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Impact of Mining on Forests and Its Biological Diversity at Kirandul Iron Ore Mines, Dantewada, South Bastar, Chhattisgarh: A Case Study

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Abstract

Mining activities have several impacts on the environment. In our study, emphasis was given to assess biodiversity in one of the leading iron ore mining sites of Bailadila-Kirandul Iron Ore Mines (KIOM) of Dantewada District, South Bastar of Chhattisgarh. Habitat fragmentation, loss and deforestation are highly prevalent in the area. However, the study reveals high species richness of 110 and 253 plant species in core and buffer zone respectively. Canopy cover was found to be within 10 to 40% and in places in the buffer zone canopy cover with > 40% was recorded. Species diversity index indicates the instability of vegetation structure in the area with indices of 1.44 in core and 1.88 in buffer zone. Although species richness is high, about 10 floral species (7 herbs, 3 trees) are recorded under REET (Rare Endangered Extinct Threatened) species while locally endangered floral species are 6 and locally critically endangered are 4. Similarly, 208 faunal species belong to 10 faunal groups was recorded out of which 34 species are listed in different Schedules of Indian Wildlife (Protection) Act, 1972. Therefore, it is an urgent need for planning to undertake appropriate management strategies to conserve biodiversity in the area.

Keywords: biodiversity, species diversity, dominance, canopy statistics, life forms

1. Introduction

Significant and potential risks are found for tropical forests in the world due to mining processes. Globally, over the past 10 years, the mineral production have risen (Kooroshey et al., 2014). A study by Sonter et al., 2017 shows loss of Amazon forest of about 11,670km^2 area deforestation between the years 2005 to 2015 where 9% of the loss is contributed by mining leases. The area that includes extensive forest resources, in some of which mining—directly and/or indirectly—is thought to have contributed to significant deforestation (Swenson et al., 2011). Similarly, gold mining at Peruvian Amazon also resulted in deforestation (Asner et al., 2013). A sharp increase in mineral prices can result in a surge in mining activity, which contributes to deforestation in some locations. A study by the University of Puerto Rico found that tree cover loss in the Madre de Dios region of Peru has increased significantly since 2007 as a result of artisanal gold mining (Alvarez-Berríos & Aide, 2015). Area of land involved in mining is small but it affects the surrounding area along with its species, and it is very intensive and very destructive (Mather, 1991; Sands, 2005). Mining is a lucrative activity promoting development booms which may attract population growth with consequent deforestation. The deforestation rate due to mining activities in Guyana from 2000 to 2008 increased 2.77 times according to an assessment by the World Wildlife Fund-Guianas (Staff, 2010). Similarly, in the Philippines, mining, along with logging, has been among the forces behind the country's loss of forest cover: from 17 million hectares in 1934 to just three million in 2003 or an 82 per cent decline (Docena, 2010). Nearly 2,000 hectares of tropical forest in the Municipality of Coahuayana in the State of Michoacán (south-western Mexico) will completely be destroyed by mining iron minerals planned by the Italo-Argentine mining company TERNIUM (Anonymous, 2008). Similarly, Nyamagari hills in Orissa India currently threatened by Vedanta Aluminum Corporation's plan to start bauxite mining will destroy 750 hectares of reserved forest (Griffiths & Hirvela, 2008). Massive and unchecked mining of coal, iron ore and bauxite in Jharkhand, India has caused large scale deforestation and created a huge water scarcity (Anonymous, 2011). In return for US$3.8 billion of investment, the agreements between the State government of Jharkhand, India and mining companies, there will be a massive land acquisition which will deforest no less than 57,000 hectares of forest and displace 9,615 families, many of them located in legally protected Scheduled Areas

set aside for indigenous peoples in the State (Mullick & Griffiths, 2007). Moreover, Roads constructed to support the mining operations will open up the area to shifting agriculturists, permanent farmers, ranchers, land speculators and infrastructure developers. For instance the core of Brazil's Amazon development strategy were infra-structure development projects such as roads providing access to frontier regions, mining area and large hydroelectric reservoirs (Mahar, 1988; Fearnside & Barbosa, 1996; Carvalho et al., 2002, 2004).

Therefore, one of the key underlying assumptions about biodiversity management is that native species and ecological processes are most likely to be maintained. To maintain and strengthen the biodiversity management recommendations are primarily aimed at managed forests. The recommendations are designed to promote long term stand level maintenance and recruitment of important structural attributes such as: wildlife, diversity of species, special or unique habitats for floral and faunal wealth, riparian areas and wetlands, coarse woody debris, horizontal and vertical structural diversity.

National Mineral Development Corporation (NMDC) is India's single largest iron ore producer and exporter, presently producing about 30 million tons of iron ore from 3 fully mechanized mines viz., Bailadila Deposit-14/11C, Bailadila Deposit-5, 10/11A both within the state of Chhattisgarh and Kumaraswamy and Donimalai Iron Ore Mines (Karnataka State) which are awarded ISO 9001:2008, ISO 14001:2004 and OHSAS 18001:2007 certification. The iron Ores of Bailadila ranges being the purest in the world is valued highly in the international market. Bailadila range of hills has iron ore reserve of above 1500 million tons of high grade iron ore in 14 deposits.

Dantewada district has rich forest reserves with 64% of its land under forest cover and almost 79% tribal population. Although rich in natural wealth, the district has not seen much development, only 30% of the populations are literate and the district ranks seventh among the 150 backward districts of the country. Therefore the study area is selected to explore further for knowing the impacts of mining on forests. The main objective of the study is understanding various components of the ecosystems in the core as well as buffer zone and to study floral and faunal diversity in the proposed area of mines that aims to achieve the structural as well as functional aspects of it through proper management policies, and adopting scientific approach towards preparing biodiversity conservation and management plan to provide alternate habitat for existing flora and fauna in the ML as well as buffer zone.

2. Method

2.1 Study Area

Bailadila lies in the Survey of India topo-sheet no. 65F/2 within latitude 18°32′32″N and 19°36′5″N and longitude 81°13′ and 81°14′30″. The study area comes under Kirandul Iron Ore Mine (KIOM) (Figure 1). Total area within Kirandul Mining Project is 1364.115ha under three deposits adjacent to reach other namely (i) Deposit-14 (322.368ha) ML area (ii) Deposit-14 NMZ (506.742ha) ML area and (iii) Deposit-11B (535.005 ha) ML area. The study covers 10km radius around the core area.

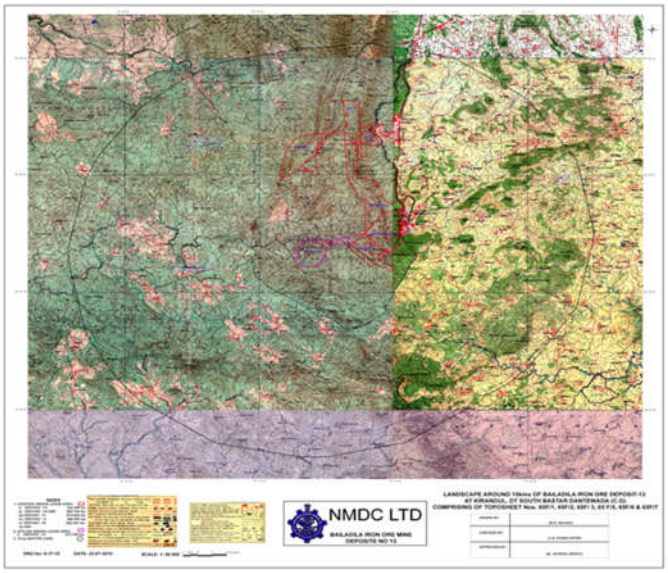


Figure 1. Location map of the iron ore deposits (Mining lease area) and buffer zone of 10km radius of study area

2.2 Drainage of Bailadila Range

There are number of perennial streams flowing from the hills and the entire region is a part of Godavari basin. The eastern slopes drain through streams which flow towards northeast to Sankhini river. Drainage in between the eastern and western ridges is through two streams flowing in opposite direction, Galli nala towards south and Sankhini nala cuts across the eastern ridge near Jhirka village flows down east and north east and becomes the Sankini river. This joins with Dankini river near Dantewada and becomes Dantewada river, which ultimately flows through west and joins Indravati river. The western slopes drain through Mari nadi, Berudi nadi and other streams to river Indravti, which joins Godavari river near Bhopalpatnam in the downstream. Southern part of the complex drain through Malinger nadi joining Sabari rivedr and Galli nala joining Talperu river, all again flows to Godavari River.

2.3 Geology

The iron ores of Bailadila range belong to the Bailadila series which are associated with slightly metamorphosed iron-ore bearing sedimentary rocks of Pre-Cambrian age. Iron ore occurs as separate ore bodies on the crest of the two sub-parallel hills running north-south. These hill ranges comprises shales, banded hematite, quartzite and conglomerates containing pebbles of quartzite and shale.

2.4 Sampling Technique

Random samples were taken to assess the ecological structure of the study area and get some simple idea of the ecological functions. The study area is basically a hill running in East-West direction. The whole core area where mining activity is in progress is almost completely denuded and rarely has any species. In some places where species available was recorded as per the findings of transact walk. Random sampling was done with the help of Satellite Imagery and toposheet of the area. Samples were studied both within mining sites (ML area) and in the buffer area i.e., 10 km radius of the ML area of the three mines namely 14ML, 14NMZ and a part of 11ML i.e., 11B. Each site studied is marked with geographical coordinates recorded in GPS handset (GARMIN-12). Studies were done for understanding the phytosociology, inventorisation of faunal species as well as their habitat.

2.5 Floral Study

Quadrat sampling was done in the buffer zone only where there are both forest areas and non-forest areas. At the outset a species area curve was prepared in eastern side of the hill to find out the minimum size of the quadrat required for the study of three layers (considered as separate communities) such as tree, shrub and herb (Cain, 1938). It was inferred that for tree layer the minimum size of the quadrat required for study was $500m^2$ (50m X 10m) for trees, (5m X 5m) $25m^2$ for shrubs and (1m X 1m) $1m^2$ for herbs. In each of the sample sites a quadrat of $500m^2$ was laid to study the tree community (Philip, 1959), Diversity Index, and Canopy Cover. In each of the tree quadrat four shrub quadrats were laid on alternate sides and similarly five herb quadrats were for study of herb layer. Each quadrat was given a code and marked by GPS reading. The sampling sites are as follows (Table 1).

