

Priliminary Phytosociological Study of Medicinal Plants Conservation Area (MPCA) At Forests of Buxa Tiger Reserve (BTR) and Gorumara National Park

Dr. Barin Kumar Pramanik¹, and Dr. Debabrata Das²,

Head, Department of Economics, Darjeeling Govt. College, Darjeeling, W.B., India, 734101
Post Graduate Department of Botany, Darjeeling Govt. College, Darjeeling, W.B., India, 734101

Abstract: *Community composition of a forest is determined by its climatic and edaphic factors with special interactions with biotic factors too. Though altitude is a factor, it governs the whole area by its unique composite interactions to develop a self occupied auto regulated vegetation of special kind. Buxa Tiger Reserve (BTR) in Buxa National Park and Lataguri of Gorumara National Park (GNP) are therefore distinct sites with associate composition of varied kind. It is somehow different from other tracts because it is neither Himalayan type nor the actual riverine type. The people in such specific habitats interact with their own flora, fauna and microorganisms of own kind. Therefore, the present research works revealed a result of significant study of preliminary kind which boosts a goal to know the composition of vegetation in both the sites. The result is comprehensive and comparative one which has been made with the study of different indices. Hope that the present study would help much to the foresters, economists, botanists, ecologists, environment specialist, zoologist, forestry people, horticulturists, tourists, Social Scientists and conservation specialists with a keen knowledge to manage the ecosystem distinctly. Social workers, policy makers, and field biologists would take the opportunity for further study to generate a good knowledge on the aspect of community study. It is essential because to make a role model and framing an ecosystem model for management of flora and fauna and the interactions which is required in a proper way. Not only that the study will emphasis the comparative aspects of vegetation and present scenario with the help of mathematical manipulation using indices. This preliminary study, though this need continuous and rigorous study to come to a fixed decision after 3-4 year study or more in the same field. Hope that the monitoring of vegetation will discuss a jest posture in near future to manage the ecosystem healthy and sound in near future.*

Keywords: *Phytosociology-Buxa-Gorumara-diversity-indices-management.*

I. Introduction

Tropical forest ecosystems are one of the richest terrestrial ecosystems which support a variety of life forms which maintain huge global biodiversity (Shi and Singh, 2002). Both structure and diversity of vegetation have strong functional role in controlling ecosystem processes like biomass production, cycling of water and nutrients (Gower et al., 1992). A strong correlation also exists between structural diversity and species diversity (Sahu et al., 2008). Tropical dry deciduous forest constitutes about 38 percent of total forest area in India (Dixit, 1997). This is correct in a sense that these forests produce huge amount of renewable resource that are being utilized by global people. So, economically the forests are significant, as it is productive in a sense and reducing the pollutants of the atmosphere which could be the safeguard of our toxic materials that lead to death of organisms. Therefore, all the forests of the same kind are the most productive and variable in ecosystem processes in the globe. It broadcasts nutrient cycling, elemental pool, and fate of life of living organisms through predators and consumers as a whole. So, by and large all the biogeochemical processes run in a specific purpose to make the complete ecosystem thereby. As a whole, the compositions of forests are multi-dimensional i.e. from small organisms to large animals including producers in the said area. Block wise the composition constitutes fixed assets as live plant materials including animals and microorganisms. From phytosociological view point, these are trees, shrubs, herbs, lianas, ferns, bryophytes, epiphytes, orchids, parasites etc. These are the multi-dimensional composite elements in the versatile ecosystem. Till date no complete work have been made by researchers in the Buxa Tiger Researve (Map B, C) and Lataguri Forest Range of Gorumara (Map B, D) area in North Bengal regarding species diversity and community composition study strictly for phytosociological analysis, because the site is restricted and under reserved forest. The tiger reserve and the park is situated in Northern West Bengal, India. The site is under the 'Terai' region of the Himalayan foot hills. It is a medium sized park with grass land and forest. The site is popular because it is a residential place of one horned Rhinoceros. It was declared a wildlife sanctuary in 1949 and a national park in the year 1992. The tiger reserve is situated near river Jayanti and the park is located on the bank of rivers Murti and Raidak and has vegetations of riverine grasslands along with savannah type woodlands. Forest is moist deciduous and dominant species is

Sal including Lali and Dudhe lali. Other species available are Teak, Series, Simul and Khair. The park has recorded fauna which boosts 50 mammal species 300 bird species 20 reptile species and 30 species of amphibia. Both venomous and non-venomous snakes are common in the natural habitat of Gorumara including Indian python. Some birds which include brilliant sub-montane forest type are also visible. These are Asian paradise fly catcher, drongo and great Indian hornbill. As the Gorumara park is a national park, it's amazing beauty attracts people over the globe. Not only that a large number of medicinal plants of threatened category are also available here which is the main attraction for the researchers in the said national park. In Bengali, the park is called "Gorumara Jatio Uddan". So remembering the theme, the present work has been taken into account on the basis of MPCA area study funded by National Medicinal Plant Board. The versatile works have been done following the same work made by author (Das, 2007) in the lateritic forests of Southwest Bengal. The scattered publication of similar kind made by authors from site to site in connection with the conservation of forests from other areas of West Bengal. The publications made by them are ecosystem based in the forest area which broadcast conservation and same status regarding the importance and fate of health of the ecosystem (Das, 2014b; Ghosh, 2014a; Das and Das, 2014a; Ghosh and Das, 2014c; Lodhiyal et al., 2015; Rao et al., 2015; Khan et al., 2015). All have made their works for the conservation of species and to conserve the nation through sustainable development of resource which aims a plea from ethical concern and with the conformity of aspects including pattern, structure of resource management. As a whole, not globally but spatially need to study the allocated sites and their concerned floral and faunal elements for the indigenous management in conformity with proper verification of scientific means. Therefore, the present study is required which aims the status of all species and their traits in connection with the management in the same habitat. This means that it would help community to manage the forest resources in a meaningful way. By and large all are basically local need based and after that coincide with others nationally or globally. As per this record the present studies have been taken and study in the reserved forests of North Bengal which having ethnicity and their modern base line of integrity through proper management.

Area Under Study

The study area was the Lataguri Range (Gorumara) of Bichabhanga-1 of Jalpaiguri Forest Division under the jurisdiction of working circle Biodiversity Conservation and the Bauxa-Cooch Behar Range under the forest division Buxa Tiger Reserve [BTR (W)] in the jurisdiction of working circle Biodiversity Conservation, India (Map A).

