Ecological impact of joint forest management in Tripura, India

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Abstract: This study, conducted in seventeen villages undertaking joint forest management (JFM) in Tripura, is an attempt to assess the impact of protection and management on vegetation attributes viz., species richness, diversity, stem density, status of vegetation regeneration and biomass. The majority of the JFM areas showed lower tree species richness as well as diversity values but higher stem density compared to the unprotected areas. People's main preference was fuelwood in JFM areas and timber in the unprotected areas. Findings indicate the need for promoting regeneration of fast growing species and the development of fuelwood plantations particularly around centres of high consumption.

Keywords: joint forest management; ecological assessment; Tripura; regeneration; biodiversity.

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1 Introduction

Joint forest management (JFM) is a concept of developing partnerships between forest user groups and the Forest Department (FD) on the basis of mutual trust and jointly defined roles and responsibilities in forest protection and development. Tripura was the first state in northeast India to implement the JFM programme to regenerate degraded

reserve forests. The resolution enabling JFM was notified on 20/12/91. In Tripura, JFM was implemented in a phased manner. Initially, it was implemented in nine forest divisions viz., Kailashahar, Kanchanpur, Manu, Ambassa, Teliamura, Sadar, Udaipur Bagafa and Jatanbari. Later on, the JFM programme was also implemented in the remaining forest divisions viz., Gumti and Trishna Wildlife Sanctuary. From a humble beginning of four villages in 1991 to 327 JFMCs in 2004, the JFM programme has expanded to cover all four districts of Tripura within a span of 13 years. This has come about due to the willingness of the people to cooperate, the interests and the financial support by the forest department and the untiring work of the various NGO's, Voluntary Agencies, Schools etc. in implementing the JFM programme at the grassroots level. As on December 2004, Tripura has 327 JFMCs, covering an area of 53,000 ha under JFM (Barik and Tiwari, 2004). Initially, it was supported by the Tripura State Forest Department and now it is mostly by the National Afforestation Programme (NAP) of the Government of India.

The Tripura Government order stipulates that JFM can be implemented in degraded forest areas. There is a limit of 5 ha for natural regeneration and 2 ha for intensive planting per beneficiary. The programme can be extended to good forest (crown density above 40%) areas on a pilot basis and protected areas are not open for JFM. During initial years, almost all JFMCs adopted natural regeneration by way of providing protection. The existing sal stumps and associated vegetation regenerated very fast. This was followed by assisted natural regeneration in places where some state funds were available. However, from 1998 onwards, intensive plantations were taken up in several JFMCs through the funds made available initially through Centrally Sponsored Schemes (CSSs) and later through NAP. At present, Tripura has a mix of assisted natural regeneration and pure block plantations of timber, fuelwood as well as NTFP species. Under the JFM programme, the local communities, in collaboration with the Forest Department, took up various protection and revegetation measures in Tripura. In order to understand the change in vegetation attributes, particularly species richness, diversity, status of natural regeneration and biomass of the Tree species due to protection and revegetation measures undertaken by JFMCs an ecological assessment was conducted, the findings of which are discussed in this paper.

2 Methodology

Ecological studies were conducted in 6 forest divisions viz. Bagafa, Gumti, Sadar, Teliamura, Trishna and Udaipur divisions. The study was done in 17 JFMCs viz., Betaga, Bhairabnagar, Chandra Sadhupara, Galacipa, Harbatali, Jeevandeep, Kalshimura, Karaiyamura, Khasiamangal, Killamura, Poangbari, Raiyabari, Rani, Sakbari, Siddhinagar and Tepania.

In selected sites, multiple plots were laid and quadrat method of sampling was used. In the sampled JFM plots, two tree quadrats of size 50 m × 50 m, equal to an area of 0.50 ha were laid. All trees with more than 10 cm Girth at Breast Height (GBH) i.e., 3 cm DBH were measured and their height in metres was recorded. Further, shrub quadrats of 10 m × 10 m and herb quadrats of 2 m × 2 m were laid within the tree quadrats to record shrubs, herbs and seedlings of trees below 10 cm GBH. Identical control plots were laid in the unprotected natural forest. The number and age range of the JFMCs sampled is given in Table 1.

