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Causes and consequences of shifting cultivation and its alternative in the hill tracts of eastern Bangladesh

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Abstract Shifting cultivation, which is still prevalent in the uplands of eastern Bangladesh, contributes significantly to forest loss and is the main cause of land degradation. This paper presents the causes and consequences of shifting cultivation and its potential land use alternatives. The analysis presented is primarily qualitative with a supplementary quantitative analysis of the causes of forest loss by logistic regression. The results of the study show that traditional land practices, exacerbated by poverty and associated with a lack of technical knowledge is the main cause for the continuation of unsustainable shifting cultivation. Population pressure, inadequate land for cultivation, low education levels, policy planning and implementation without local participation are all factors that influence farmers' decision to continue shifting cultivation. Intensive land management through agroforestry is a promising alternative that can sustainably manage the remaining forest resources. If adopted, such systems potentially provide good economic returns, and may significantly reduce rural poverty.

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Introduction

In recent years, there is increasing evidence of the impacts of forest depletion on the environment, such as climate change, loss of biodiversity, watershed degradation and consequent downstream effects (FAO 2006). Therefore, forests in general and tropical forests in particular have been receiving increasing attention from the world community (Miah and Islam 2007). Agenda 21 of United Nations Conference on Environment and Development (UNCED) at Rio de Janeiro (1992) devoted a full chapter to the issues of forest conservation and development (Mai 1999). A challenge for the world community today is to achieve a balance between development and maintenance of natural systems and to ensure the integrity and stability of forest ecosystems and the services they provide (Sharma 1992).

Within South and Southeast Asia, Bhutan, India and Vietnam have increased their forest cover in recent years, the majority of the other countries in the region have experienced a net loss of forest cover (FAO 2006). In Bangladesh, extensive and shifting agriculture, due to an increasing demand for food and fodder is the main driver of drastic deforestation and land degradation (Rasul et al. 2004). At present only 6.7% of the country's surface area is covered by forest, with

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a net deforestation rate estimated at −0.3%, the equivalent of 2,000 ha per year (FAO 2006). In the case of eastern Bangladesh, a drastic reduction of the shifting cultivation cycle due to high population growth is contributing to significant deforestation. This is also resulting in negative downstream effects on the environment creating a cycle of poverty that particularly affects rural farmers (Rahman et al. 2007). The people in the uplands of eastern Bangladesh have been practicing shifting cultivation from time immemorial and it is closely related with their socio-cultural identity (Miah and Islam 2007). However, in the past, they practiced shifting cultivation in the same area with a fallow period of 15–20 years, which ensured the long-term sustainability of soil fertility, and ensured forest regrowth. With the rapid growth in population, the fallow period has been dramatically reduced to 3–4 years, allowing very little time for soil or vegetative regeneration (Riessen 2000). The decrease in fallow period has led to the deterioration of faunal and microbial organisms, top soil loss, and erosion during periods of heavy rainfall (Gafur 2001).

Forest loss and degradation in the upper streams of watersheds, in particular, do not only inversely affect the socio-economic activities of local people, but also negatively influence downstream life and production, e.g., frequent and serious flooding, rapid siltation and deposits of gravel in delta areas which also have negative effects on agricultural productivity.

Shifting cultivation has gradually been replaced by more intensive forms of land use in Asia and elsewhere (Spencer 1966; Watters 1971). For instance, in the mountains of Nepal shifting cultivation had been completely replaced by intensive sedentary agriculture by the end of the nineteenth century. Such land use has been gradually replaced by agroforestry and tree based land uses in Nagaland, India (NEPED and IIRR 1999). In the mountains of northern Thailand and peninsular Malaysia, and on the islands of Java and Bali in Indonesia, shifting cultivation has been largely replaced by sedentary commercial agriculture over the last few decades (Turkelboom et al. 1996; Suraswadi et al. 2000).

