Eco-Silvicultural Options for Sustainable Management in Joint Forest Management – A Case Study of Mixed Forests of Madhya Pradesh, INDIA

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Abstract

The present paper deals with the detailed study of a degraded miscellaneous forest of Manikpur village forest committee of Mandla district of Madhya Pradesh, India by examining various socio-economic needs of people, documentation of plant diversity of the area in both qualitative and quantitative terms, regeneration behavior of various timber and non timber species, phyto-sociological structure of ground vegetation including herbs, shrubs and grasses, biomass production, fertility status of soil, identification of different land use zones for obtaining optimum productivity through their effective utilization etc.

Innovative site specific eco-silvicultural options encompassing social, economic, cultural, spiritual, ecological and institutional aspects of management, were prescribed to ensure multi-product flow of forest resources, optimum utilization of various land use zones through collaborative efforts of Ministry of Environment and Forests (MOEF) and Ministry of Agriculture, ecological balance or homeostasis of ecosystem through maintaining ecological processes like nutrient cycling and energy flow, and ultimately the prosperity of forest dependent communities.

Keywords: *Eco-silvicultural, land use, food security, multi-product flow, Joint Forest Management, homeostasis, eco-system*

1. Introduction

In pursuance of agenda 21 of Rio conference held at Rio in June 1992, India is the first country to embark on an ambitious joint forest management strategy for regeneration of degraded forests involving participation of local communities. During 1999 – 2000 MOEF prepared and released two important documents viz., National Forestry Action Program (NFAP) and National Forestry Research Plan (NFRP). Joint forest management is the outcome of the realization of a home truth that without the willing and active participation of communities living in and around forests, no progress to regenerate degraded forests would succeed. Conceptually, Joint Forest Management is a shift towards sustainability and multiple use management involving ecosystem approach. Biodiversity components play important role in functioning of ecosystem. Role served by most species is not understood. The loss of "Keystone" species would greatly reduce the productive capacity of an ecosystem. Lack of information on plant diversity at different canopy levels, population dynamics, ecological requirement of species, growth data of forests and needs of forest dependent communities, impact of past and present management systems on community structure and regeneration of species is a vexing problem for assessment of sustainability of forest management practices in natural forest ecosystem. Bio-physical information, together with community needs and preference level of plant species, help adopt appropriate silvicultural system or a combination

of systems for planning multi-canopy management, conservation of biodiversity and consequently productivity enhancement of forest ecosystem.Keeping above in view, a case study in Joint Forest Management area of mixed forest in Manikpur Village Forest Committee (VFC) was undertaken for developing a site-specific management system. The study envisaged, following objectives:

1. Community–forest profiling to document the demand and supply of various forest products.
2. Eco-silvicultural study to furnish database for better understanding of the structure and function of forests.
3. Identification of land use zones to optimize land productivity, enhancement of biodiversity and stimulate multi-product flow.

2. Materials and Methods

The area under study is situated in the western part of Mandla District. The district lies between the latitudes 22° 13' 30" and 23°13'30" and the longitudes 79°48'15" and 80°57'15" . The village forest committee, Mankipur includes three vilages viz., Manikpur, Jilahati and Bisora. The forest under this committee is surrounded in the East, West, North and South directions by Detwara, Bisora Jaidhpuri and paddikona respectively. The VFC (VRDC) Manikpur comes under Niwas Forest Range of W. Mandla Forest Division. It came into being in 1994, most part of the Mandla district lies in the Northern and western parts of the Narmada river and Eastern parts of the satpura ranges. 80% of the working forest area is the Jalgrahan area of Narmada and its tributaries. Configuration of the study area is plain with small hills. Elevation of area being 1100m above sea level Forest area is almost rocky with stones and boulders.

Geoloical formations of Mandla district fall under following systems.

(1) Laterite, Recent

(2) Crustaceous (Iosene) with Deccan trap

(3) Archean with Gneisses

(4) Dharwar system

The major soil types derived from these systems are Red and Brown. Black and yellow soils are also found in many areas.

(i) Forests: Forests of the study area is of mixed deciduous type (Southern Tropical Dry Deciduous mixed types) and categorise under Reserve forest. Density of the crop is 0.3 to 0.4.

In the forests, damages to the crop are by man and his grazing animals. As per the villagers report, the protection work of the area was started in 1984. Before it, there was scrub land present. Villagers had taken self initiatives to protect the forests. In 1994, Village Resource Development Committee was formed under JFM network. The committee got registered in 1997.

