Result

In the present study, Terai-Duars belt of the state of West Bengal has been considered for understanding the phytosociological attributes of natural vegetation, which is regarded as the native land cover, and different type of plantations and ultimately to speculate the impact of plantation forest on plant diversity of this area. The study area covers plains of Darjeeling district and entire Jalpaiguri and Alipurduar districts and extends over 8,800 sq km area. Forests and the Vegetation of this region is mainly of Tropical and plains vegetation which is characterized by high temperature and heavy rainfall and is divided into four sub types – Reverine forest, Sal forest, Dry mixed forest and Wet mixed forest. The Sub-tropical forest contiguously lies above the vegetation of Terai - Duars plain. Terai and Duars region have excellent Savannah type of thick and dense grasslands. As the present dissertation is designed to assess the influences of plantation forests on phyto-diversity of the study area, the main theme behind the methodology is to compare different types of plantations with adjacent natural vegetation that was predominant in the entire belt and considered to be the standard land-form.

Two Forest Divisions – Darjeeling and Jalpaiguri and three administrative Districts - Darjeeling, Jalpaiguri and Alipurduar are included under the study area. These two forest divisions were visited consulting with the respective DFOs and the forest ranges having plantation of different ages and types as well as the natural vegetations adjacent to that, were selected for the study. Preference was given to those areas having plantations and natural vegetation under same environmental and ecological conditions. Three such sampling sites were spotted in different parts of Terai-Duars Belt. These are-North Rajabhatkahwa, Sursuti Beat in Lataguri and North Sevokeforest area.

The chapter discusses the result on phytosociology of natural vegetation and different plantation forests, analysis of different biological indices and other parameters which have been considered for comparison of natural vegetation with different type of plantations and finally to construe their impacts on rich and unique phyto-diversity in this stretch of marshy foothill region.

6.1. VEGETATION STRUCTURE AND PHYTOSOCIOLOGY

For characterization of vegetation and analysis of different phytosociological attributes a total of 166 sample plots were laid in natural vegetation and different plantations in the selected sites. Out of these 166 quadrates a total 95 nested quadrates were laid in Natural vegetation of Terai – Duars belt to characterize the

tree, shrub and herb layers. Out of these 95 quadrates 50 were studied in NRVK site whereas 20 and 25 quadrates were studied in Sevoke and Lataguri sites respectively. 71 nested quadrates were studied in differen plantations of of terai duars region.

6.1a. Vegetation structure and community analysis

***Natural vegetation*:** Natural vegetation of Terai – Duars region appeared to be quite rich and diverse in floristic component. A total of 446 species of plants belonging to 312 genera and 97 families were recorded from the sampled sites of the study area. Among them 14 species belonging to 11 genera and 10 families were pteridophyta. Out of the Angiospermic species 135 were trees, 79 species shrubs, 126 species herbs and 92 species of climbers (Table 6.1). Highest number of species was reordered for Leguminosae (33 spp.), followed by Lamiaceae (22 spp.), Acanthaceae (19 spp.), Rubiaceae (19 spp.), Euphorbiaceae (18 spp.), Malvaceae (15 spp.), Apocynaceae (13 spp.) etc. Asteraceae, Lauraceae and Vitaceae were recorded with 12 species each whereas Poaceae with 11 species, Meliaceae and Urticaceae with 9 species.

Table 6.1. Number of different taxa and habit wise distribution of plants recorded from natural vegetation

Site	Species	Genus	Family	Tree	Shrubs	Herbs	Climbers	Fern
Lataguri	331	244	92	97	65	89	68	12
NRVK	281	226	81	90	48	72	62	9
Sevoke	224	188	68	76	42	49	51	6
Entire region	446	312	97	135	79	126	92	14

The tree layer was inhabitated by 134 species belonging to 107 genera and 46 families. 255 species belonging to 184 genera and 70 families, and 321 species under 239 genera and 81 families were found to be inhabitated in the shrub and herb layer respectively (Table 6.2). Tree layer was dominated by Leguminosae representing 12 species and was followed by Meliaceae and Malvaceae (9 spp.), Lamiaceae (8 spp.), Lauraceae (6 spp.), Combretaceae (6 spp.), Euphorbiaceae (6 spp.) etc. Shrub-layer was also dominated by Leguminosae representing 19 species. Other associated families in the shrub layer were Euphorbiaceae (17 Spp.), Rubiaceae (15 spp.), Vitaceae (12 spp.), Lamiaceae (11 spp.), Malvaceae (11 spp.), Apocynaceae (11 spp.), Lauraceae (9 Spp.), Rutaceae (9 spp.), Acanthaceae (7 spp.) etc. Acanthaceae with 22 species, dominated the herb layer and was followed by Leguminosae (21 spp.), Lamiaceae (14 spp.) etc. Other frequent families in this layer were Asteraceae, Euphorbiaceae, Vitaceae, Poaceae, Commelinaceae, Urticaceae etc.

NRVK site: In NRVK site, tree layer was represented by 89 species of angiosperm belonging to 81 genera and 39 families. Malvaceae and Leguminosae – these two families co-dominated among the trees and presented 8 species each. Meliaceae, Lauraceae, Lamiaceae, Euphorbiaceae, Apocynaceae, Phyllanthaceae etc are other

abundant families. Shrubs and herb layers are represented by 138 species under 121 genera and 51 families; and 193 species under 163 genera and 64 families respectively and thus natural vegetation of NRVK site was represented by 281species belonging to 226 genera and 81 families (Table 6.2) and frequent families were Leguminosae (16 spp.), Rubiaceae (14 spp.), Malvaceae (13 spp.), Lamiaceae (12 spp.), Acanthaceae, Apocynaceae, Euphorbiaceae, Phyllanthaceae, Vitaceae etc.

Table 6.2. Layer wise distribution of different taxa in Natural forests

Site	Layer of vegetation in				
	Taxa	**Tree**	**Shrub**	**Herb**	**Total**
NRVK	**Species**	89	138	193	281
	Genera	81	121	163	226
	Family	39	51	64	81
Lataguri	**Species**	67	199	219	331
	Genera	60	159	171	244
	Family	32	67	77	92
Sevoke	**Species**	74	117	119	224
	Genera	68	99	109	188
	Family	34	41	48	68
Entire Terai-Duars	**Species**	134	225	321	446
	Genera	107	184	239	312
	Family	46	70	81	97

Lataguri site: Natural vegetation of Lataguri region represents 331 species belonging to 244 genera and 92 families of plants including 12 species of pteridophyta belonging to 10 genera and 10 families. Among the recorded species, 97 were trees, 65 shrubs, 89 herbs and 68 species were climbers.Tree layer was represented by 67 species 60 genera and 32 families, of which Meliaceae, Lauraceae, Elaeocarpaceae, Lamiaceae, Malvaceae, Moraceae, Anacardiaceae, Apocynaceae, Leguminosaeetc were abundant ones. Meliaceae was presented by 7 members whereas Lauraceae was represented by 6 species. Shrub layer represented 199 species, 159 genera and 67 families whereas herb layer was represented by 219 species, 171 genera and 77 families (Table 6.2).

Euphorbiaceae and Leguminosae are the highest occurring families represented by 14 species each. Other more abundant families were Rubiaceae represented by 12 species, Lauraceae and Vitaceae represented by 9 species each, Lamiaceae presented by 7 species, Apocynaceae, Malvaceae, Moraceae etc. Lamiaceae, Leguminosae, Acanthaceae, Poaceae, Asteraceae, Euphorbiaceae, Vitaceae, Commelinaceae, Zingiberaceae etc. were the highly abundant families in

herb layer. Each of Lamiaceae and Leguminosae is represented by 14 species; Acanthaceae by 12 species and Poaceae by 10 species.

Sevoke site: 74 species of trees belonging to 68 genera and 34 families represented the canopy layer of natural vegetation in Sevoke site. Leguminosae and Meliaceae were recorded for highest number of species (7spp. each) and were followed by Euphorbiaceae (6 Spp.), Malvaceae (5 spp.), Apocynaceae, Combretaceae, Lamiaceae (4 spp. each) etc. Total 117 species belonging to 99 genera and 41 families; and 119 species belonging to 109 genera and 48 families represented the shrubs and herb layer respectively (Table 6.2).

Dominant families of shrubs layer were Euphorbiaceae (11 spp.), Leguminosae (9 spp.), Lamiaceae (7 spp.), Malvaceae (7 spp.), Annonaceae (6 spp.), Apocynaceae (6 spp.), Acanthaceae (5 spp.), Lamiaceae (5 spp.), Rubiaceae (5 spp.) etc.Acanthaceae, the most abundant family, presented 12 spp. and was followed by Asteraceae (8 spp.), Leguminosae (7 spp.), Poaceae (6 spp.), Lamiaceae (5 spp.), Malvaceae (5 spp.), Rubiaceae (5 spp.) etc. in ground-cover vegetation.

Plantation: A total 280 species of plant belonging to 197 Genera and 77 families were recorded from plantation areas, where 71 quadrates were laid. Out of these 71 quadrates, 23 quadrates were laid in NRVK area, of which 5 nested quadrates were studied in mixed plantation, whereas 8 and 10 quadrates were studied in Jarul and Teak plantation respectively. Recorded plant species were classified into 82 trees, 52 shrubs, 81 herbs, 53 climbers (Table 6.3). Leguminosae were recorded for highest number of species (24 spp.) followed by Lamiaceae (12 spp.). Asteraceae, Phyllanthaceae and Rubiaceae were represented by 11 species each. Other families with higher occurrences were Malvaceae (10 spp.), Acanthaceae (9 spp.), Vitaceae (8 spp.) etc.

In Lataguri site, total 25 quadrates were studied, of which 5 quadrates were laid in mixed plantation and 10 quadrates were studied in each of sal-chilauni and teak plantation. In north Sevoke site total 18 nested quadrates were studied to collect data on plantation forest. 8 quadrates were laid in Jarul plantation and 10 quadrates in teak plantation. In addition to the above, a patch of Jarul plantation was studied in Satali area of Rajabhatkhawa forest, where total 5 nested quadrates were laid.

NRVK Site: Total 154 species belonging to 133 genera and 60 families were recorded from NRVK site. Among them 43, 31, 38 and 26 species were trees, shrubs, herbs (including 7 ferns) and climbers respectively (Table 6.3).From Teak plantation of this site 26 species of trees belonging to 23 genera and 18 families were recorded in the tree layer whereas from shrub and herb layer, 48 species belonging to 46 genera and 23 families; and 70 species under 68 genera and 39 families were recorded respectively. Dominant family in the tree layer was Lamiaceae which was presented by 4 species. Other abundant families were Leguminosae (3 spp.), Apocynaceae (2 spp.), Combretaceae, (2 spp.) Lythraceae (2 spp.) Meliaceae (2 spp.) etc.

Table 6.3. Number and habit wise distribution of of different taxa recorded from plantations

Site	Plantation	Species	Genus	Family	Tree	Shrubs	Herbs	Climbers	Fern
Lataguri	Mixed	111	96	53	33	20	41	17	--
	Sal-chilauni	109	92	49	28	25	31	25	--
	Teak	127	112	50	34	27	48	18	--
	Total	**201**	**163**	**71**	**60**	**35**	**58**	**40**	**8**
Nrvk	Jarul-benteak	78	67	39	15	20	27	16	--
	Mixed	118	106	61	38	19	38	23	--
	Teak	120	111	53	37	27	37	19	--
	Total	**154**	**133**	**59**	**43**	**31**	**31**	**26**	**7**
Sevoke	Jarul	123	111	57	31	25	39	28	--
	Teak	125	108	55	37	26	37	25	--
	Total	**166**	**135**	**64**	**49**	**37**	**41**	**31**	**8**
Satali	Jarul	71	63	40	15	12	23	15	6
Terai-Duars region		**280**	**197**	**77**	**82**	**52**	**81**	**53**	**12**

In shrubs layer, Euphorbiaceae and Malvaceae presented 5 species each and were the pair of dominant families. They were followed by Lamiaceae, Leguminosae and Rubiaceae – all having 4 species, Phyllanthaceae (3 spp.), Rutaceae (3 spp.), Bignoniaceae (2 spp.), Combretaceae etc. Asteraceae was presented by 6 spp. in herb layer and dominated the ground cover vegetation of teak plantation in NRVK site. It was followed by Leguminosae (5 spp.), Rubiaceae (5 spp.), Acanthaceae (4 spp.), Commelinaceae (4 spp.), Malvaceae (3 spp.), Menispermaceae (3 spp.), Phyllanthaceae (3 spp.), Apocynaceae (2 spp.) etc.

In NRVK Jarul-Benteak plantation, total 78 spp. belonging to 67 genera and 39 families were found to occur and their habit wise distributions were – 15, 20, 27 and 16 spp. of trees, shrubs, herbs and climbers respectively (Table 6.3).Though 15 spp. of trees were recorded, tree layer was found to be constituted by 11 spp. under 10 genera and 8 families whereas shrub and herb layer were composed of 32 spp. of 29 genera under 20 families and 41 spp. of 36 genera under 24 families respectively. Tree layer was dominated by Lamiaceae (6 spp.), and other abundant families were Lythraceae (4 spp.), Bignoniaceae (2 spp.), Cornaceae (2 spp.), Euphorbiaceae (2 spp.), Magnoliaceae (2 spp.) etc. Shrub layer was dominated by Malvaceae, representing 5 spp. along with Asteraceae (3 spp.), Menispermaceae (2 spp.), Acanthaceae etc.

In case of herb layer dominant family was Asteraceae having 6 number of spp. and other associated and abundant families were Poaceae (6 spp.), Acanthaceae (2 spp.), Leguminosae (2 spp.), Oxalidaceae (2 spp.), Phyllanthaceae (2 spp.) etc.

From mixed plantation of NRVK site, total 118 spp. of plants belonging to 106 genera and 61 families were recorded. Tree shrub and herb layer were inhabitated by 31 spp. belonging to 27 genera and 20 families; 37 spp. under 36 genera and 25 families; and 66 spp., 61 genera and 39 families respectively.

Most abundant families in Tree, shrub and herb layer were Combretaceae and Lythraceae represented by 3 spp. each, Dipterocarpaceae (2 spp.), Lamiaceae (2 spp.), Lauraceae (2 spp.), Leguminosae, Meliaceae, Phyllanthaceae, etc; Leguminosae (4spp), Rubiaceae (4spp), Apocynaceae (2 spp.), Asteraceae (2 spp.), Bignoniaceae (2 spp.), Dioscoreaceae (2 spp.) etc; and Asteraceae (6 spp.), Acanthaceae (4 spp.), Commelinaceae (4 spp.), Leguminosae (4 spp.), Apocynaceae (3 spp.), Phyllanthaceae (3 spp.), Piperaceae etc. respectively. Thus tree, shrubs and herb layer were dominated by Combretaceae and Lythraceae – both represented by 3 spp. of trees; Leguminosae and Rubiaceae both having 4 spp. and Asteraceae having 6 representative spp. respectively.

Lataguri Site: In Lataguri site mixed plantation, sal-chilauni and teak plantation were studied and a total of 201 spp. were recorded from this site. They belonged to 163 genera and 71 families. Out of them 60, 35, 58 and 40 species were trees, shrubs, herbs and climbers respectively. Dominant family in respect of highest number of species in this site was Leguminosae represented by 13 species and was followed by Rubiaceae (10 spp.), Asteraceae (9 spp.), Lamiaceae (9 spp.), Malvaceae (8 spp.), Vitaceae (8 spp.), Apocynaceae (7 spp.), Acanthaceae (6 spp.) etc.

Mixed plantation harboured 31 species belonging to 29 genera and 21 families in tree layer; 39 species of 36 genera under 21 families in shrub layer and 67 species belonging to 58 genera and 36 families in herbaceous vegetation. Tree layer was dominated by Meliaceae having 4 representative species and was followed by Lamiaceae, Leguminosae, Combretaceae, Dipterocarpaceae etc. Annonaceae and Leguminosae each having 5 representative species were jointly dominant in shrub layer and are followed by Lauraceae, Asteraceae, Rubiaceae, Malvaceae, Primulaceae etc. Asteraceae and Poaceae each having 5 representative species were the co-dominant family in herbaceous layer. Other abundant families were Rubiaceae, Acanthaceae, Apocynaceae, Leguminosae, Linderniaceae etc.

Sal-chilauni plantation in Lataguri site was inhabitated by109 species of plants belonging to 92 genera and 49 families and their habit wise distribution was – 28 species of trees, 25 species of shrubs, 25 species of climbers and 31 species of herbs (Table 6.3). Total 18 species belonging to 16 genera and 14 families were recorded from the tree layer and was dominated by Lamiaceae having 3 representative species. 52 species of plants belonging to 48 genera and 30 families were recorded from the shrub layer and the dominant families were Euphorbiaceae, Leguminosae and Rubiaceae in joint, and presented 4 species each. Other abundant families were Lythraceae, Apocynaceae, and Asteraceae etc. On the other hand herbaceous vegetation was inhabitated by 61 species belonging to 54 genera and 35 families of which Asteraceae, Lamiaceae and Poaceae were the most abundant families and each of them were represented by 5 species. Other associated and frequent families in the layer were Piperaceae, Vitaceae etc.

Teak plantation was inhabitated by 127 species belonging to 112 genera and 50 families of which Rubiaceae was the most frequent and dominant one having 9 representative species. Other families with higher number of species were Asteraceae with 8 species, Lamiaceae and Malvaceae with 7 species each. Tree, shrub and herb layer of teak plantation were populated by 21 trees belonging to 20 genera under 13 families, 44 species under 41 genera of 22 families; and 87 species belonging to 79 genera and 41 families respectively.

Tree layer was jointly dominated by Apocynaceae and Lamiaceae family each representing 3 species; and were followed by Combretaceae, Euphorbiaceae, Leguminosae etc. Shrub layer was jointly dominated Euphorbiaceae, Malvaceae and Rubiaceae each having 4 representative species. Other abundant families were Lamiaceae, Leguminosae, Phyllanthaceae, Rutaceae, Combretaceae etc.

Asteraceae dominated the herbaceous vegetation, having 8 species and was followed by Rubiaceae, Vitaceae, Acanthaceae, Apocynaceae, Malvaceae, Phyllanthaceae, Poaceae, Cyperaceae, Lamiaceae etc.

Sevoke site: A total of 18 nested quadrates were laid in Sevoke site and it harboured 166 (including 8 species of pteridophytes) species belonging to 135 genera and 64 families. Among them 49 species were tree, 41 were herbs, 37 were shrubs and 31 were climbers. Leguminosae was recorded for highest number of species (15 spp.) followed by Lamiaceae (10 spp.), Euphorbiaceae and Malvaceae (8spp. each), Acanthaceae (7spp.), Asteraceae (6 spp.) etc.

Table 6.4. Layer wise distribution of species, genera and families in Plantations

Site	Taxa	Layer of vegetation in			
		Tree	Shrub	Herb	Total
Nrvk	Species	49	80	129	205
	Genera	42	71	105	165
	Family	26	36	52	69
Lataguri	Species	49	90	140	210
	Genera	43	78	117	170
	Family	28	37	52	70
Sevoke	Species	44	71	79	167
	Genera	40	60	69	137
	Family	24	30	39	66
Terai- Duars	Species	78	127	194	280
	Genera	62	101	147	197
	Family	32	47	60	77

Jarul plantation in Sevoke site was inhabitated by 29 tree species belonging to 27 genera and 18 families. Total 43 species belonging to 40 genera and 27 families and 62 species belonging to 56 genera and 34 families were recorded from shrub and herb layer respectively. Tree layer was jointly dominated by Euphorbiaceae, Lamiaceae, Leguminosae, Lythraceae and Malvaceae – each of which was represented by 3 species. Shrub layer was dominated by Malvaceae having 5 representative species and was followed by Leguminosae, Asteraceae,

Acanthaceae etc. Ground cover vegetation was dominated by Acanthaceae, Leguminosae, Araceae, Vitaceae, Poaceae, Dioscoreaceae etc.

Number of species, genus and family recorded from tree, shrub and herb layer of plantations in different site has been presented in Table 6.4. Number of individuals and taxa recorded from natural vegetation and different plantations in different seasons have been presented in Table 6.5, 6.6, 6.7 & 6.8.

6.1b. PHYTOSOCIOLOGY

For phytosociological analysis raw data was collected in 3 consecutive seasons – winter, Pre-monsoon and Post-monsoon. In case of tree layer sampling was done in two seasons – winter and Post monsoon. As minor changes occurred in canopy layer in a single year, sampling in two seasons only was enough to analyse the phytosociological attributes of the tree layer.

NRVK site: In North Rajabhatkhawa (NRVK) site mixed plantation, teak plantation, jarul-benteak plantation and jarul plantation were studied along with natural vegetation.

***Mixed Plantation*:** A total 27 species were recorded from tree layer in winter season from mixed plantation. They were distributed under 23 genera and 19 families, and total 125 individual of trees were recorded (Table 6.5). Highest relative frequency (RF) was found to occur in case of Jarul [*Lagerstroemia speciosa* (L.) Pers.] of family Lythraceae having 7.142 as RF value, and was followed by *Shorea robusta* Gaertn. [RF = 5.714], *Terminalia bellirica* (Gaertn.) Roxb. [RF = 5.714] *Terminalia alata* Wall. [RF = 5.714], *Tectona grandis* L. f. [RF = 5.714], *Neolamarckia cadamba* (Roxb.) Bosser [RF = 4.285], *Bauhinia acuminata* L., *Crateva religiosa* Forst. etc. *Neolamarckia cadamba* (Roxb.) Bosser of family Rubiaceae showed highest importance value index (IVI) that was measured to be 26.108, with relative frequency (RF), Relative density (RD) and relative abundance (RA) value of 4.286, 11.2 and 10.622 respectively. Other species showing high IVI values were *Shorea robusta* Gaertn. [IVI = 20.774, RF = 5.714, RD = 8.8, RA = 6.259]. *Terminalia bellirica* (Gaertn.) Roxb. [IVI = 18.036], *Lagerstroemia speciosa* (L.) Pers. [IVI = 17.185], *Terminalia alata* Wall. [IVI = 16.67], *Bauhinia acuminata* L. [IVI = 15.197], *Crateva religiosa* Forst. [IVI = 15.197], *Leea macrophylla* Roxb. *ex* Hornem. [IVI = 15.197], *Aphanamixis polystachya* (Wall.) Parker, *Magnolia champaca* (L.) Baill. *ex* Pierre etc (Annexure I, Table 1). Combretaceae and Lythraceae were represented by highest number of species – 3 species in each.

In Post monsoon season total 31 species were recorded from the same plantation. They were distributed under 27 genera and 20 families. Total number of individuals recorded was 132 (Table 6.5). Families showing highest number of species were – Combretaceae, Dipterocarpaceae and Lythraceae – all having 3 representative species and were followed by Lauraceae, Leguminosae, Meliaceae etc.

Table 6.5. Number of individuals and taxa recorded in different seasons from NRVK site

Plantation	Number of	Layer of Vegetation							
		Tree		Shrub			Herb		
		Winter	Postmon	Winter	Premon	Postmon	Winter	Premon	Postmon
Teak	Individual	169	181	345	481	962	233	391	565
	Species	22	26	26	29	32	39	43	50
	Genera	20	23	24	29	31	38	42	49
	Family	16	17	16	19	18	25	26	34
Mixed	Individual	125	132	303	419	619	298	548	710
	Species	27	31	28	32	37	51	56	63
	Genera	23	27	28	31	37	49	53	60
	Family	19	20	22	22	25	35	36	37
Jarul-Benteak	Individual	407	412	872	1156	1280	185	315	506
	Species	10	12	16	22	30	23	29	37
	Genera	8	10	15	21	29	23	27	34
	Family	8	8	12	15	20	18	20	23
Jarul (Satali)	Individual	109	122	236	382	473	209	332	558
	Species	12	13	19	22	26	28	32	41
	Genera	11	11	18	21	25	25	29	38
	Family	9	9	14	16	18	22	24	38

Neolamarckia cadamba (Roxb.) Bosser [Rubiaceae] showed highest value of the index [IVI = 24.229] along with 3.947, 10.606 and 9.675 as RF, RD and RA respectively. It was followed by *Shorea robusta* Gaertn. [IVI = 19.298], *Terminalia bellirica* (Gaertn.) Roxb. [IVI = 16.746], *Leea macrophylla* Roxb. *ex* Hornem. [IVI = 15.5367], *Terminalia alata* Wall. [IVI = 15.470], *Lagerstroemia speciosa* (L.) Pers., *Bauhinia acuminata* L., *Casearia vareca* Roxb. etc (Annexure I, Table 2).

In winter season from shrub layers, total 303 individuals belonging to 28 species, 28 genera and 22 families were recorded. Leguminosae presented highest number of species (4 spp.) followed by Rubiaceae having 3 representative species and Lauraceae having 2 species, Apocynaceae etc. Highest IVI value was recorded in case of *Coffea benghalensis* Heyne *ex* Schult. having the index value 97.75 and was the dominant species in shrub layer. It was followed by *Clerodendrum infortunatum* L. having IVI value 47.75, *Litsea glutinosa* (Lour.) Rob. [IVI = 15.87], *Morinda angustifolia* Roxb [IVI = 14.19], *Chromolaena odorata* (L.) King & Rob. [IVI = 11.212), *Tabernaemontana divaricata* (L.) R. Br. *ex* Roem. & Schult. [IVI = 9.62] etc. The shrub layer was dominated by *Coffea benghalensis* Heyne *ex* Schult. (Annexure I, Table 3).

In Premonsoon season 419 number of individuals were recorded and they were distributed into 32 species belonging to 31 genera and 22 families and highest number of species were recorded under the family Leguminosae (4 spp.) then Rubiaceae (3 spp), and followed by Asteraceae, Bignoniaceae, and Premonsoon vegetation was nearly similar. Not only that, regarding the dominant species also, Premonsoon shrubby vegetation was similar to winter vegetation as because of dominancy of *Coffea benghalensis* having highest IVI value 82.60 along with 6.59,

43.20, and 32.80 as relative frequency and RA in the same sequence. Other species having high IVI values were – *Clerodendrum infortunatum* L. [IVI = 54.46], *Litsea glutinosa* (Lour.) Rob. (IVI = 14.39), *Morinda angustifolia* Roxb. [IVI = 13.84], *Chromolaena odorata* (L.) King & Rob. [IVI = 12.03], *Tabernaemontana divaricata* (L.) R. Br. *ex* Roem. & Schult. [IVI = 11.24] *Solanum aculeatissimum* Jacq, *Ixora athroantha* Bremek, *Urena lobata* L. etc (Annexure I, Table 4).

