Reviving the degraded forests of Andhra Pradesh, India: an effort through joint forest management

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Abstract: Joint forest management in Andhra Pradesh was initiated to restore degraded forests and support livelihoods of forests dependents. Vegetation development in 20 JFM villages was assessed. Stem density ranged up to 321 trees/ha. Number of cut stems/ha varied from 49–92 indicating tree removals. Tree species were over 50 in Ghats, 40 in sub plains and 30 in plains indicating biodiversity improvement. Size-class distribution of trees indicates that regeneration is substantially high with more than 60% trees in <30 cm GBH category. Basal area and biomass have been increasing in JFM forests. Biomass studies in 15 VSS over a six-year period indicated a growth rate of 2 tons/ha/annum.

Keywords: joint forest management; Andhra Pradesh; species diversity; biomass.

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1 Introduction

Andhra Pradesh (AP) adopted joint forest management (JFM) programme by the formation of village level committees called Vana Samrakshana Samithis (VSS) in 1992, as a strategy to regenerate the degraded forests and to develop economy of forest dwellers. The state has a forest area of 63,580 km^2 accounting to 23.2% of total geographical area. Eastern Ghats, one of the forest rich regions, passes through 14 districts in the state. The cultural diversity of the region is vast in Eastern Ghats and nearly 33 scheduled tribes are reported from AP alone. Over the years, owing to several reasons, forest degradation has resulted in disastrous consequences such as loss of species that served as substantial income source for many forest dependent communities. Recent remote sensing imageries suggest that nearly 60% of the state's forest area need intensive management strategies for regeneration and recovery. Therefore, JFM has been implemented in a large scale, wherein people in the vicinity of the forest could manage forest resources in a sustainable and beneficial way. In this paper, we attempt to understand the impact of such a large-scale participatory initiative on tree density, species richness, forest regeneration and biomass production. In addition, the paper attempts to look holistically the measures that could be taken up for overall development of natural resources apart from forests.

2 Study sites

The state can broadly be divided into three bioclimatic zones, which incidentally also forms the sociopolitical regions. (1) Coastal Andhra (Plains) region has a typical climate influenced by the sea, and receives moderate rainfall ranging from 700 to 1000 mm/annum; (2) Telangana region, mostly associated with stable lands of the Deccan plateau, receives moderate rainfall ranging from 600 to 1000 mm/annum. The Western part of this region is considered as the semi-arid region and (3) Rayalaseema region is a part of the Western Plains of the Ghats in Southern AP and is a semi-arid zone with low rainfall of 580–800 mm/annum. The Eastern Ghats run through all the three regions and receive relatively greater rainfall, and also support large stretches of the state forests. Telangana region accounts for nearly a half of the state's forest area, while the coastal region supports diverse forest types ranging from high hill forests to mangroves.

The forests of AP are primarily Southern tropical, dominated by the deciduous types (APFD, 2002). The spread and coverage of these forest types are presented in Table 1. Nearly 70% of the forests belong to deciduous type, while moist deciduous types exist in relatively high altitude, especially in the tracts of the Eastern Ghats.

Table 1 Particulars of the forest types of Andhra Pradesh

Forest type	*Area* (million ha)	*Percentage of forest area*
Southern tropical moist deciduous forests	1.600	25.35
Southern tropical dry deciduous forests	2.800	44.36
Southern tropical thorn forests	1.600	25.35
Littoral forests	0.280	4.44
Tidal swamps and mangroves forests	0.032	0.50

Increased pressures from the ever-growing population's needs have resulted in severe degradation of nearly 37,850 km^2 (59.3%) of the 63,580 km^2 recorded forest area of the state, which required intensive management strategies, when JFM was initiated (Kameswara Rao et al., 2004). The ecological impacts of JFM was not so far reported and this study is an attempt in this direction, with a special focus on vegetation and plant communities in the regenerating forests under the JFM programme.

Most degraded forest areas of AP, apart from vegetation cover, have lost vast quantities of soil, exposing bare rock. Thus, apart from plantation activities, control of soil erosion has become a major prerequisite to the forest regeneration activities under JFM through contour trenches, contour bunding and plantation activities.

