Taylor & Francis
Taylor & Francis Group

Determinants of forest and tree uses across households of different sites and ethnicities in Bangladesh

Ronju Ahammad, Natasha Stacey & Terry Sunderland

Published online: 07 Jun 2021.

Submit your article to this journal

Article views: 45

View related articles

View Crossmark data

Taylor & Francis
Taylor & Francis Group

RESEARCH ARTICLE

Determinants of forest and tree uses across households of different sites and ethnicities in Bangladesh

Ronju Ahammad[a] (iD), Natasha Stacey[a] (iD) and Terry Sunderland[b,c]

[a]College of Engineering, Information Technology, and Environment, Charles Darwin University, Darwin, Australia; [b]Faculty of Forestry, University of British Columbia, Vancouver, Canada; [c]Center for International Forestry Research, Bogor, Indonesia

ABSTRACT

This study examines the determinants of forest and tree-product uses in rural households across three sites of different proximity to roads and forests in the Chittagong Hill Tracts region in Bangladesh. A structured questionnaire survey was conducted with 300 households of different ethnic groups, located in three different locations (remote, intermediate, on-road), to collect information on their forest and tree use during 2015–2016. We gathered information on household socioeconomic characteristics (family size, education level of head of household, size of farmland), location (three sites), and ethnic affiliation. By conducting a series of logistic regression modeling, we analyzed the key determinants that would explain the variations in forest use in the households. We recorded twelve different forest and tree products used in the households, primarily for subsistence purposes and cash income. Fuelwood, vegetables, and fish were recorded as the most important forest-sourced products used by people, regardless of socioeconomic condition, location context, and ethnic affiliation. Household land/farm size, location, and ethnic background explained significant variations in the use of forest and tree products (mainly timber, fodder for livestock). The greater the size of the landholding, the more likely timber was used for both subsistence and cash income, but the less the reliance on other products (fuelwood, thatch grass, vegetables). Our findings suggest that the location and ethnic characteristics of the rural households are important for understanding the diverse needs for forest and tree use, and should be factored into the site-specific management and sustainable use of forest and tree resources in Bangladesh and other tropical developing countries.

Introduction

Forest- and tree-based ecosystems provide a wide range of social and environmental benefits for the entire world and, in particular, sustain the rural livelihoods of people in tropical developing countries in various ways (Ninan and Inoue 2013; FAO 2016; HLPE 2017; Reed et al. 2017). A number of studies have provided strong evidence for the substantial economic contributions of forests and trees to rural livelihoods that enable people to live out of poverty and to secure food options in global and country contexts (Hogarth et al. 2013; Angelsen et al. 2014; Belcher, Achdiawan, and Dewi 2015). Most studies have pointed out that the social and economic determinants (e.g., age, education level, farm size) of rural households determine their forest use for direct food and income. Forest and tree use often largely benefit the poorer households in society – those that have limited resources, in terms of a low level of education, small farm size, and limited

available labor (i.e., size of the household). Despite this, the determinants of forest use by rural households remain complex, either due to the types of forest and tree products they use, their contexts, or their importance, regardless of social or economic conditions (Kamanga, Vedeld, and Sjaastad 2009; Kalaba, Quinn, and Dougill 2013a; Baudron et al. 2017; Mensah et al. 2017).

The relationship between forest and rural livelihoods is multidimensional, although it is broadly related to the nature of benefits and spatial contexts such as distance from markets and proximity to forests (Newton et al. 2016). A greater forest dependency of households exists in proximity to forests and remotely from market centers, particularly in rural contexts (Sunderlin et al. 2005, 2008). Forest uses vary at the broader landscape scale, with regard to market access and situation – the geographical contexts in which people depend on forests (Belcher, Achdiawan, and Dewi 2015). Studies have also reported that the proximity of rural households

---

to different forest and tree covers has contributed to an improvement in dietary diversity in rural populations (Rowland et al. 2017). The importance of forests differs with changing social-ecological systems in multifunctional landscapes, indicating the diversity of their roles in rural livelihoods (Sunderland et al. 2017). However, there is insufficient evidence to determine where forest and trees are relatively more important, in terms of people's location and cultural background in the landscape (Cuni-Sanchez et al. 2016). Without clearly identifying people's contexts and relationships with forest uses, there is less of a possibility of using and managing forests sustainably in developing countries.

Forests and trees cover only 2.52 million hectares (ha) of land (less than 10% of the total lands) in Bangladesh, but they contribute to supporting the livelihoods of more than two-thirds of the total population in rural areas (Bangladesh Forest Department 2016a, 2016b). Forest- and tree-sourced fuelwood provides almost 50% of the primary energy demand for boiling and cooking foods for 80% of the total population (Bangladesh Forest Department 2016a). Non-timber forest products (NTFPs), mainly bamboo and cane, generate informal employment for an estimated 500,000 people, although the actual number of people dependant on such resources is unknown (Bangladesh Forest Department 2016a). Forests are traditionally important in the livelihoods of a dozen different ethnic communities living in the eastern upland Chittagong Hill Tracts (CHT) region of Bangladesh. Several studies have identified the economic contributions of fuelwood, timber, and NTFPs in the livelihoods of the ethnic people in the region (Kar and Jacobson 2012; Misbahuzzaman and Smith-Hall 2015; Chowdhury et al. 2018). The diversity of physical locations (remoteness from markets and roads) and the cultural contexts of the ethnic populations both influence people's access to forest and land uses and livelihood activities (UNDP 2009). However, how these differences, in terms of location and ethnic context, determine the forest and tree uses of the households in the region remains unexplored. We argue that the socioeconomic characteristics (e.g., education level, family size, land size, livestock), physical location, and cultural background of rural households determine the use of forest and tree products in their livelihoods. Understanding the key determinants of forest and tree uses is necessary to support sustainable forest use in this landscape.

Given this context, this study aimed to examine the determinants that might explain the variations in forest and tree products used by rural households in the CHT region. To achieve this objective, we addressed an overarching question: What are the key determinants of forest and tree-product uses in the rural households of the CHT region?

