CHAPTER: VI

DISCUSSION

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"Biological resources provide the basis of life" (Rai, 2006). However, we are overdrawing and exploiting these resources beyond the regeneration capacity (McNeely *et al*, 1990). Pattern of our natural resource use is environmentally destructive and contribute to human insecurity (Meadows *et al*, 1972; Cronin and Pandya, 2009). Population explosion and hunger for development has led to conversion of a substantial amount of forest land into vast non-regenerating areas (Sarkar and Chakrabarti, 2012). This pressure is changing the structural characteristics of forested vegetation quite rapidly (Sarkar *et al*, 2009). In the recent past, Joint Forest Management (JFM) programme in India has impacted positively in several parts. In West Bengal, this programme helped to intiate institution building in and around forest areas. This involvement of 'forest underclass' (Banerjee *et al*, 2010) in forest management enhanced the forest cover (Basu, 2013). In the northern part of West Bengal, Buxa Tiger Reserve (BTR) was also benefited from this programme. However, the return for protection of forest resources is negligible compared to their livelihood demand gradually vanished their interest in forest management and as a result most of these institutions have become defunct.

BTR is divided into 13 Forest Ranges and 47 Forest Beats (Das, 2000). Jainti, at the core area of BTR, is fallen under Jainti range, consisting of 4 Beats with 22 compartments. The study revealed the presence of three types of forest, namely riverine, sal forest and mixed forest without sal. However, two forest types are matching with the classification of Champion & Seth (1968) are: Riverine forests- Northern Dry Deciduous Seral Sal, Khair, Sisoo, Simul association [$5b/1S_2$]- and Sal forest- Eastern Bhabar and Terai Sal [$3C/C_{1b}$ and $3C/C_{1c}$].

Jainti forest is contiguous with the adjacent Phipsu Wildlife Sanctuary of Bhutan throughout its northern border (www.projecttiger.nic.in/buxa). Some areas of Jainti Rrange along with Phipsu Wild Life Sanctuary are in hilly areas. So, there is ample space for free flow of floristic elements between plains and hills. Vegetation and socio-ecological analysis has been done to understand the overall scenario and to tackle the challenges for conservation.

6.1. FLORA

No detailed floristic account of BTR is available. The present survey through 50 3-tiered sample plots in the study area recorded the existence of at least 95 families of vascular plants. Of which it is observed that Fabaceae is represented by highest percentage (9.69 %) of species and is followed by Rubiaceae (4.36 %), Meliaceae (3.39 %), Vitaceae (3.39 %), Lauraceae (3.15 %), Poaceae (3.15 %), Acanthaceae (2.91 %), Asteraceae (2.91 %), Orchidaceae (2.91 %), Rutaceae (2.91 %), and Lamiaceae (2.91 %) (Table 6.1).

Among the tree species enlisted during study period *Shorea robusta* is stood top of all other tree species with IVI score of 27.08, followed by *Dysoxylum mollissimum* (IVI: 14.98), *Polyalthia simiarum* (IVI: 13.56), *Duabanga grandiflora* (IVI: 13.28), and *Tetramemles nudiflora* (IVI: 12.01) (Annexure I). Highest IVI for shruby plants in the under-storey vegetation is registered by *Atalantia missionis* (IVI: 64.67) followed by *Mussaenda roxburghii* (IVI: 61.64), *Tabernaemontana divaricata* (IVI: 59.81), *Meyna spinosa* (IVI: 26.34), and *Bambusa tulda* (IVI: 25.17) (Annexure II). In herbs, *Panicum notatum* topped with the IVI score of 44.98 followed by *Globba bulbifera* (IVI: 20.39), *Alternanthera*

philoxeroides (IVI: 18.97), *Borreria alata* (IVI: 16.40), and *Lindernia parviflora* (IVI: 12.12) (Annexure III). Other important variables viz. Simpson's Dominance Index (SDI), Shannon–Weaver Index of Diversity (SWID) and Menhinick's Index of Species Richness are also considered to measure the Phytosociological afinities of plants.

Table 6.1. Dominant families and number of species

Family	Genera	Species
Fabaceae	26	40
Rubiaceae	15	18
Meliaceae	11	14
Vitaceae	7	14
Lauraceae	6	13
Poaceae	10	13
Acanthaceae	9	12
Asteraceae	12	12
Orchidaceae	8	12
Rutaceae	9	12
Lamiaceae	12	12

Among the tree species enlisted during study period *Shorea robusta* is stood top of all other tree species with IVI score of 28.08, followed by *Dysoxylum mollissimum* (IVI: 14.98), *Polyalthia simiarum* (IVI: 13.56), *Duabanga grandiflora* (IVI: 13.28), and *Tetramemles nudiflora* (IVI: 12.01) (Annexure I). Highest IVI for shruby plants in the under-storey vegetation is registered by *Atalantia missionis* (IVI: 64.67) followed by *Mussaenda roxburghii* (IVI: 61.64), *Tabernaemontana divaricata* (IVI: 59.81), *Meyna spinosa* (IVI: 26.34), and *Bambusa tulda* (IVI: 25.17) (Annexure II). In herbs, *Panicum notatum* topped with the IVI score of 44.98 followed by *Globba bulbifera* (IVI: 20.39), *Alternanthera philoxeroides* (IVI: 18.97), *Borreria alata* (IVI: 16.40), and *Lindernia parviflora* (IVI: 12.12) (Annexure III). Other important variables viz. Simpson's Dominance Index (SDI), Shannon–Weaver Index of Diversity (SWID) and Menhinick's Index of Species Richness are also considered to measure the Phytosociological afinities of plants.

6.2. EFFECT OF ALTITUDE ON FLORA AND VEGETATION

6.2.1. Altitude and Vegetation

Altitude creates some difference in occurrence of different species of plants. The important major factors those vary with altitude are temperature, light, precipitation, evaporation and length of season, which influence the growth of vegetationa (Shaw, 1909). In the present atudy area variation in the occurrence of trees and liana, shrubs tree saplings and seedlings and herbs have been observed and found majority of the species are located in alluvium plains part of the study area (tree & liana: 22.16 %; shrub & sapling: 43.55 % and herb & seedling: 32.31 %) (Table 6.2).

6.2.2. Altitude and NTFPs

High value NTFP – shrubs are growing in higher altitude and low value NTFP trees are growing in lower altitude (Sah and Dutta, 1996). Jainti is the habitat for 112 NTFP species and these species are found in different altitude (Fig 6.1). Alluvium plain is representing 45 % of NTFPs followed by alluvium plain to foot hills (15 %). 22 % are growing throughout the study area. As much as 51 % of harvested NTFPs are found in plains and foot hills (85 – 250 m).

Table 6.2. Species distribution on altitudinal variation

Range of Altitude (m.)	Tree & Liana	Shrub & Sapling	Herb & Seedling
85-149	37 (22.16 %)	27 (43.55 %)	74 (32.31 %)
150-250	32 (19.16 %)	7 (11.29 %)	38 (16.59 %)
>250	28 (16.77 %)	4 (6.45 %)	8 (3.49 %)
All altd. Studied	70 (41.92 %)	24 (38.71 %)	109 (47.60 %)
Total	167	62	229