The study region, Visakhapatnam forest circle comprises three districts and five territorial forest divisions and has a total geographical area of 23,53,700 ha of which nearly 28% (6,56,943 ha) is forests (Ramakrishna, 2002). As on January 2002, the region had 1306 VSSs, covering 2,24,000 hectares (34.05% of forest area) and involving nearly 50,000 families (APFD, 2002). Thus it is important to understand the impact of project on the ecology of the area particularly on stem density, species diversity and biomass production aspects and the need for such studies for promoting participatory forest management Ravindranath and Sudha (2000).

The ecological studies were carried out during October 2003–July 2004, in five forest divisions of Visakhapatnam Forest Circle (Table 2). About 20 VSSs from these five forest divisions were selected randomly for laying plots and making observations (Table 2).

Table 2 Distribution of sampled study sites of Visakhapatnam Circle in terrain zones

Forest divisions	*Ghats*	*Sub plains*	*Plains*
Srikakulam	1	1	–
Vizianagaram	–	2	–
Visakhapatnam	2	4	4
Paderu	4	–	–
Narsipatnam	–	2	–
Total	7	9	4

3 Methodology

Replicates of quadrats, measuring 25 m× 25 m for trees, 10 m× 10 m for shrubs and 1 m× 1 m for herbs, were laid in the JFM area. Stems with >10 cm Girth at Breast Height (GBH) were measured and species name recorded. The vegetation data were analysed for species richness, Shannon Weiner's species diversity index, density of trees, size class distribution of trees and basal area. Biomass in tons per ha was computed as product of height, basal area (Shailaja and Sudha, 1997) and wood density. Mean annual increment of biomass under plantation was computed by dividing biomass with age of plantation. In addition, numbers of cut stems were counted in all the plots in order to understand the impact of protection.

4 Results

The flora of the study region, as recorded from the 20 study sites, comprises 422 species of angiosperms. Of these, 171 were herbs, which included 40 species of grasses; 98 were shrubs; 12 were climbers and 141 were tree species. The 422 species recorded from the present study region belonged to 82 families and 274 genera, and has a Family:Genera:Species ratio of 1:3.34:5.15. However, at individual sites, the numbers of species have varied from 136 to 289. Srikakulam division exhibited greater species richness compared to other divisions. Among the terrain zones, the plains zone had lower numbers of species.

4.1 Plant diversity

Of the 82 families recorded in the present study, 24 (29.3%) were represented by five or more species, which has been considered as high diversity families. The 24 high diversity families together contained 302 species accounting for 71.56% of the total species recorded in the region. Fabaceae family ranked first (51 species) followed by Poaceae, represented by 38 species. The species diversity has exhibited variations among the sites, within and between the three terrain zones ranging from 2.71 to 3.55 (Table 3). The evenness of the species was low at Plains zone, while its range was more or less similar in the other two zones.

Table 3 Tree species diversity measures at JFM study sites

Name of VSS	*Tree species richness*	*Species diversity index*	*Evenness index*
Ghats zone			
Mekava	65	3.55	0.85
Poolabanda	47	3.04	0.79
Lotheru	48	3.25	0.84
Titingvalsa	52	3.32	0.84
G.Gondur	33	3.04	0.87
Muttamamidi	42	2.84	0.76
M.Thotavalsa	39	2.71	0.74
Sub plains zone			
Jagannathapuram	58	3.53	0.87
Potabandapalu	42	3.36	0.90
Cheelavalsa	39	2.71	0.74
Tiruvada	40	3.10	0.84
Bethapudi	39	3.30	0.90
Ramchandrapuram	43	3.35	0.89
Punyagiri	51	3.38	0.86
G.V.Palem	59	3.14	0.77
Donipalem	43	2.71	0.72
Plains zone			
ChinnaGollapalem	34	2.89	0.82
Donkadakotturu	45	2.93	0.77
Sambuvanipalem	31	2.85	0.83
Ichapuram	37	2.31	0.64

4.2 Density of trees

Tree densities have widely varied from site to site within the same terrain zone or the forest division. The tree densities ranged from 168/ha to a height of 504/ha. However, majority of the sites had a smaller range from 200 to 435/ha. Only GV Palem village had a density of >500/ha (Table 4). Among different terrain zones, the variations in the tree densities appeared to be distinct as shown in Table 4.