Table 1. Location for vegetation enumeration in the study area

Locations for vegetation study in Deposit-14 (Buffer Zone)		
Sl. No.	Name of site	GPS bearing
1	Kirandul station	18°38′42.6″N 81°16′0.7″E Alt—625m
2	Kadampal-Patelpara	18°39′45.5″N 81°18′7.1″E Alt—575m
3	Kadampal-Patelpara forest	18°39′47″N 81°17′47″E Alt—575m
4	Kadampal water body	18°39′9.1″N 81°17′41.8″E Alt—583m
5	Kirandul 4 no. area	18°38′57.6″N 81°16′3.7″E Alt—618m
6	Kirandul No.1 nala	18°37′42.2″N 8°15′51.7″E Alt—638m
7	Tailing Dam	18°39′11.8″N 81°17′6.2″E Alt—619m
8	Water body	18°39′12.4″N 81°17′0.3″E Alt—595m
9	Water body	18°39′21.1″N 81°17′16.1″E Alt—581m
10	Behind central workshop	18°42′48.3″N 81°15′56.8″E Alt—534m
11	Near Bacheli, a stream	18°42′51″N 81°15′32.4″E Alt—541m

Locations for vegetation study in Deposit-14 (Buffer Zone)		
Sl. No.	Name of site	GPS bearing
12	Chalkipara	18°41′37.7″N 81°16′20.4″E Alt—546m
13	Foot hill near tailing pond	18°40′32.4″N 81°14′53.3″E Alt—609m
14	Middle of the hill	18°40′29.8″N 81°14′52.6″E Alt—622m
15	Top of the hill	18°40′26.5″N 81°14′50.5″E Alt—642m
16	Upper embankment of a pond	18°40′33.9″N 81°14′51.3″E Alt—575m
17	Middle embankment of a pond	18°40′44.6″N 81°14′55.2″E Alt—599m
18	Lower embankment of a pond	18°40′36.9″N 81°15′0.9″E Alt—595m
19	Malangir pump house	18°35′30.8″N 81°13′11.1″E Alt—718m
20	Malangir hill top	18°35′27.8″N 81°13′12.5″E Alt—755m
21	Malangir hill middle	18°35′29.3″N 81°13′12.7″E Alt—744m
22	Malangir foothill	18°35′30.4″N 81°13′11.2″E Alt—733m
23	1km advance to Malangir pump house	18°35′40.5″N 81°13′23.3″E Alt—742m
24	2km advance to Malangir pump house	18°35′33.6″N 81°13′41.7″E Alt—742m
25	1.5km advance to Malangir pump house	18°35′27.6″N 81°14′16.9″E Alt—682m
26	Hiroli Village—near agriculture land	18°35′38.5″N 81°15′23.5″E Alt—682m
27	Kirnar village	18°36′26.5″N 81°15′48.4″E Alt—674m
28	Near Ali Dongri	18°37′36.9″N 81°16′57.2″E Alt—611 m
30	Burdi Dongri	18°37′40.9″N 81°16′56.3″E Alt—620 m
31	Madari nala	18°37′46″N 81°17′5.3″E Alt—614 m
32	Patel para	18°37′42.1″N 81°17′39.8″E Alt—642 m
33	Madadi village	18°37′43.8″N 81°17′58.9″E Alt—622 m
34	Nayapara	18°37′45.6″N 81°18′01.5″E Alt—623m
35	Near Garma Dongri	18°37′45.6″N 81°18′01.5″E Alt—623m
36	Near Perpa Village	18°37′23″N 81°16′45.5″E Alt—623m
37	Near ESSAR plant	18°37′29.1″N 81°15′51.5″E Alt—619m
Locations for vegetation study in Deposit—14NMZ (Buffer Zone)		
1	Near Bhannara hill	18°44′9.1″N 81°16′20.8″E Alt—488m
2	Behind central workshop	18°42′48.3″N 81°15′56.8″E Alt—534m
3	Near Bacheli, a stream	18°42′51″N 81°15′32.4″E Alt—541m
4	Chalkipara	18°41′37.7″N 81°16′20.4″E Alt—546m
5	Pina bacheli	18°41′44.3″N 81°17′54.3″E Alt—532m
6	Dugeli	18°41′36″N 81°18′41″E Alt—546m
7	Kirandul No.1 nala	18°37′42.2″N 81°15′51.7″E Alt—638m
8	Tailing Dam	18°39′11.8″N 81°17′ 6.2″E Alt—619m
9	Water body	18°39′12.4″N 81°17′0.3″E Alt—595m
10	Water body	18°39′21.1″N 81°17′16.1″E Alt—581m
11	Near Ali Dongri	18°37′36.9″N 81°16′57.2″E Alt—611 m
12	Burdi Dongri	18°37′40.9″N 81°16′56.3″E Alt—620 m
13	Madari nala	18°37′46″N 81°17′5.3″E Alt—614 m
14	Patel para	18°37′42.1″N 81°17′39.8″E Alt—642 m

Locations for vegetation study in Deposit-14 (Buffer Zone)		
Sl. No.	Name of site	GPS bearing
15	Madadi village	18°37′43.8″N 81°17′58.9″E Alt—622 m
16	Nayapara	18°37′45.6″N 81°18′01.5″E Alt—623m
17	Near Garma Dongri	18°37′45.6″N 81°18′01.5″E Alt—623m
18	Near Perpa Village	18°37′23″N 81°16′45.5″E Alt—623m
19	Near ESSAR plant	18°37′29.1″N 81°15′51.5″E Alt—619m
20	Malenger pump house	18°35′30.8″N 81°13′11.1″E Alt—718m
21	Malenger hill top	18°35′27.8″N 81°13′12.5″E Alt—755m
22	Malenger hill middle	18°35′29.3″N 81°13′12.7″E Alt—744m
23	Malenger foothill	18°35′30.4″N 81°13′11.2″E Alt—733m
24	1km advance to Malenger pump house	18°35′40.5″N 81°13′23.3″E Alt—742m
25	2km advance to Malenger pump house	18°35′33.6″N 81°13′41.7″E Alt—742m
26	1.5km advance to Malenger pump house	18°35′27.6″N 81°14′16.9″E Alt—682m
27	Hiroli Village—near agriculture land	18°35′38.5″N 81°15′23.5″E Alt—682m
28	Kirnar village	18°36′26.5″N 81°15′48.4″E Alt—674m
29	Between Bennar hill and Bennar village	18°43′3.7″N 81°17′42.5″E Alt—502m
30	Bennar village	18°43′2.5″N 81°17′19.1″E Alt—498m
31	Bennar nala	18°43′8.8″N 81°17′7.1″E Alt—487m
32	Kirandul 4 no. area	18°38′57.6″N 81°16′3.7″E Alt—618m
Locations for vegetation study in Deposit-11B (Buffer Zone)		
1	Kirandul station	18°38′42.6″N 81°16′0.7″E Alt—625m
2	Kadampal—Patelpara	18°39′45.5″N 81°18′7.1″E Alt—575m
3	Kadampal—Patelpara forest	18°39′47″N 81°17′47″E Alt—575m
4	Kadampal water body	18°39′9.1″N 81°17′41.8″E Alt—583m
5	Hiroli Village—near agriculture land	18°35′38.5″N 81°15′23.5″E Alt—682m
6	Near Ali Dongri	18°37′36.9″N 81°16′57.2″E Alt—611 m
7	Burdi Dongri	18°37′40.9″N 81°16′56.3″E Alt—620 m
8	Madari nala	18°37′46″N 81°17′5.3″E Alt—614 m
9	Patel para	18°37′42.1″N 81°17′39.8″E Alt—642 m
10	Madadi village	18°37′43.8″N 81°17′58.9″E Alt—622 m
11	Nayapara	18°37′45.6″N 81°18′01.5″E Alt—623m
12	Near Garma Dongri	18°37′45.6″N 81°18′01.5″E Alt—623m
13	Near Perpa Village	18°37′23″N 81°16′45.5″E Alt—623m
14	Near ESSAR plant	18°37′29.1″N 81°15′51.5″E Alt—619m
15	Kirandul 4 no. Area	18°38′57.6″N 81°16′3.7″E Alt—618m
16	Kirandul No.1 nala	18°37′42.2″N 81°15′51.7″E Alt—638m
17	Tailing Dam	18°39′11.8″N 81°17′6.2″E Alt—619m
18	Water body	18°39′12.4″N 81°17′0. 3″E Alt—595m
19	Water body	18°39′21.1″N 81°17′16.1″E Alt—581m
20	Malenger pump house	18°35′30.8″N 81°13′11.1″E Alt—718m
21	Malenger hill top	18°35′27.8″N 81°13′12.5″E Alt—755m

Locations for vegetation study in Deposit-14 (Buffer Zone)		
Sl. No.	Name of site	GPS bearing
22	Malenger hill middle	18°35′29.3″N 81°13′12.7″E Alt—744m
23	Malenger foothill	18°35′30.4″N 81°13′11.2″E Alt—733m
24	1km advance to Malenger pump house	18°35′40.5″N 81°13′23.3″E Alt—742m
25	2km advance to Malenger pump house	18°35′33.6″N 81°13′41.7″E Alt—742m
26	1.5km advance to Malenger pump house	18°35′27.6″N 81°14′16.9″E Alt—682m
27	Hiroli Village—near agriculture land	18°35′38.5″N 81°15′23.5″E Alt—682m
28	Kirnar village	18°36′26.5″N 81°15′48.4″E Alt—674m
29	Behind central workshop	18°42′48.3″N 81°15′56.8″E Alt—534m
30	Near Bacheli, a stream	18°42′51″N 81°15′32.4″E Alt—541m
31	Chalkipara	18°41′37.7″N 81°16′20.4″E Alt—546m

2.6 Canopy Statistics

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

2.7 Species Diversity (Alpha Diversity)

Since Shannon and Wiener's H' is an index of information, it was employed to measure diversity of any assemblage (Shannon & Wiener, 1963). The Simpson's Dominance Index (D) was also calculated (Simpson, 1949).

2.8 Life Form Study

The life form composition of the community is the manifestation of the adaptations of its component species to the climatic condition, and contributes to community architecture (Jamir et al., 2006). Life form spectrum is the sum of adaptations of plants to the climate. Following the system of Braun-Blanquet's (1951) system the area possesses five major classes like Phanerophytes, Therophytes, Hydrophytes, Hemicryptophytes and Geophytes.

2.9 Taxonomic Identification of Plant Species

Plant species were identified following standard flora by Hooker (1872-1897), Verma et al. (1985) and Kumar et al., (2005). Names of the plant species were verified using Bennet (1987). The help of scientists of Botanical survey of India (BSI), Kolkata was taken.