Table 1 Number of JFMCs sampled and age range of the JFMCs

Forest division	*Number of JFMCs*	*Number of plantation*	*Age range* (*years*)
Bagafa	6	14	4–8
Gumti	1	3	4
Sadar	2	2	7–12
Teliamura	2	2	5–7
Trishna	2	5	4–5
Udaipur	4	4	7–11
Total	17	30	4–12

The parameters recorded in each tree quadrat included species name, girth of the tree at breast height in cm, approximate height of the tree, regeneration status of plants-whether from coppice or seedlings (i.e., naturally regenerating or planted individuals).

The species diversity index was calculated following the formula of Shannon and Weaver (1963) and the growing stock was calculated using the species-specific volume equation (FSI, 1996). For those species where the specific volume equations was not available, the growing stock was calculated using the equation

$$\text{Volume } (m^3) = 0.8 \times D \text{ ^ } 2 \times H$$

where

D: diameter at breast height
H: height of tree in meter.

The mean annual increment was obtained by dividing the growing stock in tonnes per hectare by the age of the plantation.

3 Results

Assessment of impact of community protection, management and extraction practices on vegetation, species richness, diversity, size-class distribution of individuals and basal area are described in this section.

3.1 Species richness and diversity

The overall tree species richness in the sampled JFMCs ranged from 2 to 24, the highest was in Karaiyamura and Gobindatilla JFMC (24). Jeevandeep, the oldest among the sampled JFMCs, recorded a species richness of 22. Among <7 year age category, mean species richness was 14 in JFM plantation and 17 in the unprotected plantations. In case of >7 year age range, the mean species richness was 12 in JFM plantations and 11 in unprotected plantations (Table 2).

Table 2 Number of tree species and Shannon Weaver diversity index (H') in sampled JFMCs

Forest division	*JFMC*	*Age (years)*	*Number of tree species*		*Tree species diversity index (H')*	
			JFM	*Control*	*JFM*	*Control*
	Betaga	8	19	31	1.84	2.99
	Galacipa	5	19	25	2.98	3.49
Bagafa	Harbatali	7	11	15	0.67	2.91
	Killamura	4	15	19	3.02	3.6
	Poangbari	5	11	21	2.06	4.01
	Sakbari	6	11	17	0.64	3.17
Gumti	Gobindatilla	4	24	21	3.52	3.09
Sadar	Kalshimura	7	11	17	1.26	2.79
	Jeevandeep	12	21	6	1.3	1.59
Teliamura	Chandra Sadhupara	5	7	6	1.46	1.49
	Khasiamangal	7	7	3	0.55	0.54
Trishna	Bhairabnagar	5	9	14	1.05	5.34
	Siddhinagar	4	16	16	1.53	1.65
	Karaiyamura	7	24	8	1.85	2.28
Udaipur	Raiyabari	8	3	5	0.04	1.03
	Rani	11	15	6	2.6	2.12
	Tepania	7	2	8	0.01	1.36

Diversity index for trees in JFM plantations ranged from 0.01 in Tepania to 3.52 in Gobindatilla. The diversity index of JFM area was higher in unprotected area except in Rani JFMC and Gobindatilla JFMC. It was observed to be more or less the same in the case of Chandra Sadhupara and Khasiamangal JFMCs. In 76% of the JFMCs, the diversity index for trees in protected area was less than that of the unprotected areas (Table 2). Overall it can be inferred that the JFM area shows lower tree species diversity than the unprotected areas (control plots). For shrubs, the diversity index ranged from 0 in Jeevandeep and Sakbari to 2.99 in Siddhinagar. 47% of the sampled JFM plantations recorded higher diversity values than the unprotected areas. In case of herbs, the diversity index in 71% of JFM plantations was higher than unprotected areas.

3.2 Density of trees and basal area

The tree density per hectare in the sampled JFMC areas indicates the positive impact of protection and management on the growing stock. It was observed that mean tree density (>5 cm DBH) in the protected area was higher than unprotected area except in Bagafa (Table 3). Among the protected plots of seven forest divisions, the highest mean basal area was recorded in Gumti division (14.67 m^2/ha). In JFM plantations (82%), the mean tree density was higher than the unprotected area but the corresponding basal areas were lower. This could be due to the presence of more individuals in <5 cm DBH class.

