Evaluation of Agroforestry System under Different Marketing and Institutional Environments: A Case of Chittagong Hill Tracts of Bangladesh

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1 Introduction

Ecological, economic, and social benefits of agroforestry are well documented (Carson, 1992; Sanchez, 1996; Kang and Akinnifesi, 2000; Neupane and Thapa, 2000). Because of its various positive contributions, emphasis has been laid on promoting agroforestry as a viable land use in different parts of the world, particularly in developing countries. A specialized research institute ICRAF has been created for comprehensive research and development of agroforestry. Several donors and NGOs have been providing support in the development and promotion of agroforestry. Despite great effort, current adoption of agroforestry at the farm household level is much less than desired Many success stories can be found but overall adoption of agroforestry by farm household is low and remains dependent largely on external support (Raintree; 1983; Neupane, 2000).

A theoretical question therefore arises: why have promising agroforestry practices in trials not been accepted by the majority of the farmers? One of the main reasons for slow adoption of agroforestry is that little attention has been given to the marketing problems of agro-forestry products, which deter farmers from large- scale adoption of agro-forestry practices (Kjell, 1992; Mala; 1999; Vosti, et al., 2003). Conventionally, agroforestry has been considered a subsistence activity to fulfill food, fuelwood, fodder and other subsistence requirements of households (Neupane, 2000) and previous research and promotion programs were targeted mainly on biophysical conditions such as biophysical suitability, species suitability, soil quality, biological productivity, and their technical solutions (Franzel, *et al.*, 2001; Franzel, and Scherr, 2002; Neupane *et al.*, 2002). Biophysical suitability and productivity were viewed as the decisive factors of adoption of agro-forestry. Insufficient attention has been given to the farmers, their choice and preferences.

Recently, although attention has been turned to farmers, their socio-economic conditions, culture and behavior, focus still remains on production such as making such inputs as seeds, seedlings, fertilizers, and credits available to farmers. The view is that availability of inputs along with awareness and motivation will facilitate the adoption of agro-forestry technology. Although productivity growth, input availability and meeting subsistence requirements are important in decision making, farmers, being rational decision-makers (Schultz, 1964), compare income accrued from different uses of scarce resources. Profitability is, therefore, an overriding factor in farmers' land-use decisions, which are, in time, largely determined by marketing facilities.

Marketing agroforest outputs is different from other agricultural commodities because of their diverse nature. Some products such as timber are often subject to government rules and regulations, which influence market conduct, performance and even structure. Imperfect and inefficient marketing systems reduce farmers' profit margin, thereby influencing their land use decisions (Ehui et al., 1994; Janvry and Sadoulet, 1994).

It is now increasingly realized that to promote agroforestry, it is necessary to consider it as a competitive land use, not just a supplementary strategy to fulfill subsistence requirements. This necessitates detailed evaluation of agro-forestry systems with other competitive land use systems in terms of financial and economic viability as well examination of market structure, conduct and performance to identify the factors which influences that viability (Pagiola, 2001; Vosti et al., 2003). In view of this, this study made an attempt to evaluate the agroforestry system with other competitive land use systems practiced in Chittagong Hill Tracts, a hilly region of Bangladesh, from both the financial and economic perspectives. Financial analysis is important because farmers will adopt no new land use system unless it provides satisfactory financial benefits. However, farmers' financial interests may not always match the social interest as different land use practices exert a differential level of costs and benefits to the society through soil erosion and other on-site and off-site effects. While an individual farmer's concern is financial, society's concern is both financial and the long-term environmental and social sustainability of production systems. Financially profitable but economically unprofitable land use would lead to inefficient use of scarce national resources and impose a net drain on the society, resulting in poverty and resources degradation (Monke and Pearson, 1989; Pagiola, 2001).

1. Framework for Financial and Economic Evaluation

2.1 Selection of Crops and Households Representing Land Use Systems

Most of CHT is steep slopes. Shifting cultivation, locally known as *jhum,* dominated, both in terms of area occupied and percentage of farmers engaged. Several other land use systems, such as annual cash crops dominated by root crops, agroforestry, horticulture and tree farming have been gradually evolving in CHT. Annual cash crops and agroforestry are the keenest competitors among them. Analyses, therefore, were conducted on the three land-use systems: *jhum*, annual cash crops, and agroforestry.