The study area Lataguri range included within the 200 Ha forest area represented as medicinal plant conservation area (MPCA). The position of the site was in between latitude $26^{\circ} 43' 71.13''$ N and $88^{\circ} 46' 55.54''$ E longitude (Map 1). The administrative district in which it is situated is Jalpaiguri District of West Bengal. The stations taken for the study were selected randomly using EXEL programme and marked as stations A ($26^{\circ} 45' 29.4''$ N and $88^{\circ} 47' 9.7''$ E), B ($26^{\circ} 43' 32.8''$ N and $88^{\circ} 46' 49.6''$ E), C ($26^{\circ} 43' 41.4''$ N and $88^{\circ} 47' 12.8''$ E), D ($26^{\circ} 42' 54.9''$ N and $88^{\circ} 46' 38.8''$ E), and E ($26^{\circ} 43' 14.9''$ N and $88^{\circ} 47' 42.5''$ E). The total area under study was 200 Ha while we have selected 5% area for the study area which was thoroughly studied for checklist preparation. The overall area was taken for consideration on the basis of point through which big transacts was drawn. The transact was drawn against each station and then the area was marked as quadrats for the study of plant species in the quadrats following some principles in Ecology and standardized with the help of Species area curve method. So, the total area covered for the study was within the MPCA area specified, but for complete ecological study, nursery of forest department and some local gardens of common people were taken as per the method of the study included in ecosystem restoration process.

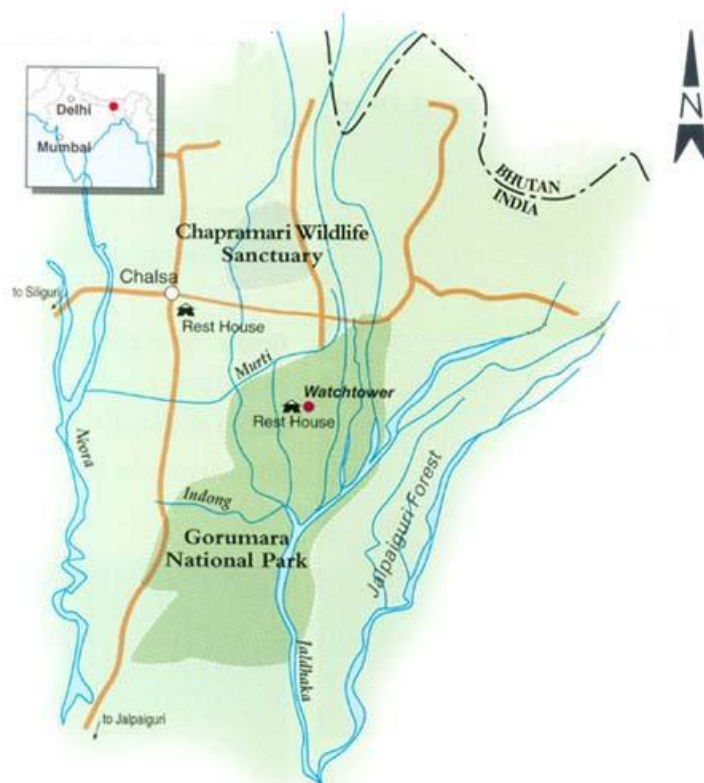
The Buxa Tiger Reserve [BTR (W)] study area included within the NRVK-9 & 10 medicinal plant conservation area (MPCA). The position of the site is in between latitude $26^{\circ} 40' 55''$ N and $89^{\circ} 33' 2.79''$ E longitude. The administrative district in which it is situated is Alipurduar District. The stations for the study were selected randomly using EXEL programme and marked as stations A ($26^{\circ} 40' 48.8''$ N and $89^{\circ} 33' 7.4''$ E), B ($26^{\circ} 40' 49.6''$ N and $89^{\circ} 32' 45.2''$ E), C ($26^{\circ} 40' 39.1''$ N and $89^{\circ} 33' 4.3''$ E), D ($26^{\circ} 41' 46.2''$ N and $89^{\circ} 33' 33.7''$ E), and E ($26^{\circ} 41' 14.1''$ N and $89^{\circ} 32' 58.5''$ E). The total area under study was 200 Ha though we have selected 5% area for the study and for checklist preparation all the area was taken for consideration. The transact was drawn against each station and then the area marked as quadrats for the study of plant species in the quadrats following some principles in Ecology and standardized with the help of Species area curve method. So, the total area covered for the study was within the MPCA area specified but for complete ecological study nursery of forest department and some local gardens of common people also visited as per the method of the study in ecosystem restoration.



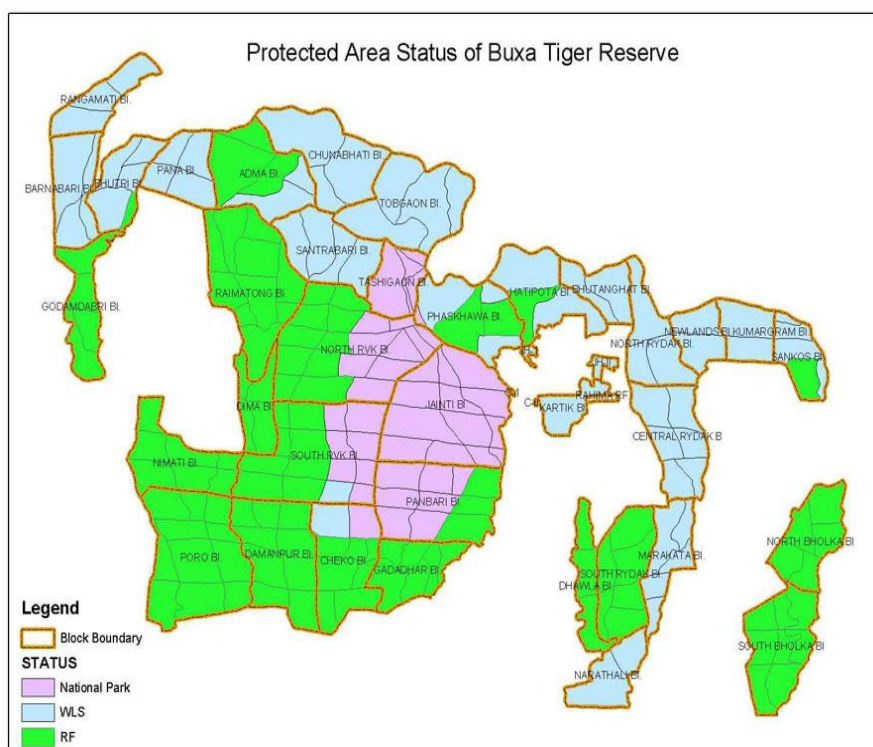
Map A: Map of India showing the state of West Bengal (Red Colour), Source: www. Webnet



Map B: Map of West Bengal showing MPCA Study Areas (Buxa and Gorumara)



Map C: Map of Gorumara National Park, Source: www.Wikipedia.



Map D: Map of Buxa Tiger Researve, Source: www.website, internet.