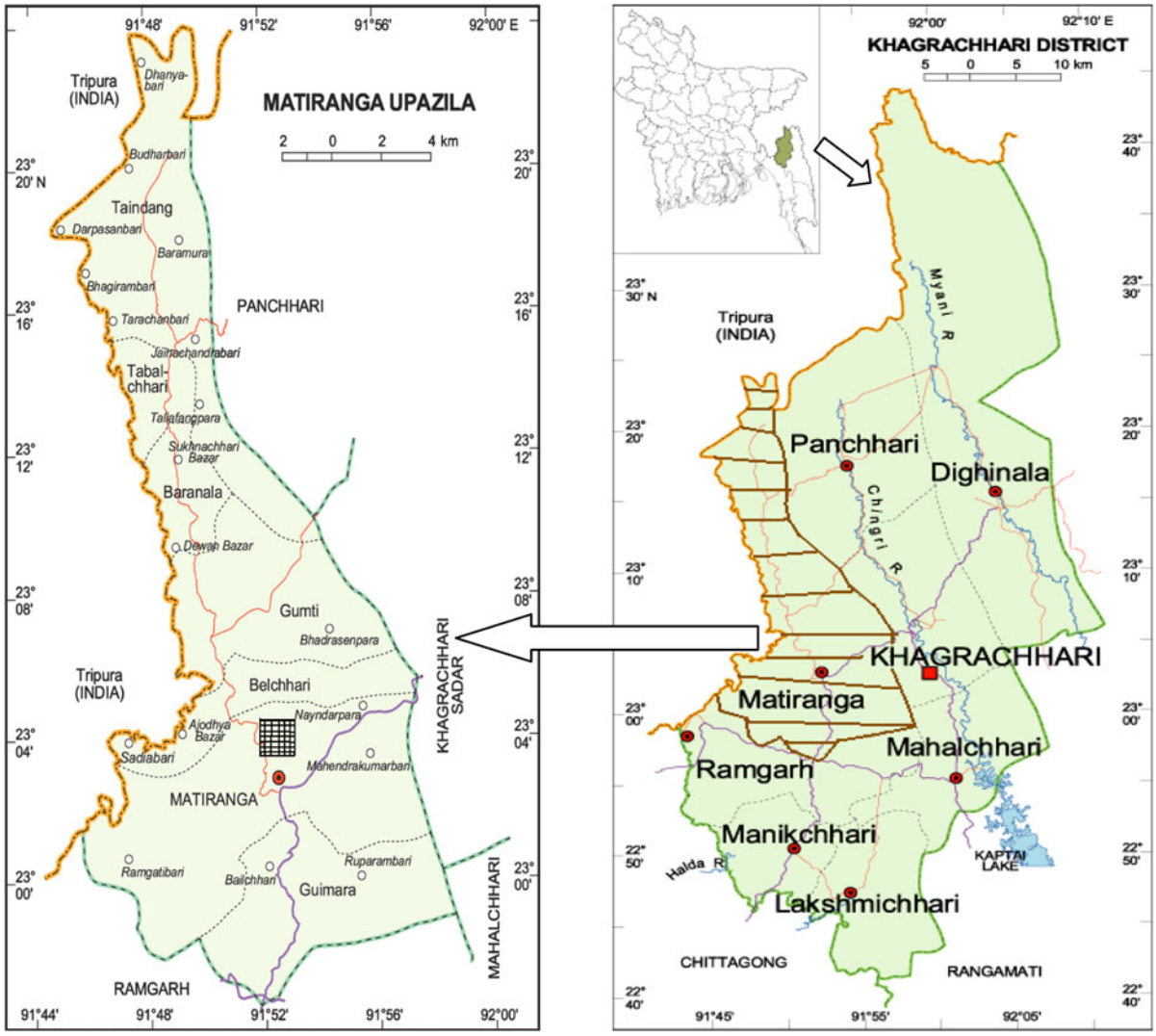
The main objective of this research is to identify the underlying cause of shifting cultivation, its impact on environment and livelihoods, and the potential of agroforestry as an alternative land use option in the uplands of eastern Bangladesh.

Materials and methods

Dashnong village of Matiranga Upazila (a small administrative unit) of Khagrachari District in the uplands of eastern Bangladesh was selected for the study, because of its remoteness and the fact that, historically, shifting cultivation is a common cultivation practice in this region (Map 1). The study village is a part of the Chittagong Hill Tracts (CHT), the only extensive upland area (with a mean elevation of 160 ft above sea level) in Bangladesh which lies in the eastern part of the country between 23°04′56.24″N–23°05′16.1″N and 91°51′53.64″E–91°52′45.16″E. The climate of this region is characterized by a tropical monsoon climate with mean annual rainfall over 2,540 mm (BBS 2009). The vegetation is characterised by semi-evergreen (deciduous) to tropical evergreen forest dominated by tall trees belonging to the families: Dipterocarpaceae, Euphorbiaceae, Lauraceae, Leguminosae and the Rubiaceae and a species of grass (*Imperata arundinacea*) known locally as *shan* (BBS 2007).

With its current population of ca. 500 people (90 households), the village of Dashnong which is inhabited by an ethnic group of Mongolian descent called the Tripura. Most of the houses are made by bamboo, straw and mud, where only one primary school and a narrow road poorly accessible especially in the rainy season. The lands are occupied by dwelling units, home gardens, shifting cultivation fields and natural forest. The staple crops rice and maize are cultivated in the shifting cultivation fields, and harvested forest produce, i.e., firewood, timber, bamboo, rattan, wild fruits, mushrooms, bush meat, etc., is primarily for consumption at the household level with any surplus sold.

Primary data has been collected through Participatory Rural Appraisal (PRA) and household surveys with a purposive sampling of 60 shifting cultivators (households). The household surveys were undertaken using structured questionnaires that included questions on the underlying drivers of shifting cultivation, i.e., household size, income, assets, credit behaviour, land size, livelihood strategies typology, etc. The questionnaire was prepared before arriving on site, and was subsequently tested with six households in the area to make sure the questions were pertinent. A number of questions were refined with the help of people on site, with additional input



Map 1 Location of study village (marked in *grid lines*)

from the implementation of Rapid Rural Appraisal, techniques and by the reconnaissance visits.

Supporting primary data has been gathered by the way of personal communication and key informants interviews (and semi-structured) with village headmen, technical officials and local authorities in order to obtain additional information of the reason and consequences of shifting cultivation practice, and the policies of government organizations at the research site.

Secondary data from statistical year books, local administrative records and various related sources on local natural, socio-economic and environmental conditions, existing cultivation practices, forest resource uses, potential land use option, i.e., agroforestry have also been used. The research questions and related hypotheses under specific objective, as well as data requirements, and data collection and analysis methods are listed in Table 1.