Of the three land use systems, *jhum* and agroforestry have been evaluated as a whole in all crops as different crops are grown together and it is not possible to evaluate the costs and benefits of a single crop. Although jhumming is dominant land use, its importance to household economy varies largely. While some households entirely depend on *jhum*, others role of *jhumin* household economy negligible just practice for vegetables for household consumption. Households that who have devoted 50 % of their cropland in *jhuming* and practice *jhum* continuously for the last 12 years were considered representative of the *jhum* system. Of the total 304 sample farmers, 127 farmers met these criteria. One-third of them were selected randomly for interviews to collect detailed information about the *jhum* production system.

Farmers were selected from agroforestry systems based on two criteria: those who planted trees deliberately in the crop field and who have received some income within the last 12 months from the arboreal components of the agroforestry system. Of the total 103 farmers who practice some agroforestry crops, 27 farmers met these criteria

Cash crops are practiced as a monocrop. Ginger, aroid and turmeric are the major annual cash crops grown in CHT. Among them, ginger is the most important both in terms of contribution to household income and proportion of area occupied; therefore ginger was considered as a representative crop for evaluation. Farmers who cultivated ginger for the last 12 years and whose income from annual cash crops contributed at least 10 percent of the household income was considered for interview. Of the 86 farmers who cultivate annual cash crops, 32 farmers met these criteria.

2.2 Estimation of Costs and Benefits

Different land use systems have different production cycles; a 12 year time horizon was considered to facilitate the comparison. In agroforestry there are both annuals and perennials, including fruits and timber trees. As farmers mainly grow short-rotation timber trees, 12 years was considered one rotation. Some of the fruit trees give fruits for quite a long time, but their yields decrease rapidly after 12 years. Farmers reported that some fruit trees such as mango, jackfruit shaddock and guava start giving fruits after five to six years of plantation and give maximum yields for more six years. However, some fruit trees such as jalpai and blackberry continue to give high yield even after 12 years. In one 12 year period, three *jhum* cycles of 3-4 years and six cash crop cycles of one to two years can be completed.

Costs and benefits of each land use system were analyzed based on reported inputs used and outputs obtained by farmers at different points of time and their prices at the time of purchase and sale. Input and output prices paid and received at the farm gate we are used for financial analysis. Labor used in a particular land use system was calculated based on the actual labor used for each activity. Normally, eight hours of work by an adult male was considered one work-day. One and a half female days was equivalent to one work-day. Eight hours of work done by children aged 12 to 15 years and elderly people more than 60 years was considered equivalent to a half work-day. These ratios were determined based on farmers' experiences elicited through group discussions. The opportunity cost of labor varies between males and females and from one area to another. Male labor earns from 70 to 90 taka (Tk) and female labor from 40 to 60. On average, we consider Tk 90 for male and 60 for female irrespective of household labor or hired labor, as these rates prevail most of the year. Costs of seeds, seedlings, and planting materials were calculated based on current market prices, irrespective of whether farmers used inputs available on-farm or purchased from the market. The prices of inorganic fertilizers, pesticides and insecticides were based on local market prices. Then, the financial cost incurred over the year was calculated on a per acre (2.47 acre = 1 hectare) basis and was subjected to discounting at 12 %, although the national interest rate for agricultural credit is 11 percent, however, farmers incur additional costs. Outputs of different land use systems include different types of products such as cereals, fruits, timber and wood fuel. Farmers reported amounts of produces were converted into monetary values according to the average farm gate prices of produces. Then per acre financial benefits were calculatedwith a discount rate of 12 %.

2.3 Evaluation Criteria

Returns to land, returns to labor, and the benefit-cost ratio (BCR), were considered for evaluation of land use systems in the study area.

