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RESEARCH PAPER

Village Common Forest Management in Komolchori, Chittagong Hill Tracts, Bangladesh: An Example of Community Based Natural Resources Management

Md. Arif Chowdhury, et al. ***[full author details at the end of the article]***

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Abstract

Chittagong Hill Tracts (CHTs) in Bangladesh covers about 50% of the country's natural forest resources, providing sources of food, fuel-wood, medicinal plants, timber and water supply to the ethnic communities living in the area. The ethnic communities in CHTs have been managing a small patch of forest known as a village common forest (VCF) adjacent to their village following a community based forest management approach. Taking a case study of Komolchori VCF, this study examined dependency of community people on VCF resources, their conservation-related attitudes and awareness, indigenous management, and forest phyto-sociological structure. A survey and focus group discussions were conducted among the settlers and non-settlers in Thana Chandra para and Jaduram para villages of the Komolchori VCF. Key informant interviews were conducted with two non-government organizations (NGOs) and the headman in the study area. To assess phyto-sociological structure of vegetation, 25 quadrats (10 m × 10 m) were laid out randomly. Results revealed that non-settlers were more inclined towards VCF conservation and women played a crucial role as they were directly involved in forest products and water collection. Soil erosion caused by shifting cultivation has made community people more aware of forest degradation. Training program provided by NGOs on different horticultural techniques and a "Saving-Credit program" improved livelihood conditions and reduced pressures on VCF resources. Locally devised traditional rules guide the community people to manage the VCF sustainably. The vegetation survey showed that the density of Komolchori VCF was 1420 trees/ha with a basal area of 27.98 m^2/ha. The Shannon–Weiner index, species diversity index and index of dominance in the study area were 2.91, 0.62, 0.09, respectively.

Keywords Ethnic communities · Community based forest management · Village common forest · Natural resources management · Biodiversity conservation

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Introduction

In Bangladesh about 17.5% of the land area (equivalent to 2.53 million ha) is forest land, of which 1.53 million ha are managed by the forest department (Arannayak Foundation 2018). Of the forests managed under the forest department, about 50% of the total natural forests are located in the Chittagong Hill Tracts (CHTs). The CHTs are located in the south-eastern part of Bangladesh and is home to at least 11 ethnic communities (UNPO 2018). It is characterized by the hilly topography (Baten et al. 2010). Traditionally, ethnic people have some customary rights to use forest produces. Their culture, lifestyle and livelihood are mostly related to forests and forest resources.

During and after the British colonial period, four-fifth of the forest land in the CHTs was declared as reserved forests which restricted the access by ethnic communities (Roy 2002). Since then the local ethnic communities planned to conserve their scarce forest resources following their traditional resource management approaches which is termed Mouza Reserves or village common forests (VCFs). The VCFs are considered a common property resource where local ethnic communities have open access to support various dimensions of livelihood, e.g. food, fuel wood, water, medicines, etc. Sometimes they can also sell some of the forest produces, usually bamboo and less occasionally timber to meet community needs for school and temple construction, and for emergency medical expenses (Baten et al. 2010). Every VCF is managed by a local forest user group (FUG) under traditional rules. If anybody breaks the law, offenders are brought under punishment by the local community. This is the reason why the ethnic people in the CHTs have been able to manage the VCF sustainably for at least 200 years while public forests have been seriously degraded (Nath et al. 2016).

However, due to population pressure, geographical constraints, primitive and traditional agricultural practices, lack of cultivable land and alternative income sources, the VCFs are now being overexploited. Presently, it has become a major challenge to ensure the sustainable use of land and reduce forest degradation simultaneously.

Having the aforesaid context, Proshika (an NGO) under its social forestry program has been working closely with the ethnic communities of Khagrachari to conserve the community forest reserves (known as the Komolchori VCF) through a project entitled 'Conservation and Restoration of Biodiversity of Village Common Forest in Khagrachari' (CRBVCFK) with financial assistance from the Arannayk Foundation since August, 2011. The objectives of this project are manifold including (1) to conserve and restore VCF for improving floral and faunal biodiversity; (2) to increase water yield; (3) to improve institutional and technical capacity of the community for VCF management; (4) to promote alternative income generating activities in the communities to reduce their dependency on forest resources; and (5) to create awareness about the benefits of VCF conservation and biodiversity (Arannayak Foundation 2018).

This study was carried out in Komolchori village common forest (VCF) with the following objectives:

- To understand the dependency of community people on VCF resources,
- To explore their conservation-related attitudes and awareness, and indigenous management, and
- To assess the forest phyto-sociological structure of the VCF vegetation.

It was expected that this study will enrich our understanding of community based forest management (CBFM) practices in the VCF of CHTs for natural resources management at local and regional level.

