Paper ID 40

Current conditions of social forests in Teknaf and Shilkhali ranges of Bangladesh

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Abstract

This study discusses the current conditions of social forest (SF) in Teknaf and Shilkhali ranges in 2013, ten years after the first implementation of the SF scheme in Teknaf. Field and interview surveys were carried out from 9 to 17 September 2013 and 4 to 9 March 2014 and normalized difference vegetation index (NDVI) was analysed from the satellite imagery taken in 2010. Correlation matrix was used to describe the relationship between these factors. We found that 70.3% of SFs was with active cutting of the trees until 2013, but in eight *Acacia* spp. SFs, thinning management was delayed from the predicted SF regulations; in 11 SFs, thinning was done properly, and five broad leaved and seven cleared SFs were confirmed. These results were mapped, to show the differences in SFs current conditions as well as the local measurement requirements. The findings would help to conserve the SF in the study area.

INTRODUCTION

The need for forest conservation of Teknaf Peninsula has been emphasised in the past years because of the importance of the forest to the local residents' livelihood and the biodiversity. However, there was intensive forest degradation in the past decades prompting the government to declare this region the Teknaf Wildlife Sanctuary in 2009. The Forest Department (FD) has started Social Forest (SF) plantation of the cleared buffer zone since 2003/04 in Teknaf area. However, the unabated forest degradation continued and current level of deforestation was reported [1].

This study investigates the status of social forests (SFs) and the level of forest destruction in 2013, ten years since the enactment of the SF management regulations in Teknaf. Understanding the factors that caused the differences in SFs current conditions will be beneficial for implementation of appropriate future measurements for a successful regional environmental conservation.

MATERIALS AND METHODS

The state of the SFs in 2013 was evaluated based on three surveys: interviews with forest officers, field surveys, and analysis of satellite imagery.

A. Research site and dates of field studies

Surveys were conducted in Teknaf and Shilkhali ranges after obtaining a research permit from the Forest Department (FD) range officer. Field surveys were carried out from September 9 to 17, 2013 and from March 4 to 9, 2014. The boundary of the visited ranges and beat zones are given in Fig. 1 [2].

B. Interviews

During field surveys, we visited two ranges and seven beat offices and conducted interviews with officers located in all of them. Main questionnaire enquired about the active SFs information: the year it was established, area size, plant species, beneficially number who has contract with FD, each journal of SFs, current conditions, and boundary of SFs. The exact location and boundary of every social forest was determined from the interviews with the FD's beat officer, forest guard, and a headman who helped us trace the boundaries on the satellite images (resolution: 1/10,000) [3]. Afterwards, accompanied with one of them, we visited every social forest and carried out field surveys.

C. Field survey

Field survey was designed to study current conditions in all SFs. Collected data were compared statistically. Due to the remoteness of the sites, it was not possible to establish several survey plots for every SF; therefore, one to three survey plots were carefully selected across different SF current conditions. Each plot area was with 5-m radius. For each plot we recorded: species of the trees, tree diameter at breast height (DBH) for trees with DBH > 5 cm, tree height, canopy cover rate was determined visually, GPS data were recorded (longitude, and latitude), and a hemispherical photograph of the canopy from the eye-sight height and a photo of the plots' scene were taken.

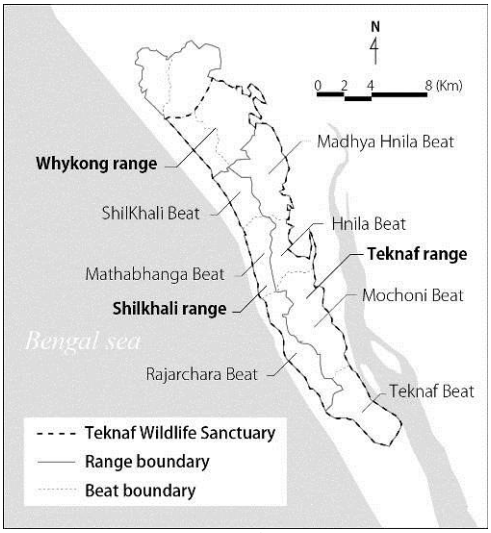

Fig. 1. Teknaf Peninsula

D. Satellite image analysis

The SFs area polygon data were created using GIS software TNTmips, version 2013 (MicroImages Inc., Lincoln, NE, USA) from satellite imagery [3]. Vegetation index was calculated by masking the agricultural field and shading image area for each SF polygon data. The Normalized Difference Vegetation Index (NDVI) was calculated as follows:

NDVI = (NIR – Red)/(NIR + Red),

Where, NIR = 780 - 920 nm; Red = 655 - 690 nm.