2.10 Faunal Study

An ecological survey of the study area for understanding the fauna of the study area was conducted, particularly with reference to listing of species and assessment of the existing baseline ecological conditions in the study area through Direct Count Method; Transect Method; Photographic-survey Based; Dropping/scat; Collection of dissociable body parts and Interviewing Local Villagers.

The study was conducted during post monsoon season in the year 2015-16. The study for fauna was conducted before sunrise to late night (5:30AM to 11:30PM). The adults of Odonata, Lepidoptera and Hymenoptera were collected in the field with aspirator, manually and aerial sweeping nets. The collected insects were preserved by using benzene and kept in insect collection boxes for further examination in the laboratory. Mollusca, Amphibians and Reptiles were collected with the help of forceps manually and Fishes with the help of Aquatic net and all the materials preserved in 70% Alcohol. The random collection and field observation were also made on different groups of the fauna of the study area. The Reptiles, Aves and Mammals were identified by using Binocular (10mm X 25mm) and their presence was recorded by taking photographs. The presence of some Mammals species is also ascertained on the basis of pugmarks, interview with wildlife and forest officials, NMDC staff and villagers residing in study area (Sunquist, 1981; Tamang, 1982; McDougal, 1997; Srestha & Basnet, 2005).

3. Result and Discussion

3.1 Status of Phytodiversity

Bailadila Reserve Forest can prove to be a paradise for both plant and wildlife diversity. The Dantewada district of Chhattisgarh lies on the Gondwana Biodiversity Zone, which mostly comprises of the Tropical Forests. As this area is full of terrains, much of the forest remains unexplored and it is highly probable that this area contains some of the undocumented species. The forest area in the buffer zone comes under Reserve Forest and has following classes as per classification of Forest Survey of India.

(i) Closed Forest/Very Dense Forest—Where canopy cover is above 70%

(ii) Dense Forest—Where canopy cover is between 40%-70%

(iii) Open Forest—Where canopy cover is between 10%-40%

(iv) Degraded Forest—Where canopy cover is below 10%

The vegetation occurring in the area belongs to Southern tropical dry deciduous forests (Class-5A) which intermingles with Class-5B (Northern tropical dry deciduous type) according to Champion and Seth Classification of forest types of India 1968. According to the classification of Legris and Pascal (1982) the area falls under Deciduous climax forests and this type of forests does not have the potentiality of secondary moist deciduous forests. The most characteristic tree of this type is *Anogeissus latifolia* while *Terminalia tomentosa* is a very typical associate. *Diospyros melanoxylon* is also common. *Boswellia serrata* and *Lagersatroemia parviflora* are very wide spread and conspicuous in this category of forests. Bamboo is generally of poor quality. Grass is conspicuous till it is grazed or burnt in forest fire. Woody climbers are few like *Bauhinia vahlii*. This type of forest, being especially prevalent in the drier localities occurs throughout the study area. But the rain fall being around 3000mm annually it can hardly be classified under dry forest type. Therefore some patches can be classified under Tropical Moist Deciduous Forest with types as $3B/C_1$ and $3B/C_2$. In this type of forests, trees are comparatively tall. It has a leafless period during dry season which may or may not begin with the cold weather.

The boundaries of biogeographic provinces i.e., Eastern Plateau (6B2) and Eastern Highlands (6C2) are not very sharp and they inter-grade into each other. Interestingly the recent physiographic map adopted by the Forest Survey of India also classifies this region into three zones viz., North Deccan, East Deccan and South Deccan by apparently giving more weightage to the political boundary between Maharashtra and Chhattisgarh. The entire area forms the South-Western and Westernmost part of historical Dandakaranya region. This region extends up to North-Eastern Ghats.

The top canopy remains leafless between February-May. The under storey is well defined and the forest floor is full of vegetal growth. Portions of moist deciduous forests were clear felled and converted into plantations of different species such as Teak (*Tectona grandis*), *Eucalyptus sps*, etc. But none of these species being indigenous to this region and planted without any ecological impact study could not successfully establish themselves. In some of the plantation area invasive species like *Lanatana camara* and/or *Eupatorium odoratum* has invaded. The adjacent areas to drainage *nallas* show rich vegetation whereas the hill top shows barren condition with clear signs of laterization. In the hill top soil formation process is poor and simultaneously there is rapid washing out of top soil.

In the hilly areas of Bailadila, availability of iron ore and vegetation change with altitude. According to Mooney (1942a), vegetation at the study area is divided into three zones and has been sub-divided to different associations depending upon various sites in the hill range as,

i. The outer slope of the Hill Range up to an altitude above 914m above sea level—Northern portion of the hill "vegetation is of Hill type with dense bamboo" with evergreen species like Sataparni (*Alstonia scholaris*), Garari (*Cleistanthus collinus*), and *Bauhinia vahlli*. In the southern half of the hill species like Haldu (*Adina cordifolia*), and Mahua (*Madhuca indica*) are available in low quantity. Bijasal (*Pterocarpus marsupium*) with good girth size is found in this side.

ii. The crest of the Hill Range and the adjoining slope—this comes within 914m to 1224m above MSL. This region has high rock content and laterite with low soil content. Trees are stunted, sparse and dense grass (*Physalanona sp*) noticed. Tree species are Saja (*Terminalia alata*), Tendu (*Diospyros melanoxylon*), Awnla (*Emblica officinalis*), Achar (*Buchanania latifolia*), Harra (*Terminalia chebula*), and Sal (*Shorea robusta*), etc. Mooney (1942b) has described this grass dominated region as sub-climax or pro-climax type as a result of shifting cultivation that was in practice even few years back.

iii. The Central valley—the central valley do not come under the study site but is in the buffer area—has species like Saja (*Terminalia alata*), Bijasal (*Pterocarpus marsupium*), Kusum (*Schleichera oleosa*), Semal (*Bombax ceiba*), Kala-Siris (*Albizzia lebbbek*), and Kadamba (*Anthocephalus cadamba*), etc. Bamboo is conspicuously low in this region. Here are few types of forests dominated by species as stated below provided undisturbed: Saja forest, Dhaora (*Anogeisus latifolia*) forest, Garari (*Cleistanthus collinus*) forest, Bhirra (*Chloroxylon swietenia*) forest, Khair (*Acacia catechu*) forest, Jamun (*Syzygium cumini*) forest, Anjan (*Hardwickia binata*) forest, and Mixed Forest with miscellaneous species.

The major floral associations of the forest area of Bailadila are grouped under the following six categories basing on the description of earlier authors and present study of IVI (Table 2).

Table 2. Floral association of the study area

Acacia catechu (Khair)	The coarse gravelly soil supports the xerophytic growth of Khair. The forests are generally open. Quality of the crop and natural reproduction is generally poor.
Anogeissus latifolia (Dhaora)	The most common constituent of the mixed deciduous forests, often growing more or less gregariously. Avoids swampy and badly drained grounds and requires good drainage. It produces abundant natural regeneration but most of it gets severely damaged and killed in areas with low density due to severe annual forest fires.
Chloroxylon swietenia (Bhirra)	Commonly found in areas where the soil is shallow, arid and sandy.
Cleistanthus collinus (Garai)	Patches of practically pure Garai forest are sometimes seen in the mixed forests in which there are very few associates in the overwood. The reasons for its occurrence in a gregarious form are not quite understood. This sub-type forms an important future reserve for poles and fuel. Density is generally full.
Syzygium cumini (Jumun)	Commonly found in the open forests of Gollapalli, Nilamadugu and Kollaiguda reserves and some of the reserves of Sukma range. It exhibits xerophytic characters and is narrow leaved. Its seedlings die back annually for some years in their early stages.
Terminalia alata (Saja)	It alone thrives in such places where the soil is moist but somewhat heavy owing to the presence of fine clay, where the drainage is hampered and the species are that are susceptible to bad soil aeration disappear.
Hardwickia binata (Anjan)	It is scattered in the southern portion of Gollapalli reserve. This has probably spread from the adjoining area of Andhra Pradesh where it is commonly seen. The areas under this sub-type are not much of any economic importance.

3.2 Life Form Status

Life-form refers rather to the vegetative form of the plant body which is assumed by many ecologists to be a result of morphological adjustments to the environment. Those organisms which show the same general morphological features (woody lianas, stem succulents, annuals, tap-rooted perennials with a basal rosette of leaves and the renewal bud at the soil surface, tall broad-leaf deciduous trees, etc.) belong to the same life-form whatever their systematic position in the plant families. It is inherent in the so-called ‘‘biological” concept of life-form that there is a fundamental harmony or analogy between the members of such structural groups and the environment in which they prevail. Presence of large percentage of phanerophytes (trees and shrubs) and therophytes (annuals and herbaceous vegetation) indicates semiarid to tropical vegetation structure. The life form status of the study area is given in Figure 2.

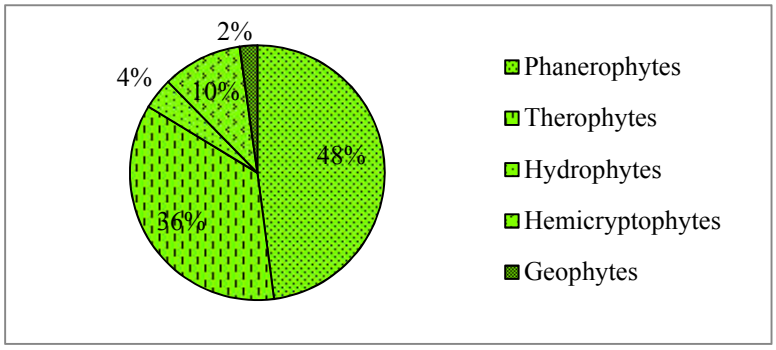


Figure 2. Life form in core and buffer zone

3.3 Vegetation within ML Area

The three mines within Kirandul Complex namely Deposit-14, 14 NMZ and a part of 11 (11B) have a very large area given to NMDC for mining as mined lease area and is almost broken. In spite of all out mining activities in all the mining leases as stated above Deposit-14 has 101 floral species within it. This includes 18 tree species, 26 species of shrubs and 57 species of herbs. Mining lease 14 NMZ has 80 floral species within it. This includes 17 tree species, 18 species of shrubs and 44 species of herbs. A part of mining lease 11 (11B) has 93 floral species within it. This includes 21 tree species, 24 species of shrubs and 48 species of herbs. Trees from Fabaceae family include species like *Butea monosperma* and *Cassia fistula*. Within the members of Poaceae *Thysanolaena maxima* is seen very frequently around comparatively stable broken area. There are species like *Parthenium hysterophorus* which are alien and also invasive in nature.