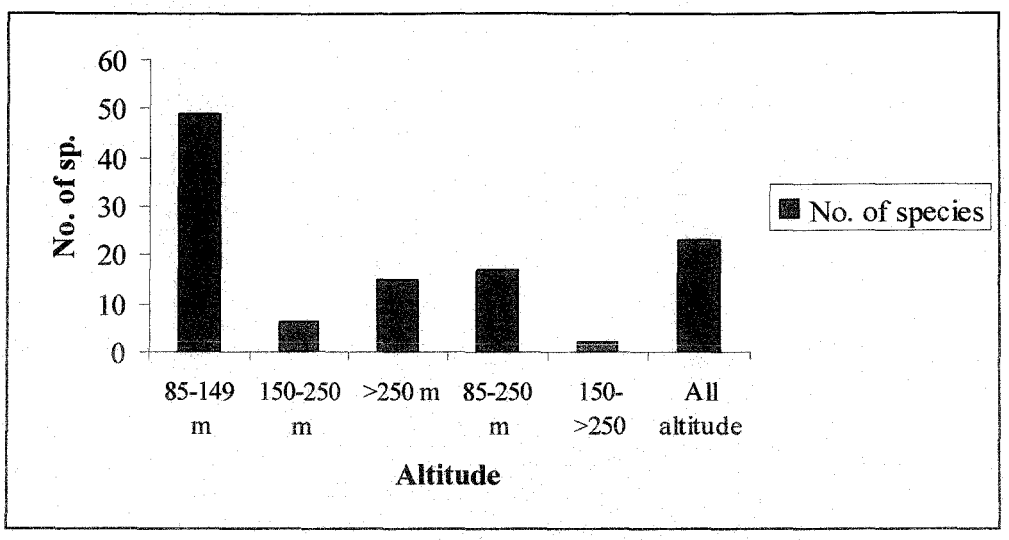

Fig 6.1. Distribution of NTFPs across the altitude

6.2.3. Altitude and volume of plants

Volume of tree and liana is highest (58.97 %) in the alluvium plain areas (85 – 149 m) of Jainti forest and lowest (04.07 %) in areas located over 250 m altitude. Similarly, volume of shrubs and saplings is highest (61.84 %) in the alluvium plains and lowest (03.59 %) in high (above 250 m) (Table 6.3).

Table 6.3. Variation in volume across different altitudinal ranges

Altitude (m.) Range	Volume M^3	
	Tree & Liana	**Shrub & Sapling**
85 – 149	3112.66 (58.97%)	7.45 (61.84%)
150 – 250	610.52 (11.57%)	1.32 (10.99%)
> 250	214.95 (04.07%)	0.43 (03.59%)
All altitude	1339.95 (25.39%)	2.84 (23.58%)
Total Volume	5278.09	12.05

6.2.4. Effect of altitude on crown and ground-cover

Altitudinal variations also determine the crown and ground cover percentage in the study area. In Jainti, crown and ground percentage is gradually decreasing with the increase of altude during winter and pre-monsoon. However, during post-monsoon lowest crown percent observed between 85-149 m altitude and ground cover is lower 150-250 m than >250 m. altitude. This is happening due to foliage type of species occupying the particular ares (Table 6.4).

Table 6.4. Effect of altitude on crown and ground-cover [C&G = Crown & Ground]

Altitudinal Range (m)	Winter (%)		Pre-monsoon (%)		Post-monsoon (%)	
	Tree	Herb	Tree	Herb	Tree	Herb
85 – 149	53.75	41.55	62.50	19.05	25.00	48.00
150 – 250	53.10	29.38	54.89	24.79	59.07	35.44
> 250	50.00	20.45	53.71	29.00	56.85	39.775

6.2.5. Altitude and Epiphyte

Prevalence of epiphyte is an indicator of forest condition. Good forest with old trees harbouring ample epiphytes. Survival of epiphytes depends on moisture content of the ambient atmosphere. The result of survey in Jainti forest is showing that the occurrence of epiphyte is inversely proportionate with the altitude. Highest average has been recorded in altitude between 85 – 149 m and lowest in areas over 250 m (Fig 6.2).

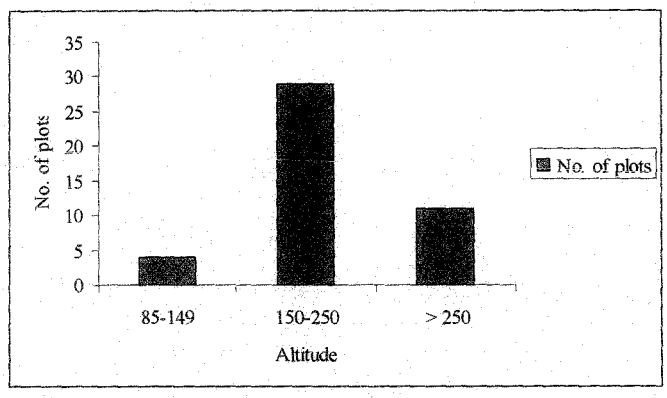

Fig 6.2. Effect of altitude on the occurance of epiphytes

6.3. EFFECT OF SLOPE ON FLORA AND VEGETATION

6.3.1. Slope and stem count

Direct effect of slope on the growth of floral species in Jainti forest is not prominent. However, stem count of trees and shrubs varies (Table 6.5).

Table 6.5. Impact of stem counts on plot slope

Range of slope	Avg. of three seasons	Winter		Pre-Monsoon		Post-Monsoon	
	Tree & liana	Shrub & sapling	Herb & seedling	Shrub & sapling	Herb & seedling	Shrub & sapling	Herb & seedling
0°	8.44	5.92	64.77	6.08	63.58	3.07	13.11
1– 10°	7.97	5.50	98.00	0.50	25.5	1.94	13.39
11-20°	9.67	2.00	17.00	0.00	27.00	0.50	13.67
21-30°	8.78	6.00	29.33	7.50	70.50	4.00	20.00
31-40°	5.52	3.44	28.75	4.50	48.75	3.00	8.00
41-50°	3.33	4.00	12.00	3.00	41.00	0.00	0.00
51-60°	2.67	0.00	0.00	0.00	40.00	0.00	0.00
61-70°	1.00	2.00	18.00	0.00	0.00	0.00	0.00

Average tree and liana stem count is highest (9.67) in slope between 11° – 20° followed by 21° – 30° (8.78), 0° (8.44), 1° – 10° (7.97). Highest stem count for shrubs and saplings in three seasons – winter, pre-monsoon and post-monsoon is in slope between 21° – 30°. Similarly highest stem of herbs and seedlings in three respective seasons is also recorded in slope between 1° – 10° during winter and recorded data showed highest stem (20) during post-monsoon recorded between 21° – 30°. So, general analysis finds 21° – 30° slope is the most suitable for floral growth (Table 6.5; Fig 6.3).

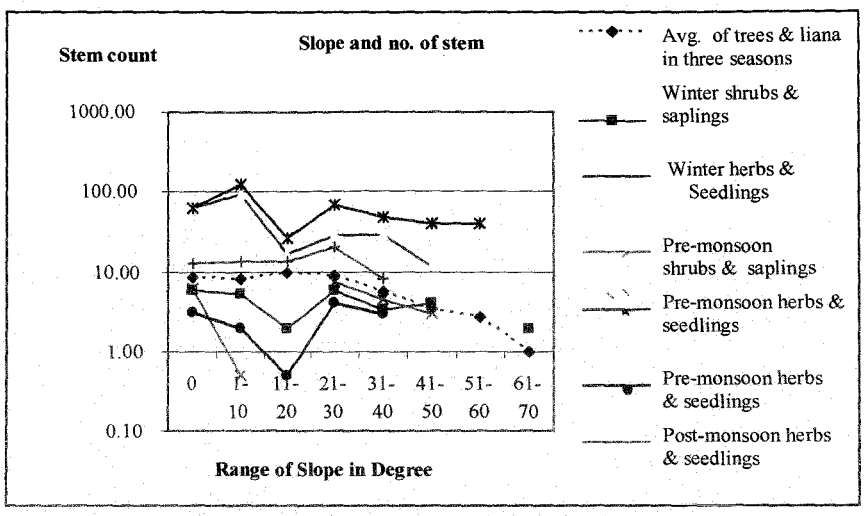

Fig 6.3. Variation in stem count in plots on different slopes

6.3.2. Slope on vegetation volume

Volume of trees and liana measured highest (1894.98 M^3) in areas with no slope or is on alluvium plain. Shrubs and sapling studied during winter and pre-monsoon noted for the highest volume (6.53 M^3 and 10.08 M^3) in alluvium plain. However, during post-monsoon highest volume of shrub and sapling is found in slope between 1° – 10° (198.27 M^3). Overall observation revealed that volume of plant is better in areas without slope and it decreases with the increase of slope angle. The most unsuitable slope for volume concern is between 51° – 60° for the present study area. It is also observed that, shrub and sapling volume is measurably low during winter and pre-monsoon (Table 6.6 and Fig 6.4).