Materials and methods

Setting of the study area in the CHT region

The CHT region is a unique geographical and cultural landscape located in the southeastern part of Bangladesh. It comprises three administrative districts – Rangamati, Bandarban, and Khagrachari. Twelve different ethnic groups live in the region – the Chakma, Marma, Tripura, Mrung, Tanchangya, Bawm, Chak, Pangkhua, Lushai, Khyang, Khumi, and Rakhain (Ahammad and Stacey 2016). Aside from these traditional ethnic groups, the Bangalee (the predominant ethnic group in the country) account for almost half the population at present. Indigenous ethnic groups comprise 51% of the population (UNDP 2009). The majority of rural households in the CHT are dependent on agriculture-related activities such as swidden farming and conventional plainland agriculture, including horticulture, for producing food and generating income. Over 50% of the annual net income of all CHT households also comes from different agriculture-related activities (UNDP 2009). Forest and trees provide a wide range of benefits to local communities in the CHT, as well as to the national economy (Ahammad and Stacey 2016). Fuelwood, foods (mainly vegetables, mushrooms, bamboo shoots, animals), primary medicines, shelter-building materials, and agricultural implements are common forest and tree uses in the region. Bamboo and thatching grass are directly used for building houses (Miah et al. 2012).

The level of forest dependency or its economic contribution in the CHT may be higher than in other regions due to the diversity of products and uses, as well as persistent pressure for the conversion of forest into agricultural land (Ahammad and Stacey 2016). An over-harvesting of trees, and clearing/burning in swidden farming, has caused the deforestation and degradation of the forest landscape in the CHT (Ahammad et al. 2019; Hasan, Sarmin, and Miah 2020). A limited number of local people have access to lands with a secure title for private forests or tree-covered lands that are not properly documented. As a result, sustainable forest use is a key challenge due to severe deforestation and the land-use rights of local communities that have not been properly addressed in national policies and legislation (Ahammad, Stacey, and Sunderland 2021).

Table 1. Basic social, ecological, economic, and institutional features across three sites in the CHT region (Ahammad and Stacey 2016).

	Remote (Site 1)	Intermediate (Site 2)	On-road (Site 3)
Names of villages	Uluchari, Chainda, Marma, Pangkhua para	Paglachara, Angadpara, Bijoypara, Suanglupara	Khamadong, Kamalong, Jogeshkarbaripara, Bagmara, Headmanpara
Ethnic groups	• Tanchangya/Chakma • Pangkhua • Marma	• Tanchangya/Chakma • Marma • Bawm	• Marma • Tanchagya/Chakma
Population density (per km^2)	38	62	176
Elevation/altitude (in meters)	100–350	70–172	50–90
Age of villages (settlement years)	25–30	30–50	>50
Main economic activities	Subsistence farming, forest-product harvesting and trading, day labor	Farming, forest-product harvesting and trading, fruit-tree gardening, day labor, employment	Farming, day labor, forest and tree product trading, employment, small business, land rental
Forest types (ecological)	Secondary forests (tropical evergreen and semi-evergreen), plantation	Mixture of forest types, mostly secondary forests with small natural forest, industrial and private plantation	Mostly industrial and private plantation
Access to forest types	State-owned forest reserve (Rhainkhyong Reserve and Kaptai National Park)	State and private plantations and community-owned forest reserve	State and private plantations
Distance to natural forests (km)	<0.5	0.5–5	>5
Distance to sub-district/ district market (km/time)	2–3 hours by boat	0.5–1 hour by motorbike	15–30 minutes by motorbike

Data collection approach

Selection of the study sites

We considered the location of the settlements, in terms of distance to market, population density, economic activities, forest types, and forest management – as proxies for three site selections (referred to as remote (Site 1), intermediate (Site 2), and on-road (Site 3) locations, following Deakin, Kshatriya, and Sunderland (2016) and Sunderland et al. (2017) (see Table 1 and Figure 1). A scoping survey was organized in 2015 to select the three representative sites and villages following these criteria (Ahammad and Stacey 2016). The three sites and respective villages were selected after consultation and discussion with local government and non-governmental organization officials, and local elected union chairmen/members in the region. Twelve villages were randomly selected within the three sites that fall within the three subdistricts – Belaichari, Rowangchari, and Bandarban Sadar. The remote site was situated in Belaichari (Rangamati district), the intermediate site in Rowanchari (Bandarban district), and the on-road site in Bandarban Sadar (Bandarban district). The distance of the remote site to the main road/district town is approximately a 45 kilometer (km) and 2–3 hour journey by water transport. The villages of the intermediate site are 5–8 km distant from the main road and one hour travel to access a district market. The villages in the on-road site are within close proximity (i.e., 1–3 km) to the main road and market (Ahammad and Stacey 2016).

The data were collected from the sampled households in twelve villages of the three sites during 2015–2016. In each village, 64% of the households (of a total of 475 households) were surveyed. This covered 50% of the total population. A total of 304 households (approximately 100 households from each site) were surveyed using a structured questionnaire administered via the heads of the households (Table 1). Over 90% of those heads of household and the respondents to the survey were male. The respondents provided information on the types of forest products they used in their households for self-consumption and income generation.