Returns to Land

Given the scarcity of land, both private and social objectives are to maximize returns from per unit of land. Return to land is expressed by net present value (NPV). NPV determines the present value of net benefits by discounting the streams of benefits and costs back to the beginning of the base year. The NPV of each land use system was calculated using the following formula:

$$NPV = \sum_{t=0}^{n} \frac{(B_t - C_t)}{(1+r)^t}$$

where:

B_t - the benefits of production by a particular land use in different years.
C_t - the costs of production by a particular land use in different years.

t - the year time.
r - the discount rate.

The benefit-cost ratio (B/C), which compares the discounted benefits to discounted costs of each land use system, was calculated based on the following formula.

$$B/C = \frac{\sum_{t=0}^{n} \frac{B_t}{(1+r)^t}}{\sum_{t=0}^{n} \frac{C_t}{(1+r)^t}}$$

A B/C ratio greater than 1 indicates that the land use system is profitable and the ratio less than 1 indicates that it is unprofitable.

Return to labor

Smallholder households seek to maximize returns to family labor as long as it is their main productive asset. Therefore, return to labor was also used to compare land use systems. Return to labor was calculated by subtracting the cost (without labor) from the gross benefit and dividing the proceeds by the total work-days following Fagerstoem et al. (2001).

2.4 Consideration for Economic Evaluation

Financial analysis shows the net benefit and costs received by land user under each land use system based on market price. It does not consider non-market costs such as soil erosion, which exerts high economic and environmental costs and affects long-term sustainability. However, soil erosion varies from one land use system to another (Table 1). It is therefore necessary to examine the cost of soil erosion under each land use system.

Table 8.1 Soil erosion in CHT under different agricultural land use systems

Agricultural land use		Soil loss (ton/ha)	Soil loss (ton/ha)	Soil loss (ton/ha	Average soil loss (ton/ha)
Jhum (shifting cultivation)		39.00 [b]	39.70 [e]	45.00 [g]	41.23
Root [a] crops	Conventional tillage (spading) no mulch	88. 85 [d]	109.45 [f]	-	99.15
Mixed plantation /agroforestry/ fallow jhum at five years		10.00 [b]	-	-	10.00

[a]Ginger mukhi kachu, turmeric; [b]Gafur, et al., 2000; [c] Chowdhury, 2001; [d] Quader et al., 1990-91; [e] Shoaib, 2000; [f] Uddin et al., 1991-92; g = SRDI, 1998.

Soil erosion has both on-site and off-site effects. On-site effects are soil nutrient depletion and deterioration of physical and biological structure of soil, which cannot be replenished in the short-run. Due to lack of data required for all sorts of on-site and off-site effects of soil erosion, this study considers only the cost of nutrient depletion to assess relative environmental sustainability of land use systems in the study area.

Valuation of Soil Erosion

The most significant on-site effect of soil erosion is loss of soil fertility (Attaviroj, 1990; Alfsen, *et al.*, 1996; Barbier, 1998). This results from depletion of organic matter and decreased availability of phosphorous, nitrogen and potassium and other trace elements. Farid *et al.*, (1992) using data collected from 215 sample sites in CHT found considerably less (from 25 to 40%) availability of organic carbon, nitrogen, phosphorous and potassium in eroded soil than in non-eroded soil. Similarly, Gafur et al. (2002) reported nutrient loss due to soil erosion in the same district.

Valuation Techniques

To estimate the cost of soil erosion, several valuation techniques have been proposed in the literature (for instance Margrath and Arnes, 1989; Enters, 1998). The most common of them are: (i) hedonic pricing or property valuation, (ii) change of productivity and (iii) replacement cost (Enters, 1998). Each technique has its own advantages and disadvantages.