In Post monsoon, total 619 individuals of shrubs were recorded from the quadrate areas. They were distributed into 37 species, belonging to 37 genera and 25 families. Family Leguminosae and Rubiaceae were represented by 4 species each and were followed by Asteraceae, Bignoniaceae, Dioscoreaceae etc. In this season also shrubby vegetation were dominated by *Coffea benghalensis* having IVI score 64.79 along with RF, RD and RA value to be 6.92, 35.38 and 22.49 respectively. In respect of IVI value, next species were *Clerodendrum infortunatum* L. [IVI = 56.86], *Morinda angustifolia* Roxb. [IVI = 13.00], *Chromolaena odorata* (L.) King & Rob. [IVI = 12.53], *Litsea glutinosa* (Lour.) Rob. [IVI = 11.42], *Tabernaemontana divaricata* (L.) R. Br. *ex* Roem. & Schult., *Solanum aculeatissimum* Jacq., *Urena lobata* L. etc (Annexure I, Table 5).

Ground cover vegetation of NRVK mixed plantation in winter season, composed of 51 species belonging to 49 genera and 35 families. In winter total number of individuals recorded was 298 whereas in Premonsoon and Post monsoon season 584 and 710 individuals were recorded. They belonged to 56 species, 53 genera and 36 families; and 63 species, 60 genera and 37 families respectively (6.5). Asteraceae presented highest number of species in both Premonsoon and Post monsoon seasons – 6 species in each seasons followed by Acanthaceae having 4 species and Apocynaceae having 3 species. Winter ground cover vegetation was dominated by *Chromolaena odorata* (L.) King & Rob. showing IVI value 15.83 along with 5.56, 7.38 and 2.89 as RF, RD and RA values respectively. *Chloranthus elatior* Link. was co-dominant species having almost similar index value [IVI = 15.36] along with 5.56, 7.05 and 2.76 to be RF, RD and RA values. Following species were *Mikania micrantha* Kunth. [IVI = 13.87], *Diplazium esculentum* (Retz.) Sw. [IVI = 13.61], *Coffea benghalensis* Heyne *ex* Schult. [IVI = 12.21], *Piper mullesua* Buch.-Ham. *ex* D. Don [IVI = 11.12], *Commelina suffruticosa* Blume, *Oplismenus burmanni* (Retz.) Beauv. etc (Annexure I, Table 6).

Premonsoon herbaceous vegetation was found to be co-dominated by a number of species showing more or less similar index value. They were *Mikania micrantha* Kunth. [IVI = 15.81], *Dryopteris sikkimensis* (Bedd.) Kuntze [IVI = 14.13], *Chromolaena odorata* (L.) King & Rob. [IVI = 12.33], *Chloranthus elatior* Link [IVI = 11.85], *Pupalia lappacea* (L.) Juss. [IVI = 10.73], *Oplismenus burmanni* (Retz.) Beauv. [IVI = 9.89], *Coffea benghalensis* Heyne ex Schult. [IVI = 9.74], *Ageratum conyzoides* (L.) L., *Synedrella nodiflora* (L.) Gaertn. etc (Annexure I, Table 7). Postmonsoon herbaceous vegetation was also co-dominated by a group

of species. *Dryopteris sikkimensis* (Bedd.) Kuntze was found to have highest of IVI value of 15.88 with 4.91, 8.03 and 2.94 as RF, RD and RA values, and was followed by *Diplazium esculentum* (Retz.) Sw. having IVI value 12.33, *Mikania micrantha* Kunth. [IVI = 10.44], *Chloranthus elatior* Link [IVI = 10.26], *Coffea benghalensis* Heyne *ex* Schult. [IVI = 10.24], *Impatiens trilobata* Colebr. [IVI = 10.21] etc (Annexure I, Table 8).

Teak plantation: In case of teak [*Tectona grandis* L. f.] plantation in NRVK site, a total of 169 trees belonging to 22 species, 20 genera and 16 families; and 181 individuals belonging to 26 species, 23 genera and 17 families were recorded in winter and Post monsoon seasons respectively. Apocynaceae, Combretaceae, Lamiaceae and Lythraceae were found to be presented by 2 species each in winter community of trees. Whereas in post monsoon season tree layer was dominated by Lamiaceae having 4 species, and was followed by Leguminosae having 3 recorded species, then Apocynaceae, Combretaceae, Lythraceae etc. Total 122 individuals of teak plant were recorded from 10 quadrates whereas the total numbers of individuals of all the trees were counted to be 169. Importance Value Index of teak was calculated to be 126.58 along with 19.23, 72.19 and 35.16 as RF, RD and RA values. Other species showing high IVI values were *Lagerstroemia speciosa* (L.) Pers., [IVI = 19.04], *Croton caudatus* Geiseler [IVI = 15.57], *Magnolia pterocarpa* Roxb. [IVI = 12.94], *Terminalia alata* Wall. [IVI = 11.98] etc but all with IVI values below 20 (Annexure I, Table 9).

In post monsoon season, the IVI value of teak was calculated to be 113.96 along with 15.38, 66.85 and 31.73 as RF, RD and RA value in respective order. It was followed by *Croton caudatus* Geiseler having IVI value 19.11, *Lagerstroemia speciosa* (L.) Pers. [IVI = 16.15], *Casearia vareca* Roxb. [IVI = 10.99], *Terminalia alata* Wall. [IVI = 10.32] etc (Annexure I, Table 10). In case of shrub layer, a total of 345 individuals belonging to 26 species, 24 genera, 16 families; 481 individuals belonging to 29 species, 29 genera, 19 families; and 962 individuals belonging to 32 species, 31 genera and 18 families were recorded in Winter, Premonsoon and Post monsoon seasons respectively (Table 6.5). Highest number of species was presented by Rubiaceae having 4 species in case of winter vegetation. Other families showing higher number of species were Lamiaceae having 3 species, Malvaceae, Leguminosae, Lythraceae, Phyllanthaceae etc. In Premonsoon season, Malvaceae represented highest number of species (4 species) followed by Leguminosae (3 species), Rubiaceae (3 species), Euphorbiaceae etc. Post monsoon shrubby vegetation was dominated by Euphorbiaceae having 5 representative species and was followed by Leguminosae (3 spp.), Malvaceae (3 spp.), Rutaceae (3 spp.), Lamiaceae, Lythraceae etc. In winter shrub layer was dominated by *Coffea benghalensis* Heyne *ex* Schult. showing IVI value 67.24 along with 14.89, 35.94 and 16.40 as RF, RD and RA respectively. Other two co-dominant species were *Clerodendrum infortunatum* L. having IVI value 48.47 and *Morinda angustifolia* Roxb. having IVI value 45.86 (Annexure I, Table 11). Premonsoon shrubby vegetation was dominated by *Coffea benghalensis* Heyne *ex* Schult. showing IVI

value 61.33 along with RF, RD and RA value to be 12.84, 31.81 and 16.67 respectively. Next species were *Clerodendrum infortunatum* L. having IVI value 49.98, *Morinda angustifolia* Roxb. showing IVI value 42.31, *Chromolaena odorata* (L.) King & Rob (IVI = 19.20) etc (Annexure I, Table 12). *Clerodendrum infortunatum* L. that showed 11.97, 32.33 and 19.61 as RF, RD and RA in respective order was found to be the dominant species in shrub layer of teak plantation in post monsoon season. *Coffea benghalensis* Heyne *ex* Schult. showing 61.57 as IVI value was considered to be co-dominant species and was followed by *Morinda angustifolia* Roxb. [IVI = 34.59], *Chromolaena odorata* (L.) King & Rob [IVI = 15.63], *Clausena excavata* Burm.f. [IVI = 13.01] etc (Annexure I, Table 13).

A total 233 individuals belonging to 39 species, 38 genera and 25 families; 391 individuals belonging to 43 species, 42 genera and 26 families; and 565 individuals belonging to 50 species, 49 genera and 34 families were recorded from the herbaceous vegetation of teak plantation in winter, Premonsoon and Post monsoon season respectively (Table 6.5). Asteraceae was the most abundant family and was represented by 4, 6 and 5 species in winter, Pre monsoon and Post monsoon seasons respectively. It was followed by Rubiaceae having 3 species, Acanthaceae, Apocynaceae, Meliaceae etc in winter; by Commelinaceae, Rubiaceae, Acanthaceae, Leguminosae etc. in premonsoon and Leguminosae, Commelinaceae, Poaceae, Rubiaceae, Acanthaceae etc. in Post monsoon season. *Oplismenus burmanni* (Retz.) Beauv. was dominant species in winter season having index value 31.63 along with 13.01, 15.35 and 3.26 as RF, RD and RA value respectively. Other species having higher IVI values were *Coffea benghalensis* Heyne *ex* Schult. [IVI = 17.34], *Mikania micrantha* Kunth. [IVI = 17.18], *Lygodium flexuosum* (L.) Sw. [IVI = 16.54] etc (Annexure I, Table 14). Premonsoon herbaceous vegetation was co-dominated by *Chromolaena odorata* (L.) King & Rob. having index value 19.02 and *Coffea benghalensis* Heyne *ex* Schult. [IVI = 18.55], *Oplismenus burmanni* (Retz.) Beauv. [IVI = 17.4], *Mikania micrantha* Kunth. [IVI = 17.63], *Diplazium esculentum* (Retz.) Sw. [IVI = 13.92] etc (Annexure I, Table 15). Post monsoon herb layer was co-dominated by, *Coffea benghalensis* Heyne *ex* Schult., *Mikania micrantha* Kunth. and *Diplazium esculentum* (Retz.) Sw. having IVI value 16.80, 16.11 and 14.19 respectively (Annexure I, Table 16).

Jarul-Benteak Plantation: A total of 407 individuals belonging to 10 species, 8 genera and 8 families were recorded from Jarul Ben-teak plantation in winter season. But in post monsoon season a total of 412 numbers of trees belonging to 12 species, 10 genera and 8 families were recorded (Table 6.5). In winter 346 number of jarul plants were recorded out of a total of 407 individuals of all the tree species and IVI value was calculated to be 194.86 for Jarul. Other species with higher IVI values were *Lagerstroemia microcarpa* Wight [IVI = 37.88] and *Leea macrophylla Roxb. ex* Hornem.[IVI = 20.30] (Annexure I, Table 17). In postmonsoon season IVI values for *Lagerstroemia speciosa* (L.) Pers., the dominant species, was 187.90 and was followed by *Lagerstroemia microcarpa* Wight with index value 35.27, and *Leea macrophylla* Roxb. *ex* Hornem. with index value 19.32 (Annexure I, Table 18).

A total 872 individuals of shrubs were recorded in winter season and they were distributed under 15 species belonging to 15 genera and 12 families (Table 6.5). Highest number of species was recorded for Malvaceae (4 spp.), followed by Rutaceae (2 spp.). There were 10 families having single species and the vegetation was somehow homogeneous with two species having nearly equal IVI score – *Clerodendrum infortunatum* L. having IVI value 93.68 and *Coffea benghalensis* Heyne *ex* Schult. having IVI of 83.74. Other species having higher IVI were *Chromolaena odorata* (L.) King & Rob [IVI = 29.00], *Sida acuta* Burm. f. [IVI = 15.87], *Clausena excavata* Burm.f. [IVI = 13.32] etc (Annexure I, Table 19).

In post monsoon season total number of recorded shrubs was 1156 and they were distributed under 22 species belonging to 21 genera and 15 families. Families showing highest number of recorded species was Malvaceae (5 spp.) followed by Asteraceae (3 spp.), and Rutaceae (2 spp.) and other 12 families were represented by single species each. Premonsoon shrubby layer was somewhat homogeneous with 2 species having nearly equal IVI score – *Coffea benghalensis* Heyne *ex* Schult. with IVI score 92.20 and *Clerodendrum infortunatum* L. having index value 76.83. Other species having high IVI score was *Chromolaena odorata* (L.) King & Rob [IVI = 26.48], *Sida acuta* Burm.f. [IVI = 14.54] etc (Annexure I, Table 20).

In post monsoon season, from this layer total 1283 individuals were recorded which were distributed under 30 species, 29 genera and 20 families. Highest number of species was recorded for Malvaceae (5 spp.) followed by Asteraceae (3 spp.), Rubiaceae (3 spp.), Rutaceae (3 spp.) and other 16 families with single species. Like winter and Pre monsoon season, Post monsoon vegetation was somewhat homogeneous assemblage of species with *Coffea benghalensis* Heyne *ex* Schult. [IVI = 80.47], as dominant species. It was followed by *Clerodendrum infortunatum* L. having IVI value 74.82, *Chromolaena odorata* (L.) King & Rob. showed IVI value of 22.81. Other species showed IVI below 10 (Annexure I, Table 21).

From herb layer of Jarul plantation in NRVK site a total of 185 individuals belonging to 23 species, 23 genera and 18 families; 315 individuals belonging to 29 species, 27 genera and 20 families; 506 individuals belonging to 37 species, 34 genera and 23 families were recorded in winter, Premonsoon and Post monsoon seasons respectively (Table 6.5).

Highest numbers of species were recorded for Asteraceae having 4 species and was followed by Poaceae (2 spp.), in winter season. In case of pre monsoon season, highest number of species was represented by Asteraceae (5 spp.), followed by Poaceae (3 spp.), Convolvulaceae, Oxalidaceae and Piperaceae each having 2 species. Highest number of species was recorded for Asteraceae (6 spp.) following Poaceae (5 spp.) and other in case of herbaceous vegetation in post monsoon season. Commelinaceae, Convolvulaceae, Leguminosae, Oxalidaceae and Amaranthaceae – these five families were represented by 2 species each. This vegetation was co-dominated by *Pupalia lappacea* (L.) Juss. having IVI value 25.50 and *Mikania*

micrantha Kunth. with IVI = 24.61. Other species with high IVI score are *Ageratum houstonianum* Mill. [IVI = 18.75], *Spermacoce alata* Aubl. [IVI = 17.05], *Oplismenus compositus* (L.) P. Beauv. [IVI = 15.46], *Persicaria chinensis* (L.) Gross [IVI = 14.10] etc.

Lataguri site: In Lataguri site mixed plantation, teak plantation and sal-chilauni plantation were sampled.

Mixed plantation: In mixed plantation of Lataguri site total 05 nested quadrates were studied and a total of 111 species belonging to 96 genera and 53 families were recorded. Out of them 41 were herbaceous species, 20 were shrubs, 33 were trees and 17 species were climber. A total of 123 individual of tree belonging to 24 species, 23 genera and 18 families were recorded from canopy layer in winter season whereas in post monsoon season a total of 131 individuals belonging to 31 species, 28 genera and 20 families were recorded (Table 6.6).

Table 6.6. Number of individuals and taxa recorded in different seasons from Lataguri site

Plantation	Number of	Layer of Vegetation							
		Tree		Shrub			Herb		
		Winter	Postmon	Winter	Premon	Postmon	Winter	Premon	Postmon
Teak	Individual	196	216	407	569	1020	258	523	896
	Species	19	21	24	30	34	37	45	69
	Genera	**18**	20	23	28	33	36	44	57
	Family	12	13	14	17	21	25	30	34
Mixed	Individual	123	131	575	642	671	198	276	426
	Species	24	31	22	27	36	48	55	61
	Genera	23	28	20	26	35	44	52	60
	Family	18	20	16	17	21	31	36	36
Sal-Chilauni	Individual	145	171	197	440	466	184	200	465
	Species	15	18	34	46	52	43	48	56
	Genera	13	16	32	43	68	42	45	53
	Family	12	15	22	27	29	31	30	33

Highest numbers of species were recorded for Dipterocarpaceae (3 species), Lamiaceae (3 species), Meliaceae (3 species). Combretaceae and Lythraceae were represented by 2 species each and other 13 families were with a single species in winter season. But in Post monsoon season, highest number of species were recorded for Meliaceae (4 species), Dipterocarpaceae (3 species), Lamiaceae (3 species), Leguminosae (3species) etc. Mixed plantation was a heterogeneous assemblage and more than 2 species having high IVI score instead of dominance by a single species were found. Highest IVI score was recorded for *Neolamarckia cadamba* (Roxb.) Bosser [IVI = 38.06] and *Leea macrophylla* Roxb. *ex* Hornem. [IVI = 38.05] and were followed by *Terminalia alata* Roth. [IVI = 29.24], *Terminalia bellirica* (Gaertn.) Roxb. [IVI = 21.07] etc during winter season (Annexure I, Table 25). In Post monsoon season highest IVI score was recorded for *Neolamarckia kadamba* (Roxb.) Bosser [IVI = 34.44] and was followed by *Terminalia alata* Roth. [IVI = 25.75], *Terminalia bellirica* (Gaertner) Roxb. [IVI =

18.32], *Casearia vareca* Roxb. [IVI = 18.18], *Crateva religiosa* Forst. [IVI = 17.91] etc. Thus it's clear from the IVI score of above mentioned species that post monsoon tree layer was also heterogeneous assemblage of few species instead of single dominancy (Annexure I, Table 26).

From shrub layer a total of 575 individuals belonging to 22 species, 20 genera and 16 families; 642 individuals belonging to 27 species, 26 genera and 17 families; and 671 individuals belonging to 36 species, 35 genera and 21 families were recorded in winter, Premonsoon and Post monsoon season respectively (Table 6.6). Highest number of species was recorded for Lauraceae (5 spp.) and Leguminosae (5 spp.) in winter and Premonsoon. In Post monsoon season Moraceae (5 spp.) and Leguminosae (5 spp.) presented the highest number of species and were followed by Apocynaceae (4 spp.). *Coffea benghalensis* Heyne *ex* Schult. was recorded to be the dominant species in shrubby vegetation in all the three seasons, having IVI score 119.82, 107.64 and 98.97 in winter pre monsoon and post monsoon seasons respectively. It was followed by *Clerodendrum infortunatum* L. with IVI score 39.23, 38.55 and 34.97 in the sane sequence. Thus the shrub layer was nearly homogeneous throughout the year (Annexure I, Table 27, 28 & 29).

In case of herbaceous vegetation number of individuals recorded were – 198 belonging to 48 species, 44 genera and 31 families in winter; 276 individuals belonging to 55 species, 52 genera and 36 families in pre monsoon and 426 individuals belonging to 61 species, 60 genera and 36 families in post monsoon season (Table 6.6). Regarding highest number of species represented by a family, shrubby layer in both Premonsoon and Post monsoon seasons were almost similar. Highest number of species were recorded for Asteraceae (4 spp.) and Rubiaceae (4 spp.) and were followed by Acanthaceae (3 spp.), Apocynaceae (3 spp.), Linderniaceae (3 spp.) etc. in both the Pre and Post monsoon vegetation, whereas in winter season highest number of species was recorded jointly for Acanthaceae, Apocynaceae, Asteraceae and Poaceae – each with three species.

Dryopteris sikkimensis (Bedd.) Kuntze was a dominant species in the herb layer in all the three seasons having IVI score of 32.24, 26.42 and 18.77 in winter, Premonsoon and Post monsoon season in the same sequence. Next to the dominant species were *Pupalia lappacea* (L.) Juss. [IVI = 20.71], *Mikania micrantha* Kunth [IVI = 20.44] in winter (Annexure I, Table 30); *Mikania micrantha* Kunth [IVI = 16.02], *Pupalia lappacea* (L.) Juss. [IVI = 15.75] in Premonsoon (Annexure I, Table 31), and *Pupalia lappacea* (L.) Juss. [IVI = 15.23]; *Diplazium esculentum* (Retz.) Sw. [IVI = 13.00] in post monsoon season (Annexure I, Table 32). Thus ground cover was more or less heterogeneous assemblage of more than one species showing high IVI value.

Sal-Chilauni plantation: A total 109 species belonging to 92 genera and 49 families were recorded from 5 nested quadrates from Sal – Chilauni plantation in Lataguri site. Among the recorded species 28 were trees, 25 were shrubs, 31 were herbs and

25 were climbers. In case of tree layer 145 individuals distributed into 15 species, 13 genera and 12 families were recorded in winter (Table 6.6). Highest number of species was recorded for Combretaceae, Lamiaceae and Lythraceae – all having 2 species each. The canopy layer was dominated by *chilauni* [*Schima wallichii* Choicy] with IVI score 97.25 and was followed by *Shorea robusta* Gaertn. having IVI score 65.87 and the vegetation was almost homogeneous (Annexure I, Table 33). In Postmonsoon season, 171 individuals belonging to 18 species, 16 genera and 15 families were recorded. Lamiaceae was recorded for representing highest number of species (3 spp.). IVI score of the dominant species [*S. wallichii* Choicy] was calculated to be 80.12 in Post monsoon and was followed by 58.67 for *Shorea robusta* Gaertn. A total 197 individuals of shrubs belonging to 34 species, 32 genera and 22 families; 440 individuals belonging to 46 species, 43 genera and 27 families; and 466 individuals belonging to 52 species, 48 genera and 29 families were recorded in winter Premonsoon and Post monsoon season respectively (Table 6.6). Euphorbiaceae was recorded for highest number of species (3 spp.) in winter. Leguminosae presented highest number of species along with Rubiaceae in Premonsoon shrub layer. Both of them were presented by 4 species and were followed by Euphorbiaceae (3 spp.), Lythraceae (3 spp.), Phyllanthaceae (3 spp.) etc. In Post monsoon shrubby vegetation also Leguminosae along with Rubiaceae presented highest number of species (4 spp. each) and were followed by Euphorbiaceae (3 spp.), Apocynaceae (2 spp.) etc. *Clerodendrum infortunatum* L. was found to be the dominant species in shrub layer in both pre and post monsoon season having IVI score 34.94 and 41.48 respectively (Annexure I, Table 36 & 37). *Coffea benghalensis* Heyne *ex* Schult. was in second position in IVI score having 26.87 and 23.32 index value in pre monsoon and post monsoon vegetation of shrubs. In case of winter vegetation, shrub layer was dominated by *Coffea benghalensis* having IVI score 42.84 and was followed by *Clerodendrum infortunatum* L. [IVI = 36.44], *Chromolaena odorata* (L.) King & Rob. [IVI = 22.44], *Tabernaemontana divaricata* (L.) R. Br. *ex* Roem. & Schult. [IVI = 19.45] etc.

Total number of individuals recorded from herbaceous vegetation was 184 belonging to 43 species, 42 genera and 31 families; 200 belonging to 48 species, 45 genera and 30 families; 465 belonging to 57 species, 53 genera and 33 families in winter, premonsoon and post monsoon season respectively (Table 6.6). Asteraceae presented highest number of species (5 spp.) in winter vegetation and was followed by Poaceae (3 spp.), Acanthaceae (2 spp.) etc whereas in Premonsoon and Post monsoon herb layer families with highest number of species were Asteraceae and Piperaceae in joint having 4 species each, followed by Lamiaceae (3 spp.), Poaceae (3 spp.) etc.; and Poaceae (5 spp.) followed by Asteraceae (4 spp.), Lamiaceae (4 spp.), Piperaceae (3 spp.) etc. Throughout the year ground cover vegetation in Sal – Chilauni plantation was of more or less similar type having no single dominant species. Instead of that a number of species having higher IVI score formed the important component of the vegetation. They are *Mikania micrantha* Kunth [IVI = 18.48], *Coffea benghalensis* Heyne *ex* Schult. [IVI = 18.29], *Chloranthus elatior*

Link. [IVI = 16.48], *Ichnocarpus frutescens* (L.) Aiton [IVI = 15.60] etc. in winter (Annexure I, Table 38); *Mikania micrantha* Kunth. [IVI = 17.75], *Coffea benghalensis* Heyne *ex* Schult. [IVI = 16.02], *Lygodium flexuosum* L. [IVI = 14.15], *Ichnocarpus frutescens* (L.) Aiton [IVI = 13.87] etc. in Premonsoon (Annexure I, Table 39); and *Imperata cylindrical* (L.) Raeusch [IVI = 13.33]. *Oplismenus burmanni* (Retz.) Beauv. [IVI = 12.41], *Mikania micrantha* Kunth [IVI = 11.31], *Elephantopus scaber* L. [IVI = 11.08] in Post monsoon season (Annexure I, Table 40).

Teak Plantation: A total 127 species distributed under 112 genera and 50 families including 7 ferns were recorded from teak plantation of Lataguri site. They include 34 trees, 27 shrubs, 48 herbs and 18 climbers. Tree layer was represented by 19 species belonging to 18 genera and 12 families, in winter season and a total 196 individuals were recorded and they were distributed under 21 species, 20 genera and 13 families (Table 6.c). Highest number of species was recorded for Lamiaceae (3 species) in winter, Apocynaceae, Combretaceae, Euphorbiaceae, Leguminosae and Rubiaceae were represented by 2 species each. Apocynaceae and Lamiaceae both having 3 species each, Combretaceae, Euphorbiaceae, Leguminosae and Rubiaceae were with 2 species each. IVI score of Teak was recorded 121.89 along with 14.71, 66.84, and 40.35 as RF, RD and RA respectively. It contributed near about half of the IVI score of all the tree species in the habitat. Some other species were *Gmelina arborea* Roxb. [IVI = 16.95], *Croton caudatus* Geiseler [IVI = 16.36], *Pueraria sikkimensis* Prain [IVI = 16.36) showing IVI score next to teak (Annexure I, Table 41). In post monsoon season, IVI score of teak was 111.72 and was followed by *Pueraria sikkimensis* Prain [IVI = 19.84], *Croton caudatus* Geieser [IVI = 18.56], *Gmelina arborea* Roxb. [IVI = 16.88] etc (Annexure I, Table 42).

In shrub layer, total 44 species belonging to 41 genera and 22 families were found to be grown throughout the year. In winter total 407 individuals belonging to 24 species, 23 genera and 14 families were recorded whereas in Premonsoon season number of recorded individuals were 569 and were distributed into 30 species, 28 genera and 17 families (Table 6.6). Post monsoon shrubby vegetation was composed of 34 species, 33 genera and 21 families and 1020 individuals were recorded from the sampled area in this season. Highest number of species were recorded from Rubiaceae (4 spp.) followed by Lamiaceae (3 spp.), Malvaceae (2 spp.), Phyllanthaceae (3 spp.) etc in winter; for Lamiaceae (3 spp.), Leguminosae (3 spp.). Malvaceae (3 spp.), Rubiaceae (3 spp.) in joint in Premonsoon season; and for Euphorbiaceae (4 spp.) followed by Malvaceae (3 spp.), Phyllanthaceae (3 spp.), Rutaceae (3 spp.) etc. in post monsoon season.

