>Achyranthes bidentata</i> Blume
2	Lamiaceae	<i>Achyrospermum wallichianum</i> (Benth.) Benth. ex Hook.f.
3	Asteraceae	<i>Acmella uliginosa</i> (Sw.) Cass.
4	Lauraceae	<i>Actinodaphne obovata</i>
5	Amaranthaceae	<i>Aerva lanata</i>
6	Meliaceae	<i>Aglaia spectabilis</i> (Miq.) S.S. Jain & S. Bennet
7	Simaroubaceae	<i>Ailanthus excelsa</i> Roxb.
8	Cornaceae	<i>Alangium chinense</i> (Lour.) Harms
9	Fabaceae	<i>Albizia procera</i>
10	Fabaceae	<i>Albizia procera</i> mature
11	Apocynaceae	<i>Alstonia scholaris</i>
12	Amaranthaceae	<i>Alternanthera pungens</i> Kunth
13	Commelinaceae	<i>Amischotolype hookeri</i> (Hassk.) H. Hara
14	Vitaceae	<i>Ampelocissus sikkimensis</i> (M.A. Lawson) Planch.
15	Lamiaceae	<i>Anisomeles indica</i> (L.) Kuntze
16	Phyllanthaceae	<i>Aporosa octandra</i> (Buch. -Ham. ex D. Don) Vickery mature
17	Myrsinaceae	<i>Ardisia solanacea</i> (Poir.) Roxb.
18	Convolvulaceae	<i>Argyreia roxburghii</i> (Wall.) Arn. ex Choisy
19	Moraceae	<i>Artocarpus chaplasi</i>
20	Acanthaceae	<i>Barleria cristata</i>
21	Acanthaceae	<i>Barleria strigosa</i> Willd.
22	Fabaceae	<i>Bauhinia vahlii</i> Wight & Arn.
23	Rhamnaceae	<i>Berchemia floribunda</i> (Wall.) Brongn.
24	Blechnaceae	<i>Blechnum sp</i>
25	Asteraceae	<i>Blumia lacera</i>
26	Urticaceae	<i>Boehmeria hamiltoniana</i> Wedd.
27	Malvaceae	<i>Bombax ceiba</i>
28	Rubiaceae	<i>Borreria alata</i>
29	Phyllanthaceae	<i>Bridelia sp</i>
30	Caesalpiniaceae	<i>Caesalpinia cuculata</i>
31	Arecaceae	<i>Calamus sp</i>
32	Lamiaceae	<i>Callicarpa sp</i>
33	Capparaceae	<i>Capparis zeylanica</i> L.
34	Lecythidaceae	<i>Careya arborea</i> Roxb.
35	Fabaceae	<i>Cassia sp</i>
36	Fagaceae	<i>Castanopsis indica</i>
37	Meliaceae	<i>Chisocheton cumingianus</i> (C.DC.) Harms
38	Meliaceae	<i>Chisocheton cumingianus</i> (C.DC.) Harms Mature
39	Chloranthaceae	<i>Chloranthus elatior</i> Link

40	Meliaceae	<i>Chukrasia tabularis</i> A. Juss.
41	Meliaceae	<i>Chukrasia tabularis</i> A. Juss. Mature
42	Lauraceae	<i>Cinamomum zeylacum</i>
43	Rutaceae	<i>Clausena excavata</i> Burm.f.
44	Cucurbitaceae	<i>Coccinia grandis</i> (L.) Voigt
45	Rubiaceae	<i>Coffea benghalensis</i> B. Heyne ex Schult.
46	Araceae	<i>Colocasia esculenta</i> (L.) Schott
47	Combretaceae	<i>Combretum</i> sp
48	Commelinaceae	<i>Commelina paludosa</i> Blume
49	Commelinaceae	<i>Commelina suffruticosa</i> Blume
50	Capparaceae	<i>Crateva religiosa</i> G. Forst.
51	Amaryllidaceae	<i>Crinum amoenum</i> Ker Gawl. ex Roxb.
52	Euphorbiaceae	<i>Croton caudatus</i> Geiseler
53	Zingiberaceae	<i>Curcuma amada</i> Roxb.
54	Fabaceae	<i>Dalbergia stipulacea</i> Roxb.
55	Amaranthaceae	<i>Deeringia</i> sp
56	Urticaceae	<i>Dendrocnide sinuata</i>
57	Fabaceae	<i>Desmodium heterocarpam</i>
58	Annonaceae	<i>Desmos dumosus</i>
59	Acanthaceae	<i>Dicliptera bupleuroides</i> Nees
60	Dilleniaceae	<i>Dillenia pentagyna</i> Mature
61	Dioscoreaceae	<i>Dioscorea</i> sp
62	Athyriaceae	<i>Diplazium esculentum</i> (Retz.) Sw.
63	Apocynaceae	<i>Dregea volubilis</i> (L.f.) Benth. ex Hook.f.
64	Caryophyllaceae	<i>Drymaria cordata</i> (L.) Willd. ex Schult.
65	Dryopteridaceae	<i>Dryopteris sparsa</i> (D. Don) Kuntze
66	Lythraceae	<i>Duabanga grandiflora</i> (DC.) Walp.
67	Asteraceae	<i>Elephantopus scaber</i> L.
68	Asteraceae	<i>Eleutheranthera ruderalis</i> (Sw.) Sch.Bip.
69	Acanthaceae	<i>Eranthemum griffithii</i> (T. Anderson) Bremek. & Nann. -Bremek.
70	Salicaceae	<i>Flacourtia indica</i> (Burm.f.) Merr.
71	Fabaceae	<i>Flemingia strobilifera</i> (L.) W.T. Aiton
72	Burseraceae	<i>Garuga floribunda</i> Decne.
73	Zingiberaceae	<i>Globba racemosa</i> Sm.
74	Acanthaceae	<i>Hygrophila phlomoides</i> Nees
75	Lamiaceae	<i>Hyptis suaveolens</i> (L.) Poit.
76	Apocynaceae	<i>Ichnocarpus frutescens</i> (L.) W.T. Aiton
77	Balsaminaceae	<i>Impatiens tricolor</i> Ridl.
78	Convolvulaceae	<i>Ipoemia</i> sp
79	Oleaceae	<i>Jasminum</i> sp
80	Acanthaceae	<i>Justicia hypoluca</i>
81	Lythraceae	<i>Lagerstroemia parviflora</i> Roxb.

82	Lythraceae	<i>Lagerstroemia parviflora</i> Roxb. Mature
83	Lythraceae	<i>Lagerstroemia speciosa</i> (L.) Pers.
84	Lythraceae	<i>Lagerstroemia speciosa</i> (L.) Pers. Mature
85	Acanthaceae	<i>Lepidagathis incurva</i> Buch. -Ham. ex D. Don
86	Lamiaceae	<i>Leucas aspera</i>
87	Lauraceae	<i>Litsea glutinosa</i> (Lour.) C.B. Rob.
88	Lauraceae	<i>Litsea glutinosa</i> (Lour.) C.B. Rob. Mature
89	Lauraceae	<i>Litsea monopetala</i> (Roxb.) Pers.
90	Lauraceae	<i>Litsea spp</i>
91	Onagraceae	<i>Ludwigia sp</i>
92	Cucurbitaceae	<i>Luffa acutangula</i> (L.) Roxb.
93	Euphorbiaceae	<i>Macaranga denticulata</i>
94	Primulaceae	<i>Maesa indica</i> (Roxb.) A. DC.
95	Magnoliaceae	<i>Magnolia champaca</i>
96	Anacardiaceae	<i>Mangifera sylvatica</i>
97	Melastomataceae	<i>Melastoma malabathricum</i> L.
98	Sabiaceae	<i>Meliosma simplicifolia</i> (Roxb.) Walp
99	Convolvulaceae	<i>Merremia vitifolia</i> (Burm. f.) Hallier f.
100	Rubiaceae	<i>Meyna spinosa</i> Roxb. ex Link
101	Dennstaedtiaceae	<i>Microlepia sp</i>
102	Rubiaceae	<i>Mitracarpus vertisilaster</i>
103	Rubiaceae	<i>Morinda angustifolia</i> Roxb.
104	Rutaceae	<i>Murraya koenigii</i> (L.) Spreng.
105	Ranunculaceae	<i>Naravelia zeylanica</i> (L.) DC.
106	Icacinaeae	<i>Natsiatum herpeticum</i> Buch. -Ham. ex Arn.
107	Acanthaceae	<i>Nelsonia canescens</i> (Lam.) Spreng.
108	Rubiaceae	<i>Neolamarckia camamba</i> (Roxb.) Bosser Mature
109	Nephrolepidaceae	<i>Nephrolepis auriculata</i>
110	Oxalidaceae	<i>Oxalis debilis</i> var. <i>corymbosa</i> (DC.) Lourteig
111	Pandanaceae	<i>Pandanus sp</i>
112	Polygonaceae	<i>Persicaria chinensis</i> (L.) H. Gross
113	Polygonaceae	<i>Persicaria sp</i>
114	Acanthaceae	<i>Phaulopsis imbricata</i> (Forssk.) Sweet
115	Acanthaceae	<i>Phlogacanthus thyrsifloras</i>
116	Urticaceae	<i>Pilea sp</i>
117	Piperaceae	<i>Piper longum</i> L.
118	Piperaceae	<i>Piper spp</i>
119	Piperaceae	<i>Piper sylvestre</i>
120	Myrtaceae	<i>Psidium guajava</i> L.
121	Pteridaceae	<i>Pteris biaurita</i> L.
122	Malvaceae	<i>Pterospermum acerifolium</i>
123	Amaranthaceae	<i>Pupalia lappacea</i> (L.) Juss.
124	Acanthaceae	<i>Rungia pectinata</i> (L.) Nees

125	Phyllanthaceae	<i>Sauropus compressus</i> Müll.Arg.
126	Theaceae	<i>Schima wallichii</i>
127	Dipterocarpaceae	<i>Shorea robusta</i> Gaertn.
128	Dipterocarpaceae	<i>Shorea robusta</i> Gaertn. Mature
129	Malvaceae	<i>Sida acuta</i> Burm.f.
130	Malvaceae	<i>Sida rhombifolia</i> L.
131	Smilacaceae	<i>Smilax perfoliata</i> Lour.
132	Menispermaceae	<i>Stephania glabra</i> (Roxb.) Miers
133	Malvaceae	<i>Sterculia villosa</i> Roxb.
134	Bignoniaceae	<i>Stereospermum tetragonum</i> DC.
135	Acanthaceae	<i>Strobilanthes</i> sp
136	Acanthaceae	<i>Strobilanthes</i> sp
137	Myrtaceae	<i>Syzygium</i> spp
138	Apocynaceae	<i>Tabernaemontana divericata</i> (L.) R. Br. Ex Roem. & Schult.
139	Lamiaceae	<i>Tectona grandis</i> L.f.
140	Lamiaceae	<i>Tectona grandis</i> L.f. Mature
141	Dilleniaceae	<i>Tetracera sarmentosa</i> (L.) Vahl
142	Vitaceae	<i>Tetrastigma dubium</i> (Lawson) Planch.
143	Vitaceae	<i>Tetrastigma planicaule</i> (Hook. f.) Gagnep.
144	Vitaceae	<i>Tetrastigma serrulatum</i> (Roxb.) Planch.
145	Vitaceae	<i>Tetrastigma</i> sp
146	Thelypteridaceae	<i>Thelypteris</i> sp
147	Acanthaceae	<i>Thunbergia fragrans</i>
148	Acanthaceae	<i>Thunbergia grandiflora</i> (Roxb. ex Rottl.) Roxb.
149	Euphorbiaceae	<i>Trewia nudiflora</i> var. polycarpa (Benth.) Susila & N.P. Balakr.
150	Euphorbiaceae	<i>Trewia nudiflora</i> var. polycarpa (Benth.) Susila & N.P. Balakr. Mature
151	Malvaceae	<i>Urena lobata</i> L.
152	Annonaceae	<i>Uvaria</i> sp
153	Apocynaceae	<i>Wrightia pubescens</i> R.Br.
154	Cucurbitaceae	<i>Zanonia indica</i> L.
155	Rutaceae	<i>Zanthoxylum</i> sp
156	Rhamnaceae	<i>Zizyphus rugosus</i>

a. Statistical evaluation:

i) Analysis of the vegetation data of fodder management plots:

Sukna Range:

Total 87 species were recorded from this range in pre monsoon season only. Total numbers of grass fodder and sedge species from this zone were recorded were 7, out of which 3 species were planted by Forest Department. Two more tree fodder species planted by Forest Department along with grass and bamboo fodder were also found here.

Statistical analysis of all the species found in the zone shows that highest IVI was recorded by *Oplismenus burmanni* (IVI= 73.72) followed by *Eragrostis sp* (IVI= 48.96). Both species belonged to the naturally grown grass fodder.

In planted species *Setaria palmifolia* possesses the highest IVI values (6.79) followed by *Bambusa tulda* (2.79).

In weed species *Mikania micrantha* recorded the highest IVI value of IVI= 7.57 followed by *Ageratum houstonianum* (IVI= 6.49).

Simpson Diversity Index (SDI) for Species diversity was calculated to be 0.74 for all plant species found in Sukna Range of Mahananda.

Table 60: Statistical analysis of all plant species recorded in Sukna Range of Mahananda WLS

SI no		Name of The Species	NI	O	F %	RF %	D/sq .m.	RD %	A	RA %	IVI	SDI
1	Planted species	<i>Setaria palmifolia</i> (J. Koenig) Stapf	200	1	14.29	0.60	0.29	1.70	200.00	4.49	6.79	0.74
2		<i>Bambusa tulda</i>	27	4	57.14	2.41	0.04	0.23	6.75	0.15	2.79	
3		<i>Mallotus philippensis</i> (Lam.) Müll.Arg. Juvenile	7	2	28.57	1.20	0.01	0.06	3.50	0.08	1.34	
4		<i>Bambusa spp</i>	16	1	14.29	0.60	0.02	0.14	16.00	0.36	1.10	
5		<i>Terminalia bellirica</i> (Gaertn.) Roxb.	1	1	14.29	0.60	0.00	0.01	1.00	0.02	0.63	
6	Natural Grass fodder and sedge	<i>Oplismenus burmanni</i> (Retz.) P. Beauv.	5440	5	71.43	3.01	7.77	46.29	1088.00	24.43	73.72	
7		<i>Eragrostis sp</i>	2420	2	28.57	1.20	3.46	20.59	1210.00	27.16	48.96	
8		<i>Digitaria sp</i>	400	1	14.29	0.60	0.57	3.40	400.00	8.98	12.99	
9		<i>Cyperus sp</i>	2	1	14.29	0.60	0.00	0.02	2.00	0.04	0.66	
10	Weeds	<i>Mikania micrantha</i> Kunth	351	5	71.43	3.01	0.50	2.99	70.20	1.58	7.57	
11		<i>Ageratum houstonianum</i> Mill.	268	2	28.57	1.20	0.38	2.28	134.00	3.01	6.49	
12		<i>Ageratum conyzoides</i> (L.) L.	121	2	28.57	1.20	0.17	1.03	60.50	1.36	3.59	
13		<i>Chromolaena odorata</i> (L.) R.M. King & H. Rob.	58	3	42.86	1.81	0.08	0.49	19.33	0.43	2.73	
14		<i>Triumfetta rhomboidea</i> Jacq.	40	3	42.86	1.81	0.06	0.34	13.33	0.30	2.45	
15		<i>Clerodendrum infortunatum</i> L.	24	3	42.86	1.81	0.03	0.20	8.00	0.18	2.19	
16		<i>Stephania hernandiifolia</i> (Willd.) Walp.	6	3	42.86	1.81	0.01	0.05	2.00	0.04	1.90	
17		<i>Paederia foetida</i> L.	10	2	28.57	1.20	0.01	0.09	5.00	0.11	1.40	
18		<i>Ipomoea nil</i> (L.) Roth	4	1	14.29	0.60	0.01	0.03	4.00	0.09	0.73	
19		<i>Lantana camara</i> L.	9	1	14.29	0.60	0.01	0.08	9.00	0.20	0.88	

20		<i>Mukia maderaspatana</i> (L.) M. Roem.	1	1	14.29	0.60	0.00	0.01	1.00	0.02	0.63
21	Other Species	<i>Nelsonia canescens</i> (Lam.) Spreng.	300	1	14.29	0.60	0.43	2.55	300.00	6.73	9.89
22		<i>Dryopteris sparsa</i> (D. Don) Kuntze	375	4	57.14	2.41	0.54	3.19	93.75	2.10	7.70
23		<i>Pupalia lappacea</i> (L.) Juss.	353	4	57.14	2.41	0.50	3.00	88.25	1.98	7.39
24		<i>Phaulopsis imbricata</i> (Forssk.) Sweet	193	5	71.43	3.01	0.28	1.64	38.60	0.87	5.52
25		<i>Piper sp</i>	176	4	57.14	2.41	0.25	1.50	44.00	0.99	4.89
26		<i>Dicliptera bupleuroides</i> Nees	104	4	57.14	2.41	0.15	0.88	26.00	0.58	3.88
27		<i>Achyrosperrum wallichianum</i> (Benth.) Benth. ex Hook.f.	100	1	14.29	0.60	0.14	0.85	100.00	2.24	3.70
28		<i>Diplazium esculentum</i> (Retz.) Sw.	104	3	42.86	1.81	0.15	0.88	34.67	0.78	3.47
29		<i>Merremia vitifolia</i> (Burm. f.) Hallier f.	16	5	71.43	3.01	0.02	0.14	3.20	0.07	3.22
30		<i>Lagerstroemia speciosa</i> (L.) Pers. Juvenile	13	5	71.43	3.01	0.02	0.11	2.60	0.06	3.18
31		<i>Sida acuta</i> Burm.f.	75	3	42.86	1.81	0.11	0.64	25.00	0.56	3.01
32		<i>Rungia pectinata</i> (L.) Nees	74	3	42.86	1.81	0.11	0.63	24.67	0.55	2.99
33		<i>Urena lobata</i> L.	31	4	57.14	2.41	0.04	0.26	7.75	0.17	2.85
34		<i>Morinda angustifolia</i> Roxb.	8	4	57.14	2.41	0.01	0.07	2.00	0.04	2.52
35		<i>Trewia nudiflora</i> var. <i>polycarpa</i> (Benth.) Susila & N.P. Balakr.	4	4	57.14	2.41	0.01	0.03	1.00	0.02	2.47
36		<i>Coffea benghalensis</i> B. Heyne ex Schult.	25	3	42.86	1.81	0.04	0.21	8.33	0.19	2.21
37		<i>Pteris biaurita</i> L.	51	1	14.29	0.60	0.07	0.43	51.00	1.14	2.18
38		<i>Strabilanthes sp</i>	46	2	28.57	1.20	0.07	0.39	23.00	0.52	2.11
39		<i>Boehmeria hamiltoniana</i> Wedd.	45	2	28.57	1.20	0.06	0.38	22.50	0.51	2.09
40		<i>Alangium chinense</i> (Lour.) Harms	6	3	42.86	1.81	0.01	0.05	2.00	0.04	1.90
41		<i>Ardisia solanacea</i> (Poir.) Roxb.	34	2	28.57	1.20	0.05	0.29	17.00	0.38	1.88
42		<i>Chisocheton cumingianus</i> (C.DC.) Harms	3	3	42.86	1.81	0.00	0.03	1.00	0.02	1.86
43		<i>Alternanthera pungens</i> Kunth	40	1	14.29	0.60	0.06	0.34	40.00	0.90	1.84
44		<i>Piper spp</i>	38	1	14.29	0.60	0.05	0.32	38.00	0.85	1.78
45		<i>Lepidagathis incurva</i> Buch. -Ham. ex D. Don	27	2	28.57	1.20	0.04	0.23	13.50	0.30	1.74
46		<i>Tetrastigma serrulatum</i> (Roxb.) Planch.	26	2	28.57	1.20	0.04	0.22	13.00	0.29	1.72
47		<i>Ichnocarpus frutescens</i> (L.) W.T. Aiton	35	1	14.29	0.60	0.05	0.30	35.00	0.79	1.69
48		<i>Maesa indica</i> (Roxb.) A. DC.	20	2	28.57	1.20	0.03	0.17	10.00	0.22	1.60
49		<i>Thelypteris sp</i>	14	2	28.57	1.20	0.02	0.12	7.00	0.16	1.48
50		<i>Achyranthes bidentata</i> Blume	7	2	28.57	1.20	0.01	0.06	3.50	0.08	1.34
51		<i>Chisocheton cumingianus</i> (C.DC.) Harms Juvenile	5	2	28.57	1.20	0.01	0.04	2.50	0.06	1.30
52		<i>Trewia nudiflora</i> var. <i>polycarpa</i> (Benth.) Susila & N.P. Balakr. Juvenile	2	2	28.57	1.20	0.00	0.02	1.00	0.02	1.24
53		<i>Acmella uliginosa</i> (Sw.) Cass.	16	1	14.29	0.60	0.02	0.14	16.00	0.36	1.10
54		<i>Eleutheranthera ruderalis</i> (Sw.) Sch.Bip.	13	1	14.29	0.60	0.02	0.11	13.00	0.29	1.00
55		<i>Piper longum</i> L.	11	1	14.29	0.60	0.02	0.09	11.00	0.25	0.94
56		<i>Tetrastigma dubium</i> (Lawson) Planch.	11	1	14.29	0.60	0.02	0.09	11.00	0.25	0.94
57		<i>Crinum amoenum</i> Ker Gawl. ex Roxb.	8	1	14.29	0.60	0.01	0.07	8.00	0.18	0.85
58		<i>Litsea sp</i>	8	1	14.29	0.60	0.01	0.07	8.00	0.18	0.85
59		<i>Lagerstroemia speciosa</i> (L.) Pers.	6	1	14.29	0.60	0.01	0.05	6.00	0.13	0.79
60		<i>Ipoemia sp</i>	4	1	14.29	0.60	0.01	0.03	4.00	0.09	0.73
61		<i>Barleria strigosa</i> Willd.	3	1	14.29	0.60	0.00	0.03	3.00	0.07	0.70

62	<i>Commelina suffruticosa</i> Blume	3	1	14.29	0.60	0.00	0.03	3.00	0.07	0.70
63	<i>Impatiens tricolor</i> Ridl.	3	1	14.29	0.60	0.00	0.03	3.00	0.07	0.70
64	<i>Litsea monopetala</i> (Roxb.) Pers.	3	1	14.29	0.60	0.00	0.03	3.00	0.07	0.70
65	<i>Meyna spinosa</i> Roxb. ex Link	3	1	14.29	0.60	0.00	0.03	3.00	0.07	0.70
66	<i>Natsiatum herpeticum</i> Buch. -Ham. ex Arn.	3	1	14.29	0.60	0.00	0.03	3.00	0.07	0.70
67	<i>Oxalis debilis</i> var. <i>corymbosa</i> (DC.) Lourteig	3	1	14.29	0.60	0.00	0.03	3.00	0.07	0.70
68	<i>Clausena excavata</i> Burm.f.	2	1	14.29	0.60	0.00	0.02	2.00	0.04	0.66
69	<i>Combretum</i> sp	2	1	14.29	0.60	0.00	0.02	2.00	0.04	0.66
70	<i>Flemingia strobilifera</i> (L.) W.T. Aiton	2	1	14.29	0.60	0.00	0.02	2.00	0.04	0.66
71	<i>Aglaia spectabilis</i> (Miq.) S.S. Jain & S. Bennet	1	1	14.29	0.60	0.00	0.01	1.00	0.02	0.63
72	<i>Ailanthus excelsa</i> Roxb.	1	1	14.29	0.60	0.00	0.01	1.00	0.02	0.63
73	<i>Careya arborea</i> Roxb.	1	1	14.29	0.60	0.00	0.01	1.00	0.02	0.63
74	<i>Chukrasia tabularis</i> A. Juss.	1	1	14.29	0.60	0.00	0.01	1.00	0.02	0.63
75	<i>Coccinia grandis</i> (L.) Voigt	1	1	14.29	0.60	0.00	0.01	1.00	0.02	0.63
76	<i>Dregea volubilis</i> (L.f.) Benth. ex Hook.f.	1	1	14.29	0.60	0.00	0.01	1.00	0.02	0.63
77	<i>Duabanga grandiflora</i> (DC.) Walp.	1	1	14.29	0.60	0.00	0.01	1.00	0.02	0.63
78	<i>Flacourtia indica</i> (Burm.f.) Merr.	1	1	14.29	0.60	0.00	0.01	1.00	0.02	0.63
79	<i>Garuga floribunda</i> Decne.	1	1	14.29	0.60	0.00	0.01	1.00	0.02	0.63
80	<i>Lagerstroemia parviflora</i> Roxb.	1	1	14.29	0.60	0.00	0.01	1.00	0.02	0.63
81	<i>Lagerstroemia parviflora</i> Roxb. Juvenile	1	1	14.29	0.60	0.00	0.01	1.00	0.02	0.63
82	<i>Litsea glutinosa</i> (Lour.) C.B. Rob.	1	1	14.29	0.60	0.00	0.01	1.00	0.02	0.63
83	<i>Luffa acutangula</i> (L.) Roxb.	1	1	14.29	0.60	0.00	0.01	1.00	0.02	0.63
84	<i>Murraya koenigii</i> (L.) Spreng.	1	1	14.29	0.60	0.00	0.01	1.00	0.02	0.63
85	<i>Psidium guajava</i> L.	1	1	14.29	0.60	0.00	0.01	1.00	0.02	0.63
86	<i>Sterculia villosa</i> Roxb.	1	1	14.29	0.60	0.00	0.01	1.00	0.02	0.63
87	<i>Tetracera sarmentosa</i> (L.) Vahl	1	1	14.29	0.60	0.00	0.01	1.00	0.02	0.63

NI= Number of Individuals, O= Occurance, F= Frequency, RF=Relative Frequency, D/sq m=Density per sq metre, RD=Relative Density, A=Abundance, RA= Relative Abundance, IVI= Importance Value Index, SDI= Simpson's Diversity Index

West Range:

Total 99 species were recorded from this range in pre monsoon season only. Total numbers of grass fodder and sedge species from this zone were recorded were 12, out of which 6 species were planted by Forest Department. Four more tree fodder species planted by Forest Department along with grass and bamboo fodder were also found here.