The hedonic pricing technique takes into account change in land prices as a result of soil erosion. This approach is not applicable to this study; the private market of land has not yet developed in the study area, as most land belongs to the government. Shifting cultivators use the land as community property and land is considered a free good. The change of productivity approach has also some drawbacks, as the link between soil loss and loss of production is not well established; many other factors influence crop yield (Norse and Saigal, 1992). Besides, in the context of the study area, there is a lack of appropriate information for valuation of the cost of soil erosion following this method. The replacement cost approach has also some drawbacks, as soil erosion does not only affect nutrient contents. It also affects physical structure and resilience of the soil (Lal, 1995). Although precise valuation is difficult, a general estimation can be made using this method to understand the magnitude of loss under different systems of land use (Francisco, 1986; Gadrinab, 1989; Salzer, 1993; Gafur et al., 2002). Secondary information on nutrient loss caused by soil erosion under different systems of land use is available for the study area (Table 8.1). Therefore, despite some limitations, this study has adopted the replacement method for valuation of the economic cost of soils erosion. As a renewable resource, soil also regenerates through a natural process. In order to estimate the reliable value of soil loss, it is necessary to deduct the natural rate of soil formation from the rate of erosion. Hamer (1982, cited in Salzer, 1993:98) estimated the natural rate of soil formation in temperate climates at about 10 t/ha/yr. In Thailand, Salzer, (1993:93) estimated the rate of soil formation at 15 t/ha/y. Since Salzer's study area is similar to ours in terms of climatic condition and topography, we have adopted soil formation rate of 15 t/ha/y.

3 Financial Performances of Land-use Systems

Financial analysis shows that net financial benefit is highest in the annual cash crops Tk. 21, 750 ($ 382), followed by agro-forestry Tk. 8,963 ($ 157) and lowest in jhum. In *jhum*, net benefit is negative (Table 2). Net financial benefit is more than two times in cash crops than agroforestry. Return to labor is also highest in cash crops and lowest in jhum. In jhum return to labor is lower than the opportunity cost, Tk.90 per work-day. One may raise question the economic rationale of practicing such land use when return is less than the opportunity cost of labor. In the study area, like in other subsistence economies, there are rare alternative employment opportunities for the labor force. Therefore, the household labor force has no choice other than working on their farms and getting whatever return is available. In agroforestry, return to labor just exceeds the opportunity cost of labor. The benefit/cost ratio, however, is highest in agroforestry followed by cash crops.

When opportunity costs of labor are considered, all land use systems have positive NPVs except *jhum*. Annual cash cropping system is the most attractive, while *jhum* is the least. In agro-forestry, profit is moderate. However, when the opportunity cost of household labor is considered zero, the situation is dramatically changed (Table 2): the NPV of *jhum* rivals that of the agroforestry system. The benefit-cost ratio also improves considerably (Table 2). The B/C ratio appear highest in *jhum*, followed by agro-forestry system, while it is lowest from *jhum* when opportunity cost of labor is considered. Such a high B/C cost ratio of *jhum* is attributed to the low level of non-labor costs involved in jhum and agro-forestry land use systems. Labor is the major cost component in both systems (Table 2).

Table 2 Financial performances of three land use systems

		Jhum	Cash crops	Agro-forestry
Gross benefits (Tk. [a]/acre)		32,715	112,320	40,803
Total costs (Tk./acre)		39,789	90,570	31,841
Labor costs (Tk./acre)		34,560	50,220	22,912
		(0.87)	(0.55)	(0.72)
Non- labor costs (Tk./acre) [b]		5,229	40,350	8,928
		(0.13)	(0.45)	(0.28)
Financial performance				
Net benefits	With opportunity cost of HH labor	-7074	21,750	8,963
(Tk./acre)	Without opportunity cost of HH labor	27,486	79,170	31,875
Return to labor (Tk./workday)		72	129	91
B/C ratio	With opportunity cost of HH labor	0.82	1.24	1.28
	Without opportunity cost of HH labor	6.26	2.78	4.57

[a] I US $ = Taka 57. b non- labor costs include material cost seeds, seedlings, fertilizers, pesticides and interest on capital.

4. Economic Performance of Land-use Systems

While soil loss rates are considerably higher than the soil formation rates under annual cash crop and *jhum* systems, they are less than the formation rates under agro-forestry systems. Net soil loss under annual cash crops is more than 80 t/h/y and more than 26 t/ha/y under the *jhum* system. However, under agroforestry there is net gain of 5 t/ha/y (Table 3).