Table 4 Trees density and basal area in JFM sites of Eastern Ghats

Site no.	*Villages*	*Year of JFM initiation*	*Tree density*	*Basal area* (m^2/ha)
Ghats zone				
1	Mekava	1996	267	5.94
2	Poolabanda	1996	240	5.72
3	Lotheru	1996	284	5.21
4	Titingvalsa	1998	341	8.98
5	G.Gondur	1994	423	12.10
6	Muttamamidi	2001	218	4.25
7	M.Thotavalsa	1997	193	4.81
		Average	281 ± 79	6.72 ± 2.82
Sub plains zone				
8	Jagannathapuram	1994	306	7.65
9	Potabandapalu	1995	261	7.53
10	Cheelavalsa	1996	426	9.65
11	Tiruvada	1994	431	10.78
12	Bethapudi	1997	306	8.06
13	Ramchandrapuram	1994	211	5.15
14	Punyagiri	1996	257	5.98
15	G.V.Palem	1996	504	13.35
16	Donipalem	1997	187	4.92
		Average	321 ± 109	8.12 ± 2.76
Plains zone				
17	ChinnaGollapalem	1998	205	5.38
18	Donkadakotturu	1998	168	4.67
19	Sambuvanipalem	1998	398	9.25
20	Ichapuram	1999	212	6.05
		Average	246 ± 103	6.34 ± 2.02

The Sub Plains zone had greater densities compared to the other two zones. On the other hand, the densities at the sites of Plains zone were significantly low and the deviation from one site to another also is very high. However, statistically the mean tree densities were not significantly different.

4.3 Basal area

The ground occupancy (basal area) by the tree stratum varied from 4.25 m^2/ha at Site 6 to 13.35 m^2/ha at Site 15 (Table 4). The basal area of trees was relatively high only in three VSSs, of which two were in Sub Plains zone and one in Ghats zone (Table 4).

The mean basal areas for the Ghats, sub plains and the plains zone were 6.72 m^2/ha, 8.12 m^2/ha and 6.34 m^2/ha, respectively (Table 4). The tree basal areas showed low relationship with the age of protection. Though the means of basal areas appeared to be increasing with the increased time under JFM, the deviations among different sites were very high (more than two times) and statistically not significant.

4.4 Distribution of trees according to size

Trees of higher girth class and climax type were very low in number, and thus, young trees with low GBH (<30 cm) and smaller height classes (<5 m) have dominated the community. Hence, these forests can be considered as regenerating forests or sites with secondary succession. The tree population was considered in four girth and height classes (Table 5). In 13 of the 20 VSSs, trees of >90 cm class were absent. In the remaining VSSs, the presence of this class was very insignificant and accounted for a maximum of 1.59% of the total density. Most of the trees that were recorded under this class were the species, which were protected for various reasons like income generation, religion or cultural importance.

Table 5 Girth and height class distribution in JFM sites in Eastern Ghats

VSS name	*Girth classes* (cm)				*Height classes* (m)			
	<30	*30–60*	*60–90*	*>90*	*<5*	*5–10*	*10–15*	*>15*
Ghats zone								
Mekava	91.39	5.99	1.12	1.50	88.76	6.74	3.75	0.75
Poolabanda	81.25	15.00	3.75	0.00	78.75	13.33	7.92	0.00
Lotheru	89.08	9.51	1.41	0.00	91.90	4.93	3.17	0.00
Titingvalsa	69.79	19.94	9.38	0.88	75.07	14.96	7.04	2.93
G.Gondur	76.12	17.02	6.86	0.00	77.54	11.82	8.51	2.13
Muttamamidi	87.16	12.84	0.0	0.00	83.94	14.68	1.38	0.00
M.Thotavalsa	72.54	22.80	4.66	0.00	79.27	15.54	5.18	0.00
Sub plains zone								
Jagannathapuram	85.62	8.50	5.56	0.33	80.39	10.78	7.52	1.31
Potabandapalu	85.44	13.79	0.77	0.00	95.40	4.21	0.38	0.00
Cheelavalsa	89.67	7.04	2.82	0.47	93.19	5.63	0.70	0.47
Tiruvada	78.42	17.40	4.18	0.00	65.43	16.94	9.74	7.89
Bethapudi	92.16	5.88	1.96	0.00	90.85	6.54	1.96	0.65
Ramchandrapuram	88.63	9.48	1.89	0.00	87.68	6.64	4.27	1.42
Punyagiri	80.16	11.28	7.39	1.17	73.54	14.01	10.89	1.56
G.V.Palem	77.58	16.07	4.76	1.59	68.25	13.69	10.32	7.74
Donipalem	83.96	11.76	4.28	0.00	79.68	14.44	5.88	0.00
Plains zone								
ChinnaGollapalem	83.41	14.15	2.44	0.00	76.59	17.56	5.85	0.00
Donkadakotturu	77.98	22.02	0.0	0.00	85.71	14.29	0.00	0.00
Sambuvanipalem	79.90	14.82	5.28	0.00	85.47	8.04	5.03	1.51
Ichapuram	53.02	13.21	3.30	0.47	77.83	17.92	2.83	1.42