The three core zones in total have 110 species and maximum number of species is observed in ML-14 (Table 3). This is due to the fact that there is a good patch of vegetation within the ML area of Deposit-14 on both sides of Dhobinala. This is a perennial stream and it originates just below the waste dump of the deposit. The other two deposits have less number of species due to lack of any forest patch. The species that are available are mostly in the road sides and slopes where anthropogenic interventions are least.

Table 3. List of plant species at core area of Kirandul Iron Ore Mine

Sl. No.	Scientific name of the species	Family
Tree		
1	*Acacia auriculiformis*	Fabaceae
2	*Adina cordifolia*	Rubiaceae
3	*Aegle mermelos*	Rutaceae
4	*Albizzia procera*	Fabaceae
5	*Bauhinia acuminate*	Fabaceae
6	*Boswellia serreta*	Burseraceae
7	*Buchanania lanzen*	Anacardiaceae
8	*Butea monosperma*	Fabaceae
9	*Cassia fistula*	Fabaceae
10	*Cedrela tonna*	Meliaceae
11	*Cliestanthus collinus*	Euphorbiaceae
12	*Dillenia pentagyna*	Dilleniaceae
13	*Diospyros melanoxylon*	Ebnaceae
14	*Emblica officinales*	Euphorbiaceae
15	*Ixora arborea*	Rubiaceae
16	*Kydia sp.*	Malvaceae

Sl. No.	Scientific name of the species	Family
Tree		
17	*Lagerstromea perviflora*	Lythraceae
18	*Lannea coromandelica*	Anacardiaceae
19	*Phoenix sylvestris*	Arecaceae
20	*Sleichera oliosa*	Sapindaceae
21	*Soymida febrifuga*	Meliaceae
22	*Syzizium cumini*	Myrtaceae
23	*Terminalia belerica*	Combretaceae
24	*Terminalia tomentosa*	Combretaceae
25	*Trema orientalis*	Urticaceae
Shrub		
1	*Asparagus racemosus*	Liliaceae
2	*Bauhinia vahlii*	Fabaceae
3	*Caesalpinia bonducella*	Caesalpiniaceae
4	*Calotropis procera*	Asclepiadaceae
5	*Capparis spinosa*	Capparidaceae
6	*Casiarea varacca*	Samydaceae
7	*Coccinia grandis (= Cephalandra indica)*	Cucurbitaceae
8	*Cryptolepis buchanani*	Apocynaceae
9	*Dioscorea bulbifera*	Dioscoreaceae
10	*Flacourtia ramontchi*	Flacourtiaceae
11	*Gardenia gummifera*	Rubiaceae
12	*Gymnema sylvestre*	Asclepiadaceae
13	*Hemidesmus indicus*	Asclepiadaceae
14	*Icnocarpus frutescens*	Apocynaceae
15	*Jatropha gossypifolia*	Euphorbiaceae
16	*Lantana camara*	Verbenaceae
17	*Phoenix acualis*	Arecaceae
18	*Randia uliginosa*	Rubiaceae
19	*Ricinus communis*	Euphorbiaceae
20	*Rivea hypocrateriformis*	Convolvulaceae
21	*Smilax macrophylla*	Liliaceae
22	*Streblus asper*	Moraceae
23	*Tephrosia purpurea*	Papilionaceae
24	*Thespesia lampus*	Malvaceae
25	*Trema orientales*	Urticaceae
26	*Vangueria spinosa*	Rubiaceae
27	*Vitex negundo*	Verbenaceae
28	*Woodfordia floribunda*	Lythraceae
Herb		
1	*Aerva lanata*	Amaranthaceae

Sl. No.	Scientific name of the species	Family
Tree		
2	*Ageratum conyzoides*	Asteraceae
3	*Alternanthera sessilis*	Amaranthaceae
4	*Alysicarpus monilifer*	Fabaceae
5	*Amaranthus spinosus*	Amaranthaceae
6	*Aristida adscenscionis*	Poaceae
7	*Asparagus racemosus*	Asperagaceae
8	*Atylosia scarabaeoides*	Papilionaceae
9	*Bonnaya brachiata*	Scrophulariaceae
10	*Botrychium daucifolium*	Ophioglossaceae
11	*Cassia occidentalis*	Caesalpiniaceae
12	*Cassia tora*	Fabaceae
13	*Celosia argentia*	Amaranthaceae
14	*Curculigo orchioides*	Amaryllidaceae
15	*Cynodon dactylon*	Poaceae
16	*Cyperus rotundus*	Cyperaceae
17	*Dactyloctenium aegypticum*	Poaceae
18	*Desmodium triflorum*	Papilionaceae
19	*Digitaria sanguinalis*	Poaceae
20	*Dioscorea alata*	Dioscoreaceae
21	*Eichhornia crassipes (= E. speciosa)*	Pontederiaceae
22	*Elephantopus scaber*	Asteraceae
23	*Eragrostis tenella*	Poaceae
24	*Eragrostis uniloides*	Poaceae
25	*Euphorbia hirta*	Euphorbiaceae
26	*Euphorbia microphylla*	Euphorbiaceae
27	*Evolvulus alsenoides*	Convolvulaceae
28	*Evolvulus nummularius*	Convolvulaceae
29	*Fimbristylis japonicum*	Cyperaceae
30	*Flemingia chapper*	Fabaceae
31	*Gymnema sylvestre*	Asclepiadaceae
32	*Habenaria diphylla*	Orchidaceae
33	*Hemidesmus indicus*	Asclepiadaceae
34	*Indigofera pulchella*	Fabaceae
35	*Ionidium suffruticosum*	Violaceae
36	*Leea sp.*	Leeaceae
37	*Panicum repens L.*	Poaceae
38	*Parthenium hysterophorus*	Asteraceae
39	*Paspalidium flavidum*	Poaceae
40	*Perotis indica (= P. latifolia)*	Poaceae
41	*Phagmatis karka*	Poaceae

Sl. No.	Scientific name of the species	Family
Tree		
42	*Phyllanthus amarus*	Euphorbiaceae
43	*Phyllanthus niruri*	Euphorbiaceae
44	*Rivea hypocretaroformis*	Convolvulaceae
45	*Rungia parviflora*	Acanthaceae
46	*Scoparia dulcis*	Scrophulariaceae
47	*Setaria glauca*	Poaceae
48	*Sida cordifolia*	Malvaceae
49	*Solanum zylanicum*	Solanaceae
50	*Spermacoce hispida*	Rubiaceae
51	*Stephania harnandifolia*	Menispermaceae
52	*Thysanolaena maxima*	Poaceae
53	*Trichosanthus sp.*	Cucurbitaceae
54	*Tridax procumbens*	Asteraceae
55	*Triumfetta rhomboidea*	Tiliaceae
56	*Urena lobata*	Malvaceae
57	*Vernonia cinerea*	Asteraceae

3.4 Vegetation in the Buffer Zone

Buffer zone comes within 10km radius of the mine-lease area and it is within Bailadila Reserve Forest and within Dantewada Taluk, Dantewada district of Chhattisgarh. Buffer zone is mostly covered with undulated hilly terrain within 180m-1200m altitude. More than one third of the Buffer zone is within Bailadila RF, Bijapur RF and Palnar PF. But within 10km radius there is no notified Wildlife Sanctuary and National Park. Talperu and Malenger Nadi are passing through the Buffer Zone. There are few nallahs and stream within the buffer area.

The buffer zone has 253 species in total within which 77 are tree species, 72 are shrubs and 81 are herbs. There are also 2 bamboo species, 3 epiphytes, 1 species of insectivorous plant in this ecosystem (Table 4). Number of herb and shrub species is comparatively much less in the buffer zone than the core zone taking the area in to account. The season of study being winter number herbaceous species in general and grasses in particular are ephemerals in these habitat conditions and therefore not possible to identify.

Table 4. List of plant species at buffer area of Kirandul Iron Ore Mine

Sl. No.	Scientific name of the species	Family
Tree		
1	*Acacia catechu*	Fabaceae
2	*Acacia leucophloea*	Fabaceae
3	*Adina cordifolia*	Rubiaceae
4	*Aegle mermelos*	Rutaceae
5	*Alanzium lamarkii*	Cornaceae
6	*Albizzia lebbek*	Fabaceae
7	*Albizzia odoratissima*	Fabaceae
8	*Albizzia procera*	Fabaceae
9	*Anogeissus latifolia*	Combretaceae
10	*Anthocephalus cadamba*	Rubiaceae

Sl. No.	Scientific name of the species	Family
Tree		
11	*Azadirachta indica*	Meliaceae
12	*Bassia latifolia*	Sapotaceae
13	*Bauhinia acuminate*	Fabaceae
14	*Bauhinia malabarica*	Fabaceae
15	*Boaswellia serrate*	Burseraceae
16	*Bombax ceiba*	Malvaceae
17	*Borassus flabellifer*	Arecaceae
18	*Bridelia retusa*	Euphorbiaceae
19	*Buchanania lanzen*	Anacardiaceae
20	*Butea monosperma*	Fabaceae
21	*Careya arborea*	Myrtaceae
22	*Carryota urens*	Arecaceae
23	*Casearia varacca*	Samydaceae
24	*Cassia fistula*	Fabaceae
25	*Cedrela toona*	Meliaceae
26	*Chloroxylon swietenia*	Meliaceae
27	*Cliestanthus collinus*	Euphorbiaceae
28	*Cochlospermum religiosum*	Bixaceae
29	*Dalbergia paniculata*	Fabaceae
30	*Dalbergia sisoo*	Fabaceae
31	*Dillenia pentagyna*	Dilleniaceae
32	*Diospyros melanoxylon*	Ebnaceae
33	*Emblica officinales*	Euphorbiaceae
34	*Ficus bengalensis*	Moraceae
35	*Ficus glomerata*	Moraceae
36	*Ficus religiosa*	Moraceae
37	*Flacourtia indica*	Flacourtiaceae
38	*Gardenia latifolia*	Rubiaceae
39	*Gardenia turgid*	Rubiaceae
40	*Garuga pinnata*	Burseraceae
41	*Gmelina arborea*	Verbinaceae
42	*Grewia tiliaefolia*	Tiliaceae
43	*Hardwickia binate*	Fabaceae
44	*Ixora arborea*	Rubiaceae
45	*Kydia calycina*	Malvaceae
46	*Lagerstromea perviflora*	Lythraceae
47	*Lannea coromandelica*	Anacardiaceae
48	*Mallotus phillipensis*	Euphorbiaceae
49	*Mitragyna parviflora*	Rubiaceae
50	*Morinda tinctoria*	Rubiaceae

