Valuing Ecosystem Services for Promoting Sustainable Agricultural Land Use Systems in Hills and Mountains[1]

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Summary

Payments for environmental services have gaining acceptance as a mechanism to provide financial incentive to land users for stewardship of environmental services. Despite its increasing recognition, its use has remained elusive due to difficulties valuing the environmental services as many environmental services have no direct market value and are largely unrecorded and often ignored. This paper estimated the environmental services including soil conservation, carbon sequestration, and biodiversity conservation provided by four agricultural land-use systems practiced in Chittagong Hill Tracts of Bangladesh using non-market valuation techniques. NPV was used as a criterion to assess their relative profitability from private and social perspectives. The results of the financial cost-benefit analysis revealed annual cash crops as the most attractive option, and agroforestry is the least. Horticulture and farm forestry held the middle-ground between these two systems. The relatively higher returns from annual cash crops accrued at the expense of high environmental costs such as soil erosion, carbon sequestration and biodiversity loss. When the environmental costs are taken in account annual cash crops appeared to be the most costly land use system and agroforestry and farm forestry become economically more attractive. Potential for payments of environmental services as a means of poverty alleviation and ecosystem services are examined and policy recommendations are made.

Key words: agricultural land use, market failure, cost-benefit analysis, non-market valuation, Chittagong Hill Tracts, Bangladesh

1. Introduction

Degradation of natural resources particularly land and forest has become a matter of serious concern in developing countries where the vast majority of the rural people depend largely on these resources for their sustenance (FAO 1999). About 2 billion hectares of the world's agricultural land have been degraded because of deforestation and inappropriate agricultural practices (Pinstrup-Andersen and Pandya-Lorch 1998). The rate of degradation is relatively high in Asia. In most parts of Asia, forest is shrinking; agriculture is gradually expanding to marginal and sloppy lands; and land degradation is accelerating through nutrient leaching and soil erosion (Napier et al. 1991; Rambo 1997; Scherr and Yadav 2001; Bakhtani 2003). About 20 percent of

[1] This is a short version. The full version of the paper will appear soon in the Journal of **Sustainability Science: Practice and Policy.**

the agricultural land in Asia has been degraded over last several decades (WRI 1993). The pace of degradation is much higher in environmentally fragile areas, such as in mountains (Jodha 2005). It is estimated that over 300 million ha of land in the Hindu Kush- Himalayas has been degraded to a certain extent (Partap 2003:10).

Although, several bio-physical and geo-morphological factors are responsible for land degradation, inappropriate land use practices have accelerated its' pace (Rambo 1997). According to WRI (2003), over two-third of the land degradation in Asia is caused by deforestation and inappropriate agricultural practices. Land use change, including conversion of forestland into agriculture, not only accelerates land degradation but also accelerates carbon emission and loss of biological resources (Kremen et al. 2000; Jackson et al. 2007) It estimated that about 20 to 30% of carbon emissions is caused from tropical deforestation and land use changes (Kremen et al. 2000:1828). Change in land use particularly mono-cropping has accelerated the loss of agro-biodiversity (Partap and Sthapit 1998:1; Jackson et al. 2007:194).

Land degradation caused by unsustainable agricultural intensification raises concern about long-term sustainability of agricultural systems (WRI 2000). Sustainable development requires that the human exploitation of natural resources does not exceed the renewal capacity of the Earth's biosphere (WCED 1987). The sustainability principles demand that the stock of natural resources and environmental services be maintained so that future generations have no less of the means to meet their needs than we do ourselves (Turner et al. 1994; Hediger 1999).