Trees in 60–90 cm girth class also were absent in 2 VSSs and in the remaining VSSs it ranged up to 9.38% of the total density. Trees of 30–60 cm girth class accounted for 5.88 – 22.80% of the total density in different VSS. The most dominant class in all the VSSs was <30 cm girth class, the contribution of which to the total density ranged from 53 to 92% of the total density in different villages. The height classes also showed almost the same pattern, and the dominance of the higher classes declined rapidly as in the case of the girth classes. More than half (53 – 78%) of the individuals in <30 cm girth and <5 m height classes were the trees grown under plantations and the remaining belonged to the natural regeneration from the rootstock.

4.5 Tree species promoted under JFM in the Eastern Ghats

The tree species promoted under the JFM programmes are very few in number and mostly included a mix of forest species and non-forest species. In addition to zone specific species, four major species, *Phyllanthus emblica*, *Tamarindus indica, Pongamia pinnata* and Bamboo were planted in all the terrain zones. In Ghats zone, *Artocarpus integrifolia* and *Bixa* spp. accounted for nearly a half of the plantation area. In the Sub Plains zone, *Bixa* spp., *Sterculia urens* and *Annona squamosa* were dominant; and in plains zone, Acacia, Eucalyptus and *Annona squamosa* were dominant. Total plantation area was limited to a maximum of 5 ha/annum. Planting was at 2 m× 2 m spacing and Bamboo at 40/ha.

4.6 Number of cut stems and protection measures

Number of cut stems varied widely across terrains, and among sites within terrain. The Ghats zone had maximum number of the cut stems and among different sites it ranged from 72 to 118/hectare, with a mean of 91 cut stems/ha. In the sub plains zone cut stems ranged from 83 to 104/ha. In the Plains zone, the range was 38 to 63/ha (Table 6). Ghats zone and the Sub Plains zone experienced severe tree felling. However, these zones had good rootstocks, therefore may recover through regeneration.

Table 6 Number of cut stems in JFM sites of different zones in Eastern Ghats

Terrain zone	*Number of cut stems/ha*			*Coefficient of variation* (%)
	Minimum	*Maximum*	*Mean ± SD*	
Ghats zone	72	118	91 ± 17	18
Sub plains zone	83	104	92 ± 08	8
Plains zone	38	63	49 ± 11	22

4.7 Regeneration status

Although representation in lower girth height classes indicate regeneration potential, seedling density from seed origin and coppice origin will be helpful in understanding the regeneration trends on long term basis. These newly developing individuals are recognised into two categories: Small trees of Seed Origin (SSO) and Small trees of Coppice Origin (SCO). The density of SSO at different sites had a range from 28/ha at Site 19 to 105/ha at Site 10. The sites of VSP division had shown relatively greater densities than those of Srikakulam division. The density of SCO at the study sites had ranged from 10/ha at Site 19 to 93/ha at Site 10 (Table 7). This information was recorded only at 12 VSSs, and the information indicted that the SCO and the SSO did not show any pattern and appeared to be site specific in all the terrain zones. However, their mean densities show that the sub Plains zone had good regeneration compared to the other two zones.

4.8 Standing woody biomass

Standing woody biomass covers major wood portion existing in stem and main branches of the tree. The biomass was first estimated during 1998 for 12 JFM sites and the second estimate was during 2004. These two are compared here. Standing woody biomass ranged from 1.21 tons/ha at Site 13 to 36.43 tons/ha at Site 11 during the year 1998 and there has been substantial increase in biomass in six years. Growth rates varied from 2.43 t/ha/ annum at Site 2 to 5.54 t/ha/ annum at Site 5 (Table 8).