Statistical analysis of all the species found in the zone shows that highest IVI was recorded by *Axonopus compressus* (IVI= 115.53) followed by *Oplismenus burmanni* (IVI= 14.34). Both species belonged to the naturally grown grass fodder.

In planted species *Bambusa spp* possesses the highest IVI values (4.08) followed by *Setaria palmifolia* (2.90).

In weed species *Clerodendrum infortunatum* recorded the highest IVI value of 5.51 followed by *Chromolaena odorata* (IVI= 3.87).

Simpson Diversity Index (SDI) for Species diversity was calculated to be 0.79 for all plant species found in West Range of Mahananda.

Table 61: Statistical analysis of all plant species recorded in West Range of Mahananda WLS

SI no		Name of The Species	NI	O	F %	RF %	D/sq.m	RD %	A	RA %	IVI	SDI
1	Planted species	<i>Bambusa spp</i>	49	8	72.73	3.56	0.04	0.44	6.13	0.09	4.08	0.79
2		<i>Setaria palmifolia</i> (J. Koenig) Stapf	90	4	36.36	1.78	0.08	0.80	22.50	0.32	2.90	
3		<i>Alpina nigra</i>	64	1	9.09	0.44	0.06	0.57	64.00	0.90	1.92	
4		<i>Terminalia myriocarpa</i> Van Heurck & Müll. Arg.	4	3	27.27	1.33	0.00	0.04	1.33	0.02	1.39	
5		<i>Saccharum narenga</i>	35	1	9.09	0.44	0.03	0.31	35.00	0.49	1.25	
6		<i>Mallotus philippensis</i> (Lam.) Müll.Arg.	14	2	18.18	0.89	0.01	0.12	7.00	0.10	1.11	
7		<i>Bambusa sp (non-Thorny bamboo)</i>	3	1	9.09	0.44	0.00	0.03	3.00	0.04	0.51	
8		<i>Coix lacryma-jobi</i> L.	3	1	9.09	0.44	0.00	0.03	3.00	0.04	0.51	
9		<i>Dillenia indica</i> L.	2	1	9.09	0.44	0.00	0.02	2.00	0.03	0.49	
10		<i>Terminalia bellirica</i> (Gaertn.) Roxb.	1	1	9.09	0.44	0.00	0.01	1.00	0.01	0.47	
11	Natural Grass fodder and sedge	<i>Axonopus compressus</i> (Sw.) P. Beauv.	5000	1	9.09	0.44	4.55	44.43	5000.00	70.65	115.53	
12		<i>Oplismenus burmanni</i> (Retz.) P. Beauv.	1038	6	54.55	2.67	0.94	9.22	173.00	2.44	14.34	
13		<i>Eragrostis sp</i>	521	5	45.45	2.22	0.47	4.63	104.20	1.47	8.32	
14		<i>Digitaria sp</i>	35	1	9.09	0.44	0.03	0.31	35.00	0.49	1.25	
15		<i>Carex sp</i>	22	1	9.09	0.44	0.02	0.20	22.00	0.31	0.95	
16		<i>Cyperus sp</i>	5	1	9.09	0.44	0.00	0.04	5.00	0.07	0.56	
17	Harmful weeds	<i>Clerodendrum infortunatum</i> L.	220	7	63.64	3.11	0.20	1.96	31.43	0.44	5.51	
18		<i>Chromolaena odorata</i> (L.) R.M. King & H. Rob.	141	5	45.45	2.22	0.13	1.25	28.20	0.40	3.87	
19		<i>Mikania micrantha</i> Kunth	118	5	45.45	2.22	0.11	1.05	23.60	0.33	3.60	
20		<i>Triumfetta rhomboidea</i> Jacq.	46	3	27.27	1.33	0.04	0.41	15.33	0.22	1.96	
21		<i>Ageratum conyzoides</i> (L.) L.	66	2	18.18	0.89	0.06	0.59	33.00	0.47	1.94	
22		<i>Ageratum houstonianum</i> Mill.	66	2	18.18	0.89	0.06	0.59	33.00	0.47	1.94	
23		<i>Stephania hernandiifolia</i> (Willd.) Walp.	14	3	27.27	1.33	0.01	0.12	4.67	0.07	1.52	
24		<i>Ipomoea nil</i> (L.) Roth	22	2	18.18	0.89	0.02	0.20	11.00	0.16	1.24	
25		<i>Paederia foetida</i> L.	11	2	18.18	0.89	0.01	0.10	5.50	0.08	1.06	
26		<i>Leea asiatica</i> (L.) Ridsdale	6	1	9.09	0.44	0.01	0.05	6.00	0.08	0.58	
27		<i>Streblus asper</i> Lour.	2	1	9.09	0.44	0.00	0.02	2.00	0.03	0.49	
28		<i>Cassia pinnata</i> Voigt	2	1	9.09	0.44	0.00	0.02	2.00	0.03	0.49	
29		<i>Leea guineensis</i> G. Don	1	1	9.09	0.44	0.00	0.01	1.00	0.01	0.47	
30	Other Species	<i>Coffea benghalensis</i> B. Heyne ex Schult.	385	7	63.64	3.11	0.35	3.42	55.00	0.78	7.31	
31		<i>Drymaria cordata</i> (L.) Willd. ex Schult.	380	2	18.18	0.89	0.35	3.38	190.00	2.68	6.95	
32		<i>Pupalia lappacea</i> (L.) Juss.	298	5	45.45	2.22	0.27	2.65	59.60	0.84	5.71	
33		<i>Strobilanthus sp</i>	275	3	27.27	1.33	0.25	2.44	91.67	1.30	5.07	
34		<i>Piper spp</i>	198	5	45.45	2.22	0.18	1.76	39.60	0.56	4.54	

35	<i>Dryopteris sparsa</i> (D. Don) Kuntze	191	5	45.45	2.22	0.17	1.70	38.20	0.54	4.46
36	<i>Commelina suffruticosa</i> Blume	207	2	18.18	0.89	0.19	1.84	103.50	1.46	4.19
37	<i>Litsea spp</i>	121	6	54.55	2.67	0.11	1.08	20.17	0.28	4.03
38	<i>Maesa indica</i> (Roxb.) A. DC.	107	6	54.55	2.67	0.10	0.95	17.83	0.25	3.87
39	<i>Eranthemum griffithii</i> (T. Anderson) Bremek. & Nann. -Bremek.	166	2	18.18	0.89	0.15	1.48	83.00	1.17	3.54
40	<i>Lepidagathis incurva</i> Buch. -Ham. ex D. Don	158	3	27.27	1.33	0.14	1.40	52.67	0.74	3.48
41	<i>Chisocheton cumingianus</i> (C.DC.) Harms	50	6	54.55	2.67	0.05	0.44	8.33	0.12	3.23
42	<i>Phaulopsis imbricata</i> (Forssk.) Sweet	76	4	36.36	1.78	0.07	0.68	19.00	0.27	2.72
43	<i>Barleria strigosa</i> Willd.	99	3	27.27	1.33	0.09	0.88	33.00	0.47	2.68
44	<i>Combretum sp</i>	35	5	45.45	2.22	0.03	0.31	7.00	0.10	2.63
45	<i>Boehmeria hamiltoniana</i> Wedd.	90	3	27.27	1.33	0.08	0.80	30.00	0.42	2.56
46	<i>Diplazium esculentum</i> (Retz.) Sw.	88	3	27.27	1.33	0.08	0.78	29.33	0.41	2.53
47	<i>Tectona grandis</i> L.f. Mature	10	5	45.45	2.22	0.01	0.09	2.00	0.03	2.34
48	<i>Persicaria chinensis</i> (L.) H. Gross	75	2	18.18	0.89	0.07	0.67	37.50	0.53	2.09
49	<i>Microlepia sp</i>	49	3	27.27	1.33	0.04	0.44	16.33	0.23	2.00
50	<i>Achyrosperrum wallichianum</i> (Benth.) Benth. ex Hook.f.	62	1	9.09	0.44	0.06	0.55	62.00	0.88	1.87
51	<i>Rungia pectinata</i> (L.) Nees	62	1	9.09	0.44	0.06	0.55	62.00	0.88	1.87
52	<i>Merremia vitifolia</i> (Burm. f.) Hallier f.	31	3	27.27	1.33	0.03	0.28	10.33	0.15	1.75
53	<i>Commelina paludosa</i> Blume	50	2	18.18	0.89	0.05	0.44	25.00	0.35	1.69
54	<i>Lagerstroemia speciosa</i> (L.) Pers. Mature	16	3	27.27	1.33	0.01	0.14	5.33	0.08	1.55
55	<i>Natsiatum herpeticum</i> Buch. -Ham. ex Arn.	10	3	27.27	1.33	0.01	0.09	3.33	0.05	1.47
56	<i>Naravelia zeylanica</i> (L.) DC.	8	3	27.27	1.33	0.01	0.07	2.67	0.04	1.44
57	<i>Urena lobata</i> L.	34	2	18.18	0.89	0.03	0.30	17.00	0.24	1.43
58	<i>Alangium chinense</i> (Lour.) Harms	6	3	27.27	1.33	0.01	0.05	2.00	0.03	1.41
59	<i>Persicaria sp</i>	38	1	9.09	0.44	0.03	0.34	38.00	0.54	1.32
60	<i>Morinda angustifolia</i> Roxb.	26	2	18.18	0.89	0.02	0.23	13.00	0.18	1.30
61	<i>Tetrastigma serrulatum</i> (Roxb.) Planch.	23	2	18.18	0.89	0.02	0.20	11.50	0.16	1.26
62	<i>Thunbergia grandiflora</i> (Roxb. ex Rottl.) Roxb.	9	2	18.18	0.89	0.01	0.08	4.50	0.06	1.03
63	<i>Chloranthus elatior</i> Link	25	1	9.09	0.44	0.02	0.22	25.00	0.35	1.02
64	<i>Croton caudatus</i> Geiseler	6	2	18.18	0.89	0.01	0.05	3.00	0.04	0.98
65	<i>Lagerstroemia speciosa</i> (L.) Pers.	5	2	18.18	0.89	0.00	0.04	2.50	0.04	0.97
66	<i>Litsea glutinosa</i> (Lour.) C.B. Rob.	4	2	18.18	0.89	0.00	0.04	2.00	0.03	0.95
67	<i>Trewia nudiflora</i> var. <i>polycarpa</i> (Benth.) Susila & N.P. Balakr. Mature	4	2	18.18	0.89	0.00	0.04	2.00	0.03	0.95
68	<i>Hygrophila phlomoides</i> Nees	22	1	9.09	0.44	0.02	0.20	22.00	0.31	0.95
69	<i>Pteris biaurita</i> L.	22	1	9.09	0.44	0.02	0.20	22.00	0.31	0.95
70	<i>Shorea robusta</i> Gaertn. Mature	3	2	18.18	0.89	0.00	0.03	1.50	0.02	0.94
71	<i>Tectona grandis</i> L.f.	3	2	18.18	0.89	0.00	0.03	1.50	0.02	0.94
72	<i>Wrightia pubescens</i> R.Br.	3	2	18.18	0.89	0.00	0.03	1.50	0.02	0.94
73	<i>Anisomeles indica</i> (L.) Kuntze	18	1	9.09	0.44	0.02	0.16	18.00	0.25	0.86
74	<i>Sida rhombifolia</i> L.	16	1	9.09	0.44	0.01	0.14	16.00	0.23	0.81

75	<i>Dicliptera bupleuroides</i> Nees	12	1	9.09	0.44	0.01	0.11	12.00	0.17	0.72
76	<i>Colocasia esculenta</i> (L.) Schott	8	1	9.09	0.44	0.01	0.07	8.00	0.11	0.63
77	<i>Tetragstigma sp</i>	8	1	9.09	0.44	0.01	0.07	8.00	0.11	0.63
78	<i>Argyreia roxburghii</i> (Wall.) Arn. ex Choisy	7	1	9.09	0.44	0.01	0.06	7.00	0.10	0.61
79	<i>Clausena excavata</i> Burm.f.	6	1	9.09	0.44	0.01	0.05	6.00	0.08	0.58
80	<i>Melastoma malabathricum</i> L.	6	1	9.09	0.44	0.01	0.05	6.00	0.08	0.58
81	<i>Tetragstigma dubium</i> (Lawson) Planch.	6	1	9.09	0.44	0.01	0.05	6.00	0.08	0.58
82	<i>Capparis zeylanica</i> L.	5	1	9.09	0.44	0.00	0.04	5.00	0.07	0.56
83	<i>Crateva religiosa</i> G. Forst.	4	1	9.09	0.44	0.00	0.04	4.00	0.06	0.54
84	<i>Deeringia sp</i>	3	1	9.09	0.44	0.00	0.03	3.00	0.04	0.51
85	<i>Tetragstigma planicaule</i> (Hook. f.) Gagnep.	3	1	9.09	0.44	0.00	0.03	3.00	0.04	0.51
86	<i>Ampelocissus sikkimensis</i> (M.A. Lawson) Planch.	2	1	9.09	0.44	0.00	0.02	2.00	0.03	0.49
87	<i>Chukrasia tabularis</i> A. Juss. Mature	2	1	9.09	0.44	0.00	0.02	2.00	0.03	0.49
88	<i>Ichnocarpus frutescens</i> (L.) W.T. Aiton	2	1	9.09	0.44	0.00	0.02	2.00	0.03	0.49
89	<i>Lagerstroemia parviflora</i> Roxb. Mature	2	1	9.09	0.44	0.00	0.02	2.00	0.03	0.49
90	<i>Sauropus compressus</i> Müll.Arg.	2	1	9.09	0.44	0.00	0.02	2.00	0.03	0.49
91	<i>Smilax perfoliata</i> Lour.	2	1	9.09	0.44	0.00	0.02	2.00	0.03	0.49
92	<i>Stephania glabra</i> (Roxb.) Miers	2	1	9.09	0.44	0.00	0.02	2.00	0.03	0.49
93	<i>Bauhinia vahlii</i> Wight & Arn.	1	1	9.09	0.44	0.00	0.01	1.00	0.01	0.47
94	<i>Berberis floribunda</i> (Wall.) Brongn.	1	1	9.09	0.44	0.00	0.01	1.00	0.01	0.47
95	<i>Careya arborea</i> Roxb.	1	1	9.09	0.44	0.00	0.01	1.00	0.01	0.47
96	<i>Dalbergia stipulacea</i> Roxb.	1	1	9.09	0.44	0.00	0.01	1.00	0.01	0.47
97	<i>Dillenia pentagyna</i> Mature	1	1	9.09	0.44	0.00	0.01	1.00	0.01	0.47
98	<i>Globba racemosa</i> Sm.	1	1	9.09	0.44	0.00	0.01	1.00	0.01	0.47
99	<i>Zanonia indica</i> L.	1	1	9.09	0.44	0.00	0.01	1.00	0.01	0.47

NI= Number of Individuals, O= Occurance, F= Frequency, RF=Relative Frequency, D/sq m=Density per sq metre, RD=Relative Density, A=Abundance, RA= Relative Abundance, IVI= Importance Value Index, SDI= Simpson's Diversity Index

South Range:

Total 85 species were recorded from this range in pre monsoon season only. Total numbers of grass fodder and sedge species from this zone were recorded were 15, out of which 4 species were planted by Forest Department. Two more tree fodder species planted by Forest Department along with grass and bamboo fodder were also found here.

Statistical analysis of all the species found in the zone shows that highest IVI was recorded by *Oplismenus burmanni* (IVI= 29.02) followed by *Eragrostis spp* (IVI= 26.15). Both species belonged to the naturally grown grass fodder.

In planted species *Bambusa spp* possesses the highest IVI values (3.49) followed by *Saccharum narenga* (2.60).

In weed species *Ageratum houstonianum* recorded the highest IVI value of 5.46 followed by *Mikania micrantha* (IVI= 4.87).

Simpson Diversity Index (SDI) for Species diversity was calculated to be 0.92 for all plant species found in South Range of Mahananda.

Table 62: Statistical analysis of all plant species recorded in South Range of Mahananda WLS

Sl no		Name of The Species	NI	O	F %	RF %	D/sq.m.	RD %	A	RA %	IVI	SDI
1	Planted species	<i>Bambusa spp</i>	12	4	66.67	3.28	0.02	0.15	3.00	0.06	3.49	0.92
2		<i>Saccharum narenga</i>	43	2	33.33	1.64	0.07	0.53	21.50	0.43	2.60	
3		<i>Themeda arundinacea</i>	26	2	33.33	1.64	0.04	0.32	13.00	0.26	2.22	
4		<i>Dillenia indica</i> L.	3	2	33.33	1.64	0.01	0.04	1.50	0.03	1.71	
5		<i>Mallotus philippensis</i> (Lam.) Müll.Arg.	12	1	16.67	0.82	0.02	0.15	12.00	0.24	1.21	
6		<i>Alpina nigra</i>	6	1	16.67	0.82	0.01	0.07	6.00	0.12	1.01	
7	Natural Grass fodder and sedge	<i>Oplismenus burmanni</i> (Retz.) P. Beauv.	1400	3	50.00	2.46	2.33	17.18	466.67	9.38	29.02	
8		<i>Eragrostis spp</i>	1322	4	66.67	3.28	2.20	16.22	330.50	6.64	26.15	
9		<i>Imperata cylindrica</i>	400	1	16.67	0.82	0.67	4.91	400.00	8.04	13.77	
10		<i>Saccharum spontaneum</i>	400	1	16.67	0.82	0.67	4.91	400.00	8.04	13.77	
11		<i>Axonopus compressus</i> (Sw.) P. Beauv.	525	3	50.00	2.46	0.88	6.44	175.00	3.52	12.42	
12		<i>Cynodon dactylon</i> (L.) Pers.	200	1	16.67	0.82	0.33	2.45	200.00	4.02	7.29	
13		<i>Themeda sp</i>	48	1	16.67	0.82	0.08	0.59	48.00	0.96	2.37	
14		<i>Carex sp</i>	25	1	16.67	0.82	0.04	0.31	25.00	0.50	1.63	
15		<i>Digitaria sp</i>	22	1	16.67	0.82	0.04	0.27	22.00	0.44	1.53	
16		<i>Alpinia galanga</i>	16	1	16.67	0.82	0.03	0.20	16.00	0.32	1.34	
17		<i>Cyperus sp</i>	4	1	16.67	0.82	0.01	0.05	4.00	0.08	0.95	
18	Weeds	<i>Ageratum houstonianum</i> Mill.	158	3	50.00	2.46	0.26	1.94	52.67	1.06	5.46	
19		<i>Mikania micrantha</i> Kunth	92	4	66.67	3.28	0.15	1.13	23.00	0.46	4.87	
20		<i>Chromolaena odorata</i> (L.) R.M. King & H. Rob.	77	4	66.67	3.28	0.13	0.95	19.25	0.39	4.61	
21		<i>Clerodendrum infortunatum</i> L.	29	2	33.33	1.64	0.05	0.36	14.50	0.29	2.29	
22		<i>Stephania hernandiifolia</i> (Willd.) Walp.	3	1	16.67	0.82	0.01	0.04	3.00	0.06	0.92	
23		<i>Ipomoea nil</i> (L.) Roth	2	1	16.67	0.82	0.00	0.02	2.00	0.04	0.88	
24		<i>Leea asiatica</i> (L.) Ridsdale	2	1	16.67	0.82	0.00	0.02	2.00	0.04	0.88	
25		<i>Streblus asper</i> Lour.	1	1	16.67	0.82	0.00	0.01	1.00	0.02	0.85	
26	Other Species	<i>Piper sylvestre</i>	600	1	16.67	0.82	1.00	7.36	600.00	12.06	20.24	
27		<i>Phaulopsis imbricata</i> (Forssk.) Sweet	400	1	16.67	0.82	0.67	4.91	400.00	8.04	13.77	
28		<i>Amischotolype hookeri</i> (Hassk.) H. Hara	448	2	33.33	1.64	0.75	5.50	224.00	4.50	11.64	
29		<i>Commelina paludosa</i> Blume	300	1	16.67	0.82	0.50	3.68	300.00	6.03	10.53	
30		<i>Pupalia lappacea</i> (L.) Juss.	312	2	33.33	1.64	0.52	3.83	156.00	3.13	8.60	
31		<i>Mitracarpus vertisilaster</i>	200	1	16.67	0.82	0.33	2.45	200.00	4.02	7.29	
32		<i>Nelsonia canescens</i> (Lam.) Spreng.	200	1	16.67	0.82	0.33	2.45	200.00	4.02	7.29	