Sl. No.	Scientific name of the species	Family
Tree		
51	*Ougeinia oogeinensis*	Fabaceae
52	*Phoenix sylvestris*	Arecaceae
53	*Polyalthia cerasoides*	Annonaceae
54	*Pongamia pinnata*	Fabaceae
55	*Pterocarpus marsupium*	Fabaceae
56	*Randia uliginosa*	Rubiaceae
57	*Saccopetalum tomentosum*	Annonaceae
58	*Schrebera swietenioides*	Olieaceae
59	*Semecarpus anacardium*	Anacardiaceae
60	*Sleichera oliosa*	Sapindaceae
61	*Solanum verbassifolium*	Solanaceae
62	*Soymida febrifuga*	Meliaceae
63	*Sterculia urens*	Sterculaceae
64	*Sterospermum personatum*	Bignoniaceae
65	*Sterospermum suaveolens*	Bignoniaceae
66	*Strychnos nux-vomica*	Loganiaceae
67	*Syzizium cumini*	Myrtaceae
68	*Tamarindus indica*	Fabaceae
69	*Tectona grandis*	Verbinaceae
70	*Terminalia alata*	Combretaceae
71	*Terminalia belerica*	Combretaceae
72	*Terminalia tomentosa*	Combretaceae
73	*Termmalia arjuna*	Combretaceae
74	*Trema orientalis*	Urticaceae
75	*Wrightia tinctoria*	Apocynaceae
76	*Xylia xylocarpa*	Fabaceae
77	*Zizyphus mauritiana*	Rhamnaceae
Shrub		
1	*Abrus precatorius*	Fabaceae
2	*Acacia caesia*	Fabaceae
3	*Acacia pennata*	Fabaceae
4	*Achyranths aspera*	Amaranthaceae
5	*Alangium salvifoloum*	Cornaceae
6	*Andrographis paniculata*	Acanthaceae
7	*Antidesma diandrum*	Euphorbiaceae
8	*Aristolochia indica*	Aristolochiaceae
9	*Asparagus racemosus*	Liliaceae
10	*Bambusa arundinacea*	Poaceae
11	*Bauhinia vahlii*	Fabaceae
12	*Butea superba*	Fabaceae

Sl. No.	Scientific name of the species	Family
Tree		
13	*Caesalpinia bonducella*	Caesalpiniaceae
14	*Calotropis procera*	Asclepiadaceae
15	*Capparis spinosa*	Capparidaceae
16	*Carissa spinarum*	Apocynaceae
17	*Casiarea varacca*	Samydaceae
18	*Catasibee spinosa*	Flacourtiaceae
19	*Celastrus paniculata*	Celastraceae
20	*Clerodendron serratum*	Verbinaceae
21	*Coccinia grandis (= Cephalandra indica)*	Cucurbitaceae
22	*Combretum roxburghii*	Combretceae
23	*Cryptolepis buchanani*	Apocynaceae
24	*Cucuma aromtica*	Zingiberaceae
25	*Dendrocalamus strictus*	Poaceae
26	*Desmodium laxiflorum*	Fabaceae
27	*Dioscorea bulbifera*	Dioscoreaceae
28	*Dioscorea floribunda*	Dioscoreaceae
29	*Dioscoria alata*	Dioscoriaceae
30	*Dioscoria belophylla*	Dioscoriaceae
31	*Dioscoria pentaphylla*	Dioscoriaceae
32	*Embilia robusta*	Myrsinaceae
33	*Eranthemum pulchellum*	Acanthaceae
34	*Eulaliopsis binate*	Poaceae
35	*Flacourtia indica*	Flacourtiaceae
36	*Flacourtia ramontchi*	Flacourtiaceae
37	*Gardenia gummifera*	Rubiaceae
38	*Grewia hirsute*	Tiliaceae
39	*Gymnema sylvestre*	Asclepiadaceae
40	*Helisteris isora*	Sterculaceae
41	*Hemidesmus indicus*	Asclepiadaceae
42	*Hibiscus ficulneus*	Malvaceae
43	*Holarrhena antidysenterica*	Apocynaceae
44	*Icnocarpus frutescens*	Apocynaceae
45	*Indigofera arborea*	Fabaceae
46	*Indigofera tinctoria*	Fabaceae
47	*Jatropha gossypifolia*	Euphorbiaceae
48	*Lantana camara*	Verbenaceae
49	*Leea macrophylla*	Vitaceae
50	*Lygodium japonicum*	Schizaeaceae
51	*Mahonia semialata*	Fabaceae
52	*Mukuna puruita*	Fabaceae

Sl. No.	Scientific name of the species	Family
Tree		
53	*Nyctanthus arbortris-tis*	Oleaceae
54	*Oxytenanthera nigrocilliat*	Poaceae
55	*Petalidium barlerioides*	Acanthaceae
56	*Phoenix acualis*	Arecaceae
57	*Randia uliginosa*	Rubiaceae
58	*Ricinus communis*	Euphorbiaceae
59	*Rivea hypocrateriformis*	Convolvulaceae
60	*Smilax macrophylla*	Liliaceae
61	*Stephania harnadifolia*	Apocyanceae
62	*Streblus asper*	Moraceae
63	*Swertia angustifolia*	Acanthaceae
64	*Tephrosia purpurea*	Papilionaceae
65	*Thespesia lampus*	Malvaceae
66	*Trema orientales*	Urticaceae
67	*Vangueria spinosa*	Rubiaceae
68	*Ventilago denticulate*	Rhamnaceae
69	*Vitex negundo*	Verbinaceae
70	*Woodfordia floribunda*	Lythraceae
71	*Zizyphus oenoplia*	Rhamnaceae
72	*Zizyphus rugosa*	Rhamnaceae
Herb		
1	*Aerva lanata*	Amaranthaceae
2	*Ageratum conyzoides*	Asteraceae
3	*Alocasia macrorhiza (= A. indica)*	Araceae
4	*Alternanthera sessilis*	Amaranthaceae
5	*Alysicarpus monilifer*	Fabaceae
6	*Amaranthus spinosus*	Amaranthaceae
7	*Aristida adscenscionis*	Poaceae
8	*Asparagus racemosus*	Asperagaceae
9	*Atylosia indica*	Papilionaceae
10	*Atylosia scarabaeoides*	Papilionaceae
11	*Barleria prionitis*	Acanthaceae
12	*Bonnaya brachiate*	Scrophulariaceae
13	*Botrychium daucifolium*	Ophioglossaceae
14	*Cassia occidentalis*	Caesalpiniaceae
15	*Cassia tora*	Fabaceae
16	*Celosia argentia*	Amaranthaceae
17	*Crinum asiaticum*	Liliaceae
18	*Curculigo orchioides*	Amaryllidaceae
19	*Curcuma amada*	Zinziberaceae

Sl. No.	Scientific name of the species	Family
Tree		
20	*Curcuma aromatic*	Zingiberaceae
21	*Cuscuta reflexa*	Convolvulaceae
22	*Cynodon dactylon*	Poaceae
23	*Cyperus rotundus*	Cyperaceae
24	*Dactyloctenium aegypticum*	Poaceae
25	*Dendrofthoe fulcata*	Loranthaceae
26	*Desmodium triflorum*	Papilionaceae
27	*Digitaria sanguinalis*	Poaceae
28	*Dioscorea alata*	Dioscoreaceae
29	*Eclipta prostrate*	Asteraceae
30	*Eichhornia crassipes (= E. speciosa)*	Pontederiaceae
31	*Elephantopus scaber*	Asteraceae
32	*Eleusine coarcana*	Poaceae
33	*Eleusine indica*	Poaceae
34	*Eragrostis tenella*	Poaceae
35	*Eragrostis uniloides*	Poaceae
36	*Eulalipsis binate*	Poaceae
37	*Euphorbia hirta*	Euphorbiaceae
38	*Euphorbia microphylla*	Euphorbiaceae
39	*Evolvulus alsenoides*	Convolvulaceae
40	*Evolvulus nummularius*	Convolvulaceae
41	*Fimbristylis japonicum*	Cyperaceae
42	*Habenaria diphylla*	Orchidaceae
43	*Hemidesmus indicus*	Asclepiadaceae
44	*Heteropogon contortus*	Poaceae
45	*Imperata cylindrical*	Poaceae
46	*Indigofera pulchella*	Fabaceae
47	*Ionidium suffruticosum*	Violaceae
48	*Leea sp.*	Leeaceae
49	*Lygodium japonicum*	Schizaeaceae
50	*Mukuna prurita*	Fabaceae
51	*Ocimum canum*	Lamiaceae
52	*Panicum milare*	Poaceae
53	*Panicum repens*	Poaceae
54	*Parthenium hysterophorus*	Asteraceae
55	*Paspalidium flavidum*	Poaceae
56	*Paspalum scrobiculatum*	Poaceae
57	*Perotis indica (= P. latifolia)*	Poaceae
58	*Phagmatis karka*	Poaceae
59	*Phyllanthus amaru*	Euphorbiaceae

Sl. No.	Scientific name of the species	Family
Tree		
60	*Phyllanthus niruri*	Euphorbiaceae
61	*Rivea hypocretaroformis*	Convolvulaceae
62	*Rungia parviflora*	Acanthaceae
63	*Saccharum spontaneum*	Poaceae
64	*Scoparia dulcis*	Scrophulariaceae
65	*Setaria glauca*	Poaceae
66	*Setaria sp.*	Poaceae
67	*Sida cordifolia*	Malvaceae
68	*Sida cordata*	Malvaceae
69	*Sida rhomboidea*	Malvaceae
70	*Solanum zylanicum*	Solanaceae
71	*Spermacoce hispida*	Rubiaceae
72	*Stephania harnandifolia*	Menispermaceae
73	*Thysanolaena maxima*	Poaceae
74	*Trichosanthus sp.*	Cucurbitaceae
75	*Tridax procumbens*	Asteraceae
76	*Triumfetta rhomboidea*	Tiliaceae
77	*Urena lobata*	Malvaceae
78	*Vernonia cinerea*	Asteraceae
79	*Vetiveria zizanoides*	Poaceae
80	*Viscum articulatum*	Loranthaceae
81	*Zornia diphylla*	Papilionaceae
Epiphytes		
1	*Cuscuta roxburghii*	Convolvulaceae
2	*Viscum articulatum*	Viscaceae
3	*Vanda roxburghii*	Loranthaceae
Bamboos		
1	*Dendrocalamus strictus*	Poaceae
2	*Bambusa arundinacea*	Poaceae
Insectivorous plant		
1	*Drocera burmanii*	Droceraceae

The diversity index (Table 5) in the tree level (2.10) is much more in the buffer zone in comparison to core zone (1.44). However, in our study, the species diversity index is lower than compared to other studies done at Eastern Ghats (Sahu et al., 2007; Reddy et al., 2008; Ganguli et al., 2016). Anthropogenic activity within forest area seems to be low in the tree layer as observed from the count of cut off stumps. Canopy cover in most places of the forest area in this zone is within 40-70% which is known to be dense forest as per the FSI classification.