Land use, thus presents us with a dilemma. While some agricultural practices provide economic benefits as well as conserve natural resources and provide ecosystem services, such as modulating water quality and quantity, organic waste disposal, soil formation, biological nitrogen fixation, maintenance of biological diversity, biotic regulation, and contribution to global climatic regulation (Paoletti et al. 1992; Pimentel et al. 1997; Bjoeurklund et al. 1999), other forms of agricultural practices degrade natural capital and ecosystems services. A particular type of land use might be highly beneficial to an individual land user but may degrade local and global environment through soil erosion, carbon emission, biodiversity loss and other negative externalities. Because of this, private interest may not always match with the social interest as individual farmer's primary concern is financial return where as society's concern is both financial return and long-term sustainability of production systems. Land use, which is privately profitable but socially unprofitable, 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).

The challenge faced by policy makers and development practitioners in developing countries is - how to minimize the divergence between private and social interests so that agricultural development and resource conservation goals could be achieved at the same time. In pursuit of seeking such policies, it is important particularly for the policymakers to know the detailed costs and benefits of alternative land use options. Although, agricultural practices provide both economic and environmental benefits, the benefits of environmental services, such as biodiversity, carbon sequestration, soil conservation are often overlooked (Barbier et al. 1994). Failure to recognize the economic value of environmental services of different land use systems often lead to policies, which provide disincentives to environment-friendly agriculture practices.

It is therefore imperative to value both economic and environmental benefits of agricultural practices in order to show the real costs and benefits of a particular land use system (Ninan 2007; Bjoueurklund et al. 1999). In view of this, using a case study from the Chittagong Hill Tracts (CHT) of Bangladesh, this study examines the private and social profitability[2] of the major land use systems emerging in CHT. Findings of this study are envisaged to be useful for formulation of policies conducive to promotion of sustainable land use systems in CHT and elsewhere.

2. Research Methods

2.1 The study area: the Chittagong Hill Tracts of Bangladesh

The CHT is located in Bangladesh (21.25–23.45◦ N, 91.45–92.50◦ E). Geographically, it is a part of Hill Tripura and Arakan Yoma branching off from the Himalayan range and continuing to the south through Assam and Hill Tripura of India to Arakan of Myanmar. With an area of 13 183 km^2, the region covers about one-tenth of Bangladesh's land area. Two-thirds of the area is characterized by steep slopes and the remaining area by an undulating topography. Steep slopes combined with heavy seasonal rainfall (2032–3810 mm yr^{-1}) impose limits on arable agriculture; 73% of the land in the CHT is suitable only for forests, 15% for horticulture and only 3% for intensive terraced agriculture (Forestal 1966).

Although the entire area of CHT was covered with dense forest in the early nineteenth century; now most of the area has been denuded and covered with obnoxious weeds with some scattered trees and shrub (Roy 1995; ADB 2001, Adnan 2004; Rasul 2006). This has resulted in accelerated soil erosion, soil nutrient mining (Shoaib et al. 1998; DANIDA 2000; Gafur 2001). Recent studies estimated that soil loss under different land use ranges from 10 to 100 t/ha^{-1} (Table 1). The soil loss is washing away 27 per cent of the nutrient content in the upper 10 cm of soil of CHT (Gafur et al. 2000) resulting in many onsite and offsite effects, including soil nutrient depletion, carbon sequestration, biodiversity loss.

Table 1 Soil erosion in CHT under different agricultural land use systems

Land use		Soil loss (ton/ha/yr)	Average soil loss (ton/ha/yr)
Pineapple		18.05 [d]	18.05
Root crops [e]	Conventional tillage: hoeing without mulch	88. 85[f] 109.45[g]	99.15
	Conventional tillage: hoeing with mulch	35.43 [d] 34.89 [g]	35.16

[2]Private profitability is measured based on prices faced by individual farmers (e.g., price of seeds, fertilizers, rice, or wheat), at which goods and services are actually being exchanged. These are also called market or financial prices. Social profitability, on the other hand, is measured based on undistorted prices, which would prevail in absence of any policy distortions and market imperfections. These are sometimes called shadow prices, efficiency prices, or opportunity costs (Monke and Pearson 1989).