Table 3 Density of trees and basal area in JFM and control plots

Division	*JFMC*	*Age* (*years*)	*Mean density/ha*		*Basal area* (m^2/ha)	
			JFM	*Control*	*JFM*	*Control*
Bagafa	Killamura	4	146	44	1.1	0.5
	Galacipa	5	138	366	2.4	5.8
	Poangbari	5	274	76	1.3	0.5
	Sakbari	6	462	196	5.8	3.1
	Harbatali	7	154	192	2.4	6.8
	Betaga	8	518	852	3.1	10.4
	Mean	*4–8*	*282 ± 170*	*287 ± 299*	*2.66 ± 1.70*	*4.35 ± 3.89*
Sadar	Jeevandeep	12	1834	1166	26.1	15.1
	Kalshimura	7	1570	286	8.8	8.4
	Mean	*7–12*	*1702 ± 187*	*726 ± 622*	*15.31 ± 12.23*	*9.05 ± 4.74*
Gumti	Gobindatilla	4	322	184	6.8	14.7
Teliamura	Chandra Sadhupara	5	74	42	0.75	1
	Khasiamangal	7	688	202	2.4	6.8
	Mean	*5–7*	*381 ± 434*	*122 ± 113*	*1.60 ± 1.17*	*3.76 ± 4.10*
Trishna	Siddhinagar	4	354	286	1.8	0.2
	Bhairabnagar	5	112	22	0.4	0.1
	Mean	*4–5*	*233 ± 171*	*154 ± 187*	*1.08 ± 0.99*	*0.84 ± 0.07*
Udaipur	Karaiyamura	7	2808	48	16.8	4.9
	Tepania	7	2170	1188	1.7	1.2
	Raiyabari	8	322	68	6.2	0.9
	Rani	11	814	16	16.1	7.4
	Mean	*7–11*	*1528 ± 1157*	*330 ± 572*	*10.04 ± 7.45*	*3.53 ± 3.12*

Higher density and lower basal area suggest that the plantations are younger. Higher basal area in Sadar and Gumti divisions could be attributed to the presence of large trees. The lowest mean basal area was recorded in the plantations of the Trishna forest division with least mean tree density (Table 3).

In 82% cases, the mean density in the JFM area was greater than the unprotected area. The tree density ranging from 74 to 2808 indicates the effectiveness of protection. The density was highest in Karaiyamura (2808) followed by Jeevandeep (1834) and the lowest in Chandra Sadhupara (74) JFMC (Table 3). Jeevandeep was the oldest JFMC with highest basal area (26.1 m^2/ha). In the <7 year old plantations, the mean basal area was 2.5 m^2/ha in JFM area and 3.4 m^2/ha in non-JFM area. In case of >7 year old plantations, the mean basal area was found to be 9.2 m^2/ha in JFM area and 6.1 m^2/ha in non-JFM area. The higher density in Jeevandeep, Karaiyamura, Tepania and Kalshimura are probably a reflection of better protection. But they do suggest that silvicultural operations like thinning have not been carried out.

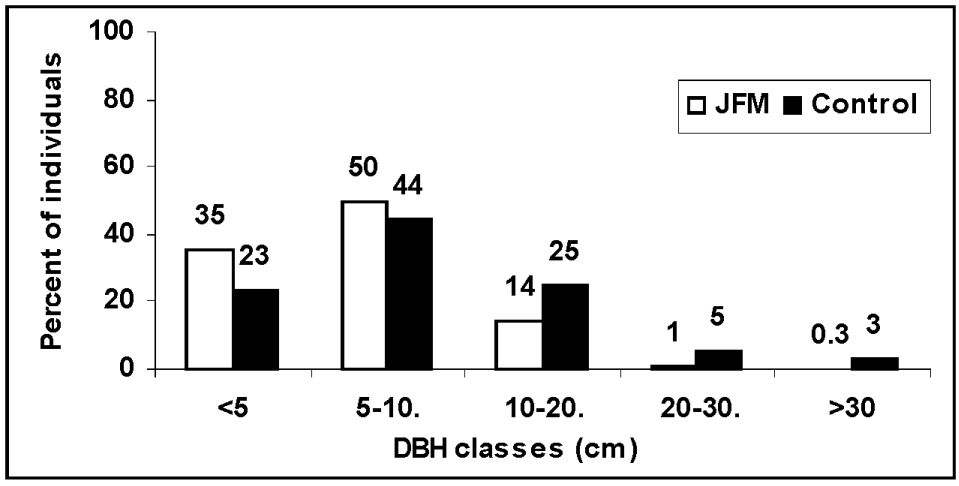
3.3 Distribution of trees according to size

