

Multidimensional Outlook on Environment

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A comprehensive ecological study of the Kiriburu - Meghahatuburu Iron Ore Mine area of Jharkhand, India

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ABSTRACT

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Biodiversity rich Saranda Forest consist of Moist Deciduous and Tropical Dry Deciduous Forest. It is scattered in the state of Jharkhand. Saranda is mostly dominated by Shorea-Terminalia-Adina series of plants. The Importance Value Index (IVI) states the fact that Saranda is a Sal (*Shorea robusta*) dominated forest. Indian Elephants frequently migrate in between Dalma and Saranda forest. The Kiriburu-Meghahatuburu Iron ore mining area is a border town between Jharkhand and Odisha. The whole area (820 sqkm) is mined by various iron and steel companies and governed by SAIL. The Kiriburu-Meghahatuburu and its adjacent areas are located on this natural migration pathway of Asiatic elephants (*Elephas maximus*) in eastern India. This study focuses on the ecological impact of mining on the Kiriburu-Meghahatuburu area and its surrounding biodiversity.

1. Introduction

Forests cover 31 percent of the global land area (1). Forests act as a source of food, medicine and fuel. In addition to this, helps to combat climate change, protect soil, water, air and biodiversity, provide many essential services that contribute to socio-economic development and are particularly important for millions of people in the rural world (2). Almost 93% of the forest is composed of naturally regenerating forest and 7% is planted forest (1). But, an estimated 420 million Ha forest area has been lost worldwide through deforestation since 1990, as the area of naturally regenerating forest

has decreased despite increase in the area of plantation.

Forest is the second largest land use in India after agriculture, covering 23.34 percent of the total geographical area of the country (3) contributing 2% of the total global forest area. Jharkhand is one of the biodiversity and mineral rich state of India, physiographically located on Chhotanagpur plateau. The state Jharkhand is blessed with rich variety of forest comprising of dry peninsular Sal (*Shorea* sp.) forest (45.03%), dry mixed deciduous forest (41.21%), moist peninsular Sal forest (2.66%), dry deciduous scrub (3.01%) and dry bamboo brake (4.00%) (4). The

state is covered with 29.61% of total forest area, which contributes 3.07% in the total forest area of India (3), where in term of forest canopy, the state has 3.27 percent of very dense forest (VDF), 12.15 percent of moderately dense forest (MDF) and 14.20 percent of open forest (OF). Despite the increase of total forest area from 28.34 percent in the year 2005 to 29.61 percent in the year 2017 (5), the percent of tree cover has fallen rapidly from 6.295 in the year 2003 to 3.495 in the year 2017 (6).

In India, mining plays an important role in Industrial and economic growth of the country (7). However, the pollution that is generated from the mining area affects the soil, water, air, biodiversity and human health (8). Open cast mining technique generate more waste and disturb forest and agriculture land than the underground mining technique (9). Iron ore mines and big steel companies are walking side by side in Jharkhand State for last few decades. Singbhum is well-known for its large reserve of Hematite Iron Ore that constitutes 25% of the total known reserve in India (10). Saranda forest is a dense forest in the hilly region of West Singbhum district in Jharkhand. There are seven (7) operational, twenty (20) closed iron and manganese ore mines in the Saranda forest division (11). It is a continuous process of opening of new iron ore mines as well as establishment of new iron-based industry. The whole area is mined by various iron and steel companies and governed by SAIL.

The present distribution of Asiatic elephant is confined to Bangladesh, Bhutan, Myanmar, China, India, Indonesia, Cambodia, Laos, Malaysia, Nepal, Sri Lanka, Thailand and Vietnam (12). The elephant habitat in Central India extended over 17000 km² in the state of Orissa, Jharkhand, and

southern West Bengal (13). Jharkhand has two distinct elephant population, viz. Palamou and Singbhum. The Singbhum population occupies about 2570 km² of the available forest area of Dalma Wildlife Sanctuary and the forest of Saranda forest division. Mining has been one of the most serious threat to the elephant population (10) in this area.

A comprehensive floral survey was done in Kiriburu-Meghahatuburu Iron ore mines in Saranda forest division and the surrounding areas to assess the plant species diversity in both the areas and a comparative account of plant species structure for assessing the impact of mining on the natural habitat and corridor of Asiatic elephant.

2. Methodology

2.1 Study area

The floral study focused on Kiriburu Iron-ore Mine (KIOM) and Meghahataburu Iron-ore Mine (MIOM) and the surrounding forest area covering approximately 314 km². The study sites were categorized into two regions, Central Block (CB) i.e. core mining area and Valley Region (VR) i.e. adjacent forest area and non-forest area. On the degree of ecological disturbance the area was segmented into Highly Disturbed area (up to 3 km radius of CB), Moderately Disturbed area (3 km- 5 km radius of CB) and Least Disturbed area (5 km – 10 km) (Fig.1).