Composition of Forest Vegetation

The forest floor is more or less moisen so round the year small shrubs like *Ervataima divaricata* (L.) Burkill./, *Coffea bengalensis* Roxb. Ex Schult., *Morinda citrifolia* L., *Mallotus philippensis* Muell., *Lea edgeworthii* Santapau, *Bridelia retusa* Spreng., *Dillenia indica* L., *Aphanamaxis polystachya* (Wall.)R N Parker,

Smilax ovalifolia Roxb. are available. Species like Clerodendrum japonicum (Thunb.) Sweet, Mikania scadens (L.) Willd., Eupatorium odoratum L., Alpinia allughas Retz. etc. are available. Other species available as medicinal plants are Scitamineous species like Costus speciosus (Koenig.) Sm., Globba bulbifera Roxb., Kaempferia rotunda L., Curcuma aromatic Salisb., Curcuma zedoaria (Christm) Roscoe, Zingiber capitatum Roxb., Zingiber rubens Roxb., Alpinia malaccensis Roscoe and Alpinia allughas Retz. occur in pure stand formation in some small areas along with Shorea robusta which is predominated in most of the sites as old stock. Other medicinal plants of economic importance are Morinda tinctoria Roxb., Morinda angustifolia Roxb. along with Phlogacanthus thyrsoflorus Nees. Erenthimum nervosum (Vahl) R. Br. ex Roem & Schultz., Tabernaemontana divaricata (L.) R. Br. ex Roem, Leea bracteata C.B. Clarke (Leea compactiflora Kurz.), Leea crispa Royen ex L. and Leea alata Edgew (flower and fruit red) occur in many plots and grow gregariously. Legumes like Flemingia bracteata (Roxb.) Wight., Indigofera pulchella Roxb., are available as common while Desmodium gyrans DC. is not common.

Regeneration pattern of some species noticed with good and healthy offspring found in the same forest floor. These are elements like Michelia champaca L., Elaeocarpus spp., Talauma hodgsonii Hook. & Thom., Actinodaphne obovata (Nees) Blume, Shorea robusta Gaertn.f., Schima walichii (DC.) Korth., Machilus villosa (Roxb.) Hook.f., Lannea corromendelica (Houtt.) Merr., Castsnopsis spp., Sterculia villosa Roxb. Ex Smith in Rees, Amoora wallichii King., Alangium begonifolium Ball. and Saurauia spp. Some sites having a few number of canes with dispersed distribution along with a few number of Duabanga sp.

II. Result And Discussion

The highest Importance Value Index (IVI) of herbaceous species was observed in case of Curculigo orchioides Gaertn. in both the areas of Buxa and Gorumara region with IVI value 26.59 followed by Drymeria cordata (L.) Willd.ex R.&S. (IVI=16.0). The lowest IVI value of shrubby species was observed in case of Ageratum conyzoides L. (IVI=5.49) at Buxa area and Commelina erecta L. (IVI=3.5) at Gorumara area. Other species of medicinal importance are Globba ophioglosa (IVI=9.86) at both the Buxa and Gorumara area, and Solanum ferox L. IVI=10.80 at Buxa area and IVI=5.80 at Gorumara area. Here all the species available were medicinal but as a whole are not economically viable because all having no commercial importance in the said market (Table 1). The importance value indices of Buxa is observed to be in the better position or superior than the Gorumara area (Graph-2)

Table 1: Importance Value Indices (IVIs) of herbs available at Buxa and Gorumara MPCA, West Bengal, India.

Sl. No.	Name	IVI at Buxa	IVI at Gorumara
1.	Achyranthes bidentata Bl.	11.44	11.43
2.	Agastache anethiodorum (Nutt.) Brid.	8.72	8.72
3.	Ageratum conyzoides L.	5.49	5.49
4.	Commelina erecta L.	-	3.5
5.	Commelina paludosa Blume.	-	4.5
6.	Coutleya spicata (J.M. Sm.) Bak.	9.30	9.29
7.	Curculigo orchioides Gaertn.	26.59	26.59
8.	Cyperus alternifolius L.	5.92	5.91
9.	Cyperus nutans Vahl.	10.56	10.56
10.	Drymeria cordata (L.) Willd.ex R.&S.	16.00	16.00
11.	Dryneria quercifolia (L.) Sm.	15.52	15.52
12.	Elatostemma sessile J.R. Forst.	14.83	14.83
13.	Euphorbia hirta L.	14.73	14.73
14.	Globba ophioglosa Wight.	9.86	9.86
15.	Hedyotis scandens Roxb.	10.45	10.44
16.	Piper sp.	12.12	-
17.	Piper peepuloides Roxb.	-	12.11
18.	Polygonum capitatum Buc.-Ham. Ex Don.	8.96	8.96
19.	Pouzolzia hirta Hassk (Blume) Hassk	9.82	4.0
20.	Ruellia prostrata Poir.	5.92	9.81
21.	Rungia parviflora Nees.	8.87	5.92
22.	Selaginella bryopteris (L.)Bak.	15.63	8.86
23.	Sida acuta Burm.	7.01	15.62
24.	Solanum ferox L.	10.80	7.00
25.	Sonchus oleraceous L.	9.13	5.80
26.	Sphenomeris chinensis (L.) Maxon.	9.90	7.13
27.	Spilathes calva DC.	11.36	5.89
28.	Urena lobata L.	9.21	10.36
29.	Urtica dioica L.	17.61	9.21
	Total:	295.71	295.75

The Buxa forest is homogenous with admixed type of floral elements. Here most of the shrubby species found as climbers though some are moderately tree species found as shrubs due to middle aged stage. Other species found here are woody climbers. These are more or less 30 mt tall. These are globally called African Dream or Snuff Box Sea Bean, Cacao Vine (*Entada rheedii* Spreng.), Rubi Lahara (*Ampelocissus latifolia* (Roxb.) Planch.), Sal Lahara (*Spatholobus parviflora* (Roxb.) Kuntze), Velvet bean (*Mukuna pruriens* (L.) DC.), Dudhe Lahara (*Trachelospermum lucidum* (D. Don.) Schum), Hatu Bhanga (*Leea indica* (Burm.f.) Merr.), Charchare Lahara (*Parthenocissus semicordata* (Wall.) Planch. etc. (Table 2). Other abundant species available in the jungle are Jungli coffe (*Coffea benghalensis* Roxb. ex Schult.), Bhtbhairabi (*Chromolaena odorata* (L.) King & Robin.), Bhat (*Clerodendrum coleobrookianum* Walp.), Togor (*Tabermontana divaricata* (L.) E. Br., Bangla Ghari (*Thunbergia grandiflora* Roxb.), and Dhairo (*Woodfordia fruticosa* Kurtz.).

Community composition of the forest showed the homogenous frequency of species of shrubs. Here highest density was observed in case of *Parthenocissus semicordata* (Wall.) Planch. (16.25), followed by *Ampelocissus latifolia* (Roxb.) Planch. (12.5), where as lowest density was observed in case of *Lygodium japonicum* (Thunb.) Sw.(5).