Qualitative and quantitative analysis methods were used to analyse the information. Descriptive statistics, such as logistic regression, was applied to clarify the factors that affect the farmers' decision on slash-and-burn practice as well as the consequences of this choice.

The logistic regression is applied to obtain a deeper insight into the causes of shifting cultivation. Such analysis is based on the cumulative distribution function, which shows the conditional probability that an event will occur given the value of a set of

Table 1 Matrix of research questions, hypotheses, data collection and analysis

Research questions	Hypotheses	Data requirements	Data collection/ method	Data analysis
1. What is the underlying cause of shifting cultivation?	1.1. Household condition (socio-economic and demographic), livelihood strategy and local custom coupled with underdeveloped markets and inappropriate government policies are the main reason of shifting cultivation continuation	Household size, income, assets, credit behaviour and land size Household decision makers age and education Local land use practices Local market structure Existing government policies Livelihood strategies typology	PRA Structured household questionnaire survey Personal communication and key informant interview Secondary data collection	Quantitative analysis with descriptive statistics (i.e., frequency, mean, logistic regression) Qualitative analysis
2. What are the local livelihoods and environmental impacts of Shifting cultivation?	2.1. Shifting cultivation has negative impacts on environment, e.g., deforestation, soil erosion and other downstream effects 2.2. Forest clearance and declining land productivity due to soil erosion from shifting cultivation results in low income and poverty	Cultivation type, fallow period and yields. Way of forest clearance Forest products availability Soil erosion rate	Structured household questionnaire survey Personal communication and key informant interview Secondary data collection	Quantitative analysis with descriptive statistics Qualitative analysis
3. Does agroforestry have potential as an alternative land use option?	3.1. Agroforestry is a potential land use option that could benefit livelihoods and environment, i.e., cash income, forest land restoration, soil erosion control	Income, feasibility, effectiveness, and efficiency of agroforestry Evidence from agroforestry projects Tenure assessment	Secondary data collection Content analysis	Qualitative analysis

independent influential factors. The logistic distribution function is specified as follows:

$$P_i = \frac{1}{1 + e^{-z_1}} \quad (1)$$

where P' is the probability that the event Y will occur ($Y' = 1$) in observation i for given value of the affecting factors, and Z' is the linear combination of these factors:

$$Z = \beta_0 + \beta_1 X_{li} + \cdots + \beta_k X_{k_2} \quad (2)$$

Logit is simply the natural log of the odd ratio in favour of event Y—the ratio of the probability that the event Y will occur to the probability that it will not occur:

$$L_i = \ln\left(\frac{P_i}{1 - P_i}\right) = \ln\left(\frac{1 + e^{z_1}}{1 + e^{-z_1}}\right) = \ln e^{z_1} = Z_i \quad (3)$$

Hence $Z = \beta_0 + \beta_1 X_{li} + \cdots + \beta_k X_{ki}$.

The interpretation of the logit model is as follows: the slope p_i measures the change in L' for a unit change in X_{ki}. The interpretation of the intercepts may not have any physical meaning. Once the coefficients b_k are estimated, the probability of the occurrence of event Y_i can be obtained directly from Eq. 1.

Results

Characteristics of shifting cultivation at research site

The study village has its own territory which is not encroached upon by outsiders without the agreement of village residents. This inviolability of the village territory is respected by all people and any violation is punished. All residential and cultivation activities take place within that territory. Most of the land in the study site is owned by the state. However, residential land in the village is allocated to each family and the shifting cultivation fields in the forest are owned by each clan or family, but they do not have permanent or long-term statutory land transfer rights.

The villagers rely on a subsistence economy based on rotational shifting cultivation locally called *jhum* which is primarily practiced on the hill slopes (Rahman et al. 2007). Forest is cleared for cultivation and the planting of upland rice, sometimes in combination with maize, cassava and vegetables on steep slopes. Vegetation is cut, slashed and burnt between January and May, and crops are then planted. These are harvested between June and December. The village has a custom of using only one upland plot per agricultural season. The size of cultivation plot depends on food requirement and available labour of each family. This plot is used for only 1 year. It is then left fallow and another plot will be cleared for cultivation the following year. Traditionally, the fallow period was 10–25 years, but it is now 2–3 years due to an increased population and a concomitant decreasing availability of land (Table 2).

The vegetable seeds are usually mixed with the rice seeds and both are sown together. Sometimes, a small plot of cassava is planted and it is harvested only gradually when there is the need for immediate consumption. No other inputs than labour are necessary for all crops.

Table 2 The schedule of cultivation work during a year is as follows

Time	Activities
January and February	Land clearance
March	Field burning (at the end of the month)
April	Maize and early rice plantation
May	Main rice plantation
June	Weeding
July	Weeding and maize harvest
August	Weeding
September	Early rice harvest
October and November	Main rice harvest

Causes and consequences of shifting cultivation

Despite the government's effort and considerable investment on fixed cultivation and sedentarization for tribal people, the majority of the villagers still practice shifting cultivation. Why does this happen and what consequences may be attributed to shifting cultivation?

Causes of shifting cultivation

Traditional cultivation customs

The first principal driver of shifting cultivation is tradition. It is a part of culture and has already been practiced by generations. The ingrained customs and habits restrict efforts to integrate modern high-yielding varieties, species and cultivation techniques and hence, undermine a possible tendency towards intensive farming.