Mixed plantation/ Fallow *jhum* (five-year rotation), Agroforestry, tree plantation	10.00 [a]	10.00

[a]Gafur, 2001; [b]Shoaib, 2000; [c] = SRDI, 1998; [d]Chowdhury, 2001; [e]Ginger, *mukhi kachu (Colocasia esculanta)*, turmeric; [f] Quader and others 1991; [g] Uddin and others 1992.

2.2 Data Collection Methods

This study is based on both primary and secondary data. Primary data were collected through a household survey, focus group discussions, key informant interviews, and case studies. Information was collected at two stages from two representative sub-districts, namely *Bandarban Sadar* and *Alikadam* in Bandarban district of CHT from January to December 2002. Initially, information on farmers' socioeconomic condition, land use, land management and farming systems, employment, income, and personal experience in different types land uses was collected from 304 randomly sampled farm households using a standard questionnaire. This was followed by collection of additional information on specific land use practices, such as area under cultivation, amount of inputs used, price of inputs, output produced, price of outputs, and management practices adopted and time spent on each management activity through detailed interviews with randomly sampled farm households. The validity of information provided by individual farmers was verified with key informants, agriculture extension and forestry officials, and local NGO workers and particular land user group through focus-group discussions and key informant interviews.

2.3 Specification of land-use systems under study

Land use in CHT is changing gradually; traditional agriculture practices such as shifting cultivation is declining and several types of land uses are being emerging. Among the emerging land use practices most important of them are annual cash crops, horticulture, agroforestry and farm forestry (Rasul 2006). These four emerging land-use systems were considered for detailed analysis. A detailed discussion regarding the methods followed for determining representative crops or tree species and households to be surveyed from each land-use system can be found in Rasul (2006).

Different land use systems have different production cycles. For annual crops, the production cycle is one year, in horticulture five to six years, and in tree farming 12 years. In order to compare the costs and benefits of different land use systems, a 12-year time horizon was considered. The costs and benefits of each land use system were analyzed based on inputs used, outputs and farm-gate prices of produces sold. The opportunity cost of labor in the study area varies by gender and season. Following the prevailing wage labor rates, US $ 1.58 and US $ 1.05 were considered to be the daily per capita opportunity costs of adult male and female workers, respectively. The national interest rate for agricultural credit is 11% and farmers incur additional cost of about one percent while getting credit. Therefore, a discount rate 12% was considered to reflect the cost of capital. Same discount rate was considered to reflect the cost of capital in some forestry projects of neighboring country India (Kumar 2002).

Evaluation criteria

Returns to land was used as criteria to evaluate the land use systems under the scope of the study. Given the scarcity of land, both private and social objectives are to maximize returns from a unit of land. Returns to land are expressed by net present value (NPV), which determines the present value of net benefits by discounting the streams of benefits and costs back to the base year. The NPV of each land use system was calculated using the following formula:

$$NPV = \sum_{i=0}^{n} \frac{(Bt - Ct)}{(1+r)t}$$

where

B_t is land use specific benefits accrued over the years,

C_t is land use specific costs incurred over the years,

r is the discount rate, and

t is time period.

Valuation of environmental services

As the environmental services varies from one type of land use to another, it is necessary to examine and give monetary values to environmental services in competitive land use systems. In view of this, I tried to estimate the value of carbon sequestration, biodiversity conservation and the cost of soil erosion attached to each land use system.

Valuation of soil erosion

Soil erosion has both on-site and off-site effects. On-site effects are soil nutrient depletion and deterioration of the physical and biological structure of soil, which cannot be replenished in the short run (Attaviroj 1990; Alfsen and others 1996). Due to a lack of data required for all sorts of on-site and off-site effects of soil erosion, I considered only the cost of nutrient depletion to assess the value of soil erosion. As others (e.g., Barbier 1998; ESR/USDA 2002; Gafur 2001), are in opinion that, though partial, such an analysis provides better idea about the environmental costs and benefits of alternative land uses than simple subjective assessment. This eventually enables the policymakers to promote land uses which are environmentally and economically sustainable.