The highest Importance Value Index (IVI) of shrubby species was observed in the same forest with IVI value 54.42 in case of *Ampelocissus latifolia* (Roxb.) Planch., followed by *Parthenocissus semicordata* (Wall.) Planch. (IVI=51.25), and the lowest IVI value of shrubby species was observed in case of *Lygodium japonicum* (Thunb.) Sw. (16.8). The species like, *Abelmoscus moschatus* (L.) Medic., which is called, "latakasturi" was important medicinal plant available in the forest and is being utilized by the local people. They used broadly the species to gain seeds by cultivation in their agricultural field to develop economy. Most of the NGOs are engaged to develop the trade and transport of the species. The Importance Value Index of the same medicinal plant *Abelmoscus moschatus* (L.) Medic. was observed 27.2. It may be regarded as potent plant for economic development. Other species of medicinal importance are *Smilax wightii* DC., and *Smilax ovalifolia* Roxb. Plants used to prepare natural dye available there is *Mallotus phillippensis* Muel.-Arg.

In case of Gorumara National Park the forest is homogenous with admixed type of floral elements. Here most of the shrubby species found as climbers though some are moderately tree species found as shrubs due to middle aged stage. Other species found here are woody climbers. These are more or less 20 – 25 mt. tall. These are globally called African Dream or Snuff Box Sea Bean, Cacao Vine (*Entada rheedii* Spreng.), Rubi Lahara (*Ampelocissus latifolia* (Roxb.) Planch.), Sal Lahara (*Spatholobus parviflora* (Roxb.) Kuntze), Velvet bean (*Mukuna pruriens* (L.) DC.), Dudhe Lahara (*Trachelospermum lucidum* (D. Don.) Schum), Hatu Bhanga (*Leea indica* (Burm.f.) Merr.), Charchare Lahara (*Parthenocissus semicordata* (Wall.) Planch. etc. (Table 2). Other abundant species available in the jungle are Jungli coffe (*Coffea benghalensis* Roxb. ex Schult.), Bhtbhairabi (*Chromolaena odorata* (L.) King & Robin.), Bhat (*Clerodendrum coleobrookianum* Walp.), Togor (*Tabermontana divaricata* (L.) E. Br., Bangla Ghari (*Thunbergia grandiflora* Roxb.), and Dhairo (*Woodfordia fruticosa* Kurtz.). Community composition of the forest showed the homogenous frequency of species of shrubs. Here highest density was observed in case of *Parthenocissus semicordata* (Wall.) Planch. (16.25), followed by *Ampelocissus latifolia* (Roxb.) Planch. (12.5), where as lowest density was observed in case of *Lygodium japonicum* (Thunb.) Sw.(5). The highest Importance Value Index (IVI) of shrubby species was observed in the same forest with IVI value 54.42 in case of *Ampelocissus latifolia* (Roxb.) Planch., followed by *Parthenocissus semicordata* (Wall.) Planch. (IVI=51.25), and the lowest IVI value of shrubby species was observed in case of *Vitis pedata* (Lam.) Wall. ex Wight (12.0). The species like, *Abelmoscus moschatus* (L.) Medic., which is called, "latakasturi" was important medicinal plant available in the forest and is being utilized by the local people. They used broadly the species to gain seeds by cultivation in their agricultural field to develop economy. Most of the NGOs are engaged to develop the trade and transport of the species. The Importance Value Index of the same medicinal plant *Abelmoscus moschatus* (L.) Medic. was observed 27.2. It may be regarded as potent plant for economic development. Other species of medicinal importance are *Smilax wightii* DC., and *Smilax ovalifolia* Roxb. Plants used to prepare natural dye available there is *Mallotus phillippensis* Muel.-Arg.

Table 2: Importance Value Indices (IVIs) of Shurbs available at Buxa and Gorumara MPCA, West Bengal, India.

Sl. No.	Name	IVI at Buxa	IVI at Gorumara
1.	<i>Abelmoscus moschatus</i> (L.) Medic.	27.2	27.2
2.	<i>Ampelocissus latifolia</i> (Roxb.) Planch.	54.42	54.42
3.	<i>Entada rheedii</i> Spreng.	25.63	25.63
4.	<i>Lygodium japonicum</i> (Thunb.) Sw.	16.8	16.8
5.	<i>Mikania micranta</i> Kunth.	31.1	31.1
6.	<i>Mukuna pruriens</i> (L.) DC.	17.59	17.59
7.	<i>Parthenocissus semicordata</i> (Wall.) Planch.	51.25	51.25
8.	<i>Spatholobus parviflora</i> (Roxb.) Kuntze	17.58	17.58
9.	<i>Stephania glabra</i> (Roxb.) Miers	22.1	22.1
10.	<i>Trachelospermum lucidum</i> (D. Don.) Schum	28.47	26.47

11.	Vitis pedata (Lam.) Wall. ex Wight	-	12.0
12.	Vitis trifolia Roxb.	-	12.25
	Total:	292.14	316.39

At Buxa Tiger Reserve area the highest Importance Value Index (IVI) of herbaceous species was observed in case of *Curculigo orchioides* Gaertn. with IVI value 26.59 followed by *Drymeria cordata* (L.) Willd.ex R.&S. (IVI=16.0). The lowest IVI value of shrubby species was observed in case of *Ageratum conyzoides* L. (IVI=5.49). Other species of medicinal importance are *Globba ophioglosa* (IVI=9.86), and *Solanum ferox* L. (IVI=10.80). Here all the species available were medicinal but as a whole are not economically viable because all having no commercial importance in the said market (Table 3).

In case of Gorumara National Forest the highest Importance Value Index (IVI) of herbaceous species was observed in case of *Curculigo orchioides* Gaertn. with IVI value 26.59 followed by *Urena lobata* L. (IVI=17.61). The lowest IVI value of shrubby species was observed in case of *Commelina erecta* L. (IVI=3.5). Other species of medicinal importance are *Globba ophioglosa* (IVI=9.86), and *Solanum ferox* L. (IVI=5.80). Here all the species available were medicinal but as a whole are not economically viable because all having no commercial importance in the said market (Table 3).

Table 3: Importance Value Indices (IVIs) of trees available at Buxa and Gorumara MPCA, West Bengal, India.

Sl. No.	Name	IVI at Buxa	IVI at Gorumara
1.	<i>Alstonia scholaris</i> (L.) R. Br.	22.5	22.5
2.	<i>Amoora spectabilis</i> Miq.	52.5	45.0
3.	<i>Bischofia javanica</i> Blume	-	22.5
4.	<i>Callicarpa arborea</i> Roxb.	22.5	22.5
5.	<i>Cephalanthus occidentalis</i> L.	22.5	-
6.	<i>Elaeocarpus lanceaefolium</i> Roxb.	22.5	-
7.	<i>Garuga pinnata</i> Roxb.	30	30.0
8.	<i>Gynocardia odorata</i> Roxb.	-	22.5
9.	<i>Lagerstroemia prviriflora</i> Roxb.	30	-
10.	<i>Machilus villosus</i> (Roxb.) Hkf.	22.5	22.5
11.	<i>Michelia champaca</i> L.	-	30.0
12.	<i>Tetrameles nudiflora</i> R.Br.	52.5	52.5
13.	<i>Wrightia tomentosa</i> Roem. & Schult.	22.5	30.0
	Total: 13 Species	300	300

From Table-4 data revealed that in case of Buxa Tiger Reserve diversity of trees is least in comparison to herbs or shrubs, whereas species richness index of shrubs is higher than trees. It showed that species richness index of herbs is higher than shrubs. Here highest dominance was observed in case of *Ampelocissus latifolia* (Roxb.) Planch. (31.92), followed by *Trachelospermum lucidum* (D. Don.) Schum (12.22), where as lowest dominance of shrubby species was observed in case of *Mikania micranta* Kunth. (1.1). Data revealed that diversity of trees is least in comparison to herbs or shrubs, whereas species richness index of shrubs is higher than trees. It showed that species richness index of herbs is higher than shrubs.