2.2 Sampling Technique

In each site a random quadrat was laid and the GPS reading of the site was recorded (Table 1). For GPS reading GARMIN-12 handset was used and all the readings were stored in the GPS memory. The study was conducted during the months of March 2006 to July 2006 in three phases. Apart from that, forest walk was done to record the species outside the quadrats (Transact

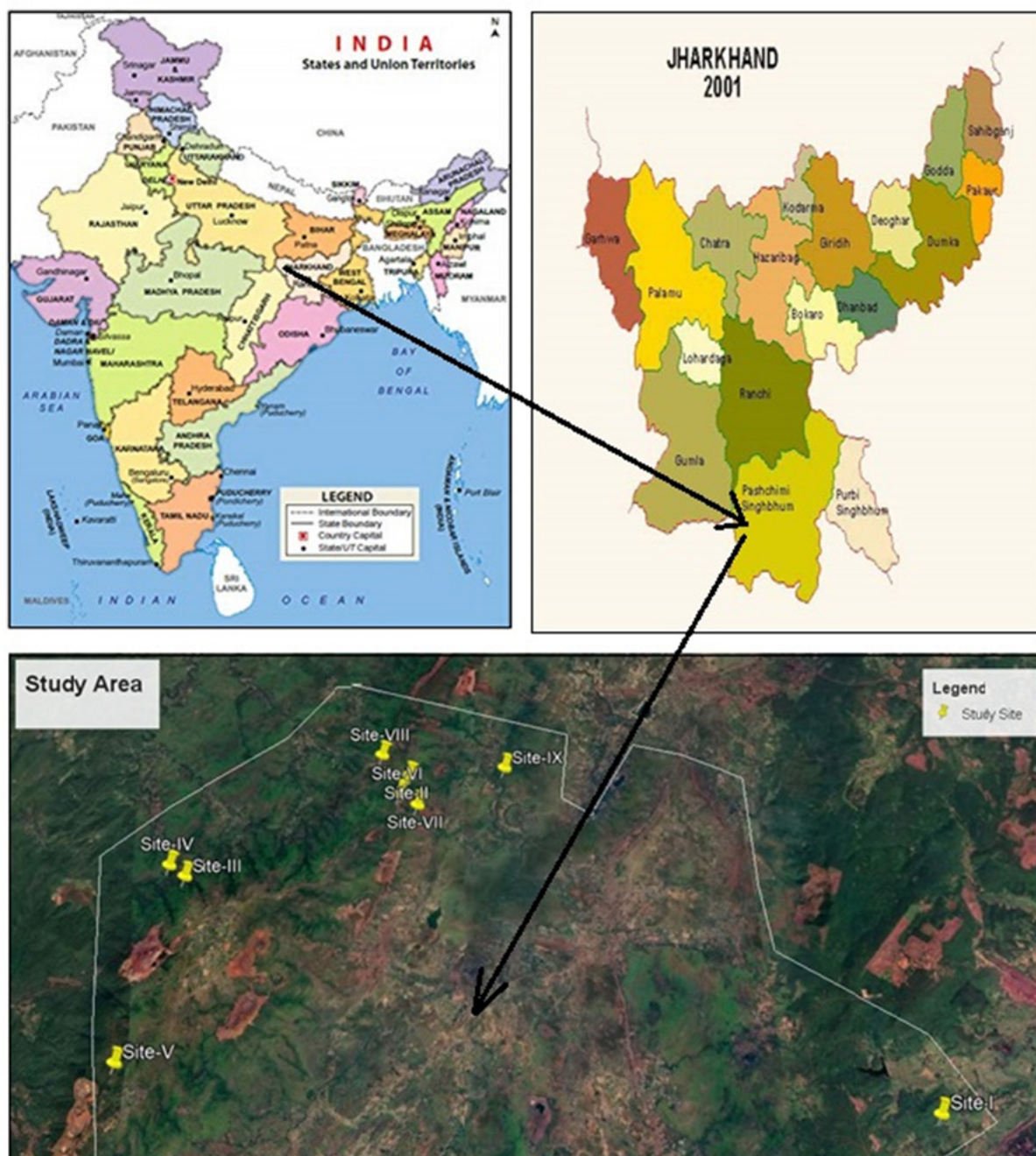


Fig.1: The map is showing the study sites

Walk).

2.3 Quadrat Method

At the outset a species area curve was prepared in eastern side of the hill to find out the minimum size of the quadrat (14) required for the study at three layers (considered as separate communities) such as tree, shrub and herb (Fig.2). It was inferred that for tree layer the minimum size of the quadrat

required for study was 500 sq. mtrs (50 mtrs x 10 mtrs), 25sq. mtrs(5mtrs x 5mtrs) for shrubs and 1sq. mtrs(1mtr x 1mtr) for herbs. In each of the sample site a quadrat of 500sq. mtrs (50mtrs x 10mtrs) was laid in the north-south direction to study the tree community for its parameters like Density, Importance Value Index (IVI) and Diversity Index.