The most significant on-site effect of soil erosion is the loss of soil fertility (Attaviroj 1990; Alfsen and others 1996; Barbier 1999). This results from the depletion of organic matter and decreased availability of phosphorous, nitrogen and potassium and other trace elements.

Different approaches have evolved to estimate the value of non-market goods and services (Costanza et al.1997; Daily et al. 2000). Following several other studies in Asia (e.g., Kim and Dixon 1986; Salzer 1993; Samarakoon and Abeygunawardena 1995; Gunatilake and Vieth 2000), I adopted the replacement cost method for valuation of the cost of soil erosion. 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 to be about 10 ton/ha/yr. In Thailand, Salzer (1993) estimated that the rate of soil formation was 15 ton/ha/yr. Since Salzer's study area is similar to CHT in terms of climatic condition and topography, we assumed that the soil formation rate of 15 ton/ha/yr is applicable to our study area.

Valuation of carbon sequestration and biodiversity services

While estimation of carbon sequestration is relatively straightforward (Huang and Kronrad 2001; Ching-Hsun and Kronrad 2001; Olschewski and Benıtez, 2005; Zbinden and David 2005) estimating economic value of biodiversity is extremely difficult (Pagiola et al 2004, Jackson et al. 2007). However, Pagiola et al (2004) developed an index of biodiversity for different land uses, which varies from 0 to 1; 0 for annual crops (annual, grains, tubers) and 1 for primary forest; other land uses lies between the two extreme and estimated the proxy value of biodiversity. Although this index may vary considerably based on variation on biophysical condition, I used this index to estimate the value of biodiversity and carbon sequestration, as there is no other precise method available in study area. The value of carbon sequestration and biodiversity services were estimated using following formula.

Index of carbon sequestration services (ICSS) = Point of carbon sequestration in specific land use X Price of carbon (ton/year)

Index of Biodiversity services (IBS) = Point of biodiversity in specific land use x Price of biodiversity services (ha/y)

3. Results and Discussion

3.1 Financial Performance of Alternative Land-use Systems: Private Perspective

The financial analysis shows the highest NPV from the annual cash crops, followed by horticulture and tree farming (Figure 1). NPV is lowest in Agroforestry. Return from cash crops is about three times higher than agroforestry. Similarly, return to labor is highest in annual cash crop and lowest in agroforestry. Horticulture and tree farming are between them.