33	<i>Melastoma malabathricum</i> L.	74	4	66.67	3.28	0.12	0.91	18.50	0.37	4.56
34	<i>Borreria alata</i>	120	2	33.33	1.64	0.20	1.47	60.00	1.21	4.32
35	<i>Piper sp</i>	81	1	16.67	0.82	0.14	0.99	81.00	1.63	3.44
36	<i>Elephantopus scaber</i> L.	80	1	16.67	0.82	0.13	0.98	80.00	1.61	3.41
37	<i>Diplazium esculentum</i> (Retz.) Sw.	79	2	33.33	1.64	0.13	0.97	39.50	0.79	3.40
38	<i>Ichnocarpus frutescens</i> (L.) W.T. Aiton	47	2	33.33	1.64	0.08	0.58	23.50	0.47	2.69
39	<i>Maesa indica</i> (Roxb.) A. DC.	25	2	33.33	1.64	0.04	0.31	12.50	0.25	2.20
40	<i>Lagerstroemia speciosa</i> (L.) Pers.	22	2	33.33	1.64	0.04	0.27	11.00	0.22	2.13
41	<i>Coffea benghalensis</i> B. Heyne ex Schult.	40	1	16.67	0.82	0.07	0.49	40.00	0.80	2.11
42	<i>Litsea spp</i>	19	2	33.33	1.64	0.03	0.23	9.50	0.19	2.06
43	<i>Lagerstroemia speciosa</i> (L.) Pers. Mature	9	2	33.33	1.64	0.02	0.11	4.50	0.09	1.84
44	<i>Syzygium spp</i>	9	2	33.33	1.64	0.02	0.11	4.50	0.09	1.84
45	<i>Litsea monopetala</i> (Roxb.) Pers.	6	2	33.33	1.64	0.01	0.07	3.00	0.06	1.77
46	<i>Shorea robusta</i> Gaertn. Mature	2	2	33.33	1.64	0.00	0.02	1.00	0.02	1.68
47	<i>Ludwigia sp</i>	23	1	16.67	0.82	0.04	0.28	23.00	0.46	1.56
48	<i>Dryopteris sparsa</i> (D. Don) Kuntze	22	1	16.67	0.82	0.04	0.27	22.00	0.44	1.53
49	<i>Lepidagathis incurva</i> Buch. -Ham. ex D. Don	22	1	16.67	0.82	0.04	0.27	22.00	0.44	1.53
50	<i>Sida acuta</i> Burm.f.	22	1	16.67	0.82	0.04	0.27	22.00	0.44	1.53
51	<i>Tectona grandis</i> L.f. coppies	16	1	16.67	0.82	0.03	0.20	16.00	0.32	1.34
52	<i>Macaranga denticulata</i>	14	1	16.67	0.82	0.02	0.17	14.00	0.28	1.27
53	<i>Litsea glutinosa</i> (Lour.) C.B. Rob.	13	1	16.67	0.82	0.02	0.16	13.00	0.26	1.24
54	<i>Acmella uliginosa</i> (Sw.) Cass.	12	1	16.67	0.82	0.02	0.15	12.00	0.24	1.21
55	<i>Dactyloctenium aegyptium</i>	12	1	16.67	0.82	0.02	0.15	12.00	0.24	1.21
56	<i>Thelypteris sp</i>	12	1	16.67	0.82	0.02	0.15	12.00	0.24	1.21
57	<i>Persicaria chinensis</i> (L.) H. Gross	8	1	16.67	0.82	0.01	0.10	8.00	0.16	1.08
58	<i>Chisocheton cumingianus</i> (C.DC.) Harms Juvenile	5	1	16.67	0.82	0.01	0.06	5.00	0.10	0.98
59	<i>Desmodium heterocarpam</i>	5	1	16.67	0.82	0.01	0.06	5.00	0.10	0.98
60	<i>Hyptige suaveolens</i>	5	1	16.67	0.82	0.01	0.06	5.00	0.10	0.98
61	<i>Tetrastigma planicaule</i> (Hook. f.) Gagnep.	5	1	16.67	0.82	0.01	0.06	5.00	0.10	0.98
62	<i>Albizia procera</i>	4	1	16.67	0.82	0.01	0.05	4.00	0.08	0.95
63	<i>Bridelia sp</i>	4	1	16.67	0.82	0.01	0.05	4.00	0.08	0.95
64	<i>Actinodaphne obovata</i>	3	1	16.67	0.82	0.01	0.04	3.00	0.06	0.92
65	<i>Desmos dumosus</i>	3	1	16.67	0.82	0.01	0.04	3.00	0.06	0.92
66	<i>Dillenia indica</i> L. mature	3	1	16.67	0.82	0.01	0.04	3.00	0.06	0.92
67	<i>Dregea volubilis</i> (L.f.) Benth. ex Hook.f.	3	1	16.67	0.82	0.01	0.04	3.00	0.06	0.92
68	<i>Globba racemosa</i> Sm.	3	1	16.67	0.82	0.01	0.04	3.00	0.06	0.92
69	<i>Shorea robusta</i> Gaertn.	3	1	16.67	0.82	0.01	0.04	3.00	0.06	0.92
70	<i>Tabernaemontana divericata</i> (L.) R. Br. Ex Roem. & Schult.	3	1	16.67	0.82	0.01	0.04	3.00	0.06	0.92
71	<i>Urena lobata</i> L.	3	1	16.67	0.82	0.01	0.04	3.00	0.06	0.92
72	<i>Curcuma amada</i> Roxb.	2	1	16.67	0.82	0.00	0.02	2.00	0.04	0.88

73	<i>Litsea glutinosa</i> (Lour.) C.B. Rob. Mature	2	1	16.67	0.82	0.00	0.02	2.00	0.04	0.88
74	<i>Tectona grandis</i> L.f. Mature	2	1	16.67	0.82	0.00	0.02	2.00	0.04	0.88
75	<i>Tetrastigma</i> sp	2	1	16.67	0.82	0.00	0.02	2.00	0.04	0.88
76	<i>Aglaia spectabilis</i> (Miq.) S.S. Jain & S. Bennet	1	1	16.67	0.82	0.00	0.01	1.00	0.02	0.85
77	<i>Alangium chinense</i> (Lour.) Harms	1	1	16.67	0.82	0.00	0.01	1.00	0.02	0.85
78	<i>Albizia procera</i> mature	1	1	16.67	0.82	0.00	0.01	1.00	0.02	0.85
79	<i>Aporosa octandra</i> (Buch. -Ham. ex D. Don) Vickery mature	1	1	16.67	0.82	0.00	0.01	1.00	0.02	0.85
80	<i>Bombax ceiba</i>	1	1	16.67	0.82	0.00	0.01	1.00	0.02	0.85
81	<i>Chukrasia tabularis</i> A. Juss.	1	1	16.67	0.82	0.00	0.01	1.00	0.02	0.85
82	<i>Coccinia grandis</i> (L.) Voigt	1	1	16.67	0.82	0.00	0.01	1.00	0.02	0.85
83	<i>Neolamarckia camamba</i> (Roxb.) Bosser Mature	1	1	16.67	0.82	0.00	0.01	1.00	0.02	0.85
84	<i>Trewia nudiflora</i> var. <i>polycarpa</i> (Benth.) Susila & N.P. Balakr. Mature	1	1	16.67	0.82	0.00	0.01	1.00	0.02	0.85
85	<i>Uvaria</i> sp	1	1	16.67	0.82	0.00	0.01	1.00	0.02	0.85

NI= Number of Individuals, O= Occurance, F= Frequency, RF=Relative Frequency, D/sq m=Density per sq metre, RD=Relative Density, A=Abundance, RA= Relative Abundance, IVI= Importance Value Index, SDI= Simpson's Diversity Index

North Range:

Total 102 species were recorded from this range in pre monsoon season only. This part of the sanctuary belongs to the hilly area. Total numbers of grass fodder and sedge species from this zone were recorded were 12, out of which 5 species were planted by Forest Department. Two more tree fodder species planted by Forest Department along with grass and bamboo fodder were also found here.

Statistical analysis of all the species found in the zone shows that highest IVI was recorded by *Drymaria cordata* (IVI= 73.99) followed by *Eragrostis* sp (IVI= 54.61). The first species was categorized as other species and the 2nd one belonged to the naturally grown grass fodder.

In planted species *Bambusa spp* possesses the highest IVI values (5.82) followed by *Thysanolaena maxima* (5.32).

In weed species *Chromolaena odorata* recorded the highest IVI value of 5.13 followed by *Ageratum conyzoides* (IVI= 2.91).

Simpson Diversity Index (SDI) for Species diversity was calculated to be 0.82 for all plant species found in North Range of Mahananda.

Table 63: Statistical analysis of all plant species recorded in North Range of Mahananda WLS

Sl no		Name of The Species	NI	O	F %	RF %	D/sq.m	RD %	A	RA %	IVI	SDI
1	Planted species	<i>Bambusa spp</i>	161	11	100.00	5.02	0.146	0.683	14.64	0.12	5.82	0.82
2		<i>Thysanolenia maxima</i>	560	4	36.36	1.83	0.509	2.377	140.00	1.12	5.32	
3		<i>Dillenia indica</i> L.	20	4	36.36	1.83	0.018	0.085	5.00	0.04	1.95	
4		<i>Alpina nigra</i>	70	2	18.18	0.91	0.064	0.297	35.00	0.28	1.49	
5		<i>Mallotus philippensis</i> (Lam.) Müll.Arg.	7	3	27.27	1.37	0.006	0.030	2.33	0.02	1.42	
6		<i>Themeda arundinacea</i>	38	1	9.09	0.46	0.035	0.161	38.00	0.30	0.92	
7		<i>Curculigo recurvata</i>	4	1	9.09	0.46	0.004	0.017	4.00	0.03	0.51	
8	Natural Grass fodder and sedge	<i>Eragrostis sp</i>	7700	3	27.27	1.37	7.000	32.681	2566.67	20.56	54.61	
9		<i>Oplismenus burmanni</i> (Retz.) P. Beauv.	1348	8	72.73	3.65	1.225	5.721	168.50	1.35	10.72	
10		<i>Carex sp</i>	944	4	36.36	1.83	0.858	4.007	236.00	1.89	7.72	
11		<i>Cyperus sp</i>	141	5	45.45	2.28	0.128	0.598	28.20	0.23	3.11	
12		<i>Saccharum spontaneum</i>	28	1	9.09	0.46	0.025	0.119	28.00	0.22	0.80	
13		<i>Kylinga nemoralis</i>	9	1	9.09	0.46	0.008	0.038	9.00	0.07	0.57	
14		<i>Alpinia galanga</i>	4	1	9.09	0.46	0.004	0.017	4.00	0.03	0.51	
15	Harmful weeds	<i>Chromolaena odorata</i> (L.) R.M. King & H. Rob.	429	6	54.55	2.74	0.390	1.821	71.50	0.57	5.13	
16		<i>Ageratum conyzoides</i> (L.) L.	200	1	9.09	0.46	0.182	0.849	200.00	1.60	2.91	
17		<i>Clerodendrum infortunatum</i> L.	161	4	36.36	1.83	0.146	0.683	40.25	0.32	2.83	
18		<i>Lygodium flexuosum</i>	30	3	27.27	1.37	0.027	0.127	10.00	0.08	1.58	
19		<i>Cassia pinnata</i> Voigt	20	3	27.27	1.37	0.018	0.085	6.67	0.05	1.51	
20		<i>Lantana camara</i> L.	34	2	18.18	0.91	0.031	0.144	17.00	0.14	1.19	
21		<i>Paederia foetida</i> L.	23	2	18.18	0.91	0.021	0.098	11.50	0.09	1.10	
22		<i>Stephania hernandiifolia</i> (Willd.) Walp.	9	2	18.18	0.91	0.008	0.038	4.50	0.04	0.99	
23		<i>Eupatorium adenophorum</i>	22	1	9.09	0.46	0.020	0.093	22.00	0.18	0.73	
24		<i>Vernonia ceneria</i>	12	1	9.09	0.46	0.011	0.051	12.00	0.10	0.60	
25		<i>Triumfetta rhomboidea</i> Jacq.	2	1	9.09	0.46	0.002	0.008	2.00	0.02	0.48	
26	Other Species	<i>Drymaria cordata</i> (L.) Willd. ex Schult.	6000	1	9.09	0.46	5.455	25.466	6000.00	48.07	73.99	
27		<i>Nephrolepis auriculata</i>	1650	2	18.18	0.91	1.500	7.003	825.00	6.61	14.53	
28		<i>Justicia hypoluca</i>	600	1	9.09	0.46	0.545	2.547	600.00	4.81	7.81	
29		<i>Coffea benghalensis</i> B. Heyne ex Schult.	628	5	45.45	2.28	0.571	2.665	125.60	1.01	5.95	
30		<i>Strobilanthes sp</i>	424	3	27.27	1.37	0.385	1.800	141.33	1.13	4.30	
31		<i>Dicliptera bupleuroides</i> Nees	364	4	36.36	1.83	0.331	1.545	91.00	0.73	4.10	
32		<i>Pilea sp</i>	348	2	18.18	0.91	0.316	1.477	174.00	1.39	3.78	
33		<i>Shorea robusta</i> Gaertn.	119	6	54.55	2.74	0.108	0.505	19.83	0.16	3.40	
34		<i>Barleria cristata</i>	200	1	9.09	0.46	0.182	0.849	200.00	1.60	2.91	
35		<i>Sauropus compressus</i> Müll.Arg.	55	5	45.45	2.28	0.050	0.233	11.00	0.09	2.60	
36		<i>Syzygium spp</i>	17	5	45.45	2.28	0.015	0.072	3.40	0.03	2.38	
37		<i>Barleria strigosa</i> Willd.	162	2	18.18	0.91	0.147	0.688	81.00	0.65	2.25	
38		<i>Clausena excavata</i> Burm.f.	37	4	36.36	1.83	0.034	0.157	9.25	0.07	2.06	
39		<i>Eranthemum griffithii</i> (T. Anderson)	95	3	27.27	1.37	0.086	0.403	31.67	0.25	2.03	

	Bremek. & Nann. -Bremek.									
40	<i>Lagerstroemia speciosa</i> (L.) Pers.	28	4	36.36	1.83	0.025	0.119	7.00	0.06	2.00
41	<i>Macaranga denticulata</i>	64	3	27.27	1.37	0.058	0.272	21.33	0.17	1.81
42	<i>Ichnocarpus frutescens</i> (L.) W.T. Aiton	52	3	27.27	1.37	0.047	0.221	17.33	0.14	1.73
43	<i>Lepidagathis incurva</i> Buch. -Ham. ex D. Don	93	2	18.18	0.91	0.085	0.395	46.50	0.37	1.68
44	<i>Wrightia pubescens</i> R.Br.	38	3	27.27	1.37	0.035	0.161	12.67	0.10	1.63
45	<i>Litsea glutinosa</i> (Lour.) C.B. Rob.	32	3	27.27	1.37	0.029	0.136	10.67	0.09	1.59
46	<i>Uvaria</i> sp	32	3	27.27	1.37	0.029	0.136	10.67	0.09	1.59
47	<i>Combretum</i> sp	30	3	27.27	1.37	0.027	0.127	10.00	0.08	1.58
48	<i>Meyna spinosa</i> Roxb. ex Link	25	3	27.27	1.37	0.023	0.106	8.33	0.07	1.54
49	<i>Lagerstroemia parviflora</i> Roxb.	22	3	27.27	1.37	0.020	0.093	7.33	0.06	1.52
50	<i>Schima wallichii</i>	14	3	27.27	1.37	0.013	0.059	4.67	0.04	1.47
51	<i>Tectona grandis</i> L.f.	12	3	27.27	1.37	0.011	0.051	4.00	0.03	1.45
52	<i>Smilax perfoliata</i> Lour.	53	2	18.18	0.91	0.048	0.225	26.50	0.21	1.35
53	<i>Pupalia lappacea</i> (L.) Juss.	50	2	18.18	0.91	0.045	0.212	25.00	0.20	1.33
54	<i>Litsea</i> spp	26	2	18.18	0.91	0.024	0.110	13.00	0.10	1.13
55	<i>Jasminum</i> sp	21	2	18.18	0.91	0.019	0.089	10.50	0.08	1.09
56	<i>Bauhinia vahlii</i> Wight & Arn.	14	2	18.18	0.91	0.013	0.059	7.00	0.06	1.03
57	<i>Tabernaemontana divaricata</i>	13	2	18.18	0.91	0.012	0.055	6.50	0.05	1.02
58	<i>Castanopsis indica</i>	12	2	18.18	0.91	0.011	0.051	6.00	0.05	1.01
59	<i>Thunbergia fragrans</i>	10	2	18.18	0.91	0.009	0.042	5.00	0.04	1.00
60	<i>Pteris biaurita</i> L.	9	2	18.18	0.91	0.008	0.038	4.50	0.04	0.99
61	<i>Litsea monopetala</i> (Roxb.) Pers.	6	2	18.18	0.91	0.005	0.025	3.00	0.02	0.96
62	<i>Stereospermum tetragonum</i> DC.	4	2	18.18	0.91	0.004	0.017	2.00	0.02	0.95
63	<i>Meliosma simplicifolia</i> (Roxb.) Walp	3	2	18.18	0.91	0.003	0.013	1.50	0.01	0.94
64	<i>Zanthoxylum</i> sp	3	2	18.18	0.91	0.003	0.013	1.50	0.01	0.94
65	<i>Leucas aspera</i>	33	1	9.09	0.46	0.030	0.140	33.00	0.26	0.86
66	<i>Phaulopsis imbricata</i> (Forssk.) Sweet	22	1	9.09	0.46	0.020	0.093	22.00	0.18	0.73
67	<i>Phlogacanthus thyrsoifloras</i>	22	1	9.09	0.46	0.020	0.093	22.00	0.18	0.73
68	<i>Elephantopus scaber</i> L.	18	1	9.09	0.46	0.016	0.076	18.00	0.14	0.68
69	<i>Piper</i> sp	16	1	9.09	0.46	0.015	0.068	16.00	0.13	0.65
70	<i>Caesalpinia cuculata</i>	12	1	9.09	0.46	0.011	0.051	12.00	0.10	0.60
71	<i>Aerva lanata</i>	9	1	9.09	0.46	0.008	0.038	9.00	0.07	0.57
72	<i>Blumia lacera</i>	8	1	9.09	0.46	0.007	0.034	8.00	0.06	0.55
73	<i>Albizia procera</i>	6	1	9.09	0.46	0.005	0.025	6.00	0.05	0.53
74	<i>Aglaia spectabilis</i> (Miq.) S.S. Jain & S. Bennet	5	1	9.09	0.46	0.005	0.021	5.00	0.04	0.52
75	<i>Cinamomum zeylacum</i>	5	1	9.09	0.46	0.005	0.021	5.00	0.04	0.52
76	<i>Dendrochride sinuta</i>	5	1	9.09	0.46	0.005	0.021	5.00	0.04	0.52
77	<i>Ampelocissus sikkimensis</i> (M.A. Lawson) Planch.	4	1	9.09	0.46	0.004	0.017	4.00	0.03	0.51
78	<i>Dillenia pentagyna</i> Mature	4	1	9.09	0.46	0.004	0.017	4.00	0.03	0.51
79	<i>Morinda angustifolia</i> Roxb.	4	1	9.09	0.46	0.004	0.017	4.00	0.03	0.51
80	<i>Zizyphus rugosus</i>	4	1	9.09	0.46	0.004	0.017	4.00	0.03	0.51

81	<i>Actinodaphne obovata</i>	3	1	9.09	0.46	0.003	0.013	3.00	0.02	0.49
82	<i>Aporosa octandra</i> mature	3	1	9.09	0.46	0.003	0.013	3.00	0.02	0.49
83	<i>Cassia</i> sp	3	1	9.09	0.46	0.003	0.013	3.00	0.02	0.49
84	<i>Dalbergia stipulacea</i> Roxb.	3	1	9.09	0.46	0.003	0.013	3.00	0.02	0.49
85	<i>Microlepidia</i> sp	3	1	9.09	0.46	0.003	0.013	3.00	0.02	0.49
86	<i>Pterospermum acerifolium</i>	3	1	9.09	0.46	0.003	0.013	3.00	0.02	0.49
87	<i>Artocarpus chaplasi</i>	2	1	9.09	0.46	0.002	0.008	2.00	0.02	0.48
88	<i>Blechnum</i> sp	2	1	9.09	0.46	0.002	0.008	2.00	0.02	0.48
89	<i>Calamus</i> sp	2	1	9.09	0.46	0.002	0.008	2.00	0.02	0.48
90	<i>Capparis zeylanica</i> L.	2	1	9.09	0.46	0.002	0.008	2.00	0.02	0.48
91	<i>Careya arborea</i> Roxb.	2	1	9.09	0.46	0.002	0.008	2.00	0.02	0.48
92	<i>Globba racemosa</i> Sm.	2	1	9.09	0.46	0.002	0.008	2.00	0.02	0.48
93	<i>Magnolia champaca</i>	2	1	9.09	0.46	0.002	0.008	2.00	0.02	0.48
94	<i>Pandanus</i> sp	2	1	9.09	0.46	0.002	0.008	2.00	0.02	0.48
95	<i>Thunbergia grandiflora</i> (Roxb. ex Rottl.) Roxb.	2	1	9.09	0.46	0.002	0.008	2.00	0.02	0.48
96	<i>Alstonia scholaris</i>	1	1	9.09	0.46	0.001	0.004	1.00	0.01	0.47
97	<i>Calycarpus</i> sp	1	1	9.09	0.46	0.001	0.004	1.00	0.01	0.47
98	<i>Chisocheton cumingianus</i> (C.DC.) Harms	1	1	9.09	0.46	0.001	0.004	1.00	0.01	0.47
99	<i>Desmodium heterocarpum</i>	1	1	9.09	0.46	0.001	0.004	1.00	0.01	0.47
100	<i>Dioscorea</i> sp	1	1	9.09	0.46	0.001	0.004	1.00	0.01	0.47
101	<i>Mangifera sylvatica</i>	1	1	9.09	0.46	0.001	0.004	1.00	0.01	0.47
102	<i>Trewia nudiflora</i> var. <i>polycarpa</i> (Benth.) Susila & N.P. Balakr.	1	1	9.09	0.46	0.001	0.004	1.00	0.01	0.47