The DBH distribution of trees has been analysed to understand the regeneration status. The sampled JFMCc are categorized into two age range classes- <7 year old plantations and >7 year old plantations. The <7 year old plantations category comprises eight JFMCs in four divisions – Bagafa Division (Killamura, Galacipa, Poangbari and Sakbari JFMCs), Gumti Division (Gobindatilla JFMC), Teliamura Division (Chandra Sadhupara JFMC) and Trishna Division (Bhairabnagar and Siddhinagar JFMCs). The remaining nine JFMCs fall under the >7 year old plantations category. These are: Betaga and Harbatali under Bagafa Division, Kalshimura and Jeevandeep under Sadar division, Khasiamangal under Teliamura division and Karaiyamura, Raiyabari, Rani and Tepania under Udaipur division.

3.3.1 Size class distribution of trees based on DBH

Higher percentage of individuals in <10 cm DBH class were found in JFM protected areas than unprotected areas. JFM areas show lesser number of individuals in higher DBH classes as compared to unprotected areas (Figure 1). The higher number of individuals in lower DBH class in protected areas indicate good regeneration and also the effectiveness of protection.

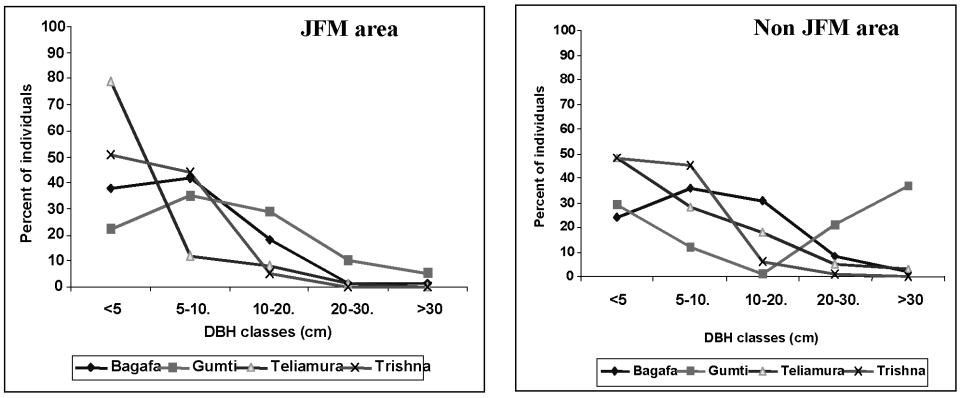
Figure 1 Distribution of individuals in various DBH classes in protected and unprotected areas