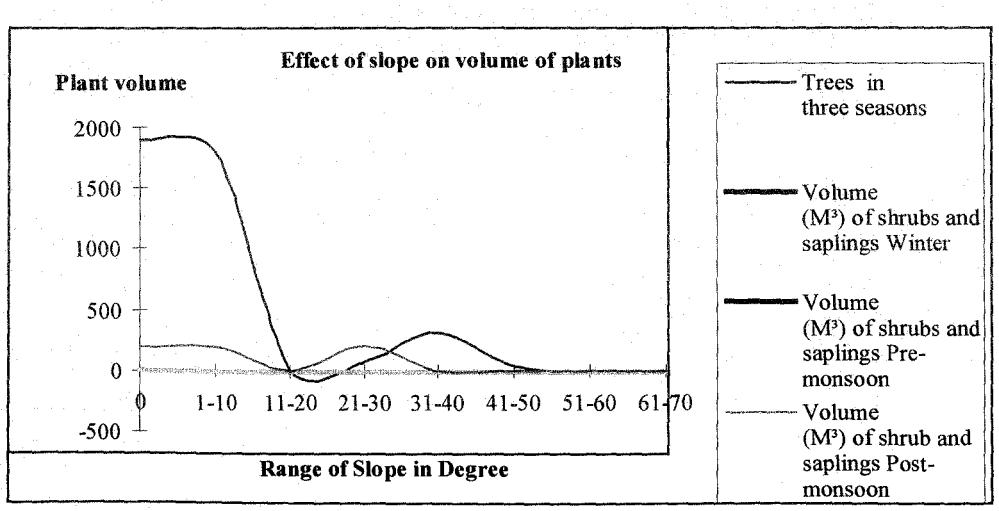

Fig 6.4. Effect of slope on floral volume

Table 6.6. Effect of slope on floral volume

Range of slope in Degree	Tree & Liana in three Seasons	Volume (M^3) of Shrub and Saplings		
		Winter	Pre-monsoon	Post-monsoon
0°	1894.98	6.53	10.08	193.57
1-10°	1795.22	2.33	0.001	198.27
11-20°	16.95	0.02	0.00	3.09
21-30°	77.06	0.35	0.62	211.50
31-40°	307.66	2.47	0.18	0.00
41-50°	33.81	0.25	0.00	0.00
51-60°	0.00	0.00	0.07	0.00
61-70°	1.49	0.089456	0.00	0.00

6.4. EFFECT OF ASPECT ON FLORA AND VEGETATION

6.4.1. Aspect and vegetation

Aspect of a plot is generally ignored. However, present study has given importance to this and data showed its impact on the number of stems. East aspect denoted the highest stem count per plot for trees and liana. In terms of shrubs and saplings, number of highest stem has been found in alluvium plain in all the three seasons. But, the number of herbs and seedlings varies season to season (Table 6.7).

Table 6.7. Impact of stem count on plot aspect

Aspect	Tree & liana	Avg. of three seasons					
		Winter		Pre-monsoon		Post-monsoon	
		Shrub & Sapling	Herb & Seedling	Shrub & Sapling	Herb & Seedling	Shrub & Sapling	Herb & Seedling
Alluvium plain	10.69	5.73	64.77	6.08	67.39	3.07	13.11
North	6.25	5	39.25	15	19.5	0	0
Northeast	12.00	0.5	24	0	0	0	0
East	13.00	5	122	0	41	6	14.5
Southeast	10.14	4.71	83.43	1.33	37.67	0.25	15
South	8.00	5	61.5	2	33	1	13.75
Southwest	0.00	0	0	2.33	102	2.83	11.5
West	6.50	5.5	55.5	0	0	1.25	18.25
Northwest	7.75	4.25	26	3.5	149	2	3.5

6.4.2. Aspect and vegetation volume

Like the stem count, aspect is also affecting on plant volume. Highest volume, 1132.96 M^3 of trees and liana is found in Northwest aspect. But, highest volume of shrubs and saplings is collected in different aspects in different seasons (Table 6.8).

6.4.3. Major soil nutrients and other components

Soil is like a mothers womb sheltered innumerable numbers of living beings. Most of the flora grows on the soil and nourished by the components present there. A few of those are moisture, pH, organic carbon (OC), Nitrogen (N), Phosphorus (P), Potassium (K) and Sulphur (S). Growth of a plant, its flowering and fruiting depends greatly on the availability of nutrients in soil (Burkley and Irwin, 2009).

Soil moisture is a medium of solution where different nutrients retain. Plants absorb water as a solution to get necessary nutrients. pH is expressing the value of acidity or alkalinity of a solution and it determines the concentration of Hydrogen ion in it. Salinity inhibits the normal growth of a plant (Lauchli and Grattan, 2007; Jaleel *et al*, 2008). Soil in study area has a tendency towards neutrality. Soil Carbon provides the structural growth of floras (Ellert *et al*, 2008). Higher production of plants is observed by CO_2 fertilization (Conte, 2009). On the other hand, combination of organic matter and mineral provides the ideal environment for plants' growth (Eid *et al*, 2006). Organic matter helps soil to retain water.

According to Lovblad (2000), atmospheric deposition of nitrogen provides a significant nutrient input to both terrestrial and marine ecosystems. It is biologically combined with Carbon, Hydrogen, Oxygen, and Sulphur to create amino acids – the building blocks of proteins (Uchida, 2000; Persson, 2000). Soil Nitrogen availabity has strong positive effect on reproduction of different plants (Munoz *et al*, 2005). Supply of Nitrogen regulates the interactions between different trophic levels (Hogberg *et al*, 2000). Like Nitrogen, Sulphur is also an essential nutrient to plant. It's deficiency decreses the yield of vegetation (Awad *et al*, 2011). Necessary amount of Potassium required for branching and days required for emergence of flower bud (Pal and Ghosh, 2010). This also increases Nitrogen, Phosphorus and chlorophyll content in leaves. Posphorus helps plants to increase fine litter production and take important role in nucleotide production. Nitrogen, Phosphorus and Potassium provide good structural and functional growth to a plant (Wright *et al*, 2011; Awad *et al*, 2011; Eni *et al*, 2012).

Vegetation and soil are interrelated and provide reciprocal effects on each other (Eni *et al*, 2012; Gairola *et al*, 2012). N_2 is bonded in the soil by biotic components. P and K are produced from the degradation of rock. In Jainti, P and K are readily available due its geological advantage. According to Marx *et al* (1999), presence of < 10 ppm Nitrogen, >10 ppm of Phosphorus, > 150 ppm of Potassium and > 2 ppm Sulphur are considered as low for better plant health. According from this standard, overall observation of soil in studied area indicates low quantity of Nitrogen and Potassium and very high quantity of Phosphorus and Sulphur is present. However, apparently, variation of soil nutrients in different seasons at varied topography do not disturb floral growth and their existence in studied plots (Oliveira-Filho *et al*, 1994) as there is no information available to compare those.

Table 6.8. Impact of plot aspect on vegetation volume

Plot Aspect	Average Tree & Liana Volume (M^3)	Volume (M^3) of Shrub and Sapling		
		Winter	Pre-monsoon	Post-monsoon
Alluvium plain	190.94	0.00	361.98	193.57
North	197.62	0.00	16.44	0.00
Northeast	69.14	0.01	0.00	0.00
East	112.45	0.15	0.00	193.57
Southeast	223.90	0.00	211.50	16.44
South	16.52	0.00	3.09	166.47
Southwest	0.00	0.00	11.40	214.60
West	3.66	0.00	0.00	12.97
Northwest	1132.96	1.16	0.07	1.95

6.5. PHYTOSOCIOLOGY

Phytosociology has been calculated between 10 dominant tree and liana species and 10 herb species. This may be due to the affection between trees and lianas or herbs or between trees and lianas and herbs and seedlings.