Review of Existing Literature

Historically, forests in Bangladesh have been managed following a top-down approach which failed to gain the trust of local people, resulting in a conflicts of interest between local communities and the forestry department (Nath and Inoue 2010). Due to conflicts, the forestry department, in most cases, was unsuccessful in conserving forest resources. The failure of state-led management systems gave rise to participatory management or community based resource management where local communities are included as stakeholders (Nath and Inoue 2010).

Community-based natural resource management is an emerging model of successful natural resource management which has been performing well for the past 30 years. The primary reasons for its success are its ability to address both social justice and environmental protection issues (Agrawal and Gibson 1999; Gauld 2000; Gruber 2010). Centralized or traditional management systems lack a sense of ownership over forest resources and follows the top-down approach which often results in illegal felling and forest encroachment (Jashimuddin and Inoue 2012). Moreover, centrally made plans were often subjected to faulty designs, inefficiencies, and corruption (Agrawal and Gibson 1999). The development of community-based resource management has led to devolution of forest management from centralized government control to local user groups (Adhikari et al. 2004). Although the shift from state management to co-management is a step in the right direction, it has been observed that participants remain active only as long as they are supported by development programs.

People living in and around forest areas, especially in developing countries, are largely dependent on the forests for their livelihoods. The needs and behaviors towards the conservation of the resources needs to be considered as it could jeopardize the long-term sustainability of it (Chowdhury et al. 2014). Local peoples' attitude shape the nature of common resource pools; positive attitudes enhance it whereas the opposite is also true (Mukul and Rashid 2012). Some researchers have shown that the behavioral changes in targeted community populations may alter the expected outcome of natural resources conservation initiatives (Mukul et al. 2010; Mukul and Rashid 2012; Meijaard et al. 2013). So, the conservation project planners include the training component as it could help the community people to enhance their capacity along with reshaping their ideas (Miah and Ahmed 2014).

Demographic factors like age, gender, occupation, and ethnicity status are widely used as a means of understanding attitudes towards the management of the village

commons (Mukul et al. 2010; Allendorf et al. 2014; Nath et al. 2016). The perception of the community people towards the condition of the natural resources of an area is crucial for the sustainable management as they are the key stakeholders of it (Lynam et al. 2007).

Over the past 40 years, community-based forestry (CBF) has drawn attention as a top-down management systems. It is estimated (as of 2016) that, almost one-third of the world's forest area is under some form of CBF management (Gilmour 2016). Most of the developing countries of Africa, East Asia and South Asia have already adopted some sort of CBF.

According to the classification of the Food and Agricultural Organization (FAO), CBF can be—delegated (e.g., participatory conservation), shared (e.g., joint forest management), partly devolved (e.g., community forest with limited devolution), fully devolved (e.g., community forestry with substantial devolution) or owned (e.g., private forest ownership) (Gilmour 2016). As the structure of CBF differs a lot with region, management system and local community, it is difficult to scale up and compare one with another. In addition, reliable data on CBF effectiveness at regional and global scales are limited, which hinders informed decision-making as well as the progress of CBF in general (Gilmour 2016).

From several studies in African (Tanzania, Mozambique, Cameroon, Madagascar) and East Asia (Laos, Vietnam, Philippines), it has been evident that people become motivated to manage and conserve nature, only when they could legally secure long-term benefits, both monetary and non-monetary, from forest resources (Mustalahti 2009). It has also been shown that well managed forests often contribute towards household income and thus conservation and household needs can be fulfilled simultaneously (Gosling et al. 2017). In addition, ensuring local carbon payment mechanisms (Lescuyer 2013) and determining appropriate management regimes are good ways to get local people more interested in CBFM because applying only CBFM cannot guarantee sustainability (Rasolofoson et al. 2015). In addition, policy makers should devolve some issuance of resource use permits to the local Department of Environment and Natural Resources offices so that they can share the incentives with forest-dependent populations which will enhance the sustainability of forest resources (Hashiguchi et al. 2016).

Based on a review of the literature, CBFM has been found to be fruitful in Nepal (Gurung et al. 2013). Apart from the environmental services, CBFM improves forest conditions and increases the availability of forest products to the local users thereby improving their livelihoods. Similar scenarios were also found in the Himalayan region of Pakistan. From that study, it was evident that the participation in a forest-based livelihood, had a positive impact on household income (Ali and Rahut 2018). Apart from the direct income from forest resources, CBFM can be a great source of income for the local community by adopting carbon payment mechanism of REDD + (reduced emission from deforestation and forest degradation) (Poffenberger 2015).

In the context of Bangladesh, CBFM has been adopted in different forest types, e.g., the Sal forests (deciduous *Dipterocarps* forest) (Safa 2004), the Sundarbans Mangrove forests (Safa 2004), the Hill forests in CHTs (Misbahuzzaman and Smith-Hall 2015). Among these case studies of CBFM in Bangladesh, Misbahuzzaman

and Smith-Hall (2015) only discussed the VCFs. From that study, it is evident that due to extensive use of forest resources, tribal people have transitioned to agricultural practices. The contribution of agricultural income was found to be much higher (77%) than that of all forest-related income (12%) in average household of the tribal community. Other case studies in Bangladesh showed flaws of existing policies (Roy and Gow 2015; Chowdhury et al. 2014; Rahman and Giessen 2014) and needs for policy interventions (Giessen et al. 2016).