3.3.2 Size class distribution of trees and age range

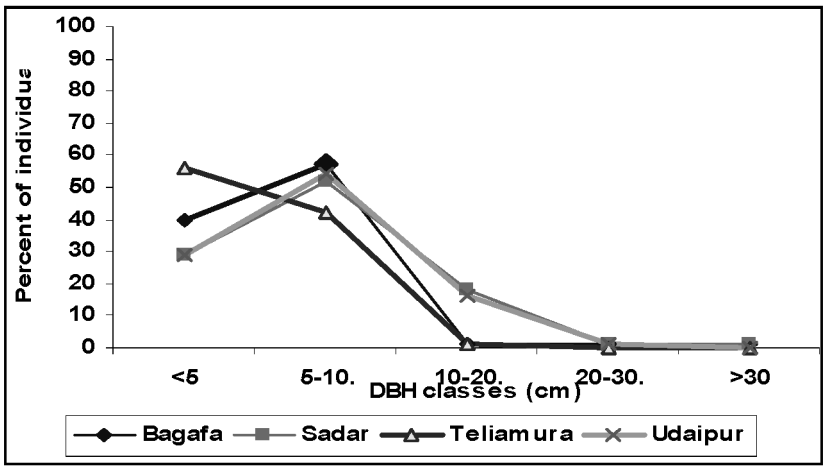
Among <7 year JFM plantations, the Teliamura forest division had the highest number of individuals (79%) in 0–5 cm DBH class followed by Trishna with 51%. In unprotected areas individuals were 48% in both the divisions in the same size class category. JFM areas in Bagafa and Gumti witnessed a higher percentage of individuals in the 5–10 cm class than <5 cm class. Gumti has lesser percentage of individuals in the higher DBH classes in the JFM area as compared to the control plots (Figure 2).

Figure 2 DBH distribution of individuals in the <7 year plantations



In >7 year old plantations, Teliamura had the maximum number of individuals in the <5 cm class (56%) while Sadar and Udaipur had the least (29%). Bagafa recorded 40% of the individuals in this DBH range. Representation of individuals in the >20 cm class and above was insignificant in all divisions (Figure 3), indicating that older plantations had large trees.

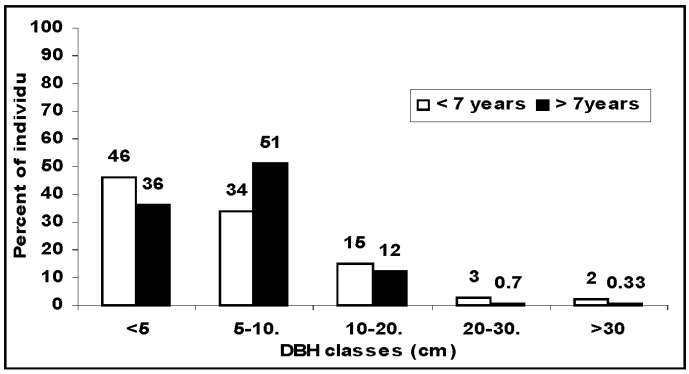
Figure 3 DBH distribution of individuals in the >7 year plantations



Overall, it was observed that younger JFMCs had a comparatively higher number of individuals in lower DBH classes. The percentage of individuals in the 5–10 cm DBH class was highest, accounting for 48% of the total in both young and old JFMCs. A large percent of individuals, accounting for nearly 80% were of smaller DBH class range (<10 cm DBH) in both the categories. This indicates that JFM has helped regeneration of trees and the regenerating trees are being protected.

Among sampled JFMCs, individuals in the higher size classes (>20 cm DBH) were negligible, indicating that the forest patches have regenerated after inception of JFM. The regeneration was evident in young and old plantations alike (Figure 4).

Figure 4 Distribution of individuals (%) of different age range in the DBH classes



In Raiyabari, Rani and Tepania all individuals are of natural origin. In case of Bairabnagar, Betaga, Galacipa, Khasiamangal and Siddhinagar JFMCs all the individuals in the >10 cm DBH are of natural origin. Overall, 62% of the individuals in the <10 cm DBH class are naturally regenerated, while in the >10 cm DBH class, 68% of the individuals are of natural origin (Table 4). Among the divisions, Trishna recorded the highest percent of naturally regenerated individuals in both the categories. In the <10 cm as well as >10 cm DBH category, the percentage of naturally regenerated individuals was found to be more than the planted individuals in 65% of the sampled JFMCs.