The household surveys included a set of structured questions relating to the basic characteristics of the respondents, such as age, gender of the head of household, education level, land area owned, main economic activities, forest and tree uses, and quantity of livestock (Table 2). The survey was led by the first author and facilitated by field assistants who were local to the region. The surveys were conducted in four languages (Tanchangya, Marma, Bawm, and Bengali) in most instances. The field assistants communicated to the respondents in local languages where respondents indicated preference. For the specific survey questions about forest and tree-product uses, a list of forest and tree products common in the CHT region was prepared from previous studies (Ahammad and Stacey 2016). This list guided the interviews of the respondents when asked about the types of forest and tree products that their family collected and used (mainly for subsistence or cash) from the forest or planted trees
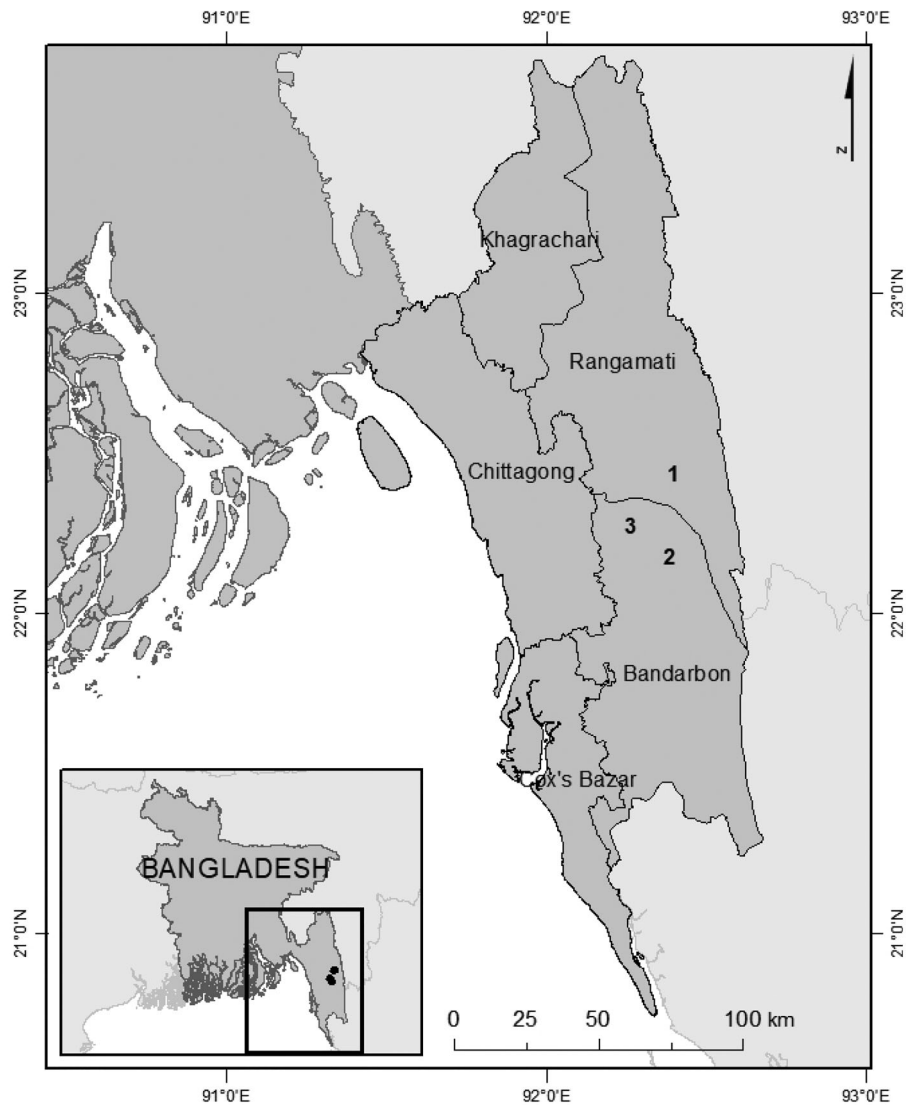
Figure 1. Three study sites (1 – remote, 2 – intermediate and 3 – on-road) in the CHT region of Bangladesh.

Table 2. Descriptive characteristics of the respondents surveyed in the CHT region of Bangladesh (2015–2016).

Household characteristics	Number of respondents ($n = 289$)	Mean
Family size (numbers)		4.7
Completed education of head of households (years)		4.11
Farm size of household (ha)		1.75
Site/location wise respondents		
Remote	92	
Intermediate	97	
On-road	100	
Ethnicity wise affiliation of the respondents		
Group 1	137	
Group 2	104	
Group 3	48	

(own land) in a year. A 12-month recall period was employed in collecting the information on forest and tree-product uses. Up to 300 households were surveyed to collect information on the use of forest- and tree-sourced products. After data cleaning, the information from 289 households, concerning the use of forest and tree products, was used. The surveys were usually undertaken once, although several reviews of certain topics (e.g., forest- and tree-product use) were performed, where necessary, concerning the collection of forest products and land-use types, for example. In the absence of heads of household, any family member older than 18 years was interviewed. The survey was undertaken in the period of the year with better accessibility and availability of transportation to study villages.

Data analysis

After data cleaning, we used the information from 289 households to analyze their uses of forest and tree products. The main statistical analyses applied were descriptive statistics and logistic regressions. The descriptive analysis provided counts of the respondents who used the household forest and tree products, such as fuelwood, timber, bamboo, wild animals, vegetables, mushrooms, bamboo shoots, fodder, thatch, and broom grass. The proportions of respondents who used specific forest and tree products for subsistence and cash income were calculated. To predict the key determinants of the households that explained variations in the forest products used, we analyzed the socioeconomic characteristics (family size, education level, farm size), sites (location of the household in Site 1 (remote), Site 2 (intermediate) and Site 3 (on-road) and ethnicity (Ethnic Group 1, Ethnic Group 2, and Ethnic Group 3). The surveyed ethnic groups comprise Tanchangya and Chakma (Ethnic Group 1), Marma (Ethnic Group 2), and Bawm and Pangkhua (Ethnic Group 3). A logistic regression model was developed to examine the key determinants (Equations (1) and (2)). The logistic regression model explained the outcome (categorical) variables using predictor (one or more categorical or continuous) variables (Equation (1)). In order to predict which forest and tree products (outcome variables) used by the households were determined by the household characteristics (predictor variables), we considered the logistic regression in Equation (2).

$$\text{logit}(Y) = \ln[p/(1-p)]$$
$$= \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5$$
$$+ \cdots \beta_m X_m$$

$$(1)$$

$$\text{logit}(\text{forestandtree} - \text{productsused}) = \ln[p/(1-p)]$$
$$= \beta_0 + \beta_1(\text{familysize}) + \beta_2(\text{education})$$
$$+ \beta_3(\text{landsize}) + i_4(\text{site}) + \beta_5(\text{ethnicity})$$

$$(2)$$

where ln is the natural logarithm, p is the probability that the forest-product use (Y) occurs, p ($Y = 1$), $p/(1-p)$ is the odds ratio, and $\ln[p/(1-p)]$ is the log odds ratio or logit.