The detailed literature review along with the major findings can be found in Appendix 1 of the Supplemental Materials. It is evident that only a few articles discuss the common issues in VCF management, (e.g., Misbahuzzaman et al. 2008; Misbahuzzaman and Smith-Hall 2015; Baten et al. 2010). That is why this study could be a benchmark for the knowledge base regarding VCF management in Bangladesh.

Methodology

Study Area

The study was conducted in Komolchori VCF (locally called reserve) in Buarchari Mouza (Mouza no- 264), Khagrachari Sadar, Bangladesh from June 2014 to December 2015. The area of this VCF is 127.88 ha and is managed by the local ethnic communities living in Komolchori para (village) located about 5 km away from the VCF. The managers of the VCF are considered co-management agents due to their inheritance of the VCF. These people have a well-developed sense of responsibility for the conservation of the forest for their needs and survival. Inhabitants of Komolchori, Thana Chandra para and Jaduram para village collect forests produces such as bamboo, timber, medicinal plants, and cane from the Komolchori VCF for their livelihoods. People of these villages are poor and only a small portion of them work (e.g., auto rickshaw driver) outside the communities. The nearest city is far away and so they cannot go there easily for alternative income opportunities.

Household Survey

Household surveys were conducted to collect information on livelihood, dependency on VCF resources, knowledge of available forest resources, attitudes towards VCF conservation and indigenous management practices. A pre-tested semi-structured questionnaire was used. In the study area, we found two groups of people: settlers and non-settlers. VCF management committee rehabilitated 11 landless ethnic families around the VCF. They are known as the settlers. On the other hand, the non-settlers are the inhabitants who are living in areas surrounding the VCF for a long time. We interviewed both groups to find out whether they act in similar manners in terms of conservation of the VCF. The total number of households in Komolchori, Thana Chandra para and Jaduram para were about 300, 120 and 120, respectively. We found 11 settler households in the Komolchori village and

all of them were surveyed. In addition, individual surveys were conducted with 30 (10% sampling intensity) randomly selected families from Komolchori village and 30 randomly selected families (25% sampling intensity) from the Thana Chandra para and Jaduram para. Three focus group discussions (FGDs) were conducted in Komolchori, Thana Chandra para and Jaduram para in order to know about vulnerabilities, the potential to engage with alternative income sources, availability of forest resources, and rules and institutional arrangement for VCF management. In each FGD, ten respondents, including male and female respondents participated. Three key informant interviews (KIIs) were also conducted with the Headman (Head of the ethnic community) of the Komolchori VCF and two officers of NGOs (Arranayk foundation and Proshika) using a semi-structured questionnaire. Key informants were selected purposively considering the fact that they were engaged with Komolchori VCF management.

Forest Survey

In order to assess the phyto-sociological structure of forest vegetation, a forest survey was conducted in the Komolchori VCF. A total of 25 quadrats (Fig. 1) of 10 m × 10 m were randomly located. In each quadrat, species of trees and diameters at breast height (dbh) were recorded. The common and scientific names of the

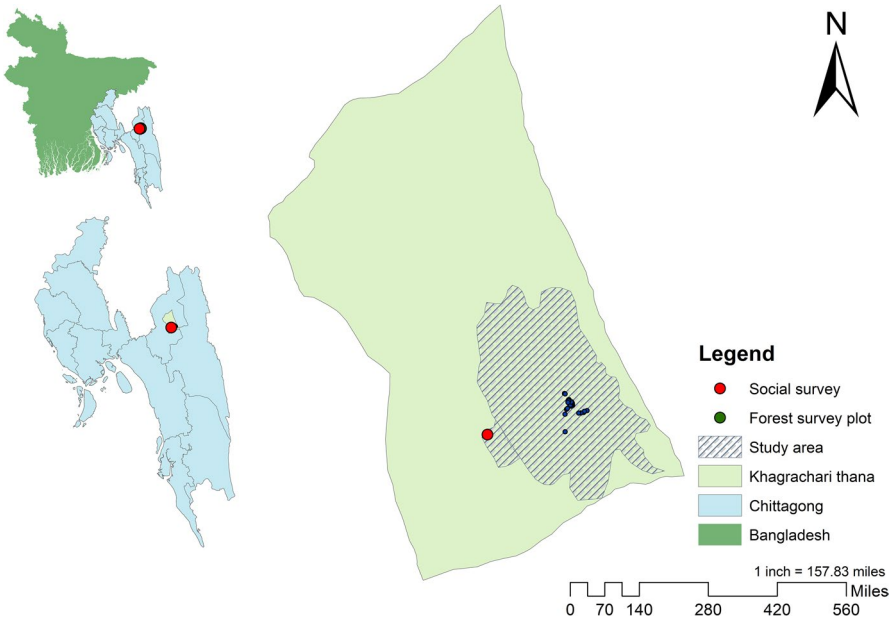

Fig. 1 Location of forest survey and social survey in Komolchori, Khagrachari (Study area)

species were determined by consulting local people, forestry officials, and taxonomists. The biodiversity indices and phyto-sociological parameters considered for this study were: (a) basal area; (b) density; (c) Shannon–Weiner diversity index; (d) species diversity index; and (e) index of dominance (Table 1).