(ii) Climate: Climate of the study area is tropical with three distinct seasons viz; summer, winter and Rainy. Summer extends from April to mid June; Rainy from mid June to September and winter lasts till February starting from November. Average annual rainfall and annual mean maximum and mean minimum Temperature of the District being 1410 mm, 31.7°C and 7.1°C respectively. Mean number of rainy days per annum being 67.

Methodology used to analyze various aspects is described below:

2.1. Community - Forest Profiling

For sustainable planning of Forest Management particularly of a village forest, it is essential to analyse the social composition of a village, its population, infrastructural facilities and use pattern of forests. The use pattern and relative importance of species has changed over space and time and has a great influence on the structure and function of a forest ecosystem. For management of a forest on sustainable basis, it is essential to quantity and categorizes requirements of local people for multiple products deriving from the forests.

Participatory Rural Appraisal (PRA) followed by group discussion, household survey, interview with pre-designed questionnaire methods were used to estimate the quantity of different forest products flowed through the forests to meet their daily and economic needs. The 40% sampling was made in each hamlet of a village for their need analysis of different forest produce and socio-economic status.

2.2. Ecological Aspects

2.2.1. Phytosociology of Vegetation

Keeping in view the variety and variability of soils, crop composition, intensity of biotic pressure and different level of degradation five plots of each were laid 1 km. interval starting from settlement zone, at each site for vegetational analysis regeneration status and growth studies of trees, shrubs, ground flora etc. In each major plot (1ha), 3 small plots of 0.1 ha (10 x 100 m) were laid for phytosociological study of tree vegetation. In each tree plot. Plots of 5 sq/m each were laid for enumeration of established regeneration of trees, shrubs and climbers. Ground flora and tree regeneration below 1m height were studied using 1 sq m quadrats. In each major plot ; and quadrats were studied for recording shrubs and ground flora respectively.

The primary data recorded from the sampling units on presence, number of trees, shrubs, herbs, GBH of trees, height of trees, tree regeneration were analysed for the secondary attributes like frequency, density, abundance, basal area, Important Value Index (IVI), biodiversity Index, concentration of dominance adopting following methods :-

1. Frequency, Density, Abundance and Basal Area- – Curtis & Mc Intosh, 1950.

2. Relative values of Frequency, Density & Dominance- – Philips, 1959.

3. Importance value Index (Cumulative value of RF,RD and relative dominance – Curtis, 1959

4. Biodiversity Index – Shannon-Weiner, 1963

$$H = -\sum_{S} [Ni/N] \log 2 (Ni/N)]$$

Where,
H = Biodiversity Index
Ni =Importance value of individual species,
N=Total of importance of importance value of all species.

5. Concentration of Dominance

$$C = \sum_{i=1}^{S} (Ni/N)^2$$

Where,
C =Concentration of Dominance
Ni = Importance Value of Species ' i '
N = Total of all importance values.

2.2.2. Biomass Estimation

(i) Ground Flora

The biomass of herb/grass layers was quantified using harvest method (Mishra, 1968). the study was conducted in the optimum growth period of herb/grass i.e. post monsoon months of October and November. Sampling was tone using 50 quadrats of 1 sq m size. Plots were laid randomly in each stand and harvested. Samples were brought to the laboratory and over dried at ± 80°C for a constant weight and thus, per hectare production was estimated. Same procedure was adopted at each site.

(ii) Tree Vegetation

Standing biomass or biomass productivity of trees is the most important parameter for making management decision on the quantity of sustainable tree biomass extraction. Biomass is the wood weight or volume of trees (including stems and branches) at a given time (standing) or over a period of time (productivity) in the prescribed area (SPWD, 1992).

Harvest method of estimating biomass (Newbould, 1967) is not practical or desired particularly in degraded forests. Biomass estimation of certain trees on the basis of their height and DBH is also possible, but it is available for a limited number of important tree species. Alternatively, based on data from a number of forests in India, a rough estimation of standing biomass is also possible using basal area per hectare data (SPWD, 1992):

Total biomass = b + a (Basal area in $M^2/ha)^2$

(Where, b and a are constant as follows - b = 35.23. a = 0.156, SE = 0.0351; $R^2 = 0.68$)

In the present study, standing biomass was determined for different stands using above mentioned formula.

2.2.3. Litter Production

For determining the litter production of tree species, the period between 15the April to 15th May was considered suitable because this is the period of optimum availability of litter on floor. This is also the period when wind spread does not alter much the uniformly thick mat like characters of forest floor needed for any random sampling.