Table 4 DBH distribution of species in the JFMCs (percentage of planted and naturally regenerating species) in various JFMCs

Division	*JFMC*	*Age* (*years*)	*<10 cm*			*>10 cm*		
			Total	*NR*(%)	*Pln*(%)	*Total*	*NR*(%)	*Pln*(%)
Bagafa	Killamura	4	161	53	47	29	59	41
	Galacipa	5	96	89	12	22	100	0
	Poangbari	5	206	72	28	19	26	74
	Sakbari	6	188	2	98	95	1	99
	Harbatali	7	150	9	91	8	25	75
	Betaga	8	393	98	2	8	100	0
Gumti	Gobindatilla	4	177	11	89	89	81	19
Sadar	Kalshimura	7	1146	93	7	131	89	11
	Jeevandeep	12	1223	5	95	314	50	50
Teliamura	Chandra Sadhupara	5	162	69	31	16	17	83
	Khasiamangal	7	783	43	57	9	100	0
Trishna	Siddhinagar	4	334	87	13	21	100	0
	Bhairabnagar	5	114	99	1	2	100	0
Udaipur	Karaiyamura	7	1743	17	83	283	11	89
	Tepania	7	908	100	0	320	100	0
	Raiyabari	8	232	100	0	28	100	0
	Rani	11	687	100	0	103	100	0

3.4 Tree species promoted under JFM

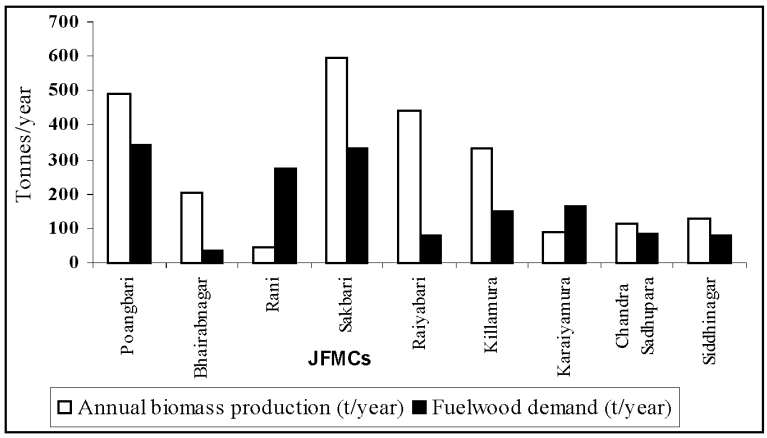
The proportion of the area under JFM to be demarcated for fuelwood, timber and NTFP species depend on the choice of the local communities and the forest department. It was observed that among the timber species *Tectona grandis* and *Shorea robusta* were the dominant ones in both the JFM plantations and unprotected areas. Among NTFP species *Melocanna baccifera*, Mretanga bamboo, *Bambusa vulgaris, Holarrhena antidysenterica* and *Terminalia arjuna* dominate in the JFM area, while in the unprotected areas the dominant NTFP yielding species were *Careya arborea, Syzygium cumini, Emblica officinalis, Odina wodier* and *Phyllanthus officinalis*. Dominant among the fuelwood species were *Cassia siamia, Aporosa roxburghii* and *Acacia auriculiformis* in the JFM area and *Holarrhena antidysentrica* and *Lagerstromea parviflora* in the unprotected area. In JFM area, 63% species were fuelwood, 22% NTFPs and 15% timber species, while in the unprotected area, timber species accounts for 60%, fuelwood species 28% and NTFP species 12% of the total.

Timber species account for about 15% and 60% of the total species in the JFM areas and non-JFM areas respectively. In the JFM areas, timber species accounts for only 22% of the planted individuals while in the non-JFM areas, all the planted species were for timber purpose. Among the planted timber species, *Tectona grandis* accounts for a major share in both JFM as well as non-JFM plantations. It contributes to 58% of the total planted timber species in the JFM and 92% in the non-JFM plantations. In the JFM plantations, *Eucalyptus citrodora* also figures prominently in the planted category accounting for about 31% of the planted individuals. The dominant naturally regenerating timber species in the JFM plantations are: *Shorea robusta* (50%), *Syzygium cumini* (12%) and *Tectona grandis* (8%). *Shorea robusta* (36%), *Tectona grandis* (22%) and *Albizia marginata* (6%) are dominant naturally regenerating timber species in the unprotected areas.