Data Analysis

Household Data Analysis

The study area comprises people who have been living in the area for a long time as well as others who were settled for rehabilitation. This ethnic diversification might be a crucial factor to examine their perceptions towards forest management or conservation. Otherwise, whatever policy is adopted without considering this fact may be inadequate. In order to justify this concept, we hypothesized that the perception regarding the status of VCF is independent of the other factors.

The dataset used in this study, consists of 12 variables of which only one, age, was continuous and. The variables in the dataset were age, profession, village, status of ethnicity (soe), training on biodiversity (tob), perception regarding the village common forest (prvcf), perception regarding soil quality (prsq), perception regarding water resources (prwr), perception regarding biodiversity (prb), necessity to conserve forests (ntcf), and willingness to conserve forest (wtcf). Perceptions regarding the status of the village common forest was the targeted response variable. Since the outcome variable is categorical (improving or not), we used a Generalized Linear Model (GLM) with a binary family link function (Rahman et al. 2017). But first we tested the multi-collinearity and auto-correlations in the dataset. We used the Durbin–Watson (DW) test for auto-correlation and Variable Inflation Factors (VIF) for

Table 1 Specification of biodiversity indices in the Komolchori VCF

Attributes	Definitions	References
Basal area (BA)	$BA = \frac{\pi}{4} \times (dbh)^2$	Chaturvedi and Khanna (1982)
Basal area per hectare (BA/ha)	$BA/ha = \frac{\sum BA}{Area\ of\ all\ quadrats} \times 10,000$	Shukla and Chandel (1980)
Density (D)	D = (Total no. of individual of a species in all quadrats/total no. of quadrats)	Shukla and Chandel (1980)
Shannon–Weiner diversity index (H)	$H = -\sum_{i=1}^{n} P_i (\ln P_i)$	Michael (1984)
Species diversity index (SDI)	$SDI = \sum_{i=1}^{s} \log (ni/N)/\log(1/S)$	Singh et al. (1993)
Index of dominance (ID)	$ID = \sum_{i=1}^{s} (ni/N)^2$	Colwell (2009)

dbh = diameter at breast height; Pi = No. of individuals of one species/total no. of all individuals in the sample; ni = the number of individual of each species, N = total number of trees of all species, S = total number of species

multi-collinearity diagnostics (Islam et al. 2018). The binomial family of GLM used in this analysis is:

$$\log\left(\frac{P_i}{1-P_i}\right) = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_i x_i \quad (1)$$

$$P(x) = \frac{e^{\alpha+\beta_1 x_1+\beta_2 x_2+\cdots+\beta_i x_i}}{1+e^{\alpha+\beta_1 x_1+\beta_2 x_2+\cdots+\beta_i x_i}} \quad (2)$$

The GLM has three components; (a) a dependent/response variable (categorical in this case), (b) the predictor/independent variable(s), and (c) a link function that link both (a) and (b). In the above equations, P(x) is the probability of the response variable (probability of perception of a respondent whether it is improved or decreased), β_i are the regression co-efficient of the predictor variable. The exponential of the regression co-efficient (odds ratio) determines whether a predictor variable is correlated with others (Islam et al. 2018).

Forest Survey Data Analysis

The collected field data was compiled and analyzed to calculate the basal area, density, Shannon–Weiner diversity index, Species diversity index and index of dominance using methods and equations shown in Table 1.

Results

Peoples' Perceptions Towards VCF Conservation

The results of the multi-collinearity and auto-correlation are shown in Table 2. The Durbin–Watson value is 1.66 (close to 2) with a *p* value of less than 0.05 in. So, it can be inferred that there was no auto-correlation in our dataset. Since, there were no VIF values greater than five in the dataset, it can be concluded that there were no multi-collinearity problems (Table 2).

Out of the nine predictor variables in the GLM, three were found to be statistically significant (Table 3). Only for these three predictor variables, the null hypothesis is rejected and it can be inferred that the perception varies depending upon gender, profession and ethnicity.

Being male implies that the log odds of the perception regarding VCF changes by −6.28 over the female (Table 3). Having an occupation as a housewife versus a day labor changes the log odds of the perception regarding the status of VCF by −5.19. The log odds of the perception of a settler about the VCF changes by 2.67 than that of a non-settler.