From these images, the average NDVI was calculated across the SFs areas and the field survey plots area (5 m radius).

E. Data analysis

To establish the validity of the SFs survey plots data, the correlation between survey data and NDVI average values for SFs area were analysed by correlation matrix. The canopy openness value of trees was analysed from hemispherical photographs using CanopOn 2 v2.03c (CanopOn, 2003; [4]). The SFs current condition was expressed as the rate of canopy cover and the tree density over the years since the establishment of the SFs. To evaluate the SFs current conditions, the current conditions types were determined from

the graph projection of the tree density and the thinning protocol and depicted as a Teknaf SFs current conditions map.

RESULTS AND DISCUSSION

A. Number of social forest and it attribution

Thirty-seven social forests were confirmed in the studied area, of which 28 were located in Teknaf range and nine in Shilkhali range. The majority of SFs was established on the eastern side of Teknaf peninsula. The implementation of the SF legislation started in 2003 by FD. Most of the SFs were designed for short rotation forests (10 years plan for harvest) with planted mainly *Acacia* spp. We collected the journals from each office, 58 from Teknaf range and 13 from in Shilkhali range including state forests and the SFs that were devastated and had the SFs contract terminated. Those forests were excluded from the list in Table 1. The frequency rate of planted species in SF was calculated from the journals and it is given in Table 2 [5]. The FD has planted not only the early growth non-native species, but also native species to increase the bio-diversity in the forest. Several SFs were long-rotation forests (40-year plan for harvest) and re-forestation for wild animal conservation (called "animal feed") was included. However, local people demand the short rotation (SR) plants such as the early growth species *Acacia* spp. As a result, such SFs with SR species were more frequent than others in 2013 (Table 1). Nevertheless, several other species are dominant in SFs as well (Table 1). Hence, the existence of these SFs is an interesting future research question in studying the social aspects and bio-diversity of the SFs.

Table 1. The social forest list of Teknaf range and Shilkhali range, and corresponding plot field data, NDVI values, and the current conditions types