Poverty

Another important cause of shifting cultivation is poverty. This area can be classified as a remote area with poor infrastructure and social conditions, low commodity production and living standards. The villagers are primarily subsistence farmers. The first priority related to their agricultural production is to produce enough foods for the family's survival. Nevertheless, most of them are very poor and normally suffer with food shortages for 3–5 months a year. In our research we found 65% of the sample

households as "extreme poor" (income below US $1/per head/day), 32% poor (income below US $2/per head/day) and 3% medium and better off households in the village (Fig. 1). During periods of food shortage, most households harvest bamboo shoots, vegetables and other forest products (63.9%), procure rice and other foodstuffs from their relatives or neighbors (51.4%) or go to work as hired labourers (34.7%). The government's subsidies through pension allowances (aged 57 and above), disabled and vulnerable women's scheme, etc., are modest and only four interviewed households have received in-kind agricultural subsidies because they have particularly good relations with local government officials. Incomes from sources other than agricultural production are very limited. Thus, poverty driven shifting cultivation due to lack of capital and limitation of low lying land for permanent cultivation keep farmers in a cycle of poverty.

Limited availability of permanent agricultural land

There is a limitation of low lying land for permanent cultivation in the study site. Insufficient land for cultivation results in low agricultural outputs and is thus insufficient of the family's needs. The reclamation of unused land requires huge capital that goes beyond the capacity of the families who are already in poverty. Therefore, the tendency is to cut forests in the hills and practice shifting cultivation.

Population pressure on land

There are some factors that put increased pressure on the agricultural land, which is already limited in extent. Firstly, it is the *unawareness of family planning*. The population growth rate in the region is relatively high: ca. 2.60% (BBS 2007). The second factor is in-migration. The government's policy of settlement has created a huge stream of subsidized immigrants to this region since 1976 and together with them, increasing requirements for agricultural land for their subsistence. The situation is further exacerbated by a growing spontaneous migration in recent years, also resulting in ethnic conflict. Even a remote small commune in our study site, has grown from only eight households to 90 households, with a population of 500 persons, over the past 100 years. As such, a large portion of total communal agricultural land (384 ha out of 1,335 ha, or 28.8%) is now cultivated by the people of the commune. This land is comprised mainly of both agricultural and fallow land, which are compatible for rice cultivation.

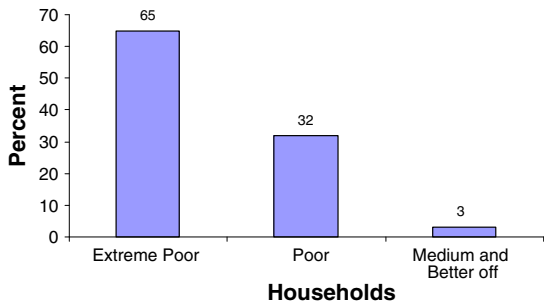


Fig. 1 Household classification (extreme poor, US $1/per head/day; poor, US $2/per head/day). *Source* Village Survey (2008); $n = 60$

Lack of capital

Land shortages can be overcome by an increase in land productivity. This can be obtained by increasing the investment in the production inputs, or in the development of more intensive farming systems. However, poor people do not have enough money even for their subsistence, while access to credit is limited. There is a difficulty in procedure for credit application and for repayment in the short term. With this resulting lack of capital, most farmers are rarely able to apply fertilizers and other agrochemical inputs for annual crops which results in very low productivity. The yields of main crops at the researched site in comparison with the ones of the country, the region and the village are shown in Table 3.

Lack of technical knowledge

Another way to improve land productivity is to use appropriate techniques of planting and cultivation for each tree and crop species. However, the popular cultivation technique in the study site remains shifting cultivation of upland rice and traditional maize with little or no fertilizer application. Most people are not familiar with the cultivation techniques of wetland rice and other new crop species. They do not know how to grow and select the seeds and seedlings, to apply fertilizers and agrochemicals appropriately.

Table 3 Yields of main annual and perennial crops (kg/ha)

Products	National average	Khagrachari district	Study village
Upland rice	–	2,291	1,197
Paddy rice	3,980	3,590	2,310
Maize	2,391	3,315	2,575

Sources BBS (2007), Khagrachari Statistical Office (2008), Village Survey (2008)

At the same time, the capacity of government extension services is very poor. The majority of extension workers have little knowledge of the study site, and optimum cultivation practices. They are restricted by a lack of resources and are de-motivated due to the low salaries they receive. As a result, the most popular extension work is to deliver prescriptive messages. All the demonstration plots have been made in the fields close to the town for easy management and ensuring success; hence new technologies rarely reach those that need them most. Extension workshops are seldom organized for the more remote villagers.

Poor education and health care systems

The education level is low in the study site, as the education system has not yet been adequately developed (Fig. 2). Lack of education is a constraint to the farmers' capability of embracing new cultivation techniques. Poor education also accompanies the lack of awareness of family planning, which results in increasing population pressures on the land. It also results in low levels of environmental consciousness. In our study we found that the people do not understand the relation between the forest loss and natural disasters such as soil erosion. There is little evidence of the application of erosion control measures by shifting cultivators and incidences of soil erosion are high. Most of the farmers are in poor health which results in low productivity of most labourers and thus, correspondingly low crop yields. Due to the reasons described above, limited education and poor health are indirect motives for people to change or adapt their existing cultivation practices.