3.5 Fuelwood supply and demand

Mean annual increment of JFM plantations ranged from 1.05 t/ha/yr in Rani to 10.89 t/ha/yr in Sakbari, while in the control it ranged from 0.31 t/ha/yr in Rani to 4.87 t/ha/yr in Sakbari. The average mean annual increment was 4.2 t/ha/yr. Total biomass available from plantations was 2443 t/yr and the estimated fuelwood demand was 1539 t/yr. Considering 50% of the biomass available as the sustainable harvest limit, the biomass production in the JFMC plantations sampled can potentially meet about 79% of the total fuelwood demand of the communities involved in joint forest management. In most of the JFMCs the fuelwood availability scenario is comfortable (Figure 5). Biomass production in JFM area was found to be higher than the demand in 78% of the JFMCs while it was lower in Rani and Karaiyamura JFMCs.

Figure 5 Biomass production vs. fuelwood demand in the JFMCs



4 Discussion

JFM has made a significant impact on the regeneration of vegetation in Tripura. It has resulted in an increase in the density as well as canopy cover of tree (Tiwari, 2004). This was mainly because of an increase in the total forest cover as a result of plantations and the protection of already existing forests after the initiation of JFM, and also because several new economically as well as socially useful species were introduced. Linking of socioeconomic incentives and forest regeneration has been singularly instrumental in eliciting community participation. The institutional involvement in various forest protection and developmental activities has made promising impacts on the biophysical and socioeconomic environment of the JFM areas (Tiwari, 2004). However, there is still ample scope for improvement. Many degraded forest areas of the state do not require high capital investment but only proper protection and aided regeneration. Existing rootstock in degraded sal forest areas, if appropriately protected, would effectively regenerate such areas as seen in the present study. Apart from enhancing natural regeneration, planting fuelwood species on lands incapable of regeneration would help in improving productivity and biodiversity in forests. Identification of quick growing trees with high calorific value and development of fuelwood plantations around centres of high consumption would help meeting the biomass needs of the people and thus conserve natural forests. This would strengthen people's access to forests, and the local people would directly appropriate benefits.

Most JFMCs are too young to show any sign of participatory forest management or adaptive forest management. However in two JFMCs viz. Jeevandeep and Kalshimura people have taken up the responsibility of monitoring and some signs of adaptive forest management are emerging. The present study showed that the biomass availability in the JFM area could meet nearly 80% of the fuelwood demand. However, the gap between demand and supply of fuelwood can be overcome either by reducing demand or by increasing supply. Both the approaches tend to be essentially technology oriented. Installation of improved stoves and other devices has taken place in a few JFMCs in the Bagafa and Udaipur divisions. Switching to other fuels like LPG and developing alternative supply sources can also help in reducing the fuelwood consumption.

In Tripura, *Gmelina arborea* occupies a unique position as a fast growing species with the advantage of its manifold use like timber and furniture making (Chatterjee, 1984). Usually, higher income people may prefer plantation of timber species like teak and sal, while the lower income group generally want fuel wood and fruit bearing trees (Tiwari and Barik, 2004). For quick benefits, long gestation trees should be supplemented with an understorey of bushes and shrubs, which could satisfy the immediate needs. This is already happening as is reflected in the promotion of NTFPs in the JFM areas.

4.1 Promotion of agroforestry, homestead gardens and agriculture development

JFM has created a boom of tree plantation in many parts of Tripura. People have started planting trees in homesteads, as well as community lands. In some JFMCs e.g., Baxanagar people have taken up fisheries inside JFMC protected forests that are providing additional income to the communities. To reduce pressure on the protected forest for fuelwood and other subsistence needs, tree farming on wastelands in 3,647 private holdings was taken up under Angan Ban Prakalpa during 2003–2004 covering an area of 620 hectares. An additional 153 hectares of rubber plantation was raised through the Tripura Forest and Plantation Development Corporation (TFPDC), for rehabilitation of Jhumias. The main objective of NAP is to take up afforestation in forests and adjoining land areas including village common lands, community lands, revenue wastelands, jhum lands and private lands. The state forest department has also taken up a centrally funded project for development of bamboo resources and medicinal plants as a means of livelihood in JFM areas.

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