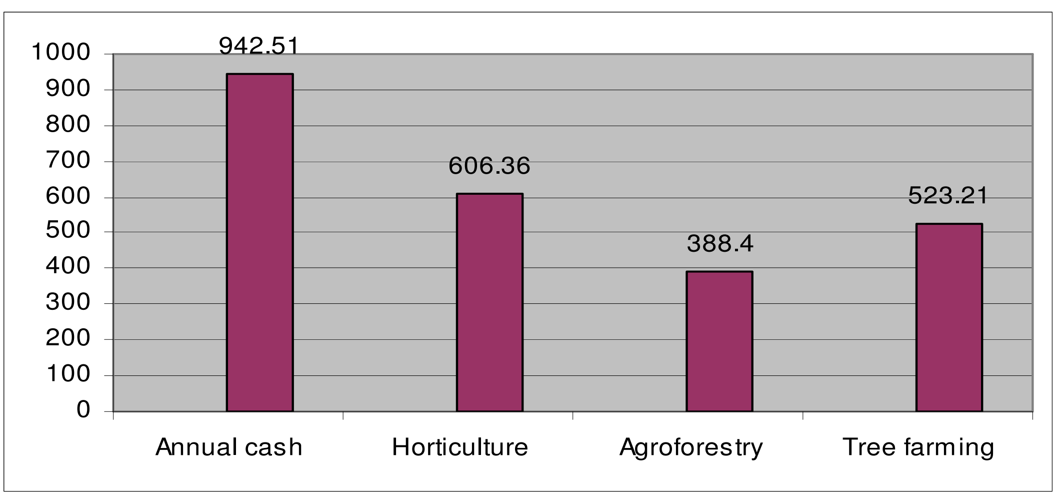

Figure 1: Financial performances of four land use systems NPV in US $ per ha

3.2 Economic performance of Alternative of Land-use Systems: Social Perspective

While individual land users concern about financial returns, society as whole is concern about the long term sustainability of production system i.e. maintaining natural as well as externalities generated through the production systems. Land use is no more an individual or local issue it has national and global implications as land use may associated with positive and negative externalities (Foley et al. 2005). Unsustainable land use practices my degrade the local environment and undermine ecosystem services, human welfare, and the long-term sustainability of human societies (Pagiola et al. 2004). Natural capital such as land, forest, pasture, water and environment is primary productive base of a nation**.** If its stock of natural capital assets depreciates and its institutions are not able to improve efficiency sufficiently to compensate for that depreciation, its productive base will shrink (Dasgupta 2007). In view of this, I carried out an economic analysis to examine the environmental suitability of different types of land use by converting the soil nutrients loss through erosion into monetary value.

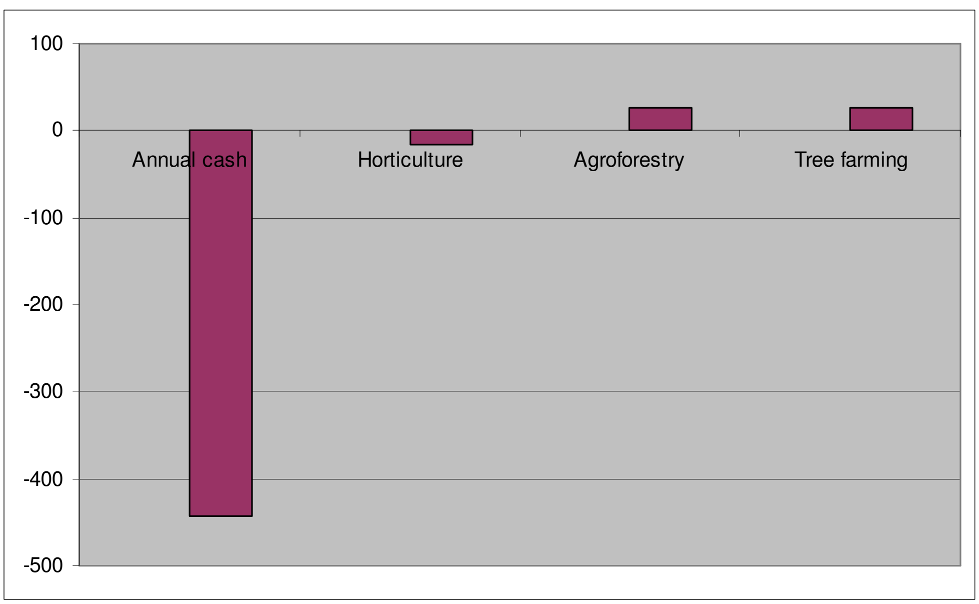

Figure 2: Cost of soil erosion under different land use systems

The result of the analysis shows that the economic value of soil nutrient depletion is ranges from US $ 16, under horticulture, to US $ 443 ha/yr, under annual cash crops (Figure 2). Replenishing the lost soil fertility would entail substantial increment in farmers' production costs. The cost of soil erosion under the annual cash crop system accounts for about 11% of the total production cost. However, under the agroforestry and tree farming systems, farmers have savings of about US $ 26, as soil formation rate exceeds the erosion rate. As a result, the profitability of land-use systems is changed substantially (please see Figure 1 and Figure 3). Horticulture appears to be the most profitable land use, followed by tree farming. By contrast, the profitability of annual cash crop system is considerably reduced, because of the high rate of nutrient depletion through soil erosion. The actual cost of nutrient loss, however, may be higher than the estimated cost, as the price that farmers are paying for inorganic fertilizers is normally higher than the border price used in the analysis.