Land tenure insecurity

Most land in the study site is owned by the state. Although the tribal people of Dashnong village use state land for their traditional shifting cultivation they do not have any permanent or long-term rights to the land. Tenurial insecurity combined with frequent displacement cultivates a feeling of insecurity, discouraging investment in better land, including fallow, management. Tenurial insecurity also limits access to formal credit required for initial investment and for procuring the inputs needed to improve land use practices. *The Chittagong Hill Tracts Forest Transit Rules, 1973* and subsequent administrative orders regulate the harvesting and marketing of timber and other forest products available from private land. These rules require people to obtain written permission from government offices before harvesting and transporting forest products for marketing, especially timber. And getting permission is often difficult as in most cases government officials require direct, and illegal, payment to issue licenses. As a result, small-scale tree growers are compelled to sell timber to local traders at a price much lower than the market price, which has discouraged them from establishing large-scale tree plantations, where tenurial insecurity also another important factor. Besides, farmers and traders have to pay a tax to several local government organizations, including hill district councils, municipalities and union *parishods* (rural local government), for transporting and marketing agricultural products. These taxes depress local prices

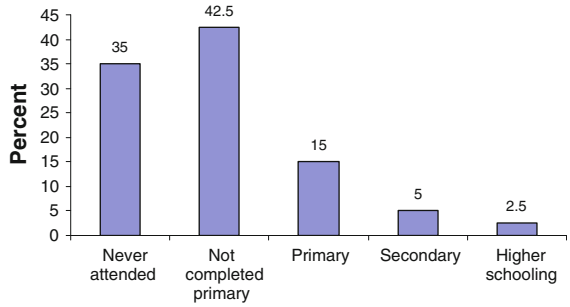


Fig. 2 Educational levels of the farmers

and ultimately discourage farmers from adopting the cultivation of locally-suitable cash crops.

Underdeveloped markets

The market structure for permanent agricultural products is very underdeveloped in the area. Hence, farmers usually have to sell their crops at low and unstable prices which undermines their income. The low prices are also caused by the low quality of the products because of the absence of logistics and processing facilities in the region. The absence of a formal market also promotes subsistence agriculture because of two main factors. Firstly, there are no other sources of food supply than the production by farmers themselves. Second, there are very few opportunities for off-farm income; hence the sources of income are restricted to their own cultivated fields.

Construction and implementation of government development policies without people's participation

The government has conducted a series of programmes in order to stabilize and improve the life of ethnic minorities in the uplands. However, all these programmes are imposed without a concern for tradition, cultural features and cultivation practice of each ethnic group. Therefore, ethnic minorities passively participate in a change of livelihood strategies, as if they are objects of exterior interference but not actors. The Forest Enterprise in the study site, for instance, selected areas for protection based on its own maps and information, without studying people's traditional land use boundaries. Hence, they chose only the forests surrounding the villages for easy control. As a result, people lost significant areas of fallow land close to the villages that previously belonged to them. The fallow rotation was shortened, the soil was degraded and the productivity decreased which forced people to find more land for cultivation to meet their subsistence. Therefore, shifting cultivation is not controlled, but is encouraged to be practiced in forests further from the village where there is little or no control over land use.

Empirical test by logistic regression

The logistic regression is applied here to provide a deeper insight into the causes of shifting cultivation. The dependent variable in our case is binary which takes the value "1" if the farmer practices shifting cultivation and "O" if otherwise. The definition and expected signs of the explanatory variables are described in the Table 4.

It is expected that the older and non educated farmers relate more closely to the shifting cultivation tradition and have greater tendency to practice it. The exclusion of shifting cultivation land from the land variable is based on the supposition that with less available permanent cultivation land the farmer will be more inclined to practice shifting cultivation. Large family size and the lack of the opportunities of off-farm earnings all significantly increase the farmer's possibility to opt for shifting cultivation. More off-farm incomes help households to cover their basic needs that the farm production cannot fully provide, therefore reducing their reliance on shifting cultivation. The probability of permanent agriculture may be increased through more investment and access to available credit.

The regression results can be interpreted as follows:

- *LAND, INCOME, CREDIT and EDUCATION*: The insignificance of land, income and credit

Table 4 Definition and expected signs of independent variables in logistic regression

Variables	Definition	Expected signs
AGE[a]	Decision maker's age in years	+
EDUCATION	Decision maker's year of schooling	+
LAND	Household's non-shifting-cultivation land, in hectares	+
HEAD[a]	Total number of people in the household, in person	+
INCOME	Household's non-agricultural incomes	+
CREDIT	= 1 if the farmer has got credit from any sources, and 0 otherwise	+

[a] Significant variables

variables are quite contradictory from our previous analysis and thus can be explained by the fact that tradition and customs are still a decisive factor influencing the farmers' choice of shifting cultivation. The education of the majority of the farmers remains low (Fig. 2), and the small and scattered cultivation plots restrict the efficiency of the productive assets. Therefore, the farmers' education have limited effect on agricultural production and hence on the farmers' probability of changing from shifting cultivation.

- *AGE and HEAD:* The regression coefficients of these variables once again prove that the younger farmers with small household size play an important role in the decrease of the shifting cultivation probability and practice (Tables 5, 6).