Attribution of Social forest					Plot field data					NDVI				Current condition type
Name of range					Rate of canopy cover					Value of social forest area		Value of plot area (5m radius)		
	The time in years since establishment					Openness of tree canopy								
	Name of beat	Establish year	Area (ha)	(y)	(%)	(%)	Density (the trees/ha)	Total of DBH area (cm^2)	Speicies of the trees	Average	Standard Deviation	Average	Standard Deviation	
Teknaf	Teknaf	2002-2003*	15	10	60.0	32.7	635.7	1290.2	Akashimoni	38.2	12.5	40.0	6.7	II
	Teknaf	2002-2003**	15	10	35.0	53.9			Cane, Chikrashi, Gorjon	41.7	10.7	39.0	5.1	I b
	Teknaf	2003-2004	30	9	0.0				-	39.6	11.2	-	-	III c
	Teknaf	2004-2005	10	8	80.0	17.1	1271.5	3115.8	Akashimoni,Gamar	48.1	11.2	54.8	7.4	I
					75.0	19.7	1398.6	1974.3	Akashimoni,Gamar,Gorjon	-	-	50.4	6.7	
	Teknaf	2005-2006	20	7	0.0					37.2	9.3	-	-	III c
	Teknaf	2005-2006*	20	6	5.0	38.9	1271.5	505.0	Agar, Akashimoni	38.2	10.6	34.5	5.5	II
					15.0	40.7	890.0	995.1	Mangium	-	-	40.0	6.2	
	Teknaf	2006-2007	20	6	70.0	16.4	1017.2	522.3	Teak	36.2	10.8	37.6	4.5	I b
	Teknaf	2007-2008	4	5	95.0				Akashimoni	36.4	8.0	-	-	-
	Teknaf	2011-2012	40	1	0.0				Akashimoni	36.7	10.0	-	-	-
	Mochoni	2003-2004*	30	9	25.0	28.6	635.7	2026.4	Akashimoni	41.9	10.6	23.8	5.0	II
	Mochoni	2003-2004**	30	9	80.0	15.1	762.9	1707.0	Akashimoni	45.1	9.6	48.2	4.6	II
	Mochoni	2004-2005*	20	8	75.0	19.5	1780.0	1473.8	Akashimoni	39.4	11.6	49.3	2.7	I
	Mochoni	2004-2005**	20	8	10.0	51.8	635.7	1519.7	Akashimoni	41.9	10.6	46.3	7.6	II
	Mochoni	2005-2006*	20	7	40.0	31.2	762.9	1359.9	Hybrid Mangium	42.5	10.6	48.4	9.9	II
	Middle Hnila	2003-2004*	20	8	35.0	28.4	1652.9	1699.5	Akashimoni	37.9	11.4	50.4	4.6	I
	Middle Hnila	2003-2004**	20	9	60.0	24.9	1017.2	1713.1	Hybrid	43.8	11.1	53.4	6.7	I
					80.0	29.9	890.0	2465.7	Sil-koroi, Bohera,	-	-	56.5	4.3	
	Middle Hnila	2003-2004*	5	9	5.0	71.3	254.3	2696.7	Gamari, Cane	34.4	11.0	32.7	5.8	I b
	Middle Hnila	2003-2004**	5	9	30.0	30.0			Bamboo	40.1	9.9	38.1	3.8	I b
	Middle Hnila	2004-2005	20	8	40.0	32.2	1398.6	1377.4	Akashimoni	33.5	10.6	47.3	4.3	I
	Middle Hnila	2005-2006	10	7	45.0	28.1	2034.3	1582.3	Akashimoni	42.8	10.8	52.8	3.9	I
					40.0	37.9	1398.6	1492.9	Akashimoni	-	-	-	-	
	Middle Hnila	2007-2008*	15	5	15.0	47.7	1271.5	628.9	Akashimoni	34.3	9.6	43.1	3.1	II
	Middle Hnila	2007-2008**	15	5	0.0					36.0	9.5	-	-	III c
	Middle Hnila	2007-2008	25	5	40.0	36.7	1398.6	772.3	Akashimoni	34.7	9.4	34.1	4.2	II
	Hnila	2002-2003*	10	10	25.0	35.2	890.0	1096.9	Akashimoni	39.8	11.8	45.8	5.3	II
	Hnila	2002-2003**	10	10	35.0	24.9	635.7	1558.9	Akashimoni	44.6	11.1	46.0	4.3	II
	Hnila	2004-2005	30	8	60.0	18.8	635.7	850.9	Akashimoni	40.9	11.9	42.6	5.3	II
	Hnila	2005-2006	40	7	35.0	31.3	1017.2	844.1	Akashimoni	38.8	11.5	49.3	3.6	II
	Hnila	2012-2013	30	0	0.0					-	-	-	-	-
Shilkhali	Rajar chora	2005-2006	20	7	35.0	31.7	890.0	1269.8	Akashimoni	41.1	13.2	52.8	7.6	II
	Rajar chora	2004-2005	10	8	85.0	21.6	890.0	2097.4	Sil-koroi	42.0	13.3	50.0	4.6	I b
					85.0	19.2	635.7	689.2	Gamari	-	-	43.3	7.9	I b
					30.0	26.0	1144.3	1238.8	Akashimoni	-	-	49.9	7.0	II
	Mathabanga	2003-2004	20	9	85.0	15.2	1017.2	1671.1	Gamari	38.7	12.2	51.7	4.2	I
					85.0	16.2	1144.3	1471.7	Akashimoni	-	-	50.1	3.4	
	Mathabanga	2005-2006	20	7	75.0	14.2	2034.3	2084.2	Akashimoni	41.0	14.3	37.5	9.0	I
	Mathabanga	2011-2012	15	1	0.0					30.2	11.9	-	-	-
	Shilkhali	2003-2004	50	9	0.0					45.4	12.2	-	-	III c
	Shilkhali	2004-2005	20	8	0.0					39.7	12.6	-	-	III c
	Shilkhali	2005-2006	60	7	0.0				Akashimoni	32.1	11.1	-	-	III c
	Shilkhali	2007-2008	25	5	0.0					34.1	9.8	-	-	III c

*, **: This mark was assigned for indetify the social forest of those same establish year and area size.