Sampling procedures were broadly followed after Ovington (1954). In each stand 50 quadrats of 1 sq m each were laid along the parallel transects running across the contour lines. Leaf litter was collected and weighed to estimate per hectare production of leaf litter at each site. Attempt will be made to study leaf litter production and rate of decomposition using trap method at all the sites.

2.2.4. Physico-chemical Properties of Soils

It has long been recognized that vegetation exerts a decisive influence on morphological, physical and chemical properties of soils. Heterogeneity is reported in chemical composition of soils in forests even over distance of few centimeters. Biotic disturbances including grazing, fire, and human pressure lead to disturb nutrient cycling and a huge release of nutrient from the soils. Biomass production cannot be sustained in the absent of mineral cycling. Moreover, for making any management decision or planning productivity enhancement in the forests, it is essential to study the fertility status of soils. With the above in view, physico-chemical properties of surface soils (0 - 6") were undertaken for each site. Five samples of surface have been taken randomly from each tree plot (0.1 ha size) and composite sample was made for it. In all, three composite samples were taken for analysis from each 1 ha plot soils was analyzed especially for mechanical properties, pH, EC, organic carbon, NPK adopting Jackson (1973) methods.

2.3. Silvicultural Aspects

Details regarding management history, current silvicultural operations being carried out were recorded and critically analyzed with a view of sustainable management and multitier development approach adopting questionnaire technique and group discussion with forest officials and VFC members. For growth study of different tree species, trees were marked and initially measured for their gbh and height in 0.1 ha plot within each one hectare plot. In all, 5 plots of 0.1 ha each at 1 km. interval were laid as sample plots for growth measurement of trees at each site.

2.4. Land Use Pattern and its Management

With the aim of improving overall stability and developing creative and intensive management prescriptions, identification of land use zones in the village and forests were carried out at each site using transect method by examining soil moisture, soil fertility, use pattern, products, species, composition and management problems prevailing in different zones. Management opportunities were identified keeping in view the multitier development approach of forest and to reduce biotic pressure from the forests zones.

3. Results and Discussions

3.1. Community-Forest Profiling

The Village Forest Committee (VFC) Manikpur includes three villages viz., Manikpur, Jilahati and Vishora. Most of the infrastructural facilities are available at Amagaon, Visora and Niwas. In all, 386 households are there in this Village Forest Committee (VFC) with the human and cattle population of 1830 and 931 respectively. Population of adjoining villages like Chauda and Paddicona is also putting pressure on the forest of this village for animal grazing, fuel wood and NWFPs collection.

Social composition of Village Forest Committee (VFC) and adjoining villages exhibits moderate level of homogeneity. Land use breakup for village Manikpur suggests that most of agricultural land (88.16%) is un-irrigated. Annual requirement of fuel wood, bamboos and poles per annum for Village Forest Committee (VFC) was worked out to be 1045.35 tonnes, 6784(no.) and 9504(no.) respectively. Against this, 1046.80 tonnes fuel wood, 6624 bamboos

and 9958 poles are required in adjoining villages. Both stall feeding and grazing in forests are practiced in the village. Annual requirement of green fodder and tree foliage worked out for Manikpur village was 684 and 279tonnes respectively.

Important NWFPs of this area are *Madhuca indica* J.F. Gimelin, *Semecarpus anacardium* L.f., *Buchanania lanzan.* Spreng., *Syzygium cumini*(L.) skeels, *Emblica officinalis* Gaertn , *Mangifera indica* L., *Diospyros melonoxylon* Roxb. and *Terminalia chebula* Retz. Commercially important NWFPs are tendu (*Diospyros melonoxylon.* Roxb.) leaves, fruits and flowers of mahua (*Madhuca indica.* J.F. Gimelin), aonla (*Emblica officinalis.* Gaertn) and fruits of harra (*Terminalia chebula* Retz.).

3.2. Ecological Aspects

3.2.1. Phyto-sociology of Vegetation

Five stands of one hectare each were studied for quantitative assessment of vegetation. Plots were laid at 1km intervals considering the variation found in soil, vegetation and biotic pressure. Phyto-sociological data of tree vegetation and ground flora was analyzed for frequency, density, abundance, basal area, Importance Value Index (IVI), distribution pattern and Shannon's general diversity index (Table-1 and 2). Salient features of biodiversity components are described as under:

In all, 38 species were recorded, namely, *Terminalia tomentosa* Roxb.ex DC., *Syzygium cumini* (L.) skeels , *Anogeissus latifolia* (Roxb.ex DC.) Wall.ex Bedd., *Emblica officinali.* Gaertn., *Buchanania lanzan* Spreng., *Terminalia chebula* Retz, *Azadirachta indica* A. Juss., *Diospyros meneloxylon* Roxb,*Butea monosperma* (Lam.) Taub., *Miliusa tomentosa* (Roxb.) Sinclair., *Garuga pinnata* Roxb., *Grewia tiliaefolia* Vahl., *Pterocarpus marsupium* Roxb., *Casearia graveolens* Dalz., *Schleichera oleosa* (Lour.)Oken., *Madhuca indica* J.F. Gimelin, *Lannea coromendelica* (Houtt.)Merr., *Adina cordifolia* (Roxb.) Hook.f.ex Brandis, *Bridelia retusa* (L.) Spreng., *Terminalia belerica* (Gaertn.) Roxb., *Elaeodendron glaucum* Pers. , *Cassia fistula* L., *Mangifera indica* J.F. Gimelin , *Flacourtia indica* (Burm.f.) Merr., *Semicarpus anacardium* L.f., *Ziziphus xylopyrus* (Retz.) Willd., *Randia dumetorum* (Retz.)Poir., *Bauhinia variegata* L., *Bauhnia vahlii* Wight. & Arn., *Bombax ceiba* L., *Carissa opaca* Stapfex Haines, *Cordia dichotoma* G. forster, *Bauhinia racemosa* Lamk., *Ficus glomerata* Roxb., *Stereospermum chelanoides* (L.f.) DC. Of these, 30% species are of NWFPs value and rest of 70% are of timber and fuel wood uses. The species showing invariable occurrence in all the study plots were *Terminalia tomentosa* (Roxb.ex DC.), *Anogeissus latifolia* (Roxb.ex DC.) Wall.ex Bedd., *Buchanania lanzan* Spreng., *Terminalia chebula* Retz., *Diospyros melanoxylon.* Roxb, *Emblica officinalis* Gaertn. and *Lagerstroemia parviflora* Roxb.

Almost similar types of associations were recognized in different study plots. *Terminalia tomentosa* Roxb.ex DC, *Buchanania lanzan* Spreng and *Anogeissus latifolia* (Roxb.ex DC.)Wall.ex Bedd are the characteristic dominant species found in different stands.

Species composition in top, middle and lower canopies is as under –

Top canopy: *Pterocarpus marsupium* Roxb., *Adina cordifolia* (Roxb.) Hook.f.ex Brandis,

Middle canopy: *Buchanania lanzan* Spreng, *Emblica officinalis* Gaertn, *Terminalia chebula* Retz, *Terminalia belerica* (Gaertn.) Roxb., *Schleichera oleosa* (Lour.) Oken., *Semicarpus anacardium* L.f., *Lagerstroemia parviflora* Roxb, *Ziziphus xylopyrus* (Retz.) Willd.

Lower canopy and ground flora: *Ziziphus oenoplia* (L.) Mill., *Nyctanthes arbor-tris-tis l.*, *Woodfordia fruticosa* (L.)Kurz., *Asparagus racemosus* Willd.

Salient phytosociological features (Table-1) of the vegetation are as under:

- Density of tree species varied from 812 to 1455 trees/ha.
- Basal area of tree species varied from 4.28 to 9.63 m^2/ha
- Shannon's general diversity index varied from 1.94 to 2.63 in tree species.
- Concentration of dominance varied from 0.10 to 0.24 in tree stratum.

The diversity index for Indian forests reported to be ranged between 0.83-4.1 (Singh *et.al.*, 1984; Parthasarthy *et.al.* 1992). The value of diversity index in present case showed moderate ecological development of forest stands in the area. Value of diversity index in the present case also reflected that stands are moderately sensitive towards stability and complexity of the ecosystem.

On comparing the data of density and basal area with Indian status as suggested by Swaminath (2000), these forests have high stem density and low status of basal area. Swaminath, (2000) has suggested 8 forests sustainability indicators along with their status values for different forest types of the country **(Annexure-1).** Most of them are related with structural sustainability of forest ecosystem.