67% is the model accuracy, which means 67% of predicted data match the observed.

Consequences of shifting cultivation

As we have shown, traditional shifting cultivation, in the context of low population density and the absence of the market economy, presented itself as a sustainable cultivation method that did not cause significant negative consequences for either the environment or society. However, given the lack of land and an increasing population this is no longer the case. The two main consequences of actual shifting cultivation are forest and land degradation, and deforestation.

Forest and land degradation

With shortened fallow periods, there is not enough time for forest regeneration and young, secondary forest gradually replaces old forest. Field clearance by slash-and burn cultivation prevents the regeneration of evergreen forest, leading serious soil erosion and declining in productivity.

Also cultivation has to be done on young forest soils after short periods of fallow, as the soil becomes impoverished, the weed pressure increases which then requires more labor inputs for weeding, and the rice yields are subsequently lower. All the village elders, village headmen and experienced farmers, who were respondents of the survey, realized that the cultivation in the "old" forests with the fallow period of more than 12 years may give the yields of 2.5–3 tons of upland rice, and 100–300 kg of traditional maize per ha. The yields for cultivation in young forests with less than 3–5 years of fallow are only 0.5–1 ton and 50–60 kg per ha, respectively. Therefore, the shifting cultivation has become unsustainable and inefficient. It drives the

Table 5 Age as a function of people interested in agroforestry

Variables in the equation						
	B	SE	Wald	df	Sig.	Exp(*B*)
Step 1[a]						
AGE	−0.084	0.027	10.110	1	0.001	0.919
Constant	3.574	1.123	10.128	1	0.001	35.670

Classification table[b]			
Observed	Predicted		
	Interest in agroforestry		Percentage correct
	No	Yes	
Step 1			
Interest in agroforestry			
No	17	11	60.7
Yes	9	23	71.9
Overall percentage			66.7

[a] Variable(s) entered on step 1: AGE

[b] The cut value is 0.500

Table 6 Household size as a function of people interested in agroforestry

Variables in the equation[a]						
	B	SE	Wald	df	Sig.	Exp(*B*)
Step 1[a]						
HSIZE	−0.590	0.230	6.609	1	0.010	0.554
Constant	2.655	1.009	6.922	1	0.009	14.229

Classification table[b]			
Observed	Predicted		
	Interest in agroforestry		Percentage correct
	No	Yes	
Step 1			
Interest in agroforestry			
No	15	13	53.6
Yes	7	25	78.1
Overall percentage			66.7

[a] Variable(s) entered on step 1: HSIZE

[b] The cut value is 0.500

cultivators into increasing poverty with regular food shortages.

Deforestation

The most severe deforestation by shifting cultivation can occur two ways. Firstly, the shifting cultivators who left their land fallow after cultivation then continue clearing forests for further cultivation. Secondly, forest fires are caused by uncontrolled burning during land clearance for shifting cultivation. The lands for shifting cultivation now are scattered, the forest land is no longer the ancestral property of the village, therefore no punishment is applied for setting deliberate forest fires by the community.

Forest product impoverishment

Forest degradation and deforestation bring about the local extirpation of forest products. Some forest products such as litsea bark (*Litsea glutinosa*), forest ginger (*Zingiber* spp.) and alpinia (*Alpinia galangal*) can only be found at more than 10 km from the village. Rattan is almost no longer collected due to its scarcity. Therefore, harvesters have to spend more time and labor to collect once common forest products including bamboo shoots or fuelwood. As a result, the life of the villagers has been directly impoverished and their living standard has been lowered.

Soil erosion and impoverishment

The loss of vegetation cover increases the incidence of soil erosion because the soil is more frequently affected by precipitation. The soils of hilly area are the most susceptible to water erosion in which sheet, rill and gully erosion occurs (Shoaib et al. 1998; Sfeir-Younis and Dragun 1993). About 75% of the hilly areas have very high susceptibility to erosion, 20% have high susceptibility and 5% have moderate susceptibility to erosion (BARC 1999). Shifting cultivation in hilly area causes gully erosion and losses in topsoil ranges from 10 to 120 tons/ha/year (Farid et al. 1992). In the past, the thick forests surrounding shifting cultivation fields helped to control the erosion. Nowadays, with the decrease in forest cover, soil erosion has become increasingly problematic.

The average organic matter content of top soils (high land and medium high land situation) has reduced from about 2 to 1% over the last 20 years due to intensive cultivation which means and decline by 20–46% (Miah et al. 1993). Each year, the eroded

soil from all the *jhum* fields in CHT carries out about 4,309 tons of nitrogen along with other nutrients (Gafur 2001). About 14,071 tons of commercial fertilizers would be required to replace nutrients in eroded soil that would cost approximately US $1.8 million annually (Gafur 2001).

The reduction in availability of forest products due to forest loss and degradation lowers the productivity of agricultural land by a decrease in soil fertility due to soil erosion and shorten fallow periods. There is a cycle of poverty being caused by shorter cropping cycles and soil impoverishment leading to more poverty. In short, poverty is the primary motive for shifting cultivation of the study site which results in negative impacts on the wider environment.

Downstream effects

The soil erosion and hydrological regime disruption in the upper watershed result in a range of downstream effects for its lowland and coastal region. More frequent and more serious flooding, more rapid siltation of irrigation channels and deposits of gravel (as well as silt) in delta areas have the effects on agricultural productivity and outputs of the lowland farmers, and thus on their standard of living as well.