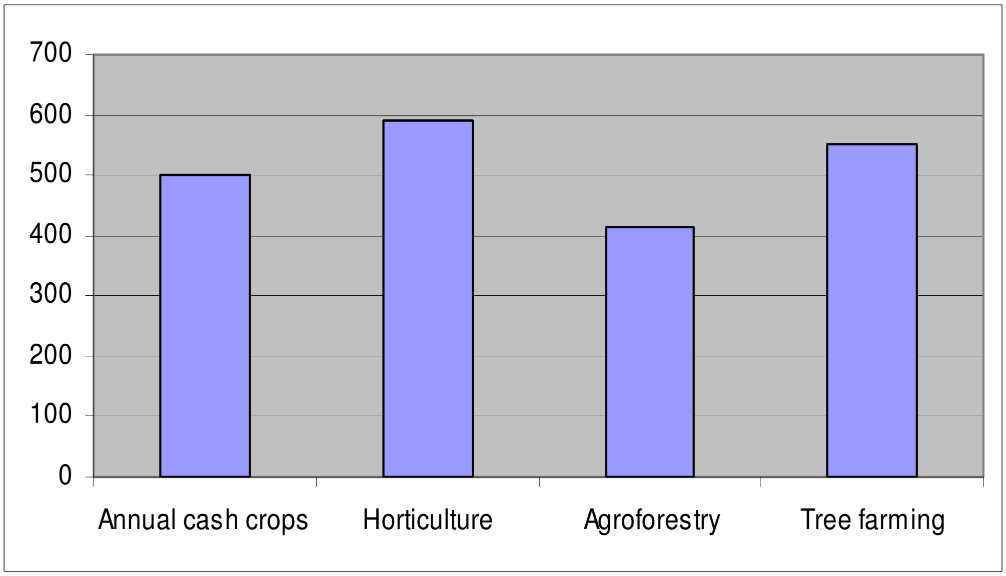

Figure 3: Economic performance of four land use systems

Biodiversity and Carbon Sequestration

In addition to soil conservation, land uses have differential impact on many other environmental and social services such as biodiversity conservation and climate regulation through carbon sequestration (Daniel et al. 2004; Pagiola et al. 2007). For promoting sustainable land use practices all types of costs and benefits need to be taken into account while government design policies. In view of this, I estimated the monetary value of biodiversity and carbon sequestration by different land use systems following Pagiola et al. 2004; Pagiola et al. 2007.

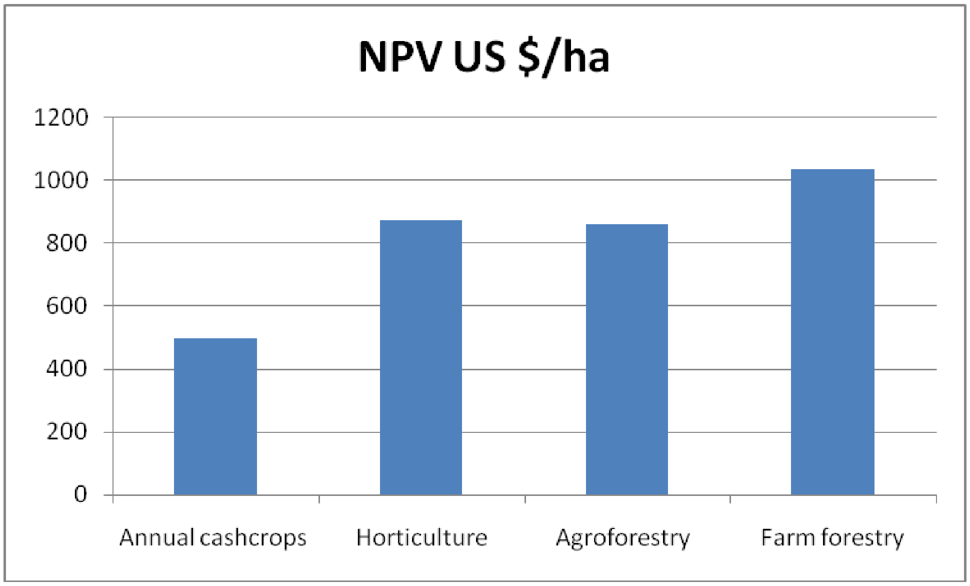

Figure 4 Performance of land use systems with biodiversity and carbon sequestration value