3.2.2. Biomass, Litter Production and Soil Fertility

Standing biomass of a tree is the most important parameter for making management decision on the quantity of sustainable tree biomass harvesting. On the basis of biomass estimation, one can decide the sustainable harvest level of firewood from the stand. Based on preliminary findings (SPWD, 1992), the sustainable harvest level may lie around 3-6 % of the standing biomass as firewood. The average standing biomass for the study area was estimated from 38.09 to 49.70 tonnes/ha **(Table-3).** On an average, standing biomass of the whole forest was found to be 45.22 tonnes/ha. Considering the sustainable harvest criteria (3% of the standing biomass), community could harvest 1.35 tonnes /ha as firewood from the existing forests. Of the total 186.8 ha forest area comes under Village Forest Committee (VFC), 252.18 tonnes (3%) fuel wood can be harvested sustainably against the huge demand (1045.35 tonnes/annum) of fuel wood of Manikpur V.F.C .There is a strong need to adopt agro- forestry system to enhance the productivity and to develop alternatives to meet fuel wood demand with the view of sustainable forest management. Besides tree biomass, the forests are devoid of ground vegetation. The average air-dry biomass of ground vegetation worked out to be 1.34 quintal./ha **(Table-3).** The soil was found to be deficient with respect to N, P and K **(Table-5**), based on soil rating given by ICAR, New Delhi (1980) **(Annexure-2).**

3.3. Silvicultural Aspects

3.3.1. Regeneration and Population Structure

Regeneration is the functional aspect of forest ecosystem to maintain the resilience of ecosystem. Regeneration potential of a species is influenced by various biotic and abiotic factors. Following issues emerged out of the regeneration study of different species in quantitative terms:

- Density of regenerating plants varied from 1083.84 to 3023.64 ha^{-1}
- Number of regenerating tree species and biodiversity index in different stands studied are summarized in **Table –6.**

- Poor ecological status of species in recruitment layer was of *Pterocarpus marsupium*,Roxb. *Madhuca indica* J.F. Gimelin, *Casearia graveolens* Dalz., *Schleichera oleosa* (Lour.) Oken., *Grewia tiliaefolia* Vahl, *Garuga pinnata* Roxb., *Terminalia chebula* Retz., *Butea monosperma* (Lam.) Taub.,*Cassia fistula* L., *Lannea coromandelica* (Houtt.) Merr., *Bauhinia purpurea, Ziziphus xylopyrus* (Retz.) Willd., *Randia dumetorum* (Retz.)Poir, *Bauhinia vahlii Wight. & Arn.* Wight. & Arn. Species like *Asparagus racemosus* Willd., *Celastrus paniculatus* Willd., *Hemidesmus indicus (*L.) R.Br., *Ventilago calyculata* Tulasne, *Andrographis paniculata* (Burm.f.) Wallich ex Nees, *Woodfordia fruticosa* (L.)Kurz., *Nyctanthes arbor-tristis* L. had little ecological representations at various sites studied. These are valuable from socio-economic and socio-medico view points and need special attention for their preponderance.
- Population structure of a community reflects the dynamism of the community and is of vital importance for planning management strategies. The population structure showing density breakup in different girth classes in the different stands, is portrayed in **table-7**.
- Three types of recruitment patterns were recognized in different stands studied:

  (a) Frequent reproduction –In this pattern, species had greater number of individuals in recruitment class compared to larger girth classes. This population structure is indicative of progressive regeneration of the species. Such species could be recent invaders and may form sub canopy later on.

  (b) Another pattern exhibited by species having most of individuals in intermediate girth classes with lower number in recruitment stage. This pattern is indicative of diminizing population of such species.

  (c) Species having greater number of individuals in larger girth classes and absence in recruitment classes. This pattern is also indicative of diminizing population of such species.

Species belonging to category (ii) and (iii) are proposed to be planted through enrichment planting along with medicinal plants and tubers for multi-canopy management. These are as follows: *Syzygium cumini* (L.) skeels, *Kydia calycina* Roxb., *Anogeissus latifolia (Roxb.ex DC.) Wall.ex Bedd., Bridelia retusa* (L.) Spreng., *Terminalia tomentosa* (Roxb.ex DC.), *Terminalia belerica* (Gaertn.) Roxb., *Terminalia chebula* Retz., *Bauhinia malaberica, Bauhinia vahlii* Wight. & Arn., *Pterocarpus marsupium*,Roxb., *Mitragyna parviflora* (Roxb.) Korth. Most of these species belong to middle and lower canopy stratum and are of social-economic, ecological and ethno-botanical values. The over use of most of these species for collection of fruits/wood, is among the prime causes of their absence in the recruitment stage. This population structure is indicative of a diminishing population of these species. Many workers investigated population structure by size class distribution. The information derived from them has been used to understand regeneration and the intensity of disturbances and future sustainability of tree population in forest communities (Schnelz and Lindsey, 1965; Robertson, 1978; Ralhan *et.al*., 1982; Upreti, 1982).