Although the profession was statistically significant in the GLM, considering the overall effect to the model, it was insignificant (based on Wald test) (*p* value greater than 0.05). The Chi square test statistic of 7.2, with 1 degree of freedom

Table 2 Multi-collinearity and auto-correlation diagnostic statistics for the perception of respondents about the Komolchori VCF

Variable	*df* (degrees of freedom)	VIF	Durbin–Watson value	
Gender	1	3.84	DW	*p* value
Age	1	1.72	1.66	0.02467
Profession	5	1.47		
Village	2	1.26		
Soe	1	1.57		
Tob	1	1.51		
Prsq	2	1.40		
Prwr	2	1.34		
Prb	2	1.29		
Ntcf	1	1.57		
Wtcf	1	1.23		

The outcome variable is *prvcf* perception regarding VCF; and others are predictors, *soe* settler or ethnic, *tob* training on biodiversity, *prsq* perception regarding soil quality, *prwr* perception regarding water resources, *prb* perception regarding biodiversity, *ntcf* necessary to conserve forest, *wtcf* willingness to conserve forest

is associated with a *p* value of 0.007 indicates that the overall effect of gender was statistically significant (Table 4). In case of status of ethnicity of the respondents, it was also same as the variable gender.

Model Accuracy

The Chi square value of 29.86 with 19 degrees of freedom and an associated *p* value of 0.05 tells us that our model as a whole fits significantly better than an empty model (Table 5). We also used the McFadden pseudo R^2 to evaluate the model strength.

The McFadden R^2 value is greater than 0.2 (Table 6). So, it can be inferred that the model is strong enough to predict the perception of the status of the VCF.

Capacity Enhancement Through Alternative Income Generation (AIG)

The average monthly cash income of the respondents was 9028.82 BDT (1 USD = 80 BDT) and ranged from about 583–71,666 BDT per month. Most of the people in the study area were surviving with minimum expenses but a sudden disaster or shortages of natural resources could easily hinder their normal way of living (Source: FGD). Local people were trying to adapt themselves in different types of professions or sources of income without hampering the natural resources of Komolchori VCF. Non-governmental organizations (NGOs), for example, were providing training on different approaches e.g. mushroom cultivation, tailoring, horticulture, awareness on biodiversity conservation (through involving people in different types of training for example, carbon sequestration work of REDD + program to increase the use

Table 3 Result of the generalized linear model of the perception of respondents about the Komolchori VCF

Variable	Parameter estimates	Std. error	z-value	Pr(>|z|)	e^{β}
Intercept	3.60	4.03	0.89	0.37	36.60
genderMale	−6.28	2.34	−2.68	0.007**	0.00**
Age	−0.05	0.05	−1.01	0.31	0.95
professionFarmer	0.34	1.54	0.22	0.82	1.40
professionHousewife	−5.19	2.57	−2.02	0.042*	0.01*
professionOthers	18.55	1613.06	0.01	0.99	NA[a]
professionSmall business	0.23	1.96	0.12	0.91	1.26
professionBusiness	−2.22	1.86	−1.19	0.23	0.11
villageKomolchori	−0.35	1.03	−0.34	0.74	0.70
villageThanda Chandra Para	−0.91	1.19	−0.76	0.45	0.40
soeSettler	2.67	1.36	1.97	0.049*	14.44*
tobOther	1.56	1.04	1.50	0.13	4.76
prsqImproving	2.87	1.48	1.94	0.052	17.64
prsqNo change	2.71	1.59	1.71	0.08	15.03
prwrImproving	−0.51	1.22	−0.41	0.68	0.60
prwrNo change	−2.97	2.02	−1.47	0.14	0.05
prbImproving	−0.08	1.56	−0.05	0.96	0.92
prbNo change	0.49	2.13	0.23	0.82	1.63
ntcfNot necessary	3.06	1.84	1.66	0.09	21.33
wtcfWilling	1.07	1.18	0.91	0.36	2.92

[a]The calculated odds ratio was 113,805,339.66. The reason behind getting such high value was the number of respondents for the variable professionOthers (only 2). Therefore, we excluded it from the table as it was not found to be statistically significant

Signif.codes: 0.001 '**' 0.01 '*' 0.05 (for abbreviation please see the note below Table 2)

Table 4 Wald test of the overall effect of only the significant variables of the GLM

Variable	χ^2	*df*	*p* value
Gender	7.2	1	0.007
Profession	6.2	5	0.29
Soe	3.9	1	0.04

For abbreviation please see the note below Table 2

Table 5 Analysis of deviance of the GLM about the perception of respondents in the Komolchori VCF

Residuals *df*	Residuals deviance	*df*	Deviance	Pr(>Chi)
51	65.376	–	–	–
70	95.234	19	29.858	0.05

Table 6 Pseudo R^2 value of the GLM model of the perception of respondents in the Komolchori VCF

Means of calculation	Pseudo R^2 value
McFadden	0.31

of improved cooking stoves) and calf rearing (Source: KII). After training, NGOs provided small amount of loan to them to initiate alternative income generating activities. Moreover, local communities were involved in a "Saving-Credit program" where they deposited a fixed amount of money per week and earned 1% interest on these savings. The borrower has to return the money within 1 year with monthly installments (Source: KII).