For Gorumara National Park, Lataguri the diversity of trees is least in comparison to herbs or shrubs, whereas species richness index of shrubs is higher than trees. It showed that species richness index of herbs is higher than shrubs Here highest dominance was observed in case of *Ampelocissus latifolia* (Roxb.) Planch. (31.92), followed by *Trachelospermum lucidum* (D. Don.) Schum (10.22), where as lowest dominance of shrubby species was observed in case of three species like *Mikania micranta* Kunth. (1.0), *Vitis pedata* (Lam.) Wall. ex Wight (1.0) and *Vitis trifolia* Roxb. (1.0). Data revealed that diversity of trees is least in comparison to herbs or shrubs, whereas species richness index of shrubs is higher than trees. It showed that species richness index of herbs is higher than shrubs (Table-4).

Comparing both the regions of Buxa and Gorumara the diversity indices in case of trees, shrubs and herbs of Gorumara is higher than in Buxa. Whereas in case of dominance index trees of Gorumara is higher than Buxa and for shrubs and herbs Buxa is higher than Gorumara. In case of evenness index for all the species of trees, shrubs and herbs Gorumara is higher than Buxa. For the richness index also for all the three species i.e. trees, shrubs and herbs Gorumara is higher than Buxa (Table-4).

Table 4: Different Diversity Indices of Trees, shrubs and herbs at Buxa and Gorumara forest.

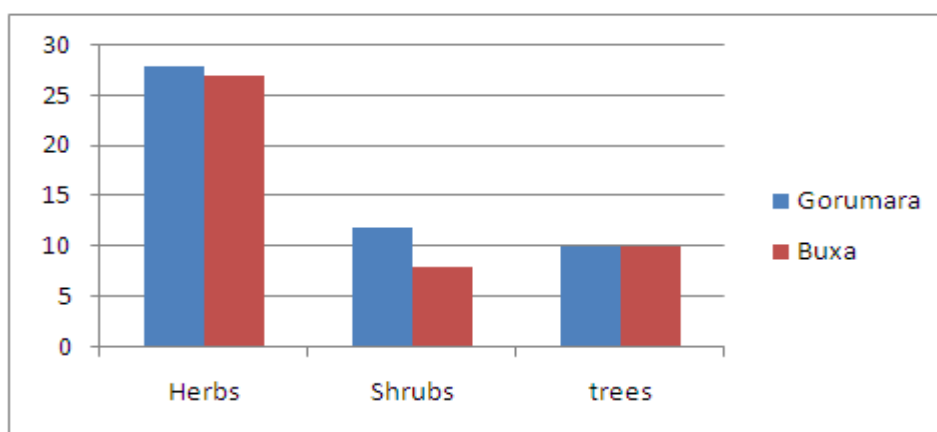
	Trees	Shrubs	Herbs
Diversity Index (H) at Gorumara	0.97	1.02	1.40
Diversity Index (H) at Buxa	0.005	0.012	0.009
Dominance Index (cd) at Gorumara	1.11	0.10	0.04
Dominance Index (cd) at Buxa	0.115	1.05	0.984
Evenness Index (e) at Gorumara	0.97	0.98	0.97

Evenness Index (e) at Buxa	0.006	0.012	0.005
Species Richness Index (d) at Gorumara	3.64	4.45	10.52
Species Richness Index (d) at Buxa	0.03	3.651	4.401

Table 5: Similarity Indices of Trees, shrubs and herbs available at Buxa and Gorumara of West Bengal.

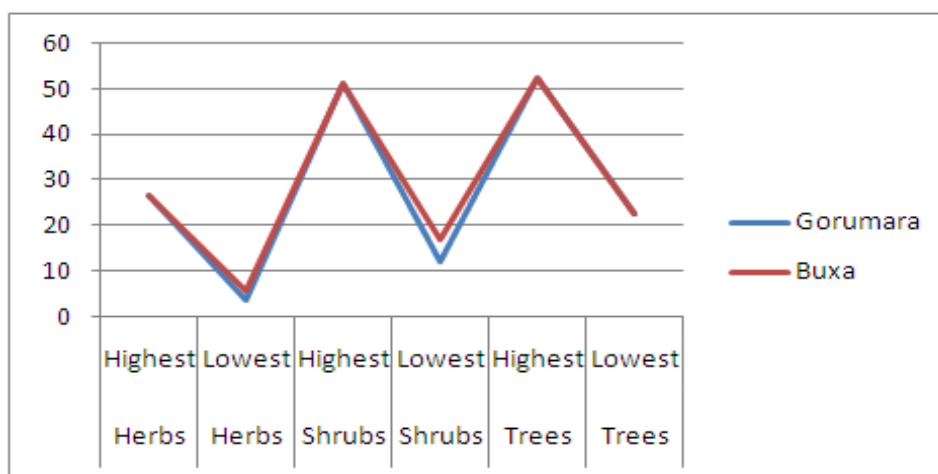
Types	Number in Buxa (A)	Number in Gorumara (B)	Common Species (C)	IS=(2C/A+B)*100
Tree	10	10	7	70
Shrubs	10	12	10	90.99
Herbs	26	27	26	98.11
Total	46	49	43	90.52

Number of species of herbs in Gorumara was 28 which are highest in number in compare to the species like shrubs (12) and trees (10). It is revealed that the BTR was lower in species composition than Gorumara forest (Graph-1). Similarly, BTR has 26 herbs which are highest in number compare to the species like shrubs (8) and trees (10). So, more or less in both the sites herbs are dominant than shrubs than trees.



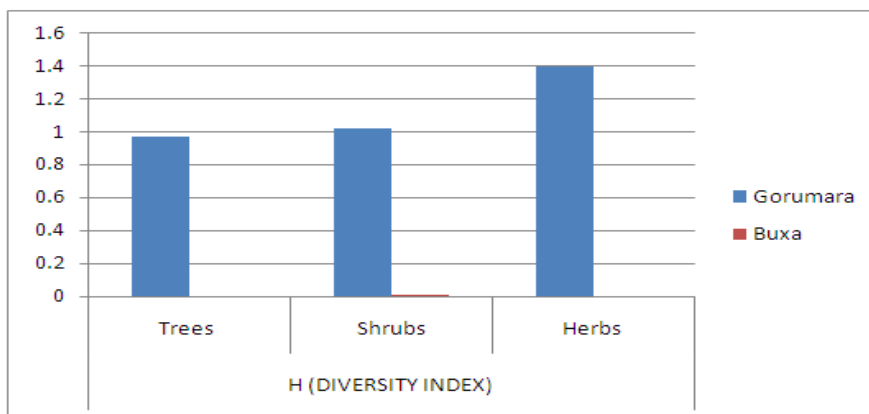
Graph-1: Comparative account of Species number against each type (Herbs, Shrubs and Trees), of Gorumara and Buxa forests of West Bengal in India.