Table 2. Frequency rate of planted species based on data extracted from the journals of social forests made by the Forest Department Teknaf and Shilkhali range offices

Bengal name	Scientific name	(%)
Gamar	*Gmelina arborea*	67
Akashmoni and Belgium	*Acacia auriculiformis and Acacia mangium*	65
Hybrid akashmoni	*Acacia hybrid*	63
Mehogoni	*Swietenia mahagoni*	49
Bohera	*Terminalia bellirica*	44
Koroi	*Albizia* spp.	42
Amlaki	*Phyllanthus emblica*	42
Arjun	*Terminalia arjuna*	37
Haritoki	*Terminalia chebula*	23
Garjan	*Dipterocarpus* sp.	14
Neem	*Azadirachta indica and Melia azadirachta*	14

Other planted species: Shegun, Rain tree, Cane (Bet), Chikrashi, Jarul, Sal, Telsur, Jam, Bamboo, Bakain, Boilan, Kadam, Dhakkijam, Kainjal, Bahdi, Chambaful, Shisso, Khanta kari, Kawfol, Chalta, Accasia, jolpai, Tetul, Domor, Jack fruts, Epel epel, Banana, Shimul, Koshoi, Chapalish, Supari, Baut

B. Correlation analysis between variables: the time in years since SFs establishment, field survey data, and satellite image NDVI

Correlation matrix is shown in Table 3. Several results are explained as follows.

i. Effectiveness of the statistical analysis using field survey data from 2013 and satellite imagery from 2010.

There was a strong correlation between the rate of canopy cover and NDVI canopy cover (0.462, $p < 0.05$). Although there is a three years difference between the time of the field survey and the time satellite images were taken, the correlation matrix analysis is useful. During three years, there were the canopy closures from thinning years or canopy openness by thinning operation. However, these variable overall had a correlation that indicate canopy open-close and plant remaining status.

ii. Social forest contribution for re-forestation

There was a strong correlation between the time in years since the SFs establishment and the total of DBH area (0.476, $p < 0.05\%$) and the NDVI average of SF area (0.580, $p < 0.05$). It is clear that vegetation has increased by the SFs establishment activities in planted areas. There was correlation between the NDVI average of SFs and the rate of canopy cover (0.363, $p < 0.01$) as well as the openness of tree canopy (-0.440, $p < 0.01$).

iii. Effectiveness of the value for rate of canopy cover measured visually.

There was a strong correlation between the rate of canopy cover and the openness of tree canopy (-0.795, $p < 0.05$). These results suggest that the variable of the rate of canopy cover measured visually is useful on this study.

C. The rate of canopy cover in 2013

The rate of canopy cover in 2013 and the time in years since SF establishment are shown in Fig. 2. The data were categorized into three groups based on the canopy cover rate of 20% and 50% as thresholds. This graph shows that 11 SFs had the canopy cover rate at more than 50%. The remaining 26 SFs had less than 50% of canopy coverage. Hence, thinning activities are happening in these SFs. It was revealed that in 70.3% of SFs active tree cutting occurred until 2013. As a result, SFs differ in current conditions.

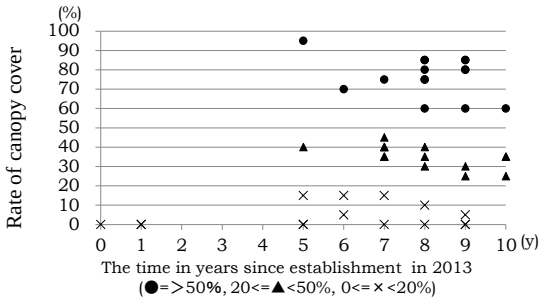

Fig. 2. The canopy covers and the time in years since SF establishment until 2013.