Table 5. Phytosociological parameters of core and buffer zones of Kirandul complex

Sl. No.	Indices	Core Zone	Buffer Zone
1	Canopy Cover (%)	0%-10% (40% in one site)	10%-40% and 40%-70%
2	Diversity Index		
	Tree Level	1.44	2.10
	Shrub level	1.75	2.05
	Herb level	1.13	1.49
3	Dominance Index		
	Tree level	0.36	0.27
	Shrub level	0.42	0.13
	Herb level	0.52	0.22

Dominance index in the tree level of the buffer zone is only 0.27 which is much lower to 0.36 in comparison to core zone. This signifies that the tree layer in the buffer zone is shared by many species rather than a few ones which is a tendency towards mixed forest type rather than dominance of few tree species. Dominancy of single species is often attributed to niche diversification, disease, species competition and grazing (Whittaker & Levin, 1977; Harper, 1977). It is also observed that within the buffer zone there are few important species like *Bauhinia malabarica, Cedrela toona Dalbergia paniculata, Croton oblongifolia, Shorea robusta, and Annona squoamosa* which are considered to be prominent forest species of central India. The availability of some of these species is not very frequent in the core zone. Species like *Borassus flabellifer, Azadirachta indica, Terminalia tomentosa, Eugenia jambolana, Ficus glomerata, Terminalia arjuna, Diospyros montana, and Mangifera indica* share the tree canopy layer in the non-forest area of the buffer zone. Diversity in the tree level in the non-forest areas is further enhanced by the availability of non-forest species like *Mangifera indica*, and *Acacia auriculiformis*, etc. Shrub species like *Lantana camara* and *Eupatorium odoratum, Parthenium sp* are also available in this region which is considered to be the invasive species in Indian forests as well as non-forest areas. These invasive species are also very frequently available in the core area. Availability of these species in the buffer zone signifies that there is considerable anthropogenic intervention in the ecosystem which has resulted in alteration of species composition of the core as well as buffer zone which is similar to the studies on impact of invasive species on forests (Gordon, 1998; Sanders et al., 2003; Charles & Dukes, 2007; Capers et al., 2009; Devine & Fei, 2011; Priyanka & Joshi, 2013).

There may be less extraction of forest resources form the buffer zone due to its remoteness but long term impact of human habitation and planting of domesticated species and exotic species like teak and *Eucalyptus sp* certainly have a negative impact on the ecosystem. This is why initiative on the part of NMDC in developing positive attitude towards conserving the forest resources in the buffer zone is suggested. Habitat development, therefore, cannot confine within the efforts of plantation, water body creation or soil conservation only. It also will include developing participatory conservation approach taking the villagers of the buffer as well as fringe area in to confidence. There is a clear negative relationship between the diversity and dominance indices in both core and buffer zone. In the buffer zone this relationship is more evident because of its pristine nature.

3.5 Faunal Study

The State of Chhattisgarh falls under the Deccan Bio-geographical Zone (Rodgers et al., 2000). Of its forests, 11% are under the Protected Area Network. During the study period around 208 species belongs to 10 Faunal Groups recorded from the Core and Buffer Areas of Kirandul Complex Iron Ore Mines study sites, in that 18 species recorded belongs to Mollusca; 1 species of Crustacean; 19 species of Odonata; 41 species of Lepidoptera; 3 species of Hymenoptera; 8 species of Fishes; 4 species of Amphibians; 7 species of Reptiles; 92 species of Birds and 15 species of Mammals. Out of total 208 species recorded, 34 species (i.e., 1 species of Lepidoptera, 21 species of Birds and 12 species of Mammals) are listed in different Schedules of Indian Wildlife (Protection) Act, 1972 (Table 6). The locatrion map of different species spotted in the study area is shown in Figure 3.

Table 6. Details of Fauna recorded at Kirandul Iron Ore Mine (Core and Buffer Area)

Sl. No.	Species	Kirandul Complex Iron Ore Mines			
		Deposit 14	Deposit 14NMZ	Deposit 11B	Buffer Area
(A) Mollusca					
1	*Bellamya bengalensis* form *typica*	-	-	-	+
2	*Bellamya crassa*	-	-	-	+
3	*Bellamya dissimilis*	-	-	-	+
4	*Bithynia (Digoniostoma) cerameopoma*	-	-	-	+
5	*Bithynia (Digoniostoma) pulchella*	-	-	-	+
6	*Melanoides tuberculata*	-	-	-	+
7	*Tarebia lineata*	-	-	-	+
8	*Lymnaea (Pseudosuccinea) acuminata* form *typica* and form *chlamys*	-	-	-	+
9	*Lymnaea (Pseudosuccinea) luteola* form *typica*	-	-	-	+
10	*Lamellidens corrianus*	-	-	-	+
11	*Lamellidens marginalis*	-	-	-	+
12	*Corbicula striatella*	-	-	-	+
13	*Cyclophorus (Litostylus) polynema*	-	-	-	+
14	*Edouardia orbus*	-	-	-	+
15	*Pterocylus rupestris*	-	-	-	+
16	*Ariophanta laidlayana*	-	+	-	+
17	*Hemiplecta basileus*	-	-	-	+
18	*Macrochlamys indica*	+	-	-	+
(B) Crustacean (Crab)					
19	*Brachytelphusa jaquemontii*	-	-	-	+
(C) Odonata (Damsel & Dragonflies)					
20	*Ceriagrion coromandelianum*	-	-	-	+
21	*Ischnura aurora*	-	-	-	+
22	*Pseudagrion rubriceps*	-	-	-	+
23	*Ictinogomphus rapax*	-	-	-	+
24	*Anax immaculifrons*	-	-	-	+
25	*Acisoma panorpoides*	-	-	-	+
26	*Brachythemis contaminata*	-	-	-	+
27	*Crocothemis servilia*	+	-	+	+
28	*Diplacodes trivalis*	-	+	-	+
29	*Orthetrum glaucum*	-	-	-	+
30	*Orthetrum pruinosum*	+	-	-	+
31	*Orthetrum sabina*	-	-	+	+
32	*Orthetrum triangulare*	-	-	-	+
33	*Palpopleura sexmaculata*	-	-	-	+
34	*Pantala flavescens*	+	+	+	+

Sl. No.	Species	Kirandul Complex Iron Ore Mines			
		Deposit 14	Deposit 14NMZ	Deposit 11B	Buffer Area
35	*Tramea virgina*	-	-	-	+
36	*Trithemis aurora*	-	-	-	+
37	*Trithemis festiva*	-	+	-	+
38	*Trithemis pallidinervis*	-	-	-	+
(D) Lepidoptera (Butterflies)					
39	*Graphium agamemnon*	-	-	-	+
40	*Papilio polytes*	-	+	-	+
41	*Papilio demoleus*	-	-	-	+
42	*Atrophaneura aristolochiae*	-	-	-	+
43	*Eurema hecabe*	+	+	-	+
44	*Catopsilia pomona*	-	-	-	+
45	*Catopsilia pyranthe*	-	+	+	+
46	*Colotis danae*	-	-	-	+
47	*Ixias marianne*	+	-	-	+
48	*Ixias pyrene*	-	-	-	+
49	*Pieris brassicae*	-	-	-	+
50	*Pieris canidia*	-	-	-	+
51	*Cepora nerissa*	-	+	-	+
52	*Delias eucharis*	+	-	-	+
53	*Belenois aurota*	-	-	-	+
54	*Castalius rosimon*	-	-	-	+
55	*Catochrysops strabo*	-	-	-	+
56	*Pseudozizeeria maha*	+	+	-	+
57	*Tirumala limniace*	-	-	-	+
58	*Danaus genutia*	-	+	-	+
59	*Danaus chrysippus*	+	+	-	+
60	*Euploea core*	-	-	-	+
61	*Polyura athamas*	-	-	-	+
62	*Melanitis leda*	-	-	-	+
63	*Acraea violae*	-	-	-	+
64	*Argyreus hyperbius*	-	-	-	+
65	*Phalanta phalantha*	-	-	-	+
66	*Moduza procris*	-	-	-	+
67	*Athyma perius*	-	-	-	+
68	*Euthalia nais*	-	-	-	+
69	*Tanaecia lepidea*	-	-	-	+
70	*Cyrestis thyodamas*	-	-	-	+
71	*Ariadne ariadne*	-	-	-	+
72	*Junonia orrithiya*	-	-	-	+

