Sustainability of Soil and Vegetation under Community Managed Forests: a Case Study from Southwest Bengal

Tapan Kumar Mishra and ****Sri Bhagaban Roy***

Raja N. L. Khan Women's College, Midnapur (West Bengal) INDIA-721 102
E-mail: mishratapan@hotmail.com
*Chairman, IBRAD, 3A Hindustan Road, Calcutta-700 029

1 Introduction

The major cause of degradation of biological diversity has been attributed to the effect of human activity. This also poses a serious threat to human development. It was also emphasized to recognize and foster traditional methods and the knowledge of indigenous people and their communities. This was the point where participation of communities in management of natural resources was felt necessary. The main agenda before our present study is to know to what extent the ecology of such jointly managed forests and ecorestoration activities have been able to reverse the process of depletion of soil as well as biological diversity.

2 Study site

The present study site is the plateau tract in the southwestern side of Bengal and lies within 21 ° 36 N latitude and 85° 49 to 87 ° 46 E longitude. It is under Midnapore, Purulia, and Bankura administrative districts of West Bengal. Entire tract has undulating topography with old alluvium as parent material. Average annual rainfall of the entire lateritic belt varies from 1200 to 1400 mm. Maximum temperature during summer goes up to 47°C and in winter it comes down to 8°C. The spell of dry season varies 7 to 8 months in a year. The geological formation of the study has been described as older alluvium of sub-recent to pleistocene. The alluvium appears to have been dislodged from the decomposed rock of adjacent territories and deposited in this area. The transported soil then underwent further weathering in the new environment.

Joint Forest Management (JFM) of forests brought about visible quantitative and qualitative changes in the future of forest communities, to some extent, in this region. The region has led the JFM movement in India and at present has about 2,546 Forest Protection Committees (FPCs). In the present study comparison of some ecological parameters in between a managed (by the community) and unmanaged degraded land has been done.

The site (Gopegarh) where a specific comparative study on different ecological aspects of managed and unmanaged stands was carried out is a highly undulated land in Kansabati catchment lying between 86°33′N latitude in the East Midnapore Forest Division, West Bengal. The region was originally covered with coppice *sal* (*Shorea robusta*) forests with associated species. As a consequence of mass felling and biotic interference about 174 hectares of land at Gopegarh were completely denuded with exposed laterites. The surface mineral horizon of the soil was almost absent due to heavy erosion prior to the plantation work because the site has complex slope with 5%—7% gradient towards north-eastern side and a sharp slope of 10%—12% gradient in south-eastern direction (towards Kansabati river).

The site exhibited sheet erosion, rill erosion and gully erosion prior to the conservation activities. Three earthen dams of 95 m, 75 m and 50 m in length and 1 m, 2.55 m and 3.20 m in height were constructed at different locations during 1988—1989 to store water and to arrest siltation. Total area of three reservoirs is 0.77 ha. Plantation of *Acacia auriculiformis* was raised along with few *Tectona grandis* saplings during the rainy season of 1989 with a spacing of 2.5 m × 2.5 m. At the first phase, plantation was raised in 90 ha of land and then in 1990 and 1991, 55 ha were covered. 'V' shaped trenches were dug in 90 ha of land at an interval of 20 m in the year 1989. During the time of study i.e. in the year 1994,

about 30 ha of the land with clear ridges and furrows was still lying barren and this area was considered as control.

3 Material and methods

For the phytosocilogical study of lateritic forests of Midnapur district from the whole area 15 pairs of forest patches were selected basing on the following parameters. The list of the forest patches managed by different Forest Protection Committees (FPC) is available in Table 1. Adjacent unmanaged forest patches were also selected in each case for a comparative study: (1) Per capita forest available (2) Length of protection and year of registration (3) Accessibility (Remote/Accessible) (4) Anthropogenic composition of FPC (Gender and Caste wise) (5) Nature and composition of the community and (6) Topography. The survey work was conducted during June to October (rainy season) when maximum number of species of vascular flora was available. At different aspects 12 random quadrates each of 10 m $\times$ 10 m for trees, 5 m $\times$ 5 m for shrubs and 1 m $\times$ 1 m for herbs were laid out for phyto-sociological study. The size and number of quadrates were determined by species area curve (Misra, 1968) and running mean method (Kershaw, 1973) respectively.

