SUMMARY

The present study deals with the vegetation, production, decomposition, soil and microbiological parameters of a natural regenerating teak (Tectona grandis) forest on a hillock named Laxmi Dungri (21°44'N Latitude and 83°50' E Longitude) situated in the Sambalpur District of Orissa, India. Towards the south of the hill, flows the river Mahanadi and to the east passes the National-Highway No.6. Hirakud town is situated to the west of the site. Prior to the construction of Hirakud Dam, Laxmi Dungri and its adjacent area was under the thick forest cover. Quite a large number of teak trees were felled during the construction of "Hirakud Dam". After being demarcated as the reserve forest, the hill is slowly recovering with natural regeneration of teak and other tree species. Considering the heterogenity of the area with respect to vegetation growth and the biotic interference, nine sites are selected for the study. These are River site (site facing the river Mahanadi), NH-I, NH-II, NH-III, NH-IV (sites facing the National-Highway No. 6), HS-I, HS-II, HS-III and HS-IV (sites facing Hirakud town).
The climate of the area is seasonal tropical in nature with 3 distinct seasons (summer, rainy and winter). Annual rainfall of the area is 1634 mm., out of which 80% falls during the rainy season (June-September). The mean air temperature varies from as low as 10.9°C in December to as high as 39.9°C in May. The relative humidity of the area fluctuates from 19% during April-May to 96.3% during July-August period.

The height of the hill ridges varies from 700 to 900 ft. The foot hill portions are plain to gently sloping but at some points towards south, the slopes are quite steep.

The foot hill portion has good depth (2 to 3.5m) of alluvial soil with small pebbles. In the slopes and the hill tops, the soil is relatively swallow with the underneath granular granite type of rock. It is interesting to note that though the region of Sambalpur in general has acidic soils of red and yellow lateritic type, the soil of Laxmi Dungri is of basic vertic brown soil type (pH -7.1 - 7.5) in nature.

The textural analysis of soil samples collected from different regions revealed 59% to 82% sand, 11% to 22% silt and 7% to 19% clay. The bulk density varied from 1.3 g/cm³ to 1.7 g/cm³ and water holding capacity from 42%
to 50%. The organic carbon content of different soil samples varied from 0.77% to 1.73%. Total soil nitrogen ranged from 834 µg/g soil to 1830 µg/g soil. The C : N ratio showed a range of 8.48 to 10.22.

Results of the study in different regions of the study area are summarised as follows:

1. Quantitative analysis of tree and herbaceous vegetation of the study area.

(i) Study of stratification revealed the presence of 2 to 5 strata (5 strata are: Overwood, underwood, scrub level, field level and ground level) in different regions of the study area. Only in one site (NH-II site) all these five strata were present and in rest of the sites, there were 3 to 4 strata.

(ii) Tree species recorded from the study area were 20 in number. Except in HS-II site, in all other sites Tectona grandis was the dominant species, co-dominant species were either Butea monosperma or Cleistanthus collinus or Holarrhena antidysenterica or Diospyros melanoxylon.

(iii) The vegetational diversity was quantified using Shannon-Wiener's diversity index (H). The value of (H) for tree species varied from 1.251 to 2.035. The
dominance index (Cd) of the tree vegetation exhibited a range of 0.189 to 0.454. The relationship between diversity and dominance was observed to be inverse. Equitability index (EI) ranged from 1.5 to 1.8 in different regions of the study area.

(iv) Dominance-diversity curve for tree species in different sites revealed that in most of the sites, the curve fit to geometric series except HS-II site. In HS-II site, the curve approached log normal distribution with Bombax ceiba occupying top niche. In other sites, the top niche was occupied by Tectona grandis and there was absence of any intermediate niche.

(v) The total density of phanerophytes varied from 1670 no/ha to 4060 no/ha and total basal cover exhibited a range of 4.433 m²/ha to 124.513 m²/ha in different sites. The relationship between total tree density and total basal area was observed to be negative. Further, there observed a positive relationship between diversity and tree density.

(vi) Population structure of tree species were analysed considering percent distribution of different CBH (Circumference at Breast Height) girth classes. Analysis
of population structure indicated that most of the species were either in seedling or sapling stage. Trees having CBH > 135 cm were absent in all the sites. In River site and HS-IV site the population structure being upright pyramidal was observed to be normal. In other sites, relatively disrupted population structure of tree species were observed.

(vii) Analysis of herbaceous ground vegetation revealed the presence of all total 31 species of which *Ocimum canum* was the dominant species in all the sites. The co-dominant species were *Sida cordifolia*, *Atylosia scarabaeoides* and *Cynodon dactylon*. In all the sites maximum number of species were observed during rainy season and minimum during summer.

(viii) Values of herbaceous species diversity ($H$) showed a range of 0.639 to 3.18 and dominance index (Cd) 0.04 to 0.54 respectively. In all the sites, diversity $H$ was calculated to be maximum during rainy season and minimum during summer season. However, dominance index was maximum during summer and minimum value during rainy season. The correlationship between diversity and dominance revealed a significant negative relationship.
2. Quantification of biomass and production of herbaceous and tree vegetation.

(i) The annual herbaceous production showed a range of 297.65 g/m² to 558.52 g/m². Herbaceous production exhibited significant positive relationship with herbaceous diversity and negative relationship with herbaceous dominance. Correlation between herbaceous production and tree basal area was found to be inverse. The tree density showed a significant positive relationship with herbaceous production.