Although this indices have been used in several studies in valuing environmental service, there are certain variation in rate of payment. While Pagiola et al. (2004) estimated US$75/point/year payment for environmental services, Costa Rica's PSA program pays US$45/ha/year for environmental services. I used US $ 45 for per point of environmental services and discounted 25% of the value with assumption that some of the products and biomass will be used by farmhouse hold themselves for fuelwood, fodder and other uses. This yields US $ 33.75 /point/ha for environmental services.

The results show that the value of biodiversity services varies considerably across the land use systems. While annual cash crops do not provide any positive environmental services in terms of biodiversity conservation, farm forestry provide highest environmental services. Agroforestry and horticulture are in between the spectrum (Figure 4). There are, however, considerable variation among agroforestry, farm forestry and horticulture. While agroforestry provides highest benefits in terms of biodiversity, farm forestry provides highest benefits in carbon sequestration.

When the benefits of environmental services are taken into account, annual cash crops become the least profitable and farm forestry the most profitable land use. The returns from agroforestry also become almost double than annual crops.

4. Conclusion and Policy Recommendations

Poverty reduction and conservation of natural resources and protection of environment are high on the global agenda on sustainable development. The divergence between private and social benefits in resource use lead to inefficient resource allocation and unsustainable resource use practices. The costs and benefit analysis of four alternative land use systems practices in CHT provides some useful insights on divergence between private and social interests in agriculture land use. The analyses revealed that annual cash crops are financially more attractive than agroforestry, farm forestry, and horticulture systems. However, higher financial benefits in annual cash crops come through high environmental costs such as soil erosion, carbon emission and biodiversity loss. The high rate of soil erosion associated with annual cash crops raise the production cost through nutrient depletion and undermines the long-term sustainability of agricultural systems.

Although agroforestry and farm forestry provide many environmental services such as soil conservation, carbon sequestration, biodiversity conservation and regulation of volumes of water in rivers and streams (Montagnini and Nair 2004; Albrecht and Kandji 2003) and these land use system are found environmentally suitable in CHT, the adoption of such environmental friendly land use systems is very low. Only a few farmers have utilized a small proportion of their farm plots for horticulture, agroforestry and farm forestry. The analysis revealed that their relative low financial performance is one of the important reasons for their low adoption. Farmers, generally, ignore the social and environmental cost involve in agriculture practices as they do not receive any benefits from environment friendly land use practices. As a result, farmers make investment in land use systems that provide relatively higher benefits, irrespective of environmental effects.

When the economic benefits of alternative land use systems are analyzed by taking into account the cost of nutrient depletion caused by soil erosion, horticulture appears to be more attractive than annual cash crops. Agroforestry and farm forestry still less attractive than annual crops. The real impact of soil erosion, however, could be far greater than the simple loss of nutrients (Stocking 1987). When the topsoil is lost, the compact structure of the subsoil is exposed, eventually reducing water infiltration, increasing surface runoff (Miller et al. 1985; Pimentel et al. 1995; Alfsen et al. 1996) and reducing the rooting depth of crops. Soil erosion also accelerates the frequency and intensity of drought (Miller et al. 1985; Lal 1987; Alfsen et al. 1996). Moreover, different land uses have differential impact on biodiversity conservation and carbon sequestration. Agroforestry and farm forestry conserve higher biodiversity and sink relatively more carbon than annual cash crops (Nair 2003 in Pagiola 2004; Predo 2004; Upadhyay et al. 2005). When the value of biodiversity conservation and carbon sequestration are taken into account, farm forestry, horticulture and agroforestry become far more beneficial than annual cash crops.