Shrub layer was found to be heterogeneous assemblage of 3 co-dominant species in winter season – *Coffea benghalensis* Heyne *ex* Schult. [IVI = 64.08], *Clerodendrum infortunatum* L. [IVI = 48.57] and *Morinda angustifolia* [IVI = 41.22]. They contributed to about 50% of the IVI score of all the species in this season. Some other important species were *Maesa chisia* Buch.-Ham. *ex* D. Don

[IVI = 16.85], *Chromolaena odorata* (L.) King & Rob. [IVI = 15.95], *Urena lobata* L.[IVI = 14.72] etc (Annexure I, Table 43). But in Premonsoon season, shrubs layer converted into homogeneous one, as *Coffea benghalensis* Heyne *ex* Schult. Became dominant species showing IVI score 70.24. Other species having IVI score near the higher end were *Clerodendrum infortunatum* L. [IVI = 46.11] and *Morinda angustifolia* Roxb. [IVI = 35.88] (Annexure I, Table 44).

In Post monsoon season composition of shrubby vegetation was more or less similar with that of Premonsoon one with *Coffea benghalensis* Heyne *ex* Schult. as dominant species having IVI score 69.34. Other important components of Post monsoon vegetation in shrub layer were *Clerodendrum infortunatum* L. [IVI = 46.12], *Morinda angustifolia* Roxb. [IVI = 32.36], *Chromolaena odorata* (L.) King & Rob. [IVI = 16.5] etc (Annexure I, Table 45).

Sevoke site: Jarul and teak plantation were studied in Sevoke site.

Jarul Plantation: A total number of 123 species belonging to 111 genera and 57 families were recorded from all the three layer – tree, shrub and herb layer, of Jarul plantation in Sevoke site and among them 31 species were categorise as tree, 25 species as shrubs, 39 species as herbs and 28 species were grouped as climber.

Table 6.7. Number of individuals and taxa recorded in different seasons from Sevoke site

Plantation	Number of	Layer of Vegetation							
		Tree		Shrub			Herb		
		Winter	Postmon	Winter	Premon	Postmon	Winter	Premon	Postmon
Teak	Individual	208	222	406	699	1055	254	555	720
	Species	25	29	34	41	46	42	49	57
	Genera	24	28	34	40	46	38	46	54
	Family	18	20	20	21	23	26	30	32
Jarul	Individual	147	169	404	571	717	315	659	1013
	Species	23	28	31	36	41	44	52	61
	Genera	22	27	30	35	39	40	48	27
	Family	17	18	21	24	27	26	28	33

Tree layer composed of 23 species, belonging to 22 genera and 17 families and total 147 individuals were recorded from the sampled area in winter season whereas in Post monsoon, a total of 169 individuals belonging to 28 species, 27 genera and 18 families were recorded from canopy layer (Table 6.7). Highest number of species was recorded for a single family Lamiaceae (3 spp.) in winter and was followed by Apocynaceae (2 spp.), Euphorbiaceae (2 spp.), Leguminosae (2 spp.) etc. But in Post monsoon season highest number of species was recorded for 3 families – Euphorbiaceae, Lamiaceae and Malvaceae all having 3 representative species each. In the monoculture of *Jarul* [*Lagerstroemia speciosa* (L.) Pers.], for which IVI score was recorded as 107.13 in winter and was followed by *Callicarpa arborea* Roxb. [IVI = 19.72], *Tectona grandis* L. f. [IVI = 15.71], and *Croton*

caudatus Geiseler [IVI = 11.81] and others (Annexure I, Table 49). In post monsoon, IVI of the dominant species was recorded to be 94.86 and was followed by *Callicarpa arborea* Roxb. [IVI = 18.61], *Croton caudatus* Geiseler [IVI = 15.77], *Pueraria sikkimensis* Prain [IVI = 11.72] etc (Annexure I, Table 50).

From the shrub layer of Jarul plantation in Sevoke site, 404 individuals belonging to 31 species, 30 genera and 21 families were recorded in winter; 571 individuals belonging to 36 species, 35 genera and 24 families in Premonsoon; and 717 individuals belonging to 41 species, 39 genera and 27 families were recorded (Table 6.7).

Coffea benghalensis Heyne *ex* Schult. and *Clerodendrum infortunatum* L. were co-dominant species showing IVI score 50.34 and 49.93 respectively, in winter season. They were followed by *Urena lobata* L. [IVI = 33.44], *Triumfetta rhomboidea* Jacq. [IVI = 21.76], *Chromolaena odorata* (L.) King & Rob. [IVI = 21.11] etc. Thus the vegetation was more or less heterogeneous assemblage of 3 or 4 specie having more or less same IVI values (Annexure I, Table 51). In Premonsoon and Post monsoon season also the shrub layer was more or less similar in the dominance pattern. But the IVI values of the species were slightly changed. IVI values of *Coffea benghalensis* Heyne *ex* Schult. was recorded to be 43.64 in Premonsoon and 38.38 in Post monsoon season (Annexure I, Table 52 & 53).

From herbaceous vegetation of Jarul plantation in Sevoke site, 315 individuals of herbs were recorded and they were distributed under 44 species, 40 genera and 26 families in winter season. On the other hand, 659 individuals belonging to 52 species, 48 genera and 28 families; and 1013 individuals belonging to 61 species, 57 genera and 33 families were recorded from Premonsoon and Post monsoon vegetation in herb layer respectively (Table 6.7). Highest number of species were recorded for Acanthaceae (5 species) and was followed by Poaceae, Vitaceae, Zingiberaceae etc. – all having 3 species, in winter vegetation. In Premonsoon and Post monsoon season also highest number of species was recorded for Acanthaceae (5 and 6 spp. respectively). Other families with higher number of species were Zingiberaceae, Leguminosae, Amaranthaceae, Araceae etc in Premonsoon and Zingiberaceae, Araceae, Leguminosae, Amaranthaceae, Asteraceae etc in descending order in Post monsoon season.

Herbaceous vegetation was an assemblage of numerous species without any particular species as dominant. In winter season IVI values calculated for *Pupalia lappacea* (L.) Juss. [IVI = 20.97] was quite higher than other and was followed by *Setaria palmifola* (J.Koenig) Stapf. [IVI = 15.44], *Oplismenus burmanni* (Retz.) Beauv. [IVI = 15.21] etc (Annexure I, Table 54). In Premonsoon vegetation IVI score of *Coffea benghalensis* was 19.73. Highest IVI value was calculated for *Diplazium esculentum* (Retz.) Sw. in post monsoon season.

Teak Plantation: A total of 125 species (including 7 Pteridophytic species) belonging to 108 genera and 55 families were recorded from teak plantation in

Sevoke site. They were distributed under 37 species of trees, 26 shrubs, 37 herbs and 25 climbers. Highest number of species was recorded for Leguminosae (11 species) and was followed by Euphorbiaceae (8 spp.), Lamiaceae (8 spp.), Commelinaceae (4 spp.), Rubiaceae (4 spp.), Vitaceae (4 spp.), Amaranthaceae (3 spp.) etc.

As it was an almost monoculture, highest number of individuals were recorded for the planted species i.e teak (142 individuals) while 208 individuals were recorded for all the species in the tree layer from the sampled area. Total 25 species were recorded from the winter vegetation in tree layer, and they were distributed under 24 genera and 18 families (Table 6.7). Highest number of species was recorded for Lamiaceae (4 spp.) and was followed by Leguminosae (3 spp.), Lythraceae (2 spp.), Meliaceae (2 spp.) etc. IVI score of the dominant species [*Tectona grandis* L. f.] was recorded to be 118.12 along with 14.71, 68.27 and 35.15 as RF, RD and RA respectively. Other species with IVI value next to the dominant species were – *Pueraria sikkimensis* Prain [IVI = 16.86], *Bauhinia variegata* L. [IVI = 13.21], *Careya arborea* Roxb. [IVI = 12.23] etc (Annexure I, Table 57).

In Post monsoon season, a total of 222 individuals of trees including 139 individual of Teak were recorded from the tree layer. They belonged to 29 species, 28 genera and 20 families (Table 6.7). Lamiaceae and Leguminosae were found to be presented the highest number of species – 4 species in each case. Euphorbiaceae, Lythraceae and Meliaceae were presented by 2 species each. IVI score of *Teak* [*Tectona grandis* L. f.], the dominant species, was recorded to be 105.78 that was contributed by RF of 13.51, RD of 62.61 and RA of 29.66. Other species next to the dominant one, were *Pueraria sikkimensis* Prain [IVI = 18.16], *Bauhinia variegata* L. [IVI = 12.02], *Crateva religiosa* Forst. f. [IVI = 11.31] etc (Annexure I, Table 58).

In winter season a total of 406 individuals belonging to 34 species, 34 genera and 20 families were recorded from shrub layer. Malvaceae was recorded for highest number of spp. (5 spp.) followed by Rubiaceae (4 spp.), Euphorbiaceae (3 spp.), Acanthaceae (2 spp.) etc. In Premonsoon and Post monsoon season, 699 individuals belonging to 41 species, 40 genera and 21 families; and 1055 individuals belonging to 46 species , 46 genera and 23 families were recorded respectively. Leguminosae with 6 species was recorded for highest number of species and was followed by Malvaceae (5 spp.), Euphorbiaceae (4 spp.), Rubiaceae (4 spp.), Lamiaceae etc. in Premonsoon vegetation. Whereas in Post monsoon vegetation Euphorbiaceae and Leguminosae were recorded for higher number of spp. (6 spp. each), followed by Malvaceae (5 spp.), Rubiaceae (4 spp.), Lamiaceae (3 spp.) etc.

Shrub layer was more or less homogeneous without any single dominant species, throughout the year. But the IVI scores of important species were changed seasonally. In winter the shrub layer was the association of important species like *Coffea benghalensis* Heyne ex Schult [IVI = 49.39], *Clerodendrum infortunatum* L. [IVI = 49.10], *Urena lobata* L. [IVI = 33.06], *Triumfetta rhomboidea* Jacq. [IVI =

21.08], *Chromolaena odorata* (L.) King & Rob. [IVI = 20.21] etc (Annexure I, Table 59). In Premonsoon also the association was almost similar but *Urena lobata* with IVI score 41.37 was in second position instead of third. The composition in Post monsoon season was more inclusive than that of winter and premonsoon due to incorporation of some other species.

A total 254 individuals belonging to 42 species, 38 genera and 26 families were recorded from herbaceous vegetation in winter season, whereas 555 individuals belonging to 49 species, 46 genera and 30 families; and 720 individuals belonging to 57 species, 54 genera, and 32 families, were recorded in Premonsoon and Post monsoon season respectively (Table 6.7).

All over the year, Acanthaceae was found to be represented by highest number of species (6 species) and was followed by Amaranthaceae with 3 species. No single species was found to be dominant in winter and Post monsoon herbaceous layer whereas *Oplismenus burmanni* (Retz.) Beauv. was found showing dominancy to some extent having IVI score 23.90 along with RF, RD and RA values as 1.48, 9.19 and 13.23 respectively. Next one was *Setaria palmifola* having index value 15.90. Winter vegetation was represented by a number of species having similar IVI score. They were – *Setaria palmifola* (J.Koenig) Stapf. [IVI = 19.97], *Oplismenus burmanni* [IVI = 19.84], *Pupalia lappacea* Beauv. [IVI = 17.20], *Commelina diffusa* Burman. f. [IVI = 12.94] etc (Annexure I, Table 62). *Oplismenus burmanni* Beauv. [IVI = 16.05], *Mikania micrantha* Kunth. [IVI = 15.24], *Dioscorea bulbifera* L. [IVI = 14.25], *Commelina suffruticosa* Blume [IVI = 12.90], *Synedrella nodiflora* (L.) Gaertn. [IVI = 12.36] etc were important component of Post monsoon herbaceous vegetation (Annexure I, Table 64). General tendency of this vegetation was – dominancy of Monocolyledonous plants-throughout the year.

Jarul plantation in Satali, under NRVK site was populated by 71 species, 63 genera and 40 families including 6 species of pteridophytes. They were categorized under 15 climbers, 29 herbs, 12 shrubs and 15 trees. Highest number of species was recorded for Asteraceae having 5 species and was followed by Leguminosae (4 species) Convolvulaceae, Dioscoreaceae, Lamiaceae, Moraceae, Urticaceae, Vitaceae – all represented by 3 species. From tree layer, 14 species, 11 genera and 9 families were recorded. In shrub layer 65 species, 64 genera and 19 families were found to occur whereas herb layer harboured 42 species belonging to 39 genera and 28 families.

A total 109 trees belonging to 12 species 11 genera and 09 families were recorded in winter from tree layer whereas in Post monsoon season, number of recorded individual was 122, belonging to 13 species, 11 genera and 09 families (Table 6.5). Leguminosae, Lythraceae and Moraceae were recorded for highest number of species in winter; whereas in Post monsoon, highest number of species were recorded for Moraceae (3 species), and was followed by Lamiaceae (2 species), Leguminosae (2 species), Lythraceae (2 species) etc.

As it was a monoculture of Jarul [*Lagerstroemia speciosa* (L.) Pers.], highest value of IVI was recorded for it [126.15] and that was accompanied by higher values of RF, RD and RA as 13.51, 62.39 and 50.25 respectively. Regarding IVI score the species next to *Jarul*, were *Litsea monopetala* (Roxb.) Pers. [IVI = 28.42], *Albizia lucidior* (Steud.) Nielsen [IVI = 21.86], *Crateva religiosa* Frost. f. [IVI = 18.18] etc (Annexure I, Table 65). In Postmonsoon season IVI score of *Jarul* was recorded to be 120.40 along with 12.82, 59.84 and 47.74 as RF, RD and RA respectively. Species next to *Jarul* were *Litsea monopetala* (Roxb.) Pers. [IVI = 27.56], *Albizia lucidior* (steud.) Nielsen [IVI = 23.14], *Crateva religiosa* Forst f. [IVI = 21.72] etc (Annexure I, Table 66). Thus the tree layer was almost similar in both winter and Post monsoon season.

From shrub layer of *Jarul* plantation, a total of 236 individuals belonging to 19 species, 18 genera and 14 families in winter; 382 individuals belonging to 22 species, 21 genera and 16 families in Premonsoon and; 473 individuals belonging to 26 species, 25 genera and 18 families were recorded in Postmonsoon season (Table 6.5). Asteraceae, Dioscoreaceae, Moraceae, Urticaceae etc. were with highest number of species in winter. In Premonsoon, Primulaceae with 3 species was recorded for highest number of species and was followed by Asteraceae (2 spp.), Dioscoreaceae (2 spp.), Moraceae (2 spp.), Urticaceae (2 spp.) etc. On the other hand Dioscoreaceae was recorded for highest number of species (3 species) in Postmonsoon and was followed by Asteraceae (2 spp.), Moraceae (2 spp.), Primulaceae (2 spp.) etc.

Coffea benghalensis Heyne *ex* Schult. was recorded for high IVI score in all the winter, Premonsoon and Postmonsoon vegetation and thus dominated the vegetation all over the year (Annexure I, Table 67 – 69). Only the index values changed in different seasons: 123.26 in winter, 93.43 in Premonsoon and 81.54 in Postmonsoon season. *Clerodendrum infortunatum* L. was found next to the dominant species in respect of IVI score and the index values for which were calculated to be 45.32, 32.15 and 31.88 in winter, Premonsoon and Postmonsoon in the same order.

A total of 209 individuals belonging to 28 species, 25 genera and 22 families; 332 individuals belonging to 32 species, 29 genera and 24 families; and 558 individuals belonging to 41 species, 38 genera and 29 families were recorded from herbaceous vegetation of *Jarul* plantation in winter, Premonsoon and Postmonsoon season respectively (Table 6.5).

Convolvulaceae was recorded for representing highest number of species in winter and Premonsoon season. Three species were recorded in each season and was followed by Amaranthaceae having 2 species. On the other hand Asteraceae was recorded for largest number of species (4 species) in Postmonsoon season. Clear dominancy by a single species [*Diplazium esculentum* (Retz.) Sw.] was found in case of winter vegetation. IVI score for dominant species was recorded to be 43.34

along with 17.95, 20.57 and 4.81 as RF, RD and RA in the same order. *Dioscorea bulbifera* L. [IVI = 26.28], *Pouzolzia hirta* Blume *ex* Hassk. [IVI = 23.53], *Oplismenus burmanni* (Retz.) Beauv. [IVI = 20.78], *Pupalia lappacea* (L.) Juss. [IVI = 19.45], *Dioscorea pentaphylla* L. [IVI = 17.31] etc. were other species forming a group next to the dominant species (Annexure I, Table 70). In Premonsoon vegetation of herbaceous species, *Diplazium esculentum* Retz. showed the tendency to be the dominant one having IVI value of 34.95 along with RF of 14.50, RD of 16.27 and RA of 4.18. It was followed by *Dioscorea bulbifera* L. having IVI value of 28.98, *Spermacoce alata* Aubl. [IVI = 17.33], *Oplismenus burmanni* (Retz.) Beauv. [IVI = 16.29] etc (Annexure I, Table 71).

No clear dominancy of a single species was found in Post monsoon vegetation. But two species – *Diplazium esculentum* (Retz.) Sw. [IVI = 25.99] and *Dioscorea bulbifera* L. [IVI = 23.17] were found to have co-dominancy. Other species having high IVI were – *Pouzolzia zeylanica* (L.) Benn. [IVI = 13.78], *Chloranthus elatior* Link. [IVI = 13.49], *Oplismenus burmanni* Beauv. [IVI = 12.30] etc. Thus it is better to conclude that the Postmonsoon vegetation of herbaceous species was an assemblage of numerous species without any single dominant species (Annexure I, Table 72).

***Natural Vegetation*:**

NRVK site: In winter season a total of 871 individuals of trees belonging to 88 species, 80 genera and 46 families were recorded from 50 quadrates in tree layer of natural vegetation of NRVK site (Table 6.8). Malvaceae and Leguminosae were recorded for highest number of species – 8 species in each, and was followed by Meliaceae [6 spp.], Lauraceae, Lamiaceae, Euphorbiaceae, Apocynaceae – each with 5 species, Phyllanthaceae with 4 species etc in tree layer.

Table 6.8. Number of individuals and taxa recorded in different seasons from Natural Vegetation

Site	Number of	Layer of Vegetation							
		Tree		Shrub			Herb		
		Winter	Postmon	Winter	Premon	Postmon	Winter	Premon	Postmon
NRVK	Individual	871	893	3412	4436	5825	3025	4506	6735
	Species	88	91	89	102	111	123	134	157
	Genera	80	82	81	88	102	114	131	135
	Family	46	44	80	46	43	55	58	51
Lataguri	Individual	280	291	989	1122	1369	1008	1288	1529
	Species	64	67	127	131	151	112	123	149
	Genera	54	58	107	111	120	94	108	127
	Family	30	30	54	56	56	50	61	62
Sevoke	Individual	274	290	918	1057	1407	1013	1529	1926
	Species	69	73	67	72	76	74	83	90
	Genera	62	66	62	68	71	71	80	88
	Family	32	34	31	29	38	35	49	44

Highest number of individuals was recorded for *Tabernaemontana divaricata* (L.) R. Br. *ex* Roem. & Schult. (85 individuals), followed by *Dendrocnide sinuata* [71 individuals], *Trewia nudiflora* L. [63 individuals] etc. Thus highest IVI value also was recorded for *T. divaricata* [IVI= 17.98], followed by *D. Sinuata* [IVI= 15.00], *T. nudiflora* L. [IVI= 14.50], *Aphanamixis polystachya* (Wall.) Parker [IVI= 10.07], *Leea guinensis* G. Don [IVI= 8.90], *Litsea monopetala* (Roxb.) Persoon [IVI= 8.90], *Polyalthea simiarum* (Hook. f. & Thomson) Hook .f. & Thomson [IVI= 8.45] etc (Annexure I, Table 73). Other important species were – *Casearia vareca*, *Ailanthus integrifolia*, *Tetrameles nudiflora*, *Croton caudatus*, *Agalia spectabilis* etc. Thus the vegetation was not dominated by single species but it was an assemblage of numerous species having more or less similar IVI value.

In post monsoon season, total 893 Individuals belonging to 91 species, 82 genera and 44 families were recorded from tree layer. Highest number of individuals were recorded for *Tabernaemontana divaricata* and was followed by *Dendrocnide sinuata* (Blume) Chew, *Trewia nudiflora* L etc. Like winter vegetation, no prominent dominancy of a single species was recorded in post monsoon season also (Annexure I, Table 74). Nearly similar type of IVI score was shown by the above mentioned species. Thus both the winter and post monsoon tree Layer were of similar type in respect of dominancy pattern and species composition.

In shrub layer total 100 number of $5\times5m^2$ quadrates were studied in NRVK site and a total of 3412 individuals belonging to 89 species, 81 genera and 40 families; 4436 individuals belonging to 102 species, 88 genera and 46 families; and 5825 individuals belonging to 111 species, 102 genera and 43 families were recorded in Winter, Pre monsoon and Post monsoon season respectively. Vitaceae was recorded for highest number of species (9 spp.) and was followed by Leguminosae & Malvaceae with species each, Apocynaceae, Euphorbiaceae, Rubiaceae with 7 species each, Phyllanthaceae, Rutaceae with 6 species each etc in shrub layer. Highest IVI value was recorded for *Coffea benghalensis* Heyne *ex* Schult. [IVI= 20.61, RF= 3.84, RD= 12.10, & RA= 4.67] and was followed by *Clerodendrum infortunatum* L. [IVI= 18.75, RF= 2.96, RD= 10.52 & RA= 5.27], *Tabernaemontana divaricata* (L.) R. Br. *ex* Roem. & Schult. [IVI= 14.22, RF= 4.78, RD= 7.21 & RA= 2.23], *Dendrocnide sinuata* (Blume) Chew [IVI= 12.98], *Morinda angustifolia* Roxb. [IVI= 11.06] etc. in winter vegetation (Annexure I, Table 75).

Premonsoon shrub layer of natural vegetation in NRVK site was an amalgamation of a large number of species with more or less equal index value without any prominent dominancy. That was evident from the RF, RD, RA and IVI values. Highest IVI value was recorded for *Coffea benghalensis* Heyne *ex* Schult. [IVI=18.34], followed by *Clerodendrum infortunatum* L. [IVI=15.7], *Dendrocnide sinuata* (Blume) Chew. [IVI=15.51], *Tabernaemontana divaricata* (L.) R. Br. *ex* Roem. & Schult. [IVI=12.20] etc (Annexure I, Table 76).

In post monsoon shrubby vegetation also highest index value was recorded for *Coffea benghalensis* Heyne *ex* Schult. [IVI=20.85, RF=3.74, RD=13.29, RA=3.82] and was followed by *Dendrocnide sinuata* (Blume) Chew. [IVI=12.76], *Pueraria sikkimensis* Prain [IVI=12.34], C*lerodendrum infortunatum* L. [IVI=12.00], *Tabernaemontana divaricata* (L.) R. Br. *ex* Roem. & Schult. [IVI=10.34] etc (Annexure I, Table 77). Thus the vegetation in shrub layer in post monsoon season was an assemblage of a number of species with similar type of index value but without any clear and true dominancy though a tendency of dominancy was noted in case of *Coffea benghalensis* Heyne *ex* Schult.

From groundcover vegetation of NRVK natural forest, total 3025 individuals belonging to 123 species, 114 genera and 58 families; 4506 individuals belonging to 134 species, 131 genera and 58 families; and 6735 individuals belonging to 157 species, 135 genera and 51 families were recorded in Winter, Premonsoon and Postmonsoon season respectively (Table 6.8). Highest number of species was recorded in case of Acanthaceae for herb layer. Other important families were- Leguminosae & Rubiaceae each with 9 species, Lamiaceae with 8 species, Apocynaceae, Araceae Asteraceae, Malvaceae & Vitaceae with 7 species each etc.

Chloranthus elatior Link. was recorded for highest index value [IVI=12.32] and was followed by *Mikania micrantha* Kunth. [IVI=8.04], *Achyrospermum wallichianum* Bentham [IVI=7.00], *Phaulopsis imbricata* (Forssk.) Sweet [IVI=7.00], *Gomphostemma ovatum* wall. *ex* Benth [IVI=5.7] etc (Annexure I, Table 78). Thus *Chloranthus elatior* played the role of the dominant species in the ground cover vegetation in winter population whereas in Premonsoon season highest value of IVI was recorded for *Coffea benghalensis* Heyne *ex* Schult. [IVI=12.2], and was followed by *C. infortunatum* L. [IVI=7.60], *Chromolaena odorata* (L.) King & Rob. [IVI=7.60], *Achyrospermum wallichianum* (Benth.) Benth. *ex* Hook. f. etc (Annexure I, Table 79). Thus *Coffea benghalensis* Heyne *ex* Schult. showed a tendency to be dominant species in Premonsoon vegetation. Postmonsoon vegetation also was represented by a number of species having similar type of index value. Composition of species was more or less similar in all the 3 season but differed in the highest IVI value only. In Postmonsoon season the highest IVI value was recorded for *Coffea benghalensis* Heyne *ex* Schult. and was calculated to be 8.79 only (Annexure I, Table 80).