The economic value of soil nutrient depletion is therefore as high as Tk. 14,000 ha/y under annual cash cropping system (Table 4). Such cost would substantially increase farmers' production costs in order to replenish soil fertility. In *jhum,* the cost of soil erosion is about 5% of the total production cost. In the annual cash crops system, it is about 7% of the total cost. However, under agro-forestry system farmers have savings of about Tk.865 ha/y (Table 4).

When these external costs and benefits are taken into account, the profitability of different land use systems is changed substantially (Table 4). Due to high rates of soil erosion, profitability under cash crops decreases substantially as compared to agroforestry. As a result, differences in profitability between cash crop and agroforestry shrink. Returns to labor and B/C ratio become highest in agroforestry although NPV is still highest in cash crops.

However, this approximation may still understate the real impact of erosion (Stocking, 1987). In this analysis, costs such as loss of organic matter, loss of yield, and off-site are not considered. Soil erosion may thus lead to more serious damage than just loss of nutrients such as changing soil structure by reducing soil organic matter. When topsoil is lost, the subsoil is exposed, which has a poorer structure and is more compact that reduces water infiltration capacity and increase surface runoff (Miller et al., 1985; Pimentel, et a., 1995; Alfsen et al., 1996). Soil provides the growth medium for the plant. When soil and nutrients are removed, rooting depth for plants is reduced. Moreover, erosion increases the frequency and intensity of drought (Lal, 1987; Miller et al., 1985; Alfsen et al., 1996).

Furthermore, the present analysis did not consider the positive externalities of agro-forestry systems. Such positive externalities may include soil erosion control and build-up of soil organic matter over time. The result of this study is therefore highly conservative. The incorporation of these positive externalities would further increase the profitability of agroforestry systems.

Table 3 Economic valuation of soil loss by land-use system

		Jhum	Annual cash crops	Agro-forestry
Soil loss rate (ton/ha/y) [a]		41.23	99.15	10
Natural rate of soil formation (ton/ha/y)		15	15	15
Net soil loss (ton/ha/y)		(-26.23)	(-84.15)	(+5.00)
Loss equivalent to commercial fertilizers (kg)* [b]	N (total)- Urea	235.64	755.98	44.91
	P (available) - TSP	11.89	38.47	2.29
	K (exchangeable) -MP	15.74	58.90	3.5
	Ca -lime	103.61	332.39	19.75
	OM	63.82		
Economic loss/gain (Tk./ha) [c]	N (total)	2262	7257	431
	P (available)	137	439	26
	K (exchangeable)	151	486	29
	Lime	311	997	59
	OM	1674	5370	319.10
	Total	(-4535)	(-14550)	865

[a] Average soil loss under different land use systems. Please see last column Table 8.1.

[b] Loss equivalent to commercial fertilizers = the net soil loss rate x nutrient lost per ton x conversion factor.

* According to Gafur *et al.* (2002), nutrient loss (kg/ ton of eroded soil) is: N (total) = 4.14;

P (available) = 0.09; K (exchangeable) = 0.35; Ca = 1.58, and OM = 63.82.

* Nutrient/fertilizer conversion factors adopted from Bangladesh Agricultural Research Council (1997) are as follows: N – urea 2.17; P (available) – TSP 5.08; K (exchangeable) – MP 2.00; Ca – lime 2.50.

[c] Economic loss was calculated based on the border price of commercial fertilizers. Border prices were determined by taking average of c.i.f. prices. The prices used were as follows: Urea = 9.6 TK/kg, P = 11.4 TK/kg, K = 8.25 TK/kg, lime = 3.0 TK/kg, and OM = 1.0 TK/kg.