2.4 Data collection and analysis

Table 1: Locations of study area

Locations	Quadrat Location	GPS Bearing
Least Disturbed Area	Site-I: Beside KarmpadaLake	22°03'39.5"N 85°16.09'0"E
	Site-II: Beside Tumberapur spring	22°8'33.5"N 85°20'17.3"E
	Site-III: On the Meghatiburu-Rangring tailing pond road	22°7'17.4"N 85°17'8.7"E
	Site-IV: Kumdi pump house	22°8'23.89"N 85°20'13.10"E
Moderately Disturbed Area	Site-V: On the side of the road from Kiriburu to Kalta mine	22°4'53.7"N 85°16'24.9"E
	Site-VI: On Saddle Gate-Kiriburu Road	22°8'17.5"N 85°20'9.1"E
	Site-VII: On Baraiburu road near the spring to Karo river	22°8'7"N 85°20'24"E
Highly Disturbed Area	Site-VIII: Saddle Gate	22°8'53.9"N 85°19'54.8"E
	Site-IX: Tatiba village area	22°8'35.8"N 85°21'41.1"E

2.4.1 Taxonomic identification of plant species

Plant species identification were done to prepare plant inventory of the studied area following standard books on flora by Hooker (15), Verma et al. (16) and Kumar et al. (17). Names of the plant species were verified using Bennet (18). The help of scientists of Botanical survey of India (BSI), Kolkata was taken in cases of controversy. A comparison of elephant fodder species in CB (central block) and VH (valley region) was done to find out the possibility of use of Central Block as a corridor by Asiatic Elephants. Both qualitative as well as quantitative study of vegetation had been done in the least disturbed as well as highly disturbed forest areas of the

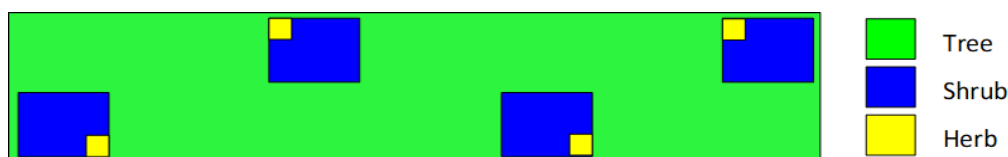
impact zone.

2.4.2 Species Diversity of tree

Tree trunk Diameter at breast height (dbh) Frequency, Basal Area were calculated for the identified plant species. From the above mentioned parameters Importance Value Index (IVI) was calculated utilizing three characteristics of the plant community as Relative Frequency, Relative Density, Relative dominance (19).

Frequency = (Number of quadrats in which species occurred x 100) / Total no. of quadrats studies

Basal area = $\pi D^2/4$ where, D=dbh


Fig.2: Quadrat structure

$$\text{Important Value Index (IVI)} = \text{RD} + \text{RDen} + \text{RF}$$

Where,

$$\text{RD (Relative Dominance)} = (\text{Total basal area of a species} \times 100) / \text{Total basal area of all species}$$

$$\text{R.Den (Relative Density)} = (\text{Number of individual of a species} \times 100) / \text{Number of individuals of all species}$$

$$\text{RF (Relative Frequency)} = (\text{Frequency of occurrence of species} \times 100) / \text{Number of occurrences of all species}$$

2.4.3 Species Diversity of herbs and shrubs

Species Diversity was calculated by Berger-Parker index (d) (20, 21). The Berger-Parker index expressed the relative importance of the most abundant species.

$$d = N_{\max} / N$$

Where, $N_{\max}$ = the number of individuals in the most abundant species and N = total number of species occurred in a quadrat.

2.4.4 Canopy statistics

A geometric measurement was adopted to estimate canopy cover, by measuring the crown diameter at right angles, in a specified quadrat. The total canopy cover area (C) in a sample quadrat equals to the sum total of the canopy areas to all trees within the quadrat, $\sum \pi r^2$. Thus, the canopy cover index (CC) is the proportion of C to A, where $A = XY$, (X and Y denoting axes of the quadrat being measured). Open canopy was inferred when $CC < 0.4$ (22).

3. Result and Discussion

3.1 Forest Type

Sal (*Shorea robusta*) forest of the tropical and subtropical regions, getting rainfall ranges from of 1200mm to over 2000mm with a dry season of 6 to 7

months (23). The forest of Kiriburu-Meghahatuburu and its adjacent areas of Saranda forest was dry peninsular Sal forest due to the lower precipitation and wide range of dry period. The vegetation type encountered in this patch of forest of Saranda is mostly Shorea-Terminalia-Adina series but there was no trace of *Cleistanthus collinus* as an associate plant to Sal (*Shorea robusta*), which was observed in the other part of Chhotanagpur plateau of Jharkhand state. In Kodalibad *Terminalia* sp. or *Croton oblongifolia* dominated over Sal within the sampled transacts, inferring that the forest was more a mixed forest than a Sal dominated one.

The forest structure in Saranda was mostly three storied. The upper canopy reached to a height of 15 to 25m and the under story was ranges from 10 to 15m high. The under growth rose from 3 to 5m. Lianas were common in the dense forests.