Agroforestry as an alternative land use option

Agroforestry is considered as one of the major strategies for sustainable forest management as well as poverty reduction in Bangladesh, where there is obvious priority for food crop production. Research (Rahman and Islam 1997) has indicated that agroforestry may not only be an optimal solution for afforestation, biodiversity conservation (Alam et al. 1996) and the sustainability of the environment, but may also have better economic rates of return. Through agricultural intensification, agroforestry not only helps to increase food and fodder but also protects the existing forest where unemployed and poor people earn their livelihoods (Elevitch and Wilkinson 2000). Now agroforestry has earned a distinct identity as an approach to sustainable land use. Agroforestry helps to lift the rural poor from poverty through market driven, locally led tree cultivation systems that generates income and build assets, It also contributes to the conservation of biodiversity through integrated conservation-development solutions based on agroforestry technologies (Garrity 2004). Furthermore, it can protect forest through agroforestry based solutions; assist the rural poor to better adapt to change, and to benefit from emerging carbon markets, through tree cultivation.

Evidence from Upland Settlement Project (USP)

Project history and profile

The USP, a community-focused land management and agroforestry project, is located in the CHT region of Bangladesh. The project attempts to 'rehabilitate and develop' impoverished ethnic farmers (Marma, Tripura, Chakma and the Tanchangya) through the promotion of an agroforestry 'model'. These farmers have hitherto been engaged in shifting cultivation (Khan and Khisa 2000).

In line with the previous attempts in resettlement of the ethnic communities in CHT, USP was originally conceived in 1979 under the purview of the government's premier agency charged with the development of CHT, known as the Chittagong Hill Tracts Development Board (CHTDB). The project became fully operational in 1985 and it 'resettled' some 2,000 ethnic families in a number of purposively-developed agroforestry plots. As a sequel to the first phase of the USP, the second phase started in 1994, involving 1,000 landless and marginal shifting cultivator families who have been resettled in 20 purposely-developed 'project villages' in the districts of Khagrachari and Bandarban. The stated goals of the project include the following:

(i) organized settlement of ethnic shifting cultivators in the upland areas of Khagrachari and Bandarban districts in CHT;
(ii) development of the marginal and degraded upland areas (which currently remains fallow, underutilized or unsustainably exploited) through integrated and intensive agroforestry activities, including rubber plantations;
(iii) promotion of long-term socioeconomic uplifting and empowerment of the targeted families;
(iv) enhancement of local community participation in development activities;
(v) securing, widening, and sustaining a source of livelihoods for the participating ethnic communities; and
(vi) improvement of the local environment, especially in the forms of reducing the rate of soil

erosion and deforestation, and increasing the tree coverage in the area.

The agroforestry model, which USP attempts to promote and disseminate, is known as the Contour Hedgerow Intercropping Agroforestry Technology (CHIAT) (for a fuller description of CHT and the context of development of CHIAT in the region, see respectively Khan and Khisa 2000).

Each participating shifting cultivator family has been allotted a total of 2.12 ha of land, out of which 0.5 ha is intended for homestead and agroforestry activities, and 1.6 ha for raising rubber (intercropped with banana) plantations. Table 7 depicts the common land use pattern in the study area.

Summary of lessons

The project has contributed to the increased status and recognition of the farmers by providing them with the ownership of the land and by augmenting their income level. It has also been observed that the project farmers have emerged as a 'power group' in the local government elections and, therefore, have received increased attention from the local political leadership, patron–client relations between farmers and the local elite are manifested in such occasions as accessing political power; securing loan and assistance from informal money lenders, and accessing the formal sectors.

The project has, however, contributed significantly towards increasing the social status of women both at the family and organizational levels. The limited income which they earn by participating in the project activities seems to instill a sense of self-esteem among the women (Bhuiyan 1994).

As compared to their earlier predicament, farmers' income has increased after joining the project. The project also shows positive impact on expansion of greenery and soil conservation. It has a strong influence on the working dynamics of the principal forces of deforestation in the locality. The farmers seem to be aware and conscious about the nature and causes of resource depletion in the locality (Bhuiyan 1994).

Evidence from the Betagi and Pomora Social Forestry (SF) project

Project history and profile

The Betagi and Pomora SF projects are located respectively in Betagi and Pomora villages, about 25 km northeast of Chittagong City in eastern Bangladesh. The total area under the Betagi project is 190 ha of state land under the Ministry of Land. The Pomora project constitutes 276 ha of protected forest land (under purview of FD) and 24 ha fallow land (ADB 2001).

The Betagi and Pomora projects were launched in 1979 and 1980, respectively. The historical background and general description of the projects are also widely covered by Rahman (1992), Alim (1988), and Quddus et al. (1992).