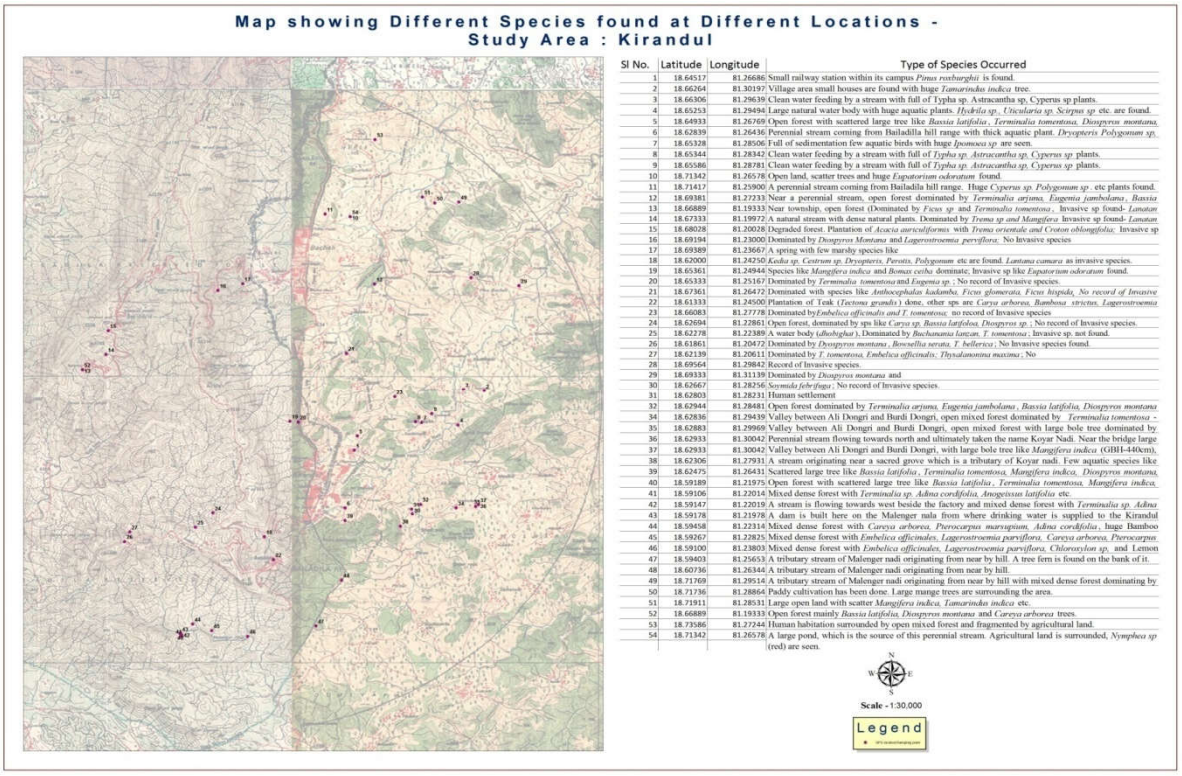
Sl. No.	Species	Kirandul Complex Iron Ore Mines			
		Deposit 14	Deposit 14NMZ	Deposit 11B	Buffer Area
73	*Junonia hierta*	-	-	-	+
74	*Junonia iphita*	-	+	+	+
75	*Junonia atlites*	-	-	-	+
76	*Junonia almana*	-	-	-	+
77	*Junonia lemonias*	+	+	+	+
78	*Hypolimnas misippus*	-	-	-	+
79	*Kallima inachus*	-	-	-	+
(E) Hymenoptera (Bees and Wasp)					
80	*Apis (Megapis) dorsata dorsata*	+	-	-	+
81	*Ropalidia brevita*	-	-	-	+
82	*Delta pyriforme pyriforme*	-	-	-	+
(F) Pisces (Fishes)					
83	*Channa gachua*	-	-	-	+
84	*Danio dangila*	-	-	-	+
85	*Danio rerio*	-	-	-	+
86	*Garra mullya*	-	-	-	+
87	*Pethia conchonius*	-	-	-	+
88	*Puntius amphibius*	-	-	-	+
89	*Rasbora daniconius*	-	-	-	+
90	*Schistura dayi*	-	-	-	+
(G) Amphibians (Toad and Frogs)					
91	*Duttaphrynus melanostictus*	-	-	-	+
92	*Euphlyctis cyanophlyctis*	-	-	-	+
93	*Fejervarya syhadrensis*	-	-	-	+
94	*Fejervarya orissaensis*	-	-	-	+
(H) Reptiles (Lizards, Skinks and Snakes)					
95	*Calotes versicolor*	+	+	+	+
96	*Psammophilus dorsalis*	+	-	+	+
97	*Hemidactylus brooki*	-	-	-	+
98	*Lygosoma punctata*	-	-	-	+
99	*Mabuya macularia*	-	-	-	+
100	*Echis carinatus*	-	-	-	+
101	*Lycodon aulicus*	+	-	+	+
(I) Aves (Birds)					
102	*Gallus gallus*	-	-	-	+
103	*Pavo cristatus*	-	-	-	+
104	*Hemicircus canente*	-	-	-	+
105	*Dendrocopos nanus*	-	-	-	+
106	*Dendrocopos canicapillus*	-	-	-	+

Sl. No.	Species	Kirandul Complex Iron Ore Mines			
		Deposit 14	Deposit 14NMZ	Deposit 11B	Buffer Area
107	*Dinopium benghalense*	-	+	-	+
108	*Megalaima lineata*	-	-	-	+
109	*Megalaima asiatica*	-	-	-	+
110	*Megalaima haemacephala*	-	-	-	+
111	*Coracius benghalensis*	+	+	+	+
112	*Halcyon smyrensis*	-	-	-	+
113	*Nyctyornis athertoni*	-	-	-	+
114	*Merops orientalis*	-	+	+	+
115	*Merops leschenaulti*	-	-	-	+
116	*Hierococcyx varius*	-	-	-	+
117	*Phaenicophaeus tristis*	-	-	-	+
118	*Centropus sinensis*	+	-	-	+
119	*Psittacula cyanocephala*	-	-	-	+
120	*Cypsiurus balasiensis*	-	+	-	+
121	*Columba livia*	-	+	+	+
122	*Streptopelia chinensis*	+	-	-	+
123	*Actitis hypoleucos*	-	-	-	+
124	*Vanellus malabaricus*	-	-	-	+
125	*Vanellus cinereus*	-	+	-	+
126	*Vanellus indicus*	-	-		+
127	*Milvus migrans*	-	-	-	+
128	*Spilornis cheela*	-	-	-	+
129	*Accipiter badius*	-	-	-	+
130	*Spizaetus cirrhatus*	-	-	-	+
131	*Falco tinnunculus*	+	+	-	+
132	*Phalacrocorax niger*	-	-	-	+
133	*Egretta garzetta*	-	-	-	+
134	*Mesophoyx intermedia*	-	-	-	+
135	*Bubulcus ibis*	-	+	+	+
136	*Ardeola grayii*	-	-	-	+
137	*Pseudibis papillosa*	-	-	-	+
138	*Pitta brachyura*	+	+	-	+
139	*Chloropsis cochinchinensis*	-	-	-	+
140	*Lanius cristatus*	-	-	-	+
141	*Lanius schach tricolor*	-	-	-	+
142	*Dendrocitta vagabunda*	-	-	-	+
143	*Corvus splendens*	+	+	-	+
144	*Oriolus tenuirostris*	-	-	-	+
145	*Oriolus xanthornus*	-	-	-	+

Sl. No.	Species	Kirandul Complex Iron Ore Mines			
		Deposit 14	Deposit 14NMZ	Deposit 11B	Buffer Area
146	*Coracina melaschistos*	-	-	-	+
147	*Pericrocotus divaricatus*	-	-	-	+
148	*Pericrocotus erythropygius*	-	-	-	+
149	*Pericrocotus flammeus*	+	-	-	+
150	*Rhipidura aureola*	-	-	-	+
151	*Dicrurus macrocercus*	-	-	-	+
152	*Dicrurus caerulescens*	-	-	-	+
153	*Dicrurus aeneus*	-	+	-	+
154	*Dicrurus paradiseus*	-	-	-	+
155	*Hypothymis azurea*	-	-	-	+
156	*Aegithina tiphia*	-	-	-	+
157	*Monticola solitarius*	-	-	-	+
158	*Monticola cinclorhynchus*	+	-	-	+
159	*Zoothera citrina cyanotus*	-	-	-	+
160	*Zoothera dauma*	-	-	-	+
161	*Eumyias thalassina*	-	-	-	+
162	*Cyornis poliogenys*	-	-	-	+
163	*Copsychus saularis*	-	-	-	+
164	*Saxicoloides fulicata*	+	-	-	+
165	*Phoenicurus ochruros*	-	-	-	+
166	*Sturnus contra*	-	-	-	+
167	*Acridotheres tristis*	-	-	-	+
168	*Sitta castanea*	-	+	-	+
169	*Sitta frontalis*	-	-	-	+
170	*Parus xanthogenys*	-	-	-	+
171	*Hirundo rustica*	+	-	-	+
172	*Pycnonotus melanicterus*	-	-	-	+
173	*Pycnonotus jocosus*	-	-	-	+
174	*Pycnonotus cafer*	-	-	-	+
175	*Prinia socialis*	-	-	-	+
176	*Zosterops palpebrosus*	-	-	-	+
177	*Orthotomus sutorius*	-	-	-	+
178	*Phylloscopus colybita*	-	+	-	+
179	*Phylloscopus trochiloides*	-	-	-	+
180	*Pomatorhinus horsfieldii*	-	-	-	+
181	*Pellorneum ruficeps*	-	-	-	+
182	*Chrysomma sinense*	+	-	-	+
183	*Turdoides striatus*	-	-	-	+

Sl. No.	Species	Kirandul Complex Iron Ore Mines			
		Deposit 14	Deposit 14NMZ	Deposit 11B	Buffer Area
184	*Turdoides affinis*	-	-	-	+
185	*Dicaeum erythrorynchos*	-	-	-	+
186	*Nectarinia asiatica*	-	-	-	+
187	*Passer domesticus*	+	+	+	+
188	*Motacilla flava*	-	-	-	+
189	*Motacilla cinerea*	-	-	-	+
190	*Anthus rufulus*	-	+	-	+
191	*Anthus campestris*	-	-	-	+
192	*Lonchura striata*	-	-	-	+
193	*Lonchura punctulata*	+	-	-	+
(J) Mammals					
194	*Macaca mulatta*	+	+	+	+
195	*Semnopithecus entellus*	+	+	+	+
196	*Muntiacus muntjak*	-	-	-	+
197	*Sus scrofa*	-	-	-	+
198	*Melursus ursinus*	+	+	+	+
199	*Canis aureus*	-	+	-	+
200	*Vulpes bengalensis*	-	-	-	+
201	*[*]Panthera tigris*	-	-	-	+
202	*Panthera pardus*	-	-	-	+
203	*Harpestes edwardsii*	+	+	+	+
204	*Lepus nigricollis*	-	+	+	+
205	*Hystrix indica*	+	-	-	+
206	*Ratufa indica*	+	+	-	+
207	*Funambulus pennantii*	+	+	+	+
208	*Pteropus giganteus*	-	-	-	+

Discription: Where (+) indicates Presence and (-) indicates Absence of the species in the study area.