3.3.2. Past and Present Systems of Forest Management

Past history of forest management suggests that the degradation of forests was mainly attributable to injudicious applications of working plans prescriptions, ineffective protection

against fire and grazing, illicit felling due to high population pressure, excessive removal of sound and mature trees, removal of reserves during thinning in CWR (Coppice With Reserve) system, preferential treatment to commercially important top canopy, timber species, neglect of cleaning following main fellings and removal of non coppicing species during various working systems.

The details of past workings are as under:

The forest worked in the past under shifting cultivation, improvement felling and Nisar circles, clear felling and bamboo overlapping etc. At present, total area of Village Forest Committee (VFC) is under RDF system with more or less same silvicultural prescriptions. The tree crop in this region is of rootstock and is almost 15-20 years old. Majority of the trees have yet to start flowering. Soil is rocky with stones and boulders. There is much scope for application of soil and water conservation measures. The microplan of this Village Forest Committee (VFC) is yet to be prepared. Since the crop has originated through under- stocked root potential, the area requires thinning operation taken the silvicultural availability of stems into account, followed by enrichment planting. *In-situ* conservation should be given priority. People's need for fuel and small timber should be fulfilled through adoption of agro-forestry system. Since the forest area is stony and is devoid of topsoil in most part, the adoption of silvi-pasture system would be useful at the initial (up to 5 years period) stage, followed by appropriate silvicultural system. For this purpose, high quality grasses need to be introduced in the area. Soil working and water conservation measures are needed to enhance the fruit production of *Emblica officinalis* Gaertn., *Madhuca indica* J.F. Gimelin, *Buchanania lanzan Spreng.*and *Semecarpus anacardium* L.f.

3.3.3. Land Use Pattern and its Management

Joint Forest Management is a holistic and ecosystem approach for (i) increased overall yield of a system, (ii) multi-product flow to get stability and, (iii) maintenance of resources to get sustainability through people's participation. Four major land use patterns viz., settlement zone, agriculture zone, wastelands and forest zones were recognized in the Manikpur Village Forest Committee (VFC). These zones were being used under separate systems. **I**ssues related to sustainable management in different land use zones are described as under:

(i). Settlement Zone

Water scarcity and unfertile soil are the main problems associated with the productivity of lands in this land use zone. Adoption of water harvesting techniques and agro forestry systems particularly silvi-oleri-culture and silvi-agriculture would help to optimize the land productivity per unit area.

Development of tanks and tube –wells is also among the issues needed for sustainable management of this zone. Utilization of FYM, fertilizer and adoption of scientific farm practices would increase productivity manifolds. Besides agriculture, cattle rearing, selling of milk are also among the use patterns of settlement zone. Improved and high yielding milk cattle(s) need to be introduced by replacing present ones.

Forest nursery present in this zone must raise fruit bearing and medicinally important plants along with fast growing multipurpose trees. Medicinal plants and tubers should be planted in the agricultural field on bunds or in the fields to enhance income. There is high market potential for medicinal plants in this area. Ponds present in this zone should be improved and be used for fish cultivation through Village Forest Committee (VFC). Promotion of mushroom cultivation can enhance the income of villagers and would be a

proper use of settlement zone. Villagers already received training in this regard. Watershed management near tanks is needed through adoption of silvi-medico system.

(ii). Waste Lands (50 ha.)

Degraded forestlands devoid of vegetation and soil cover are available as wastelands. The place is known as Ajhar pahari. Topography is hilly and it is extended in 50 ha. Bamboo had been planted in this area through forest department. This area can be developed for fodder production through silvi-pasture system. Nutritional grasses be planted in grass beds. Natural grass cover on this Pahari is reported to be available for 8 months period. Thus, this land zone can be properly developed as Pastureland to meet the fodder demand of the whole Manikpur Village Forest Committee (VFC). This will help reduce grazing pressure on forestlands. Medicinal planted like *Asparagus racemosus* Willd. (Satawar), *Aegle marmelos*Correa(L.) (Bel), *Terminalia chebula* Retz.(Harra), *Rauvolfia serpentina* (L.) Benth. ex Kurz (Sarpagandha), *Emblica officinalis* Gaertn (Aonla), *Terminalia belerica* (Gaertn.) Roxb. (Bahera) can also be planted intermittently.