As a result of consecutive training programs and alternative income generation activities, a consensus on forest conservation has developed among the local community. The main profession of the people in the area was "Jhum cultivation". As people were going through the changing forest resources conditions, so they were trying to run small businesses inside the villages e.g. grocery shops and vegetable sellers (Source: FGD). They understood that the VCF needs to be conserved and they should not rely solely on the forest for their livelihood, as they have before. Proshika provided seedlings for mango and papaya to reduce pressure on the VCF and engaged more people in horticulture (Source: KII). Moreover, young people who were more educated desired to work as rickshaw pullers locally known as "Tom-tom" (Source: FGD). They thought that working as a puller was more prestigious than farming. Both men and women were being encouraged to practice tailoring and livestock rearing including pigs, cows and poultry hens and ducks. Women were encouraged to participate in these types of professions so they could generate income without hampering other daily events (Source: FGD).

Sustainable Management of Land, Water and Biodiversity

Local communities, due to the changing conditions of VCF, were more aware of managing land, water and biodiversity in a sustainable way. They were engaged in horticultural practices such as, mango orchards, banana gardens and rearing domestic animals e.g. cow, pig, goat. To avoid fires in the forest, collection of litter and burning were not permitted (Source: FGD). There was a strict provision that if anybody harvests bamboo without permission, he/she had to pay 50 BDT/bamboo as a penalty (Source: KII).

Drinking water is a scarce resource in the area. "Chara" (stream) is the only source of drinking water for the communities. Drinking water availability was being increased due to the increase of forest cover. People of this area were fetching drinking water in various ways. They collect seepage water from the bottom of hills and stored it in mud jars. For water collection they dig hole about a 1 m in diameter and 0.5 m in depth in a sedimentary rock, where water deposits naturally (Source: Field observation). Furthermore, for agricultural purposes, they build earthen dams '1.83' m wide and '0.91' m deep at the end point of a canal or "Chara" outside near

agricultural fields. They also use bamboo to irrigate their agricultural lands (Source: Field Observation and FGD).

The commercial dealing of forest products is forbidden unless the local committee decides to sell forest products for community development. Killing of any type of animals, including birds, for commercial purpose is also restricted in the VCF. Medicinal plants are collected by herbal doctors, locally known as "Kobiraj". The "Kobiraj" marked some species as medicinal and it is prohibited to harvest them.

The community people can collect forest produces e.g. edible parts of the selected flora and fauna only after ensuring their viability. In most of the cases, the VCF committee only give seasonal permission, for instance, rainy season to collect Bansgula (*Bamboosa* spp.). Some of the species are naturally growing whereas other species are grown the homestead vegetable gardens (Source: FGD).

Fishermen from the ethnic communities used to collect fish from the "Chara". Women and children used to collect some other edible items from the canal (Source: FGD).

Various kinds of plant parts like flowers, twigs, leaves, bark and fruits were used in various religious purposes in ethnic communities (Source: FGD).

The villagers plant cane and bamboo surrounding the VCF. In order to protect forest from illegal extraction of trees and other natural resources, at first stage, about 700 seedlings of cane were planted as a live fence around the VCF. In the subsequent stages, more seedlings were also planted depending on the nature of the fence (Source: KII). In 2011, Proshika and Arannayk Foundation planted a total of 2910 seedlings of native fruits and timber species. Among total seedlings, 1000 of them were 20 native tree species. At present, about 29 species of trees are available in the Komolchori VCF which are different from the tree species found in other forest areas of Bangladesh (Source: FGD and KII).

We have documented the detailed list of available natural resources with their uses in Appendix 2–9 in the Supplemental Materials. Available bamboo species (Appendix 2), animal and bird species (Appendix 3), edible floral items (Appendix 4), edible faunal items (Appendix 5), medicinal plants (Appendix 6), sacred species (Appendix 7), cane species (Appendix 8), tree species (Appendix 9) in the VCF of Komolchori area are listed with full details.

Institutional Set Up for VCF Management

The Komolchori VCF is managed by a group of people known as forest user group or FUG. The village "Headman" is the head of that group. Local villagers or those who are engaged in monitoring work are considered members of the group (Source: KII). The ethnic communities elect their headman following traditional rules. All of the members of the village are bound to obey him and follow his instructions until he passes away or is physically disable. (Source: KII).