First, we built separate models for each of the forest products (bamboo, timber, fuelwood, thatch and broom grass, fodder for livestock, vegetables, bamboo shoots, mushrooms, wild fruit, fish, and animals) that the households reported against their demographic (family size, education level), land/farm size, location of household (site), and ethnic-group characteristics. The regression was performed in two parts, with bamboo, timber,

fuelwood, thatch and broom grass, and fodder for livestock modeled first. Then, forest-sourced foods (vegetables, bamboo shoots, mushrooms, wild fruit, fish, and animals) were considered in the regression. All statistical analyses were conducted using R programming software. A series of logistic regressions was conducted using the R programming environment, which used the lme4 package. In R, the logistic regression was run using the generalized linear model (glm()) function.

Results

Patterns of forest- and tree-product use in households

The surveyed households used different forest and tree products, such as fuelwood, bamboo (raw and processed), fodder for livestock, timber, and thatch, and broom grass, both for subsistence and cash income (Figure 2). Different plant and animal foods, such as vegetables, fish, mushrooms, bamboo shoots, wild fruit, and wild animals, were gathered from the forests for direct consumption in the households. The most common products used were fuelwood, vegetables, and fish across the three sites (Figure 2). Over two-thirds of the surveyed households gathered fuelwood to meet their primary energy demands and vegetables and fish to meet their dietary requirements. Bamboo and timber were important construction materials for almost half of the respondents, followed by thatch grass. Thatch grass is commonly used for roofing and fencing purposes. Just half of the respondents reported livestock grazing in the forest and the collection of fodder. In addition, households collected broom grass for making flour. Only bamboo and timber were reported as being used for cash income.

Determinants of forest- and tree-product use for subsistence purposes

The logistic regression highlighted the important household characteristics that influenced the forest products (bamboo, timber, fuelwood, thatch grass, broom grass, fodder for livestock) used for subsistence purposes (Table 3). Head of household education level, farm size, location, and ethnic background were found to significantly influence forest- and tree-product use. Bamboo use was found to be not significantly different across the households, and not reliant on education level or farm size. Household location (site) and ethnicity, however, did have a significant influence on the level of bamboo used. People in the on-road location (Site 3) were more likely to use bamboo than those at the other sites. The respondents affiliated with Ethnic
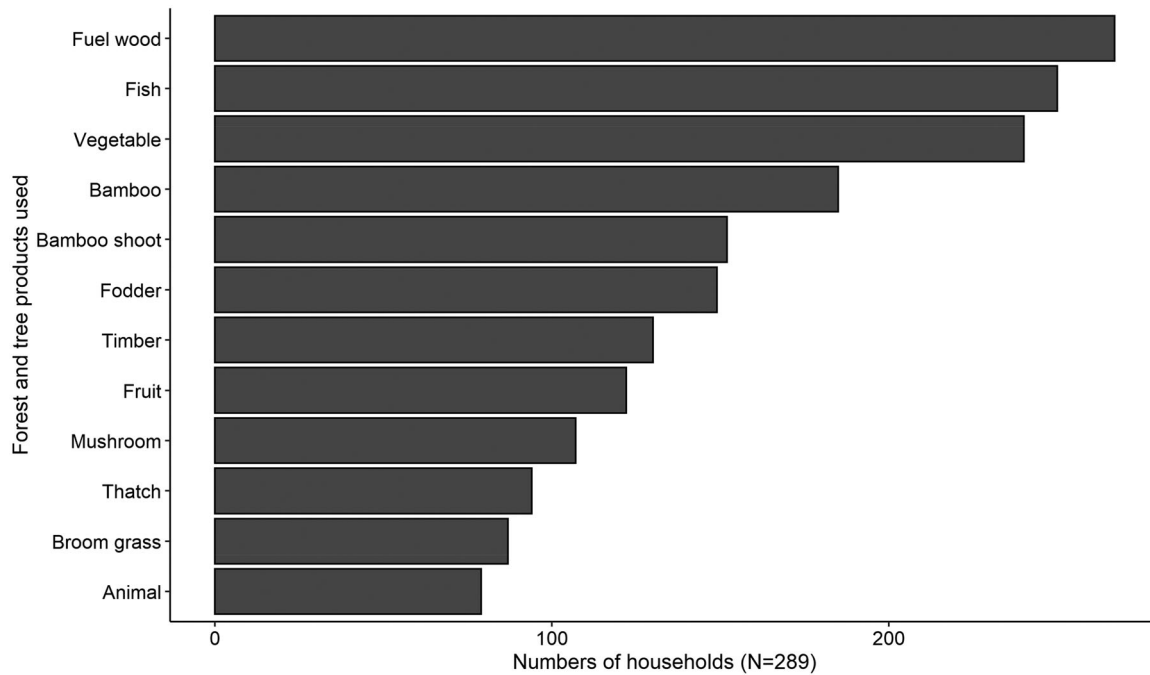
Figure 2. Forest- and tree-product use reported by households for subsistence purposes in three surveyed sites in the CHT region of Bangladesh (surveys conducted in 2015–2016).

Table 3. Determinants of forest and tree product uses for subsistence purposes.

	Bamboo estimate (z statistic)	Timber estimate (z statistic)	Fuelwood estimate (z statistic)	Broom-grass estimate (z statistic)	Thatch-grass estimate (z statistic)	Fodder for livestock estimate (z statistic)
Constant	−0.09 (−0.18)	−1.24 (−2.34)*	6.51 (4.61)***	−1.10 (−1.84)	0.86 (1.51)	−0.24 (−0.45)
Family size	0.09 (0.92)	0.04 (0.47)	−0.11 (−0.70)	−0.05 (−0.48)	−0.01 (−0.07)	0.03 (0.28)
Education	−0.02 (−0.52)	−0.02 (−0.50)	−0.14 (−2.08)*	−0.09 (−2.21)*	−0.12 (−3.05)**	−0.03 (−0.47)
Land size	0.09 (1.14)	0.67 (5.69)***	−0.42 (−3.84)***	−0.10 (−1.04)	−0.73 (−4.89)***	0.74 (5.76)***
Site/location						
Site 2	−0.27 (−0.76)	−0.04 (−0.11)	−1.73 (−1.52)	1.84 (4.66)***	0.14 (0.37)*	−0.76 (−0.34)*
Site 3	1.58 (3.78)***	−0.50 (−1.23)	−0.48 (−0.21)	−0.02 (−0.04)	−2.90 (−5.40)***	−1.27 (−3.13)**
Ethnicity						
Group 2	−1.34 (−3.15)**	−0.20 (−0.48)	−1.35 (−1.14)	−0.04 (−0.09)	2.21 (4.21)***	−0.44 (−1.05)
Group 3	1.57 (3.35)***	−0.78 (−1.99)*	−0.15 (−0.21)	1.70 (4.05)***	0.81 (1.94)	−1.27 (−3.17)**
Chi-square[a]	33.11	64.53	38.28	71.17	77.93	81.39
McFadden's pseudo R^{2b}	0.10	0.16	0.25	0.20	0.21	0.20