(iii). Forest Lands

This is the overused land zone devoid of topsoil and humus layer. Boulders and stones are found all over the area. Topography is undulating with moderate to steep slope. Soil and water conservation is the prime need of forest floor development. High gaps can be filled through planting with shrubs *Carissa opaca* Stapfex Haines (Karonda), *Ziziphus jujuba* Mill. (Ber), *Ziziphus oenoplia* (L.) Mill.(Makoi), *Woodfordia fruticosa* (L.)Kurz.(Dhawai), *Asparagus racemosus* Willd.(Satawar), *Rauvolfia serpentina* (L.)Benth. ex Kurz (Sarpagandha),Aloe vera (L.) Burm.f. (Agave), *Hemidesmus indicus*(L.)R.Br. (Anantmool), *Andrographis paniculata* (Burm.f.) Wallich ex Nees(Burm.f.)(Chiraita,) and seedlings of middle canopy trees like *Emblica officinalis* Gaertn (Aonla), *Terminalia chebula* Retz. (Harra), *Terminalia belerica* (Gaertn.) Roxb. (Bahera), *Buchanania lanzan* Spreng. (Achar), *Madhuca indica* J.F. Gimelin (Mahua),*Dendrocalamus strictus* (Roxb.) Nees (Bamboo), *Hardwickia binata* Roxb.Roxb.(Anjan).

Table 1. Characteristics of Tree Vegetation Important from Sustainability Point of View

Stand No.	No. of species	Density (trees*/ha)	Basal area (sqm/ha)	Shannon's diversity index	Concentration of dominance
1.	18	850	8.591	2.205	0.143
2.	14	812	4.282	2.111	0.182
3.	16	862	7.273	2.467	0.105
4.	14	1249	9.092	1.946	0.246
5.	29	1455	9.633	2.603	0.130

* Over 20 cm GBH

Table 2. Characteristics of Ground Vegetation Important from Sustainability Point of View

Stand No.	No. of species	Density(plants/hectare)	Abundance (plants /sqm)	Shannon's diversity index
1.	17	19.97	87.79	2.242
2.	20	24.36	145.51	2.541
3.	17	11.67	71.16	2.369
4.	16	19.96	139.53	2.390
5.	13	12.22	72.61	2.126

Table 3. Biomass Production of Vegetation

Stand No.	Tree biomass (tonnes/ha)	Biomass of ground flora (qnt./ha)
1.	46.74	1.25
2.	38.09	1.50
3.	43.48	1.00
4.	48.12	2.00
5.	49.70	0.96
Average	45.22	1.34

Table 4. Litter Production (tonnes/ha) in Different Stands

Stand No.	**Litter production (tonnes/ha)**
1.	0.75
2.	0.35
3.	1.00
4.	1.20
5.	1.50
Average	**0.96**

Table 5. Physico–chemical Properties of Soils in Different Stands of Manikpur Forest

S.N.	Parameters	Stands No.				
		1	2	3	4	5
1.	pH	5.93	5.87	6.31	5.99	5.81
2.	Electrical conductivity (mmhorsec.m^{-1})	0.369	0.249	0.345	0.253	0.265
3.	Organic matter %	6.72	2.496	9.393	5.170	6.850
4.	Available N (kg/ha)	120	110	131	102	123
5.	Available P (kg/ha)	5.88	4.46	4.23	5.67	4.85
6.	Available K (kg/ha)	44.5	40.6	48.5	37.9	35.1

Table 6. Characteristics of Established Regeneration in Different Stands of Manikpur Forest

Stand No.	No. of species	Biodiversity index
1.	19	2.641
2.	22	2.529
3.	20	2.553
4.	17	2.403
5.	27	2.830

Table 7. Population Structure Showing Distribution Pattern of Trees in Different Girth Classes

Stand No.	Density (trees* / ha) in different girth classes				
	6- 20	21- 30	31- 40	41- 50	>50
1.	1084	437	236	111	65
2.	2737	719	77	13	03
3.	2081	613	230	13	07
4.	1372	846	316	37	50
5.	3024	1146	206	67	37

*trees over 20 cm GBH.