The FUG has been managing the VCF through traditional communal land rights by forming an organization named as "Pally Kallyan Samiti" (PKS) consisting of nineteen executive members. The committee has a written constitution and rules on forest use and management. The VCF members are required to pay a small fee

(approximately 50–100 BDT) for harvesting forest products. The income generated from the forest based activities, goes to the community fund. In 2008, 11 landless families (settlers) were relocated around the VCF and each of them was allocated 0.81 ha of land for a home and agriculture (Source: KII).

Some members of the VCF committee were included in the PKS. The functions of the VCF committee and the PKS are different. All of the members of the committee are involved in VCF management while the members of the PKS mainly work on forming the regulatory rules and economic development for the community. Since the sphere of the work doesn't overlap, there remains hardly any conflict between the two authorities (Source: KII).

Forest Phyto-sociological Status in the Komolchori VCF

The tree density of the VCF was estimated as 1420 trees/ha. If we compare this density to some other forest areas of Bangladesh, we can see that tree density in the VCF was remarkably higher (Table 7). For example, Mamun et al. (2015) calculated the tree density in a hilly forest area of Bangladesh as 691 trees/ha. The calculated basal area/ha in the study area was approximately 28 m^2/ha. This indirectly signifies the healthy structures of the trees inside the VCF. The Shannon–Weiner index and species diversity index in Komolchori VCF were 2.91 and 0.62, respectively. Compared to the findings of Muhammed et al. (2011), the Komolchori VCF is more diverse. The index of dominance of the VCF was estimated as 0.09.

Discussion

The perception of the people regarding the conservation of forests is important. Firstly, it will give an overview of their persisted idea of resources conservation of the forests as they are very close to it for a long time to manage their livelihoods, and secondly it will demonstrate the difference in ideas among the community people on different issues e.g. forest cover change over time, importance of forest resources conservation etc. In this study, it was found that ethnicity status and gender were significant considering the conservation issue. But in order to manage a common pool resource the conservation practice and idea should be one dimensional. The settlers group of people should be motivated in order to conserve the VCF sustainably. The conservationists, forestry department, and the national policy maker should

Table 7 Density, basal area, Shannon–Weiner index, species diversity index and index of dominance in the Komolchori VCF of Bangladesh

Parameters	Value
Density (trees/ha)	1420
Basal area/ha (m^2)	27.98
Shannon–Weiner index	2.91
Species diversity index	0.62
Index of dominance	0.09

take this aspect in mind while making the policy. Apart from it, the female members of the society can contribute better than that of their encounters in case of the overall natural resources conservation. This finding contains a significant message to be conveyed.

Meijaard et al. (2013) studied forest related factors that influenced the well-being of communities and found spatial variation in perceptions. This means that perceptions differ among different study sites. But in this study, we didn't find such difference among the three studied village. The probable explanation is our study sites shared the same socio-political and demographic conditions. Sunderland et al. (2014) in their global comparative study described some common perceptions regarding natural resources conservation and uses among males and females. They found that both men and women contribute equally to household income from unprocessed forest products. Their global scale dataset also depicts that men participate more in forest user groups than women. In our study, we found that women contributed well to the household income with men. However, they couldn't contribute much in the decision making process in the FUG as most of the cases their thoughts were overlooked.

The VCF in Komolchori is an important source of wood, herbs, bamboo, edible items, medicinal plants, and water supply that help to ensure the sustainability of the ethnic Chakma communities in the CHTs. These ethnic communities are the main managers of this rich fore reserve. Community based management by ethnic communities is possible because they have been maintaining their resources following traditional practice for their own needs as a common property. As they are living far from the mainland, members of the Chakma community are very much interconnected by their social, cultural and religious norms and values. Jashimuddin and Inoue (2012) also identified community based programs for common natural resources played a critical role in social welfare appearance in the ethnic communities of Bangladesh.

Under a community based approach, the user community generally fixes the rules of VCF management and punishes those who break the rules. Extraction of forest resources for personal interest is banned except by permission from the executive committee. Individual families can collect wood and other natural resources for their domestic uses. The villagers also sell some of the forest products, such as bamboo and in some cases timber, to meet community needs for example, temple construction and for emergency medical expenses. Findings of this research regarding the extraction of natural resources coincides with the description provided by Olarieta et al. (2007). Routine based systematic collection of forest resources indirectly helped the VCF to conserve its species. The members of the community also got an economic profit from the VCF every year on a regular basis. Besides, community development was also going well from the utilization of forest resources in community infrastructures.

Villagers believed that water supply was being increased in the "Chara" due to improvement of forest canopy coverage and density. Local ethnic communities conserve trees to prevent soil erosion and use the forests for timber, fuel wood, and twigs. The community considered several trees as the sacred species, for example, Bodhi (*Ficus religiosa*), Bot (*Ficus benghalensis*), Osottho (*F. religiosa*) and Pakur

(*Ficus lacor*). They brought (candle) light to the bottom of the trees in several occasions as they believed that they can obtain blessings of God through worshipping the leaf, root and twig of those trees. Peoples' perception of this VCF on protecting religious plants coincides with the study of Luo et al. (2009) where people in Tibetan villages of Gansu region conserve sacred forests to fulfill religious beliefs. The local Chakma community of Komolchori VCF is Buddhist and most of them worship leaves and twigs of trees to satisfy nature where people in Gansu also protect trees to gratify nature and God.