There had been an unsuccessful attempt to plant teak (*Tectona grandis*) surrounded by the studied part of Saranda forest by the Forest Department without proper assessment of the climate and soil type of the region (22). The scars of such improper attempts were still visible in the forest of this region. The Sal of Saranda comes under moist peninsular valley soil type "Cc (iii)" as per the classification of Champion and Seth (24). This subtype occurred as downwash from crystalline rocks giving a deep loam soil, which carried a moderate shrubs growth. These climatic conditions have been ignored while planting teak. The parent rocks in Sal dominated forests are reported to be acidic (25) while the Teak forest need a basic soil and in India its majestic presence is well visible where sandstone is present as parent material (26). Therefore, it is evident that in this region,

teak has not been able to influence the vegetation structure in spite of the efforts of State Forest Department to change the natural ecosystem structure.

3.2 Vegetation

Within the studied area, a total of 197 plant species were identified during the study period. Out of which sixty three (63) were trees (31.97% of total plant species), forty six (46) were shrubs and 88 were herbs (23.35% and 44.67% of total species respectively). The total density of trees ranged between 800 trees/ha and 1800 trees/ha. The sixty three tree species belonged to 27 families. Fabaceae was the most dominant family among the trees having 7 species followed by Euphorbiaceae (six species), Rubiaceae, Combretaceae, Meliaceae (four species each), Myrtaceae (three species), Malvaceae, Rutaceae, Apocynaceae, Sterculaceae, Anacardiaceae, Ebnaceae, Phyllantaceae, Rhamnaceae (two species each) and Cornaceae, Urticaceae, Sapotaceae, Sapindaceae, Moraceae, Verbenaceae, Orobanchaceae, Lythraceae, Lecythidaceae, Diptocarpaceae, Solanaceae, Lamiaceae (one species each) (Table 2). Among the shrubs, Euphorbiaceae and Verbenaceae were the most common families with 3 species each (Table 3). Among the herbs, (Table 4) Poaceae held maximum (nine Species) number followed by Fabaceae, Aracaceae, Dioscoreaceae (five species each), Amaranthaceae, Asteraceae, Zinziberaceae, Euphorbiaceae, Convolvulaceae and Malvaceae (four species each).

The valley was surveyed to get an idea of the community of primary producers. Out of the total identified species at least 24 were probable fodder species of elephants. Within the fodder list of elephants all forms of plant habits such as trees (thirteen species), shrubs

(six species) and herbs (five species) were present. Tree species like *Artocarpus lakucha*, *Bauhinia retusa*, *Coclospermum religiosum*, *Dillenia indica* etc were found. Shrub species like *Gardenia gummifera*, *Holarrhena antidysenterica*, *Randia spinose*, *Bauhinia vahlii* etc. whereas *Revea hypocreterariformis*, *Mimosa pudica*, *Oplismenus compositus* etc. of herb species were present.

In the forested area forest cover varied from closed canopy cover within Kodalibad (like Kumdi- site-IV) to open canopy cover near Baraiburu (site- VII) and Tatiba (site- IX). It was observed that some exotic species like *Lantana camara*, *Ageratum conyzoides* and *Eupatorium odoratum* were trying to invade in the central block (CB) and colony area, whereas in the closed forest area the invasion of exotic species were comparatively less compared to the CB, colony areas as well as on the road sides. The anthropogenic activities and introduction of an exotic tree species like teak might be the possible causes of such invasion. But this trend might be made an inroad to the natural habitat of indigenous species which was confined to the roadsides only during the study period. The luxuriant growth of indigenous species, considerable tree canopy cover and availability of litter in the forest floor are the few causes, which keep the invasion of exotic species like *Lantana camara* and *Eupatorium odoratum* within a limit. Such invasions if not cared and managed would have a deteriorating effect on the habitat quality of this region of Saranda.

3.2.1 Vegetation within Heavily Disturbed Area

Plant community richness of Central Block (CB) (sites-VIII and IX) mining area (upto 3km radius) was comparatively less in comparison to the outside of the mine as per as the species

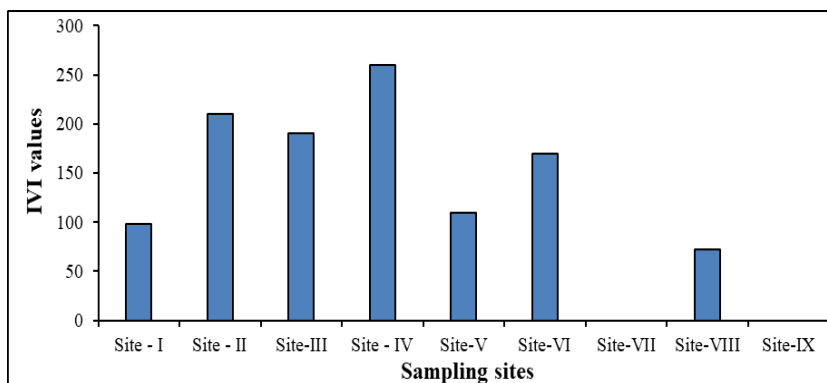


Fig.3: IVI of Sal in Kiriburu-Meghahatuburu area under different disturbance conditions