All the 9 dominat tree species, except *Tetrameles nudiflora* are comfortable to grow in association with *Shorea robusta*. *Shorea robusta* and *Tectona grandis* has weak relationship. *Schima wallichii* has strong association with *Shorea robusta* and comparatively weak relationship with remaining species. It has no relation with *Tetrameles nudiflora* and *Aphanamixis polystachia*. *Duabanga grandiflora* is well associated with *Aphanamixis polystachia* and has no relation with *Dysoxylum mollissimum*, *Tetrameles nudiflora* and *Magnolia pterocarpa*. *Polyalthia simiarum* formed good association with *Magnolia pterocarpa*, *Shorea robusta* and *Dysoxylum mollissimum* and do not grow with *Tetrameles nudiflora* and *Tectona grandis*. *Tetrameles nudiflora* is growing only in association with *Magnolia pterocarpa*. *Wendlandia coriacea* has no association with these dominant species. *Magnolia pterocarpa* is growing in association with most of the species excluding *Duabanga grandiflora*, *Tetrameles nudiflora* and *Tectona grandis*. *Tectona grandis* is somehow associated with *Shorea robusta*, *Schima wallichii* and *Polyalthia simiarum*, but, it prefers to grow alone.

Dominant shrub, *Atalantia missionis* is forming a strong association with *Mussaenda roxburghii* and *Meyna spinosa*. However, a few other species like *Bambusa tulda*, *Tabernaemontana divaricata*, *Clerodendrum infortunatum* and *Eranthemum grifithii* has weak association. *Mussaenda roxburghii* has formed an association with *Atalantia missionis* and *Eranthemum grifithii*. *Meyna spinosa* is socializing strongly with *Atalantia missionis* and a weak association with *Citrus limon*. *Citrus limon* is growing with *Atalantia missionis* and *Mussaenda roxburghii*. *Eranthemum grifithii* is growing with *Tabernaemontana divaricata*, *Mussaenda roxburghii* and *Atalantia grifithii*. *Arbotrys caudatus* is only associated with *Atalantia missionis*. *Bambusa tulda* and *Buddlejia asiatica* have no associated species.

Panicum notatum is forming an association with *Globba bulbifera*, *Borreria alata*, *Alternanthera philoxeroides*, *Lindernia parviflora*, *Cynodon dactylon* and *Eragrostis tenella* and has no association with *Barleria prionitis* and *Bulbophyllum careyanum*. *Globba bulbifera* is associated with *Panicum notatum*, *Alternanthera philoxeroides* and *Borreria alata*. *Borreria alata* has good association with all species except *Cynodon dactylon* and *Eragrostis tenella*. *Lindernia parviflora* has no association with *Cynodon dactylon*. *Barleria prionitis* is socializing with *Borreria alata*, *Lindernia parviflora*, *Eragrostis tenella*, *Piper mullesua* and *Bulbophyllum careyanum*. *Cynodon dactylon* has a weak association only with *Panicum notatum*. *Eragrostis tenella* is associated to *Alternanthera philoxeroides*, *Lindernia parviflora* and *Barleria prionitis*. *Piper mullesua* is associated with most of the species except *Alternanthera philoxeroides*, *Cynodon dactylon* and *Eragrostis tenella*. *Bulbophyllum careyanum* has strong association with *Borreria alata*, *Lindernia parviflora*, *Barleria prionitis* and *Eragrostis tenella*.It has weak association with other dominant species and no association with *Cynodon dactylon* and *Panicum notatum* (Table 6.9).

6.5.1. Phytosociology of NTFPs

Eighteen species of NTFPs (*Mangifera indica*, *Sorindeia madagascariensis*, *Litsea cubeba*, *Caryota ochlandra*, *Psidium guajava*, *Calamus acanthospathus*, *Thysanolaena latifolia*, *Acacia catechu*, *Musa paradisiaca*, *Bauhinia scandens*, *Piper sylvaticum*, *Piper pedicellatum*, *Lindernia crustacea*, *Wendlandia coriacea*, *Aegle marmelos*, *Ficus cunia*, *Alpinia calcarata* and *Ipomoea batatas*) has no association with any one of the 10 dominant tree species.

Wendlandia coriacea (except few plots), *Syzygium praecox*, *Aegle marmelos*, *Macaranga indica*, *Lagerstroemia hypoleuca*, *Pterospermum acerifolium*, *Careya arborea*, *Eugenia formosa*, *Mangifera indica*, *Callicarpa arborea*, *Phyllanthus fraternus*, *Engelhardtia spicata*, *Bauhinia acuminata*, *Tetrameles nudiflora* etc are less dominant plants and are forming an association. However, shrub and herb species have no such special social affection within their own habit groups.

During analysis of togetherness of NTFP plants, it is expected that at least in five plots they should be phytosociologically strongly affiliated and less than 5 would be taken as phytosociologically weak. In terms of these criteria *Shorea robusta* have strong sociology with 7 NTFP spcies (*Sida acuta, Clausena excavata, Tinospora crispa, Dioscorea prazeri, Polyalthia simiarum, Duabanga grandiflora* and *Piper betloides*. *Dysoxylum mollissimum* has strong phytosociology with 2 species, *Shorea robusta* and *Dioscorea prazeri*. *Polyalthia simiarum* is phytosociologically associated with *Clausena excavata* and *Shorea robusta*. Similarly strong phytosociology was determined between *Duabanga grandiflora* with 12 species (*Quercus spicata, Clausena excavata, Tinospora crispa, Smilax ovalifolia, Piper pedicellatum, Dysoxylum mollissimum, Shorea robusta, Piper mullesua, Amoora spectabilis, Magnolia pterocarpa, Piper betloides* and *Neocinnamomum caudatum*); *Tetrameles nudiflora* with 9 species (*Quercus spicata, Clausena excavata, Tinospora crispa, Smilax ovalifolia, Polyalthia simiarum, Piper pedicellatum, Dysoxylum mollissimum, Piper mullesua, Piper betloides* and *Magnolia pterocarpa*) and *Wendlandia coriacea* with 15 species (*Cheilocostus speciosus, Quercus spicata, Stephania japonica, Curculigo orchioides, Bambusa tulda, Polyalthia simiarum, Fagerlindia fasciculata, Stephania glabra, Calamus viminalis, Schima wallichii, Luffa aegyptiaca, Shorea robusta, Piper mullesia, Morus laevigata* and *Piper betloides*); and *Aphanamixis polystachya* is with 9 species (*Quercus spicata, Clausena excavata, Smilax ovalifolia, Polyalthia simiarum, Piper pedicellatum, Shorea robusta, Piper mullesua, Amoora spectabilis*, and *Piper betloides*). *Magnolia pterocarpa, Schima wallichii* and *Tectona grandis* has not found any phytosociologically strong associate.