NI= Number of Individuals, O= Occurance, F= Frequency, RF=Relative Frequency, D/sq m=Density per sq metre, RD=Relative Density, A=Abundance, RA= Relative Abundance, IVI= Importance Value Index, SDI= Simpson's Diversity Index

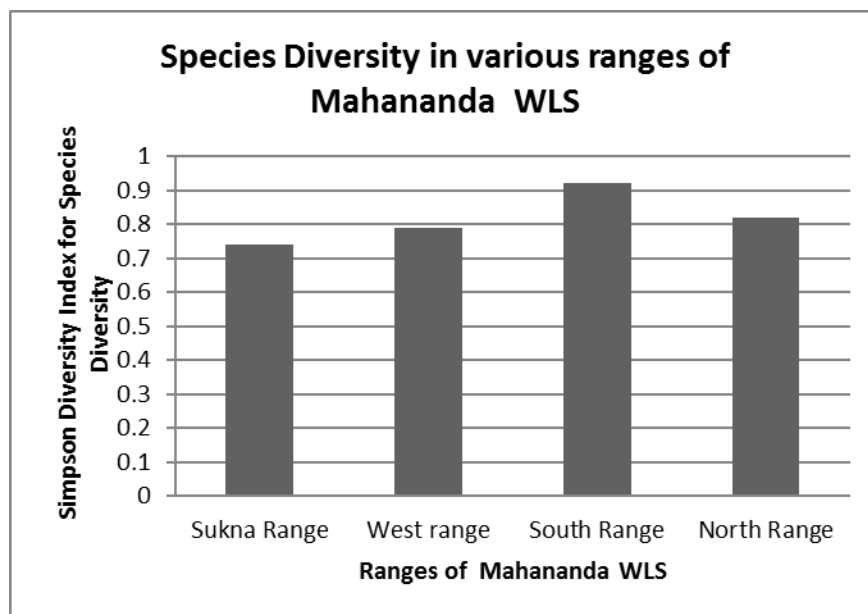


Figure 48: Comparison of species diversity in different Ranges in Mahananda

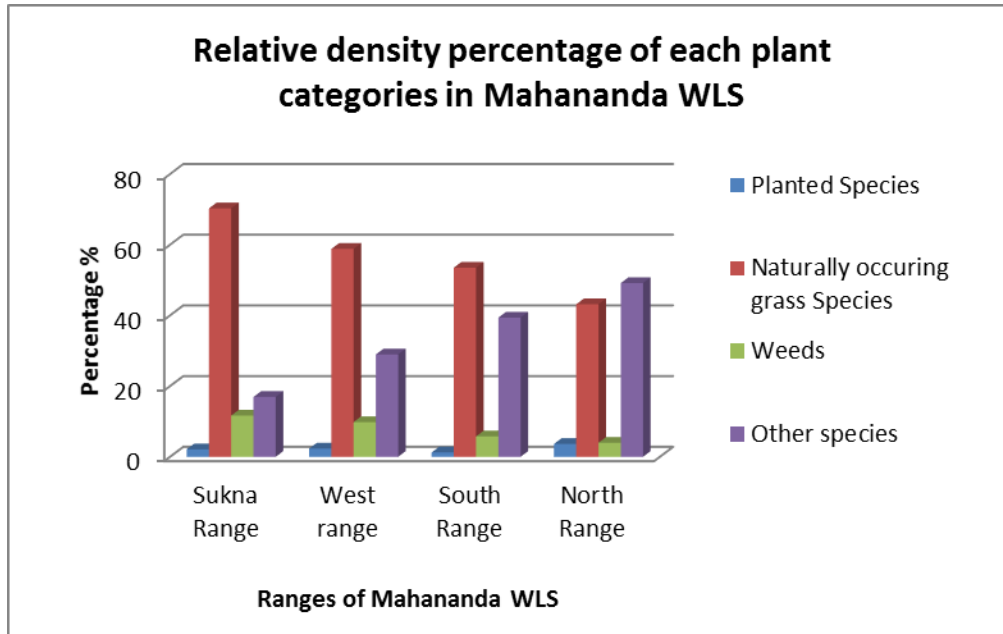


Figure 49: Comparison of Relative density of each plant categories within different ranges

Table 64: Statistical analysis of all plant species recorded in whole Mahananda WLS

SI No.	Class	Name of The Species	NI	O	F %	RF %	D/sq.m.	RD %	A	RA %	IVI	SDI
1	Planted Grass fodders, bamboo and tree fodder species	<i>Bambusa spp</i>	238	24	68.57	3.29	0.068	0.43	9.92	0.08	3.81	0.9
2		<i>Thysanolenia maxima</i>	560	4	11.43	0.55	0.160	1.02	140.00	1.19	2.76	
3		<i>Setaria palmifolia</i>	290	5	14.29	0.68	0.083	0.53	58.00	0.49	1.71	
4		<i>Mallotus philippensis</i>	40	8	22.86	1.10	0.011	0.07	5.00	0.04	1.21	
5		<i>Alpina nigra</i>	140	4	11.43	0.55	0.040	0.26	35.00	0.30	1.10	
6		<i>Dillenia indica</i>	25	7	20.00	0.96	0.007	0.05	3.57	0.03	1.03	
7		<i>Saccharum narenga</i>	78	3	8.57	0.41	0.022	0.14	26.00	0.22	0.77	
8		<i>Themeda arundinacea</i>	64	3	8.57	0.41	0.018	0.12	21.33	0.18	0.71	
9		<i>Bambusa tulda</i>	27	4	11.43	0.55	0.008	0.05	6.75	0.06	0.65	
10		<i>Terminalia myriocarpa</i>	4	3	8.57	0.41	0.001	0.01	1.33	0.01	0.43	
11		<i>Terminalia bellirica</i>	2	2	5.71	0.27	0.001	0.00	1.00	0.01	0.29	
12		<i>Curculigo recurvata</i>	4	1	2.86	0.14	0.001	0.01	4.00	0.03	0.18	
13		<i>Bambusa sp</i> (non-Thorney bamboo)	3	1	2.86	0.14	0.001	0.01	3.00	0.03	0.17	
14		<i>Coix lacryma-jobi</i>	3	1	2.86	0.14	0.001	0.01	3.00	0.03	0.17	
15	Natural Grass, fodder and Sedge	<i>Eragrostis spp</i>	11963	14	40.00	1.92	3.418	21.82	854.50	7.26	31.00	
16		<i>Oplismenus burmanni</i>	9226	22	62.86	3.01	2.636	16.82	419.36	3.56	23.40	
17		<i>Axonopus compressus</i>	5525	4	11.43	0.55	1.579	10.08	1381.25	11.74	22.36	
18		<i>Imperata cylindrica</i>	400	1	2.86	0.14	0.114	0.73	400.00	3.40	4.27	
19		<i>Carex sp</i>	991	6	17.14	0.82	0.283	1.81	165.17	1.40	4.03	
20		<i>Saccharum spontaneum</i>	428	2	5.71	0.27	0.122	0.78	214.00	1.82	2.87	
21		<i>Digitaria sp</i>	457	3	8.57	0.41	0.131	0.83	152.33	1.29	2.54	
22		<i>Cynodon dactylon</i>	200	1	2.86	0.14	0.057	0.36	200.00	1.70	2.20	
23		<i>Cyperus sp</i>	152	8	22.86	1.10	0.043	0.28	19.00	0.16	1.53	
24		<i>Themeda sp</i>	48	1	2.86	0.14	0.014	0.09	48.00	0.41	0.63	
25		<i>Alpinia galanga</i>	20	2	5.71	0.27	0.006	0.04	10.00	0.09	0.40	
26		<i>Dactyloctenium aegypticum</i>	12	1	2.86	0.14	0.003	0.02	12.00	0.10	0.26	
27		<i>Kylinga nemoralis</i>	9	1	2.86	0.14	0.003	0.02	9.00	0.08	0.23	

28	Weeds	<i>Chromolaena odorata</i>	705	18	51.43	2.47	0.201	1.29	39.17	0.33	4.08
29		<i>Mikania micrantha</i>	561	14	40.00	1.92	0.160	1.02	40.07	0.34	3.28
30		<i>Clerodendrum infortunatum</i>	434	16	45.71	2.19	0.124	0.79	27.13	0.23	3.21
31		<i>Ageratum houstonianum</i>	492	7	20.00	0.96	0.141	0.90	70.29	0.60	2.45
32		<i>Ageratum conyzoides</i>	387	5	14.29	0.68	0.111	0.71	77.40	0.66	2.05
33		<i>Stephania hernandiifolia</i>	32	9	25.71	1.23	0.009	0.06	3.56	0.03	1.32
34		<i>Triumfetta rhomboidea</i>	88	7	20.00	0.96	0.025	0.16	12.57	0.11	1.23
35		<i>Paederia foetida</i>	44	6	17.14	0.82	0.013	0.08	7.33	0.06	0.96
36		<i>Ipomoea nil</i>	28	4	11.43	0.55	0.008	0.05	7.00	0.06	0.66
37		<i>Cassia pinnata</i>	22	4	11.43	0.55	0.006	0.04	5.50	0.05	0.63
38		<i>Lantana camara</i>	43	3	8.57	0.41	0.012	0.08	14.33	0.12	0.61
39		<i>Lygodium flexuosum</i>	30	3	8.57	0.41	0.009	0.05	10.00	0.09	0.55
40		<i>Eupatorium adenophorum</i>	22	1	2.86	0.14	0.006	0.04	22.00	0.19	0.36
41		<i>Leea asiatica</i>	8	2	5.71	0.27	0.002	0.01	4.00	0.03	0.32
42		<i>Streblus asper</i>	3	2	5.71	0.27	0.001	0.01	1.50	0.01	0.29
43		<i>Vernonia ceneria</i>	12	1	2.86	0.14	0.003	0.02	12.00	0.10	0.26
44		<i>Leea guineensis</i>	1	1	2.86	0.14	0.000	0.00	1.00	0.01	0.15
45		<i>Mukia maderaspatana</i>	1	1	2.86	0.14	0.000	0.00	1.00	0.01	0.15
46	Other Species	<i>Drymaria cordata</i>	6380	3	8.57	0.41	1.823	11.63	2126.67	18.08	30.12
47		<i>Nephrolepis auriculata</i>	1650	2	5.71	0.27	0.471	3.01	825.00	7.01	10.30
48		<i>Justicia hypoluca</i>	600	1	2.86	0.14	0.171	1.09	600.00	5.10	6.33
49		<i>Piper sylvestre</i>	600	1	2.86	0.14	0.171	1.09	600.00	5.10	6.33
50		<i>Coffea benghalensis</i>	1078	16	45.71	2.19	0.308	1.97	67.38	0.57	4.73
51		<i>Pupalia lappacea</i>	1013	13	37.14	1.78	0.289	1.85	77.92	0.66	4.29
52		<i>Nelsonia canescens</i>	500	2	5.71	0.27	0.143	0.91	250.00	2.13	3.31
53		<i>Phaulopsis imbricata</i>	691	11	31.43	1.51	0.197	1.26	62.82	0.53	3.30
54		<i>Strobilanthus sp</i>	699	6	17.14	0.82	0.200	1.27	116.50	0.99	3.09
55		<i>Amischotolype hookeri</i>	448	2	5.71	0.27	0.128	0.82	224.00	1.90	3.00
56		<i>Dryopteris sparsa</i>	588	10	28.57	1.37	0.168	1.07	58.80	0.50	2.94
57		<i>Piper spp</i>	509	12	34.29	1.64	0.145	0.93	42.42	0.36	2.93

58	<i>Dicliptera bupleuroides</i>	480	9	25.71	1.23	0.137	0.88	53.33	0.45	2.56
59	<i>Pilea sp</i>	348	2	5.71	0.27	0.099	0.63	174.00	1.48	2.39
60	<i>Barleria cristata</i>	200	1	2.86	0.14	0.057	0.36	200.00	1.70	2.20
61	<i>Mitracarpus vertisilaster</i>	200	1	2.86	0.14	0.057	0.36	200.00	1.70	2.20
62	<i>Lagerstroemia speciosa</i>	74	14	40.00	1.92	0.021	0.13	5.29	0.04	2.10
63	<i>Commelina paludosa</i>	350	3	8.57	0.41	0.100	0.64	116.67	0.99	2.04
64	<i>Lepidagathis incurva</i>	300	8	22.86	1.10	0.086	0.55	37.50	0.32	1.96
65	<i>Litsea spp</i>	174	11	31.43	1.51	0.050	0.32	15.82	0.13	1.96
66	<i>Diplazium esculentum</i>	271	8	22.86	1.10	0.077	0.49	33.88	0.29	1.88
67	<i>Maesa indica</i>	152	10	28.57	1.37	0.043	0.28	15.20	0.13	1.78
68	<i>Barleria strigosa</i>	264	6	17.14	0.82	0.075	0.48	44.00	0.37	1.68
69	<i>Eranthemum griffithii</i>	261	5	14.29	0.68	0.075	0.48	52.20	0.44	1.60
70	<i>Chisocheton cumingianus</i>	54	10	28.57	1.37	0.015	0.10	5.40	0.05	1.51
71	<i>Combretum sp</i>	67	9	25.71	1.23	0.019	0.12	7.44	0.06	1.42
72	<i>Commelina suffruticosa</i>	210	3	8.57	0.41	0.060	0.38	70.00	0.60	1.39
73	<i>Ichnocarpus frutescens</i>	136	7	20.00	0.96	0.039	0.25	19.43	0.17	1.37
74	<i>Shorea robusta Gaertn.</i>	122	7	20.00	0.96	0.035	0.22	17.43	0.15	1.33
75	<i>Achyrosperrum wallichianum</i>	162	2	5.71	0.27	0.046	0.30	81.00	0.69	1.26
76	<i>Merremia vitifolia</i>	47	8	22.86	1.10	0.013	0.09	5.88	0.05	1.23
77	<i>Urena lobata</i>	68	7	20.00	0.96	0.019	0.12	9.71	0.08	1.17
78	<i>Boehmeria hamiltoniana</i>	135	5	14.29	0.68	0.039	0.25	27.00	0.23	1.16
79	<i>Litsea glutinosa</i>	50	7	20.00	0.96	0.014	0.09	7.14	0.06	1.11
80	<i>Rungia pectinata</i>	136	4	11.43	0.55	0.039	0.25	34.00	0.29	1.08
81	<i>Morinda angustifolia</i>	38	7	20.00	0.96	0.011	0.07	5.43	0.05	1.07
82	<i>Syzygium spp</i>	26	7	20.00	0.96	0.007	0.05	3.71	0.03	1.04
83	<i>Sauropus compressus</i>	57	6	17.14	0.82	0.016	0.10	9.50	0.08	1.01
84	<i>Borreria alata</i>	120	2	5.71	0.27	0.034	0.22	60.00	0.51	1.00
85	<i>Alangium chinense</i>	13	7	20.00	0.96	0.004	0.02	1.86	0.02	1.00
86	<i>Clausena excavata</i>	45	6	17.14	0.82	0.013	0.08	7.50	0.06	0.97
87	<i>Melastoma malabathricum</i>	80	5	14.29	0.68	0.023	0.15	16.00	0.14	0.97

88	<i>Sida acuta</i>	97	4	11.43	0.55	0.028	0.18	24.25	0.21	0.93
89	<i>Tectona grandis</i>	31	6	17.14	0.82	0.009	0.06	5.17	0.04	0.92
90	<i>Pteris biaurita</i>	82	4	11.43	0.55	0.023	0.15	20.50	0.17	0.87
91	<i>Elephantopus scaber</i>	98	2	5.71	0.27	0.028	0.18	49.00	0.42	0.87
92	<i>Tectona grandis</i>	12	6	17.14	0.82	0.003	0.02	2.00	0.02	0.86
93	<i>Macaranga denticulata</i>	78	4	11.43	0.55	0.022	0.14	19.50	0.17	0.86
94	<i>Trewia nudiflora</i> var. <i>polycarpa</i>	7	6	17.14	0.82	0.002	0.01	1.17	0.01	0.84
95	<i>Wrightia pubescens</i>	41	5	14.29	0.68	0.012	0.07	8.20	0.07	0.83
96	<i>Persicaria chinensis</i>	83	3	8.57	0.41	0.024	0.15	27.67	0.24	0.80
97	<i>Lagerstroemia speciosa</i>	25	5	14.29	0.68	0.007	0.05	5.00	0.04	0.77
98	<i>Lagerstroemia parviflora</i>	24	5	14.29	0.68	0.007	0.04	4.80	0.04	0.77
99	<i>Microlepia</i> sp	52	4	11.43	0.55	0.015	0.09	13.00	0.11	0.75
100	<i>Tetrastigma serrulatum</i>	49	4	11.43	0.55	0.014	0.09	12.25	0.10	0.74
101	<i>Litsea monopetala</i>	15	5	14.29	0.68	0.004	0.03	3.00	0.03	0.74
102	<i>Uvaria</i> sp	33	4	11.43	0.55	0.009	0.06	8.25	0.07	0.68
103	<i>Smilax perfoliata</i>	55	3	8.57	0.41	0.016	0.10	18.33	0.16	0.67
104	<i>Meyna spinosa</i>	28	4	11.43	0.55	0.008	0.05	7.00	0.06	0.66
105	<i>Natsiatum herpeticum</i>	13	4	11.43	0.55	0.004	0.02	3.25	0.03	0.60
106	<i>Shorea robusta</i>	5	4	11.43	0.55	0.001	0.01	1.25	0.01	0.57
107	<i>Strabilanthes</i> sp	46	2	5.71	0.27	0.013	0.08	23.00	0.20	0.55
108	<i>Alternanthera pungens</i>	40	1	2.86	0.14	0.011	0.07	40.00	0.34	0.55
109	<i>Thelypteris</i> sp	26	3	8.57	0.41	0.007	0.05	8.67	0.07	0.53
110	<i>Persicaria</i> sp	38	1	2.86	0.14	0.011	0.07	38.00	0.32	0.53
111	<i>Tabernaemontana divericata</i>	16	3	8.57	0.41	0.005	0.03	5.33	0.05	0.49
112	<i>Bauhinia vahlii</i>	15	3	8.57	0.41	0.004	0.03	5.00	0.04	0.48
113	<i>Ardisia solanacea</i>	34	2	5.71	0.27	0.010	0.06	17.00	0.14	0.48
114	<i>Leucas aspera</i>	33	1	2.86	0.14	0.009	0.06	33.00	0.28	0.48
115	<i>Schima wallichii</i>	14	3	8.57	0.41	0.004	0.03	4.67	0.04	0.48
116	<i>Thunbergia grandiflora</i>	11	3	8.57	0.41	0.003	0.02	3.67	0.03	0.46
117	<i>Chisocheton cumingianus</i>	10	3	8.57	0.41	0.003	0.02	3.33	0.03	0.46

118	<i>Naravelia zeylanica</i>	8	3	8.57	0.41	0.002	0.01	2.67	0.02	0.45
119	<i>Acmella uliginosa</i>	28	2	5.71	0.27	0.008	0.05	14.00	0.12	0.44
120	<i>Aglaia spectabilis</i>	7	3	8.57	0.41	0.002	0.01	2.33	0.02	0.44
121	<i>Globba racemosa</i>	6	3	8.57	0.41	0.002	0.01	2.00	0.02	0.44
122	<i>Trewia nudiflora</i> var. <i>polycarpa</i> (Mature)	5	3	8.57	0.41	0.001	0.01	1.67	0.01	0.43
123	<i>Careya arborea</i>	4	3	8.57	0.41	0.001	0.01	1.33	0.01	0.43
124	<i>Jasminum</i> sp	21	2	5.71	0.27	0.006	0.04	10.50	0.09	0.40
125	<i>Chloranthus elatior</i>	25	1	2.86	0.14	0.007	0.05	25.00	0.21	0.40
126	<i>Tetrastigma dubium</i>	17	2	5.71	0.27	0.005	0.03	8.50	0.07	0.38
127	<i>Ludwigia</i> sp	23	1	2.86	0.14	0.007	0.04	23.00	0.20	0.37
128	<i>Hygrophila phlomoides</i>	22	1	2.86	0.14	0.006	0.04	22.00	0.19	0.36
129	<i>Phlogacanthus thyrsoifloras</i>	22	1	2.86	0.14	0.006	0.04	22.00	0.19	0.36
130	<i>Albizia procera</i>	10	2	5.71	0.27	0.003	0.02	5.00	0.04	0.33
131	<i>Tetrastigma</i> sp	10	2	5.71	0.27	0.003	0.02	5.00	0.04	0.33
132	<i>Thunbergia fragrans</i>	10	2	5.71	0.27	0.003	0.02	5.00	0.04	0.33
133	<i>Anisomeles indica</i>	18	1	2.86	0.14	0.005	0.03	18.00	0.15	0.32
134	<i>Tetrastigma planicaule</i>	8	2	5.71	0.27	0.002	0.01	4.00	0.03	0.32
135	<i>Achyranthes bidentata</i>	7	2	5.71	0.27	0.002	0.01	3.50	0.03	0.32
136	<i>Capparis zeylanica</i>	7	2	5.71	0.27	0.002	0.01	3.50	0.03	0.32
137	<i>Actinodaphne obovata</i>	6	2	5.71	0.27	0.002	0.01	3.00	0.03	0.31
138	<i>Ampelocissus sikkimensis</i>	6	2	5.71	0.27	0.002	0.01	3.00	0.03	0.31
139	<i>Croton caudatus</i>	6	2	5.71	0.27	0.002	0.01	3.00	0.03	0.31
140	<i>Desmodium heterocarpam</i>	6	2	5.71	0.27	0.002	0.01	3.00	0.03	0.31
141	<i>Dillenia pentagyna</i> (Mature)	5	2	5.71	0.27	0.001	0.01	2.50	0.02	0.30
142	<i>Sida rhombifolia</i>	16	1	2.86	0.14	0.005	0.03	16.00	0.14	0.30
143	<i>Aporosa octandra</i> (mature)	4	2	5.71	0.27	0.001	0.01	2.00	0.02	0.30
144	<i>Dalbergia stipulacea</i>	4	2	5.71	0.27	0.001	0.01	2.00	0.02	0.30
145	<i>Dregea volubilis</i>	4	2	5.71	0.27	0.001	0.01	2.00	0.02	0.30
146	<i>Stereospermum tetragonum</i>	4	2	5.71	0.27	0.001	0.01	2.00	0.02	0.30
147	<i>Meliosma simplicifolia</i>	3	2	5.71	0.27	0.001	0.01	1.50	0.01	0.29