***Lataguri site*:** It has been mentioned earlier that a total 331 species belonging to 244 genera and 92 families were recorded from natural vegetation of Lataguri site, and their habitual division was like - 101 species of herbs, 65 species of shrubs, 97 species of trees and 68 species of climber. Tree layer in winter season was inhabitated by 64 species belonging to 54 genera and 30 families and a total of 280 individuals were recorded from the sampled area (Table 6.8). Highest number of stem count was found in case of *Machilus glaucescens* (Nees) Wight. with 24 individuals and was followed by *Bauhinia variegata* L. (18), *Stereospermum tetragonum* DC. (17) etc. Highest IVI was recorded for *M. glaucescens* (Nees)

Wight. with index value 16.21 along with 4.39, 8.57 and 3.24 of Relative frequency, Relative density and Relative abundance. Other species with high index value were – *Bauhinia variegata* L. [IVI= 14.82], *S. Tetragonum* DC. [IVI = 13.65], *Baccaurea ramiflora* Lour [IVI= 13.55], *Actinodaphe obovata* (Nees) Blume [IVI = 11.54], *Agalia spectabilis* (Miq.) Jain and Bennet [IVI = 11.45], *Sorindeia madagascariensis* Bail. [IVI = 10.51], *Shorea* r*obusta* Gaertner f. [IVI = 9.50], *Turpinia pomifera* (Roxb.) DC. [IVI = 9.50], *Gynocardia odorata* R. Br. [IVI = 8.49] etc (Annexure I, Table 81). Thus the vegetation was a collection of numerous important species without any prominent dominancy by a single species or even the co- dominancy.

In post monsoon vegetation of trees 291 stem count were recorded for 67 species belonging to 58 genera and 30 families. The highest index value was recorded for *Machilus glaucescens* (Nees) Wight. [IVI = 15.49] and was followed by *B. variegata* L. [IVI = 14.11], *Stereospermum tetragonum* DC. [IVI = 13.00], *Baccaurea ramiflora* Lour. [IVI = 12.90], *Actinodaphe obovata*. (Nees) Blume [IVI = 11.02], *Agalia spectabilis* (Miquel) Jain & Bennet [IVI = 10.90] etc (Annexure I, Table 82). Thus both the winter and post monsoon vegetation of trees were almost similar in respect of species composition and dominance pattern. Only difference was in the index value. Tree layer in the natural vegetation in Lataguri site was an assemblage of numerous species having similar type of index value and were quite stable. Increases in number of stem count from winter to post monsoon was found and that was due to the increase in diameter in breast height (DBH) or more simply for the growth of saplings of some fast growing species.

In winter season 989 individuals of shrubs including saplings of trees belonging to 127 species, 107 genera and 55 families were recorded. On the other hand 1122 individuals belonging to 131 species, 111 genera and 56 families in winter seasons; and 1359 individuals belonging to 151 species, 120 genera and 56 families in premonsoon; and 1369 individuals belonging to 151 species, 120 genera and 56 families in post monsoon seasons, were recorded from the shrub layer of natural vegetation (Table 6.8). *Mikania micrantha* Kunth. was recorded for highest index value in both pre monsoon [IVI= 20.49] and post monsoon season [VI = 21.81] and was followed by *Chromolaena odorata* (L.) King & Rob. [IVI = 9.94], *Justicia adhatoda* L. [IVI = 9.8], *Croton caudatus* Geiseler [IVI = 8.78], *Clerodendrum infortunatum* L. [IVI = 8.29], *Litsea monopetala* (Roxb.) Pers [IVI = 6.94] etc in pre monsoon vegetation.

Other important component of the vegetation were *Capparis acutifolia* sweet [IVI = 6.81], *Baliospermum solanifolium* (Burm.) Suresh. [IVI = 6.25], *Meyna spinosa* Roxb. *ex* Link [IVI = 5.63], *Antidesma bunius* (L.) Spreng. [IVI = 4.88] etc (Annexure I, Table 84). But in post monsoon vegetation *Mikania micrantha* was followed by *Alpinia nigra* (Gaertn.) Burtt [IVI = 12.14], *Alpinia calcarata* (Haw.) Roscoe [IVI = 11.34], *Piper peepuloides* Roxb [IVI = 10.71], *Chromolaena odorata* (L.) King & Rob. [IVI = 10.25], *Phlogacanthu*

thyrsiformis (Roxb. *ex* Hardw.) Mabb. [IVI = 9.17], *Alpinia nigra* (Gaertn.) Burtt [IVI = 8.80] etc (Annexure I, Table 85). Thus pre monsoon and post monsoon shrub layer were more or less similar in species composition. Though post monsoon vegetation was higher in respect of number of species and the individuals.

A total of 1008 individuals including seedlings of trees and shrubs were recorded from the winter vegetation of herb layer of Natural vegetation in Lataguri site. They belonged to 112 species under 94 genera and 50 families (Table 6.8). Highest value of Relative frequency (RF) was recorded in case of *Mikania micrantha* Kunth. (RF = 10.38) followed by *Piper betlioides* DC. (RF = 6.60), *Oplismenus burmanni* (Retz.) P. Beauv. [RF = 5.09], *Ageratum houstonianum* Miller [RF = 4.34], *Dryopteris sparsa* (D. Don) Kuntz. [RF = 3.96] etc. On the other hand, highest relative density was recorded for *M. micrantha* Kunth [RD = 10.22], followed by *A. houstonianum* Miller [RD = 6.75], *Oplismenus burmanni* (Retz.) P. Beauv. [RD = 6.35], *Dryopteris sparsa* (D. Don) Kuntze [RD = 4.86], *P. betleoides* DC. [RD = 4.06] etc. In case of relative abundance, *Glycosmis pentaphylla* (Retz.) D. Don showed highest value [RA = 3.39], and was followed by *Crinum amoenum* [RA = 1.94], *Elatostemma monandrum* (D. Don) Hara [RA = 1.82], *Eragrostis amabilis* (L) wight & Arn. [RA = 1.74] etc.

Highest IVI value was recorded for *Mikania micrantha* Kunth [IVI = 21.50], followed by *Oplismenus burmanni* (Retz.) P. Beauv. [IVI=12.59], *A. houstonianum* Miller [IVI = 12.52], *P. betleoides* D. [IVI = 11.24], *D. sparsa* (D. Don) Kuntze [IVI = 9.95], *Clerodendrum infortunatum* L. [IVI = 7.57], *Chloranthus elatior* Link [IVI = 6.91] etc. Thus the herb layer was dominated by *M. micrantha* Kunth (Annexure I, Table 86)

A total of 1288 individuals belonging to 123 species, 108 genera and 61 families, and 1529 individuals belonging to 149 species, 127 genera and 62 families, were recorded in Premonsoon and Postmonsoon vegetation of herb layer, respectively (Table 6.8). They included the seedlings of trees and shrubs. Highest relative frequency was recorded for *Phyllanthus urinaria* L. [RF = 7.31], *Pupalia lappacea* [RF = 7.10], *Oplismenus compositus* (L.) P. Beauv, [RF = 4.95], *M. micrantha* [RF = 4.73] etc. In Premonsoon season, whereas *Piper chuvya* (Miguel) C. DC [RF = 7.212], *Oplismenus burmanni* (Retz.) P. Beauv. [RF = 14.66], *D. sikkimensis* (Redd.) Kuntze [RF = 4.02] etc were recorded for higher relative frequency in Postmonsoon season. Highest value of RD was recorded for *Oplismenus compositus* (L.) P. [RD = 9.08], followed by *P. urinaria* L. [RD = 6.83], *Phyrium pubinerve* Blume [RD = 5.20], *Spermacoce alata* [RD = 4.81] etc in Premonsoon (Annexure I, Table 87). *Eranthemum pulchellum* Andrews showed the highest Relative abundance value [RA = 4.55] followed by *Alpinia galanga* (L.) Willd. [RA = 4.44], *Commelina diffusa* Burman f. [RA = 3.25] etc. Regarding the importance value index [IVI], highest score was found in case of *O. compositus* with index value of 15.68 and was followed by *Phyllanthus urinaria* L.[IVI = 14.98], *P. pubinarve* Blume [IVI = 9.77], *M. micrantha* Kunth [IVI = 9.44], *S. alata* [IVI =

9.05], *D. sikkimensis* (Bedd.) O. Kuntze [IVI = 8.56] etc. Thus no clear dominancy of a single species played an important role in the community and formed a homogeneous assemblage.

Sevoke site: A total of 274 individuals of trees belonging to 69 species, 62 genera and 32 families were collected from the canopy layer of natural vegetation of Sevoke site**.** Number of individuals collected in the post monsoon season was – 290 belonging to 73 species, 66 genera and 34 families (Table 6.8). Both in the winter and post monsoon – *Lagerstroemia speciosa* (L.) Pers. was recorded for highest IVI score and calculated values of the index were 19.40 [RF = 5.78, RD = 10.58, RA = 3.03] in winter and 18.38 [RF = 5.50, RD = 10, RA= 2.89] in post monsoon season. In winter tree community dominant species was followed by *Shorea robusta* Gaertner. f. [IVI = 13.86, RF = 5.20, RD = 6.56, RA = 2.09] *Castanopsis indica* (Roxb.) A. DC. [IVI = 10.93, RF = 2.89, RD = 5.11, RA = 2.93], *Agalia spectabilis* (Miquel) Jain & Bennet [IVI = 10.22, RF = 4.05, RD = 4.38, RA = 1.79], *Aphanamixis polystachya* (Wall.) Parker, [IVI = 10.08, RF = 4.62, RD = 4.01, RA = 1.44], *Stereospermum tetragonum* DC. [IVI = 8.68, RF = 4.05, RD = 3.29, RA = 1.35], *Terminalia myriocarpa* Van Heurck & Müll. Arg. [IVI = 8.63], *Firmiana colorata* (Roxb.) R. Br. [IVI = 8.63] etc (Annexure I, Table 89).

On the other hand in post monsoon season dominant species was followed by *Shorea robusta* Gaertner [IVI = 13.14, RF = 4.95, RD = 6.21, RA = 1.99], *Aglaia spectabilis* (Miq.) Jain & Bennet [IVI = 12.12, RF = 3.85, RD = 5.86, RA = 2.42], *Castanopsis indica* (Roxb.) A. DC. [IVI = 10.36, RF = 2.75, RD = 4.83, RA = 2.79], *Aphanamixis polystachya* (Wall.) Parker, [IVI = 10.36, RF = 4.40, RD = 3.79, RA = 1.37], *Stereospermum tetragonum* DC. [IVI = 8.23, RF = 3.85, RD = 3.10, RA = 1.28], *Firmiana colorata* (Roxb.) R. Br. [IVI = 8.19] *Callicarpa arborea* Roxb. [IVI = 7.54] etc (Annexure I, Table 90).

A number of 918 individuals belonging to 67 species, 62 genera and 31 families; 1057 individuals belonging to 72 species, 68 genera, 29 families; and 1407 individuals belonging to 76 species, 71 genera and 38 families, were recorded from shrubs layer in winter, Premonsoon and Postmonsoon seasons respectively (Table 6.8). *Coffea benghalensis* Heyne *ex* Schult. was recorded for highest IVI value [IVI = 24.80] along with 4.98, 14.27 and 5.56 of RF, RD and RA respectively. It was followed by *Chromolaena odorata* (L.) King & Rob. [IVI = 17.53, RF = 3.55, RD = 9.04 and RA = 4.93], *Mikania micrantha* Kunth. [IVI = 18.81, RF = 4.50, RD = 8.61 and RA = 3.70], *Lantana camara* L. [IVI = 10.63, RF = 1.66, RD = 4.14 and RA = 4.84] *Croton caudatus* Geiselar [IVI = 10.01], *Ardisia solanacea* Roxb. [IVI = 8.84], *Phlogacanthus thyrsiformis* (Roxb. *ex* Hardw.) Mabb. [IVI = 8.72], *Ichnocarpus frutescence* (L.) Aiton [IVI = 8.58], *Lygodium flexuosum* (L.) Sw. [IVI = 8.58] etc (Annexure I, Table 91 – 93).

A total of 1013 individuals (including seedlings of trees and shrubs) belonging to 74 species, 71 Genera and 35families were collected from the

herbaceous winter vegetation of natural forest in Sevoke site. A total of 1529 individuals belonging to 83 species, 80 genera and 39 families, and 1926 individuals belonging to 90 species, 88 genera and 44 families, were recorded in Premonsoon and Postmonsoon vegetation of herb layer, respectively (Table 6.8). They included the seedlings of trees and shrubs. In winter highest IVI score was recorded for *Coffea benghalensis* Heyne *ex* Schult. [IVI= 14.06] along with 7.79, 5.33 and 0.94 as recorded values of RF, RD and RA respectively. It was followed by *Mikania micrantha* Kunth. [IVI = 12.73, RF = 0.61, RD = 3.45, RA = 8.36], *Oplismenus burmanni* (Retz.) Beauv. [IVI = 12.23, RF = 4.71, RD = 5.82, RA = 1.69], *Chromolaena odorata* L. [IVI = 10.70, RF = 4.71, RD = 4.63, RA = 1.35], *Pupalia lappacea* (L.) Juss. [IVI = 9.54], *Diplazium esculentum* (Retz.) Sw. [IVI = 9.38], *Synedrella nodiflora* (L.) Gaertn. [IVI = 8.93], *Clerodendrum infortunatum* L. [IVI = 8.49] etc (Annexure I, Table 94).

In Premonsoon and Postmonsoon vegetation also *Coffea benghalensis* was recorded for highest IVI values – 11.77 along with RF = 5.50, RD = 5.10, RA = 1.17 in Premonsoon and 10.15 along with RF = 3.21, RD = 5.09 and RA = 1.85 in Postmonsoon. Other associated species were – *Oplismenus burmanni* (Retz.) Beauv. [IVI = 8.90], *Dryopteris sikkimensis* (Bedd.) Kuntze [IVI = 8.78], *Chromolaena odorata* L. [IVI = 8.73], *Pupalia lappacea* [IVI = 8.70], *Synedrella nodiflora* [IVI = 7.75], *Axonopus compressus* (Sw.) P. Beauv. [IVI = 7.72], *Clerodendrum infortunatum* L. [IVI = 7.23] etc (Annexure I, Table 95). On the other hand in Postmonsoon season, *Coffea benghalensis* Heyne *ex* Schult. was followed by *Chromolaena odorata* L. [IVI = 9.75], *Clerodendrum infortunatum* L. [IVI = 8.25], *Diplazium esculentum* (Retz.) Sw. [IVI = 7.93], *Mikania micrantha* Kunth. [IVI= 7.85], *Synedrella nodiflora* (L.) Gaertn. [IVI = 7.54], *Dryopteris sikkimensis* (Bedd.) Kuntze [IVI = 6.38], *Morinda angustifolia* Roxb. [IVI = 6.05] etc (Annexure I, Table 96). Thus the herbaceous vegetation was almost similar in respect of species composition and dominancy pattern as there was no dominant species in single but a number of species played leading role in the vegetation.

6.2. BIODIVERSITY INDICES

Different biodiversity indices were studied to understand the diversity of plant community of plantation and natural vegetation, in space and time. Species diversity index [Shannon-Weiner index (1963)], Species richness [Menhinick's index (1964)], Concentration of dominance [Simpson's index (1949)] and Sorensen's similarity index (1968) were calculated for measuring species diversity in ecosystem, species richness, measurement of concentration of dominant species and its magnitude and for comparison of natural vegetation with that of different types of plantation in the study area.

6.2.1. Shannon-Weiner index (1963), Menhinick's index (1964) and Simpson's index (1949):

Species diversity index [Shannon -Weiner index (1963)], Species richness [Menhinick's index (1964)] and Concentration of dominance [Simpson's index (1949)] for tree, shrub and herb layers in Natural vegetation of Lataguri, NRVK and Sevoke sites were calculated and has been presented in tables 6.9 – 6.11.

A. Natural vegetation:

I. *Lataguri site:* In Lataguri site for the tree layer of natural vegetation Species diversity index [Shannon-Weiner index (1963)], Concentration of dominance [Simpson's index (1949)] and Species richness [Menhinick's index (1964)] were calculated to 9.48, 0.700 and 0.229, respectively, in winter vegetation, whereas in post monsoon the indices values were determined at 9.689, 0.642 and 0.230. For comparison of different seasonal vegetation average of the index values was calculated. For tree layer of natural vegetation in Lataguri site the average index values were 9.583, 0.671 and 0.229 in the same sequence (Table 6.9). Similarity index between the tree layer in winter and post monsoon seasons were found to be 0.90.

Table 6.9. Different Biodiversity indices of Natural vegetation in Lataguri site

Study site	Vegetation	Sampling season	Shannon-weiner index	Conc of dominance	Menhinick's index
Lataguri	Tree layer	Winter	9.479	0.7	0.229
		Post mon	9.686	0.642	0.23
		Average	9.583	0.671	0.229
	Shrub layer	Winter	16.453	1.9	0.128
		Pre mon	14.713	2.871	0.117
		Post mon	15.884	3.227	0.11
		Average	15.683	2.663	0.118
	Herb layer	Winter	16.124	2.605	0.111
		Pre mon	16.946	3.44	0.108
		Post mon	17.833	3.221	0.097
		Average	16.968	3.089	0.106

Shannon-Weiner index [SWI] for shrub layer was found to be 16.453, 14.713 and 15.884 in winter, Premonsoon and post monsoon seasons respectively and the average value of three seasons was 15.683. Concentration of dominance [CD] was found to be 1.90, 2.871 and 3.227 in winter, Pre-monsoon and post-monsoon season. Menhinick's index [MI] was found as 0.128, 0.117 and 0.110 in winter, Pre-monsoon and post-monsoon periods. Diversity index of herb layer was quite high 16.124 in winter, 16.946 in pre-monsoon and 17.833 in post-monsoon. Menhinick's index for the same layer was higher than the tree and shrub layers. Concentration of dominance was also higher and measured to be 3.089.

II. ***NRVK site:*** In NRVK site, for natural vegetation Shannon -Weiner index for tree, shrub and herb layers were calculated to be 14.409 (14.302 in winter and 14.515 in post-monsoon), 0.553 (0.42 in winter, 1.09 in pre-monsoon and 0.15 in post-monsoon seasons) and 32.432 (29.84 in winter, 29.54 in Pre-monsoon and 37.92 in post-monsoon seasons). So, the herb layer was much more diverse than the tree and shrub layers. Concentration of dominance for the tree, shrub and herb layers was recorded as 3.575, 83.791 and 18.32 respectively. Menhinick's index was calculated to be 3.013, 1.493 and 2.034 for tree, shrub and herb layers respectively (Table 6.10). Thus the natural vegetation of NRVK site was diverse and quite rich.

Table 6.10. Different Biodiversity indices of Natural vegetation in NRVK site

Study Site	Vegetation	Sampling Season	Shannon-Weiner Index	Conc of Dominance	Menhinick's Index
NRVK	Tree Layer	Winter	14.302	3.637	2.981
		Post Mon	14.515	3.512	3.045
		Average	**14.409**	**3.575**	**3.013**
	Shrub Layer	Winter	0.422	67.974	1.523
		Pre Mon	1.087	77.557	1.531
		Post Mon	0.149	105.841	1.454
		Average	**0.553**	**83.791**	**1.493**
	Herb Layer	Winter	29.836	10.456	2.236
		Pre Mon	29.536	19.965	1.953
		Post Mon	37.923	24.54	1.913
		Average	**32.432**	**18.32**	**2.034**

III. ***Sevoke site:*** Species diversity (Shannon-Weiner index) was calculated to be 9.60, 9.02 and 19.71 in tree, shrub and herb layers respectively. Concentration of dominance was found to be 0.53, 16.91 and 7.26 in case of shrub and herb layers in the same sequence. Menhinick's index of species richness was found to be 0.25, 0.07 and 0.058 in case of tree; shrub and herb layer respectively (Table 6.11). So, herb layer was high in species diversity than tree and shrub layers. But species richness was recorded as highest for the tree layer.

Table 6.11. Different Biodiversity indices of Natural vegetation in Sevoke site

Study Site	Vegetation layer	Sampling Season	Shannon-Weiner Index	Conc of Dominance	Menhinick's Index
Sevoke	Tree Layer	Winter	9.504	0.54	0.252
		Post Mon	9.703	0.517	0.252
		Average	**9.604**	**0.529**	**0.252**
	Shrub Layer	Winter	12.085	9.489	0.073
		Pre Mon	10.133	14.126	0.068
		Post Mon	4.836	27.101	0.054
		Average	**9.018**	**16.905**	**0.065**
	Herb Layer	Winter	16.499	5.288	0.073
		Pre Mon	20.147	7.883	0.054
		Post Mon	22.483	8.61	0.047
		Average	**19.71**	**7.26**	**0.058**

B. Plantations: Species diversity index, Species richness and Concentration of dominance for tree, shrub and herb layers of different Plantations in Lataguri, NRVK, Sevoke and Satali (NRVK) sites has been presented in Tables 6.12 – 6.15.

Table 6.12a. Biodiversity indices of Mixed Plantations in Lataguri sites

Plantation	Layer	Season	Shannon-Weiner Index	Concentration of Dominance	Menhinick's Index
Lataguri Mixed Plantation	Tree	Winter	5.184	2.356	0.211
		Post Mon	6.526	1.316	0.237
		Average	**5.855**	**1.836**	**0.224**
	Shrub	Winter	47.455	294.853	0.038
		Pre Mon	34.752	206.337	0.042
		Post Mon	19.092	116.157	0.063
		Average	**33.766**	**205.782**	**0.048**
	Herb	Winter	7.358	1.166	0.242
		Pre Mon	9.674	1.169	0.199
		Post Mon	12.582	1.657	0.143
		Average	**9.871**	**1.331**	**0.195**

Species diversity was higher [SWI=33.77] in shrub layer than the tree layer [SWI=5.86] and herb layer [SWI=9.87] in case of mixed plantation in Lataguri site. Concentrations of dominance for tree, shrub and herb layer were calculated to be 1.836, 205.78 and 1.33 respectively. Menhinick's index of species richness showed lower value for all the tree [0.224], shrubs [0.048] and herb layer [0.195]. But tree layer was a little rich than the shrub and herb layer (Table 6.12a).

Herb layer of Lataguri sal-chilauni plantation was comparatively more diverse than that of shrub and tree layer and the Shannon-Weiner index was calculated to be 10.054, 7.444 and 5.17 for herb, shrub and tree layer respectively. Concentration of dominance (Simpson's index) was found to be 1.165, 7.475 and 26.977 for these three layer in the same frequency Menhinick's index of species richness was found to be 0.20, 0.13 and 0.10 for those three layer in similar fashion (Table 6.12b).

Table 6.12b. Biodiversity indices of Sal-Chilauni Plantations in Lataguri sites

Plantation	Layer	Season	Shannon-Weiner Index	Conc of Dominance	Menhinick's Index
Lataguri Sal-Chilauni	Tree	Winter	6.77	30.742	0.103
		Post Mon	3.57	23.213	0.105
		Average	**5.17**	**26.977**	**0.104**
	Shrub	Winter	5.788	7.429	0.173
		Pre Mon	8.134	7.401	0.105
		Post Mon	8.41	7.594	0.112
		Average	**7.444**	**7.475**	**0.13**
	Herb	Winter	8.208	0.809	0.234
		Pre Mon	8.563	0.697	0.24
		Post Mon	13.392	1.989	0.123
		Average	**10.054**	**1.165**	**0.199**

Table 6.12c. Biodiversity indices of Teak Plantations in Lataguri sites

Plantation	Layer	Season	Shannon-Weiner Index	Conc of Dominance	Menhinick's Index
Lataguri Teak Plantation	Tree	Winter	-8.34	48.47	0.097
		Post Mon	-5.247	41.419	0.097
		Average	**-6.794**	**44.945**	**0.097**
	Shrub	Winter	-14.175	59.48	0.059
		Pre Mon	-17.754	82.081	0.053
		Post Mon	-37.64	184.328	0.033
		Average	**-23.19**	**108.63**	**0.048**
	Herb	Winter	8.055	3.066	0.143
		Pre Mon	10.642	6.231	0.086
		Post Mon	13.622	8.609	0.066
		Average	**10.773**	**5.969**	**0.098**

Species diversity of tree and shrub layer of teak plantation of Lataguri site was very poor having calculated index value of – 6.794 in case of tree layer and – 23.19 in case of shrub layer. But the herb layer was pretty rich having the Shannon-Weiner index value of 10.773. Concentration of dominance was highest in shrub layer [108.63] and was followed by tree layer [44.945] while herb layer showed 5.969 as concentration of dominance value. Menhinick's index of species richness was calculated to be 0.097, 0.048 and 0.098 for tree, shrub and the herb layer in the similar sequence (Table 6.12c).

Species diversity was least [SWI= - 8.494] in shrub layer, moderate in tree layer [SWI= 7.095] and highest in herb layer [SWI= 12.914] of mixed plantation in NRVK site. Concentration of dominance was calculated to be 1.074, 48.978 and 2.972 in case of tree, shrubs and herb layer respectively. Menhinick's index of

species richness was least in shrub layer [MI= 0.056], moderate in herb layer [MI= 0.122] and higher in tree layer [MI= 0.23] (Table 6.13a).

Table 6.13a. Biodiversity indices of different layer of vegetation in NRVK Mixed Plantation

Vegetation Layer	Season	Shannon-Weiner Index	Conc. of Dominance	Menhinick's Index
Tree	Winter	6.991	1.203	0.13
	Post Mon	7.198	0.945	0.144
	Average	**7.095**	**1.074**	**0.137**
Shrub	Winter	-7.127	39.802	0.075
	Pre Mon	-8.05	45.69	0.06
	Post Mon	-10.304	61.441	0.033
	Average	**-8.494**	**48.978**	**0.056**
Herb	Winter	10.236	1.317	0.167
	Pre Mon	13.563	3.629	0.11
	Post Mon	14.942	3.969	0.088
	Average	**12.914**	**2.972**	**0.122**

Table 6.13b. Biodiversity indices of different layer of vegetation in NRVK Teak Plantation

Layer of Vegetation	Season	Shannon-Weiner Index	Conc. of Dominance	Menhinick's Index
Tree	Winter	-5.122	31.092	0.025
	Post Mon	-2.284	22.019	0.029
	Average	**-3.703**	**26.556**	**0.027**
Shrub	Winter	-8.514	38.744	0.018
	Pre Mon	-12.363	55.953	0.019
	Post Mon	-44.002	203.679	0.023
	Average	**-21.626**	**99.459**	**0.021**
Herb	Winter	8.55	2.201	0.124
	Pre Mon	10.144	3.87	0.092
	Post Mon	12.954	4.558	0.073
	Average	**10.549**	**3.543**	**0.097**

Different diversity indices of teak plantation in NRVK site has been represented in table 6.13b. Shannon-Weiner index for shrub layer of teak plantation in NRVK site was found to be very low - 21.626, low in tree layer [SWI= 3.703] and high enough in herb layer [SWI= 10.549]. Concentration of dominance was very high in shrubby layer [99.459] high in tree layer [26.556] and low in herb layer [3.543]. Species richness was calculated very less in shrub layer [MI= 0.021] and tree layer [0.027] and was higher in herb layer [MI= 0.097].