Table 6.9. Phytosociology between dominant trees and herbs (Present/Plot)

Name of Plants	*Shorea robusta*	*Dysoxylum mollissimum*	*Polyalthia simiarum*	*Duabanga grandiflora*	*Tetrameles nudiflora.*	*Wendlandia coriacea*	*Aphanamixis polystachya*	*Magnolia pterocarpa*	*Schima wallichii*	*Tectona grandis*
Shorea robusta	2	2	5	3	14	3	1	3	2	4
Dysoxylum mollissimum	1	2	4	2	9	0	0	1	1	5
Polyalthia simiarum	0	1	4	2	10	1	1	0	4	3
Duabanga grandiflora	0	1	2	2	12	7	1	10	5	5
Tetrameles nudiflora.	0	3	3	4	16	7	1	7	6	7
Wendlandia coriacea	0	0	1	0	0	0	0	1	0	0
Aphanamixis polystachya	0	0	1	0	2	0	0	0	1	0
Magnolia pterocarpa	0	0	1	0	8	5	0	8	2	2
Schima wallichii	0	1	0	1	3	0	0	0	2	1
Tectona grandis	0	0	1	0	4	0	0	0	3	0

6.5.2. Effect of crown-cover on ground-cover

Jainti forest is not truly dominated by any forest type. This is a mixture of types prevailing in the entire area. Crown or ground cover percent does maintain around 50 % in the sample plots. Post-monsoon study recorded highest crown and ground cover due to much favorable moisture content in the habitat. During winter crown cover is less due to leaf shedding of deciduous plants. Ground cover starts to dry up and this rate is slower than shedding off of tree-leaves. New leaves on trees appear early in pre-monsoon period. However, ground vegetation takes little more time for new leaves to appear (Table 6.10; Fig 6.5). This is due to the deep-seated roots of trees can draw water from deeper layers of soil and herbs draw water only from the upper much drier surface-layer, which remain almost dry during pre-monsoon.

Crown cover and ground cover is inversely proportional. However, this may vary in slopes. In this study highest ground cover (91.5 %) has been noted in plot no. 32 during post-monsoon where crown cover percent is also high (75 %). Slope of the plot is 16° and this is allowing sunlight to the ground avoiding the crown hindrance (Fig 6.6).

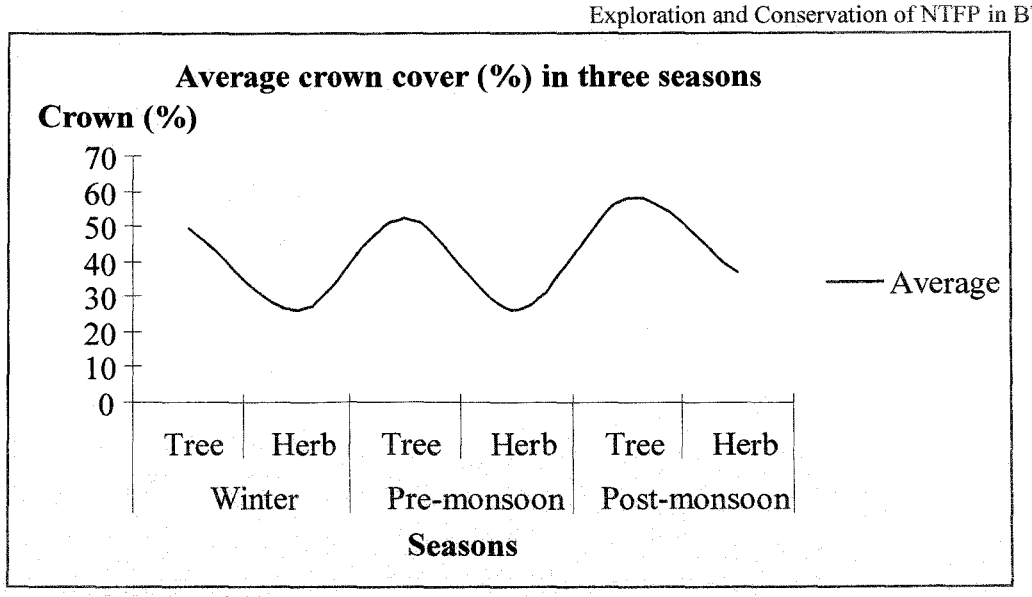

Fig 6.5. Average crown & ground cover across the seasons

Table 6.10. Average crown cover and ground cover across the seasons

Crown (%)	Winter		Pre-monsoon		Post-monsoon	
	Tree	Herb	Tree	Herb	Tree	Herb
Average	49.3	26.40	52.28	25.96	58.14	36.75

In addition to that, face of the plot plays a role for growth of ground cover. Normal scenario of crown and ground cover proportion in plot no. 32 is overruled and face might have an active role with slope. South-west face has exposed the plot maximum time to the sun light and influencing the growth of ground cover. Percent of light allowed by the crown cover is the source of light for the ground vegetation. During winter and pre-monsoon around 50 % light is obstracted by the crown cover and 25 % of remaining light is absorbed by the ground covering vegetation. Rest of light is warming up the ground soil. However, during post-monsoon around 41 % light is penetrating through crown of which 36 % of light is used by the ground vegetation and remaining 5 % is touching the ground. This creates a favourable condition for seed germination of a large number of floral species.

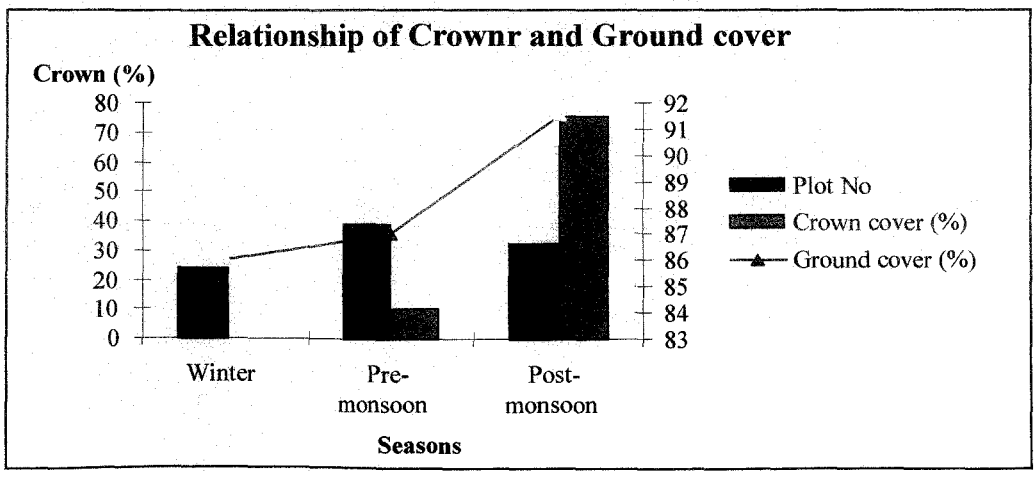

Fig 6.6. Comparabale chart of seasonal crown vs. ground cover in studied plots

6.5.3 Simpson's dominance Index (SDI)

The determined SDI of herb species is 0.94548870. Highest SDI has been recorded against *Panicum notatum* (0.9682947) followed by *Globba bulbifera* (0.9917742), *Alternanthera philoxeroides*. (0.9977471), *Eragrostis tenella* (0.9981543), *Borreria alata* (0.9983207), etc. (Table 6.11; Annexure III).

Table 6.11. Simpson's index of ten dominant herbs

Family	Scientific Name	SDI
Poaceae	*Panicum notatum*	0.9682947
Zingiberaceae	*Globba bulbifera*	0.9917742
Amaranthaceae	*Alternanthera philoxeroides*	0.9977471
Poaceae	*Eragrostis tenella*	0.9981543
Rubiaceae	*Borreria alata*	0.9983207
Poaceae	*Cynodon dactylon*	0.9987599
Linderniaceae	*Lindernia parviflora*	0.9990897
Orchidaceae	*Bulbophyllum careyanum*	0.9990897
Acanthaceae	*Barleria prionitis*	0.9991849
Piperaceae	*Piper mullesua*	0.9994130

Table 6.12. Simpson's index of ten dominant shrubs

Family	Scientific Name	SDI
Apocynaceae	*Tabernaemontana divaricata*	0.9062
Rubiaceae	*Mussaenda roxburghii*	0.9234
Poaceae	*Bambusa tulda*	0.9724
Rubiaceae	*Meyna spinosa*	0.9833
Verbenaceae	*Clerodendrum viscosum*	0.9993
Rutaceae	*Citrus limon*	0.9993
Acanthaceae	*Eranthemum griffithii*	0.9996
Rutaceae	*Atalantia missionis*	0.9998
Scrophulariaceae	*Buddleja asiatica*	0.9998
Annonaceae	*Artabotrys caudatus*	1.0000

Table 6.13. Simpson's index of ten dominant trees

Family	Scientific Name	SDI
Dipterocarpaceae	*Shorea robusta*	0.98782
Euphorbiaceae	*Polyalthia simiarum*	0.993033
Meliaceae	*Dysoxylum mollissimum*	0.997514
Theaceae	*Schima wallichii*	0.998755
Magnoliaceae	*Magnolia pterocarpa*	0.998832
Apocynaceae	*Wrightia arborea*	0.999473
Euphorbiaceae	*Trewia nudiflora*	0.999616
Myrtaceae	*Syzygium praecox*	0.999699
Meliaceae	*Chisocheton cumingianus*	0.999772
Fabaceae	*Dalbergia stipulacea*	0.999834

Similarly, the determined SDI of shrubs is 0.7871. Highest SDI recorded against *Tabernaemontana divaricata* (0.90621) followed by *Mussaenda roxburghii* (0.92342), *Bambusa tulda* (0.97244), *Meyna spinosa* (0.98333), etc. (Table 6.12; Annexure II).