148	<i>Zanthoxylum sp</i>	3	2	5.71	0.27	0.001	0.01	1.50	0.01	0.29
149	<i>Chukrasia tabularis</i>	2	2	5.71	0.27	0.001	0.00	1.00	0.01	0.29
150	<i>Coccinia grandis</i>	2	2	5.71	0.27	0.001	0.00	1.00	0.01	0.29
151	<i>Eleutheranthera ruderalis</i>	13	1	2.86	0.14	0.004	0.02	13.00	0.11	0.27
152	<i>Caesalpinia cuculata</i>	12	1	2.86	0.14	0.003	0.02	12.00	0.10	0.26
153	<i>Castanopsis indica</i>	12	1	2.86	0.14	0.003	0.02	12.00	0.10	0.26
154	<i>Piper longum</i>	11	1	2.86	0.14	0.003	0.02	11.00	0.09	0.25
155	<i>Aerva lanata</i>	9	1	2.86	0.14	0.003	0.02	9.00	0.08	0.23
156	<i>Blumia lacera</i>	8	1	2.86	0.14	0.002	0.01	8.00	0.07	0.22
157	<i>Colocasia esculenta</i>	8	1	2.86	0.14	0.002	0.01	8.00	0.07	0.22
158	<i>Crinum amoenum</i>	8	1	2.86	0.14	0.002	0.01	8.00	0.07	0.22
159	<i>Argyreia roxburghii</i>	7	1	2.86	0.14	0.002	0.01	7.00	0.06	0.21
160	<i>Cinamomum zeylacum</i>	5	1	2.86	0.14	0.001	0.01	5.00	0.04	0.19
161	<i>Dendrochride sinuta</i>	5	1	2.86	0.14	0.001	0.01	5.00	0.04	0.19
162	<i>Hyptige suaveolens</i>	5	1	2.86	0.14	0.001	0.01	5.00	0.04	0.19
163	<i>Bridelia sp</i>	4	1	2.86	0.14	0.001	0.01	4.00	0.03	0.18
164	<i>Crateva religiosa</i>	4	1	2.86	0.14	0.001	0.01	4.00	0.03	0.18
165	<i>Ipoemia sp</i>	4	1	2.86	0.14	0.001	0.01	4.00	0.03	0.18
166	<i>Zizyphus rugosus</i>	4	1	2.86	0.14	0.001	0.01	4.00	0.03	0.18
167	<i>Cassia sp</i>	3	1	2.86	0.14	0.001	0.01	3.00	0.03	0.17
168	<i>Deeringia sp</i>	3	1	2.86	0.14	0.001	0.01	3.00	0.03	0.17
169	<i>Desmos dumosus</i>	3	1	2.86	0.14	0.001	0.01	3.00	0.03	0.17
170	<i>Dillenia indica</i> (mature)	3	1	2.86	0.14	0.001	0.01	3.00	0.03	0.17
171	<i>Impatiens tricolor</i>	3	1	2.86	0.14	0.001	0.01	3.00	0.03	0.17
172	<i>Oxalis debilis</i> var. <i>corymbosa</i>	3	1	2.86	0.14	0.001	0.01	3.00	0.03	0.17
173	<i>Pterospermum acerifolium</i>	3	1	2.86	0.14	0.001	0.01	3.00	0.03	0.17
174	<i>Artocarpus chaplasi</i>	2	1	2.86	0.14	0.001	0.00	2.00	0.02	0.16
175	<i>Blechnum sp</i>	2	1	2.86	0.14	0.001	0.00	2.00	0.02	0.16
176	<i>Calamus sp</i>	2	1	2.86	0.14	0.001	0.00	2.00	0.02	0.16
177	<i>Chukrasia tabularis</i> (Mature)	2	1	2.86	0.14	0.001	0.00	2.00	0.02	0.16

178	<i>Curcuma amada</i>	2	1	2.86	0.14	0.001	0.00	2.00	0.02	0.16
179	<i>Flemingia strobilifera</i>	2	1	2.86	0.14	0.001	0.00	2.00	0.02	0.16
180	<i>Lagerstroemia parviflora</i> (Mature)	2	1	2.86	0.14	0.001	0.00	2.00	0.02	0.16
181	<i>Litsea glutinosa</i> Mature	2	1	2.86	0.14	0.001	0.00	2.00	0.02	0.16
182	<i>Magnolia champaca</i>	2	1	2.86	0.14	0.001	0.00	2.00	0.02	0.16
183	<i>Pandanus</i> sp	2	1	2.86	0.14	0.001	0.00	2.00	0.02	0.16
184	<i>Stephania glabra</i>	2	1	2.86	0.14	0.001	0.00	2.00	0.02	0.16
185	<i>Ailanthus excelsa</i>	1	1	2.86	0.14	0.000	0.00	1.00	0.01	0.15
186	<i>Albizia procera</i> (Mature)	1	1	2.86	0.14	0.000	0.00	1.00	0.01	0.15
187	<i>Alstonia scholaris</i>	1	1	2.86	0.14	0.000	0.00	1.00	0.01	0.15
188	<i>Berchemia floribunda</i>	1	1	2.86	0.14	0.000	0.00	1.00	0.01	0.15
189	<i>Bombax ceiba</i>	1	1	2.86	0.14	0.000	0.00	1.00	0.01	0.15
190	<i>Calycarpa</i> sp	1	1	2.86	0.14	0.000	0.00	1.00	0.01	0.15
191	<i>Dioscorea</i> sp	1	1	2.86	0.14	0.000	0.00	1.00	0.01	0.15
192	<i>Duabanga grandiflora</i>	1	1	2.86	0.14	0.000	0.00	1.00	0.01	0.15
193	<i>Flacourtia indica</i>	1	1	2.86	0.14	0.000	0.00	1.00	0.01	0.15
194	<i>Garuga floribunda</i>	1	1	2.86	0.14	0.000	0.00	1.00	0.01	0.15
195	<i>Luffa acutangula</i>	1	1	2.86	0.14	0.000	0.00	1.00	0.01	0.15
196	<i>Mangifera sylvatica</i>	1	1	2.86	0.14	0.000	0.00	1.00	0.01	0.15
197	<i>Murraya koenigii</i>	1	1	2.86	0.14	0.000	0.00	1.00	0.01	0.15
198	<i>Neolamarckia camamba</i> (Mature)	1	1	2.86	0.14	0.000	0.00	1.00	0.01	0.15
199	<i>Psidium guajava</i>	1	1	2.86	0.14	0.000	0.00	1.00	0.01	0.15
200	<i>Sterculia villosa</i>	1	1	2.86	0.14	0.000	0.00	1.00	0.01	0.15
201	<i>Tetracera sarmentosa</i>	1	1	2.86	0.14	0.000	0.00	1.00	0.01	0.15
202	<i>Zanonia indica</i>	1	1	2.86	0.14	0.000	0.00	1.00	0.01	0.15
NI= Number of Individuals, O= Occurance, F= Frequency, RF=Relative Frequency, D/sq m=Density per sq metre, RD=Relative Density, A=Abundance, RA= Relative Abundance, IVI= Importance Value Index, SDI= Simpson's Diversity Index										

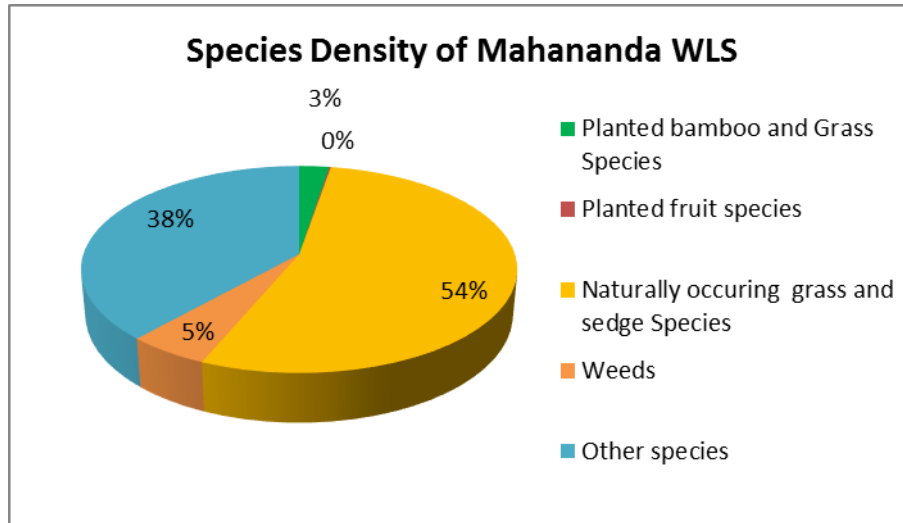


Figure 50: Species diversity in Mahananda WLS as a whole

i) Analysis of the vegetation data of Teak plantation plots:

In Mahananda WLS, vegetation data also collected in 4 Teak plantation plots in Chamta Beat of Sukna Range. These data were further statistically analysis and arranged in separate groups like grass fodders, weeds and other species. Total 50 species found from the 4 quadrates out of which 4 species belongs to grass fodders and sedge species, 8 species to weeds and rest of the plants in other species.

The highest IVI value (59.79) was recorded in *Oplismenus burmanni* which belongs to the grass species followed by *Diplazium esculentum* with IVI value of 49.54, which is belong to fern species.

Among the weed species highest IVI value observed in *Chromolaena odorata* (IVI= 11.27) followed by *Clerodendrum infortunatum* (IVI=7.13).

In the other species both the mature and juvenile *Tectona grandis* values were high.

Simpson Diversity Index for Species diversity was calculated to be 0.83 in Teak Plantation in Mahananda WLS.

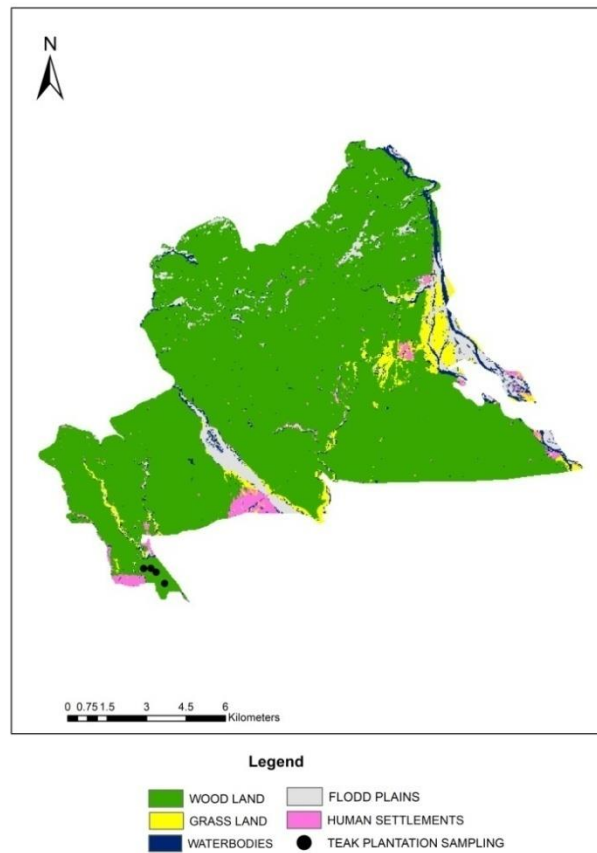


Figure 51: Teak plantation quadrates in Mahananda WLS

Table 65: Statistical analysis of all plant species recorded in Teak plantation plots of Mahananda WLS

Sl no	Class	Name of The Species	Family	NI	O	F %	RF %	D/sq.m.	RD %	A	RA %	IVI	SDI
1	Grass Fodders	<i>Oplismenus burmanni</i> (Retz.) P. Beauv.	Poaceae	1066	3	75	3.61	2.67	32.19	355.33	23.99	59.79	0.83
2		<i>Echinochloa crus-galli</i> (L.) P. Beauv.	Poaceae	48	1	25	1.20	0.12	1.45	48.00	3.24	5.89	
3		<i>Axonopus compressus</i> (Sw.) P. Beauv.	Poaceae	32	1	25	1.20	0.08	0.97	32.00	2.16	4.33	
4		<i>Cyperus sp</i>	Cyperaceae	19	1	25	1.20	0.05	0.57	19.00	1.28	3.06	
5	Weeds	<i>Chromolaena odorata</i> (L.) R.M. King & H. Rob.	Asteraceae	137	4	100	4.82	0.34	4.14	34.25	2.31	11.27	
6		<i>Clerodendrum infortunatum</i> L.	Lamiaceae	49	4	100	4.82	0.12	1.48	12.25	0.83	7.13	
7		<i>Mikania micrantha</i> Kunth	Asteraceae	61	3	75	3.61	0.15	1.84	20.33	1.37	6.83	
8		<i>Ageratum houstonianum</i> Mill.	Asteraceae	49	1	25	1.20	0.12	1.48	49.00	3.31	5.99	
9		<i>Triumfetta rhomboidea</i> Jacq.		9	2	50	2.41	0.02	0.27	4.50	0.30	2.99	
10		<i>Ageratum conyzoides</i> (L.) L.	Asteraceae	7	1	25	1.20	0.02	0.21	7.00	0.47	1.89	
11		<i>Stephania hernandiifolia</i> (Willd.) Walp.	Menispermaceae	3	1	25	1.20	0.01	0.09	3.00	0.20	1.50	
12		<i>Mukia maderaspatana</i> (L.) M. Roem.	Cucurbitaceae	1	1	25	1.20	0.00	0.03	1.00	0.07	1.30	
13	Other species	<i>Diplazium esculentum</i> (Retz.) Sw.	Athyriaceae	737	2	50	2.41	1.84	22.25	368.50	24.87	49.54	
14		<i>Thelypteris sp</i>	Thelypteridaceae	218	2	50	2.41	0.55	6.58	109.00	7.36	16.35	

15	<i>Curcuma amada</i> Roxb.	Zingiberaceae	208	2	50	2.41	0.52	6.28	104.00	7.02	15.71
16	<i>Dryopteris sparsa</i> (D. Don) Kuntze	Dryopteridaceae	198	3	75	3.61	0.50	5.98	66.00	4.46	14.05
17	<i>Tectona grandis</i> L.f. (Juvenile)	Lamiaceae	66	4	100	4.82	0.17	1.99	16.50	1.11	7.93
18	<i>Pupalia lappacea</i> (L.) Juss.	Amaranthaceae	81	2	50	2.41	0.20	2.45	40.50	2.73	7.59
19	<i>Ardisia solanacea</i> (Poir.) Roxb.	Primulaceae	48	3	75	3.61	0.12	1.45	16.00	1.08	6.14
20	<i>Tectona grandis</i> L.f. (Mature)	Lamiaceae	27	4	100	4.82	0.07	0.82	6.75	0.46	6.09
21	<i>Piper sp</i>	Piperaceae	30	3	75	3.61	0.08	0.91	10.00	0.68	5.20
22	<i>Pteris biaurita</i> L.	Pteridaceae	39	2	50	2.41	0.10	1.18	19.50	1.32	4.90
23	<i>Lepidagathis incurva</i> Buch.-Ham. ex D. Don	Acanthaceae	37	2	50	2.41	0.09	1.12	18.50	1.25	4.78
24	<i>Phyllanthus sp</i>	Phyllanthaceae	20	2	50	2.41	0.05	0.60	10.00	0.68	3.69
25	<i>Maesa indica</i> (Roxb.) A. DC.	Primulaceae	16	2	50	2.41	0.04	0.48	8.00	0.54	3.43
26	<i>Lagerstroemia speciosa</i> (L.) Pers. Juvenile	Lythraceae	18	1	25	1.20	0.05	0.54	18.00	1.22	2.96
27	<i>Aglaia spectabilis</i> (Miq.) S.S. Jain & S. Bennet Juvenile	Meliaceae	5	2	50	2.41	0.01	0.15	2.50	0.17	2.73
28	<i>Lagerstroemia speciosa</i> (L.) Pers.	Lythraceae	2	2	50	2.41	0.01	0.06	1.00	0.07	2.54
29	<i>Dicliptera bupleuroides</i> Nees	Acanthaceae	12	1	25	1.20	0.03	0.36	12.00	0.81	2.38
30	<i>Piper sylvestre</i>	Piperaceae	12	1	25	1.20	0.03	0.36	12.00	0.81	2.38
31	<i>Nelsonia canescens</i> (Lam.) Spreng.	Acanthaceae	8	1	25	1.20	0.02	0.24	8.00	0.54	1.99
32	<i>Rungia pectinata</i> (L.) Nees	Acanthaceae	6	1	25	1.20	0.02	0.18	6.00	0.41	1.79
33	<i>Sida acuta</i> Burm.f.	Malvaceae	5	1	25	1.20	0.01	0.15	5.00	0.34	1.69
34	<i>Aglaia spectabilis</i> (Miq.) S.S. Jain & S. Bennet	Meliaceae	3	1	25	1.20	0.01	0.09	3.00	0.20	1.50
35	<i>Clausena excavata</i> Burm.f.	Rutaceae	3	1	25	1.20	0.01	0.09	3.00	0.20	1.50
36	<i>Dioscorea prazeri</i> Prain & Burkill	Dioscoreaceae	3	1	25	1.20	0.01	0.09	3.00	0.20	1.50
37	<i>Flacourtia indica</i> (Burm.f.) Merr.	Salicaceae	3	1	25	1.20	0.01	0.09	3.00	0.20	1.50
38	<i>Litsea monopetala</i> (Roxb.) Pers. Juvenile	Lauraceae	3	1	25	1.20	0.01	0.09	3.00	0.20	1.50
39	<i>Microlepis sp</i>	Dennstaedtiaceae	3	1	25	1.20	0.01	0.09	3.00	0.20	1.50
40	<i>Phaulopsis imbricata</i> (Forssk.) Sweet	Acanthaceae	3	1	25	1.20	0.01	0.09	3.00	0.20	1.50
41	<i>Sauropus compressus</i> Müll.Arg.	Euphorbiaceae	3	1	25	1.20	0.01	0.09	3.00	0.20	1.50
42	<i>Ampelocissus sikkimensis</i> (M.A. Lawson) Planch.	Vitaceae	2	1	25	1.20	0.01	0.06	2.00	0.14	1.40
43	<i>Chisocheton cumingianus</i> (C.DC.) Harms Juvenile	Meliaceae	2	1	25	1.20	0.01	0.06	2.00	0.14	1.40
44	<i>Elephantopus scaber</i> L.	Asteraceae	2	1	25	1.20	0.01	0.06	2.00	0.14	1.40
45	<i>Natsiatum herpeticum</i> Buch.-Ham. ex Arn.	Icacinaceae	2	1	25	1.20	0.01	0.06	2.00	0.14	1.40
46	<i>Trewia nudiflora</i> var. <i>polycarpa</i> (Benth.) Susila & N.P. Balakr. Juvenile	Euphorbiaceae	2	1	25	1.20	0.01	0.06	2.00	0.14	1.40
47	<i>Alstonia scholaris</i> Juvenile	Apocynaceae	1	1	25	1.20	0.00	0.03	1.00	0.07	1.30
48	<i>Argyrea roxburghii</i> (Wall.) Arn. ex Choisy	Convolvulaceae	1	1	25	1.20	0.00	0.03	1.00	0.07	1.30
49	<i>Melastoma malabathricum</i> L.	Melastomataceae	1	1	25	1.20	0.00	0.03	1.00	0.07	1.30
50	<i>Naravelia zeylanica</i> (L.) DC.	Ranunculaceae	1	1	25	1.20	0.00	0.03	1.00	0.07	1.30

NI= Number of Individuals, O= Occurance, F= Frequency, RF=Relative Frequency, D/sq m=Density per sq metre, RD=Relative Density, A=Abundance, RA= Relative Abundance, IVI= Importance Value Index, SDI= Simpson's Diversity Index

Findings:

Grass and bamboo fodder species diversity in managed grassland and canopy opened plots of Mahananda WLS was calculated 3% of the total plant recorded. While fruit fodder diversity is minimal in the sample plots.

It is observed that over all *Bambusa spp* has a higher IVI value (IVI= 3.81) among the planted species, followed by *Thysanolaena maxima* IVI= 2.76, which is mostly occurred in North Range.

Density of Naturally occurring grass species is over than 50% (i.e. 54%) and density of weeds is 5% of the total plant recorded.

In naturally occurring grass species within the management plots *Eragrostis spp* has the highest IVI value of 31, which is also highest among all the other species recorded.

In weeds *Chromolaena odorata* has the highest IVI= 4.08, followed by *Mikania micrantha*, IVI= 3.28 and *Clerodendrum infortunatum* (IVI= 3.21).

Density of planted species is more or less similar to all Ranges varied from lower density of 1.25% in South range to 3.65% in North Range.

It is observed from the statistical analysis data that natural grass species is denser in Sukna Range followed by West Range, South Range and North Range.

Similarly, the density of weeds is high in Sukna, followed by West Range, South Range and North Range.

South has the maximum plant diversity followed by North Range, West Range and Sukna Range.

The Simpson's Diversity Index (0.90) of all the species that were tabulated in Mahananda indicated that the plots were diverse in terms of richness and evenness. Simpson's Diversity index also explains that there is 90% chance that 2 individuals selected at random from these plots would be from different plant species.

In comparison to the managed grassland and canopy opened plots, the teak plantation plots show less dense of grass fodder species as it was recorded 35%, while total grass and bamboo fodder density in whole Mahananda was calculated 57%.

In weed species the density the result shows the vice versa effect of the fodder species. The weed species density was calculated almost 10% in Teak plantation and 5% in the managed grassland and canopy opened plots.

6.5. Habitat use by animals

Results:

Herbivores habitat utilisation:

- *Elephant:*

The data here analysed were from February 2020 to August 2020. Through these seven months 2580 times elephants were sighted in different habitats and Ranges by the Forest Department staffs. The highest number of sightings took place in South Range followed by West Range of the Sanctuary.

In the correlation graph between elephant sightings and grassland percentage (Figure: 53) in each range shows a negative result.