Significance level: ***$p < 0.001$; **$p < 0.01$; *$p < 0.05$.
[a]Chi-square distribution for the log likelihood ratio of the fitted model against the global null model.
[b]McFadden's pseudo R^2 value calculated for the fitness of the model.

Group 2 were less likely to use bamboo, while Ethic Group 1 was more reliant on this product.

Only farm/land size and ethnicity significantly influenced the use of timber. An increase in farm size was more likely to contribute to greater use of timber, while Ethnic Group 3 was less likely to use timber than other groups. The use of fuelwood collected from forests decreased with an increase in education level and farm size, which was also the case for broom grass. Households located at Site 2 and falling into Group 3 were more likely to collect and use broom grass from the forest. Education level, farm size, site, and ethnicity significantly influenced the use of thatch grass, which significantly declined with increasing education level and farm size. Households located at Site 3 had a lower reliance on thatch grass, which was more likely to be higher at Site 2. It was also found that Ethnic Group 2 had more of a reliance on

thatch-grass use. The use of forest products as fodder for livestock was significantly associated with farm size, location, and ethnicity. Households with large farm areas were more likely to use forests for grazing and fodder purposes, while this decreased at Sites 2 and 3, as well as in Ethnic Group 3.

Overall the level of education, ethnicity, land size, and sites of the households were significant fit to model subsistence uses of forest and tree products (Table 3). The likelihood ratio test (distributed Chi-squared) and McFadden's pseudo R^2 in Table 3 indicate the fitness of these predictors in all the models of bamboo, timber, fuelwood, broom grass, thatch grass, and fodder for livestock uses (Table 3). The large chi-square distribution indicates the better model fit for subsistence uses of broom grass, thatch grass, and fodder predicted by the level of education, ethnicity, land size, and sites of the households.

Determinants of forest-sourced food uses in the households

Analysis of the forest- and tree-sourced foods gathered by the households showed significant differences (Table 4). The households collecting vegetables, bamboo shoots, mushrooms, and fish from the forests significantly correlated with family size, farm size, location, and ethnic background. The collection of vegetables was significantly low in households with greater land size ($p < 0.05$) and located in proximity to the road ($p < 0.05$). Bamboo shoots were significantly more used by households at the intermediate site ($p < 0.001$) and in Ethnic Groups 2 and 3 (both $p < 0.001$). Greater mushroom collection significantly related to large family size ($p < 0.001$), declining in households located near the road ($p < 0.01$) and in Ethnic Group 2 ($p < 0.05$). Households owning large areas of land had a significantly low dependency on forest-sourced fish/crabs ($p < 0.05$). In terms of ethnicity, fish gathered from the forests was significantly higher in Ethnic Groups 2 and 3 (both $p < 0.05$). It was also found that remotely-located households used wild fruit significantly more than intermediate or on-road sites (both $p < 0.001$). Among all the forest- and tree-sourced food uses, bamboo shoots and animals were better model fit based on the chi-squared distribution and McFadden's pseudo R^2 (Table 4).

Forest uses for direct income

Further analysis showed that bamboo and timber were the most important forest and tree products that the households used for economic purposes (Table 5). Family size and education level had no significant influence on the use of timber and bamboo for cash income. Only households with large areas of land used significantly more timber for cash income ($p < 0.001$). At the site level, households located nearest to on-road locations tended to have less of a reliance on both timber ($p < 0.001$) and bamboo ($p < 0.001$) for generating cash income. Only households located at the intermediate site used more bamboo ($p < 0.01$) for economic reasons. Bamboo was also used significantly more by Ethnic Group 2, while it declined in Ethnic Group 3 households. Both the models of bamboo and timber use for income were better fit predicted by the site/locations of the households (Table 5).

Discussion

Rural households use a wide range of forest products such as fuelwood, vegetables, fish, bamboo shoots, mushrooms, wild fruit and animals, fodder, bamboo, timber, thatch, and broom grass, in the CHT region. Fuelwood, food (vegetables and fish), structural products (bamboo and timber), and

Table 4. Determinants of specific forest- and tree-sourced food use.

	Vegetable estimate (z statistic)	Bamboo shoot estimate (z statistic)	Mushroom estimate (z statistic)	Animal estimate (z statistic)	Fish/crabs estimate (z statistic)	Wild fruit estimate (z statistic)
Constant	2.32 (3.23)**	−1.98 (−3.49)***	−1.33 (−2.65)**	−0.75 (−1.33)	2.35 (3.21)**	−0.44 (−0.90)
Family size	0.16 (1.34)	0.05 (0.57)	0.24 (2.62)**	−0.02 (−0.16)	−0.12 (−0.93)	0.10 (1.11)
Education	−0.02 (−0.58)	0.05 (1.31)	0.01 (0.24)	0.03 (0.73)	0.09 (1.80)	0.05 (1.52)
Land size	−0.20 (−2.43)*	−0.13 (−1.62)	−0.14 (−1.72)	−0.13 (−1.28)	−0.19 (−2.08)*	0.04 (0.59)
Site/location						
Site 2	−1.00 (−1.79)	1.89 (4.97)***	−0.18 (−0.52)	−0.24 (−0.63)	−0.24 (−0.49)	−1.62 (−4.43)***
Site 3	−1.34 (−2.47)*	0.35 (0.90)	−1.25 (−3.13)**	−0.59 (−1.27)	−0.78 (−1.47)	−1.34 (−3.47)***
Ethnicity						
Group 2	−0.26 (−0.51)	2.38 (5.73)***	−0.97 (−2.37)*	−0.60 (−1.29)	1.10 (2.05)*	0.53 (1.34)
Group 3	0.72 (1.16)	1.51 (3.60)***	0.02 (0.05)	1.98 (4.90)***	2.17 (2.07)*	0.82 (2.08)
Chi-square[a]	25.19	73.52	21.62	59.35	21.17	38.17
McFadden's pseudo R^{2b}	0.10	0.19	0.062	0.18	0.10	0.10

Significance level: ***$p < 0.001$; **$p < 0.01$; *$p < 0.05$.
[a]Chi-square distribution for the log likelihood ratio of the fitted model against the global null model.
[b]McFadden pseudo R^2 value calculated for the fitness of the model.