For trees, the determined SDI is 0.9646. Highest SDI is recorded against *Shorea robusta* (0.98782) followed by *Polyalthia simiarum* (0.993033), *Dysoxylum mollissimum* (0.997514), *Schima wallichii* (0.998755), etc. (Table 6.13; Annexure I).

6.5.4 Shannon - Weaver Index of Diversity (SWID)

The determined SWID for herbs is 3.771. Highest SWID is registered by *Panicum notatum* (0.0590) and is followed by *Globba bulbifera* (0.0418), *Alternanthera philoxeroides* (0.0278), *Eragrostis tenella* (0.0260), *Borreria alata* (0.0252), etc. Highest SWID ranked ten herbs has been given in Table 6.14 and the details in Annexure III.

Table 6.14. Shannon-Weaver index of dominant ten herb species

Family	Scientific Name	SWID
Poaceae	*Panicum notatum*	0.0590
Zingiberaceae	*Globba bulbifera*	0.0418
Amaranthaceae	*Alternanthera philoxeroides*	0.0278
Poaceae	*Eragrostis tenella*	0.0260
Rubiaceae	*Borreria alata*	0.0252
Poaceae	*Cynodon dactylon*	0.0227
Linderniaceae	*Lindernia parviflora*	0.0203
Orchidaceae	*Bulbophyllum careyanum*	0.0203
Acanthaceae	*Barleria prionitis*	0.0195
Piperaceae	*Piper mullesua*	0.0173

SWID for shrubs is 1.794. Highest SWID is observed in *Tabernaemontana divaricata* (0.08792) followed by *Mussaenda roxburghii* (0.08632), *Bambusa tulda* (0.07282), *Meyna spinosa* (0.06485), etc. SWID of top ten shrubs is presented in Table 6.15 and details in Annexure II.

Table 6.15. Shannon-Weaver index of dominant ten shrub species

Family	Scientific Name	SWID
Apocynaceae	*Tabernaemontana divaricata*	0.08792
Rubiaceae	*Mussaenda roxburghii*	0.08632
Poaceae	*Bambusa tulda*	0.07282
Rubiaceae	*Meyna spinosa*	0.06485
Verbenaceae	*Clerodendrum viscosum*	0.02513
Rutaceae	*Citrus limon*	0.02513
Acanthaceae	*Eranthemum griffithii*	0.02038
Rutaceae	*Atalantia missionis*	0.01503
Scrophulariaceae	*Buddleja asiatica*	0.01503
Annonaceae	*Artabotrys caudatus*	0.00875

The calculated SWID for trees is 4.095. SWID for trees is dominated by *Shorea robusta* (0.047588), *Polyalthia simiarum* (0.040602), *Duabanga grandiflora* (0.034657), *Dysoxylum mollissimum* (0.029385) and *Tectona grandis* (0.025744). However, the interesting thing observed that *Wrightia arborea* (0.017211) and *Trewia nudiflora* (0.015358) with low IVI score is positioned into the list of top ten SWID scores (Table 6.16). Details SWID for trees is given in Annexure I.

Table 6.16. Shannon-Weaver index of dominant ten trees

Family	Scientific Name	SWID
Dipterocarpaceae	*Shorea robusta*	0.047588
Euphorbiaceae	*Polyalthia simiarum*	0.040602
Lythraceae	*Duabanga grandiflora*	0.034657
Meliaceae	*Dysoxylum mollissimum*	0.029385
Lamiaceae	*Tectona grandis*	0.025744
Theaceae	*Schima wallichii*	0.02328
Magnoliaceae	*Magnolia pterocarpa*	0.022768
Rubiaceae	*Wendlandia coriacea*	0.017807
Apocynaceae	*Wrightia arborea*	0.017211
Euphorbiaceae	*Trewia nudiflora*	0.015358

6.5.5 Menhinick index of Species Richness

Species Richness of trees is highest (5.254) followed by herbs (2.457) and shrubs (1.018). Richness of saplings is 3.742 and seedlings is 4.902. Species Richness of seedlings and saplings reveals that the seeds of some plants are germinating but fail to survive till maturity due to different habitat factors.

6.6. MORTALITY AND ITS IMPACT

Among the recorded 176 species of vascular plants, number of species of seedling and tree is equal i.e. 19 or 12.1 %, seedling has not found in 14.6% (23) species and tree is absent in 7% (11) species. Absence of seedling stage of a species in the vegetation indicates its vulnarability. Species absent in both seedling and sapling stages indicates that the species is under threat. On the other hand, absence matured stage of a tree species indicates its new arrival in the area. So, this study shows 7 % of species arrived or introduced newly in Jainti forest. 14.6 % species are threatened and 12.1 % are vulnarable. Details are given in Annexure IX and Graph 6.7.

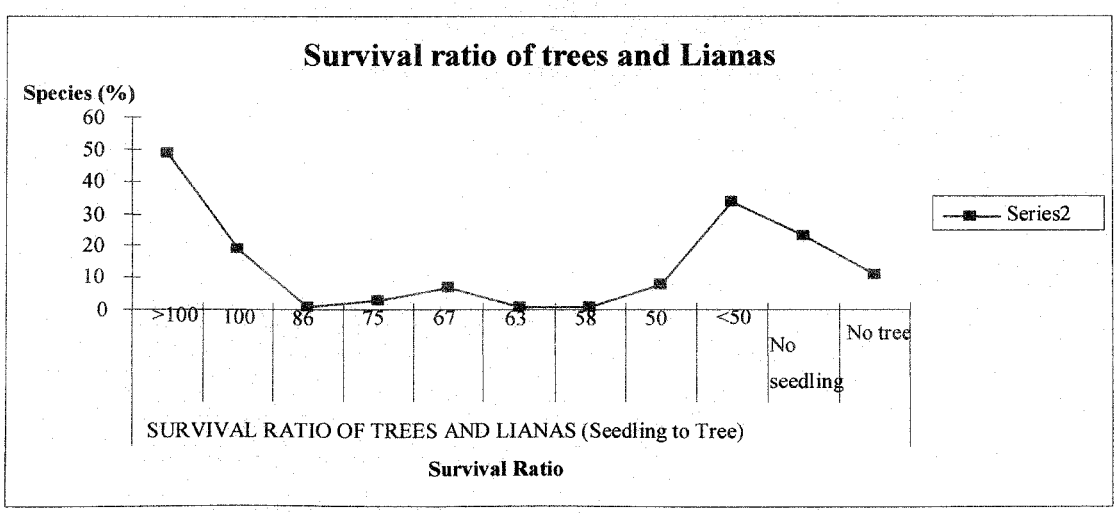

Fig 6.7. Survival ratio of tree, lianas & 8 shrub species

6.7. THREATENED AND ENDANGERED SPECIES

CITES list of species, shows that, two species in Jainti forest area are under category II (www.bsi.gov.in), and are *Rauvolfia serpentina* and *Dioscorea deltoidea.* But, both the species are commercially important

to the locals. In addition, some other plants like *Angiopteris evecta*, *Rubia manjith, Wendlandia coriacea* and *Entada phaseoloides* are extremely rare in the vegetation and are locally endangered.