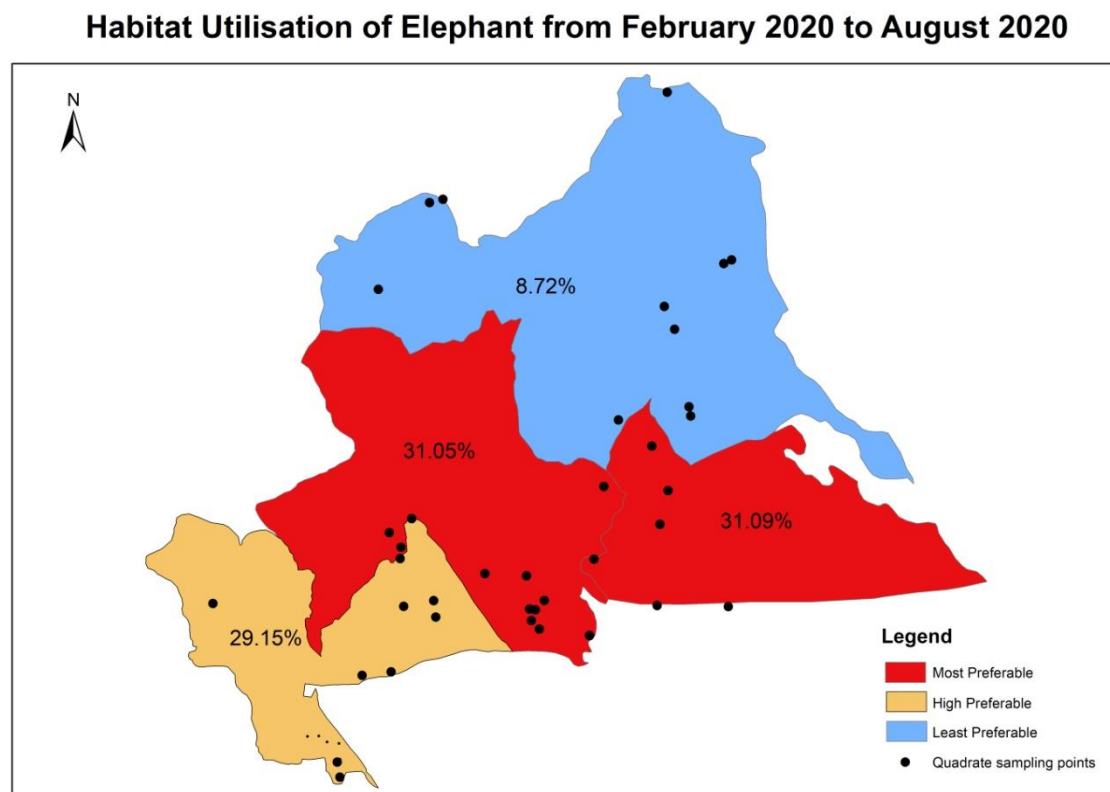


Figure 52: Habitat Utilisation map of Elephant during Feb 2020 to August 2020

Table 66: Range wise Elephant sighting with percentage of grassland in the Range

Sl no.	Ranges	Sightings (%)	Grassland (%)
1	North Range	8.72	5.58
2	South Range	31.09	1.32
3	Sukna Range	29.15	2.83
4	West Range	31.05	1.89

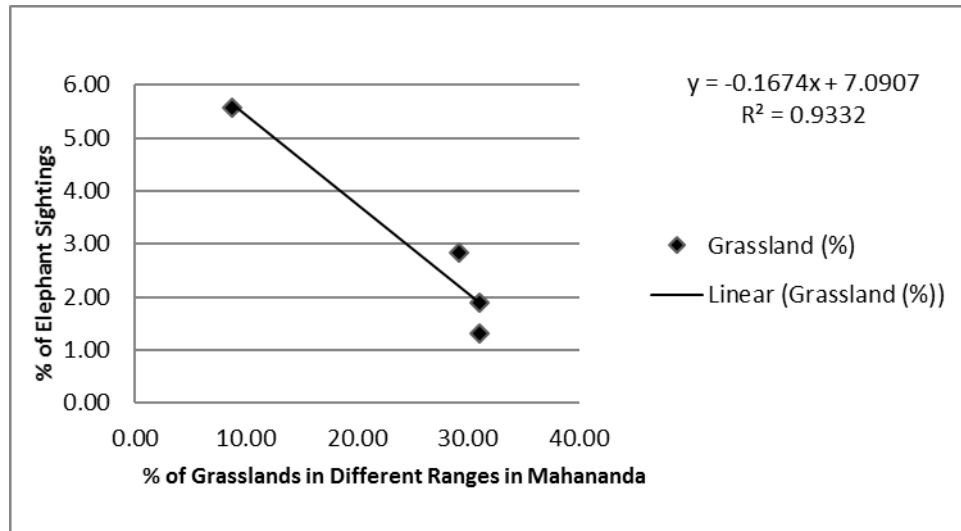


Figure 53: Correlation between grassland and Elephant sightings

- *Gaur:*

From February 2020 to August 2020 623 times Gaur were sighted in different habitats and Ranges of Mahananda by the Departmental staffs. The highest number of sightings took place in Sukna Range followed by West Range of the Sanctuary. The main reason the gaurs concentrated in these ranges were the availability of fodder, as these ranges have a moderate amount of natural as well as wet alluvial grasslands despite the abundance of woodlands (Table: 67)

In the correlation graph between gaur sightings and grassland percentage (Figure: 55) in each Range shows quite a positive result ($R = 0.216$).

Habitat Utilisation of Gaur from February 2020 to August 2020

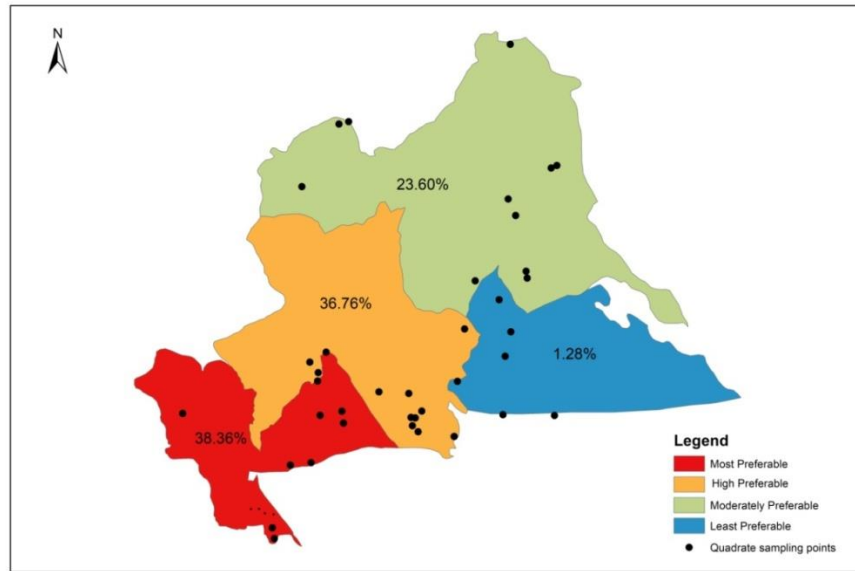


Figure 54: Habitat Utilisation map of Gaur during Feb 2020 to August 2020

Table 67: Range wise Gaur sighting with percentage of grassland in the Range

Sl no.	Ranges	Sightings (%)	Grassland (%)
1	North Range	23.60	5.58
2	South Range	1.28	1.32
3	Sukna Range	38.36	2.83
4	West Range	36.76	1.89

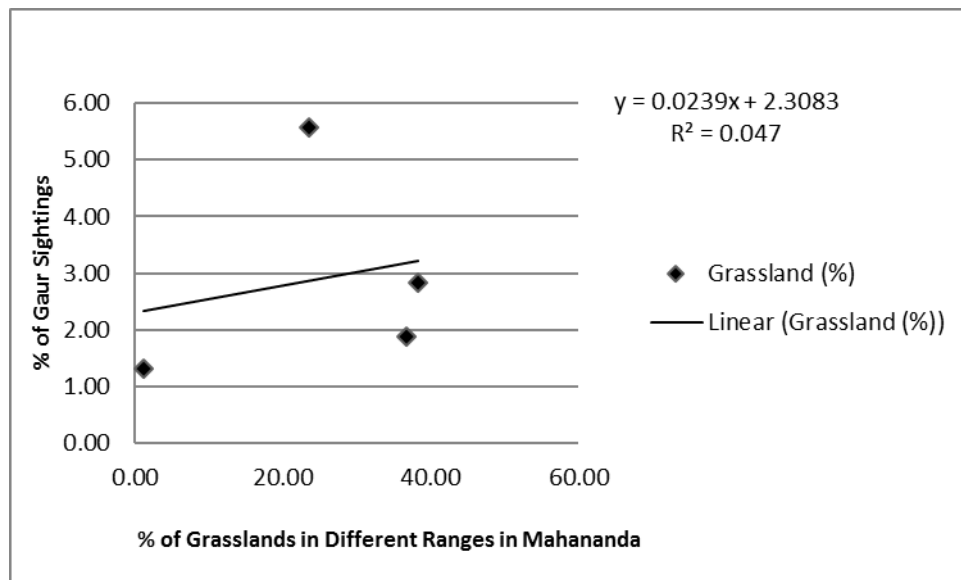


Figure 55: Correlation between grassland and Gaur sightings

Findings:

Most utilized habitat zone for the elephant was South and West Range which shows almost same percentage of sightings, followed by Sukna Range and North has the least sighting records.

The sightings of Gaur were highest in Sukna Range followed by West and North Range of the Sanctuary. South range has the least sighting records in 6 these 6 months.

In terms of all the above-mentioned herbivores West and Sukna was the most utilized Range

Only Gaur shows a positive correlation between sightings and the percentage of grassland area.

West and Sukna was the most utilized Range in terms of sightings, South is mainly utilized by elephants.

6.6. Herbivores feeding behaviour observation

Results:

The feeding and foraging observations were carried out for around 20 hours mainly in the West Sukna and South Range of Mahananda WLS, mostly from the watchtowers (Figure: 56). On direct observation a total of only 7 plant species was observed to be eaten by the Elephant, Gaur, Spotted Deer and Barking Deer. Out of these 5 species were consumed by Elephant, 2 species by barking Deer and only one species each by Gaur and Spotted deer. (Table: 68)

Elephant was encountered 5 times in which they were been observed to consume 5 different species as fodders. In which, consuming *Mikania micrantha* was noticeable.

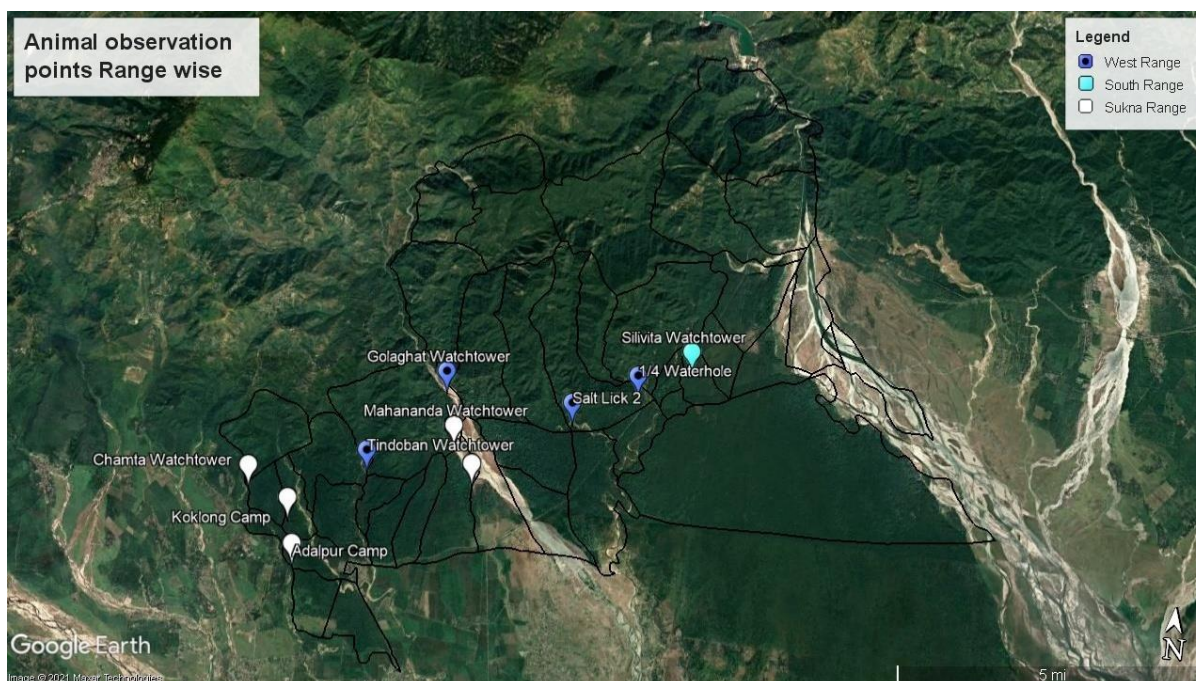


Figure 56: Range wise Herbivores foraging observation points

Table 68: Plant species consumed by herbivores in Mahananda

Sl No	Scientific Names	Family	Local Names	Eaten By			
				Elephant	Spotted Deer	Gaur	Barking Deer
1	<i>Axonopus compresus</i>	Poaceae	Chapta Ghas/ Chhoto chepti	Elephant		Gaur	Barking Deer
2	<i>Alpina nigra</i>	Zingiberaceae	Purundi	Elephant			
3	<i>Eragrostis tenella</i>	Poaceae			Spotted Deer		
4	<i>Mikania micrantha</i>	Asteraceae	Larong, Mekani	Elephant			
5	<i>Solanum torvum</i>	Solanaceae		Elephant			
6	<i>Eragrostis sp</i>	Poaceae					Barking Deer
7	<i>Phlogacanthus thyrsiflorus</i>	Acanthaceae		Elephant			

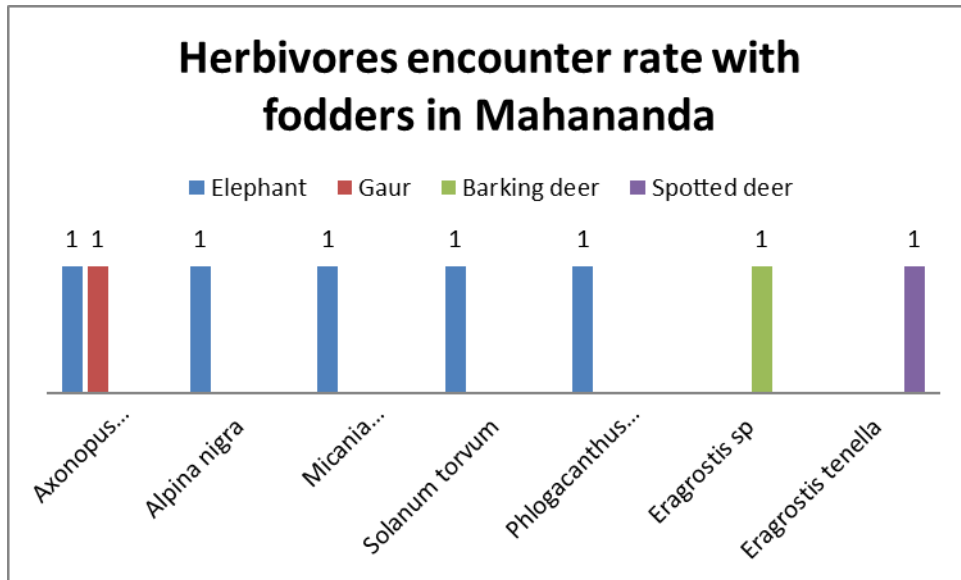


Figure 57: Eencounter rate of different Herbivores with fodders in Mahananda

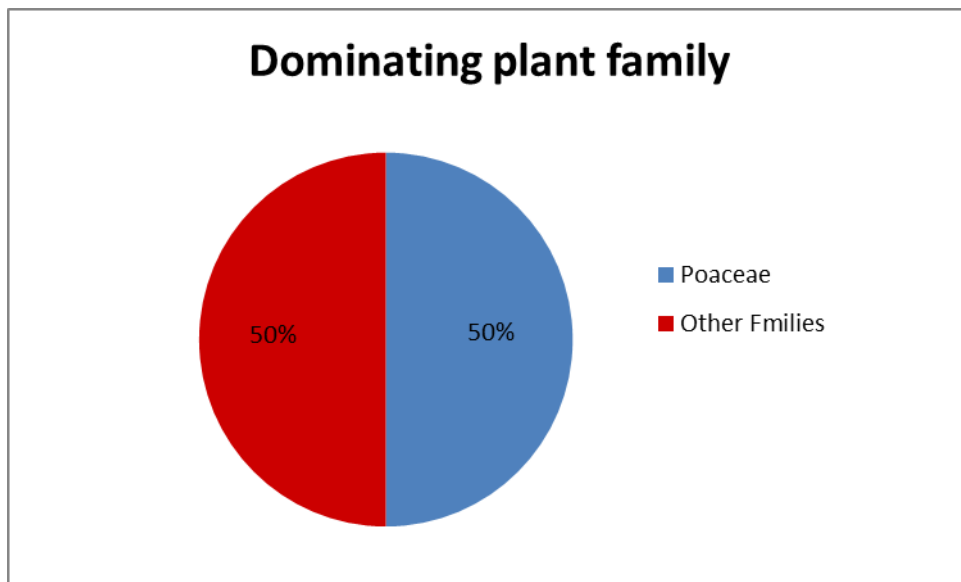


Figure 58: Grasses are equally contributed in terms of Herbivore fodders in Mahananda

Table 69: Families of Herbivore-fodders and their numerical representation at the species

SL no.	Families	Number of Plants
1	Poaceae	3
2	Zingiberaceae	1
3	Asteraceae	1
4	Solanaceae	1
5	Acanthaceae	1
	TOTAL	7

Findings:

A total of 7 plant species was recorded while consumed by the herbivores like Elephant, Gaur, Barking deer and Spotted deer.

Out of these 7 species Elephant was observed to consume 5 species, Barking Deer 2 species and one species each to Gaur and Spotted deer.

Poaceae family (Grass species) and the other are almost equally contributed as fodder species for herbivores like Elephant, Gaur and all deer species.

Mikania micrantha, which is considered as a weed, was observed to be consuming by Elephant.

6.7. Assessment of Above Ground Biomass (AGB)

Results:

10 sites from MWLS were chosen for grass collection. The sites were so chosen that at least one plot from each beat was represented.

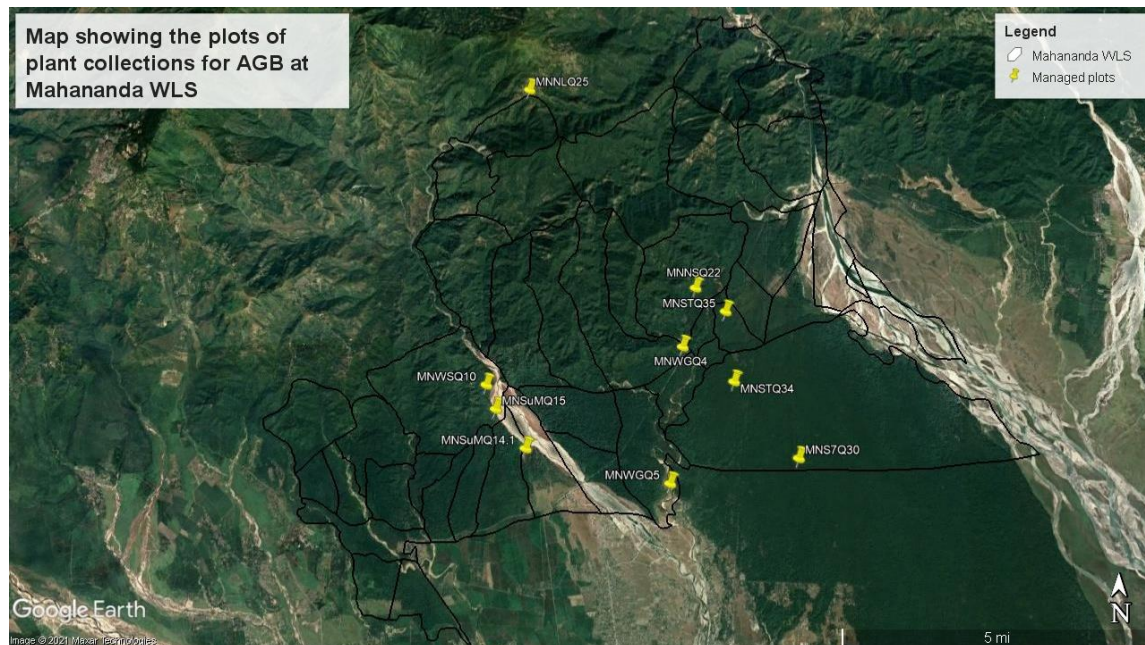


Figure 59: AGB collection points in Mahananda WLS

a. For Planted Species:

Table 70: Above Ground Biomass values of planted species in at Mahananda WLS

Mahananda Managed Plots panted species	<i>Alpina nigra</i> (kg/m ²)	<i>Bambusa sp</i> (kg/m ²)	<i>Bambusa sp</i> (non-thorney bamboo) (kg/m ²)	<i>Bambusa sp</i> (wild bamboo) (kg/m ²)	<i>Saccharum narenga</i> (kg/m ²)	<i>Themeda arundinacea</i> (kg/m ²)	Plot wise biomass value (kg/m ²)	Mean value (kg/m ²)
MNSuMQ14		0.076					0.0757	0.008
MNSuMQ15						0.075	0.0746	0.007
MNWSQ10				0.026			0.0259	0.003
MNWWGQ5			0.084				0.0842	0.008
MNWWGQ4	0.065				0.242		0.307	0.031
MNSTQ35		0.018					0.0181	0.002
MNSTQ34					0.153		0.1529	0.015
MNS7Q30	0.003				0.035		0.039	0.004
MNNSQ22		0.016					0.0156	0.002
MNNLQ25							0	0.000
Species wise biomass value	0.0679	0.109	0.0842	0.0259	0.4305	0.0746	0.7925	
Mean value	0.007	0.011	0.008	0.003	0.043	0.007		0.079

Estimated Biomass for planted species = 0.079 kg/m^{-2} or $790 \text{ kg/ha} \approx 800 \text{ kg/ha}$

Calculating of forage:

After determining annual forage production/ha (plant biomass) of planted species, using Voelkel's estimation method, the total annual forage produced by planted species in the management area must be calculated by following formula:

$$\text{Available area for grazing} \times \text{Forage production/ha} = \text{Total forage/year}$$

The total area of grassland management and grass-bamboo fodder plantation after canopy opening, in Mahananda is approximately 800 ha (Anon, 2012; Annexure 9, fodder plantation).

So, total forage in the management plot for the planted grass and bamboo species for the year would be:

$$800 \times 800 \text{ kg/ha} = 640000 \text{ kg/year}$$

According to Voelkel *et al.*, 2018, only 25% of the total forage production is utilized by grazers. Therefore, consumable forage would be produced, as follows for the managed grassland available for grazing in Park:

$$\text{Total forage/year} \times 0.25 = \text{Consumable forage/year}$$

$$640000 \times 0.25 = 160000 \text{ kg/ year}$$

There are also areas in forest land that herbivores do not graze, such as heavy brush, weeds, other non-fodder species etc. To reduce the risk of overgrazing, these areas were removed from the calculation. In this case, from our statistical analysis data of planted grass and bamboo species in managed plot in Mahananda, it was estimated that grass species density is 2.57% or say 3% among all the species found within the sample plots (Figure: 50).