Importance Value Index is the totality of relative frequency, density and abundance. So on the basis of totality of composition status, it is concluded that IVI of species (trees, herbs and shrubs) in Buxa Tiger Reserve is higher than Gorumara National Park. In both the cases IVI of trees occupy highest position than shrubs than herbs (Graph-2).



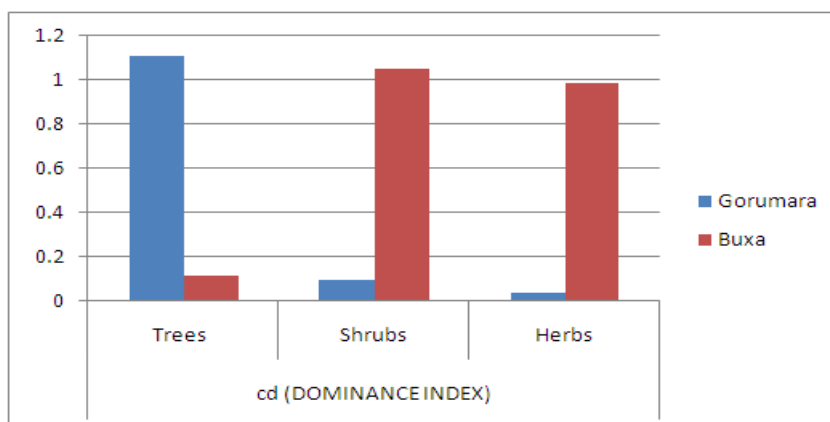
Graph-2: Comparative account of Importance Value Indices of species (Herbs, Shrubs and Trees), of Gorumara and Buxa.

Diversity Indices of species of herbs, shrubs and trees are superior to Buxa Tiger reserve (Graph-3). It is concluded that Diversity Index of herbs is more than shrubs than tree species. In case of Buxa all the indices are comparatively lower to less or least than Gorumara Forest.



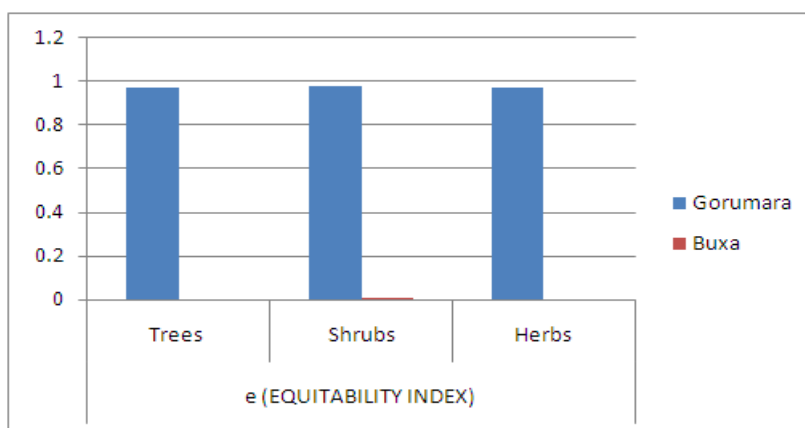
Graph-3: Comparative account of Diversity Indices of species (Herbs, Shrubs and Trees), of Gorumara and Buxa.

Dominance is opposite to diversity Index. So, it showed a negative value of diversity index. Here highest dominance index is observed in case of Tree species than shrubs than herbs (Graph-4). The situation is similar both the cases like BTR and GNP. Here, difference is observed in each case of trees where 'cd' value of Buxa is lower than Gorumara. In case of shrubs, 'cd' Buxa is higher than Gorumara. Whereas, in case of Herbs, 'cd' value of Buxa is higher than Gorumara.



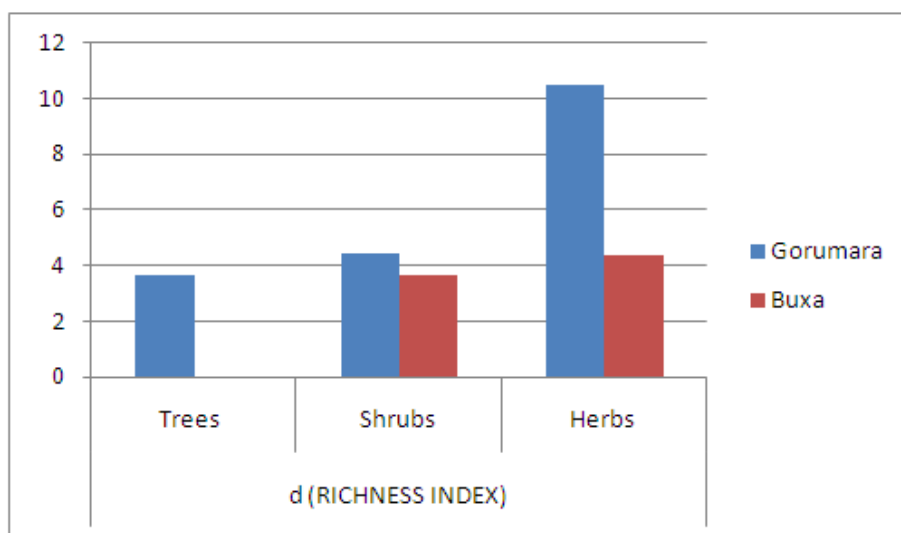
Graph-4: Comparative account of Dominance Indices of species (Herbs, Shrubs and Trees), of Gorumara and Buxa.

Equitability index of herbs, shrubs and trees are more or less same in Gorumara Nationa Forest which is greater than that of the values of Buxa Tiger Reserve (BTR). This index has least values for herbs, shrubs and trees in case of BTR (Table-5).