Table 4 Financial and economic trade–offs among three land use systems

	Jhum	Annual cash crop	Agroforestry
Financial performance			
Gross benefits (Tk./acre)[a]	32,715	112,320	40,803
Net benefits (NPV) (Tk./acre)	-7074	21,750	8,963
Return to labor (Tk./workday)	72	129	91
B/C ratio	0.82	1.24	1.28
Economic performance			
Net soil loss (t/ha)	(-26.23)	(-84.15)	5
Economic loss (Tk./ha)	(-4535)	(-14550)	865
Economic loss (Tk./acre)	(-1836)	(-5890)	350
Net benefits (NPV) (Tk/acre)	-9,935	12,571	9,523
Returns to labor (Tk/workday)	64	113	118
B/C ratio	0.77	1.13	1.30

a I US $ = Taka 57 ,

5 Evaluation of Land Use Systems Under Alternative Marketing and Institutional Environment

The preceding analyses were conducted under given market conditions. But in CHT farmers are working under imperfect market conditions, arising from inappropriate policies and institutional environment such as weak governance, poor infrastructure and support services, which distort prices of agricultural produces. Due to market imperfections, farmers receive less than one fourth the retail price of their agricultural commodities (ADB, 2001), which constrains farmers to adopt locationally suitable land use practices in line with the market demand. Agroforestry has both crop and tree components. Timber tree growers in CHT, for example, despite high demand and good price of timber in other parts of the country, receive only a small portion of the market price (Table A 1) for several reasons, including national policies. To sell and transport timber farmer need to get transit permit from the Forest Department. Due to complicated procedures and bureaucratic meandering, it is almost impossible for small farmers to get permission to sell timber freely. They are, therefore, compelled to sell timber in black markets at very low price. Traders who have transit permits are making high a profit margin by purchasing timber at low price and selling it at high price in the nearest city of Chittagong.

Likewise, farmers receive very low prices for fruits and horticultural crops, again because of government policies. The government allows local government institutions such as the Hill District Council, municipalities and Union Council[1] to collect taxes on agricultural commodities under their jurisdiction. Farmers have to pay taxes to the local authorities and traders have to pay levies to both the Hill District Council and municipalities. As a result, farmers and traders have to pay taxes to several authorities for the same commodity! Besides, traders have to bribe authorities for transfer of agricultural commodities from one place to another. These practices affect not only the price that farmers receive for their products, but

[1] The lowest tier local government institutions consist of several villages.

also the market structure and efficiency by limiting the participation and investment in trading particularly by the tribal people, who are less acquainted with the government officials and cannot deal with such complications. As a result, the whole channel of trading and transportation is controlled by a few Bengali people (Chakma, 1975 in Khisa, 1996:30) who in turn have facilitated the formation of buyers' syndicate and monopoly (ADB, 2001). All these factors coupled with high transportation cost stemming from inadequate transportation facilities have led to very low local prices of agroforestry products. The situation is further aggravated by high price fluctuation due to lack of storage facilities especially for horticultural crops. Seasonal variations in the prices of horticultural crops such as pineapple and banana range from two hundred to three hundred percent (ADB, 2001).

Although almost all agricultural commodities faces market constraints, this severity varies from one crop to another. Agroforestry products face more acute problem due to inappropriate policies and la ck of storage facilities. Rice and other food crops are relatively less affected, as their markets are localized within the district. Ginger, turmeric, mustard, dried chilies and other crops, which farmers can store in their houses, can avoid the distress selling during the harvesting period. Horticultural crops suffer most, as they need to be sold immediately due to lack of storage facilities. This, along with the market uncertainties, undermines the profitability of agroforestry products. It is, therefore, necessary to evaluate the effects of changes of policies and the institutional environment on farmers' income and profitability. What would happen if the present market constraints could be removed, and how would the profitability of different land use systems be changed? To get answers to these questions, alternative scenarios are analyzed by removing the present constraints and using the undistorted price, which would prevail without these constraints.

5.1 Scenario A: Removal of the Barriers for Timbe r Trading by Private Tree Growers

Discussion with farmers and timber traders revealed that they have to pay levies at the average rate of Tk. 80 per cft of timber to get transit permit. If this system is removed, farm gate price of timber would increase by Tk. 80 per cft[2]. When this happens the profitability of land use systems changes dramatically (Table 5). The profitability of agro-forestry increases almost two times (from 8963/acre to Tk. 21, 597). This reduces the financial attractiveness of annual cash crops substantially. As a result, agro-forestry becomes most profitable, followed by annual cash crops. Profit is negative in case of *jhum* system. The returns to labor and B/C ratio also change accordingly (Table 5), increasing in case of agroforestry and decreased in case of *jhum* and annual cash crops.