Therefore, the available forage would be determined as follows:

$$\text{Consumable forage} \times \% \text{ Grazeable areas} = \text{Available forage kg /year}$$

$$160000 \text{ kg/ year} \times 0.03 = 4800 \text{ Kg/year}$$

b. For Naturally growing grass fodder species in managed plots:

Table 71: Above Ground Biomass values of naturally growing fodder grass species in managed plots at Mahananda WLS

Mahananda Managed Plots natural growing species	<i>Carex sp</i> (kg/m ²)	<i>Cyperus</i> <i>sp</i> (kg/m ²)	<i>Digitaria</i> <i>ciliaris</i> (kg/m ²)	<i>Digitaria</i> <i>sp</i> (kg/m ²)	<i>Echinochloa</i> <i>crus-galli</i> (kg/m ²)	<i>Echinochloa</i> <i>sp</i> (kg/m ²)	<i>Eragrostis</i> <i>spp</i> (kg/m ²)	<i>Eragrostis</i> <i>tenella</i> (kg/m ²)	<i>Oplismenus</i> <i>burmannii</i> (kg/m ²)	<i>Saccharum</i> <i>spontanium</i> (kg/m ²)	<i>Seteria</i> <i>palmifolia</i> (kg/m ²)	Plot wise biomass value (kg/m ²)	Mean value (kg/m ²)
MNSuMQ14								0.110				0.110	0.011
MNSuMQ15			0.015		0.017			0.015			0.066	0.113	0.011
MNWSQ10													0.000
MNWGQ5													0.000
MNWGQ4						0.001		0.011	0.002			0.015	0.001
MNSTQ35		0.002		0.105		0.061						0.168	0.017
MNSTQ34				0.053				0.011				0.064	0.006
MNS7Q30													0.000
MNNSQ22										0.015		0.015	0.001
MNNLQ25	0.031						0.0184					0.049	0.005
Species wise biomass value	0.031	0.002	0.015	0.158	0.017	0.062	0.018	0.147	0.002	0.015	0.066	0.533	
Mean value	0.003	0.0002	0.002	0.016	0.002	0.006	0.002	0.015	0.0002	0.001	0.007		0.05325

Estimated Biomass for naturally growing fodder grass species in managed plots = 0.05325 kg/m² or 532.5 kg/ha ≈ 540 kg/ha

Calculating of forage:

After determining annual forage production/ha (plant biomass) of natural grass species in managed area, using Voelkel's estimation method, the total annual forage produced by natural grass species in the management area must be calculated by following formula:

$$\text{Available area for grazing} \times \text{Forage production/ha} = \text{Total forage/year}$$

The total area of grassland management and grass-bamboo fodder plantation after canopy opening, in Mahananda is approximately 800 ha (Anon, 2012; Annexure 9, fodder plantation).

So, total forage in the management plot for the natural grass species for the year would be:

$$800 \times 540 \text{ kg/ha} = 432000 \text{ kg/year}$$

If only 25% of the total forage production of natural grass species in managed plots is utilized by grazers, consumable forage would be produced, as follows for the managed grassland available for grazing in Park:

$$\text{Total forage/year} \times 0.25 = \text{Consumable forage/year}$$

$$432000 \times 0.25 = 108000 \text{ kg/ year}$$

There are also areas in forest land that herbivores do not graze such as heavy brush, weeds, other non-fodder species etc. To reduce the risk of overgrazing, these areas were removed from the calculation. In this case, from our statistical analysis data of natural grasslands found in managed plot in Mahananda, it was estimated that grass species density is around 54% among all the species found within the sample plots (Figure: 50).

Therefore, the available forage would be determined as follows:

$$\text{Consumable forage} \times \% \text{ Grazeable areas} = \text{Available forage kg /year}$$

$$108000 \text{ kg/ year} \times 0.54 = 58320 \text{ Kg/year}$$

Table 72: Estimated Biomass of Fodder species in Mahananda WLS at a glance

	Mean Biomass of Fodder species	Total Biomass of Fodder Species	Consumable Biomass of Fodder Species	Available Biomass of Fodder Species
Planted fodder species in management plots	0.079 kg/m ⁻² or 800 kg/ha	800 X 800 kg/ha = 6,40,000 kg/year	6,40,000 X 0.25= 1,60,000 kg/ year	1,60,000 kg/ year X 0.03= 4,800 Kg/year
Naturally occurring fodder species in management plots	0.053 kg/m ⁻² or 540 kg/ha	800 X 540 kg/ha = 4,32,000 kg/year	4,32,000 X 0.25 = 1,08,000 kg/ year	1,08,000 kg/ year X 0.54 = 58,320 Kg/year

Findings:

Dhadda (*Sachhrrum narenga*) shows the highest productivity of 0.043 kg/sq m or 430 kg/ ha in Managed plots. While, among the naturally growing grass fodder species in managed plot *Digitaria sp.* shows the highest productivity (0.016 kg/sq m or 160 kg/ ha).

The maximum estimated mean Biomass (800kg/ha) comprised of the Planted Fodder Species planted by the Forest Department in the management plots. The least Biomass (540 kg/ha) occurred among the Naturally occurring Fodder Species, which were not planted, in the management plots.

This trend was seen also in the total Biomass of the Fodder Species as well as in Consumable Biomass of Fodder Species.

However, when the percentage of the Fodder Species as recorded in the quantitative and qualitative sampling results in each case were tabulated with the Biomass of the Consumable Fodder Species to obtain the Available Biomass, it was seen that the highest Biomass of 58,320 kg/year occurred in the Naturally occurring Fodder Species, which were not planted, in the management plots, followed by the Biomass (4,800 kg/year) of Planted Fodder Species in management plots.

In fact, the Available Biomass of the Naturally occurring Fodder Species, which were not planted, in the management plots was nearly 10 times that of the Planted Fodder Species planted by the Forest Department in the management plots.

6.8. Carrying Capacity

Like Jaldapara and Gorumara Rhino is not available in Mahananda WLS. Asian elephant (*Elephas maximus*) is considered here the flagship species (Anon, 2012). Besides elephant gaur is also there as the sympatric mega herbivore. Both the herbivores preferred grass species as primary fodders (Peden *et. al.*, 1974; Roy, 2010; Lahkar *et. al.*, 2018). Therefore, the calculation shown here only based on bamboo and grass fodder available in the managed plots at the sanctuary.

For Asian Elephant it is assuming that they consume about 1.5–2.5% of its body weight of dry fodder (Sukumar, 2003) every day. Therefore, the middle value was taken consideration for this study. For the other ruminant herbivores, the consume rate is around 2% of their body weight (Murray, 1995). On the basis of their body weight the approximate DM intake value/ year are following (Table: 73).

Table 73: Body weight and Dry matter intake value

Sl. No	Common Name	Scientific Name	Average Body Weight (Kg.)	DM intake per day (Kg)	Total DM requirement/year (Kg)
1	Indian bison or Gaur	<i>Bos gaurus</i>	600 ⁺	12	4380 ≈4000
2	Asian Elephant	<i>Elephas maximus</i>	2500*	50	18250
Total DM requirement for Gaur and Elephant					22250

(*Mathur; 1991, *Roy 2010)

Elephant and Gaur both has been considered in this case, so, to determine the total animal forage requirement, all the considered animals' annual requirement has been added up and applied to the main formula of carrying capacity (Table:73).

Using this following formula, the calculations are showing below:

$$\text{Carrying Capacity (K)} = \frac{\text{Available forage kg}}{\text{Animal forage requirement kg/year}}$$

Therefore, only for available forage in planted species in Mahananda WLS

$$\begin{aligned} \text{Carrying Capacity (K) or AU} &= 4800 / (4000+18250) \\ &= 4800^* / 22250 \\ &= 0.22 \text{ AU/ year} \end{aligned}$$

*The Available forage only calculated for planted grass fodder and bamboo species

The total animal unit (AU) in Mahananda for only planted species was calculated to 0.22, which is very less and that means the planted grass and bamboo which were present at the time of biomass sample collection in management plot not even can hold one of the any species.

[Note: The biomass study was done in the dry season of the year 2021 and could not be collected data in the wet seasons as the nationwide lockdown was imposed for Covid 19 Pandemic. So, the Carrying Capacity is calculated here only on the basis for the dry season biomass availability]

For, only for forage available for natural grass species in managed plot in Mahananda WLS

$$\begin{aligned}\text{Carrying Capacity (K) or AU} &= 58320 / (4000 + 18250) \\ &= 58320 / 22250 \\ &= 2.62 \text{ AU} \approx 3 \text{ AU/year}\end{aligned}$$

*The Available forage only calculated for naturally occurring grass species within managed plots

3 AU/Year means, the non planted grass fodders that occurred in Managed area can hold a total of 3 animals (gaur+ elephant) per year if the forage available, per day consumption rate for individual animals and the other environmental conditions are constant.

The intake capacities of the herbivores are different as per their body weight and one gaur cannot consume the same amount as elephant.

Therefore, as per their consumption rate (Table: 73) it can be assumed that one elephant can consume same amount of fodders as almost 5 Gaurs can consume.

Hence, using this logic, the natural grass fodder occurring in managed plot in Mahananda WLS can support 2 Gaurs and 1 Elephants at a time.

[Note: The Carrying Capacity is based on the biomass obtained from only grass and bamboo species available in the managed plots.]

Table 74: Estimated Carrying Capacity of Large Herbivores in Mahananda Wildlife Sanctuary at a glance

	Available Forage Biomass (AB)	Animal Forage Requirement (AD)	Carrying Capacity (K) or Animal Unit (AU) = (AB/AD)
Planted fodder species in management plots	4,800kg/year	Indian Bison or Gaur – 4,000	4,800/4,000 = 1.2
		Asian Elephant- 18,250	4,800/18,250 = 0.26
		Total - 22,250	4,800/22,250 = 0.22
Naturally occurring fodder species in management plots	58,320kg/year	Indian Bison or Gaur – 4,000	58,320/4,000 = 14.58
		Asian Elephant - 18,250	58,320/18,250 = 3.20
		Total - 22,250	58,320/22,250 = 2.62
		2 Gaurs and 1 Elephant	
Planted fodder species + Naturally occurring fodder species in management plots	4,800kg/year + 58,320kg/year = 63,120 kg/year	Indian Bison or Gaur – 4,000	63,120/4,000 = 15.78
		Asian Elephant - 18,250	63,120/18,250 = 3.46
		Total - 22,250	63,120/22,250 = 2.84
		2 Gaurs and 1 Elephant	

So, the grassland management plots without the support of natural grassland can sustain only 2 Gaurs and 1 elephant in the basis for dry season biomass availability.

6.9. Discussion:

Grass and bamboo fodder species diversity in canopy opened plots of Mahananda WLS was calculated to be 3% of the total plants recorded. While fruit fodder diversity is minimal in the sample plots. In comparison to the canopy opened plots, the teak plantation plots show less dense of grass fodder species as it recorded only 35%, while total grass and bamboo fodder density in whole of Mahananda was calculated to be 57%.

Among the weeds *Chromolaena odorata*, *Mikania micrantha*, and *Clerodendrum infortunatum* were denser than others. The weed species density was calculated to be almost 10% in Teak plantation and 5% in the canopy opened plots, where it was seen that the density of these vice versa of the fodder species.

Of the two major herbivores in Mahananda only Gaur shows a positive correlation between sightings and the percentage of grassland area.

A total of 7 plant species was recorded as consumed by the herbivores like the Elephant, Gaur, Barking deer and Spotted deer. Unlike Jaldapara and Gorumara direct observation of animals feeding was very difficult in Mahananda, because it does not have any open area. So, the findings may not be accurate in the terms of the percentage of the consumed plant species.

Among the planted species Dhadda (*Sachhrrum narenga*) shows the highest productivity of 0.043 kg/sq m or 430 kg/ ha in Managed plots, while natural growing grass fodder species *Digitaria sp.* shows the highest productivity (0.016 kg/sq m or 160 kg/ ha).

The biomass of the planted species of grass fodder in the managed plots of Mahananda WLS was seen not to support any animal by its own, but with the naturally growing grass fodder species present in the managed plots it is seen to support 1 elephant and 2 gaurs on the basis of biomass in the dry season as per our findings.

7. General Discussion and Suggestions

The research findings presented in this report was conducted with the degree of skill and care consistent with customarily accepted good practices and procedures, which were applicable at the time and place of this study.

Conclusions and recommendations require the balance of diverse scientific, regulatory, economic, and other criteria. The suggestions presented are based on an assessment of conditions existing on the dates of the field reconnaissance and on readily available Forest Department data (records, reports and staff interviews) from all the three Protected Areas (JNP, GNP and MWLS), and may undergo revision as additional data are obtained and conducted over a period of time covering all the seasons.

Adaptive Management

Usually, Wildlife Management suffers from a lack of strong theoretical under-pinning. However, even where there is a good understanding of ecological processes, there are differences between sites and environmental fluctuations over time that makes predictions difficult, if not impossible. Under these conditions, a blueprint approach cannot work and adaptive management is the only option. Adaptive Management is a learning-based management approach that is used to reduce scientific uncertainty.

The advantages of the Adaptive Management approach are that 1) It enables timely intervention when a situation is fast-changing, 2) results of monitoring will provide an understanding of the system and 3) an Adaptive approach homes in on the objective with very little chance of a hit-or-miss situation.

Furthermore, we know that conditions change over time in any context -something we experience in the governance of any living being. Just as there is no universal prescription for good governance, one should not presume to impose such conditions on managers of renewable natural resources. Ecologists, conservation biologists and wildlife managers now recognize the need to manage multiple species simultaneously, or even entire communities, rather than just individual species. The appropriate scale of management is often large, requiring the spatial subdivision of management units. In addition, more researchers have acknowledged the importance of Adaptive approaches to management, and the application of multiple working hypotheses in the resolution of management uncertainty.

A common objective that motivates the management of wildlife resources is the optimal utilization by one or more animal populations, and this means of deriving an optimal" management strategy, based on the best current information. The study system need not be subjected to management mistakes incurred while reinforcement learning takes place; this is clearly advantageous for natural resource applications.

Grassland (Fodder species)

Historically, traditional grassland management promoted homogeneity-based approaches, simplifying ecosystem structure, and uniform disturbances across the landscape (Fuhlendorf

and Engle, 2001, 2004). Restoration of habitat heterogeneity continues to be a major challenge and critical need for wildlife conservation in grasslands (Johnson and others, 2011; Fuhlendorf and others, 2017). A heterogeneity-based approach to grassland management has not been well studied.

This is all the more true for grassland conservation, where a variety of grassland conditions will be required; that is, no single grassland habitat type or alternative management approach will be adequate to conserve the entire suite of grassland herbivores in a particular area (McCracken, 2005; Ribic and others, 2009).

Cover and abundance were estimated for grasses, shrubs, herbs, and sedges. Data collection in grasslands was carried out in the pre- and post-monsoon season *i.e.* December, 2018 and October, 2019.

Data was collected from 37 management plots and from five natural grassland (unmanaged) plots in Jaldapara and from 31 management plots and three natural grassland (unmanaged) plots in Gorumara NP. In Mahananda no open grasslands were there as other NPs, so the Forest Department resorted to canopy openings. For our present study Canopy opened plots were chosen and since open grasslands were not available no comparison could be made on the findings from such Canopy opened areas with areas outside these.

Our findings clearly indicate that Dhadda is not a good species to be planted in the management plots. This has also been reflected in the latest Management Plan of Jaldapara NP where they have suggested only 50% of Dhadda be considered for plantation. We would like to go a little further in that our suggestion would be to plant only 10% of Dhadda and over the next couple of years after a rapid analysis to remove the species from the plantation list. There is enough Dhadda available in the open unmanaged grasslands to be sustainable by itself. Moreover, over the years as per the plantation journals it is seen that the older plantations are left and mostly not tender and in addition occupying space where other fodder can be planted or can grow on their own as is seen in the present study. Dhadda grows vigorously and naturally, suppressing the growth of other species (Ghosh and Das, 2007).

Our suggestion for new plantations and for replanting in earlier management plots would be to take into consideration the following species that are already listed for plantation by the Forest Department like Chepti (*Themeda arundinacea*), Purundi (*Alpinia nigra*), Malsa (*Saccharum longisetosum* var. *longisetosum*) and Madhua (*Saccharum arundinaceum*), the last two being among the most preferred fodder of the large ungulates which can be planted @ 50%. In addition, as per our present findings species that are growing naturally in the management plots which are also fodder species [Thach/Son (*Imperata cylindrica*), Kasia (*Saccharum spontaneum*), Choto chepti/Chapta (*Axonopus compressus*) and Nol (*Arundo donax*)] be considered for planting along with those earlier planted and see the effect over the next two years. In addition, *Digitaria* sp. and other Bamboo sp. may be added in the list of species to be planted in Mahananda as both grass and bamboo fodder species accounted for nearly 60% of the fodder species in the canopy opened plots. Along with all these species only 10% of Dhadda may be considered for planting. Monitoring the effects regularly would help in putting forward a prescription based on the lessons learnt.

Invasive Weeds

Managers have been seeking solutions to invasion of areas by exotic species for decades. But they continue to invade and destroy once productive grassland at an alarming rate. It is becoming increasingly clear that effective land management is complicated and no one treatment or technique works across all areas. In many situations, an effective solution for exotic species infestations has not been developed or only partially developed.

In the present study among the weed species recorded, *Mikania micrantha*, *Chromolaena odorata* and *Ageratum conyzoides* were the dominant and recorded only 20% as maximum. It is suggested that weeding of these species should be done just before the opening of the fences. The Adaptive Management strategy would be to then monitor the abundance of these invasive species within two years and take action weeding. The weeds like *Mikania micrantha*, *Lantana camara*, *Leea spp*, *Eupatorium spp.*, *Clerodendron spp.*, *Cassia tora* and *Solanum nigrum* etc mostly occurred in the managed plots.

Mikania micrantha, was observed to be consumed by Rhino, Gaur, Elephant and Spotted deer both in JNP and GNP. Due to extensive growth of *Mikania* within these National Parks, animals are compelled to change their dietary habit and forced to browse on tender shoots of *Mikania* which usually they don't prefer (Anon, 2018). This weed in Jaldapara, was observed to be consumed both by Rhino and Gaur in the winter season. For the first time in the history of Jaldapara NP *Lantana camara* was recorded to be browsed by Rhinos, though it has been reported earlier from Nepal and Assam.

All these weeds have the potential to damage the habitat of Rhino and other wild animals. Cutback and burn do not help to restrict the growth of many of these species, because of simple cutting and burn does not destroy the root system. Only proper uprooting can help the cause only even it is done in initial (before fruiting and flowing) stage. So, while uprooting one has to be very specific about the weed species and the timing of its flowering and fruiting season. Also, some species like *Lantana* resprout after burning.

In fact, the suggestion given above for including some fodder species in the plantation list would help in controlling the invasion of these weeds as is seen from the present study where weeds recorded to be only 1% in natural grasslands (unmanaged).

It is suggested that the Gorumara North and South Range would require weed management much more than other PAs due to its heavy cover percentage recorded in Gorumara. This point may be taken into consideration while developing management plots in these areas.

Further the management authorities may also take into consideration the extent of coverage of weeds in the 3 PAs in figures 60, 61 and 62.

Percentage cover of vegetation other than trees in Jaldapara National Park

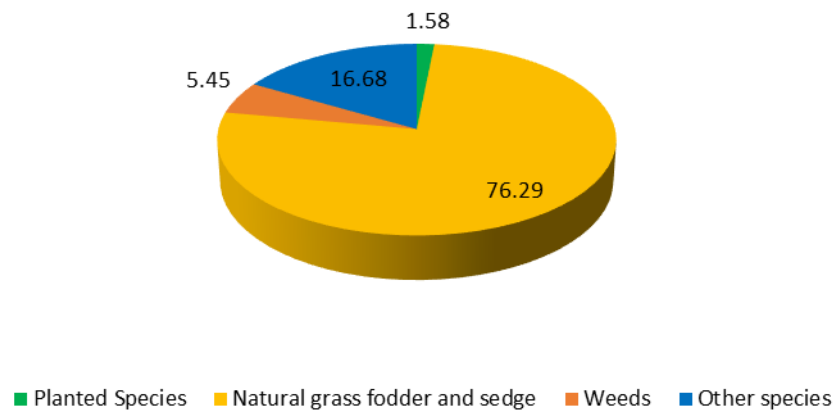


Figure 60: Percentage cover of vegetation other than Trees in Jaldapara National Park

Percentage cover of vegetation other than trees in Gorumara National Park

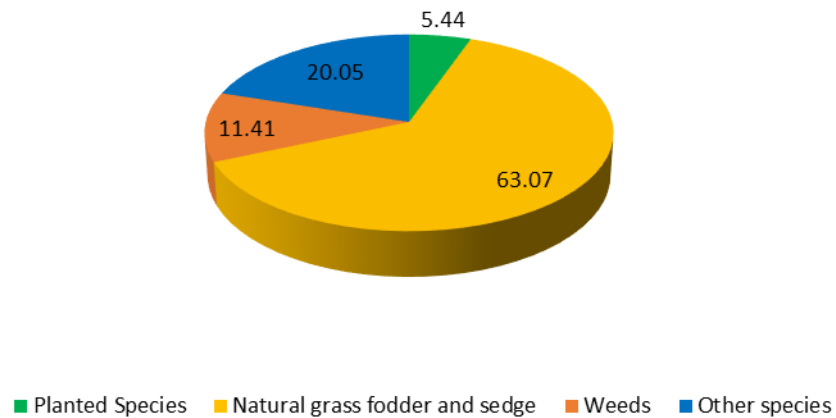


Figure 61: Percentage cover of vegetation other than Trees in Gorumara National Park

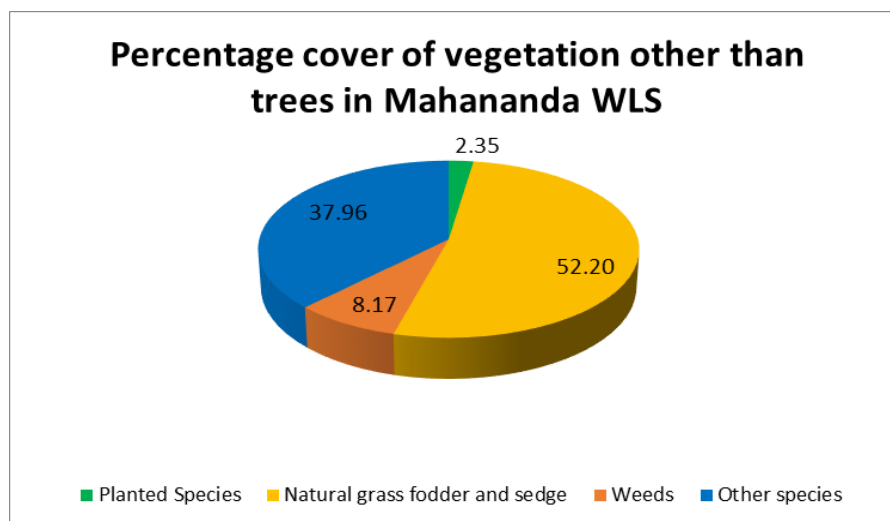


Figure 62: Percentage cover of vegetation other than Trees in Mahananda WLS

Animal Sightings

Except for the direct and indirect sightings of Hispid hare by the present investigators, all data on animal sightings have been collected from the records maintained by the Forest Department.

During the study period, 70% of the total sightings of the Hispid hare (both direct and indirect) in JNP was documented from the managed plots of West and East Range. Both the direct sightings were from Jaldapara HQ Beat. In these places the Hispid hare was seen to choose tall, coarse and old Dhadda plantation beds for its nesting ground during the months of March-April.

As mentioned earlier that Dhadda when planted, cannot be removed either manually or by fire due to the huge stump that goes well into the soil when left untouched for seven years which is the usual time for replantation in the management plots. A few of these managed plots where Dhadda had been earlier planted may set aside in Jaldapara HQ Beat and a few more in continuity with this for the recovery of the Hispid hare. In these areas to prevent natural succession Dhadda may be considered for planting, helping in maintaining the habitat of the Hispid hare.

The data on Animal Sightings maintained by the Forest department revealed that the most utilized habitat zone for both the Rhino and Gaur was in the Sissamara and Malangi beats of the East Range of Jaldapara NP.