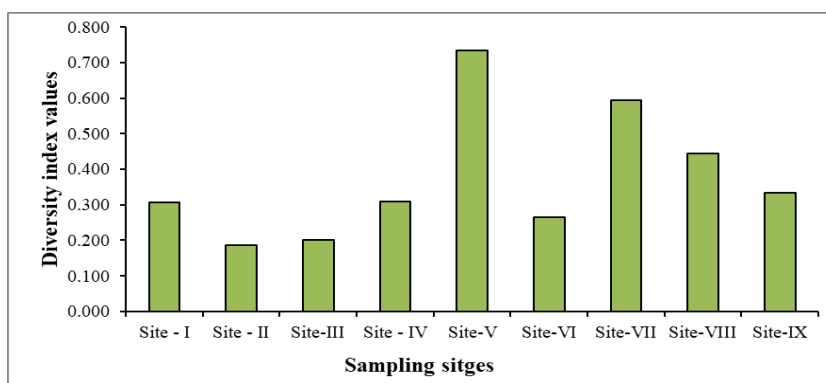


Fig.4: Diversity Index of Shrubs in Kiriburu-Meghahatuburu area under different disturbance conditions

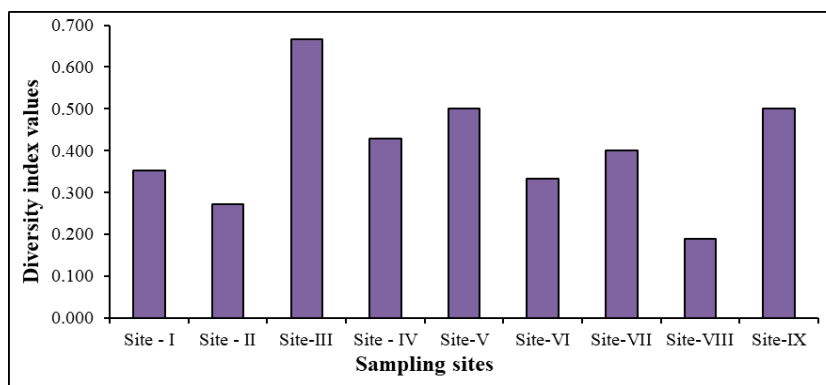


Fig.5: Diversity Index of herbs in Kiriburu-Meghahatuburu area under different disturbance conditions

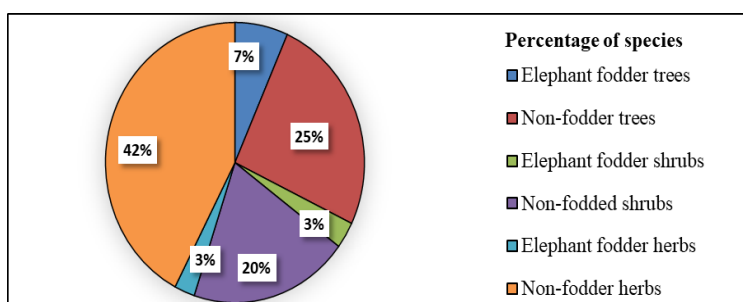


Fig.6: Elephant fodder species in relation to non-fodder plant species in Kiriburu-Meghahatuburu mining area

composition is concerned. The tree canopy was 10% to 45% with the lowest tree density was recorded as 800 trees/ha. The average IVI of Sal was 36 (Fig.3). The diversity index of shrub and herb were only 0.389 and 0.345 respectively.

Meghatu Nala was a small stream that carries drained water from the CB. This site has also profuse presence of exotics species like *Lantana camara*, *Eupatorium odoratum* and *Parthenium hysterophorus*. In the tree level it was also found that the understory was almost occupied by - *Cassia fistula*. *Cassia fistula* is not a forest species and found to be planted in large number as an avenue tree in and around Kiriburu and Meghahatuburu. Its presence in the CB depicts the fact that the low recruitment and regeneration rate of forest species has created a space for establishment of this tree species. It was therefore observed that a slow process of altering the species structure of the present study site was making it unsuitable for giant herbivores like elephants. This process is in the one hand natural and also man made to some extent.

3.2.2 Vegetation within Moderately Disturbed Area

In the valley region plant community within 3km to 5km radius (sites-V, VI and VII) was studied. It was interesting to note that in moderately disturbed areas the IVI of Sal was 93.33 (Fig.3), which was comparatively higher than that of least disturbed area as the canopy cover was within 45% to 85% with 1400 trees/ha. The diversity index was recorded as 0.532 and 0.411 for shrub and herb respectively.

These areas had slightly higher species diversity of shrubs and herbs which provide fodder to the grazing animals.

3.2.3. Vegetation within Least Disturbed

Area

The sites mentioned under this category (sites-I, II, III and IV) were mostly found in the remote areas of Saranda and within 5km – 10km from the CB of the studied area. In the least disturbed area, the average IVI (Fig.4) of Sal was also found highest (189.5). Tree species with higher IVI values indicated the good regeneration capability (6). The fact indicated that the Sal was the dominant species. Due to the dominance and quick development of sal, the abundance of herbs and shrubs were fewer and thus species diversity was low as 0.431 and 0.252 respectively. All these sites the canopy cover varies in between 85% to 95%. The density of tree species is also high in these locations (1800 trees/ha). These sites are therefore ideal hideouts for elephants and provide day time shelter for them.