(ii) Total tree biomass in the study area ranged from 18.7 t/ha to a maximum of 1115.4 t/ha. This included a non-teak tree biomass range of 11.42 - 110.06 t/ha.

(iii) From the data of annual girth increment above ground net production of Tectona grandis with respect to different sites were estimated. It showed a range of 13.5 t/ha/yr to 30.5 t/ha/yr with maximum net production in NH-II site.

(iv) Tectona grandis exhibited a biomass accumulation ratio of 1.13 to 36.59 in the study area. The production efficiency of Tectona grandis was estimated to be 1.5 to 2.72 with maximum efficiency in HS-IV site.
(v) Litter fall of tree species exhibited seasonality, with peak value of litter fall during December-March period. The total annual litter production varied from 1.86 t/ha/yr to 3.34 t/ha/yr. It was further estimated that leaf litter constituted 85% to 94% of the total litter production in different sites. However, leaf litter production of *Tectona grandis* estimated 65% to 83% of the total annual litter production.

(vi) From the data of annual litter production and standing state of partially decomposed litter during the month of December, rate of turnover of litter ($K_l$) was calculated. It showed a range of 0.84 to 0.94. The turnover time of litter was calculated to be 1.06 to 1.19 yrs. in different sites of the study area.

(vii) Litter production of different study sites showed a positive relationship with total basal area and negative relationship with the tree density. There also observed a significant negative relationship between litter production and herbaceous production.
3. Decomposition of the litter in the study area

(i) The rate of litter decomposition was marked to be at its peak during rainy season. Rate of weight loss showed a range of 0.19 to 0.24% per day for *Tectona grandis* and 0.16 to 0.22% per day for composite litter. Annual percent weight loss showed a range of 70 to 88% for *Tectona grandis*, 61 to 80% for composite litter and 52 to 68% for twig litter.

(ii) Soil moisture was observed to be one of the controlling factors for the rate of weight loss of litter. The relationship between the rate of weight loss and soil moisture was observed to be positive.

(iii) From the weight loss data, decomposition constant, 'K' was calculated following Olson (1963). Among the nine sites, value of 'K' for *Tectona grandis* and composite litter samples showed a range of 1.2 to 2.12 and 0.942 to 1.609 respectively.

(iv) Comparison of annual litter production and decomposition data in terms of carbon led to the estimation of carbon balance (in the remnant of the decomposed material at the end of one year period) in different sites of the study area. The balance of
carbon showed a range of 325.45gC/m²/yr to 446.53 gC/m²/yr. The balance as percentage of input amounted from 23.7% to 37.5% at different regions of the study area.

4. Assessment of soil microbial and metabolic status through microbial biomass and soil respiration

(i) The average value of soil respiration rate ranged from 183 mg CO₂/m²/hr to 588 mg CO₂/m²/hr. The soil respiration data exhibited seasonal variation with maximum rate during rainy period (June-August) and minimum during summer (March-April) period.

(ii) Relationship between soil respiration with soil moisture was observed to be positive and significant. The multiple correlation coefficient ‘R’ between soil respiration, soil moisture and air temperature explained more than 98% of the variability of the monthly rate of soil respiration.

(iii) There observed a significant positive relationship between soil respiration and the rate of decomposition and also with corresponding average soil organic carbon.
(iv) Average value of microbial biomass ranged from 280 μg C/g dry soil to 407 μgC/g dry soil. Microbial biomass estimates were observed to be minimum during summer season and maximum during rainy season.

(v) Monthly variation of soil microbial biomass carbon in different sites coincided with the variation of soil moisture. The relationship between the microbial biomass and soil moisture were estimated to be positive and significant. The coefficient of correlation between soil moisture and microbial biomass could explain more than 83% of the variability of microbial biomass in different sites.

(vi) Microbial biomass estimates of different sites also exhibited positive relationship with monthly rate of soil respiration and with monthly rate of decomposition in different sites.

(vii) Taking the average microbial biomass carbon and soil organic carbon data, percentage of soil organic carbon reflected in microbial biomass (microbial biomass C:org-C %) was calculated for different sites. The ratio exhibited a range of 2.15% to 3.96%.
(viii) Estimation of soil respiration per unit microbial biomass per unit time is otherwise known as microbial metabolic quotient (Anderson and Domsch, 1985). In the present study, the metabolic quotient exhibited a range of $0.639 \times 10^{-3}$ to $1.159 \times 10^{-3}$ g CO$_2$-C/g microbial biomass C/hr.

(ix) The quotient reflected the relative status of different sites in terms of microbial metabolic efficiency. The data exhibited significant positive relationship with the decomposition rate and negative relationship with microbial biomass C : soil org C ratio. A high metabolic quotient explains more carbon utilisation for microbial maintenance and relatively less carbon assimilation into microbial biomass pool.

5. Assessment of the regenerational/Successional status of different sites of the study area.

(i) On the basis of the vegetational (tree diversity, herbaceous diversity, tree density, tree biomass, herbaceous production and total litter production) and soil (organic carbon, total nitrogen, decomposition, constant, soil respiration rate and microbial biomass carbon) parameters, regenerational/successional status of different sites could be assessed in the following order
NH-II < NH-I < HS-I < HS-II < RS < HS-III < NH-IV < NH-III < HS-IV.

(ii) Performance of the teak (*Tectona grandis*) (in terms of total biomass, net production, biomass accumulation ratio and production efficiency) was observed to be positively related to different soil parameters. Thus, it was concluded that soil characteristics are the major factors which have a bearing on the regeneration of teak forest in the area.