Table 7 Densities of the small trees (seedling and sapling stages) of seed origin and coppice origin

VSS name	*Seed origin*		*Coppice origin*		*Total*
	Number/ha	*%*	*Number/ha*	*%*	
Mekawa	64	54.7	53	45.3	117
Poolabanda	31	40.3	46	59.7	77
Tittingivalasa	93	60.8	60	39.2	153
D. Gonduru	57	51.8	53	48.2	110
Jagannathapuram	44	45.8	52	54.2	96
Pothubandapalem	41	46.6	47	53.4	88
Chellivalasa	105	53.0	93	47.0	198
Bethapudi	58	43.3	76	56.7	134
Ramachandrapuram	40	43.5	52	56.5	92
Sambhuvanipalem	28	73.7	10	26.3	38
Mean	*65*	*51.2*	*62*	*48.8*	*127*

Table 8 Estimate of standing woody biomass during 1998 and 2004

Site number	*Woody biomass* (t/ha)			
	During 1998	*During 2004*	*Difference*	*Growth rate* t/ha/yr
1	2.06	17.10	15.05	2.50
2	1.87	16.47	14.60	2.43
4	2.80	25.86	23.06	3.84
5	1.58	34.84	33.26	5.54
8	1.97	22.95	20.98	3.49
9	1.72	15.66	13.94	2.32
10	8.68	27.79	19.11	3.18
11	36.43	29.75	–	–
12	1.29	24.18	22.89	3.81
13	1.21	16.06	14.86	2.47
15	13.10	40.05	26.94	4.49
19	2.11	26.64	24.53	4.08

4.9 Potential of availability of non-timber forest produce (NTFP)

Eleven NTFP species were recorded at an average of nine at individual sites. Most of the NTFP species of Srikakulam forest division ranked among the top ten Important Value Index (IVI) species. The contributions of the NTFP tree species to the total IVI was maximum (40.5%) at Site 1, where four of the seven NTFP species were among the top ten IVI species of the site (Table 9). Collection of NTFPs was higher in Visakhapatnam, Paderu and Narsipatnam divisions. Among study sites, the dependence on NTFPs for income ranged from marginal to high. However, the incomes were low, as the markets for most products are not organised. In the recent times, *Gum* collection (*Sterculia urens*) and Jafta cultivation in the JFM sites are major income-generating activities. NTFPs are collected and processed by households and sold independently.

Table 9 NTFP availability and their contribution to the important value index (IVI) at different VSS sites in the Eastern Ghats

Species	*Study sites*											
	1	*2*	*4*	*5*	*8*	*9*	*10*	*11*	*12*	*13*	*15*	*19*
Phanera vahlii	–	√	–	√	–	√	√	–	–	–	–	–
Tamarindus indica	√	√	√*	√	√	√	√	√	√	√	√	√
Sapindus emarginatus	–	–	√*	–	–	√	√	–	√	–	–	–
Terminalia chebula	√	–	√	–	√	–	–	–	√	–	–	–
Strychnos potatorum	√	–	–	–	–	–	–	–	–	–	√	–
Sterculia urens	–	√	–	–	–	√	–	–	–	–	√	–
Diospyros melanoxylon	√	–	√*	√*	–	√*	√*	–	√	√	√	–
Aristida funiculata	–	–	√	–	√	–	–	–	√	–	–	–
Phyllanthus emblica	–	√	–	–	–	–	–	√*	–	√*	√*	–
Semecarpus anacardium	√*	–	√*	–	–	√*	–	–	√*	√	√	–
Phoenix sylvestris	√*	–	√	√	–	–	–	–	–	–	–	√
Madhuca longifolia	√	–	–	–	–	–	–	√	–	√	√	–
Thysanolaena maxima	√	–	√	–	√	–	–	–	–	–	–	–
Dendrocalamus strictus	√	√	–	–	–	–	–	√	√	√	√	–
IVI contribution (%)	*28.6*	*16.2*	*40.5*	*10.9*	*12.8*	*25.6*	*11.1*	*8.2*	*17.7*	*10.2*	*11.8*	*6.9*

*Species scoring top ten IVI.

4.10 Impacts of protection on vegetation

Effective protection from greenwood collection, cattle grazing, frequent fires and illicit clearings has enabled many species to regenerate from soil seed bank or the existing rootstock. This was evident from Table 7, that excepting one site (Site 19) in the Plains Zone, all other sites had a density of tree seedlings of more than 75/ha. Owing to the large-scale gap filling plantations, the densities of the plantation species have increased significantly changing the population densities. Bamboo plantations in Ghats and Sub plains zones, and *Acacia* and Casuarinas in the Plains zone sites appeared to be occupying 60–70% of the total plantation species. Some of these plantations at VSSs, started during 1996–98, were harvested in most of the sites. Incomes varying from Rs. 30,000 to Rs. 2.5 lakhs have been generated from these harvests (Kameswara Rao et al., 2000, 2004). However, the incomes from the conventional NTFPs have not increased considerably. New types, like Gum, Jafra etc., were the NTFPs added to their traditional collections.