The study area had a gentle slope not exceeding 20 degrees to 30 degrees. This slope within a natural vegetation cover could be a good site for regeneration as there was no adverse condition so far as topography was concerned. But recruitment of indigenous species to the study area had been found very low. This might be due to the fact that the exotic invaders had been successful in competing with the indigenous species. It also observed that in spite of open canopy structure of the forest community and the period of study being rainy season the community should have been expressed its maximum potentiality in terms of species composition. But on the other hand it was observed that the species diversity in the herb and shrub level had been very poor in comparison to the forest community around (Fig.4 and Fig.5). It had been found from the study that study site-VI shows the highest diversity (0.735) whereas study site-II was the lowest diversity index

Table 2: Tree Species inventory of Kiriburu and Meghahatuburu mining area

Sl. No	Name of species	Family
1	<i>Abutilon sp.</i>	Malvaceae
2	<i>Adina cordifolia</i>	Rubiaceae
3	<i>Aegle mermelos</i>	Rutaceae
4	<i>Alanzium lamarkii</i>	Cornaceae
5	<i>Albizias tipulata</i>	Fabaceae
6	<i>Alstonia scholaris</i>	Apocynaceae
7	<i>Alstonia venenatus</i>	Apocynaceae
8	<i>Anogeissus latifolia</i>	Combretaceae
9	<i>Anthocephalas cadamba</i>	Rubiaceae
10	<i>Artocarpus lakoocha*</i>	Urticaceae
11	<i>Barringtonia sp.</i>	Lecythidaceae
12	<i>Bassia latifolia*</i>	Sapotaceae
13	<i>Bauhinia acuminata</i>	Fabaceae
14	<i>Bauhinia retusa*</i>	Fabaceae
15	<i>Bauhinia perpurea</i>	Fabaceae
16	<i>Bischofia javanica</i>	Phyllanthaceae
17	<i>Bombax ceiba*</i>	Sterculiaceae
18	<i>Bombax pentandra</i>	Sterculiaceae
19	<i>Bosowellia serreta</i>	Meliaceae
20	<i>Bridelia retusa</i>	Euphorbiaceae
21	<i>Buchanania lanzen*</i>	Anacardiaceae
22	<i>Butea monosperma</i>	Fabaceae
23	<i>Callicarpa arborea</i>	Lamiaceae
24	<i>Cassia fistula*</i>	Fabaceae
25	<i>Cassia siamea</i>	Fabaceae
26	<i>Castanopsis indica</i>	Cupuliferaceae
27	<i>Choloxylon swietenia</i>	Rutaceae
28	<i>Coclospermum religiosum*</i>	Cochlospermaceae
29	<i>Croton laccifera</i>	Euphorbiaceae
30	<i>Croton oblongifolia</i>	Euphorbiaceae
31	<i>Dillenia aurea</i>	Dilleniaceae
32	<i>Dillenia indica*</i>	Dilleniaceae
33	<i>Dillenia tomentosa</i>	Dilleniaceae
34	<i>Diospyros melanoxylon*</i>	Ebnaceae
35	<i>Diospyros Montana</i>	Ebenaceae
36	<i>Ficus hispida</i>	Moraceae
37	<i>Ficus glomerata</i>	Moraceae
38	<i>Ficus religiosa</i>	Moraceae
39	<i>Gardenia latifolia</i>	Rubiaceae
40	<i>Gmelina arborea*</i>	Verbenaceae
41	<i>Homonia riparia</i>	Euphorbiaceae
42	<i>Kydia calycina</i>	Malvaceae
43	<i>Lagerstroemia parviflora*</i>	Lythraceae
44	<i>Macaranga peltata</i>	Euphorbiaceae

Sl. No	Name of species	Family
45	<i>Mangifera indica</i>	Anacardiaceae
46	<i>Melia azadirachta</i>	Meliaceae
47	<i>Michelia champaka</i>	Magnoliaceae
48	<i>Milusa velutina</i>	Anonaceae
49	<i>Mirtagyna paerviflora</i>	Rubiaceae
50	<i>Oroxylum indicum</i>	Orobanchaceae
51	<i>Phyllanthus emblica</i>	Phyllanthaceae
52	<i>Shorea robusta</i>	Dipterocarpaceae
53	<i>Schleichera oleosa</i>	Sapindaceae
54	<i>Solanum verbassifolium</i>	Solanaceae
55	<i>Soymida febrifuga</i>	Meliaceae
56	<i>Syzizium cumini</i>	Myrtaceae
57	<i>Syzygium heyneanum</i>	Myrtaceae
58	<i>Terminalia belerica</i>	Combretaceae
59	<i>Terminalia chebula</i>	Combretaceae
60	<i>Terminalia tomentosa*</i>	Combretaceae
61	<i>Toona ciliate</i>	Meliaceae
62	<i>Zizyphus horrida</i>	Rhamnaceae
63	<i>Zizyphus jujube*</i>	Rhamnaceae

*Elephant fodder species

(0.188) of shrubs. In case of herbs study site-III showed the highest Diversity index (0.667) whereas study site-VIII was the lowest diversity index (0.189). It indicates the ecological disturbances is high in this area.