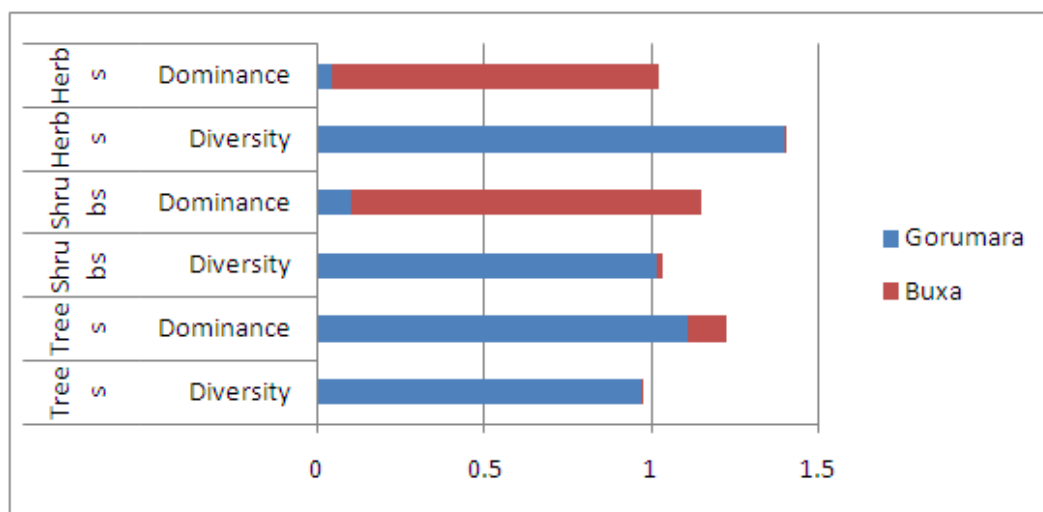
Graph-5: Comparative account of Equitability Indices of species (Herbs, Shrubs and Trees), of Gorumara and Buxa.

Richness index of species like herbs, shrubs and trees are more in case of Gorumara national Park than Buxa Tiger reserve (Graph-6). Richness index of tree species is least in Buxa in compare to the same found in Gorumara national Park. Highest richness indices are observed in case of herbs in both the sites like Gorumara and Buxa compare to tree and shrubspecies.



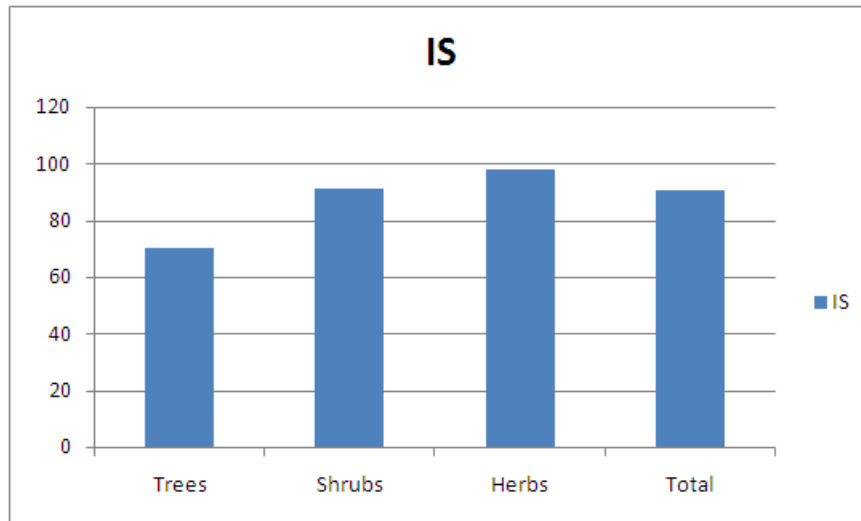
Graph-6: Comparative account of Richness Indices of species (Herbs, Shrubs and Trees), of Gorumara and Buxa.

From the Graph-7 it is concluded that highest diversity of species is observed in case of herbs of Gorumara rather than Buxa. Dominance index of herbs is lower than diversity index of herbs at gorumara which is higher than Buxa. Gorumara exhibits higher diversity, in case of herbs shrubs and trees as compare to BTR. But in case of dominance, BTR exhibits higher dominance for herbs, and shrubs as compare to Gorumara. In case of Trees the dominance index is higher at Gorumara than Buxa. So, it is argued that the BTR requires more attention regarding the conservation to promote the diversity.



Graph-7: Comparative account of Diversity and Dominance Indices of species (Herbs, Shrubs and Trees), of Gorumara and Buxa (Note that Diversity index value is inversely related to Dominance index value).

Similarity index is a comparative index to measure the diversity between two strands. Here, from Graph-8, it is found that the similarity index is highest for herbs i.e. both BTR and Gorumara forest. The result shows 90 % resemblance in case of herbaceous species available there. In case of trees it is about 65 % and in case of shrubs it is about 86%.



Graph-8: Comparative account of Similarity Indices of species (Herbs, Shrubs and Trees), of Gorumara and Buxa.

PHOTO PLATE



Figure 1. Working team with forest officers and experts along with students during work at Gorumara Foreste, Jalpaiguri District, West Bengal, India.

PHOTO PLATE



Figure 2. Working team with forest officers and students, note that authors are standing at the right hand side after the work at Buxa Tiger Researve, Alipurduar District, West Bengal, India.



Figure-3. River Jayanti at Buxa Tiger Reserve, Alipurduar, Note that aside the river is Bhutan.

PHOTO PLATE



Figure-4. Group of workers along with forest officials during MPCA research at Lataguri, Gorumara.



Figure-5. An old tree of Gante (*Gynocardia odorata* Roxb.) important medicinal plant of forest.

III. Conclusion

It is concluded that both the sites (MPCAs) are near about similar in floral composition (90.5%). Tree species found 70% as common species in both the sites. Shrubby species found 91% common in both the sites. Herbaceous species shows highest similarity i.e. 98.1% which is more than shrubs than trees (Table-5). So there is homogeneity for herbaceous species composition rather than shrubs. Tree species shows heterogeneity rather than homogeneity, which tends to be more heterogeneous due to external activities like illegal felling, browsing, grazing, illegal collection of orchids, some beetle leaves, climbers, medicinal herbs and ill-management. Advant

growth, growth by propagules, and other means are not suitable due to excessive water logging situation prevailed in the forest ground during monsoon to post monsoon season. This should be improved by artificial means that can lead to proper establishments of advent growth to a growing stock in a specified period. Not only that continuous monitoring is required to fulfill the needful aspect and manage the ecosystem healthy.

Acknowledgements

We convey our thanks and gratitude to all forest fringe people. Thanks are due to Principal Chief Conservator of Forests, Chief Conservator of Forests, Conservator of Forests, Divisional Forest Officers, Range officers, Beat officers, other forest officials, and forest guards under West Bengal Forest Directorate, for their endless help from different corners to make it a grand success. We convey our thanks to the Principal, Darjeeling Govt. College and higher authorities of Higher Education Department and Higher Education Directorate for necessary co-operation. As the work is going on so, we need more help from more people of the same field who are nearer to forests of Gorumara National Park. Thanks are also to the authorities CNH, BSI; Library section, Vidyasagar University, North Bengal University, Presidency University, Darjeeling Govt. College, Burdwan Raj College, IEST, Shibpore for help as and when required. For financial assistance authority National Medicinal Plants Board, New Delhi is well acknowledged. Last but not least thanks are to the local people, teachers and students of Local Schools, Darjeeling Govt. College, Burdwan Raj College, Presidency University, Ramananda College, RMSoEE, Kharagpur, IIT., Indian Institute of Engineering Science and Technology, Shibpore who helped us through their teachers and scholars to generate the result from field in a sequential way. Students of Darjeeling Govt. College and Burdwan Raj College are well acknowledged.