Species diversity in tree and shrub layers of Jarul-Benteak plantation in NRVK site was very low and the SWI was calculated to be -116.911 and -125.319 in respective order. That of the herb layer was little higher and was calculated to 4.722. As expected the concentration of dominance for tree and shrub layers were very high as 1128.90 and 870.372 in tree and shrub layers in the same order. That of

the herb layer was lesser than the tree and shrub layers and was calculated to be 9.987. Menhinick's index of species richness also indicated the poorness of tree [MI=0.225] and shrub [MI=0.076] layers and little bit of richness species in herb layer [MI=0.119] (Table 6.13c).

Table 6.13c. Biodiversity indices of different layer of vegetation in NRVK Jarul-Benteak Plantation

Layer of Vegetation	Season	Shannon-Weiner Index	Conc. of Dominance	Menhinick's Index
Tree	Winter	-131.19	1332.37	0.216
	Post Mon	-102.632	925.43	0.235
	Average	**-116.911**	**1128.9**	**0.225**
Shrub	Winter	-153.963	1131.938	0.092
	Pre Mon	-130.774	914.095	0.076
	Post Mon	-91.22	565.084	0.06
	Average	**-125.319**	**870.372**	**0.076**
Herb	Winter	3.153	8.028	0.171
	Pre Mon	3.723	11.042	0.096
	Post Mon	7.289	10.892	0.089
	Average	**4.722**	**9.987**	**0.119**

Jarul plantation in Sevoke site also showed least species diversity in shrub layer; lower diversity in tree layer but higher diversity in herb layer and that was revealed by the Shannon-Weiner index value of - 2.95, 0.37 and 14.25 in case of shrub, tree and herb layer respectively. Concentration of dominance of the shrub, tree and herb layer was calculated to be 30.85, 14.101 and 4.695 respectively (Table 6.14a). Menhinick's index of species richness was found to be least in shrub layer [MI=0.07] low in herb layer [MI=0.90] and higher in tree layer [MI=0.16].

Table 6.14a. Different Biodiversity indices of Jarul Plantations in Sevoke sites

Plantation	Layer of Vegetation	Season	Shannon-Weiner Index	Conc. of Dominance	Menhinick's Index
Sevoke Jarul	Tree	Winter	-0.55	16.058	0.156
		Post Mon	1.289	12.154	0.166
		Average	**0.37**	**14.106**	**0.161**
	Shrub	Winter	-4.018	28.568	0.077
		Pre Mon	-2.897	31.581	0.063
		Post Mon	-1.936	32.402	0.057
		Average	**-2.95**	**30.85**	**0.066**
	Herb	Winter	10.847	2.059	0.14
		Pre Mon	14.676	4.869	0.079
		Post Mon	17.236	7.157	0.06
		Average	**14.253**	**4.695**	**0.093**

Similar trend was found in teak plantation in Sevoke site regarding the species diversity i.e. least diverse shrub layer [SWI= - 6.619], less diverse tree layer [SWI= -3.149] and higher diversity in herb layer [SWI=11.895] and that was supported by the highest concentration of dominance in tree layer [27.869] and least concentration of dominance in herb layer [4.042]. Species richness [Menhinick's index] was least in shrub layer [MI=0.062] and higher in tree layer [MI=0.125] and in herb layer it was calculated to be 0.111. (Table 6.14b)

Table 6.14b. Different Biodiversity indices of Teak Plantations in Sevoke sites

Plantation	Layer of Vegetation	Season	Shannon-Weiner Index	Conc. of Dominance	Menhinick's Index
Teak (Sevoke)	Tree	Winter	-4.526	32.262	0.12
		Post Mon	-1.771	23.476	0.131
		Average	**-3.149**	**27.869**	**0.125**
	Shrub	Winter	-2.19	23.73	0.084
		Pre Mon	-8.062	46.031	0.059
		Post Mon	-9.605	61.839	0.044
		Average	**-6.619**	**43.867**	**0.062**
	Herb	Winter	9.732	1.555	0.165
		Pre Mon	12.175	5.016	0.088
		Post Mon	13.779	5.556	0.079
		Average	**11.895**	**4.042**	**0.111**

Species diversity was least in shrub layer of Jarul plantation in Satali and was calculated to be -14.78. It was lower in tree layer also [SWI= - 6.324]. But the herb layer was little rich having Shannon-Weiner Index value of 6.55 and concentration of dominance was calculated to be very high [76.20] in shrub layer, high in tree layer [33.351] and low in herb layer [7.736]. Menhinick's index of species richness also was very lesser in shrub layer having calculated value of 0.064. In tree and herb layer species richness was calculated to be 0.108 and 0.101 respectively (Table 6.15)

Table 6.15. Different Biodiversity indices of Jarul Plantations in Satali area

Plantation	Layer of Vegetation	Sampling Season	Shannon-Weiner Index	Conc. of Dominance	Menhinick 's Index
Jarul (Satali)	Tree	Winter	-6.324	33.506	0.11
		Post Mon	-6.324	33.195	0.107
		Average	**-6.324**	**33.351**	**0.108**
	Shrub	Winter	-14.516	69.252	0.081
		Pre Mon	-17.029	87.487	0.058
		Post Mon	-12.803	71.862	0.055
		Average	**-14.783**	**76.20**	**0.064**
	Herb	Winter	5.408	5.144	0.134
		Pre Mon	5.886	8.113	0.096
		Post Mon	8.356	9.95	0.073
		Average	**6.55**	**7.736**	**0.101**

6.2.2. Similarity index: Similarity index between different seasonal vegetations (layer wise) in natural vegetation and plantations were calculated and has been represented in Table 6.16 – 6.18.

A. *Natural Vegetation*: In case of natural vegetation, tree layer in winter and post-monsoon season was almost similar in all the three sites (Lataguri, Sevoke and NRVK) and similarity index (Sorensen similarity index) was calculated to be 0.901, 0.983 and 0.944 in Lataguri, NRVK and Sevoke site respectively. Shrub layer of natural vegetation in Lataguri site was almost similar in winter and Pre monsoon season and Sorensen index was calculated to be 0.822 (Table 6.16).

Table 6.16. Similarity index between different seasonal vegetations (layer wise) in Natural forest in Lataguri site

SITE	Layer	Similarity Index Between	Similarity Index
Lataguri	Tree Layer	Tree-Win & Tree- Postmonsoon	0.901
	Shrub layer	Shrub-Win & Shrub-Premonsoon	0.822
		Shrub-Premon & Shrub-Postmonsoon	0.624
		Shrub-Win & Shrub-Postmonsoon	0.597
	Herb layer	Herbs-Win & Herbs-Premonsoon	0.519
		Herbs-Pre & Herbs - Postmonsoon	0.610
		Herbs-Win & Herbs-Postmonsoon	0.490

Similarity index between the shrubs layer in Pre monsoon and Post monsoon season was calculated to be 0.624 while the index value was found to be 0.597 in between winter and Post monsoon shrub layer. In Lataguri site similarity index of herb layers in different seasons was found to be 0.519, 0.610 and 0.490 for herb layer in winter and Pre monsoon; Pre monsoon and Post monsoon herb layer; and winter and Post monsoon herb layer respectively.

In NRVK site also, shrub layer in different seasons was very similar having index value of 0.702, 0.779 and 0.710 for winter and Pre monsoon vegetation; Pre monsoon and Post monsoon vegetation of shrubs; and winter and Post monsoon shrub layer respectively. Index value for herb layer in winter and Pre monsoon; Pre monsoon and Post monsoon; and winter and Post monsoon, were calculated to be 0.677, 0.694 and 0.793 respectively (Table 6.17).

Table 6.17. Similarity index between different seasonal vegetations (layer wise) in Natural forest in NRVK site

SITE	Layer	Similarity Index Between	Similarity Index
NRVK	Tree Layer	*Tree-Win & Tree- Postmonsoon*	0.983
	Shrub layer	Shrub-Win & Shrub-Premonsoon	0.702
		Shrub-Premon & Shrub-Postmon	0.779
		Shrub-Win & Shrub-Postmonsoon	0.710
	Herb layer	Herbs-Win & Herbs-Premonsoon	0.677
		Herbs-Pre & Herbs - Postmonsoon	0.694
		Herbs-Win & Herbs-Postmonsoon	0.793

In Sevoke site, shrub layer in winter and pre monsoon season are similar by 46% and is revealed by calculated index value of 0.46. In case of shrub layer in pre monsoon and post monsoon, Sorensen's index of similarity was found to be 0.595 and 0.587 for the vegetation in winter and post monsoon season. In case of herb layer Sorensen's index was calculated to be 0.943, 0.659 and 0.598 for herb layer in winter and pre monsoon vegetation; Pre monsoon and Post monsoon vegetation; and winter and Post monsoon vegetation in respective order (Table 6.18).

Table 6.18. Similarity index between different seasonal vegetations (layer wise) in Natural forest in Sevoke site

SITE	Layer	Similarity Index Between	Similariry Index
Sevoke	Tree Layer	Tree-Win & Tree- Postmonsoon	0.944
	Shrub layer	Shrub-Win & Shrub-Premonsoon	0.460
		Shrub-Premon & Shrub-Postmonsoon	0.595
		Shrub-Win & Shrub-Postmonsoon	0.587
	Herb layer	Herbs-Win & Herbs-Premonsoon	0.943
		Herbs-Pre & Herbs - Postmonsoon	0.659
		Herbs-Win & Herbs-Postmonsoon	0.598

B. *Plantation*: In plantation also, the similarity index between tree layer in winter and tree layer in post monsoon season, for all plantations in all the three sites were calculated above 0.81 i.e. they are similar by 81% or more (Tables 6.19 – 6.22). Shrub layer was different to some extent in some cases like shrub layer in Pre monsoon and Post monsoon season in teak plantation in NRVK site having the calculated index value of 0.459 (Table 6.19a).

Table 6.19a. Similarity index between different seasonal vegetations (layer wise) in teak plantations in NRVK

Plantation	Vegetation Layer	Similarity Index Between	Similarity Index
Teak Plantation	Tree	Tree-Win & Tree- Postmonsoon	0.917
	Shrubs	Shrub-Win & Shrub-Premonsoon	0.727
		Shrub-Premonsoon & Shrub-Postmonsoon	0.459
		Shrub-Win & Shrub-Postmonsoon	0.552
	Herbs	Herbs-Win & Herbs-Premonsoon	0.585
		Herbs-Pre & Herbs - Postmonsoon	0.624
		Herbs-Win & Herbs-Postmonsoon	0.652

Similarly index value of shrub layer of winter and Post monsoon season was found to be 0.464 in Jarul Benteak plantation (Table 6.19b). But the index values were higher in case of other vegetations and it ranges from 0.63 to 0.93 in case of Pre monsoon and Post monsoon shrub layer; from 0.48 to 0.86 in case of winter and post monsoon shrub layer; and from 0.69 to 0.93 in case of winter and pre monsoon shrub layer. Similarity index value in between Pre monsoon herb layer and Post

monsoon herb layer ranges from 0.44 to 0.90 in all the three sites. That of winter herb and Post monsoon herb layer ranges from 0.40 to 0.86; and from 0.59 to 0.89 in case of winter herb and pre monsoon herb.

Table 6.19b. Similarity index between different seasonal vegetations (layer wise) in Jarul-Benteak plantation in NRVK

Plantation	Vegetation Layer	Similarity Index Between	Similarity Index
Jarul-Benteak	Tree	Tree-Win & Tree- Postmonsoon	0.818
	Shrubs	Shrub-Win & Shrub-Premonsoon	0.737
		Shrub-Premonsoon & Shrub-Postmonsoon	0.7697
		Shrub-Win & Shrub-Postmonsoon	0.4647
	Herbs	Herbs-Win & Herbs-Premonsoon	0.731
		Herbs-Pre & Herbs - Postmonsoon	0.849
		Herbs-Win & Herbs-Postmonsoon	0.667

Table 6.19c. Similarity index between different seasonal vegetations (layer wise) in mixed plantation in NRVK

Plantation	Vegetation Layer	Similarity Index Between	Similarity Index
Mixed Plantation	Tree	Tree-Win & Tree- Postmonsoon	0.897
	Shrubs	Shrub-Win & Shrub-Premonsoon	0.933
		Shrub-Premonsoon & Shrub-Postmonsoon	0.928
		Shrub-Win & Shrub-Postmonsoon	0.863
	Herbs	Herbs-Win & Herbs-Premonsoon	0.897
		Herbs-Pre & Herbs - Postmonsoon	0.908
		Herbs-Win & Herbs-Postmonsoon	0.86

Table 6.20a. Similarity index between different seasonal vegetations (layer wise) in Teak plantations in Lataguri site

Plantation	Layer	Similarity Index Between	Similarity Index
Teak Plantation	Tree	Tree-Win & Tree- Postmonsoon	0.95
	Shrubs	Shrub-Win & Shrub-Premonsoon	0.704
		Shrub-Premons & Shrub-Postmon	0.625
		Shrub-Win & Shrub-Postmonsoon	0.483
	Herbs	Herbs-Win & Herbs-Premonsoon	0.585
		Herbs-Pre & Herbs - Postmonsoon	0.442
		Herbs-Win & Herbs-Postmonsoon	0.396

Table 6.20b. Similarity index between different seasonal vegetations (layer wise) in Mixed plantations in Lataguri site

Plantation	Layer	Similarity Index Between	Similarity Index
Mixed Plantation	Tree	Tree-Win & Tree- Postmonsoon	0.842
	Shrubs	Shrub-Win & Shrub-Premonsoon	0.857
		Shrub-Premon & Shrub-Postmonsoon	0.794
		Shrub-Win & Shrub-Postmonsoon	0.655
	Herbs	Herbs-Win & Herbs-Premonsoon	0.835
		Herbs-Pre & Herbs - Postmonsoon	0.828
		Herbs-Win & Herbs-Postmonsoon	0.771

Table 6.20c. Similarity index between different seasonal vegetations (layer wise) in Sal-Chilauni plantations in Lataguri site

Plantation	Layer	Similarity Index Between	Similarity Index
Sal-Chilauni Plantation	Tree	Tree-Win & Tree- Postmonsoon	0.849
	Shrubs	Shrub-Win & Shrub-Premonsoon	0.8
		Shrub-Premon & Shrub-Postmon	0.919
		Shrub-Win & Shrub-Postmonsoon	0.767
	Herbs	Herbs-Win & Herbs-Premonsoon	0.791
		Herbs-Pre & Herbs - Postmonsoon	0.857
		Herbs-Win & Herbs-Postmonsoon	0.78

Table 6.21. Similarity index between different seasonal vegetations (layer wise) of plantations in Sevoke

Plantation	Layer	Similarity Index Between	Similarity Index
Jarul Plantation	Tree	Tree-Win & Tree- Postmonsoon	0.863
	Shrubs	Shrub-Win & Shrub-Premonsoon	0.896
		Shrub-Premonsoon & Shrub-Postmonsoon	0.909
		Shrub-Win & Shrub-Postmonsoon	0.806
	Herbs	Herbs-Win & Herbs-Premonsoon	0.896
		Herbs-Pre & Herbs - Postmonsoon	0.903
		Herbs-Win & Herbs-Postmonsoon	0.838
Teak Plantation	Tree	Tree-Win & Tree- Postmonsoon	0.889
	Shrubs	Shrub-Win & Shrub-Premonsoon	0.693
		Shrub-Premonsoon & Shrub-Postmonsoon	0.897
		Shrub-Win & Shrub-Postmonsoon	0.7
	Herbs	Herbs-Win & Herbs-Premonsoon	0.879
		Herbs-Pre & Herbs - Postmonsoon	0.811
		Herbs-Win & Herbs-Postmonsoon	0.747

Table 6.22. Similarity index between different seasonal vegetations (layer wise) of Jarul plantation in Satali

Plantation	Layer	Similarity Index Between	Similarity Index
Jarul Plantation	Tree	Tree-Win & Tree- Postmonsoon	0.96
	Shrubs	Shrub-Win & Shrub-Premonsoon	0.857
		Shrub-Premonsoon & Shrub-Postmonsoon	0.898
		Shrub-Win & Shrub-Postmonsoon	0.8
	Herbs	Herbs-Win & Herbs-Premonsoon	0.767
		Herbs-Pre & Herbs - Postmonsoon	0.849
		Herbs-Win & Herbs-Postmonsoon	0.783

Table 6.23. Similarity index between different plantation and natural vegetations (layer wise and seasonal) Lataguri site

Site	Between	Layer	Similarity Index Value in		
			Winter	Pre Monsoon	Post Monsoon
Lataguri	Natural Veg & Teak Plantation	Tree	0.169	-	0.227
		Shrub	0.146	0.217	0.195
		Herb	0.268	0.321	0.308
	Natural Veg & Sal-Chilauni Plantation	Tree	0.228	-	0.282
		Shrub	0.248	0.297	0.305
		Herb	0.323	0.246	0.320
	Natural Veg & Mixed Plantn Plantation	Tree	0.244	-	0.327
		Shrub	0.201	0.209	0.203
		Herb	0.325	0.303	0.286
NRVK	Natural Veg & Teak Plantation	Tree	0.234	-	0.171
		Shrub	0.055	0.137	0.322
		Herb	0.321	0.271	0.348
	Natural Veg & Jarul Benteak Plantation	Tree	0.102	-	0.117
		Shrub	0.190	0.161	0.298
		Herb	0.178	0.233	0.278
	Natural Veg &Mixed Plantation	Tree	0.261	-	0.311
		Shrub	0.342	0.284	0.419
		Herb	0.310	0.284	0.355
Sevoke	Natural Veg & Teak Plantation	Tree	0.362	-	0.412
		Shrub	0.238	0.389	0.459
		Herb	0.448	0.470	0.579
	Natural Veg & Jarul Plantation	Tree	0.304	-	0.356
		Shrub	0.286	0.407	0.427
		Herb	0.339	0.341	0.500
Satali	Natural Veg & Jarul Plantation	Tree	0.160	-	0.154
		Shrub	0.204	0.161	0.277
		Herb	0.238	0.253	0.303

In Lataguri site similarity indices of tree, shrub and herb layers of natural vegetation and teak plantation were calculated to be 0.235, 0.239 and 0.371 in respective order (Table 6.23). Thus all the three layers i.e. tree, shrub and herb layer of teak differ significantly from that of the natural vegetation and the herb layer is much more different.

In case of Sal-Chilauni plantation also tree, shrub and herb layers differed from the tree, shrub and herb layer of natural vegetation and that was revealed by lower value of Sorensen's index – 0.244, 0.352, 0.335 in respective order. But the mixed plantation showed greater similarity of its tree layer with that of natural vegetation [SI = 0.794], moderate similarity with herb layer [SI= 0.490] and lesser similarity with the shrub layer [SI= 0.342].

In NRVK site tree and shrub layer of teak plantation showed least similarity with that of the natural vegetation and was clear from the Sorensen's index value of 0.231 and 0.311 in respective order. On the other hand herb layer of teak plantation was near to moderately similar [SI = 0.410]. Jarul Benteak plantation showed very dissimilarity in all its 3 layers i.e. tree, shrubs and herb layers with that of natural vegetation and the calculated index values were found to be 0.12, 0.258 and 0.247, in case of tree, shrub and herb layer in respective order. Same type of trend was found in case of mixed plantation and the index values were calculated to be 0.283, 0.342 and 0.332 for tree, shrub and herb layer in the same sequence.

In Sevoke site tree layer of teak plantation was different from that of the natural vegetation [SI = 0.338]; shrub layer was also different [SI = 0.40]. But the herb layer showed moderate similarity [SI = 0.502]. Jarul plantation also showed the differences in the tree shrub and herb layers with the calculated index value of 0.349, 0.356 and 0.427 in respective order. But the difference in herb layer was lesser than other two layers. Tree, shrubs and herb layers of Jarul plantation in Satali site under NRVK region, showed the dissimilarity with that of the natural vegetation and that was evident from lesser value of Sorensen's index – 0.16, 0.254 and 0.272 in case of tree, shrub and herb layer in the same order. Seasonal variation of the similarity index was also calculated between the natural vegetation and plantations and is represented in Table 6.24.

Table 6.24. Sorensen's Similarity index between Natural forests and different Plantations (Layer wise)

Site	Similarity Index Between	Sorensen's Similarity Index		
		Tree Layer	Shrub Layer	Herb Layer
Lataguri	Natural Veg & Teak Plantation	0.2353	0.2390	0.3714
	Natural Veg & Sal-Chilauni Plantation	0.2449	0.3529	0.3357
	Natural Veg & Mixed Plantation	0.7949	0.3421	0.4908
NRVK	Natural Veg & Teak Plantation	0.2316	0.3118	0.4106
	Natural Veg & Jarul Benteak	0.1200	0.2588	0.2479
	Natural Veg & Mixed Plantation	0.2833	0.3429	0.3320
Sevoke	Natural Veg & Teak Plantation	0.3883	0.4064	0.5024
	Natural Veg & Jarul Plantation	0.3495	0.3563	0.4272
Satali	Natural Veg & Jarul Plantation	0.1600	0.2545	0.2723

6.3. IMPACT OF AGGRESSIVE WEEDS

The study area was invaded by a number of aggressive and exotic weeds. *Parthenium hysterophorus* L., *Lantana camara* L., *Mimosa invisa* Colla, *Tithonia diversifolia* (Hemsl.) A. Gray, *Ageratum houstonianum* Mill. Etc. are some of the important weeds of exotic origin and having strong aggressiveness. For the present study, *P. hysterophorus*, *L. camara*, *M. invisa*, *A. houstonianum* and *T. diversifolia* were considered to be assessed for their impact on local flora and vegetation. Some areas in Terai region mainly in Sukna, Salbari, Simulbari and adjoining areas were intensively invaded by these weeds. Side by side a patch of vegetation that was not invaded by them was detected through visual observation. Those non-invaded areas were considered to be the native land use pattern. A total 50 quadrates of 5 × 5 m size were laid out for the shrubby species [e.g. *Mimosa invisa*]. Out of those 50 quadrates, 25 were studied in invaded area and other 25 quadrates were laid out on non-invaded areas. Each of the 5 × 5 m quadrates contained two 1 × 1 m quadrates in its opposite corner to study the herbaceous species as well as the seedlings of shrubby species. Thus a total 100 quadrates of 1 × 1 m size were studied for the assessment of impact of exotic weeds [*M. invisa*, *T. diversifola* and *L. camara*]. On the other hand for *Parthenium hysterophorus* also a total 100 quadrates (1 × 1 m) were laid out, – 50 of those are in invaded areas and the other 50 quadrates in non-invaded areas. Phytosociological parameters for these weed was represented in tabular form (Annexure IIA, Table 1 – 6).

In the present study from a total of 813 individuals belonging to 62 species, 61 genera and 27 families were recorded from the shrub layer of non-invaded area which was considered to be the native type of vegetation. From the herb layer of non-invaded areas, a total of 1393 individuals belonging to 87 species, 81 genera and 39 families were recorded. But in case of invaded areas, a total of 915 individuals belonging to 46 species, 46 genera and 21 families; and 1485 individuals belonging to 71 species, 66 genera and 34 families, were recorded from shrub and herb layers respectively (Figure 6.3.1).

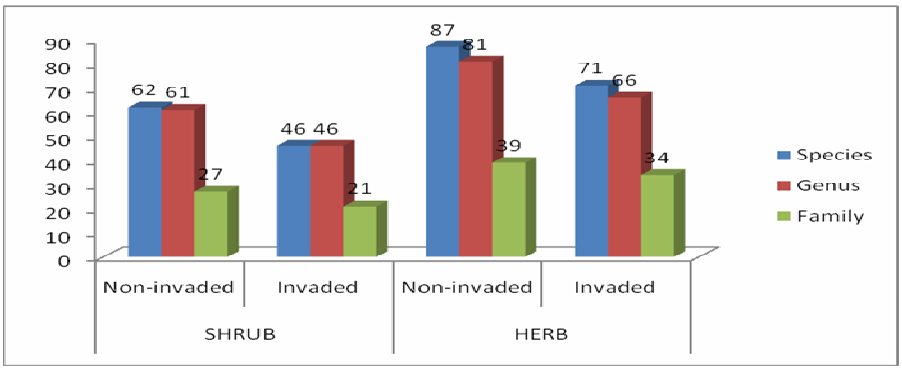

Figure 6.3.1: Number of different taxa in weed-invaded and non-invaded area

Leguminosae was recorded for highest number of 9 species in invaded areas and was followed by Lamiaceae (6 spp.), Acanthaceae (3 spp.), Compositae (3 spp.), Phyllanthaceae (3 spp.) Malvaceae (3 spp.) etc in shrub layer. In herb layer, Compositae presented highest number of 7 species and was followed by Lamiaceae (5 spp.), Leguminosae (5 spp.), Malvaceae (4 spp.) Poaceae (4 spp.) etc. In shrub layer of non-invaded areas, Leguminosae was recorded for highest number of 8 species. Other families with higher number of species were Malvaceae with 7 species, Lamiaceae with 6 species, Apocynaceae and Euphorbiaceae each with 4 species; Acanthaceae, Phyllanthaceae and Rubiaceae each with 3 species, etc. As in herb layer of invaded areas, Asteraceae was recorded for presenting maximum number of species (7 species) in case of herb layer of non-invaded areas. Other families with higher number of species were Lamiaceae (6 spp.), Leguminosae, Malvaceae and Poaceae each with 5 species, Rubiaceae (4 spp.), etc.

Picture of shrub layer: In shrub layer of non-invaded areas or control site, highest value of IVI was recorded for *Clerodendrum infortunatum* L. having an index value of 29.69 along with Relative Frequency [RF] of 5.246, Relative Density [RD] of 16.851 and Relative Abundance [RA] of 7.592. Other species with high IVI score were include *Coffea benghalensis* [IVI = 25.318; RF = 4.012; RD = 13.41; RA = 7.898], *Triumfetta rhomboidea* [IVI = 20.12; RF = 4.320; RD = 10.209; RA = 5.585], *Urena lobata* [IVI = 18.21; RF = 4.32; RD = 8.98; RA = 4.91], *Mikania micrantha* [IVI=16.74; RF=5.86; RD=7.75; RA=3.12], *Tabernaemontana divaricata* [IVI = 9.14; RF= 3.70; RD= 3.32; RA= 2.12], *Marraya paniculata* [IVI= 7.56], *Dendrocnide sinuata* [IVI=7.36] (Annexure IIA, Table 1). Thus *C. benghalensis* was turned out to be the most dominant species. But, the magnitude of dominancy was not so prominent (Figure 6.3.2) and was evident from more or less equal IVI of about 5 species.