Table 5. Determinants of forest-product uses for economic purposes.

	Timber estimate (z statistic)	Bamboo estimate (z statistic)
Constant	−1.99 (−3.47)***	−0.86 (−1.59)
Family size	0.16 (1.58)	0.08 (0.80)
Education	−0.05 (−1.27)	0.01 (0.39)
Land size	0.47 (4.87)***	−0.01 (−0.19)
Site/location		
Site 2	−0.34 (−0.89)	0.99 (2.71)**
Site 3	−2.12 (−4.16)***	−2.43 (−5.03)***
Ethnicity		
Group 2	0.39 (0.82)	1.33 (2.78)**
Group 3	−0.16 (−0.39)	−1.83 (−4.07)***
Chi-square[a]	61.33	64.94
McFadden's pseudo R^{2b}	0.20	0.18

Significance level: ***$p < 0.001$; **$p < 0.01$; *$p < 0.05$.
[a]Chi-square distribution for the log likelihood ratio of the fitted model against the global null model.
[b]McFadden pseudo R^2 value calculated for the fitness of the model.

fodder for livestock are used relatively more frequently for subsistence purposes in the region. Our findings are similar to those of the global study of Angelsen et al. (2014) who reported fuelwood as the dominant category of forest-product use by rural people, followed by food sources, such as animals and fish, in their cross-country study of Asia, Africa, and Latin America. Previous studies have only identified the importance of wild animals and vegetables as forest-sourced foods, particularly in the context of ethnic groups in the region. Compared to the findings of Angelsen et al. (2014), our study revealed that vegetables and fish are relatively more important than other food types in the households of the CHT. Vegetables and fish collected from the surrounding forests indicate the role of the forest as an indirect source of vitamins and protein for rural households, contributing to dietary diversity in the region.

The socioeconomic characteristics (mainly education level and size of farmland) of the households influenced the use of specific forest products in the region. Among other variables, the area of farmland significantly influenced the level of forest use for subsistence and cash-income purposes. As farm size increases, there is a constant increase in timber used for both subsistence and cash-income generation in the households. People with larger farm areas are more likely to use forests for fodder and grazing. However, people with more land show significantly less dependency on the use of fuelwood and thatch grass, and different forest-sourced foods, mainly vegetables, and fish. Common trends observed include the decline of forest-product use in households with more years of schooling completed by the head of household. This result is in partial agreement with the global finding that heads of households with a lower education level rely significantly more on forest resources for their livelihoods. Because no significant variations in forest-sourced food use in households based on education level were indicated, this likely reflects the role of the forest as an important contributor to dietary diversity, regardless of education status. Although other studies indicated a positive association between larger households and greater use of forests elsewhere while large family size having slight contributions to forest dependence in the CHT region.

Location of household influenced the use of forest and tree products in the CHT region. A pattern was observed at the site level, in terms of a decline in forest and tree-product use for both subsistence and cash income at intermediate and on-road locations. Our finding supports the notion that remote communities have a greater dependency on forest ecosystems in a landscape (Sunderlin et al. 2008;

Kamanga, Vedeld, and Sjaastad 2009). However, in considering the type of forest use (subsistence vs. cash), our study revealed that subsistence use is dominant in households located at on-road sites. This finding contrasts with that of Belcher, Achdiawan, and Dewi (2015), who pointed out that forests are more important contributors to subsistence use than cash income in relatively remote and highly-forested sites. The overall extraction of forest products was found to be in decline at the on-road site which is closely situated around the road and markets in the CHT. This finding actually agrees with the assumption that household proximity to roads and markets results in lower forest-based cash income due to the availability of non-forest work opportunities. Furthermore, in the context of the CHT region, such location-specific differences can be characterized by the particular forest- and tree-based ecosystems that people have access to having a strong influence on their utilization of the diverse forest and tree resources.

Forest-sourced food gathering decreases in households in tandem with location, in terms of remote to intermediate and on-road areas, in the CHT region. People at remote and intermediate sites access available plant and animal foods due to the occurrence of diverse forest types, including natural and agroforests, in those places, while the on-road site forests and trees are less diverse. The positive relationships we found between diverse food sources and forest accessibility resemble the findings of Ickowitz et al. (2014) and Rowland et al. (2017), who reported that close proximity to different forest- and tree-based ecosystems contribute to dietary diversity. Greater forest and tree cover is related to better access to dietary diversity and the availability of micronutrient-rich wild foods in households. Furthermore, as the level of food insecurity is comparatively higher in remote villages (Ahammad and Stacey 2016), these diverse food sources remain important for rural households in minimizing the risks reported in several studies (McSweeney 2005; Kalaba, Quinn, and Dougill 2013b). By contrast, an increase in monoculture-planted land use has reduced the availability and accessibility to forest food at the on-road site. So, the physical context of landscape, particularly surrounding land use and forest conditions where rural people are living, has a strong influence on their utilization of diverse forest- and tree-based foods.

The use of forest and tree products differed across the three ethnic groups surveyed in the region. Households in Ethnic Group 3 had a higher reliance on bamboo, broom grass, and various foods (bamboo shoots, fish, and wild animals) than Ethnic Groups 1 or 2. Bamboo is the most common type

of NTFP, used for diverse purposes, including construction, and basket-making for household use and in the economy of the region. Households of Ethnic Group 3 had more of a reliance on bamboo for subsistence uses than for cash income, while those of Ethnic Group 2 used bamboo primarily for cash-income purposes. Bamboo shoots, as food traditionally gathered from forests, were used more in households of Ethnic Groups 2 and 3 than Ethnic Group 1. Thatch-grass use, collected for roofing and fencing purposes, was found to be high in Ethnic Group 3. This cultural influence on forest use reveals how different ethnic groups may view the role of forests and trees in their livelihoods and their contribution to sustainable forest management.

