Shifting Cultivation and Its Alternatives in Bangladesh: Productivity, Risk and Discount Rates

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Abstract

This study evaluates the economic feasibility of replacing shifting cultivation (*Jhum*) with settled agriculture and use of new soil conservation technology based on an assessment of the farmers' risk and the corresponding discount rates in the Khagrachari hill district of Bangladesh. Shifting cultivation can cause top soil loss, degradation of soil quality, and decrease in crop yield but significant improvements in yields could also be achieved with increased fallowing. On the other hand, the use of soil conservation technology is found to be highly profitable. The study finds that the social discount rate is a crucial factor determining the switch from shifting cultivation to new soil conservation methods. *Jhum* farmers would switch to the new technology in a 3-year rotation scheme if their rate of discount is below 57.48%. Similarly, the discount rates are 46.46%, 36.44% and 32.58% for a 4-, 5- and 6-year rotation respectively. Further, high initial cost of establishment, longer gestation period, and unclear customary rights are deterrents to the adoption of soil conservation technology. The study concludes that these problems can be overcome if financial support and technical assistance were made available.

Key Words*: Shifting (Jhum) cultivation, soil erosion, MSFO technology, soil conservation, rate of return, discount rate, property rights*

SHIFTING CULTIVATION AND ITS ALTERNATIVES IN BANGLADESH: PRODUCTIVITY, RISK AND DISCOUNT RATES

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1. Introduction

Shifting cultivation can be detrimental to the environment, especially as the fallow period between cultivation cycles declines. In the Chittagong Hill Tracts of Bangladesh, shifting cultivation (*Jhum*) has been practiced from time immemorial and is closely related with the socio-cultural identity of some hill communities. In the past, they practiced *Jhum* in the same area with a fallow period of 15-20 years, which ensured the long-term sustainability of soil fertility. With the rapid growth in population, the fallow period has been reduced to 3-4 years, allowing very little time for soil regeneration (Riessen, 2000). The decrease in fallow period has led to the deterioration of faunal and microbial organisms, top soil loss, and land degradation due to slashing and burning during the period of heavy rainfall (Gafur, 2001). Hill farmers therefore face a bleak future, with *Jhum* cultivation becoming increasingly unsustainable and alternative soil conservation technology requiring high amounts of start-up expenses.

In response to this, the Bangladesh Agricultural Research Institute (BARI) launched the Hill Farming Research and Rehabilitation Programme (HFRRP) in the hilly areas during 1998-2005. The aim of this programme was to gradually replace *Jhum* cultivation by establishing Multi Strata Fruit Orchards (MSFO) on farmers' hills. This new technology has been found suitable for preventing soil erosion and degradation, and in increasing the cropping intensity of the area (Paul and Hossain, 2001). *Jhum* farmers, it has been found, can increase farm income by adopting this technology. Under the HFRRP, BARI has established a number of MSFOs, mostly on non-tribal farmers' hills, spreading over three hill districts of Bangladesh.

Jhum farmers in the study areas however have been reluctant to adopt this technology and some of those who have adopted MSFO are facing various problems too. Policy makers must therefore understand the causes of low adoption and find ways to mitigate MSFO problems. This has created doubts about the sustainability of the programme and also about the possibility of phasing out *Jhum* farming from the hill areas. This study examines alternatives to shifting cultivation by a comparative analysis of *Jhum* cultivation and MSFO.

The study aims to (a) estimate the profitability of *Jhum* cultivation by measuring the benefits of increasing the fallow period based on an assessment of farmers' risk and the corresponding discount rates; and, b) to assess the economic feasibility of replacing *Jhum* cultivation with new technology (MSFO) in the Hill areas.

Section 2 reviews the relevant literature followed in Section 3 by a description of the study area. Section 4 discusses methodological issues, the profitability of *Jhum* farming, MSFO farming, the

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NPV of the two techniques, the role of discount rates, and farmers' perceptions on *Jhum* cultivation and MSFO. Section 5 concludes the study with some policy recommendations.

2. Review of Literature

Earlier research in this area has focused on the impact of the slash-and-burn system of agriculture on land degradation, nutrient depletion, nutrient balance, soil erosion and resilience (Ewel, *et al.,* 1981*;* Kyuma, *et al.,* 1985; Andriesse, *et al*, 1987; Ramakrishnan, 1992). The bulk of the deforestation, (about 10 million hectares per year), is due to the slash-and-burn system of cultivation (Sanchez, 1995). It also causes much soil loss and, in the long run, reduces soil productivity. Soil erosion adversely affects the physical and chemical properties of the soil such as infiltration rate, water holding capacity, and loss of soil carbon (Al-Kaisi, 2001). A considerable amount of nutrients is also washed away from the upper 10 cm soil with runoff sediments as an outcome of shifting cultivation (Gafur, 2001; Gafur, *et al*., 2003). Weil (1982) has found a significant reduction in the organic content and the total nitrogen of the soil due to erosion in the Upper Mahaweli catchments in Sri Lanka.