References

Research Journals:

- [1]. Shi, H and Singh, A. An Assessment of Biodiversity hotspots using remote sensing and GIS. *Journal of the Indian Society of Remote Sensing*, 2002, **30** (1 and 2): 105-112.
 - [2]. Gower, S. T., Vogt, K.A. and Grier, C.C. Carbon dynamics of Rocky Mountain Douglas-fir: Influence of water and nutrient availability. *Ecological Monographs*, 1992, **62** (1): 43-65.
 - [3]. Sahu, P.K., Sagar, R., and Singh, J.S. Tropical Forest Structure and Diversity in relation to altitude and disturbances in a Biosphere reserve in Central India. *Applied Vegetation Science*, 2008, **11**: 461-470.
 - [4]. Dixit, A.M. Ecological Evaluation of Dry Tropical forest vegetation: An approach to environmental Impact Assessment, *Tropical Ecology*, 1997, **38**: 87-99.
 - [5]. Das, D. Ecological Studies of Ecosystem Health Indicators at Nayagram of Paschim Medinipur District in Lateritic forests of Southwest Bengal, India. *IOSR-JESTFT*, 2014b, **8**(5/1): 1-17.
 - [6]. Ghosh, P. Preliminary studies on Ethno-botanically important Non Timber Forest Produces (NTFPs) in Jamboni Block of Paschim Medinipur District of West Bengal, *IOSR-Journal of Pharmacy and Biological Sciences*, 2014a, **9**(5): 59-66.
 - [7]. Das, D. and Das, M. Vegetation Ecology of Coastal belt of Khejuri area of Purba Medinipur District with special reference to Hijili Coast, West Bengal, India. *IOSR-Jour of Pharmacy*, 2014a, **4**(2), 2014, 2319-4219.
 - [8]. Ghosh, P. and D. Das Some medicinal Plants of Joypore forest Range of Bankura, West Bengal, India, *Environment & Ecology*, Kalyani, Nadia, W.B, 2014c, **32**(2), 2014, 465-470.
 - [9]. Lodhiyal, N; Shalini, D; Lodhiyal, L.S; Bhakuni, N and Kapkoti, B. Species Diversity and Regeneration of Tilonj Oak (*Quercus floribunda* Lindl.) dominated forests of Nainatal in Kumaun Himalaya, *International Journal of Biodiversity and Conservation*, 2015, **7**(1): 21-27
 - [10]. Rao, D.S; Pragada, P.M and Kumar, O.A Floristic Composition and Ecological Assessment of Tree Species Diversity in Tropical Forests of Srikakulam and Vizianagaram Districts of Andhra Pradesh, India, *Int. Jour. Of Fundamental & Applied Sciences*, 2015, **4** (X): 1-7.
 - [11]. Khan, H; Akbar, M; Zaman, M; Ali, A; Hyder, S; Khan, M; Nafees, M.A; Raja, G; Begam, F; Hussain, S.A; Khan, S.W; Abbas, Q and Ali, M Diameter size class distribution of *Pinus gerardiana* Wall. ex Don from Gohar Abad Valley District Diaper, Gilgit – Baltistan, Pakistan, *Journal of Biodiversity and Environmental Sciences*, 2015, **6**(2): 50-56.
 - [12]. Whittaker, R.H. Evolution and measurement of species diversity, *Taxon*, 1972, **21**, 1972, 213-251.
 - [13]. Pielou, E. C. Species Diversity and pattern diversity of in the study of Ecological; Succession, *Jour. of theoretical Biology*, 1966, **10**: 370-383.
 - [14]. Sorensen, T. A. Method of establishing Groups of equal amplitude in plant sociology based on similarity of species and its application to analyses of the vegetation on Danish commons, *Kongelige Danske Videnskabemes Selskab*, 1948, **5**(4): 1-34.
- BOOKS:**
- [15]. Oosting, H. J. The structure of plant communities, WH Freeman Company., San Francisco, California, USA, 1956, pp.32-51.
 - [16]. Muller-Dombois, D. and Ellenberg, H. Aims and methods of Vegetation Ecology, NY: Wiley and Sons 1974.
 - [17]. Cooke, T. The Flora of the Presidency of Bombay, Vol.-I, II, III, B.S.I., 1908, Calcutta.
 - [18]. Prain, D. Bengal Plants, Vol.-I, (Revised Edn, 1963), BSI, 1903, Calcutta.
 - [19]. Prain, D. Bengal Plants, Vol.-II, (Revised Edn, 1963), BSI, 1903, Calcutta.
 - [20]. Mabberley, D. J. A Portable dictionary of the Vascular Plants, Cambridge University Press 1997.
 - [21]. Bennet, S. S. R. Name Changes in flowering plants of India and adjacent regions, Triseas Publishers, 1987, Dehra Dun, India.
 - [22]. Curtis, J. T. The Vegetation of Wisconsin, University of Wisconsin Press, Madison, WI, 1959, pp. 657.
 - [23]. Shannon, C.E and Wiener, W. The Mathematical theory of Communication, University Illinois Press, 1963, Urban.
 - [24]. Simpson, E. H. Measurement of Diversity, *Nature*, 1949, **163**.pp. 688.
 - [25]. Margalef, R. Perspective in Ecological theory, University of Chicago Press 1958.
 - [26]. Anonymous. Flora of West Bengal, Vol.-I , BSI, Kolkata, Flora of India, Series-2, 1997.
 - [27]. Anonymous. Medicinal Plant Resources of South West Bengal, Vol.-I, 2005, Research Wing, Directorate of Forests, Govt. of West Bengal.

- [28]. Anonymous. Medicinal Plant Resources of South West Bengal, Vol.-II, 2010, Research Wing, Directorate of Forests, Govt. of West Bengal.
- [29]. Singh, M.P. and Tewari, D. N. Agroforestry and Wastelands, Anmol Publications Pvt. Ltd., 1996, New Delhi, pp. 299.
- [30]. Mc Cann, C. Trees of India, D.B. Taraporevala Sons & Co., Hornby Road, Bombay.
- [31]. Annaduari, B.. A Text Book of Biostatistics, New Age International (P) Ltd. 2010, Pub.
- [32]. Warman, C K. Trees of India (Medicinal, Commercial, Religious & Ornamental), A Colour Atlas, S.K.Jain for CBS Publisher & Distributors, Daryaganj, 1999, New Delhi.
- Thesis:**
- [33]. Das, D. Vegetation Ecology of Forests of South West Bengal with special reference to Non-Timber Forest Produce (NTFPs) Productivity, Ph. D Thesis awarded from Vidyasagar University, 2007, West Bengal (Work from CNH, Botanical Survey of India, Shibpore, Howrah, West Bengal).
- [34]. Pramanik, B. K. Credit facilities to Muslim Minorities in West Bengal; A Case Study, Ph. D Thesis awarded from University of Calcutta, 2009, West Bengal (Work from University of Calcutta, Jhargram Raj College and Hooghly Mohsin College, West Bengal).