From our findings it was seen that the occupancy percentage of Natural grass, fodder & sedge plants in the management plots ranged from 27.85% to 94.17% in pre & post monsoon season, occupying the maximum area of 61% and 66% within the Range in Pre and post monsoon seasons respectively. Of these, *Axonopus compressus* (Chota chepti) occupied more than 70% during the post monsoon season. This further substantiates our suggestion to plant such naturally occurring species in the management plots.

Similarly, Budhram with Ramsai Ext followed by Gorumara Beat of the South Range which has most of the natural grasslands in Gorumara NP was the most utilized habitat zone for both the Rhino and Gaur.

Both these large ungulate species Rhino and Gaur showed a positive correlation between their sightings and the percentage of grassland area in both Jaldapara and in Gorumara.

Opportunistic Feeding Behaviour

In Jaldapara Rhino was seen to graze on 22 species of plants. Of these Dhadda was eaten 10 times and Chepti, 8 times while on the other grass species together 14 times and they browsed on the weeds like *Mikania* and *Lantana* 7 times. Gaur was seen to graze on Dhadda and Chepti together at about 12 times while on the other grass species together 19 times and browsed on the weeds like *Mikania* only once.

Elephants were observed only once eating *Bombax ceiba* as also Spotted deer on *Themeda arundinacea* once. The Sambar was observed to feeding on 9 species of plants.

In Gorumara Rhino was seen to graze on 7 species of plants of which Dhadda was fed upon 4 times and Chepti 5 times, while they fed on other grass species together 11 times and browsed on the weeds like *Chromolaena odorata* 3 times.

Gaur was seen to graze on Dhadda and Chepti together at about 27 times, while on the other grass species together also 27 times and browsed on the weeds like *Mikania micrantha* 7 times.

Elephants were seen to graze on Dhadda and Chepti together 11 times, while on the other grass species together 10 times and browsed on the weeds like *Mikania micrantha* and *Lantana camara* 2 times.

Spotted deer was seen to graze mostly on natural grass species, 17 times.

It is seen from the feeding behavior that these herbivores feed on a variety of fodder species of plants. However, Dhadda and Chepti seem to form nearly 50% of their diet.

Unlike Jaldapara and Gorumara direct observation was very difficult in Mahananda, because there are no open areas within it for sighting. So, the findings are shown here may not be accurate in the terms of the percentage of consumed species of plants.

Once again it is seen that there is a need to increase the naturally growing grass species by planting them in the management plots.

Fodder Biomass

A goal of any forest resource monitoring program must be to address change in biomass as well as its state. A more comprehensive and reliable approach for estimating biomass change is to combine new field studies with analysis of earlier work. At least two measurements on permanent management plots are needed to estimate biomass change. These measurements should preferably be a minimum of 3-5 years apart, particularly in forests vulnerable to change. The established management plots must be re measured regularly and be integrated into a

framework of continuous forest monitoring. This approach will provide the most accurate and precise estimates of total biomass and biomass density change for Adaptive Management.

Though the above is the best way to monitor and understand Fodder Biomass, the present study was only for three years. Though the study contract was done in Feb 2017, the study started after a short delay in getting the permit, and then it took a while for the study to be on course in pursuing the actual objective of the research project. Unfortunately, due to the Covid-19 Pandemic lockdown, left us with only one season and very little field studies for precise documentation. However, using the best time and resource at our disposal that we had, it is seen that the estimated Biomass comprising of the Planted Fodder Species planted by the Forest Department in the management plots and the estimated Biomass of the Fodder Species that occurred naturally in the Natural Grasslands (untouched/unmanaged) were the maximum. In fact, when the Available Biomass of Fodder Species was taken into consideration it is seen that the Biomass in the Management Plots is approximately $1/3^{\text{rd}}$ of the Biomass of Natural Grasslands (untouched/unmanaged).

This indicates that if this $1/3^{\text{rd}}$ of Managed plots has helped in the steady growth of these large herbivores, it is suggested that 10 to 20% more management plots may be undertaken for plantation with the species identified above under Grassland as a general prescription, with regular monitoring and use of Adaptive Management protocols. In fact, this is true of Mahananda where the Biomass of Natural Grass species growing within the management plots seem to sustain the carrying capacity of the animals, because even though Dhadda was present the planted species did not have enough Biomass to sustain even one animal.

If time was not the constraint the Biomass estimations could have been carried season wise to get a realistic picture of the availability of Fodder which would help in arriving at a reasonable estimation of the carrying capacity of these large herbivores in these Protected Areas.

Carrying Capacity

Based on the Fodder species Biomass it was estimated that in totality Jaldapara NP can sustain 111 Rhinos, 248 Gaurs and 55 Elephants. However, if only the total Fodder Biomass in management plots are considered then it is 30 Rhinos, 68 Gaurs and 15 Elephants. However interestingly if the Biomass of the planted species and the biomass of the naturally growing species within the management plots are taken into consideration separately then we see that the Biomass of the planted species alone sustains 17 Rhinos, 37 Gaurs and 8 Elephants while 14 Rhinos, 31 Gaurs and 7 Elephants are estimated when only the naturally occurring grass species within the management plots are considered.

Based on the Fodder species Biomass it was estimated that in totality Gorumara NP can sustain 38 Rhinos, 86 Gaurs and 19 Elephants. However, if only the total Fodder Biomass in management plots are considered then it is 9 Rhinos, 21 Gaurs and 5 Elephants. However interestingly if the Biomass of the planted species and the biomass of the naturally growing species within the management plots are taken into consideration separately then we see that the Biomass of the planted species alone sustains 7 Rhinos, 17 Gaurs and 4 Elephants while 2 Rhinos, 4 Gaurs and 1 Elephant are estimated when only the naturally occurring grass species

within the management plots are considered. Once again it is seen that the impact of the Biomass of naturally occurring fodder grass species in the management plots nearly enhances the sustainability of these herbivores by 1/4th.

This is true of Mahananda also, where the planted fodder species does not sustain even one animal on its own Biomass, while the Biomass of the naturally occurring species within the management area sustains at least 2 Gaurs and 1 Elephant.

Once again it is seen that the impact of the Biomass of naturally occurring fodder grass species in the management plots nearly enhances the sustainability of these herbivores twice over. The recommendation of adding the naturally occurring grass fodder species in the plantation list stands here too.

All calculations for carrying capacity were based only on grass vegetation and large stem plants were not included in the estimation of biomass, even though it is known that large herbivores feed also outside such grasslands.

8. Recommendations

Adaptive Management in the three Protected Areas – Jaldapara National Park, Gorumara National Park and Mahananda Wildlife Sanctuary.

Fodder Species

It is recommended that in addition to the list of fodder species that has been used for planting in the management plots so far by the respective Forest Department, the following fodder species may be added as their impact on the biomass is substantial. From the present study the species that can be added to the list of plantation fodder species in Jaldapara NP and Gorumara NP are **Thach/Son (*Imperata cylindrica*)**, **Kasia (*Saccharum spontaneum*)**, **Choto chepti/Chapta (*Axonopus compressus*)** and **Nol (*Arundo donax*)** be considered for planting along with those earlier planted. In addition, ***Digitaria sp.* and other Bamboo sp.** may be added in the list of species to be planted in Mahananda. However, Dhadda though featuring in the list of fodder species should not be more than 10% planted in any management plot.

In addition, seeds of **fodder grasses and legumes** should be mixed together and sown as a **mixed crop**. The inclusion of legumes is advantageous in many ways. They are rich in protein and they raise protein content of the feed. They enrich soil by fixing atmospheric nitrogen and consequently the grasses that are associated with legumes make a better growth than the grasses which are grown alone. The indigenous legumes selected should be rich in foliage growth which in turn has rich protein and minerals. Further addition of such species in the management plots would prevent the growth of weeds to a large extent. It is recommended that the following indigenous species of legumes, some of which were also recorded in our study and others commonly available throughout the North Bengal such as *Abrus precatorious*, *Abrus pulchellus*, *Crotalaria prostrata*, *Desmodium gangeticum*, *Flemingia strobilifera*, *Tephrosia candida*, *Mucuna pruriens*, *Vigna vexillata* may be consider for use in managed plots.

These fodder species may be planted based on the grazing capacity of herbivores as follows:

- 1) Primarily grazers (90 - 100%) feeding on medium to tall grass of moderate quality (bulk grazers);
- 2) Primarily grazers (90 - 100%) feeding on short grass of high quality (concentrate grazers);
- 3) Mixed feeders (11 - 89%) feeding on grass; and
- 4) Primarily browsers (90 - 100%) feeding on the woody component.

Along with a species mix ratio of 45%:20%:20%:15% for classes 1 to 4 respectively.

Grazing

The object of scientific grassland management is to maintain the grassland in the highest state of herbage production and at the same time is to satisfy the forage requirements of the grazing animals as well as to maintain the fertility of the soil unimpaired.

In any plan of grazing management, therefore the main principles are to utilize the grass at a time when the growth and reproduction are least interfered with and to utilize the grass when it is most palatable and nutritious. Grasses in general are most palatable and nutritious at the young stage, but the grazing at this stage is harmful to the plants. The palatability and nutritive value decrease with the maturity of the plant and when the grass is consumed only at the late stage, the grazing animal is at a disadvantage because of lower nutritive value.

Therefore, the timing of the removal of the fence from the management plots is very crucial both for the plants as well as for the grazers. Since the management plots will have a mixed crop of fodder species and legumes the optimum time needs to be worked out. Preferably simultaneous planting in all the management plots should not be undertaken and planting schedule should be deferred for each plot for each Range. This will help in deferred grazing where a part of the grassland area is not used until after seed maturity in order to give a chance for the herbage to make sufficient growth and to accumulate sufficient reserved food material to maintain vigour of the plants and produce new shoots next year from the seeds that are shed. This system is applicable where perennial grasses are predominant.

Grazing is allowed in the closed management plot later on, but before the herbage becomes too old and unpalatable. Grazing at this stage help in the disposal of seeds and their placement in the soil, thus favor good germination.

We recommend a deferred and rotational grazing for long term sustenance of plant species and the animal species.

Ranges

Year	Compartment closed to grazing	Months of grazing in different compartments		
		July-Oct Jan-Apr	Aug-Nov Feb-May	Sep-Dec Mar-Jun
1st	A	B	C	D
2nd	B	C	D	A
3rd	C	D	A	B
4th	D	A	B	C

In addition, if such preferred and rotational grazing is undertaken as adaptive management, simultaneously provision of salt licks and water bodies for wallowing may be provided in the compartments as mentioned above in each of the Ranges. This will not only help in easy access for feeding and resting but also help in sighting of animals as part of the eco-tourism zone, where ever these provisions are made.

Forage Biomass

Due to the inadvertent situation this time the Forage Biomass could not be done as best as we wanted it to be.

We recommend that in future for all Forage Biomass Estimations especially from management plots should be undertaken at least a couple of days before the fence are removed. Also, Biomass estimations should be reflecting at least two seasons if not the ideal four seasons. Moreover, all collections for Biomass estimation should be preferably done along with the quantitative and qualitative sampling of the Fodder species for getting a near to perfect realistic data. This will go a long way in the calculation of the Carrying Capacity of not only the grassland ecosystem but also of the animals that depend on this ecosystem. In addition to regenerate more grassland areas it is recommended that canopy opening may be undertaken in old teak plantations and in monoculture plantations in the 3 protected areas.

Carrying Capacity

The Carrying Capacity of the grasslands are adequate for the present species of animals. It is at a stage when the Carrying capacity of the Herbivores will overshoot beyond its sustenance. We recommend of having 10% extra management plots in each Range. In addition, it is useful to procure the tea gardens or at least portions of it that border the Protective Areas for future growth of the large ungulates. They are in their last home in West Bengal.

9. Conclusion

The study revealed that the impact of managing the grasslands in these Protective Areas have shown in the turnover of the large herbivores which have had a logarithmic growth since the initiation of such management practices. In effect the study revealed that the past management intervention of grassland development and canopy opening has helped enhance the ecosystem and wildlife in all the 3 PAs of North Bengal. From our study we have suggested a few alterations for the betterment of the management practices and introduce regular monitoring and correction through adaptive management.

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ANNEXURE 1

List of planted species of plants as per Plantation Journals in the selected managed plots in Jaldapara NP

Management plot Name	Dhadda (<i>Saccharum narenga</i>)	Chepti (<i>Themeda arundinacea</i>)	Purundi (<i>Alpinia nigra</i>)	Malsa (<i>Saccharum longisetosum</i> (Andersson) V. Naray. ex Bor)	Madhua (<i>Saccharum arundinaceum</i>)	Banspata (<i>Setaria palmifolia</i>)	Kasia (<i>Saccharum spontaneum</i>)	Bamboo (<i>Bambusa</i> sp)	Hogla (<i>Typha elephantina</i>)	Nol (<i>Arundo donax</i>)	Khagra (<i>Phragmites karka</i>)	Thach (<i>Imperata cylindrica</i>)	Ekra (<i>Saccharum longisetosum</i> var. hookeri (Hackel) Bor)
ESQ1	√	√	√	√	√	√							
ESQ2	√	√	√	√	√								
EJQ3	√	√	√	√	√	√							
EJQ4	√	√	√	√	√	√							
EJQ5	√	√	√	√	√	√							
EJQ6	√	√	√	√	√	√							
EMQ7	√	√	√	√	√								
EMQ8	√	√	√	√	√		√						
WBQ9		√	√					√					
WBQ10	√	√	√	√	√				√	√	√	√	
WBQ11	√	√	√	√	√				√	√	√	√	
WBQ12	√	√	√	√	√								
WBQ13	√	√	√	√	√								
WBQ14	√	√	√	√	√								√
WBQ15	√	√	√	√	√								
WBQ16	Journal Not found												
WHQ17	√	√	√		√								
WHQ18	√	√											
WHQ19	√	√	√							√			
WHQ20	√	√	√		√	√							
WHQ21	No information in journal												
WHQ22	√	√	√		√								
WTQ23	√	√	√							√	√		
WTQ24	√	√	√	√	√						√		

WTQ25	√	√	√		√								
WTQ26	√	√	√						√		√		
WTQ27	Journal Not found												
WKQ28	√	√	√		√								
WKQ29	Journal Not found												
WMQ30	√	√	√	√	√								
WMQ31	√	√	√	√	√								
N50Q32	√	√	√	√									
N50Q33	√	√	√	√									
NHQ34	√	√	√										
NSQ35	√	√											
NSQ36	√	√			√								
NHQ37	√	√											

List of planted species recorded in the selected managed plots during the study in Jaldapara NP

Management plot Name	Dhadda (<i>Saccharum naranga</i>)	Chepti (<i>Themeda arundinacea</i>)	Purundi (<i>Alpinia nigra</i>)	Malsa (<i>Saccharum longisetosum</i> var. <i>longisetosum</i>)	Madhua (<i>Saccharum arundinaceum</i>)	Banspata (<i>Setaria palmifolia</i>)	Kasia (<i>Saccharum spontaneum</i>)	Bamboo (<i>Bambusa</i> sp.)	Hogla (<i>Typha elephantina</i>)	Nol (<i>Arundo donax</i>)	Khagra (<i>Phragmites karka</i>)	Thach (<i>Imperata cylindrica</i>)	Ekra (<i>Saccharum longisetosum</i> var. <i>hookeri</i> (Hackel) Bor)	<i>Thysanolaena latifolia</i> (haru gach)
ESQ1	✓	✓			✓									
ESQ2	✓	✓												
EJQ3	✓													
EJQ4	✓	✓												
EJQ5	✓	✓			✓									
EJQ6	✓	✓			✓									
EMQ7	✓	✓	✓											
EMQ8		✓			✓									
WBQ9								✓						
WBQ10	✓	✓												
WBQ11	✓	✓			✓									
WBQ12	✓	✓												
WBQ13	✓	✓			✓									
WBQ14	✓	✓												
WBQ15	✓	✓			✓									
WBQ16	✓	✓		✓	✓	✓								
WHQ17	✓	✓	✓											
WHQ18	✓													
WHQ19	✓	✓	✓	✓										
WHQ20	✓	✓												
WHQ21	✓													✓
WHQ22	✓	✓												
WTQ23	✓													

WTQ24	√	√		√	√									
WTQ25	√	√												
WTQ26	√	√												
WTQ27	√			√										
WKQ28	√	√												
WKQ29	√	√		√										
WMQ30	√	√	√											
WMQ31	√	√												
N50Q32	√	√												
N50Q33	√	√												
NHQ34	√													
NSQ35	√	√												
NSQ36	√	√												
NHQ37	√													

List of planted species of plants as per Plantation Journals in the selected managed plots in Gorumara NP

Management plot Name	Dhadda (<i>Saccharum narenga</i>)	Chepti (<i>Themeda arundinacea</i>)	Purundi (<i>Alpinia nigra</i>)	Malsa (<i>Saccharum longisetosum</i> (Andersson) V. Naray. ex Bor)	Madhua (<i>Saccharum arundinaceum</i>)	Banspata (<i>Setaria polimifolia</i>)	Bamboo (<i>Bambusa</i> sp)	Nol (<i>Arundo donax</i>)	<i>Panicum crus-galli</i> (Chouru grass)	<i>Digitaria ciliaris</i> (Dhansi)	<i>Eragrostis</i> sp. (dal grass)	<i>Commelina diffusa</i>	<i>Eleusine indica</i> (Maua grass)	<i>Borreria alata</i> (Alu grass)	<i>Cenchrus setiger</i> (Dhabon)	<i>Phragmites karika</i> (Bas khakra)	Gosalpata/mechiaPata
GSBQ2							√										
GSBQ8	√	√		√				√									
GSBQ9	√	√															
GSBQ10	√	√		√													
GSBQ11	√	√		√													
GSBQ12	√	√		√	√										√		
GSBQ13	√	√		√	√										√		
GSBQ14	√	√		√	√										√		
GSDQ29	√	√	√	√													
GSDQ30	√	√		√	√												
GSDQ31	√	√	√		√												
GSDQ32	√	√		√	√										√	√	
GSGQ 40		√				√			√	√	√	√	√	√			
GSGQ 41	√	√	√	√													
GSGQ 42	√	√		√	√												
GSGQ 43	√	√		√	√												
GSGQ 44	√	√		√	√												
GSGQ 45	√	√		√	√												
GSGQ 46	√	√		√	√												
GSGQ 47	√	√		√	√												
GSGQ 48	√	√		√	√												
GSGQ 49	√	√		√	√										√		
GSDQ 50	√	√	√	√	√												√

GSDQ 51	√	√		√												√	
GSDQ 52	√	√		√	√											√	
GNKQ1	√	√	√	√	√			√								√	
GNKQ2	√	√		√	√												
GNKQ3	√	√		√													
GNKQ5	√	√		√													
GNMQ3	√	√															
GNMQ4	√	√	√	√													

List of planted species recorded in the selected managed plots during the study in Gorumara NP

Management plot Name	<i>Dhadda (Saccharum narenga)</i>	<i>Chepti (Themeda arundinacea)</i>	<i>Purundi (Alpinia nigra)</i>	<i>Malsa (Saccharum longisetosum (Andersson) V. Naray. ex Bor)</i>	<i>Madhua (Saccharum arundinaceum)</i>	<i>Banspata (Setaria palmifolia)</i>	<i>Bamboo (Bambusa sp)</i>	<i>Nol (Arundo donax)</i>	<i>Panicum crus-galli (Chauru grass)</i>	<i>Digitaria ciliaris (Dhans)</i>	<i>Eragrostis sp. (Dal grass)</i>	<i>Commelina diffusa</i>	<i>Eleusine indica (Marua grass)</i>	<i>Borreria alata (Alu grass)</i>	<i>Cenchrus setiger (Dhabon)</i>	<i>Phragmites karika (Bas khakra)</i>	<i>GosaiPata/mechiaPata</i>
GSBQ2							√										
GSBQ8	√	√						√									
GSBQ9	√	√		√													
GSBQ10	√	√															
GSBQ11	√	√			√												
GSBQ12	√	√													√		
GSBQ13	√	√															
GSBQ14	√	√															
GSDQ29	√	√		√	√												
GSDQ30	√	√			√												
GSDQ31	√			√													
GSDQ32	√	√		√	√												
GSGQ40	√	√															
GSGQ41	√	√															
GSGQ42	√			√													
GSGQ43	√	√															
GSGQ44	√	√			√												
GSGQ45	√	√			√												
GSGQ46	√	√		√	√												
GSGQ47	√	√		√													
GSGQ48	√	√			√												
GSGQ 49	√	√						√							√		
GSDQ 50	√	√		√	√												

GSDQ 51	√	√		√	√												
GSDQ 52	√	√		√	√												
GNKQ1	√	√															
GNKQ2	√	√		√	√												
GNKQ3	√			√													
GNKQ5	√	√															
GNMQ3	√																
GNMQ4	√	√	√	√													

List of planted species of plants as per Plantation Journals in the selected managed plots in Mahananda WLS

Management plot Name	Bamboo	Amala	Bahera	Chalta	Arjun	Haritaki	Jarul	Lator	Jackfruit	Morus sp	Sisso	Sindure	Lapshi	Dhadda (Sacharum narenga)	Chepti (Themeda arundinacea)	Dhotisara (Setaria palmifolia)	Purundi (Alpinia nigra)	Nol (Arundo donax)	Bhutta grass (Coix lachryma)	Amliso (Thysanolaena sp)
MNWGQ 1	√	√	√	√																
MNWGQ 2	√	√	√																	
MNWGQ 3	√	√	√	√										√	√	√				
MNWGQ 4														√			√	√		
MNWGQ 5	√	√	√	√	√	√	√	√												
MNWGQ 6	√	√	√	√					√											
MNWPQ 7	√															√			√	
MNWPQ 8															√	√				
MNWPQ 9	√																			
MNWSQ 11	√	√	√	√																
MNWSQ 10	√	√	√	√										√	√	√	√			
MNSCQ 12	√	√	√					√												
MNSMQ 13	No proper information																			
MNSMQ 14	√																√			
MNSMQ 15	Journal not found																			
MNSMQ 16	√																			
MNSMQ 17	Journal not found																			
MNSKQ 18	√	√	√																	
MNNSQ 19	√	√	√																	
MNNSQ 20	√	No proper information on fruit and grass species																		
MNNSQ 21	√	√	√	√																
MNNSQ 22	√	√	√			√														
MNNSQ23	√	√	√			√														
MNNLQ24	√	√	√	√								√	√							

MNNLQ25	√		√	√															
MNNLQ26	√	√	√								√			√	√	√			√
MNNKQ27	√	√																	√
MNNKQ28	√		√	√															
MNNKQ29	√		√	√															
MNS7Q30	√									√				√	√		√		
MNS7Q31	√	No proper information on fruit and grass species																	
MNS7Q32	√			√							√			No proper information on grass species					
MNSTQ33	√												√	√		√			
MNSTQ34	√	√	√	√								√		√	√	√	√		√
MNSTQ35	√	√	√	√															

ANNEXURE 2

Fodders consumed by different herbivores

RHINO



GAUR



ELEPHANT



HISPID HARE