Sl No.	Latitude	Longitude	Type of Species Occurred
1	18.64517	81.26686	Small railway station within its campus *Pinus roxburghii* is found.
2	18.66264	81.30197	Village area small houses are found with huge *Tamarindus indica* tree.
3	18.66306	81.29639	Clean water feeding by a stream with full of Typha sp. Astracantha sp, Cyperus sp plants.
4	18.65253	81.29494	Large natural water body with huge aquatic plants. *Hydrila sp., Utricularia sp, Scirpus sp* etc. are found.
5	18.64933	81.26769	Open forest with scattered large tree like *Bassia latifolia , Terminalia tomentosa, Diospyros montana,*
6	18.62839	81.26436	Perennial stream coming from Bailadilla hill range with thick aquatic plant. *Dryopteris Polygonum sp,*
7	18.65328	81.28506	Full of sedimentation few aquatic birds with huge *Ipomoea sp* are seen.
8	18.65344	81.28342	Clean water feeding by a stream with full of *Typha sp. Astracantha sp, Cyperus sp* plants.
9	18.65586	81.28781	Clean water feeding by a stream with full of *Typha sp. Astracantha sp, Cyperus sp* plants.
10	18.71342	81.26578	Open land, scatter trees and huge *Eupatorium odoratum* found.
11	18.71417	81.25900	A perennial stream coming from Bailadila hill range. Huge *Cyperus sp. Polygonum sp* . etc plants found.
12	18.69381	81.27233	Near a perennial stream, open forest dominated by *Terminalia arjuna, Eugenia jambolana , Bassia*
13	18.66689	81.19333	Near township, open forest (Dominated by *Ficus sp* and *Terminalia tomentosa* , Invasive sp found- *Lantana*
14	18.67333	81.19972	A natural stream with dense natural plants. Dominated by *Trema sp and Mangifera* Invasive sp found- *Lantana*
15	18.68028	81.20028	Degraded forest. Plantation of *Acacia auriculiformis* with *Trema orientale and Croton oblongifolia;* Invasive sp
16	18.69194	81.23000	Dominated by *Diospyros Montana* and *Lagerostroemia parviflora;* No Invasive species
17	18.69389	81.23667	A spring with few marshy species like
18	18.62000	81.24250	*Kedia sp. Centrum sp. Dryopteris, Perotis, Polygonum* etc are found. *Lantana camara* as invasive species.
19	18.65361	81.24944	Species like *Mangifera indica* and *Bomax ceiba* dominate; Invasive sp like *Eupatorium odoratum* found.
20	18.65333	81.25167	Dominated by *Terminalia tomentosa* and *Eugenia sp.* ; No record of Invasive species.
21	18.67361	81.26472	Dominated with species like *Anthocephalus kadamba, Ficus glomerata, Ficus hispida, No record of Invasive*
22	18.61333	81.24500	Plantation of Teak (*Tectona grandis*) dome, other sps are *Careya arborea, Bambosa stricta, Lagerostroemia*
23	18.66083	81.27778	Dominated by*Embelica officinalis and T. tomentosa;* no record of Invasive species
24	18.62694	81.22861	Open forest, dominated by sps like *Carya sp, Bassia latifolea, Diospyros sp.* ; No record of Invasive species.
25	18.62278	81.22389	A water body (*dhobghat*), Dominated by *Buchanania lanzan, T. tomentosa* ; Invasive sp. not found.
26	18.61861	81.20472	Dominated by *Dyospyros montana , Boswellia serata, T. bellerica* ; No Invasive species found.
27	18.62139	81.20611	Dominated by *T. tomentosa, Embelica officinalis; Thysalaenina maxima;* No
28	18.69564	81.28842	Record of Invasive species.
29	18.69333	81.31139	Dominated by *Diospyros montana* and
30	18.62667	81.28256	*Soymida febrifuga* ; No record of Invasive species.
31	18.62803	81.28231	Human settlement
32	18.62944	81.28481	Open forest dominated by *Terminalia arjuna, Eugenia jambolana , Bassia latifolia, Diospyros montana*
34	18.62836	81.29439	Valley between Ali Dongri and Burdi Dongri, open mixed forest dominated by *Terminalia tomentosa* -
35	18.62883	81.29969	Valley between Ali Dongri and Burdi Dongri, open mixed forest with large bole tree dominated by
36	18.62933	81.30042	Perennial stream flowing towards north and ultimately taken the name Koyar Nadi. Near the bridge large
37	18.62933	81.30042	Valley between Ali Dongri and Burdi Dongri, with large bole tree like *Mangifera indica* (GBH-440cm),
38	18.62306	81.27931	A stream originating near a sacred grove which is a tributary of Koyar nadi. Few aquatic species like
39	18.62475	81.26431	Scattered large tree like *Bassia latifolia , Terminalia tomentosa, Mangifera indica, Diospyros montana,*
40	18.59189	81.21975	Open forest with scattered large tree like *Bassia latifolia , Terminalia tomentosa, Mangifera indica,*
41	18.59106	81.22014	Mixed dense forest with *Terminalia sp. Adina cordifolia, Anogeissus latifolia* etc.
42	18.59147	81.22019	A stream is flowing towards west beside the factory and mixed dense forest with *Terminalia sp. Adina*
43	18.59178	81.21978	A dam is built here on the Malenger nala from where drinking water is supplied to the Kirandul
44	18.59458	81.22314	Mixed dense forest with *Careya arborea, Pterocarpus marsupium, Adina cordifolia* , huge Bamboo
45	18.59267	81.22825	Mixed dense forest with *Embelica officinales, Lagerostroemia parviflora, Careya arborea, Pterocarpus*
46	18.59100	81.23803	Mixed dense forest with *Embelica officinales, Lagerostroemia parviflora, Chloroxylon sp,* and Lemon
47	18.59403	81.25653	A tributary stream of Malenger nadi originating from near by hill. A tree fern is found on the bank of it.
48	18.60736	81.26344	A tributary stream of Malenger nadi originating from near by hill.
49	18.71769	81.29514	A tributary stream of Malenger nadi originating from near by hill with mixed dense forest dominating by
50	18.71736	81.28864	Paddy cultivation has been done. Large mange trees are surrounding the area.
51	18.71911	81.28531	Large open land with scatter *Mangifera indica, Tamarindus indica* etc.
52	18.66889	81.19333	Open forest mainly *Bassia latifolia, Diospyros montana* and *Careya arborea* trees.
53	18.73586	81.27244	Human habitation surrounded by open mixed forest and fragmented by agricultural land.
54	18.71342	81.26578	A large pond, which is the source of this perennial stream. Agricultural land is surrounded, *Nymphea sp* (red) are seen.

Figure 3. Map showing different faunal species found at different locations of the study area

3.6 Major Threats to Biodiversity

Large scale loss of biodiversity has been mainly caused by anthropogenic activities like habitat loss, degradation, fragmentation, biotic interference, grazing, demand for timber, fuel wood, pollution and introduction of exotic species, etc. Due to large scale mining during last few decades in Bailadila forest area the above mentioned causes has aggravated by few folds. Some of these factors are discussed below in brief.

3.6.1 Habitat Loss, Degradation and Fragmentation

Habitat loss, degradation, and fragmentation are important causes of known species population extinctions. The main cause of degradation and depletion of forests and wildlife are the human activity (anthropogenic pressure). Deforestation has led to reduction of rainfall, silting of rivers and dams, increase soil erosion, dryness in the air and increase in temperature, adversely affecting not only forestry but also agriculture and associated activities.

3.6.2 Biotic Interference

The collection of Non-timber Forest Produce (NTFP) in the form of small timber, fuel wood, and fodder by the people living in the surrounding villages in the project area and areas between the village and Reserved Forests are thereby exerting intensive biotic pressures on these resources. There is likelihood of increase in biotic interference with the influx of labour population during the construction of the project. This floating human population will exert serious pressure on the semi-natural ecosystems around the activity sites. Plantation of exotic species and invasion of non-native species like *Lantana camara, Parthenium sp* and *Eupatorium odoratum* are also forms of biotic interference in this region.

3.6.3 Timber Requirement

The demand for timber and other wood produce is very high in the state for various activities like the construction of houses, business centers and other development activities owing to rapid population growth.

3.6.4 Non Timber Forest Products (NTFP)

Non Wood Forest Products (NWFP) constitute important source of livelihood for the poor and especially landless. There is abundance of Tendu leaves (*Diospyrus melanoxylon*), Mahua flowers (*Madhuca indica*), Sal leaves and seeds (*Shorea robusta*), different medicinal plants like Harra (*Terminalia achebula*), Bahera (*Terminalia bellerica*), Awnla (*Emblica officinalis*), wild fruit yielding species like Jamun (*Syzygium cumini*),

Aam (*Mangifera indica*), etc. in the forest patches which are most of the times are over extracted.

3.6.5 Grazing Pressure

Various livestock species reared in the study area include cattle, buffaloes and goats. The grazing pressure leads to interference of livestock in the wilderness areas, direct competition for forage availability and degraded quality and reduction in the food availability for herbivores, transmission of communicable diseases and reduction in area of wilderness needed for the wildlife to sustain.

3.6.6 Poaching

It is one of the major causes for destruction of wildlife which is still in a practice by local dwellers in the study area. During the survey, list of Rare Endangered Extinct and Threatened (REET) species were recorded (Table 7).

Table 7. List of REET species of plants in the study area

REET plants within studied areas	Locally Endangered species	Locally Critically endangered and vulnerable
Herb: *Drocera burmanii* (18°39′26.2″N 81°17′46.7″E Alt—581m), *Equisetum sp* (18°43′42.1″N 81°15′35.2″E Alt—517m), *Plumbago zeylanica* (18°39′45.5″N 81°18′7.1″E Alt—580m.), *Cyathea arborea syn Polypodium arboreum* (Indian Tree fern) (18°35′40.5″N 81°13′23.3″E Alt—742m), *Musa sp* (Wild banana) (18°35′30.8″N 81°13′11.1″E Alt—718m), *Uticularia sp* (18°39′9.1″N 81°17′41.8″E Alt—583m)	*Butea monosperma, Clerodendron serratum, Curculigo orchioides, Curcuma aromatic* *Gymnema sylvestre, Pterocarpus marsupium*	*Celastrus paniculata, Bassia latifolia, Madhuca indica, Terminalia arjuna* (Low risk)
Tree: *Mallotus philippensis* (18°36′38.4″N 81°18′52.6″E Alt—675m), *Acacia concinna* (Sikakai) (18°35′29.3″N 81°13′12.7″E Alt—744m), *Strychnos potatorum* (18°37′23.3″N 81°16′44.7″E Alt—626m)		

4. Conclusion

This case study demonstrates the major impact of mining on flora and fauna of Kirandul Iron Ore Mine. The study entails the total destruction of forest areas within the core zone. A detailed floral account only provides supportive evidence to ensure the survival of the herbivores and the carnivores, once the adjacent habitat can offer ecological niche for maintaining a prey predator base. The undulating mountain forest is expected to have the distribution of the recorded species over a wider area.

It is evident from the study that there are few plant species of rare occurrence in the buffer zone of Kirandul complex and few animal species within Schedule-I of Indian Wildlife (Protection) Act, 1972. These species are likely to be affected by mining project and related construction and other related activities like road construction, blasting, excavation for mining, and dumping of excavated material. However, human population pressure on land and biological resources are likely to exert pressure on the biological resources of the region. The existing natural ecosystems in areas constituting a rich bio-diverse region that need protection and further strengthening of conservation efforts.

Implementing scientific forest management may be helpful in some participatory forest management contexts, but it requires users to participate in an unfamiliar knowledge culture and appropriate support mechanisms need to be in place, particularly if scaling up its use across a country.

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