Thus it can also be inferred that the vegetation was not truly dominated by a single species but with a number of species. So, the shrub layer in non-invaded areas showed heterogeneous mixture of a number of species those play important role in the vegetation.

On the other hand, in shrub layer of invaded area highest value of IVI was recorded for *Mimosa invisa* to be 61.43 [RF = 8.71; RD = 35.74; RA = 16.97]. Other species with higher IVI score were *Lantana camara* [IVI = 28.83; RF = 5.81; RD =13.44; RA = 9.58], *Mikania micrantha* [IVI = 24.35; RF = 8.71; RD = 10.60; RA = 5.04], *Clerodendrum infortunatum* [IVI = 16.65], *Chromolaena odorata* [IVI = 13.78] *Tithonia diversifolia* [IVI = 13.52], *Coffea benghalensis* [IVI = 13.48], *Argyreia roxburghii* [IVI = 10.42], *Tabernaemontana divaricata* [IVI = 8.38] etc.

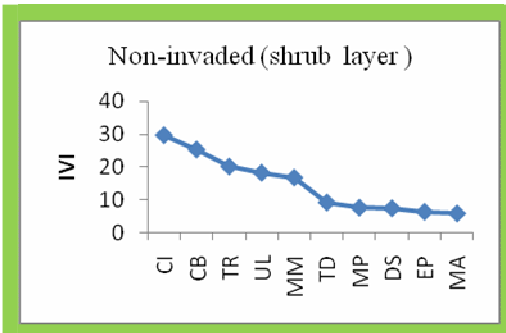

Figure 6.3.2. IVI scores of top ten species in non-invaded shrub layer

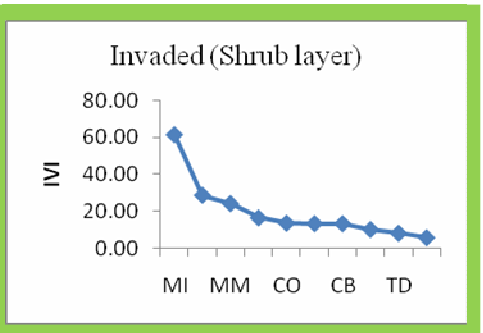

Figure 6.3.3. IVI scores of top ten species in invaded shrub layer

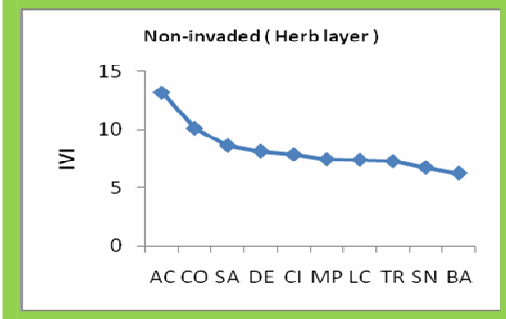

Figure 6.3.4. IVI scores of top ten species in non-invaded herb layer

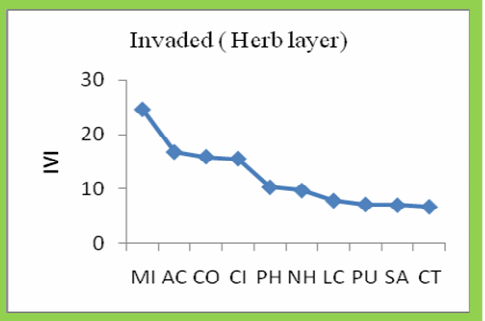

Figure 6.3.5. IVI scores of top ten species in invaded herb layer

Thus the vegetation was dominated by *M. invisa* and the magnitude of dominancy was much more than any other shrubby species (Figure 6.3.3) in the vegetation as presented in Annexure IIA, Table 2. Not only that the second dominant species [*Lantana camara*] is also a well-known invasive weed. Another aggressive weed *Tithonia diversifolia* was also on the higher side of IVI score and dominance pattern and it replaced most of the native species from their own habitat in the invaded areas.

Picture of herb layer: In herb layer of non-invaded areas, *Ageratum conyzoides* was recorded for its highest IVI score of 13.21 along with highest relative density (RD = 6.21), RF of 1.03 and RA of 5.97. It was followed by *Chromolaena odorata* [IVI = 10.12; RF = 1.29; RD = 5.00; RA = 3.84], *Sida acuta* [IVI = 8.63; RF = 0.26; RD = 1.73; RA = 6.43], *Diplazium esculentum* [IVI = 8.15; RF = 1.80; RD = 4.1; RA = 2.25], *Clerodendrum infortunatum* [IVI = 7.85], *Mimosa pudica* [IVI = 7.44], *Lantana camara* [IVI = 7.39], etc. (Annexure IIA, Table 3).

On the other hand, in the invaded area, highest value of IVI was found for *Mimosa invisa* seedlings [IVI=24.60], which actually forms an almost continuous mat, along with RF of 6.60, RD of 14.34 and RA of 3.65. *Ageratum conyzoides*, *Chromolaena odorata* and *Clerodendrum infortunatum* together formed a group of co-dominant species having IVI scores of 16.81, 15.93 and 15.57 in respectively. But, the difference in IVI score of dominant species and co-dominant group of species was quite broad. Other species having higher IVI score were *Parthenium hysterophorus*

[IVI = 10.35], *Natsiatum herpeticum* [IVI = 9.74], *Lantana camara* [IVI = 7.89], *Mimosa pudica* [IVI = 7.18], etc. (Annexure IIA, Table 4). Thus the herb layer also in invaded areas, was homogeneous type of vegetation with *Mimosa invisa* as dominant species. Dominance diversity curve of top ten species (based on IVI scores) of both non-invaded and invaded areas are presented in Figure 6.3.4 and 6.3.5 respectively.

Diversity indices: Species diversity index (Shannon-Weiner index) for shrub layer was calculated to -10.48 and 8.03 for invaded and non-invaded tracts of vegetation respectively. Concentrations of dominance of these 2 types of vegetation were recorded to be 67.10 and 13.14 in the same order. Thus high species diversity and lower dominance was found in non-invaded areas. Whereas the situation was just reverse in invaded areas, i.e. lower diversity and higher concentration of dominance (Figure 6.3.6). This was further supported by lower value of Menhinick's index of species richness, MI = 0.05, for invaded areas that indicated the poor species richness in invaded area. In case of non-invaded area the species richness index was calculated to a higher value of MI = 0.076 than that of invaded area. Similarity index of Sorensen was also calculated between these two vegetation tracts to 0.70. The vegetation in both the invaded and non-invaded areas was more of less similar in respect of species composition but differ in dominance pattern and species diversity.

For herb layer of invaded and non-invaded areas, species diversity was calculated to be 10.46 and 19.99 respectively. It indicated the less diverse vegetation of invaded areas than the non invaded one; and was further supported by the high concentration of dominance (22.50) in invaded areas than the lower value (6.36) of concentration of dominance in non-invaded site. Higher Menhinick's index value also was found in case of non-invaded areas. Similarity index of these two vegetations was found to be 0.87.]

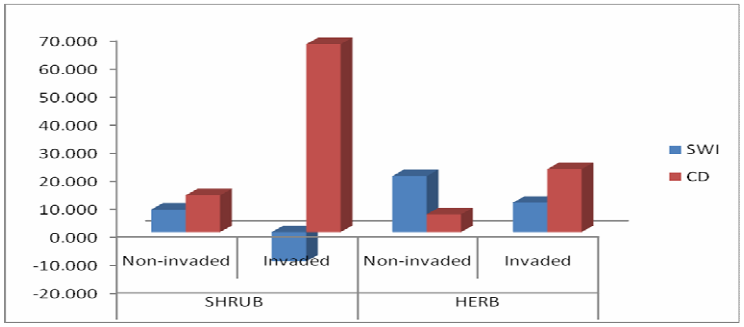

Figure 6.3.6. Shannon-Weiner Index [SWI] and Concentration of Dominance [CD] of shrub and herb layer in innvaded and non-invaded vegetation.

Impact of Parthenium hysterophorus: A total of 1408 individuals belonging to 63 species, 57 genera and 24 families were recorded from *Parthenium* invaded areas; and from non-invaded areas total 1519 individuals belonging to 76 species, 68 genera and 30 families were recorded. Highest number of species was recorded for Compositae

(15 species) from areas not invaded by *Parthenium*, and was followed byPoaceae and Rubiaceae with 6 species each, Amaranthaceae with 5 species, Euphorbiaceae with 4 species and others. In case of *Parthenium* invaded areas also, Asteraceae was represented with highest number of species (15 species), and it was followed by Amaranthaceae (5 spp.) Rubiaceae (5 spp.), Euphorbiaceae (4 spp.), Poaceae (4 spp.), Lamiaceae (3 spp.) and others.

In non-invaded areas *Axonopus compressus* was found to have highest score of IVI = 11.66 [RF of 3.65, RD of 5.86 and RA of 2.15] and was followed by *Senna tora* having IVI of 10.37 [RF = 3.93, RD = 4.81, RA = 1.64], *Amaranthus viridis* [IVI = 9.31], *Ageratum houstonianum* [IVI = 8.31], *Chromolaena odorata* [IVI = 7.32], *Chrysopogon aciculatus* [IVI = 7.20], etc. (Annexure IIA, Table 5).

Thus there was no single dominant species but a group of species formed the main component of the vegetation in herb layer of non-invaded areas. On the other hand, in case of invaded areas *P. hysterophorus* was found to have highest score of IVI [43.26] along with RF of 7.12, RD of 28.20 and RA of 7.95 and so was the dominant species (Annexure IIA, Table 6). IVI score of *P. hysterophorus* was found to be 4 times of the following species, *Axonopus compressus* [IVI = 11.48, RF = 4.69, RD = 4.76, RA = 2.03]. Other species with higher IVI values were *Senna tora* [IVI = 1072], *Ageratum houstonianum* [IVI = 7.18], *Chromolaena odorata* [IVI = 6.88], *Kyllinga nemoralis* [IVI = 6.82], etc. Thus *A. compressus* and S. *tora* are recognized as co-dominants. Herbaceous vegetation in *Parthenium* invaded areas was of quite uniform type. Both the invaded and non-invaded areas showed similar type of IVI score for co-dominant species but in invaded areas *Parthenium* was densely populated. It was further explained by the dominance diversity curve for top ten species for both, the non-invaded and invaded areas (Figures 6.3.7 & 6.3.8).

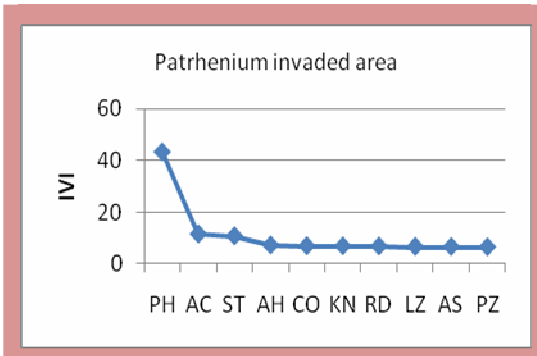

Figure 6.3.7. Dominance diversity curve of Top ten species in *Parthenium* invaded area

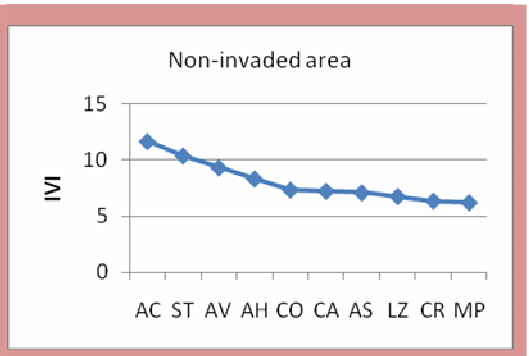

Figure 6.3.8. Dominance diversity curve of Top ten species in *non*-invaded area

Diversity indices: different diversity indices were calculated for *Parthenium* invaded and non-invaded areas. *Parthenium* invaded area was poor in species diversity whereas the non-invaded area was found to be rich enough and was evident by species diversity or Shannon-Weiner index value of 6.26 and 21.34 in invaded and non-invaded areas respectively. Concentration of dominance for invaded areas was quite high (46.31) indicating the dominance of a single species [*P. hysterophorus*]. On the other hand, for non-invaded areas it was found to be much less, only 8.72, which express that the vegetation was a heterogeneous assemblage and with no single species dominating the vegetation. Species richness of the invaded area was calculated to be lesser 0.045 and it is higher for the non-invaded area (0.080). Similarity index of these two vegetations i.e. *Parthenium* invaded and non-invaded areas was calculated to be 0.906. So they were quite similar in respect of species composition but widely differ in dominance pattern.

6.4. ABOVE GROUND HERBACEOUS BIOMASS PRODUCTION

Biomass is an important parameter to understand the functional aspects of an ecosystem (Cornet, 1981) and it also helps to understand the physical and chemical attributes of the soil. Above ground biomass is a useful measure for assessing changes in forest structure (Brown *et al*. 1989). Estimation of biomass is a crucial aspect for comparing the primary productivity of natural vegetation with that of planted forest. Above ground herbaceous biomass (AGHB) production under different tree plantations and natural forest in Terai–Duars belt of West Bengal was measured in the present study and recorded significant differences in AGHB production under plantations and natural vegetation. In Terai region, natural vegetation which was regarded as the native landuse pattern, produced 2800.32 g/m^2 of above ground herbaceous biomass of which 1080.16 g/m^2 (38.57 %) was living biomass and 1720.16 g/m^2 (61.43 %) was litter part whereas in teak plantation AGHB production was less and measured at 1737.60 g/m^2 that was the sum of 545.60 g/m^2 (31.40 %) and 1192 g/m^2 (68.60 %) of living and litter part of biomass respectively. Production of AGHB was 37.20 % lesser in teak plantation than the natural vegetation in *Sevoke* site of Terai region (Table 6.25).

Table 6.25. Above ground herbaceous biomass production in Sevoke site.

Vegetation	Season	Dry Mass (g/m^2)			Dry Mass %			Difference
		Living	Litter	Total	Living	Litter	Total	
Natural	Winter	191.68	554.4	746.08	25.69	74.31	26.64	48.62
	Pre Mon	340.8	531.2	872	39.08	60.92	31.14	21.83
	Post Mon	547.68	634.56	1182.24	46.33	53.67	42.22	7.35
	Annual	**1080.16**	**1720.16**	**2800.32**	**38.57**	**61.43**	**100**	**22.85**
Teak Planttion	Winter	65.6	208	273.6	23.98	76.02	15.75	52.05
	Pre Mon	184	484.8	668.8	27.51	72.49	38.49	44.98
	Post Mon	296	499.2	795.2	37.22	62.78	45.76	25.55
	Annual	**545.6**	**1192**	**1737.6**	**31.4**	**68.6**	**100**	**37.2**

Seasonal variations of biomass (AGHB) production were notable for both, in plantation and natural vegetation. Maximum amount of biomass was harvested during the post-monsoon period measuring 1182.24 g/m^2 in natural vegetation and 795.20 g/m^2 in teak plantation that presented 42.22 % and 45.76 % of the annual biomass production respectively. Lowest percent of AGHB was found to be produced during the winter season at 746.08 g/m^2 and 273.60 g/m^2 amounting 26.64 % and 15.77 % of the total annual production in natural vegetation and teak plantation correspondingly (Figures 6.4.1 & 6.4.2).

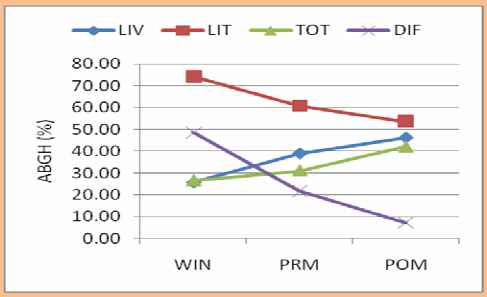

Figure 6.4.1. Seasonal variation in living and litter part of AGHB under natural vegetation in sevoke site.

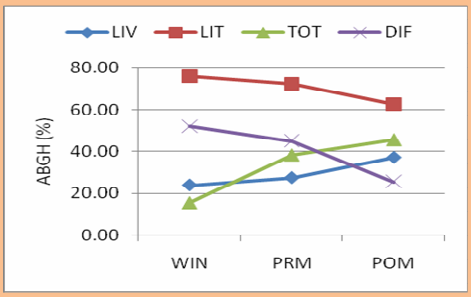

Figure 6.4.2. Seasonal variation in the living and litter part of AGHB production under teak plantation in Sevoke site

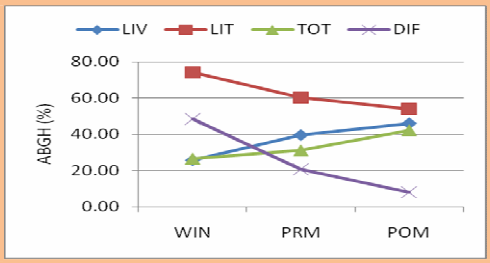

Figure 6.4.3. Seasonal variation in living and litter part of AGHB under natural vegetation in Lataguri site

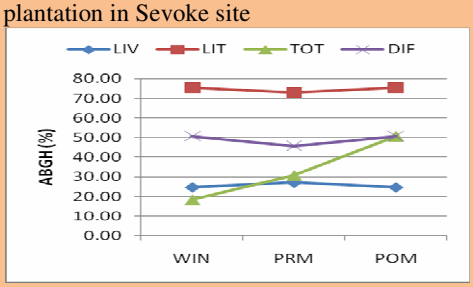

Figure 6.4.4. Seasonal variation in living and litter part of AGHB under Sal-hilauni plantation in Lataguri site

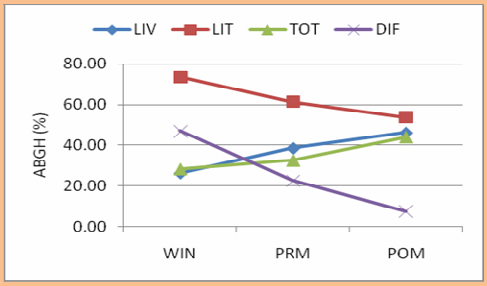

Figure 6.4.5. Seasonal variation in living and litter part of AGHB under natural vegetation in NRVK site

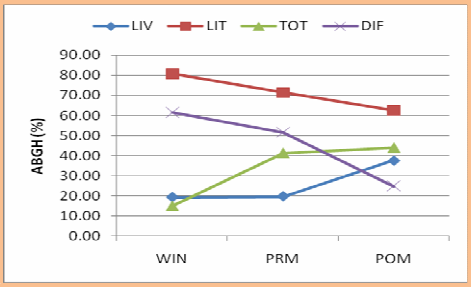

Figure 6.4.6. Seasonal variation in living and litter part of AGHB under teak plantation in NRVK sit

Biomass turnover and degradation of litter part were not dirrectly estimated in the present study but the trend of both biomass turnover and litter degradation pattern in both the natural vegetation and teak plantation were easily predictable.

The litter parts were highest in winter season (74.31 % and 76.02 % of the seasonal production in natural vegetation and teak plantation respectively) and gradually decresed and become lowest in the post-monsoon period (53.67 % in natural vegetation and 62.78 % in teak plantation). In case of living part of the AGHB, the reverse trend was found *i.e.* living masses were lowest in winter (25.69 % and 23.98 % in natural vegetation and teak plantation respectively), then increased gradually and attained the peak during the post-monsoon, 46.33 % in natural vegetation and 37.22 % in teak plantation.

The trends in litter degradation pattern and biomass turnover are almost same in both, natural vegetation and teak plantation in Terai region but the differences were in their rates. In natural vegetation, both the litter degradation and increases in living masses were rapid and during the post monsoon period the difference in litter and living part became less leaving a gap of 7.34 %. But in teak plantation, due to the slow degradation of litter part and production of lesser amount of living mass, a huge difference of 25.56 % persisted even in the post-monsoon period instead of favourable environment for decomposition and degradation of litter component in teak plantation.

In Duars region, sal-chilauni plantation in Lataguri and teak plantation in North Rajabhatkhawa (NRVK) site were studied along with a patch of natural vegetations near the respective plantations. Under sal-chilauni plantation, production of AGHB was measured 1189.86 g/m^2 of which 301.86 g/m^2 (25.37 %) was living biomass and 888 g/m^2 (74.63 %) was litter part whereas in natural vegetation AGHB production was slightly higher than the sal-chilauni plantation and measured to be 1250g/m^2 that was the sum of 450.88 g/m2 (36.05 %) and 831.84 g/m2 (66.51 %) of living and litter part of biomass respectively (Table 6.22). Production of AGHB was 60.86 g/m^2 lesser in sal-chilauni plantation than the natural vegetation. Under teak plantation in NRVK site, production was measured to be 1722.16 g/m^2 of which 473.59 g/m^2 (27.50 %) was living biomass and 1184.52 g/m^2 (68.78 %) was litter part whereas in natural vegetation AGHB production was higher than teak plantation and measured to be 2427.64 g/m^2 that was the sum of 935.86 g/m^2 (38.55 %) and 1491.78 g/m^2 (61.45 %) of living and litter parts of biomass in that order. Production of AGHB was 705.48 g/m^2 lesser in teak plantation than the Natural vegetation. Seasonal variation in production of living and litter parts of AGHB under the natural vegetation, sal-chilauni plantation and teak plantation followed the same pattern both in Terai and Duars region. Maximum amount of litter was found to be accumulated in winter, moderate in pre-monsoon and minimum in post-monsoon periods. On the other hand, least amount of living parts of AGHB were recorded in winter; increased gradually and reached at peak during the post-monsoon period (Figures 6.4.3 & 6.4.4).

Under natural vegetation in Lataguri forest, litter parts were measured 56.67 %, 54.67 % and 52.43 % during winter, pre-monsoon and post-monsoon periods respectively, whereas the living masses were 33.33 %, 35.33 % and 37.57 % in winter, pre-monsoon and post-monsoon seasons (Figure 6.4.5 & 6.4.6). The seasonal variations in litter and living biomass were least under natural vegetation. AGHB productions were nearly same throughout the year.

Table 6.26. Above ground herbaceous biomass production in Lataguri site.

Vegetation	Season	Dry Mass (g/m^2)			Dry Mass %			Difference
		Living	Litter	Total	Living	Litter	Total	
Natural	Winter	187.22	543.01	730.23	25.64	74.36	26.67	48.72
	Pre Mon	337.74	516.43	854.17	39.54	60.46	31.2	20.92
	Post Mon	529.98	623.31	1153.29	45.95	54.05	42.13	8.09
	Annual	**1054.94**	**1682.75**	**2737.69**	**38.53**	**61.47**	**100**	**22.93**
Sal-Chilauni	Winter	53.86	164.8	218.66	24.63	75.37	18.38	50.74
	Pre Mon	99.2	267.2	366.4	27.07	72.93	30.79	45.85
	Post Mon	148.8	456	604.8	24.6	75.4	50.83	50.79
	Annual	**301.86**	**888**	**1189.86**	**25.37**	**74.63**	**100**	**49.26**

That was an indicator of static AGHB production as well as the stability of the vegetation and ecosystem. The differences between litter and living masses in natural vegetation were lesser than the plantations, 23.33 %, 19.35 % and 14.87 % in winter, pre-monsoon and post-monsoon seasons respectively. Same sort of biomass turnover and degradation pattern were found under the natural vegetation in NRVK site also, where litter, living masses, and their differences were 74.36 %, 25.64 %, 48.72 % and 60.46 %, 39.54 %, 20.92 % and 54.05 %, 45.95 %, 8.09 % in winter, pre-monsoon and post-monsoon periods respectively.

Table 6.27. Above ground herbaceous biomass production in NRVK site.

Vegetation	Season	Dry Mass (g/m^2)			Dry Mass %			Difference
		Living	Litter	Total	Living	Litter	Total	
Natural	Winter	173.29	481.46	654.75	26.47	73.53	28.23	47.07
	Pre Mon	291.32	462.33	753.65	38.65	61.35	32.5	22.69
	Post Mon	471.25	547.99	1019.24	46.24	53.76	43.95	7.53
	Annual	**935.86**	**1491.78**	**2427.64**	**38.55**	**61.45**	**100**	**22.9**
Teak Planttion	Winter	49.66	207.75	257.42	19.29	80.71	14.95	61.41
	Pre Mon	139.93	505.37	709.34	19.73	71.24	41.19	51.52
	Post Mon	284	471.4	755.4	37.6	62.4	43.86	24.81
	Annual	**473.59**	**1184.52**	**1722.16**	**27.5**	**68.78**	**100**	**41.28**

Under sal-chilauni plantation, litter (75.37 % of the seasonal product) was more than three times of the green mass (24.63 %) and the difference was also high (50.74 %) in winter season and approximately 3:1 ratio of the litter and living masses was persisted throughout the year. The huge difference in litter and living biomass was mostly due to prevention of growth of herb layer under sal-chilauni

plantation by thick layer of dry leaves which are heavily cuticularized and needed long duration of time for degradation.

Seasonal productions of litter and living parts of AGHB under teak plantation in NRVK site showed some sorts of deviation from that of natural vegetation. 80.71 %, 19.29 %; 71.24 %, 19.73 % and 62.40 %, 37.60 % of the total seasonal production were litter and living masses during winter, pre-monsoon and post-monsoon correspondingly. Litter parts were about 4 times of living matter in winter and pre-monsoon, and about 2 times in post-monsoon.

Annual production of AGHB was highest under natural vegetation, 2800.32 g/m^2 in Terai region and 2427.64 g/m^2 in NRVK site of Duars region, followed by teak plantations 1737.6 g/m^2 in Terai zone and 1722.16 g/m^2 2737.69 g/m^2 in NRVK and Lataguri site of Duars region respectively (Table 6.27). In Terai region and NRVK and Lataguri site of Duars region, AGHB productions were suppressed under teak plantations by 1062.72 g/m^2, 705 g/m^2 and 1547.83 g/m^2 respectively. Under sal-chilauni plantation also, production of AGHB was reduced but by lesser amount i.e. 60.86 g/m^2.