Table 5 Profitability after removal of transit permit [a]

	Jhum	Annual cash crops	Agro-forestry
Net Benefits (Tk/acre)	**-9,935**	**12,571**	**21,597**
B/C ratio	0.77	1.13	1.69
Return to labor (Tk./workday)	64	113	152

[a] Social net benefit indicates the simulated case where increased farm gate price of timber by Tk. 80 is considered a consequence of removal of constraints of getting permission as well as the cost of soil erosion within each system of land use to reflect the real costs of production.

[2] Justification of strict transit policies are questioned as despite of this policy 100 of illegal trucks with timber passing everyday and government forest are increasingly denuded despite official banning of timber extraction from government forest (Uttam, 2000) and demand raised by different quarters to devise easy option for selling of tree of private tree growers (Roy, 2001)

5.2 Scenario B: Elimination of Double Levies and Illegal Payments

The present system of paying levies to different local government authorities imposes additional cost on agricultural commodities. According to the traders, such costs account for about 10% of the price of the commodity. In addition, traders have to make illegal payments to officials at all check-posts, established by the government to inspect transport of illegal timber while transporting agricultural commodities. Traders reported that this costs about 10% of the price of the commodity. However, this cost varies from one crop to another. Particularly for timber, it is extremely high. Despite the transit permit obtained, the traders have to pay additional Tk. 70-75 per cft to get approval for transfer of timber from the concerned authorities. The elimination of such double levies and illegal payments would increase the farm gate price of all cash crops by 20%, and timber by Tk.70 per cft.

Table 6 Profitability after removal of double levies and illegal payments

	Jhum	Annual cash crops	Agro-forestry
Net Benefits (Tk/acre)	-6,140	35,035	21,065
B/C ratio	0.86	1.35	1.67
Return to labor (Tk./workday)	74	153	150

I US $ = Taka 57

When double levy and illegal payments are removed, the profitability of all land use systems increases significantly (Table 6). Profitability of agro-forestry increased considerably and becomes closer to annual cash crops. However, the *jhum* system still provides negative returns, as the cash crop component is small in such system. The return to labor and B/C ratio are also changed considerably (Table 6). Return to labor and thee B/C ratio increase in all land use systems due to higher farm gate prices.

5.3 Scenario C: Provision o f improved marketing and storage facilities

Poor condition of roads, inadequate transportation facilities and lack of storage facilities lead to high transaction costs and high seasonal price fluctuations of agricultural commodities. Experience from elsewhere suggests that improvement of agricultural infrastructure contributes significantly to increasing the price of agricultural commodities (Posner and Mcpherson, 1982; Scherr, 1995). It is assumed that road networks, transportation facilities, marketing facilities including storage facilities are developed and thereby transaction costs and seasonal price fluctuations are reduced substantially. As a result, it is expected that farm gate price of all cash crops would increase by 10% due to reduced transaction cost, and the price of fresh fruits and vegetables would increase by 20% due to combined effects of improved transportation and storage facilities. When reduced transaction costs and price fluctuations are considered as result of improved infrastructure and marketing facilities, the profitability of land use systems increases considerably (Table 7). However, the profitability of *jhum* is still negative. The return to labor increases in all land use systems. The B/C ratio becomes highest in agro-forestry, followed by annual cash crops.

In agro-forestry, social benefits exceed private benefits, but in annual cash crops social benefits is less than private benefits. The low level of social benefit in annual cash crops is attributed to the high cost of soil erosion.