Table 7 Land use in the agroforestry plots

Slope category (%)				
Up to 5%	5–15%	15–30%	30–60%	Above 60%
Level to gently sloping	Sloping	Moderate steep	Steep	Very steep
Upland rice	Upland rice	Upland rice	Upland rice	Upland rice
Vegetable	Vegetable	Banana	Banana	Banana
Ginger turmeric	Ginger turmeric	Litchis	Litchis	Forest species (especially *Gmelina arborea*, *Tectona grandis*, *Acacia* spp., *Cassia* spp., *Leucaena* spp.)
Banana	Banana	Jackfruit	Jackfruit	
Pineapple	Pineapple	Pineapple	Pineapple	
Lemon	Lemon	Mango	Bamboo	
Guava	Guava	Amra		
Papaya	Papaya	Bel		
Custard apple	Custard apple	Areca nut		
Areca nut	Areca nut			Bamboo

Before 1950, this area was densely forested. Since the 1950s, there had been a prolific growth of commercial logging by an alliance among the local elite, urban timber traders, and a section of government and local government officials. By the early 1970s, the once dense forests of the locality were reduced to, at best, patches of "scattered bushes" (Rahman 1992) and at worst, completely barren, wide, open lands (Alim 1988).

Against this backdrop, some renowned intellectuals, senior government officials, and local philanthropists envisaged a community-based forestry program for the region with an aim to "rehabilitate the denuded hills with productive trees and the landless with subsistence economy" (Ahmed and Azad 1987). Some landless families were selected from the adjoining villages and were rehabilitated in the SF projects. Each family (farming household) was allotted 4 acres (1.62 ha) of land on annual renewal basis. In 1987, they were accorded permanent ownership of land (Bhuiyan 1994). Currently, 82 and 152 households are participating in Betagi and Pomora, respectively.

Summary of lessons

There has been a clear improvement of farmers' standard of living after joining the projects. From a state of dire poverty, they have reached a point where they can purchase nutritious food, clothing, and medicine, which were well beyond their means prior to the projects. Drawing on data gathered from 15 farmers from Betagi and 15 farmers from Pomora, the average annual income is calculated to be Tk53,200 (US $818.46) and Tk34,280 (US $527.38), respectively (Ahmed and Azad 1987). Farmers demonstrate reasonably elaborate knowledge on homegardens, horticultural species, and their uses (ADB 2001). Patronage relations are deeply ingrained in the social fabric of this area. They have profound implications for forestry resource-use in general, and the achievements of SF in particular.

Discussion

Shifting cultivation based on the slash-and-burn method of land preparation, and locally known as *jhum*, is a common agricultural land use practiced in the study site and in the uplands of eastern Bangladesh. In our research we found that tradition and customs are still a decisive factor influencing the farmers' choice of shifting cultivation. A similar finding was reported by Mai (1999), where customs and tradition play vital role to practice shifting cultivation at the Upper Stream of Lower Mekong Watershed in Dak Lak Province, Viet Nam. Poverty is another important motive for undertaking shifting cultivation but its very use creates a vicious cycle of poor land use. Although shifting cultivation was environmentally suitable in the past when the population pressure on land was low, it has recently caused adverse impacts on the environment with the gradual increase of the local population and migration of low land people to the uplands (HARS 2000; Gafur 2001). Shifting cultivation associated with incendiary fires has destroyed almost all the climax vegetation in the area (Khan and Khisha 1970; Brammer 1986) and, as a result, 37% of the total forest of this area has been destroyed over time (Farid and Hossain 1988). Declining forest cover and inappropriate land use have led to severe soil erosion (Shoaib et al. 1998). Deforestation and soil erosion have adversely affected soil quality of forest lands in Bangladesh (Khan and Khisha 1970; Shoaib et al. 1998). It is estimated that about 1 million ha of land has been degraded due to shifting cultivation (Sfeir-Younis and Dragun 1993). This, combined with reduced fallow periods due to increased population pressure have led to diminishing soil fertility and crop yields, thereby threatening the livelihood of the tribal communities. Most shifting cultivators experience food shortages varying from three to 5 months per year, and they depend on forest products to fulfill their subsistence requirements (DANIDA 2000; Sutter 2000). Likewise, the income from shifting cultivation also declines (Huq 2000). Thus, shifting cultivation is no longer a suitable land use from both the environmental and economic perspectives, and there is need to replace such land use gradually with alternative locally suitable land-use systems (DANIDA 2000; Knudsen and Khan 2002).

Farmers in our study site still prefer shifting cultivation because it is their tradition and in the short term it gives relatively stable net cash flow each year. As most of the upland area is owned by the state and although farmers are utilizing lands for shifting cultivation, they do not have tenurial rights to the land to undertake investments in agroforestry.

Conclusion

The people in the study site are still practicing shifting cultivation mainly because of their customs and traditions. The cycle is exacerbated by poverty coupled with persistent food shortages. Shifting cultivation is their way to ensure food supply for the families. The factors that contribute to the farmers' impoverishment are also the causes of shifting cultivation. They include population pressure due to both inward migration and unawareness of the family planning, poor access to credit and technical knowledge, low education, poor healthcare, and underdeveloped market for farmers' products. The actual unsustainable shifting cultivation creates a lot of inverse consequences. The environmental effects include forest and land degradation and deforestation, followed by forest product impoverishment, soil erosion and downstream effects. The environmental degradation drives shifting cultivators into a vicious cycle of poverty and may deteriorate the social and economical life of downstream people as well. Therefore, effective measures should be taken to fix shifting cultivation and farmers need knowledge and information for awareness along with other supports to enable them to adopt in agroforestry a sustainable land-use system. Government should design necessary program to address the needs of upland farmers, e.g., substantial initial investment, to support them to move from shifting cultivation to agroforestry systems.

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