Fodder species

With all these variations it could be said that the area under study was not a uniform habitat for large herbivore mammals like elephants. But there was no doubt of the fact that the presence of both the fodder species (27) of elephants as well as the plant species providing canopy cover in certain pockets of the forest provided favorable environment for the wild animals. Figure 5 gave the comparative account of elephant fodder species to the non-fodder plant species in the study area.

4. Conclusion

This study demonstrated the impact of iron ore mining on an ecologically important forest area as an elephant

corridor. The Sal forest of Chhota-nagpur plateau plays an important role balancing the ecological disturbance by regenerating the forest cover. But extreme anthropogenic interference may lead to the destruction of this forest. More profound management plan is needed to be carried out by the implementing authorities during re-forestation program in such forest area like Saranda. An elaborative study on preserving elephant corridor and its management may be carried out on the basis of this study for preparation of effective conservation plan.

Table 3: Shrub Species inventory of Kiriburu and Meghahatuburu mining area

Sl. No.	Name of species	Family
1	<i>Anisomeles ovata</i>	Lamiaceae
2	<i>Barleria cristata</i>	Acanthaceae
3	<i>Barleria lupulina</i>	Acanthaceae
4	<i>Barleria prionitis</i>	Acanthaceae
5	<i>Bauhinia vahlii*</i>	Fabaceae
6	<i>Caesalpinia bonduc</i>	Caesalpiniaceae
7	<i>Caloptropis procera</i>	Asclepiadaceae
8	<i>Carissa spinarum</i>	Apocynaceae
9	<i>Casearia vareca</i>	Samydaceae
10	<i>Catasibaea spinosa</i>	Rubiaceae
11	<i>Clerodendron infortunatum</i>	Verbenaceae
12	<i>Combretum roxburghii</i>	Combretaceae
13	<i>Costus speciosus</i>	Costaceae
14	<i>Cryptolepis buechanani</i>	Apocynaceae
15	<i>Desmodium gangeticum</i>	Fabaceae
16	<i>Eupatorium odoratum</i>	Asteraceae
17	<i>Flemingia chappar</i>	Fabaceae
18	<i>Gardenia gummifera*</i>	Rubiaceae
19	<i>Gossypium arboreum</i>	Malvaceae
20	<i>Gossypium herbaceum</i>	Malvaceae
21	<i>Helicteres isora</i>	Sterculaceae
22	<i>Helicteres spicata</i>	Sterculaceae
23	<i>Holarrhena antidysenterica*</i>	Apocynaceae
24	<i>Hyptis suaveolens</i>	Lamiaceae
25	<i>Ixora arborea</i>	Rubiaceae
26	<i>Jatropha curcus</i>	Euphorbiaceae
27	<i>Jatropha gossipifolia</i>	Euphorbiaceae
28	<i>Lantana camara</i>	Verbenaceae
29	<i>Leeam acrophylla</i>	Leeaceae
30	<i>Malastoma malabathricum</i>	Malatromaceae
31	<i>Mimosa rubricoulis</i>	Mimosaceae
32	<i>Phyllanthus simplex</i>	Euphorbiaceae
33	<i>Polyalthia cerasoides</i>	Anonaceae
34	<i>Randia spinosa*</i>	Flacourtiaceae
35	<i>Smilax macrophylla</i>	Smilacaceae
36	<i>Smilax zeylanica</i>	Smilacaceae
37	<i>Solanum torvum</i>	Solanaceae
38	<i>Thespesia lampus</i>	Malvaceae
39	<i>Thysalanolana maxima*</i>	Poaceae
40	<i>Tinospora cordifolia</i>	Menispermaceae
41	<i>Vanda roxburghii</i>	Orchidaceae
43	<i>Vanda teres</i>	Orchidaceae
44	<i>Vitex negundo</i>	Verbenaceae
45	<i>Woodfordia floribunda</i>	Lythraceae
46	<i>Ziziphus oenopolia*</i>	Rhamnaceae