The vegetational data were analyzed for frequency (F), abundance (A) and density (D) according to the formula described by Curtis and Mc Intosh (1950). The ratio of abundance to frequency (A/F) for different species was calculated for eliciting the distribution patterns. Species diversity index (H) determined using Shannon-Wiener information function (Shannon and Weaver, 1963).

Surface soils (0—15) were collected randomly from the plantation area and barren land. pH, organic carbon, mechanical composition, exchangeable cations, available phosphorus and potassium were determined by the methods described by Jackson (1973). Available nitrogen was estimated by Subbiah and Asija (1956) method.

4 Phytosociological study of southwest bengal

For the studies concerning phytosociological status of the forest patches we calculated the indices like Importance Value Index (IVI), Diversity Index (H), Richness Index (d) and Dominance Index (Cd). The Maximum IVI value was found with *sal.* If we consider the managed forest patches as one abstract community and unmanaged ones as another abstract community the two communities can be described as *Shorea-Combretum-Flacourtia* and *Diospyros-Eupatorium-Perotis* respectively. The community has been characterized basing on the IVI values. The maximum IVI values in managed forests are 300 for *Shorea* in pure patches, 64.2 for *Combretum*, and 74.9 for *Flacourtia*. In unmanaged forests the IVI values are 108.1 for *Diospyros*, 73.1 for *Eupatorium* and 70.7 for *Perotis*.

The results provide one important information regarding invasive species. Though it is a known fact that *Diospyros* is a dominant species in no canopy cover condition (as we find that there is almost no tree canopy cover in unmanaged forests). Some exotic species like *Eupatorium ododratum* invade the degraded sites pushing the indigenous species to a lower line. The other shrub species like *Lantana camara* has an IVI of 41.6 in unmanaged condition which as high as to be scared for. A higher availability of *Diospyros* in unmanaged condition provides better economic return as it produces *Tendu* leaves.

The Diversity Index (H) of trees in managed condition lay in between 0—1.854. There is no tree found in unmanaged condition. In case of shrubs the (H) in managed condition lies in between 1.731—3.015. The corresponding value in unmanaged condition is in between 0.391—2.409. The Diversity Index of herbs in managed condition lay in between 1.948—2.675 and that in unmanaged condition is 2.506—3.015.

The results show that in managed condition the shrub layer is slightly more diverse than the unmanaged one where as the later is more diverse in its herb layer. This is because of the availability of light and low level of species competition, which can accommodate more herb species. It is a point to note that the villagers are more interested in shrub layer as this layer provides more fuel-wood to them. The Dominance Index values show reverse trend as that Diversity Index as in most of the cases.

The Richness Index (d) has been calculated considering a whole forest patch as a community *i.e*. taking all the species of a community in to consideration (Table 1). The range of values in the managed condition is 7.67—17.76 and in unmanaged condition are 4.9 — 12.11. The average value in the managed condition is 11.6 and in unmanaged condition it is 8.8. The value shows that the managed forests are richer in their community structure.

Table 1 Phytosociological (Richness index) Parameter of different Managed and unmanaged forest patch of Midnapore district

Name of FPC	No. of Species		Richness index (d)	
	Managed	Unmanaged	Managed	Unmanaged
Valuka	24	13	9.29	4.9
Kamalapore	24	20	9.29	7.67
Chandabila	30	16	11.71	6.06
Nemainagar	26	15	10.09	5.65
Lalitasole	33	16	12.92	6.06
Metiadahar	31	31	12.11	12.11
Garpahar	32	23	13.32	8.88
Christanpara	20	27	7.67	10.5
Fulberia	25	28	9.69	10.9
Laljole	45	27	17.76	10.5
Kadamdanga	33	27	12.92	10.5
Birknar	27	31	10.5	12.11
Murakata	33	28	12.92	10.9
Bhagawatichawk	31	22	12.11	8.78
Kuilibandh	30	18	11.71	6.86

5 Comparative study on managed and unmanaged stands

The phyto-sociological and soil physico-chemical aspects of highly degraded lateritic land of Midnapore Forest Division, West Bengal after proper management and silvicultural practices have been studied to assess the impact of land management and its role in restoration of ecology. The conservation activities drastically changed the ecology of the region within 5 years. The tree layer had 21 species though only *Acacia auriculiformis* was planted with few *Tectona grandis* saplings during 1989. The total number of species accommodated in the plantation area were 160 whereas in the adjacent denuded and unmanaged area it was only 12. The soil was enriched nutritionally. It revealed that soil conservation measure including plantation of *A. auriculiformis* had great influence in bringing about the ecological stability.