6.8. SOCIO-ECOLOGICAL RELATIONSHIP

People of Jainti are extracting 35 species of commercial importance to maintain their livelihood except for their dependent species for fuel wood and fodder. Quantitatively, Broom stick, Bet leaf, Tanki fruit, Dhundul chhobra (fibrous mesocarp) and Narikeli fruits are harvested in more than one lakh pieces and more than one lakh kilograms harvested products are Ritha, Bet fruit, Phirphire fruit, Sikakai fruit and Lali fruit. However, in terms of cost, Chilauni fruit and leaf of Basak are recorded the highest price of Rupees 200 per kg (Annexure X).

6.8.1. Impact of NTFP on local economy

Gross annual income of NTFP harvesters is around Rs.5768870.00 (Rupees Fifty seven lakh sixty eight thousand eight hundred seventy only). Monthly average income is recorded as Rs.2716.00 per family. Per capita daily income among the NTFP harvesters from this resource is Rs.18.40. As per state average most of the NTFP harvesting families are enjoying better life taking into consideration Rs.350.17 as the demarcation of Below Poverty Line (BPL).

Recently, since 2006, Forest Department slowly allowed collecting boulders from the Jainti River and in February 2008 the scarcity of labourer has been noted. Recently, income in most of the families increased many folds (Rs. 500/- per day) compared to as in 2000 (Sarkar and Das, 2012). A few ecotourism resorts are also providing employment to the Jainti residents. In addition, 11 self-help groups were also formed. So, the dependence of Jainti villagers on NTFPs is decreasing gradually. However, the harvesters from Nurpur area are not sparing the forest even today. They are increasing their harvest and the loss of the forest is also increasing in parallel.

6.9. ROLE OF LOCAL MANAGEMENTS: COMMUNITY INSTITUTIONS

There are three user groups (people of Jainti, BBBL and Nurpur) using Jainti forest. These user groups were the part of three protection committees. However, these protection committees are now almost defunct. So, there is no effective community institution to manage the forest resources.

6.10. FUTURE CHALLENGE

The challenge is one, the conservation. Conservation of forest resources has to be achieved for the nature and for mankind. It is essential to find out the basic problem(s) and to find out ways to manage it. Presently, Nurpur user group is the primary threat against conservation. To resist these people the JEDC may be re-energized. At the time of renewal of boulder lifting liscence FD may link the clause of protection. Getting liscence, every liscence holder has to pay for a number of people. Payment procedure could be furnished through consultation with FD and local institutions.

Human Resource Mangement (HRM) is a tough task for the Range Officers. FD may consider appointing a HRM at Jainti range to handle and strengthen the basic goal of conservation. NTFPs are harvesting regularly. FD in consultation with local user groups may organize training to produce finish products and for that small facilities might be created locally. Handful products shall have to choose to initiate the process. This will reduce the quantity of harvest and will reduce pressure on resources in one hand but will increase the income of the involved people.

6.11. CONCLUSION

Phytosociology and phytogeography influences on the growth of NTFP species. Small variables like crown cover, altitude, face of the area and even slope have effect on the growth and existence of NTFP species. NTFPs are the life saving resource to the dwellers of Jainti. Market within 30 km bestwoed these people to sale some commercially demanded species and to earn a handsome!! However, over exploitation of *Acacia catechu*, *Rubia manjith*, *Rauvolfia serpentina*, *Firmiana colorata*, *Asparagus racemosus* and *Acacia concinna* have become rare in this forest.

6.11.1. Locational disadvantage and ethnobotanical knowledge

Locational disadvantage taught these people to use local resources. These isolated people maintain their own economy and science (Rai *et al*, 1998). They are using a handful plant species as life saving medicine. Jharkhandis and Nepalese are mostly using these medicines. Biharies and Bengalies mostly avoid as they don't have such ethnobotanical knowledge.

6.11.2. Alternate livelihood option(s) and forest dependance

Boulder lifting has been allowed since 2006 which has reduced the dependence on NTFPs. However, Nurpur people took it as an advantage to harvest more NTFPs from the forest. To tackle this situation a special team of FD may be created for Jainti. This group, with the help of Jainti villagers, can frame suitable strategies to tackle this problem. Appointing a Human Resource Manager is a necessity to form a pro-conservation group and to move forward. Existing resource sharing formula between FD and JEDC was a part of National Programme. However, to motivate these people, a new resource sharing mechanism needs to be framed.

6.11.3. Value addition of NTFPs to reduce exploitation

Harvested species with enough commercial demand are going directly to the nearest markets. Value addition to some selected products will reduce the harvested quantity as well as will help to raise their income. So, FD or other agency could arrange annual training programme on this purpose and will establish some small cottage-level manufacturing units for the utilization and manufacture of different finished marketable products. This will promote the local economy, and will help to reduce the gap between locals and FD staffs.

6.11.4. Soil management for nutritional rejuvenation

Overall observation of soil in studied area indicates low amount of Nitrogen and Potassium. Presence of Phosphorus and Sulphur is very high. So, a proper management system may be adopted to reclaim the amount of Nitrogen and Potassium in the forest area.

6.11.5. Management(s) in forest conservation

Lack of trust between villagers and FD is also affecting the issue of conservation. Building trust with the people is the responsibility of the FD and they have to show their willingness and trustworthiness. Institutions formed under JFM programme has to be rejuvenated to speed up the conservation goal in BTR. National and State Governments have to be worked out the legality to give the right to use certain portion of land to the local dwellers. Present set of National Forestry laws does not allow self-governance initiative by the local communities (Chakrabarti *et al*, 2004). So, the right on the property to be defined accordingly and that should be legally valid. Accordingly, appropriate legislation need to be framed by both National and State Governments in this regard.

6.11.6. Transboundary National Park to conserve BTR

Mining in adjoining Bhutan territory has raised question regarding the stability of this reserve. Creating a transboundary National Park with adjoing Phipsu Wildlife Sanctuary, Bhutan will be benefited both sides to manage the precious diversity in BTR. This move could be helpful to curb rampant blast for mining

within Bhutan's territory to stop ecological disaster in BTR. International funds for conservation can be asked to facilitate the programme.

6.11.7. Further research to conserve ethnic knowledge

Over mlliennia, many rural communities depend on indigenous and traditional plants as main source of food (Hoeven *et al*, 2013) and medicine. So, proper research programs need to be under taken to record and to test the effectivity of these plants with medicinal value as well as other values in Jainti.