Conclusions

We explored variations in forest- and tree-product uses and access at different sites in the CHT region of Bangladesh. In general, forest products were used across the rural population for their livelihoods, regardless of socioeconomic condition, location-specific context, or ethnic affiliation in the landscape. However, we determined that the uses and types of forest and tree products were significantly different within populations, based on the site/location in which they were situated. It was evident that more people who lived in close proximity to forests used forest and tree products more than those who did not. The lower forest dependency of people in the on-road site implied less accessibility to forests, but there were alternative opportunities for them to access forest-sourced foods to meet their dietary needs from their nearest markets and sources of economic activity. The observed difference in forest and tree-product use across sites and ethnic groups is a useful source of information when looking further into who uses the forest most and where the use occurs.

The national forest policy in Bangladesh generally implements "one size fits for all" management strategies across the CHT region (Ahammad, Stacey, and Sunderland 2021). The diversity of forest use (or broader ecosystem-services benefits) associated with specific locations and the differences and needs among ethnic communities and the services and benefits they derive from forests and trees in the region are unacknowledged in the management strategy. But forest and planted tree-land management result in diverse social and environmental outcomes in different landscape contexts (Reed, Ros-Tonen, and Sunderland 2020). For instance, the planted tree-land uses increased in the context of secure land ownership (i.e., specific intermediate and on-road locations of the region) and

contributed to the economic benefits of the rural communities (Ahammad et al. 2019; Ahammad, Stacey, and Sunderland 2020). However, in the remote location, people owned a limited amount of planted tree areas for their own uses, and a relatively larger number of households maintained their forest resource uses through accessing state-managed forests (Ahammad 2019). Given the undefined and insecure land-ownership context in the remote location, people are unlikely to access planted tree-land uses which also pertain to unsustainable forest uses. As result, the future of sustainable forest uses and their management will require the engagement of different ethnic/tribal communities and consideration of their locations in the region.

Ethical approval

Human ethics approval for the research was obtained through Charles Darwin University Human Ethics Committee.

Disclosure statement

No potential conflict of interest was reported by the authors.

ORCID

Ronju Ahammad http://orcid.org/0000-0001-7978-0721
Natasha Stacey http://orcid.org/0000-0002-2262-9817

References

Ahammad, R. 2019. "Recent Trends in Forest and Livelihood Relationships of Rural Communities in the Chittagong Hill Tracts Region, Bangladesh." PhD Thesis., Charles Darwin University.

Ahammad, R., and N. Stacey. 2016. "Forest and Agrarian Change in the Chittagong Hill Tracts Region of Bangladesh." In *Agrarian Change in Tropical Landscapes*, edited by L. Deakin, M. Kshatriya, and T. Sunderland, 190–233. Bogor: Center for International Forestry Research.

Ahammad, R., N. Stacey, I. Eddy, S. Tomscha, and T. Sunderland. 2019. "Recent Trends of Forest Cover Change and Ecosystem Services in Eastern Upland Region of Bangladesh." *Science of the Total Environment* 647: 379–389. doi:10.1016/j.scitotenv.2018.07.406.

Ahammad, R., N. Stacey, and T. Sunderland. 2020. "Assessing Land Use Changes and Livelihood Outcomes of Rural People in the Chittagong Hill Tracts Region, Bangladesh." *Land Degradation & Development*. Advance online publication. doi:10.1002/ldr.3795.

Ahammad, R., N. Stacey, and T. Sunderland. 2021. "Analysis of Forest-Related Policies for Supporting Ecosystem Services-Based Forest Management in Bangladesh." *Ecosystem Services* 48: 101235. doi:10.1016/j.ecoser.2020.101235.

Angelsen, A., P. Jagger, R. Babigumira, B. Belcher, N. Hogarth, S. Bauch, J. Börner, C. Smith-Hall, and S. Wunder. 2014. "Environmental Income and Rural Livelihoods: A Global-Comparative Analysis." *World Development* 64 (1): S12–S28. doi:10.1016/j.worlddev.2014.03.006.

Bangladesh Forest Department. 2016a. "Bangladesh Forestry Master Plan 2017–2036 (Final Draft)." *Government of the People's Republic of Bangladesh*, December. http://pubdocs.worldbank.org/en/848671521827530395/FMP-Full-report-final.pdf

Bangladesh Forest Department. 2016b. "Districtwise Forest Land Information." *Government of the People's Republic of Bangladesh*, December. http://www.bforest.gov.bd/site/page/837e6966-0fce-4274-a0d0-bcdfa49ce492/-

Baudron, F., J.-Y. Duriaux, R. Remans, K. Yang, and T. Sunderland. 2017. "Indirect Contributions of Forests to Dietary Diversity in Southern Ethiopia." *Ecology and Society* 22 (2): 28. doi:10.5751/ES-09267-220228.

Belcher, B., R. Achdiawan, and S. Dewi. 2015. "Forest-Based Livelihoods Strategies Conditioned by Market Remoteness and Forest Proximity in Jharkhand." *World Development* 66: 269–279. doi:10.1016/j.worlddev.2014.08.023.

Chowdhury, M., F.-T. Zahra, M. Rahman, and K. Islam. 2018. "Village Common Forest Management in Komolchori, Chittagong Hill Tracts, Bangladesh: An Example of Community Based Natural Resources Management." *Small-Scale Forestry* 17 (4): 535–553. doi:10.1007/s11842-018-9402-9.

Cuni-Sanchez, A., M. Pfeifer, R. Marchant, and N. Burgess. 2016. "Ethnic and Locational Differences in Ecosystem Service Values: Insights from the Communities in Forest Islands in the Desert." *Ecosystem Services* 19: 42–50. doi:10.1016/j.ecoser.2016.04.004.