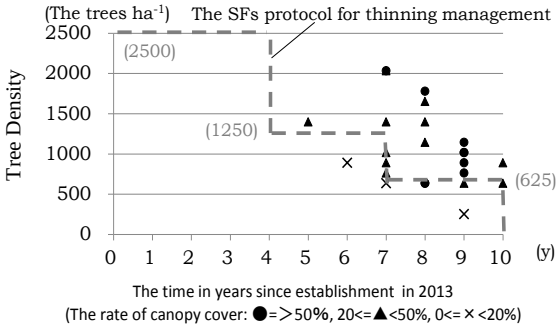

Fig. 3. Tree density and the time in years since social forest establishment of *Acacia* spp. forest.

D. Current condition types in 2013

The tree density graph is shown in Fig. 3. The SF regulations require to plant 2500 trees ha^{-1} of land area. After the year 4 since the establishment of the SF area, 50% of the trees will be thinned out (1st thinning; 1250 trees ha^{-1} will remain); after the year 7, again 50% of the remaining trees will be thinned out (2nd thinning; 625 trees ha^{-1} will remain). Finally, after the year 10 of the short rotation cycle the remaining 625 trees ha^{-1} will be harvested.

To determine current condition differences between SFs, the following current condition types were adopted for each SF [Table 1] using the density factor [Fig. 3].

Condition I: Tree density higher than the predicted SF protocol.

Condition II: Tree density mostly the same with the predicted SF protocol.

Condition IIIc: SF cleared before the predicted harvesting year.

Condition Ib: SF planted broad leaved or bamboo species and not cleared yet.

Following the above classification, in terms of *Acacia* spp. forest, eight SFs were with condition I and with delayed thinning operation. Fourteen SFs were with condition II. These were the SFs that may thin out by beneficial actions or for some other reasons. Five SFs belonged to condition Ib type, with broadleaved and bamboo forests. Finally, seven SFs were with condition IIIc.

Table 3. Correlation matrix between variables: the time in years since SFs establishment; plots of field data in 2013 and NDVI in 2010

		Ⅰ	Ⅱ	Ⅲ	Ⅳ	Ⅴ	Ⅵ	Ⅶ
Ⅰ	The time in years since establishment	-						
Ⅱ	The rate of canopy cover (%)	0.363 *	-					
Ⅲ	Openness of tree canopy	-0.079	-0.795 **	-				
Ⅳ	Tree density (the trees ha^{-1})	-0.384 *	0.153	-0.267	-			
Ⅴ	Total of DBH area (cm^2)	0.476 **	0.267	-0.024	-0.002	-		
Ⅵ	NDVI average of social forest	0.580 **	0.363 *	-0.440 *	0.031	0.421 *	-	
Ⅶ	NDVI average of survey plot	0.151	0.462 **	-0.391 *	0.260	0.241	0.410 *	-
	Test uncorrelated mother correlation coefficient (**: $p < 0.01\%$, *: $p < 0.05\%$)							

Fig. 5 indicates the differences in management condition types between each range and beat. In Teknaf range, condition I and II were with mix distribution. The condition II varied from SFs with managed 1st or 2nd thinning. Some SFs was permitted by FD but the other would not permit. In such SFs, distracted activities may happen. In the Teknaf beat zone, the condition III SFs were located around Teknaf town. In the Shilkhali range, Rajarchara beat zone, we found only two SFs. The area and number of SFs for this zone is rather small for the size of the beat area. In the Mathabhanga beat zone, three SFs were found, all belonging to the condition I type. This suggests that this zone has a better management practice. In contrast, the Shilkhali beat zone included only the condition III type SFs. Therefore, this area has the worst management practices. The mapping of these conditions is helpful in identifying the risk level for deforestation and the need for local restoration.