The analyses also revealed that environmental friendly land use practices are not necessarily financially attractive. Therefore, often there is a trade-off between private and social benefits. Although the estimation of monetary value is not comprehensive, it, however, clearly shows that annual cash crop is financially more profitable to the individual farmers although this land use practices produces high social costs through soil erosion. The financial benefits from annual cash crops exceeded the benefits of agroforestry and farm forestry even when the monetary values of soil erosion are accounted for. It suggests that any efforts to conserve soil erosion and biodiversity and carbon sequestration services in agricultural landscapes need to consider the financial incentives faced by individual land users, who decide what practices to use on their land, generally without considering what environmental benefits different land use practices may have.

The challenge is how to reduce the divergence between private and social benefits. One option could be internalizing the environmental cost by rewarding for positive externalities and taxed for degrading natural resources and ecosystems. The analysis revealed that there is an opportunity cost of producing environmental services. If farmers move from annual cash crops to agroforestry and other environmental friendly land use practice, they have to forego considerable amount of financial benefits. The poor mountain farmers can not afford to bear the costs of producing environmental services by sacrificing financial benefits. Although society at a large get benefits from environment friendly land use practices, farmers receive nothing for the environmental services as traditional market mechanism fails to capture the value of environmental services. For promoting sustainable agriculture practices, it is therefore important to develop mechanism that pays land users for the environmental services they are generating, so that the additional income stream makes the environment friendly practices privately profitable.

Although agricultural land use is a local economic activity, it has gradually become a global issues because of externalities associated with land use practices. Worldwide changes to forests, farmlands, waterways, and air, being driven by the need to provide food, fiber, water, and shelter to more than six billion people, are undermining the capacity of ecosystems to sustain food production, maintain freshwater and forest resources, regulate climate and air quality, and ameliorate infectious diseases. We have to minimize the trade-offs between immediate human needs and maintaining the capacity of the biosphere to provide goods and services in the long run. This study suggests that promoting environmental friendly and locationally suitable agriculture practices could provide significant economic, social and environmental benefits at individual, national and global levels. The study also indicates there is not only trade-off but also synergy. If environmental friendly land use practices can be made financially profitable through appropriate policy and institutional mechanisms, there is a happy convergence of private and social benefits as in the case of agroforestry, farm forestry and horticulture in CHT. It can serve three-folds goals of poverty reduction, natural resource conservation and environmental protection. As environmental friendly land uses provide benefits to global community at a large, global community should come forward for compensating the poor farmers for their services. The Kyoto Protocol, which aim is to enhance terrestrial carbon sink ironically fails to design mechanism to capture the environmental benefits generated by smallholders through environmental friendly agricultural practices. If such mechanisms are not developed, one can expect that many farmers in developing countries will continue to practice unsustainable land use practices, where financial return is more.

Policy Recommendations

Policies that allow landowners to capture the value of environmental services could provide powerful incentives for promoting environmental friendly land use practices (Pagiola et al. 2004). It is therefore important to develop mechanism that pays land users for environmental services including conserving soil, biological resources and sequestering carbon so that the additional income stream makes the environmental friendly land use practices privately profitable. Efforts to promote sustainable land use practices need to take account the constraints faced by individual land users in moving from annual crops to perennial crops such as initial investment, long-gestation period and food security. Moreover, farmers need to be given permanent land title. In CHT, the majority of farmers have neither ownership nor usufruct rights to their farmlands (Rasul 2003). People without secure land tenure can hardly be expected to practice tree-based land use systems, which require a lot of initial investment, and provide significant returns only after several years. Evidence from CHT and elsewhere suggest that secure land tenure can facilitate the adoption of suitable land use systems (Suryanata 1994; Suyanto et al., 2001). The government should immediately adopt a policy of granting secure land rights to the farmers in CHT. Incentives also should be given to adopt soil and water conservation technologies including non-tillage practices, mulching, contour and alley farming, and terrace construction while growing annual crops, which can reduce soil erosion and other environmental costs substantially.

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