The rate of soil erosion varies with the elevation of the land and the type of crop that is grown. In Bangladesh, the use of contour hedgerows on steep hill slopes (40-50%) reduced erosion by 55-80% and runoff by 30-70% compared to shifting cultivation (Khisa, 2001). Several agro-forestry production techniques, designed with locally adapted trees and crops for different slope conditions, optimised the production of agro-forestry crops and minimised environmental degradation in the hill region of Bangladesh (Paul and Hossain, 2001).

McConnell (1983) and Barbier (1988) have evaluated soil conservation benefits in Java using an optimal control model with soil quality as the state variable. Bishop & Allen (1989) and Cruz, *et al*., (1988) have estimated the costs and benefits of soil conservation in Mali and Philippines, respectively. Gunatilake and Abeygunawardena (1992), using a Tobit model, found that the period of land tenure has a negative influence while a subsidy has a positive influence on the soil conservation among tobacco farmers in the hill country of Sri Lanka. Hettiarachchi and Gunatilake (2000) used the same methodology to assess the soil conservation decisions of farmers in another watershed in the southern part of the island.

Pattanayak and Mercer (1998) have estimated soil conservation benefits to farmers in the Philippines using a three-stage analysis. Stage 1 quantified the relationship between soil conservation and soil quality. Soil quality (S) is a function of management practice (T), and a vector of environmental variables (z) composed of geological material, topography, climate, time and biota. The equation was: $S = S(z, T)$. In stage 2, the effects of changes in soil quality on individual household crop production (Y) are estimated. Crop production is a function of soil quality (S) and a vector of other human and non-human physical and financial inputs (x)where: $Y= Y(S, x)$. The final stage establishes the link between some measure of economic welfare and agricultural productivity as influenced by soil conservation. In equation (3), the money value of agricultural production affected by soil conservation (V) is a function of production and vector of prices (Py). The equation was $V = V(Y, Py)$. The study showed that investments in agro-forestry in order to improve or maintain soil capital would increase annual agricultural profits by 5-10% of total income.

Pagiola (1998) has estimated soil conservation benefits from both a private and social viewpoint in semi-arid Kenya. He has found that when on-site productivity is the primary concern, farmers tend to have strong incentives to adopt conservation measures. When off-site impacts are the

primary concern, farmers have no direct incentive to take appropriate remedial action and therefore suggest that the government subsidise the conservation measures.

Gunatilake (1998 & 2003) has estimated the on-site costs of soil erosion and on-site benefits of soil conservation using the productivity change method. Once the relationship between top soil depth (TSD) and crop yields is estimated, $p_i Y_{it} - p_i Y_{i(t+1)}$ provides the cost of soil erosion in the i^{th} land use category between time t and t+1 (p_i is the price of the i^{th} crop and Yit is the per ha i^{th} crop yield in time t). Change in soil depth is derived from soil erosion rates (here the value of eroded soil is converted to soil depth, in cm); soil depth is then substituted in the production function to obtain productivity changes. In converting the soil erosion rate to depths, a bulk density of 1.35 t/m^3 is used. Many studies suggest that the complex relationship between crop yield and topsoil depth is approximated by the production function when topsoil depth is used as an explanatory variable (Ananda, 1996; Gunatilake, 1990; McConnell, 1983; Segarra and Taylor, 1987).

3. Description of the Study Area

The total area of the Chittagong Hill Tract (CHT) is estimated at around 13,237 sq. km, which in area is about one tenth of the country (Brammer, 1997). More than half of the inhabitants of CHT belong to ethnic hill communities (12 tribes) while the rest are Bengali migrants from the plains. The Hill people are, in general, very poor and illiterate, and their livelihood depends on wage earnings and *Jhum* cultivation (Uddin, *et al.,* 2000). Tribal households own on average 2.80 ha of hilly land. Plain lands for cultivation are very scarce in this area. Livestock and poultry provide additional income. Most households own only one dwelling house with no modern amenities and their main source of drinking water is natural springs (see Table 1).

Khagrachari district, which is under CHT, is about 350 km from Dhaka City and lies in the extreme southeast of Bangladesh between the latitudes of 21.11 and 23.45^0 N and longitudes of 91.42 and 92.42^0 E (see Fig.1). The district has an estimated area of 2700 sq. km with a population density of 127 per sq. km (BBS, 2000). The area is hilly with mild to very steep slopes (from 15% to over 70%) often breaking or ending in cliffs. Recent alluviums occupy the valley floors (Khisa, 2001). The hilly terrain areas, which receive high rainfall and have a prolonged wet season, are well drained and are therefore attractive for year round agricultural production. The valleys and hilltops of the area are rich in natural resources including timber, bamboo, medicinal plants, etc. In addition, rice, sugarcane, maize, tuber crops, fruits and vegetables are also grown in the valleys and hilltops (Gafur, 2001; Uddin, *et al.,* 2000).