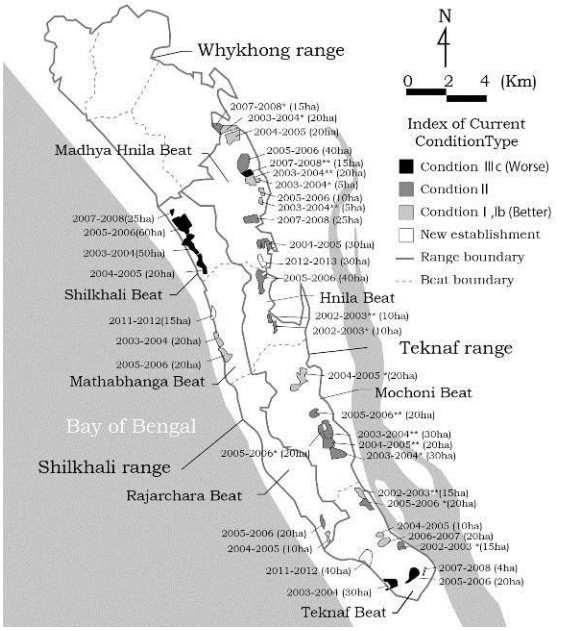

Fig. 5. Social forest current conditions map of Teknaf and Shilkhali range in 2013.
(The boundary of Madhya Hnila and Hnila beat as given here differs from that presented by IPAC)

E. Future studies

Based on the discussion with FD officials and local stakeholders, we got some ideas of future study for better forest conservation.

i. Common issue: Many articles and studies discuss the causes of forest devastation in this area. It was pointed out [1] that illegal collection of resources, scarce patrolling due to lack of logistical support and the working staff members' shortage. During the interviews conducted with the FD officers, some of them pointed out that "beneficial and local people has not been felt success of harvesting time" until 2013. Because of the harvest will starts from 2014. The beneficial or other people conducted thinning and remove the trees before the year the harvest. Another reason for devastation included political changes during the 2009 elections. These political background effects created local conflicts during which some SFs were devastated and some were burned, whereas some SFs remained in good management conditions. Additionally, Forest Department documentation procedure delayed un-cleared ownership of SFs causing some fragile situations in the management.

ii. Local issue: Western side of Teknaf peninsula has several local reasons that altered the management protocol for SFs. One of them is the occupational reason that the local people are working on the betel leaf cultivation or fisheries, which brings higher income, is preferred by local people. Beat officer in Rajarchara claimed water shortage for growing seedlings. Topographically, water catchment is small and water supply from stream and wells is not enough. Shilkhali range and beat officers claimed shortage of staff for the inability to prevent thief activities in their SFs. The thieves arrive not only by inner beat area, but from the east side of Teknaf peninsula. Shilkhali beat management condition is the worst in this study area [Fig. 5].

The differences in SFs current conditions by beat areas presented in this study can be utilized in future studies of these issues. It is considered that those differences may come from social, political, topographical, and ecological differences. It is important to study forest conservation in cooperation with other researchers and apply the resulting measures locally. Currently, co-management approach has been conducted by several NGOs working to promote social forestry, such as The Nishorgo Support Project (NSP) [2]. It also pointed out that a traditional community-based forest management practices by indigenous people may be a useful guide for policymakers looking for ways to support sustainable forest management that involves local people. As mentioned, more traditional and local way of forestry has to strive to establish local forest for local people [6].

CONCLUSION

In Teknaf and Shilkhali range of Teknaf peninsula, we confirmed 37 social forests as active management forests in 2013 after 10 years from the social forest scheme started in 2003 in this area. However, these current conditions are different for each social forest: 70.3% of SFs had actively cut the trees until the year 2013, but in eight *Acacia* spp. SFs the thinning management was delayed, 11 were thinned out properly, and five broad leaved SFs and seven cleared SFs were confirmed. Additionally, this paper discussed the background of the local differences in current conditions. Based on the findings, the FD and policy makers may make strategy to sustain the productivity and conserve the SF in the degraded Teknaf forest area.

ACKNOWLEDGEMENT

This study was supported by JSPS KAKENHI Grant #24401040. The authors are grateful to Dr. M. Zulfikar Rahman, Dr. Abu Zofar Md. Moslehuddin, and Dr. Kazi Kamrul Islam of Bangladesh Agricultural University; and Mr. Mohammed Delwar Hossain for kind help in data collection. Forest Department range officers and other beat officers and staffs are thanked for kind help in providing information and conducting field surveys. Last, I extend deep sympathy to Mr. Foyjur Rahman who was the headman of Teknaf until April 2014.

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