The species occurring in the adjacent denuded and unmanaged are as follows. Only 3 shrub and 9 herb species were noticed and identified in this area. In the plantation area, the tree layer had 21 species though only *A. auriculiformis* with few *Tectona grandis* saplings was planted during 1989. Rest of the 19 species were introduced by nature and later established themselves. The site had 56 shrub species out of which some were shrubby climbers. There were 83 herb species. The large number of herb and shrub species ensured better nutrient accumulation and recycling in the forest ecosystem (discussed later). On the contrary, the degraded area had only 9 perennial herb species and 3 shrub species.

A/F ratio in the plantation area showed that there is no species with regular distribution, only 10 species with random distribution and the rest were with contagious as per the ratio described by Curtis and Coltam (1956). Contagious distribution is generally common in manmade forests though Kershaw

(1973) and Singh and Yadav (1974) have also reported such distribution pattern under natural vegetation. In the degraded area, A/F ratio of all the 12 species was higher than 0.05 indicating contagious distribution.

In the plantation area within herb species although the density of *Dentella repens, Desmodium triflorum, Eragrostis coarctata, Euphorbia microphylla, Evolvulus nummularius, Lindernia ciliata, Lindernia crustacea, Oplismenos burmanni*, and *Setaria glauca* was more than 10 per square meter, the densities of *O. burmanni* and *L. crustacea* were exceptionally high. In the shrub layer, there were 7 species having more than 20 plants per 100 m^2. These were *Cassia sophera, Cassia tora, Combretum roxburghii, Eupatorium odoratum, Hollarhena antidysenterica, Ocimum basilicum and Sida cordifolia.* Within these 7 species, *E. odoratum* is exotic in this region. In the tree layer, the densities of only two species (*A. auriculiformis and Bambusa tulda*) were more than 100 trees per hectare. In the degraded area, the herbs present were less than 10 plants per square meter and the shrub species were within 1—2 plants per 100 m^2.

The number of species accommodated in a community is an important factor from the ecological point of view since it seems to increase as the community becomes more stable (Singh *et al.*, 1991). The total number of species accommodated in plantation area were 160 whereas in degraded area it was only 12.

In the plantation ecosystem general diversity (H) was 2.962 for herbs, 3.49 for shrubs and 1.62 for trees only (Table 2). The H value calculated for the whole community was 3.103. in the degraded area, H was low in all the cases. For herbs it was 2.09, for shrubs 1.02 and for the whole community only 2.14. The values of concentration of dominance (Cd) were 0.123 for herbs, 0.038 for shrubs and 0.398 for trees. The Cd value for the whole community is 0.086. Cd values in the degraded areas were 0.376 for herbs, 0.55 for shrubs and 0.126 for the whole community. Thus, in the community with low diversity, concentration of dominance is high.

Table 2 Different indices of diversity in plantation and degraded areas of Gopegarh

Indices	Community	Herbs	Shrubs	Trees	All the species
Diversity Index (H)	Plantation	2.962	3.490	1.621	3.103
	Degraded	2.090	1.020	—	2.140
Index of Dominance (cd)	Plantation	0.123	0.038	0.398	0.086
	Degraded	0.376	0.550	—	0.126
Richness Index (d)	Plantation	21.13	17.47	9.13	12.8
	Degraded	1.18	0.57	—	1.12

'—' Indicates that tree species is absent

The richness index (d) shows that herbs are richer ecologically than shrubs and trees in the community. In the Plantation community, the richness indices were 21.13, 17.47, 9.13 and 12.8 for herbs, shrubs, trees and the whole community respectively. In the degraded area, the richness indices for herbs, shrubs and the whole community are 1.18, 0.57 and 1.12 respectively. The lower value of richness index in the degraded area clearly indicates its ecological poverty. The high richness of herbs and shrubs in the plantation is a result of soil conservation method adopted.