6.5. RARE, ENDEMIC AND THTEATENED ELEMENTS (RET)

Terai – Duars belt of West Bengal is located at the foot of the Himalaya and is a contiguous region with the Eastern Himalaya, which is renowned for its endemic flora (Das 2002; Rai 2006) as well as the other categories of threatened plants. A total of 41 species of plants belonging to 27 families were recorded from the study site (Annexure IIB, Table 1) which includes 15 species of trees, 12 climbers, 8 herbs and 6 shrubs. Endemic, Endangered (EN), Near Threatened (NT), Vulnerable (V) and Critically Endangered (CR) – these five categories were recorded and the highest number of species were found to be endemic i.e. 22 species. 9 species were found to be Endangered, 6 species as Vulnerable, 2 species as Near Threatened, 1 species as Critically Endangered and 1 species was recorded to be endemic as well as in Endangered category. Regarding the occurrence of species, Vitaceae was found to have 2 members under RET category [EN = 2] as well as with four endemic species. Apocynaceae represented 3 species [EN = 2, NT = 1]; Lauraceae was also found to represent 1 species as CR and 2 endemic species. One species of Leguminosae was Endemic, 1 Endangered and another species was Vulnerable and thus Leguminosae also was represented by 3 species under the RET category. Meliaceae, Ophioglossaceae and Piperaceae were found to have 2 species each under the RET category. CAMP Workshop-2007 also assessed the threat status of prioritized medicinal plants of West Bengal (mainly from the Terai-Duars region) and was assigned the status of Near Threatened (NT) and above (http://envis.frlst.org). Most of the recorded species are used medicinally and are

exploited vigorously. That was claimed to be the main reason behind the threats (Das *et al.* 2010).

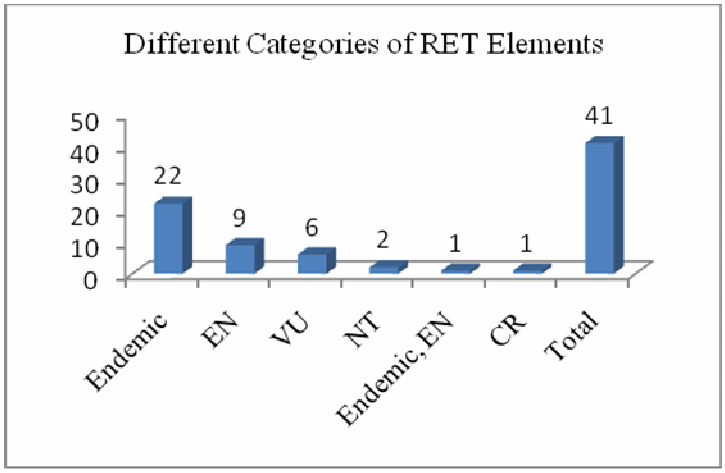

Figure 6.5.1. Number of RET plants of differnt categories in Terai-Duars belt.

6.6. NON TIMBER FOREST PRODUCES (NTFPs)

Non-Timber Forest Produces (NTFPs) are wild plants and animal products derived from forests (FPB, 2004). It may be wild fruits, vegetables, nuts, edible roots, honey, palm leaves, medicinal plants, mushroom, poisons and even the forest soil (Andel, 2006). The concepts of NTFPs differ from the timber products in specific conserevation strategy as sustained lavels of collection of NTFPs do not hamper the integrity of forests and thus plays important role in conservation of ecosystem and socio-ecological relationship and economic development (FPB, 2004).

Terai-Duars belt of West Bengal which is located at the foot of the Himalayas and contiguous with the Himalaya Biodiversity Hotspot for conservation and is unique in its phyto-diversity. Forests of this belt (both plantation and natural vegetation) are the unique sources of NTFPs. During the present study, total 186 species of plants were collected those can be recognized as Non Timber Forest Produces (NTFPs). These include 94 species of trees, 33 herbs, 25 shrubs, 28 climbers, 3 ferns and 3 bamboos (Figure 6.6.1). Out of the total collected NTFPs, 77 species were collected from the natural forest only; 68 species were collected from both the natural forest and plantation; 25 species were collected from fringe areas only. Nine species were found to occur in all of the natural forests, plantations and fringe areas. Four species were collected from natural forests and fringe areas only whereas three species were collected from the plantation only (Figure 6.6.2).

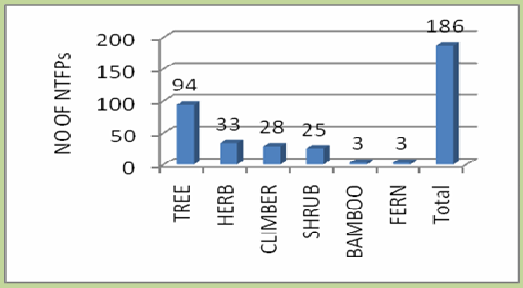

Figure 6.6.1. Different habit class of recorded NTFPs

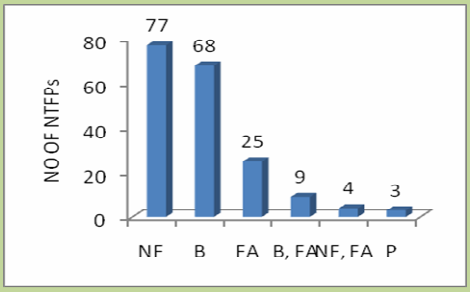

Figure 6.6.2. Occurrences of NTFPs in plantation[P], natural forest [NF] and fringe area [FA]

Important categories of NTFPs recorded from the study area includes edible or food plants, fodder, decorative elements, spices, fuel, relegious material, fibre, aromatic plants, broom, cordage, dye, dhuna, fencing and building materials, brewing materials, detergents, fish poisoning, food plate, hats, insect repellents, preservatives, etc. Though the medicinal plants are an important category of NTFPs, but it was discussed separately under another sub-heading (Medicinal plants) and only those plants having medicinal property along with some other uses, were included in the list of NTFPs (Annexure IIB, Table 2).

6.6.1. MEDICINAL PLANTS

Different types of vegetation in the Terai–Duars belt of west Bengal are rich habitat for important and rare medicinal plants (Das *et al.,* 2010) and it corresponds to the rich and wide phyto-diversity of this region. A total of 319 species of plants belonging to 244 genera and 94 families were recorded from the study area and name of species, families, their common names and habit has been presented in Table 3 of Annexure IIB. Out of the recorded species 114 were herbs, 88 species were trees, 60 species were climbers and other 57 were shrubby species. In respect of number of representative species, Leguminosae stood at first position with the presentation of 31 species from all the habit groups – trees, shrubs, herbs and climbers. Phyllanthaceae having 17 species occupied the second position. Other families having higher number of species were Compositae, Lamiaceae, Malvaceae [each have 15 species], Apocynaceae [13 species], Amaranthaceae [10 species], Rubiaceae [9 species], Euphorbiaceae [8 species], Vitaceae [8 species], Lauraceae, Orchidaceae, Rutaceae, Solanaceae, Zingiberaceae, Acanthaceae etc. Most of the tree species which were recorded to be used medicinally were found to occur either in natural vegetation or in adjoining areas of the forest. But very few of them were spotted within the plantations.

6.7. TRADITIONAL KNOWLEDGE AND ETHNOBOTANY

Ethnobotany is the systematic study of the interactions between a culture and the plants in its environment, particularly the knowledge about and use of such plants (http://medical-dictionary.the freedictionary.com/enthnobotany). The Northernmost rolling plains of North Bengal i.e. the Terai-Duars region is populated by a large number of ethnic groups – *Santal, Mahali, Malpaharia, Oraon, Rajbanshi, Munda, Polia, Mech, Rabha, Toto,* etc. At the same time this foot-hills of region of the Himalaya is well-known for it's extremely rich in Biodiversity (Das, 1996, 2011). Mainly the Phyto-diversity of this partially marshy zone is well known to the botanists as well as to the non-botanists. Having both the availability of rich forests and a large number of tribal groups and their huge populations, an excellent system of traditional knowledge base has been developed in this forested belt of Northern Bengal. During the present survey the richness of traditional knowledge system was revealed in recording of a good number of plants to be used traditionally by the ethnic groups as well as by the rural people (Sarkar, 2011). Plants which were collected to be ethnobotanically important were categorized under different groups depending on their uses.

6.7.1. Edible plants

About 71 species, belonging to 38 families were recorded to be used as food, vegetables, fruits etc. and were categorized under edible plants. Some of those plants were *Alocasia macrorrhizos*, *Annona reticulata, Antidesma acidum, Artocarpus chaplasa, Bauhinia acuminata, Brassica campestris, Cajanus cajan, Chenopodium album, Colocasia esculenata Dioscorea bulbifera, Dioscorea prazeri, Dryopteris sikkimensis, Phyllanthus emblica* etc. Plants which were collected as edible were also been used as medicine in most of the cases. Plant parts used for their medicinal properties were diverse enough – stem, bark, root, leaf, fruits, flower, seeds, gum, twig, etc. (Annexure IIB, Table 4).

6.7.2. Fodder plant

A total of 48 species of plants covering all the habit classes – tree, shrub, herb and climber were recorded to be used as food for the cattle of the tribal as well as by the other rural people in the study area (Annexure IIB, Table 5). Generally twigs, leaves, shoots, fruits, stem etc. were used for fodder purpose and in most cases fodder plants were recorded to be collected from the natural forest or fringe area or from the marginal areas of plantations. Some of the important fodders were *Ziziphus jujuba, Artocarpus lacucha, Albizia chinensis, Ficus benghalensis, Trema orientalis, Bauhinia variegata, Toona ciliata, Ficus religiosa,* etc.

6.7.3. Ethno-veterinary plants

Total 85 species of plants were collected as ethno-veterinary materials were recorded and were found to be very significant in their cattle care. They used different parts of the plants – leaves, roots, rhizome, fruits, bulb, petiole, leaf juice, latex, whole plant, twigs, seed oil, tender shoot, seeds, flowers, cotyledons etc. to cure the common ailments of their domestic animals. Those plants were found to be used along with some other substance like lime, salt, oil etc. Some of the important plant materials found are used in ethno-veterinary treatments were *Allium cepa, Allium sativum, Alocasia macrorrhizos, Alstonia scholaris, Amaranthus spinosus, Amorphophallus bulbifer, Azadirachta indica, Bambusa vulgaris* etc. (Annexure IIB, Table 6). Maximum numbers of plants were used to cure digestive ailment of cattle, mouth sore, poor lactation, dysentery, etc.

6.7.4. Ethno-medicinal plants

A good number of plants were recorded as ethno-medicinally important species. They included all the habit groups like trees, shrubs, herbs, climbers and ferns. These plants were mostly used against common cold, fever, jaundice, cut, sore, anaemia, indigestion, dysentery, malaria, insomnia, weakness, toothache etc. All the plant parts – root, leaf, stem, bark, root-bark, fruits, flowers, twig etc. were used to cure different ailments. Some of the recorded and mostly used ethnomedical plants were – *Centella asiatica*, *Tinospora sinensis*, *Terminalia chebula*, *Terminalia bellirica*, *Saraca asoca*, *Paederia foetida*, *Justicia adhatoda, Aesculus assamica, Aegle marmelos, Alstonia scholaris, Bauhinia vahlii, Bombax ceiba,* etc. (Annexure IIB, Table 7).

6.7.5. Aromatic and Spice plants

Total seven species of plants were found to be used by the forest-dependent people as aromatic plants or as spice. These were *Blumea lacera, Cinnamomum tamala, Clausena excavata, Curcuma aromatica, Zingiber zerumbet* etc (Annexure IIB, Table 8).

6.7.6. Rope and Cordage

A total of eight species of plants were collected, which are used as cordage or rope and were mainly used to tie up the bundle of grasses, fodder, fuel wood etc. Generally the plants having fibrous bark (e.g. member of Malvaceae, Araceae, Celastraceae, etc.) or climbers were used for this purpose. Some of the cordage plants were *Calamus erectus*, *Celastrus paniculatus*, *Grewia asiatica*, *Sterculia villosa,* etc. (Annexure IIB, Table 9).

6.7.7. Decorative and Ornamental plants

A good number of plants or plant parts were found to be used as decorative materials or ornamental plants. These were the integrated part of NTFPs also. Generally the dry fruits, tough leaves or fronds of fern, fibrous mesocarp, inflorescence, infructescence, flowers, seed etc. were used for this purpose. Different parts of plants like– *Luffa acutangula, Lagerstroemia speciosa, Butea monosperma, Duabanga grandiflora, Pandanus unguifer* etc. are used by them as decorative elements (Annexure IIB, Table 10).

6.8. SOIL PARAMETERS

Soil provides the nutrients and water which is very much essential for the growth of plants. On the other hand plants influence and affect the formation of soil, its physical and chemical properties etc. From the very beginning of plantation forestry, fear of soil deterioration in monoculture plantation was expressed (Joshi *et al*. 1997) and different workers had reported the modification of soil properties by plantation (Balagopalan 1995; Michelsen *et al*. 1996; Ehrenfeld 2003; Thapa *et al.*2011). As an important aspect of the present study, different soil parameters, namely soil texture, content, soil organic carbon, nitrogen, available phosphorous and potash were estimated from the soil samples of natural forests and different plantations in the study area. Comparison of plantation and natural forest were made on the basis of the above mentioned soil parameters and the result has been represented in Table 6.28 in a comprehensive way.

Table 6.28. Different Physicochemical properties of Soil in Plantation and Natural forest

Vegetation	Soil Layer	p^H	Moisture Content (%)	Organic Carbon	Potassium (ppm)	Phosphorus (ppm)	Texture			
							Silt %	Clay %	Sand %	Class
Natural Vegetation	Top	5.180	35.29	1.44	112.15	30	30	40	15	Loam
	Sub	5.275	34.98	1.355	108.9	30	30	40	15	
Mixed Plantation	Top	5.198	43.99	1.4475	87.125	25	30	40	25	Clay Loam
	Sub	5.235	42.89	1.3	83.4	20	30	40	23	
Sal-Chilauni Plantation	Top	4.945	42.16	1.485	91	22.5	30	40	25	Clay Loam
	Sub	4.845	42.50	1.355	102.9	27.5	30	39	22	
Teak Plantation	Top	5.045	36.85	2.01	105.95	25	30	40	25	Clay
	Sub	5.145	38.02	1.725	94.15	25	35	45	20	

Soil in natural vegetation was categorized as loam having 30% of silt, 40% of clay and 15% of sand in both the top and sub-soil. Mixed plantation soil was classified as clay loam having 30%, 40% and 25% of silt, clay and sand in top layer and 30%, 40% and 23% of the same in similar sequence in sub-soil. Texture of sal-chilauni plantation also was clay-loam having similar type of proportion of silt, clay and sands as in mixed plantation. Soil of teak plantation was categorized as clay (30%, 40% and 25% of silt, clay and sand in top soil and 30%, 39% and 22% of silt, clay and sand in sub-soil).

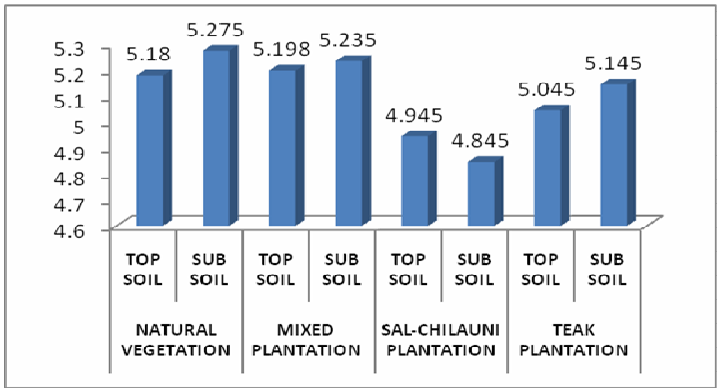

Figure 6.8.1. p^H of top and sub soil of Natural forest and different plantations

p^H of the top and sub-soil of natural vegetation was estimated to be 5.18 and 5.28 respectively. On the other hand, that of the top and sub-soil of mixed plantation, sal-chilauni plantation and teak plantation was found to be, 5.20, 5.24, 4.95, 4.85 and 5.05, 5.15 respectively (Figure 6.8.1). Moisture content of top-soil was found to be lowest (35.29%) in natural forest and highest (43.99%) in mixed plantation. Highest and lowest moisture content in sub-soil were recorded for mixed plantation and natural forest. In all the plantations, soil moisture contents in both top and sub-soil, was higher than the natural forest (Figure 6.8.2).

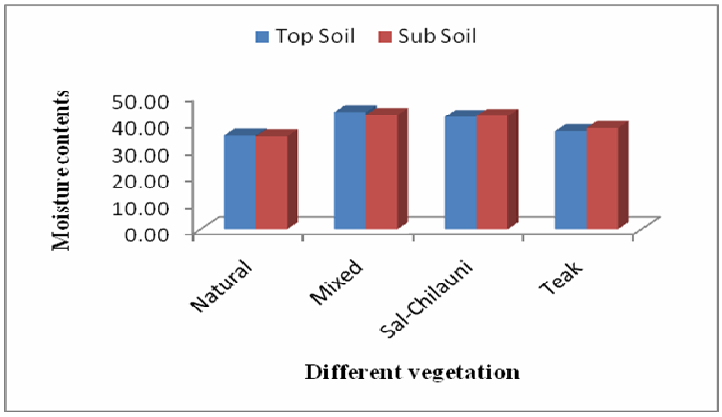

Figure 6.8.2. Moisture contents of top and sub soil of Natural forest and different plantations

Organic carbon content of top and sub layers of soil from different plantations and natural foresthas been represented in Figure 6.8.3. Lowest value of organic carbon in top layer was found in natural forest and the highest value in top soil of teak plantation. In sub-soil, lowest value of organic carbon was found in mixed plantations but highest value was recorded in teak plantation. Top soil in all the four types of vegetations was rich in organic carbon (OC) contents than the sub-soil and difference between OC contents was highest in teak plantation.

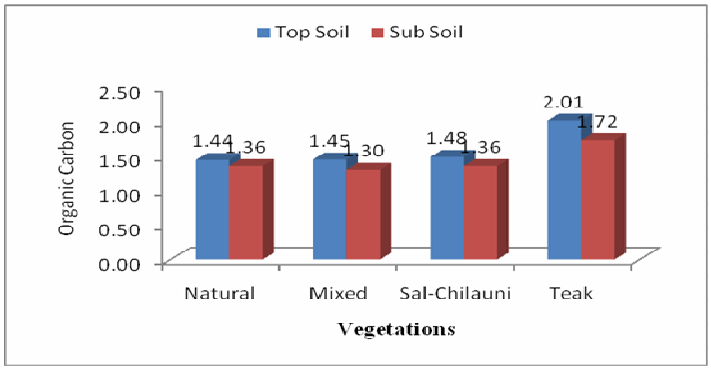

Figure 6.8.3. Organic carbon contents (%) of top and sub-soil of Natural forest and different plantations

Regarding the potassium contents, natural forest was recorded for highest value in both the top and sub-soil. Potassium content was least in both top and sub soil of mixed plantation. In teak plantation 105.95 ppm and 94.15 ppm of potassium content were estimated in top and sub-soil respectively the differences in potassium contents in top and sub-soil was highest (11.8 ppm) in teak plantation. Sal-chilauni plantation differed from all other three types of vegetation in respect of lower potassium contents in top soil than the sub-soil (Figure 6.8.4).

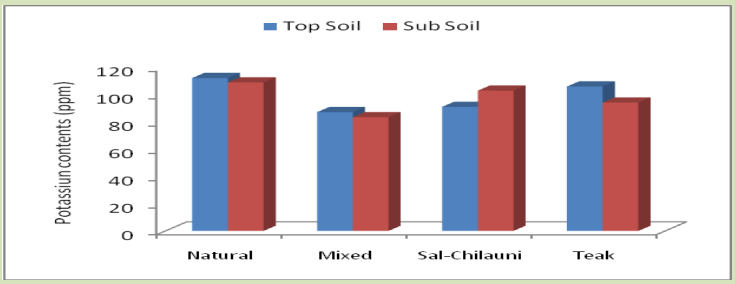

Figure 6.8.4. Potassium contents of top and sub-soil of Natural forest and different plantations

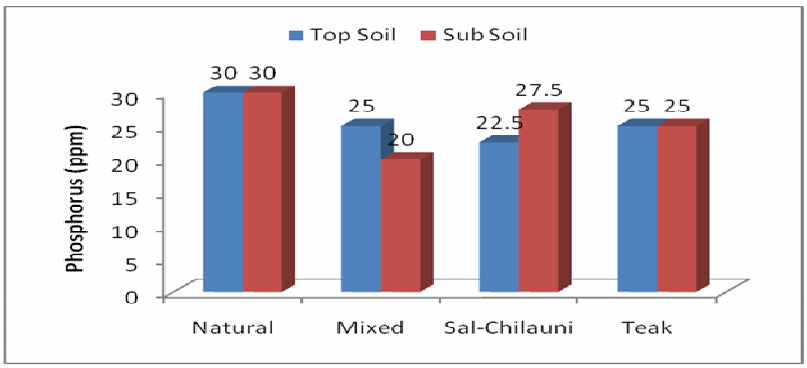

Figure 6.8.5. Phosphorus contents of top and sub-soil of Natural forest and different plantations

Phosphorous contents in both the top and sub layer of soil in the natural vegetation was estimated to be 30 ppm. In teak plantation also, the phosphorous content in both the top and sub soil were same, i.e. 25 ppm. In this respect teak plantation resembles with the natural vegetation. In mixed plantation 25 ppm and 20 ppm of phosphorus content were measured. In Sal-chilauni plantation phosphorus contents (Figure 6.8.5) in top soil (22.5 ppm) was lower than the sub-soil (27.5 ppm).

6.9. ALLELOPATHY

Allelopathy is a natural phenomenon whereby one plant releases some biochemical substances having inhibitory and stimulatory effects on some other plants (Rice, 1984; Mensah *et al.* 2015). Allelopathy acts by addition of phytotoxic elements to the environment and they inhibit germination and/or growth of some other plants. In trees and forests it is an important healthcare issue. Some agroforestry trees have been reported to have some allelopathic effects (Jayakumar *et al.* 1987; Macias *et al.* 2000; Sahoo *et al*. 2007; Manimegalai *et al.* 2012). In the present study allelopathic effects of some trees which are used to create plantation forests by the Forest Department were tested *in vitro* against some local herbaceous species having medicinal or other importance. Tables 11, 12 & 13 under Annexure IIB summarises the results.

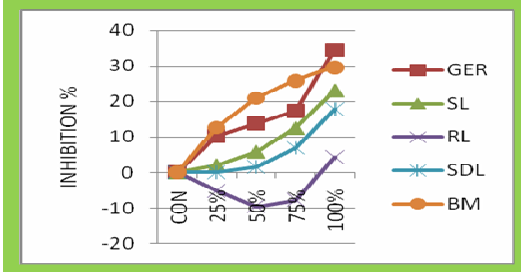

Figure 6.9.1. Effect of Teak leaf extract on germination, shoot length, root length, seedling length and biomass of *Senna occidentalis*

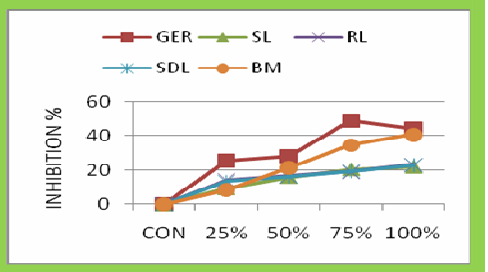

Figure 6.9.2. Effect of Teak leaf extract on germination, shoot length, root length, seedling length and biomass of *Ocimum gratissimum*

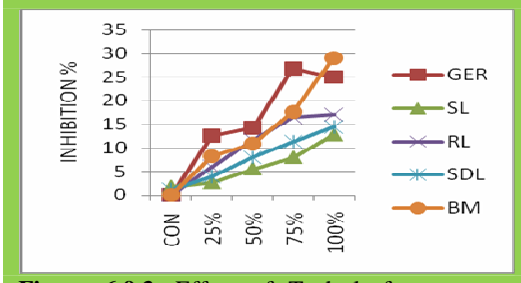

Figure 6.9.3. Effect of Teak leaf extract on germination, shoot length, root length, seedling length and biomass of *Andrographis panicula*

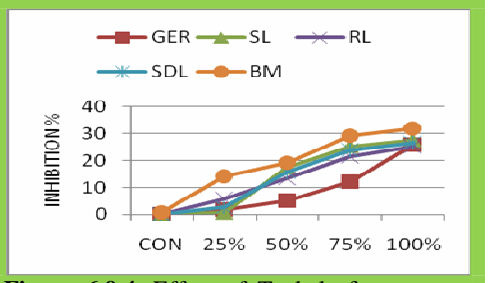

Figure 6.9.4. Effect of Teak leaf extract on germination, shoot length, root length, seedling length and biomass of *Plumbago zeylanica*

Effects of Teak [*Tectona grandis* L.f. of Lamiaceae]: Teak was found to have some effects on germination percentage, shoot, root, seedling length, fresh weight of seedlings of the test plants and other parameters (Figs. 6.9.1 – 10). It inhibited germination and percentage of inhibition were maximum in highest concentration of Teak extract (100 %) and was recorded as 34.48 %, 44.19 %, 25.86 % and 21.43 % in *Senna occidentalis* (L.) Link, *Ocimum gratissimum* L., *Plumbago zeylanica* L. and *Oxalis corniculata* L. respectively (Figures 6.9.1, 2, 4 & 5). But in *Andrographis paniculata* (Burm.f.) Nees the highest percentage of inhibition was found in 75 % concentration of Teak extract (Figure 6.9.3). Percentage of viability of seeds the test plants were according to the percentage of inhibition of seed germination. Inhibitory effect was also noted in case shoot length and root length in *O. gratissimum*, *A. paniculata*, *P. zeylanica* and *O. corniculata*. But in *S. occidentalis* shoot length was inhibited in higher concentration of extract but the root length was slightly stimulated in low to medium concentration of extract. As shoot and root length were inhibited in most of the cases, growth of seedlings were also affected and the seedling-length was also inhibited and the percentage of inhibition in highest concentration of extract were calculated to 17.87 %, 23.01 %, 14.50 %, 26.72 % and 28.46 % in *S. occidentalis O. gratissimum*, *A. paniculata*, *P. zeylanica* and *O. corniculata* respectively. A general trend of reduction in Shoot Vigour Index (SVI), Root Vigour Index (RVI) and Seedling Vigour Index (SDVI) was noted for all the test plants (Figures 6.9.6 – 6.9.10).