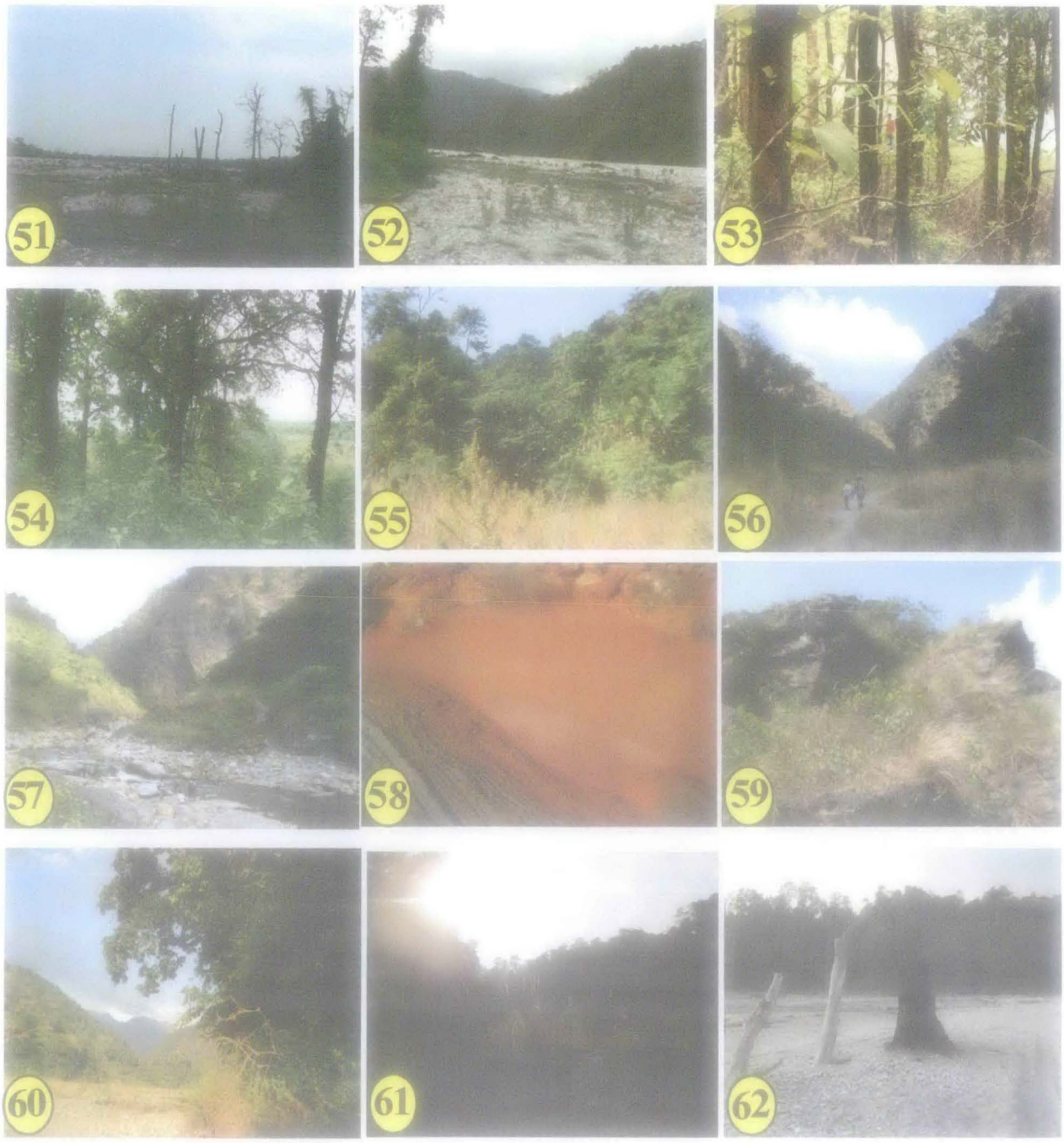

Plate V (Landscape):

51. River bed of Jainti is spreading; 52. River bed of Jainti and adjacent forest; 53. Plantation inside the core area of BTR; 54. Vegetation on the edge of a hill top; 55. Dense canopy cover ends to a grass land; 56. Grass land in valley; 57. Travellers taking rest on the bank of river Jainti; 58. Sedimentation of minerals on the bank of Jainti river; 59. Succession of vegetation on bare rock; 60. Beautiful valley leading to a hilly terrain; 61. Amazing view of shade and shine; 62. Jainti river is above the forest floor and encroching vegetation area.

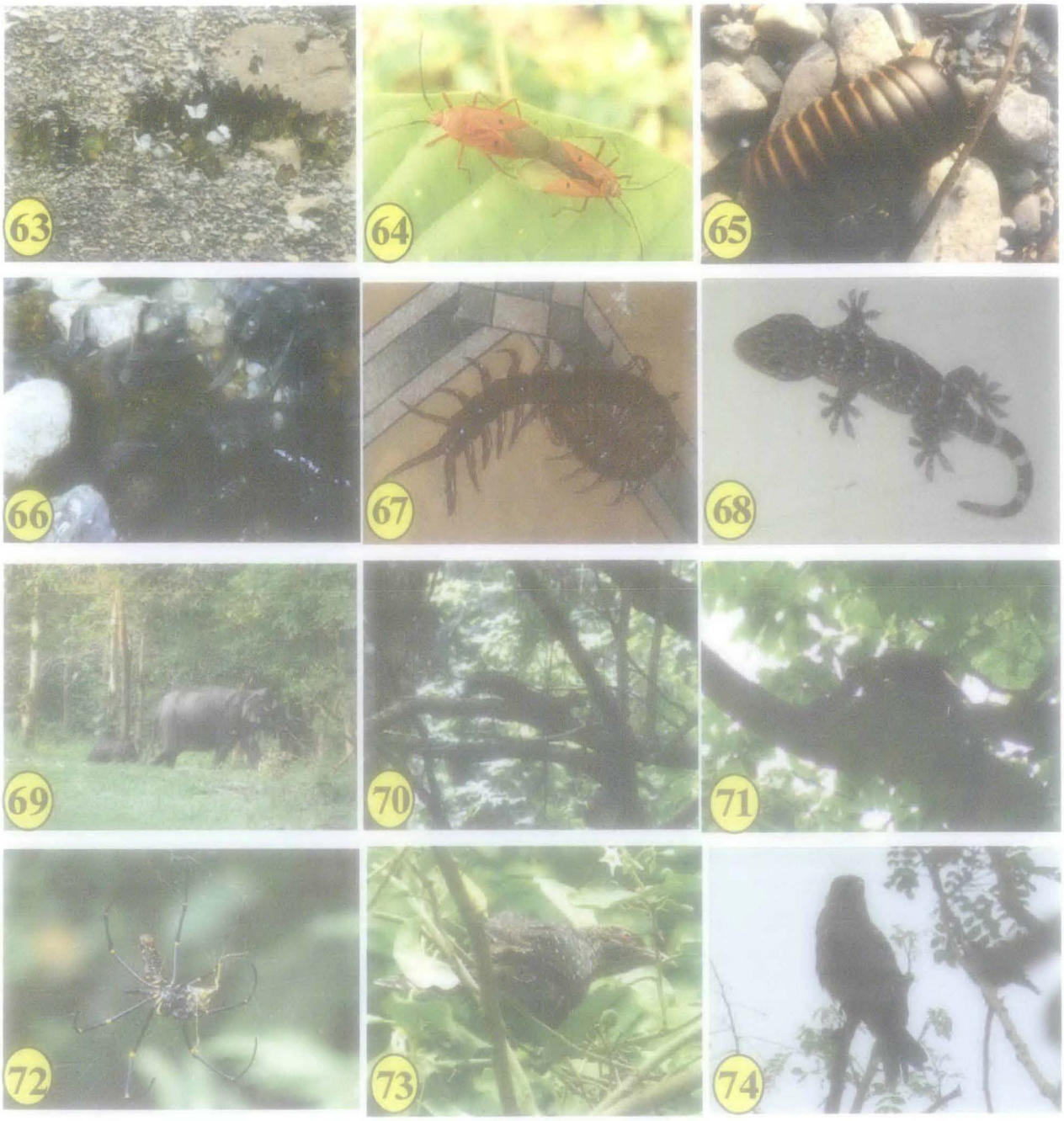

Plate VI (Fauna of Jainti):

63. Butterflies on the moist sand of Jainti river; 64. Mating of Red Bug insect (*Melamphaus rubrocinctu*); 65. Milliped (*Glomeris malmivaga*); 66. Fishes in Jainti river; 67. Centipede (*Scolopendra gigantea*) on the floor of Forest Department dormitory; 68. Tokke-Gecko (*Gekko gecko*); 69. Elephant (*Elephas maximus bengalensis*)family heading towards dense forest; 70. Himalayan Squirrel (*Callosciurus pygerythus*) taking rest on a tree branch; 71. Malabar giant squirrel (*Ratufa indica*) looking down for prey; 72. Golden Orb weaver spider (*Nephila clavipes*)waiting to catch food; 73. Indian Cuckoo (*Cuculus micropterus*) is waiting for male partner; 74. Jungle Hawk (*Peregrine falcons*) looking food.