Annexure 1. Forest Sustainability Indicators of Evergreen/Semi-evergreen and Moist/Dry Deciduous Forests of India

Indicators	Evergreen/Semi-evergreen				Moist / Dry Deciduous			
	High	Good	Average	Low	High	Good	Average	Low
Basal area/ha	70	50	35	<25	45	35	25	<20
Canopy Density	1	0.8	0.5	0.4	1	0.8	0.5	0.04
Density (Stem No/ha)	400	300	200	<100	400	300	200	<100
Species No/ha	>60	40	25	<20	30	20	10	<10
Regeneration (<10 cmgbh)	10,000	6000	4000	2000	5000	4000	2000	<1000
Conc. of Dominance	0.9	0.8	0.5	<0.5	0.5	0.4	0.3	0.1
Soil N (%)	0.8	0.6	0.4	<0.2	0.50	0.4	0.3	0.1
Grazing	0	5	8	10	0	2	4	8

Source- Swaminath, 2000

Annexure 2. Rating - Chart for the Soil-test Data

Nutrient	Low	Medium	High
Organic carbon (as a measure of available nitrogen)	below 0.5%	0.5-0.75%	Above 0.75%
Available nitrogen (N)	below 280 Kg/ha	280-560 Kg/ha	About 560 Kg/ha
Available phosphorus (P)	below 10 Kg/ha	10-25 Kg/ha	Above 25 Kg/ha
Available potassium (K)	below 110 Kg/ha	110-280 Kg/ha	Above 280 Kg/ha
pH			
(i) Acidic (ii) Normal to saline	pH below 6 pH below 6-8.5	(iii)tending to become alkaline (iv)Alkaline	pH- 8.6-9 pH above 9
Total soluble salts (conductivity in millimoles/cm)			
(i) Below 1- Normal (ii) 1-2- Critical for germination		(iii) 2-4- Critical for growth of the sensitive crops. (iv) Above 4- Injurious to most crops.	

Source-Hand book of Agriculture, ICAR, New Delhi, 1980.

4. Conclusion

Looking to the past management systems and biodiversity of the area, following treatments need to be included under the present improvement working system:

(a) No attention was paid to sustain the community structure and regeneration status of multi-canopy species in the past. Population density, basal area, diversity index are among the major indications of sustainability .In the present case, data obtained on these aspects lie towards lower side of normal ranges as reported for mature (ecologically stable) Indian forests. Thus, there is a strong need to sustain the community structure of forests. Stress should also be given on the conservation biology of species showing poor ecological representation in the area.

(b) Middle canopy trees, particularly NWFPs, should be managed in order to increase yield of fruits /seeds.

(c) Under enrichment planting, those species should be introduced which have lower density in recruitment stage in order to sustain population dynamics of forest ecosystem.

(d) Medicinal plants and tubers may be introduced in the lower canopy/ground vegetation to optimize the socio-economic welfare of forest dependent communities.

(e) Silvicultural system should focus on minimum biomass removal from forests in order to increase the litter production and its decomposition in the forest. This will lead to sustained nutrient balance and water regime of the site. For multi-canopy development, diverse eco-silvicultural requirements should be carefully considered for middle and lower canopy species before adopting any silvicultural system or a combination of systems. Fruit bearing species (middle canopy trees) were found very few in number. Ground flora was nearly absent. Thus, there is a need for multi-tier forest management for obtaining sustainability at structural and functional levels. Since the forest area is stony and is devoid of topsoil in most part, the adoption of silvi-pasture system would be useful at the initial (up to 5 years period) stage followed by appropriate silvicultural system. For this purpose, high quality grasses be introduced in the area. Soil working and water conservation measures are needed to enhance the fruit production of *Emblica officinalis* Gaertn, *Madhuca indica* J.F. Gimelin., *Buchanania lanzan* Spreng and *Semecarpus anacardium* L.f.

(f) Most stands studied are poor in tree density. Silvicultural availability of trees must be kept in mind before planning and applying any management system.

(g) Settlement zone can be utilized adopting silvi-oleri-culture system. Most of the agricultural land is un-irrigated and poor in soil fertility. The adoption of water harvesting techniques and agro-forestry can enhance the fertility of soil along with optimization of overall productivity. This will also help to reduce pressure on forests for fuel and fodder.

(h) Among social issues, the degree of male domination was found higher at the VFC level, which is not a good sign for social sustainability. The women's participation need to be increased for sustainable development of the area. Besides, degree of factionalism in the VFC was found moderate. Marginal groups have very little involvement in training programmes and other VFC activities, it needs to be

improved. In the area, no small-scale industries were observed for sustaining economy of forest dependant communities.

(i) Forest department staff needs more training on participatory methods of JFM to achieve sustainability and for human resource development.

(j) There is a need to adopt appropriate land use policy involving MOEF and Ministry of Agriculture for optimum utilization of land resources and to ensure food security for Indian prosperity.

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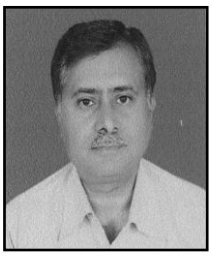

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