In the case of protecting flora and fauna, our findings are similar to the research conducted in the sacred forests of Zimbabwe where people protect their sacred forests for the conservation of natural resources (Byers et al. 2001). Findings of this study on edible flora are close to findings of Khisa (1998) where the author found similar species of edible flora in CHTs.

Reducing dependency on forest resources is very important to conserving the VCF. Proshika and Arannayk Foundations are involved with the VCF committee in order to improve the awareness of VCF conservation capacities, and self-dependency of ethnic people. A recent study conducted by Miah and Ahmed (2014) in Bandarban showed that monthly meetings of VCF committees was a means to providing training for creating awareness of the conservation of VCFs.

In addition, "Saving-Credit programs" motivated people to work in alternative sectors. It also helped them to maintain a personal savings. Miah and Ahmed (2014) identified potential alternative income generating (AIG) options e.g. horticulture, tailoring, weaving, handicrafts, rearing of livestock, vegetable cultivation etc. All of these activities contributed to reducing the pressures on the Komolchori VCF. AIG helped to reduce the dependency on forests and has been shown to be an effective way to conserve forests (Jashimuddin and Inoue 2012; Miah et al. 2012). Although the presence of government initiatives is not sufficient, NGOs activities have enormous involvement in CHTs (Nath and Inoue 2008; Jashimuddin and Inoue 2012; Mukul and Herbohn 2016). It helps to ensure sustainability of natural resources and enhances livelihoods of ethnic people by proving alternative income generating activities.

To understand the forest phyto-sociological status, it was found that the density of this VCF is 1420 tree/ha (Table 7). A study in Chittagong north forest division of Bangladesh showed that the density of trees were 1425 trees/ha (Nur et al. 2016). Considering these findings (Table 7), the VCF forests of Komolchori seem to have a good tree density per ha. It is estimated that the total basal area/ha of Komolchori VCF is 27.98 m^2. From the other study which was conducted by Misbahuzzaman et al. 2008 found the value of total basal area in reserve forests was 48.05 m^2/ha. Comparing findings of this research with the estimation of Misbahuzzaman et al. 2008, it can be said that the Komolchori VCF has a good stocking of trees. Besides, the Shannon–Weiner Diversity index for the Komolchori VCF was 2.91 whereas the for Shitalpur forest beat was as a whole it was found as 3.49 (Nur et al. 2016). The species diversity index and index of dominance in this VCF were 0.62 and 0.09 respectively. On the other hand, Nath et al. 1998 found the index of dominance ranged from 0.08 to 0.16 in Sitapahar reserve forest. Considering this fact, the value of index of dominance in Komolchori is rational and matched with the perception of

people of the VCF. The ethnic communities of the VCF are trying to conserve this forest whereas the contribution of NGOs is also facilitating their activities.

Conclusion

The natural resources of the Komolchori VCF are being effectively managed through a CBFM approach. The VCF improves watershed condition, drinking water supply in the adjacent areas. The resources of the VCF are used to develop schools, temple construction and making shelters for the people. It is possible to minimize peoples' dependency on the forest by encouraging alternative livelihoods such as small business, horticulture etc. People were receptive to the idea of VCF conservation. From this study, it can be inferred that VCF is important for biodiversity conservation and the existence of cultural activities of people in CHTs. Moreover, the VCF committee formation and collaborating program of NGOs restrict users from over-exploitation of resources. The sustainable management approach will create a way for the protection of resources, livelihoods through effective administration and utilization of forest resources of the VCF. To ensure proper management, the government should focus on the arrangement of alternative livelihood income options for the ethnic communities to reduce the dependency on forest resources. Furthermore, from decision-making to executive committee activities, women's participation should be encouraged. Indigenous technique of resources management in the VCFs in the hill tracts can be a role model in managing natural resources throughout the country and other areas where community is involved in it.

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Affiliations

Md. Arif Chowdhury[1] · Fatima-Tuz- Zahra[1] · Md. Farhadur Rahman[2] · Kamrul Islam[3]

✉ Kamrul Islam
ksujonifescu@gmail.com; kamrul-islam@g.ecc.u-tokyo.ac.jp

[1] Institute of Water and Flood Management (IWFM), Bangladesh University of Engineering and Technology (BUET), Dhaka 1000, Bangladesh

[2] Division of Forest and Biomaterials Sciences, Graduate School of Agriculture, Kyoto University, Kyoto 606-8502, Japan

[3] Department of Systems Innovation, Graduate School of Engineering, The University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo 113-8656, Japan