Table 7 Profitability with the provision of infrastructure and marketing facilities

	Jhum	Annual cash crops	Agro-forestry
Net Benefits (Tk./acre)	-8,128	23,803	11,859
B/C ratio	0.81	1.24	1.38
Return to labor (Tk./workday)	69	133	124

I US $ = Taka 57

5.4 Scenario D: Removal of all policy and institutional constraints as per scenarios A, B and C

To understand how the profitability of land use systems would be changed with the removal of all marketing and institutional constraints and the provision of improved infrastructure and marketing facilities, scenario D is analyzed. The results reveal significantly increased profitability of all land use systems except the *jhum* system (Table 8). In the *jhum* system, net benefits are still negative. Any subsistence- oriented land use systems cannot take advantage of the proposed policy and institutional reforms. The extent of profitability varies significantly from one system of land use to another. Profitability of agroforestry increases about four times. Given market constraints, financial benefits are much higher in annual cash crops than other land use systems, including agroforestry, in respect to net benefits and returns to labor. Profits of annual cash crop are more than two times higher than with agroforestry. After removal of all the marketing constraint profit of agroforestry becomes close to annual cash crops and in terms of B/C ratio and return to labor agroforestry becomes the most attractive land use. If financially more attractive species such as high value medicinal and aromatic plants could be included in agroforestry systems, financially agroforestry would be even more profitable than the annual cash crop system. Besides, if farmers were required to pay for off-site costs generated by each land use system then agroforestry would likely be financially much more attractive than annual cash crops. The latter system generates large external costs to the society by degrading land, deteriorating water resources, depleting agro-biodiversity and affecting downstream dwellers through increased floods and reduced water availability.

Table 8 Profitability following the removal of policy and institutional constraints, and the provision of improved infrastructure and marketing facilities

	Jhum	Annual cash crops	Agro-forestry
Net Benefits (Tk./acre)	-4,243	46,267	35,475
B/C ratio	0.9	1.46	2.13
Return to labor (Tk./workday)	79	173	191

I US $ = Taka 57

6. Conclusion and Policy Implications

Three representative land use systems practiced by farmers were evaluated through cost-benefit analysis (CBA) to see their relative financial and economic performances. The analysis shows that the two alternative land use systems (annual crops and agroforestry) provide much higher financial and economic return (in terms of returns to land and labor) than the *jhum* system. In *jhum*, both net financial and economic returns are negative. Financial return is highest in annual cash crops but it generates the most soil erosion, followed by *jhum*. In agro-forestry, the soil erosion rate is lower than the natural soil formation rate. When the cost of soil erosion is valued in monetary terms, agro-forestry becomes equally competitive with annual cash crops.

The financial and economic analyses show that there is a divergence between private benefits and social benefits. In annual cash crops, private benefits are high but social benefits are low, but in agro-forestry social benefit is high but private benefit is relatively low. The divergence between private and social benefits has resulted in unsustainable annual cropping which generates high soil erosion, and a disincentive to adoption of agro-forestry, which provides high social benefits by protecting soil and providing hydrological and environmental services.

The analysis of the marketing and institutional environment under which farmers work revealed that relatively low returns to agro-forestry largely result from inappropriate policies, complicated transit rules, an unfavorable institutional environment, and bureaucratic hindrances, which have distorted the prices of tree, fruits and other cash crops from this free-market level. Transit policies, which requires permission from several authorities to harvest and transport timber incur considerable financial cost and time that frustrated smallholder tree growers and force them to sell timber in black market in tree traders at one third of market price.

Simulation results based on undistorted prices show that profitability of agro-forestry increased several times if present constraints on marketing timber and cash crops are corrected. Although these figures are merely indicative, they suggest that there is not only a trade–off but a win-win situation in agro-forestry, where soil erosion is minimum and income is considerably high if current market imperfection could be corrected and infrastructural and marketing facilities could be provided. It also shows that there is a great potential to increase smallholder income, as well as to slow down the present degradation process or even enhance the quality of natural resource base by removing constraints on agroforestry product marketing.

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Appendix

Table A 1 Price of Timber round wood

Name of trees	Farmgate price	Price at local Market (Bandarban) Tk/cft	Price at Regional Market center (Chittagong) Tk/cft	Local price share of regional market (%)
Segun	170-190	200-250	750-800	29
Mehogani	120-140	150-180	400-450	39
Gamar	80-100	120-140	350-400	35
Chaplish	70-90	100-120	300-350	26
Koroi	120-150	150-200	400-450	41
Simul, kadam & other soft woods	50-60	80-90	300-350	26
Pole	20-30	40-50	150-200	26

Source: Field Survey, 2002