The density of the saplings and seedlings (Table 3) of a species can be considered as the regeneration potential of the species. The seedlings and saplings of five species were found in the plantation area during the time of survey. *A. auriculiformis* had maximum number of seedlings and saplings followed by *Azadirachta indica, Ailanthus excelsa, Holoptelia integrifolia* and *Diospyros melanoxylon*. Among other tree species entering from outside the community, *A. indica* was dominant. Some saplings of this species and also of *A. excelsa, H. integrifolia* and *D. melanoxylon* can persist this stress condition and so tree cover is expected to become more rich in near future.

The physico-chemical characteristics of the soils of the barren land and plantation site are given in Table 4. The pH of the plantation site was slightly lower than that in the barren land. In the plantation site, organic carbon content of soil was nearly four times than that in the barren land. Clay content increased in

the plantation site. This is not due to *in-situ* formation of clay but by the deposition of the finer particles of the soil from the muddy water running off the unprotected land due to the presence of a large number of ground flora which reduced considerably the velocity of runoff. Moreover, 'V' shaped trenches at frequent intervals were also supposed to reduce the runoff rate although runoff data were not calculated.

Table 3 Density of saplings and seedlings of different tree species available in Gopegarh

Tree species	Number / 100 m^2
1. *Acacia auriculiformis*	723
2. *Ailanthus excelsa*	78
3. *Azadirachta indica*	271
4. *Diospyros melanoxylon*	58
5. *Holoptelia integrifolia*	64

Table 4 Physico-chemical characteristics of the soil in Gopegarh

Attributes	Barren land	Plantation site
pH (1:2.5)	6.9	6.4
Org. C (%)	0.082	0.321
CEC (me/100g)	3.0	4.8
Clay (%)	5.8	10.5
Silt (%)	7.0	12.9
Sand (%)	87.2	76.6
Av. N (ppm)	38.0	122.0
Av. P (ppm)	Traces	1.6
Av. K (ppm)	56.0	176.0
Exch. Ca^{++} (me/100g)	0.8	1.6
Exch. Mg^{++} (me/100g)	0.3	0.7

Nutrient status of the soil of plantation site has increased considerably. The results are in agreement with those obtained by Singh *et al.* (1987) who studied the effect of vegetation covers on the nutrient status of soils of a degraded land. The available nitrogen content of the soil of barren land was only 38.0 ppm but in the plantation site it was 122.0 ppm (Table 4). The enrichment of nitrogen is not only due to the presence of the large number of ground vegetation but also due to the fixation of atmospheric nitrogen by *A. auriculiformis*, which is a NFT species. A large number of ground vegetation also directly or indirectly contributed to the enrichment of nutrients to some extent in the soil.

Thus, it appears that within 5 years, because of proper management and silvicultural practices, the environment of the whole area has been changed to some extent and the restoration of ecology is being established gradually.

References

Curtis, J.T. and Coltam, G. 1956. Plant Ecology Work Book, Burges Publishing Co., Minnesota.

Curtis, J.T. and Nc Intosh, R.P. 1951. An upland forest continuum in the Prairie forest boarder region of Wisconsin. Ecology, **32**: 476-496.

Jackson, M.L. 1973. Soil Chemical Analysis, Prentice Hall of India Pvt. Ltd., New Delhi.

Kershaw, K.A. 1973. Quantitative and Dynamic Plant Ecology, Edward Arnold Ltd., London.

Misra, R. 1968. Ecology Work Book, Oxford & IBH, New Delhi.

Odum, E.P. 1983. Basic Ecology, Holt Saunders Intl. ed. Japan.

Shannon, C.E. and Weaver, W. 1963. The Mathematical Theory of Communication, Univ. Illinois Press, Urbana.

Simpson, E.N. 1949. Measurement of diversity, Nature, **163**: 688.

Singh, J.S. and Yadav, P.S. 1974. Seasonal variation in composition, Plant biomass and net primary productivity of tropical grassland at Kurukshetra, India, Ecol. Mongr., **44**: 351-375.

Singh, R; Sood, V.K.; Bhatia, M. and Thakur, G.C. 1991. Phytosociological studies on tree vegetation around Simla, Himachal Pradesh, Ind. J. For. **14:** 169-180.

Singh, S.B.; Das, P.K.; Banerjee, S.K. and Singh, B. 1987. Effect of vegetation covers on the nutrient status of soils. J. Indian Soc. Soil Sci., **35**: 232-237.

Subbiah, B.V. and Asija, G.L. 1956. A rapid procedure for the estimation of available nitrogen in soil. Curr. Sci., **25**: 259-261.