Deakin, L., M. Kshatriya, and T. Sunderland. 2016. *Agrarian Change in Tropical Landscapes*. Bogor: Center for International Forestry Research.

Food and Agriculture Organization (FAO). 2016. *State of the World's Forests 2016. Forests and Agriculture: Land-Use Challenges and Opportunities*. Rome,: FAO.

Hasan, S., N. Sarmin, and M. Miah. 2020. "Assessment of Scenario-Based Land Use Changes in the Chittagong Hill Tracts of Bangladesh." *Environmental Development* 34: 100463. doi:10.1016/j.envdev.2019.100463.

High Level Panel of Experts (HLPE). 2017. *Sustainable Forestry for Food Security and Nutrition: A Report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security*. Rome: Food and Agriculture Organization.

Hogarth, N., B. Belcher, B. Campbell, and N. Stacey. 2013. "The Role of Forest-Related Income in Household Economies and Rural Livelihoods in the Border Region of Southern China." *World Development* 43: 111–123. doi:10.1016/j.worlddev.2012.10.010.

Ickowitz, A., B. Powell, M. Salim, and T. Sunderland. 2014. "Dietary Quality and Tree Cover in Africa." *Global Environmental Change* 24: 287–294. doi:10.1016/j.gloenvcha.2013.12.001.

Kalaba, F., C. Quinn, and A. Dougill. 2013a. "Contribution of Forest Provisioning Ecosystem Services to Rural Livelihoods in the Miombo Woodlands of Zambia." *Population and Environment* 35 (2): 159–182. doi:10.1007/s11111-013-0189-5.

Kalaba, F., C. Quinn, and A. Dougill. 2013b. "The Role of Forest Provisioning Ecosystem Services in Coping with Household Stresses and Shocks in Miombo Woodlands." *Ecosystem Services* 5: 143–148. doi:10.1016/j.ecoser.2013.07.008.

Kamanga, P., P. Vedeld, and E. Sjaastad. 2009. "Forest Incomes and Rural Livelihoods in Chiradzulu District." *Ecological Economics* 68 (3): 613–624. doi:10.1016/j.ecolecon.2008.08.018.

Kar, S., and M. Jacobson. 2012. "NTFP Income Contribution to Household Economy and Related Socio-Economic Factors: Lessons from Bangladesh." *Forest Policy and Economics* 14 (1): 136–142. doi:10.1016/j.forpol.2011.08.003.

McSweeney, K. 2005. "Natural Insurance, Forest Access, and Compounded Misfortune: Forest Resources in Smallholder Coping Strategies before and after Hurricane Mitch, Northeastern Honduras." *World Development* 33 (9): 1453–1471. doi:10.1016/j.worlddev. 2004.10.008.

Mensah, S., R. Veldtman, A. Assogbadjo, C. Ham, R. Kakaï, and T. Seifert. 2017. "Ecosystem Service Importance and Use Vary with Socio-Environmental Factors: A Study from Household Surveys in Local Communities of South Africa." *Ecosystem Services* 23: 1–8. doi:10.1016/j.ecoser.2016.10.018.

Miah, M., S. Chakma, M. Koike, and N. Muhammed. 2012. "Contribution of Forests to the Livelihood of the Chakma Community in the Chittagong Hill Tracts of Bangladesh." *Journal of Forest Research* 17 (6): 449–457. doi:10.1007/s10310-011-0317-y.

Misbahuzzaman, K., and C. Smith-Hall. 2015. "Role of Forest Income in Rural Household Livelihoods: The Case of Village Common Forest Communities in the Chittagong Hill Tracts." *Small-Scale Forestry* 14 (3): 315–330. doi:10.1007/s11842-015-9290-1.

Newton, P., D. Miller, M. Byenkya, and A. Agrawal. 2016. "Who Are Forest-Dependent People? A Taxonomy to Aid Livelihood and Land Use Decision-Making in Forested Regions." *Land Use Policy* 57: 388–395. doi:10.1016/j.landusepol.2016.05.032.

Ninan, K., and M. Inoue. 2013. "Valuing Forest Ecosystem Services: What We Know and What We Don't." *Ecological Economics* 93: 137–149. doi:10.1016/j.ecolecon.2013.05.005.

Reed, J., M. Ros-Tonen, and T. Sunderland. 2020. *Operationalizing Integrated Landscape Approaches in the Tropics*. Bogor,: Center for International Forestry Research.

Reed, J., J. van Vianen, S. Foli, J. Clendenning, K. Yang, M. MacDonald, G. Petrokofsky, C. Padoch, and T. Sunderland. 2017. "Trees for Life: The Ecosystem Service Contribution of Trees to Food Production and Livelihoods in the Tropics." *Forest Policy and Economics* 84: 62–71. doi:10.1016/j.forpol.2017.01.012.

Rowland, D., A. Ickowitz, B. Powell, R. Nasi, and T. Sunderland. 2017. "Forest Foods and Healthy Diets: Quantifying the Contributions." *Environmental Conservation* 44 (2): 102–114. doi:10.1017/S0376892916000151.

Sunderland, T., R. Abdoulaye, R. Ahammad, S. Asaha, F. Baudron, E. Deakin, J.-Y. Duriaux, et al. 2017. "A Methodological Approach for Assessing Cross-Site Landscape Change: Understanding Socio-Ecological Systems." *Forest Policy and Economics* 84: 83–91. doi:10.1016/j.forpol.2017.04.013.

Sunderlin, W., A. Angelsen, B. Belcher, P. Burgers, R. Nasi, L. Santoso, and S. Wunder. 2005. "Livelihoods, Forests, and Conservation in Developing Countries: An Overview." *World Development* 33 (9): 1383–1402. doi:10.1016/j.worlddev.2004.10.004.

Sunderlin, W., I. Dewi, A. Puntodewo, D. Muller, A. Angelsen, and M. Epprecht. 2008. "Why Forests Are Important for Global Poverty Alleviation: A Spatial Explanation." *Ecology and Society* 13 (2): 24. https://www.jstor.org/stable/pdf/26267968.pdf. doi:10.5751/ES-02590-130224.

United Nations Development Programme (UNDP). 2009. *Socio-Economic Baseline Survey of Chittagong Hill Tracts*. Dhaka: UNDP.