The vigour indices were inversely proportional to that of the concentration of Teak extracts. Shoot and root ratio of tested plants were also altered differently by the extracts of Teak leaf. In *S. occidentalis* it was reduced; in *O. gratissimum* it was of more or less similar with that of control; increased in *A. paniculata* and *O. corniculata*; whereas in *P. zeylanica* shoot and root ratio was altered differentially by different concentration of Teak extracts.

Effect of Sal [*Shorea robusta* Gaertn. of Dipterocarpaceae]: Sal exerted inhibitory effect on seed germination of *Senna occidentalis* by 17.86 %, 21.43 % and 25.00 % by extract concentrations of 25 %, 50 % and 75 % respectively (Figure 6.9.11). But in highest concentration of extract (100 %) suppression of germination was lesser, 10.71 % only.

In control, germination percentage was recorded to be 71.67 % whereas in maximum concentration, lowest percentage of germination (41.67 %) was recorded. Thus percentage of inhibition of germination was increased gradually with the increase of extract concentration and culminated into 41.86 % in highest concentration of extract solution. Viability percentage was recorded to be 100.00 %,

88.37 %, 69.77 %, 60.47 % and 58.14 % in case of control, 25 %, 50 %, 75 % and 100 % of extract solution of Sal leaf.

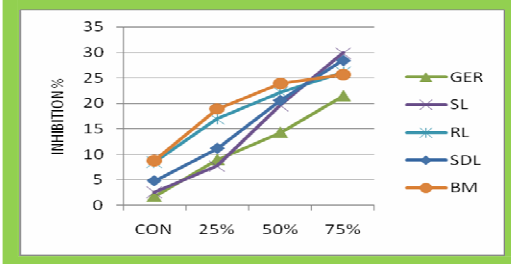

Figure 6.9.5. Effect of Teak leaf extract on germination, shoot length, root length, seedling length and biomass of *Oxalis corniculata*

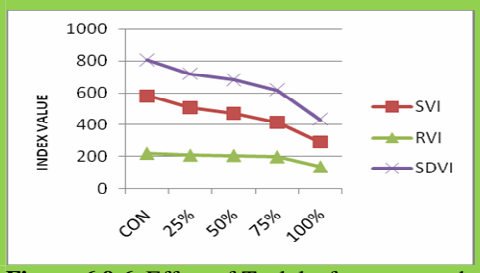

Figure 6.9.6. Effect of Teak leaf extract on shoot vigour index, root vigour index and seedling vigour index *of Senna occidentalis*

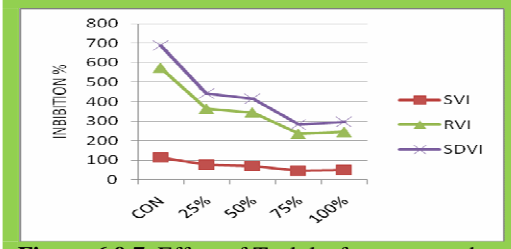

Figure 6.9.7. Effect of Teak leaf extract on shoot vigour index, root vigour index and seedling vigour index of *Ocimum gratissimum*

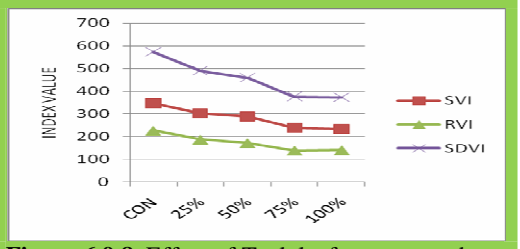

Figure 6.9.8. Effect of Teak leaf extract on shoot vigour index, root vigour index and seedling vigour index of *Andrographis paniculata*

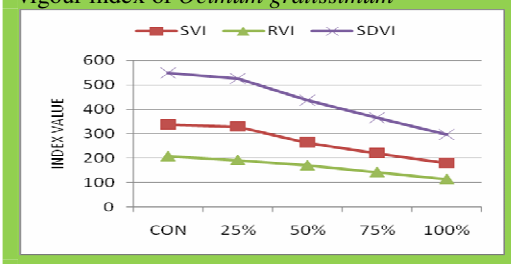

Figure 6.9.9. Effect of Teak leaf extract on shoot vigour index, root vigour index and seedling vigour index of *Plumbago zeylanica*

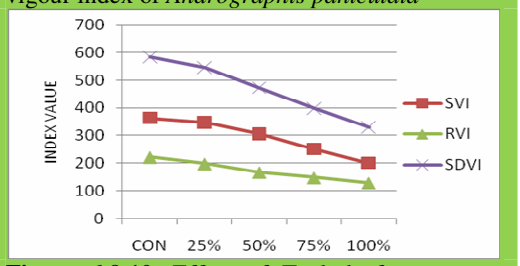

Figure 6.9.10. Effect of Teak leaf extract on shoot vigour index, root vigour index and seedling vigour index *Oxalis corniculata*

On the other hand maximum amount of inhibition in shoot length, root length and seedling length was recorded to be 32.48 %, 42.41 % and 40.78 % in 75 % concentration of the extract. SVI were also reduced by maximum level in 75 % of extract concentration. Shoot-root ratio of *O. gratissimum* seedlings was not affected by the Sal extract. Production of fresh weight by seedlings was also reduced by the extracts and maximum degree of reduction or inhibition was found in highest concentration (100 %).

In case of *A. paniculata,* effect of Sal extract was similar with that on *S. occidentalis*. Shoot-root ratio was increased gradually in different concentrations of extract due to the inhibition of root length. Biomass production was also reduced

and percentage of inhibition was found to be highest (46.77 %) by the undiluted (100 %) extract (Figs. 6.9.13 & 6.9.14).

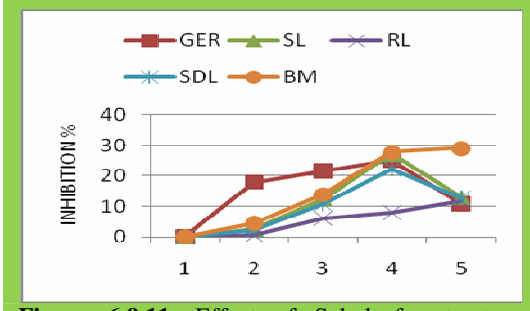

Figure 6.9.11. Effect of Sal leaf extract on germination, shoot length, root length, seedling length and biomass of *Senna occidentalis*

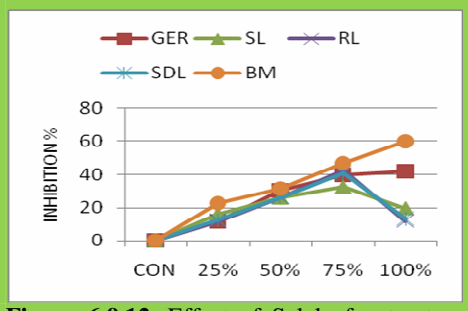

Figure 6.9.12. Effect of Sal leaf extract on germination, shoot length, root length, seedling length and biomass of *Ocimum gratissimum*

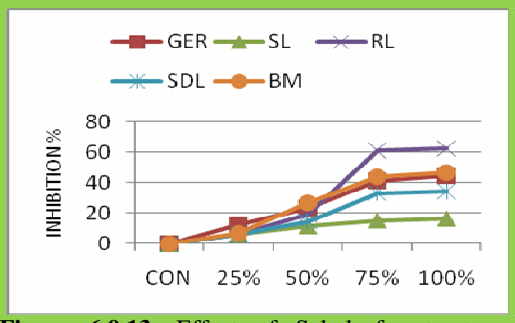

Figure 6.9.13. Effect of Sal leaf extract on germination, shoot length, root length, seedling length and biomass of *Andrographis paniculata*

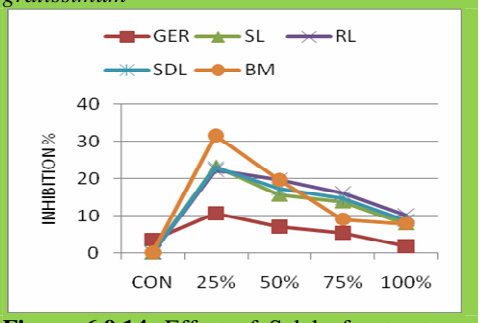

Figure 6.9.14. Effect of Sal leaf extract on germination, shoot length, root length, seedling length and biomass of *Plumbago zeylanica*

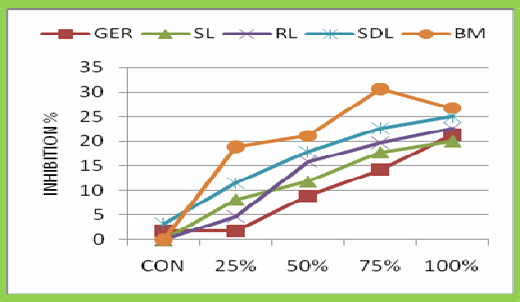

Figure 6.9.15. Effect of Sal leaf extract on germination, shoot length, root length, seedling length and biomass of *Oxalis corniculata*

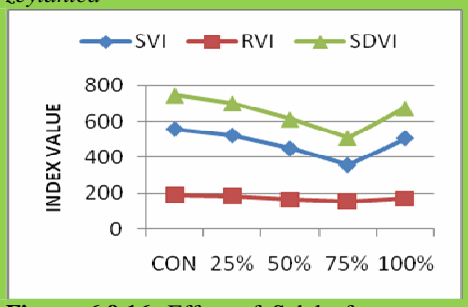

Figure 6.9.16. Effect of Sal leaf extract on shoot vigour index, root vigour index and seedling vigour index of *Senna occidentalis*

In *Plumbago zeylanica*, germination percentage of seeds was slightly increased with the increase of extract concentration, thus percentage of inhibition of seed germination was only 10.71 % in 25 % of extract concentration and other concentrations of extract exerted negligible effect. Accordingly, lowest percentage of seed viability was recorded in extract solution of 25 %. Inhibition of seedling length, along with reduction of shoot and root length was recorded to be 22.94 %

only by lowest concentration of extract solution (25 %). But in case of other higher concentrations of Sal extracts reduction of the seedling length was decreased gradually (Figure 6.9.14). Only 25 % extract solution was found to exert inhibitory effects on shoot vigour (SVI) and seedling vigour indices (SDVI) and calculated values were 222.19, 145.43 and 367.61 respectively (Figure 6.9.19). Shoot-root ratio was increased in case of treatment of different extract solution except 25 % of extract solution in which the ratio was decreased than the control. Regarding the biomass production, reduction in production of fresh weight was the maximum in 25 % extract solution and it was calculated to 31.64 %.

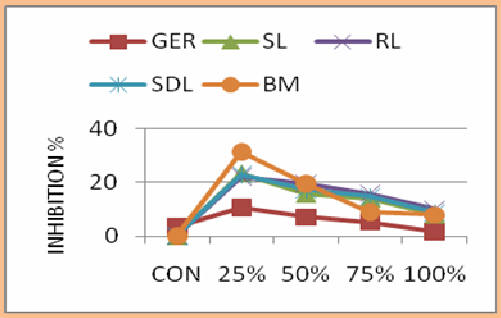

Figure 6.9.17. Effect of Sal leaf extract on shoot vigour index, root vigour index and seedling vigour index *Ocimum gratissimum*

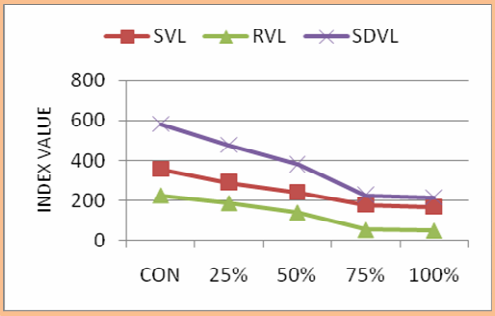

Figure 6.9.18. Effect of Sal leaf extract on shoot vigour index, root vigour index and seedling vigour index *Andrographis paniculata*

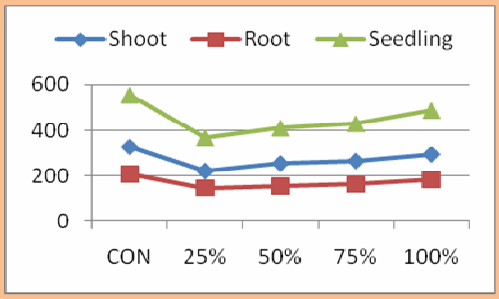

Figure 6.9.19. Effect of Sal leaf extract on shoot vigour index, root vigour index and seedling vigour index *Plumbago zeylanica*

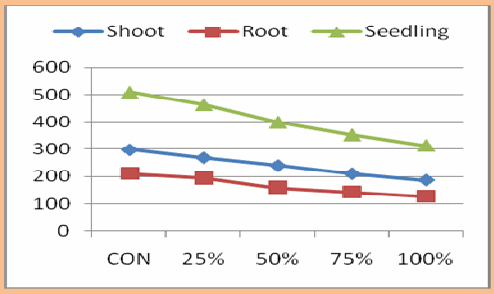

Figure 6.9.20. Effect of Sal leaf extract on shoot vigour index, root vigour index and seedling vigour index *Oxalis corniculata*

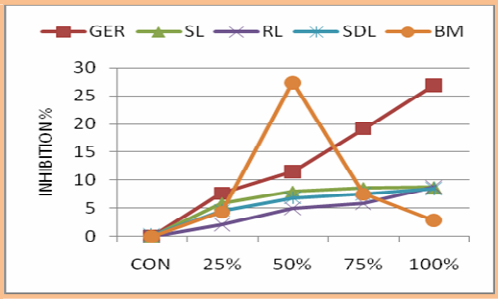

Figure 6.9.21. Effect of Jarul leaf extract on germination, shoot length, root length, seedling length and biomass of *Senna occidentalis*

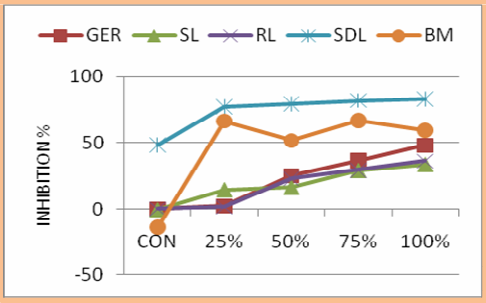

Figure 6.9.22. Effect of Jarul leaf extract on germination, shoot length, root length, seedling length and biomass of *Ocimum gratissimum*

Oxalis corniculata was found to be affected similarly as *S. occidentalis*, by the extract of Sal leaf (Figures 6.9.15 & 6.9.20). Germination percentage was recorded to be 93.33 %, 91.67 %, 85.00 %, 80.00 % and 73.33 % in control, 25 %, 50 %, 75 % and 100 % extract solution respectively. Notable percentage of inhibition of seed germination was recorded by extract solution of 75 % and 100 % and the inhibition percentage was recorded to be 14.28 % and 21.43 % respectively. Thus the viability percentage was recorded to be 85 % and 78.57 %. In those concentrations of extract shoot length, root length and seedling length were inhibited by 17.76 % in 75 % extract solution and 22.69 % in undiluted (100 %) extract; and 22.63 % in 7 5% extract and 25.07 % in 100 % extract solution respectively. All the SVI, RVI and SDVI were reduced notably by different strength of the solution and the lowest value of indices were recorded in highest concentration (100%) of extract and was followed by 75 % of extract solution. In undiluted (100 %) extract vigour indices were calculated to be 186.37 in shoot, 127.57 in root and 313.93 in seedling, in respect of 299.00 %, 210.63 % and 509.63 % in shoot, root and seedling vigour indices under the control. Biomass production was also reduced by the Sal extract in *Oxalis corniculata*. Maximum level of inhibition was recorded to be 30.70 % in 75 % of extract solution.

Effects of Jarul [*Lagerstroemia speciosa* (L.) Pers. of Lythraceae]: Another widely planted tree, Jarul was also tested against the herbs mentioned earlier and the result is represented in Table 13 in Annexure IIB. Germination percentage was found to be at least (41.67 %) in *O. gratissimum* in case of 100 % extract solution and the inhibitory effect was recorded to be 48.08 % (Figure 6.9.22).

In case of *Senna occidentalis* percentage of inhibition of seed germination was recorded to be 26.92 % in highest concentration of extract that resulted into the lowest percentage of viability (73.08 %). Shoot, root and seedling length were least affected even by the highest concentration of extract by 8.70 %, 8.80 % and 8.48 % respectively (Figure 6.9.21). Shoot vigour, root vigour and seedling vigour indices (SVI, RVI, SDVI) were calculated to be lowest in undiluted (100%) extract solution with calculated value of 347.64, 131.83 and 479.47 respectively (Figure 6.9.26). Effect on the shoot-root ratio was not prominent. But the biomass production was reduced by 27.39 % in 50 % concentration of leaf extract of Jarul tree.

Shoot length, root length and seedling length inhibition was gradually increased with the increase of concentration of leaf extract and were calculated to be 33.62%, 36.33% and 83.48% in case of 100% extract concentration in respective order in case of *O. gratissimum*. Other concentration of leaf extract were also found to exert inhibitory effects on seedling length with calculated values of 77.31% in 25%, 79.52% in 50% and 82.14% in 75% whereas in control solution, inhibition was found to be 48% (Figure 6.9.22). Shoot, root and seedling vigour was also affected

and reduced (Figure 6.9.27). Biomass production was inhibited by the extract solution but the relation with the gradient of concentration was not clear.

Andrographis paniculata was not affected remarkably by the extract of Jarul leaf (Figures 6.9.23 & 6.9.28). Lowest percentage of seed germination was found in highest concentration of extract with 66.67 % germination. Highest degree of inhibition in percentage of germination was 28.57 % in the undiluted (100 %) extract solution of jarul leaf and it was quite low in respect of other species of test plants. Viability percentage was quite high (71.43 %). Shoot length of *A. paniculata* was stimulated to a very minor extent. Inhibition of root length was not more than 19.36 % even in highest concentration of extract. Thus the inhibition of seedling length was negligible. Shoot, root and seedling vigour indices (SVI, RVI, SDVI) were reduced to some extent. Though the shoot length was stimulated and root length was inhibited in a very lesser extent, the shoot-root ratio was increased up to 2.16 from 1.59 in control. Production of fresh weight was reduced and inhibition percentage was recorded to be up to 29.02 % in highest concentration of extract solution.

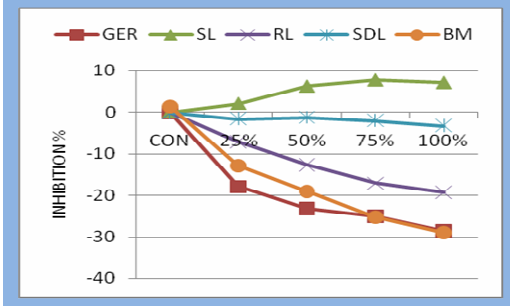

Figure 6.9.23. Effect of Jarul leaf extract on germination, shoot length, root length, seedling length and biomass of *Andrographis paniculata*

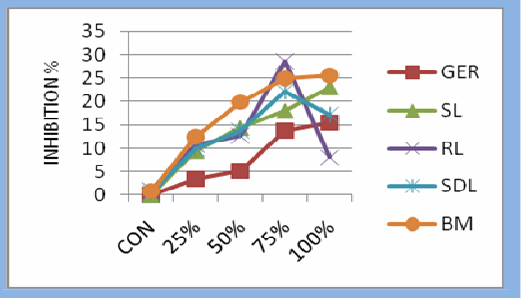

Figure 6.9.24. Effect of Jarul leaf extract on germination, shoot length, root length, seedling length and biomass of *Plumbago zeylanica*

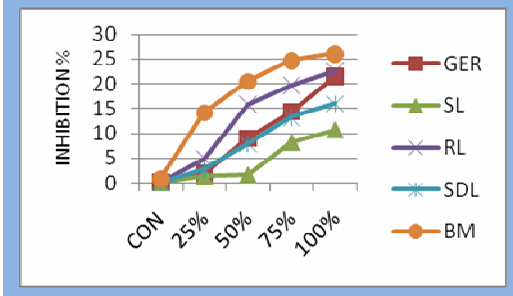

Figure 6.9.25. Effect of Jarul leaf extract on germination, shoot length, root length, seedling length and biomass of *Oxalis corniculata*

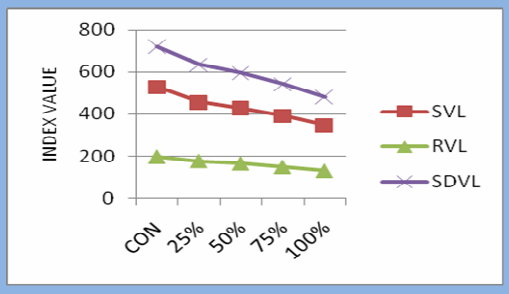

Figure 6.9.26. Effect of Jarul leaf extract on shoot vigour index, root vigour index and seedling vigour index of *Senna occidentalis*

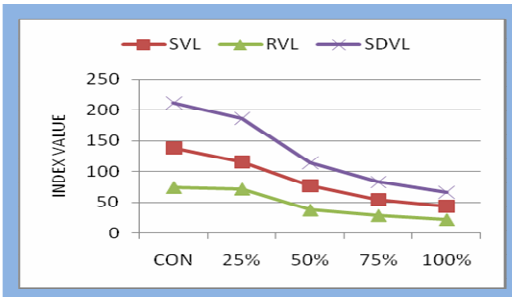

Figure 6.9.27. Effect of Jarul leaf extract on shoot vigour index, root vigour index and seedling vigour index of *Ocimum gratissimum*

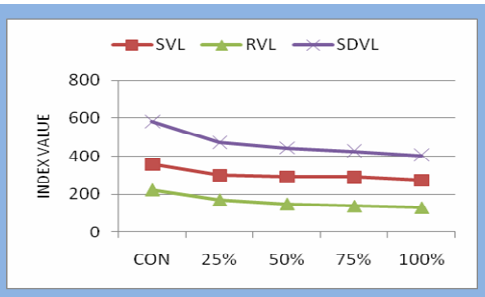

Figure 6.9.28. Effect of Jarul leaf extract on shoot vigour index, root vigour index and seedling vigour index of *Andrographis paniculata*

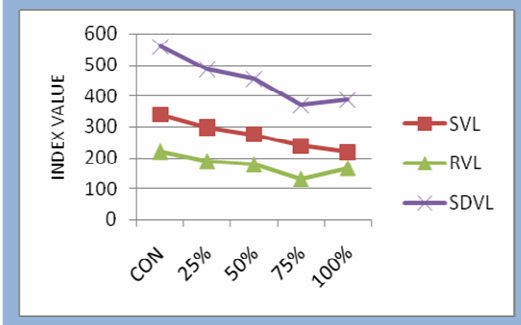

Figure 6.9.29. Effect of Jarul leaf extract on shoot vigour index, root vigour index and seedling vigour index of *Plumbago zeylanica*

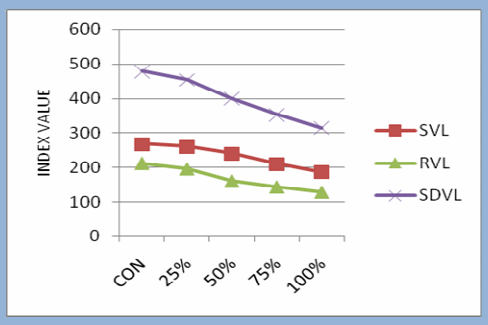

Figure 6.9.30. Effect of Jarul leaf extract on shoot vigour index, root vigour index and seedling vigour index of *Oxalis corniculata*

It has been mentioned earlier that the inhibition percentage of seed germination was very less in case of *Oxalis corniculata*. Higher concentration of extract (75 % and 100 %) showed only some impact on the seed germination and viability percentage of this cosmopolitan species with high ecological amplitude. Here, the shoot length inhibition was recorded to be 8.23 % and 10.78 % in 75 % and 100 % of extract concentrations; root length inhibition by 19.70 % and 22.69 % were recorded in 75 % and 100 % of extract concentration; and 13.24 % and 15.94 % of seedling length inhibition were found against 75 % and 100 % extract of Jarul leaf (Figure 6.9.25). The shoot, root and seedling vigour indices (SVI, RVI, SDVI) were also reduced at different concentrations of the extract. Shoot-root ratio was increased gradually along with the increased concentration of leaf extract and maximum value of the ratio was recorded to be 1.56 when trated with undiluted i.e. 100 % of the extract concentration, whereas in control it was calculated to 1.33. Production of fresh biomass was affected in the same manner and highest degree of inhibition of biomass was recorded in highest concentration of extract (Figure 6.9.30).

Figure 6(i). Working in forest and finding NTFPs: **a.** *Dioscorea pentaphylla* **b-d.** During field work; **e.** *Baccurea ramiflora;* **f.** Flower of *Oroxylum indicum*

Figure 6(ii). Rare and useful plants: **a.** *Gynocardia odorata* **b.** *Rauvolfia serpentina;* **c.** *Gynocardia odorata* seedling; **d.** *Abelmoschus moschatus;* **e.** *Dillenia pentagyna;* **f.** *Sloanea sterculacea*; (fruit) **g.** *Deeringia amaranthoides;* h. *Amorphophallus* sp.

Figure 6(iii). Threats to the forest and biodiversity: **a.** Fire damaged forest floor; **b.** Illegal cutting pit spotted in forest; **c.** Collection of fire wood

Figure 6(iv). Threats to the forest and biodiversity: **a.** Stump of a sal tree after Illegal felling; **b.** Rail road through the forest; **c.** Road for patrolling

Figure 6(v). Structural difference between plantation and natural forest: **a.** View of natural (left) and plantation forest (right); **b.** Forest floor of natural vegetation; **c.** Ground cover vegetation in teak plantation

Figure 6(vi). Some NTFPs : **a-c** Edible fungus; **d.** Ornamental fungus; **e.** *Dioscorea* tuber; **f.** *Helminthostachys zeylanica*- An edible but rare fern