5 Discussion

JFM in AP was initiated with a concern to reclaim degraded forests, enhance forest cover and to support livelihood systems of millions who depend on forests. Over the last ten years or more, the programme aiming at increasing the forest cover and tree density has made significant stride towards this goal, apart from enhancing biodiversity.

5.1 Protection measures

The number of cut stems as a measure of impact of protection indicates that stems are cut in the plantations and natural forests of JFM, yet, the productivity is comparable with any other protected regions in the vicinity. The cut stems varied among the zones indicating the pressure of population and varying necessity of people in different zones. Furthermore, the premise of JFM is to use forests and protect it. Therefore, linking protection and cut stems may not reveal the real picture, but linking cut stems and productivity and other ecological parameters would give a gross picture of overall assessment of protection measures. The following paragraphs would indicate the impact of JFM on tree diversity, regeneration and biomass productivity.

5.2 Improved biodiversity

Another aspect of JFM is to enhance the resource base of the people who live in the fringe of the forest. Specifically in three terrains, Ghats, sub plains and plains, the improvement in diversity was significant. Over 60 tree species were found in Ghats, 50 in sub plains and 30 in plains indicating substantial improvement of plant diversity. This also has enhanced the resource base on which people are dependent. This is evident from the enhanced number of species available as NTFPs in the region. However, it is important to note that only 11 NTFP species are being used or collected by the communities, while the use and potential for income generation through a large number of other species are not explored (Padmavathi Devi, 2000). Even the efforts towards enhancing tree density through plantations have made conscious effort to enhance native species diversity, particularly those that have immediate benefits to the community as NTFPs. Under various terrains, the species promoted were different indicating the promotion of species that have adapted to those zones.

5.3 Regeneration

Size-class distribution of trees in all VSS indicates that regeneration in all forests is substantially high. It is difficult to get larger trees measure girth more than 90 cm in most forests, primarily because of age of plantation and the level of degradation over years. However, over decade of JFM, the basal area and regeneration have improved significantly. The seedlings of seed and coppice origin are of the same proportion indicating that there is seed bank and rootstock equally in soil so as to improve biodiversity and biomass of the forests. This enabled recovery of species and improves species diversity in JFM areas. Such pattern reinforces the fact that in addition to management practices, protection is very important for rejuvenating a forest. The programme was implemented at the right time and if delayed many native species would have disappeared.

5.4 Biomass production

Basal area and biomass have been increasing in JFM forests. A comparison of biomass growth rates in 15 VSS over a six-year period indicates an annual growth rate of over 2 tons/ha. The net primary productivity in the areas where precipitation is around 100 cm was estimated at 9–10 t/ha/annum (Odum, 1971). Of the total net primary production of the trees, a little more than 75% exists in above ground parts, while 1–5% will be in the canopy and green leaves. Thus, the woody biomass estimates in the present study can be considered on higher side, especially for the regions where the annual rainfall is around 100 cm. These growth rates are comparable to natural forests with good protection. The basal area observation from different VSS also indicate that the observed values can be compared with protected forests in wildlife sanctuaries and natural parks of the region.

Overall, the effort towards greening AP and its ecology has made significant progress. Excepting some instances, general direction of growth of forest is improving with respect to improved stand density, basal area, regeneration and biomass. The forests, apart from enhancing biomass and diversity, also improved the livelihood potential of the people, reduced migration possibilities for jobs and enhanced the living conditions of the people. In addition, the agencies working towards JFM should also aim for overall development of natural resources such as water, soil, agriculture etc., apart from forests, as they are linked strongly to one another. This would help a long way in improving the ecology of the area. Encouraging agro-forestry would help in diversifying the economy of the farmer in addition to reducing dependence on forest. Similarly, encouraging installation of fuelwood saving energy devices in the villages would enhance reduction of fuelwood dependence. Thus, a new approach is needed to make each village self-sustainable in its energy and food demands.

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