*Elephant fodder species

Table 4: Herb Species inventory of Kiriburu and Meghahatuburu mining area

Sl. No.	Name of species	Family
1	<i>Acalypha indica</i>	Euphorbiaceae
2	<i>Adiantum capillus-veneris</i>	Pteridaceae
3	<i>Aerva lanata</i>	Amaranthaceae
4	<i>Ageratum conyzoides</i>	Asteraceae
5	<i>Alocasia acuminata</i>	Araceae
6	<i>Alocasia fornicata</i>	Araceae
7	<i>Alysicarpus monilifer</i>	Fabaceae
8	<i>Alysicarpus vaginalis</i>	Fabaceae
10	<i>Amaranthus spinosus</i>	Amaranthaceae
9	<i>Amaranthus viridis</i>	Amaranthaceae
11	<i>Amorphophallus hirsute</i>	Araceae
12	<i>Amorphophallus paeonifolius</i>	Araceae
13	<i>Andrographis paniculata</i>	Acanthaceae
14	<i>Asparagus racemosus</i>	Asperagaceae
15	<i>Atylocias carabaeoides</i>	Fabaceae
16	<i>Begonia picta</i>	Begoniaceae
17	<i>Biophytum sensitivum</i>	Oxalidaceae
18	<i>Boerhavia diffusa</i>	Nyctaginaceae
19	<i>Cardiospermum halicacabum</i>	Sapindaceae
20	<i>Cassia occidentale</i>	Fabaceae
21	<i>Cassia tora</i>	Fabaceae
22	<i>Celosia argentia</i>	Amaranthaceae
23	<i>Centella asiatica</i>	Apiaceae
24	<i>Centella rotundifolia</i>	Apiaceae
25	<i>Cesus adnata</i>	Vitaceae
26	<i>Cleome viscosa</i>	Cleomaceae
27	<i>Commelina nana</i>	Commelinaceae
28	<i>Cosmos sulfureous</i>	Asteraceae
29	<i>Crinum asiaticum</i>	Liliaceae
30	<i>Curculigo orchiodes</i>	Amaryllidaceae
31	<i>Curcuma amada</i>	Zinziberaceae
32	<i>Curcuma aromatic</i>	Zinziberaceae
33	<i>Curcuma zedoaria</i>	Zinziberaceae
34	<i>Cyperus iria</i>	Cyperaceous
35	<i>Desmodium gangeticum</i>	Fabaceae
36	<i>Desmodium triflorum</i>	Fabaceae
39	<i>Dioscorea alata</i>	Dioscoreaceae
40	<i>Dioscorea bulbifolia</i>	Dioscoreaceae
38	<i>Dioscorea esculenta</i>	Dioscoreaceae
37	<i>Dioscorea floribunda</i>	Dioscoreaceae
41	<i>Dioscorea pentaphylla</i>	Dioscoreaceae
42	<i>Eclipta prostrata</i>	Asteraceae
43	<i>Elephant opusscaber</i>	Asteraceae
44	<i>Eragrostis ciliate</i>	Poaceae

Sl. No.	Name of species	Family
45	<i>Eragrostis coarctata</i>	Poaceae
46	<i>Eragrostis tenella</i>	Poaceae
47	<i>Euphorbia hirta</i>	Euphorbiaceae
48	<i>Euphorbia microphylla</i>	Euphorbiaceae
49	<i>Evolvulus alsenoides</i>	Convolvulaceae
50	<i>Evolvulus numularius</i>	Convolvulaceae
51	<i>Globba bulbifera</i>	Zinziberaceae
52	<i>Grangea maderaspatana</i>	Asteraceae
53	<i>Hemidesmus indicus</i>	Asclepiadaceae
54	<i>Imperata arundinacea</i>	Poaceae
55	<i>Inoidium sufruiticosum</i>	Violaceae
56	<i>Lana sonchifolia</i>	Asteraceae
57	<i>Leucs cephalotes</i>	Lamiaceae
58	<i>Ludnigia octovalvis</i>	Onagraceae
59	<i>Lygodium japonicum</i>	Schizaeaceae
60	<i>Martynia annua</i>	Martyniaceae
61	<i>Merremia tridentata</i>	Convolvulaceae
62	<i>Mimosa pudica*</i>	Mimosaceae
63	<i>Oplismenus compositus*</i>	Poaceae
64	<i>Oxalis corniculata</i>	Oxalidaceae
65	<i>Pathos scandens</i>	Araceae
66	<i>Pennisetum pedicellatum*</i>	Poaceae
67	<i>Pergularia daemia</i>	Apocynaceae
68	<i>Perotis indica</i>	Poaceae
69	<i>Phyllanthus amarus</i>	Euphorbiaceae
70	<i>Phyllanthus niruri</i>	Euphorbiaceae
71	<i>Physalis minima</i>	Solanaceae
72	<i>Polygala crotalarioides</i>	Polygalaceae
73	<i>Protulaca bicolor</i>	Portulacaceae
74	<i>Pteris biaurita</i>	Pteridaceae
75	<i>Rivea hypocreteriformis*</i>	Convolvulaceae
76	<i>Rungia pectinata</i>	Acanthaceae
77	<i>Saccharum narenga*</i>	Poaceae
78	<i>Scoparia dulcis</i>	Scrophulariaceae
79	<i>Sesamum indicum</i>	Pedaliaceae
80	<i>Setaria glauca</i>	Poaceae
81	<i>Sida cordata</i>	Malvaceae
82	<i>Sida cordifolia</i>	Malvaceae
83	<i>Sida rhomboidea</i>	Malvaceae
84	<i>Stephania harnandifolia</i>	Menispermaceae
85	<i>Tridax procumbens</i>	Asteraceae
86	<i>Triumfetta rhomboidea</i>	Malvaceae
87	<i>Vernonia cinerea</i>	Asteraceae
88	<i>Zornia diphylla</i>	Fabaceae

*Elephant fodder species

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