The climate of the region is sub-tropical monsoon. The monthly rainfall ranges from 44 mm to 987 mm. The highest rainfall occurs during June-July. The hot and humid rainy season alternates with dry and cool winters. The winter starts from the middle of November and continues till late February. The soil texture varies from sandy loam to clay loam. In addition to cultivation, collection of timber, firewood, and house-construction material remain important as sources of income for hill people.

Land ownership is a complex issue in the hill areas as many villagers have customary rights to land. Generally, people have settled wherever there was enough land. Over time, however, more and more lands were settled in the name of private persons for agriculture and horticulture, creating private property rights over land (Riessen, 2000). A variety of crops, fruit trees and timber species are grown in the study area. After cultivating crops, farmers generally leave the

hill for rejuvenation of topsoils and return to it after 3-10 years for cultivation. Some Bengali farmers involved in the HFRR project are adopting the Multi Strata Fruit Orchard (MSFO) on the hill as a soil conservation measure. Livestock is often associated with crop production providing cash for important family expenses.

3.1 *Jhum* (Shifting) Cultivation

Shifting cultivation, locally called *Jhum*, is a traditional crop cultivation system of the tribal hill people. Tribal farmers select *Jhum* lands following some traditions and beliefs. Usually, they take a bath, wear clean clothes, offer prayers and go out in search of a likely *Jhum* site. If a suitable site is found, they collect a lump of soil from the site for a 'dream test'. If they dream well, they select the land for cultivation. If the dream is unfavourable, they reject the site and look for another area. Due to demographic pressure and a relative shortage of land for *Jhum* the choice of farmers in selecting land for *Jhum* has shrunk (Haq 1999 & Khan 1999).

Slashing and subsequent burning are preconditions for *Jhum* cultivation. Slashing of vegetation for cultivation is done during January-February. The dry vegetation is burnt and the hill is cleaned for sowing seeds in April-May. The important *Jhum* crops are brinjal, turmeric, rice, chili, sesame, *marpha* (cucumber), arum, sweet-gourd, and cotton. The other less important crops are maize, gourd, tassel-gourd, yard-long bean and tree potato. After the start of the first rains in April-May, they dibble different crop seeds in a hole, while simultaneously using the hoe. *Jhum* farmers broadcast smaller seeds and dibble relatively bigger and mixed seeds. They cultivate turmeric and aroids as mixed crop.

The hill farmers harvest *Jhum* crops for a long period that starts from June and ends in December depending on the maturity period of crops. They harvest leafy and fruit vegetables during June to September. Cucumber, bitter gourd, maize, sweet gourd and sinel (spices) are harvested between July and September. Other important crops like potato, chili, arum and rice are harvested during September and October. In October, they harvest white gourd, yard long bean, cotton, cassava and sesame. Only turmeric is harvested between the month of November and December.

3.2 The Multi Strata Fruit Orchard (MSFO)

The MSFO is one of the new soil conservation technologies promoted in the last 7 years for livelihood development and to mitigate the negative effects of soil erosion and among hill farmers. BARI has established a number of MSFO spreading over three hill districts under the HFRR project. Under this programme, farmers are given all kinds of inputs free of cost. The inputs are fruit sapling, pineapple sucker, fertilizers, the cost of input carrying and labour, and transplanting of fruit saplings. After harvesting *Jhum* crops, fruit saplings are planted on hills maintaining an 8-10 meter distance between two plants. Generally, dwarf-type fruit trees are planted on the top while tall fruit trees are planted on the lower base of the hill. MSFO farmers also transplant pineapple suckers in between rows of fruit saplings during the March-May period, which act both as hedge crops against soil erosion as well as cash crop for the farmers. If proper management is ensured, a hill becomes a fruit orchard after just 8-10 years. The fruit trees prevent the heavy rain from directly hitting the topsoil of the hills, which results in decreased topsoil erosion.

3.3 Sampling Design and Data Collection

Matiranga, Ramgar and Sadar *Upazila*[3] of Khagrachari district were purposively selected for interviewing MSFO farmers. The reasons behind the selection were: (i) high concentration of households practicing soil conservation technology; (ii) orchards in these areas were older than in other areas; (iii) the lack of prior studies in this area; and (iv) the existence of a BARI research station which facilitated the logistics of the field survey. A total of 60 MSFO households were chosen. Farmers were categorised according to the number (1-4) of years of MSFO technology adoption, choosing 15 farmers randomly from each category.

The Dighinala Upazila was selected for studying *Jhum* farmers. A pilot survey was conducted in the *Jhum* study area and a complete list (sample frame) of *Jhum* farmers was developed. Since repeated visits were necessary in the *Jhum* area, we restricted our sample households to those located alongside the main roads (maximum of 1 km from the main road). From this list, we stratified farms on the basis of fallow periods of 3-, 4-, 5-, and 6-year. Forty *Jhum* farmers (10 from each strata) were selected randomly.[4]

MSFO farmers were interviewed twice during April-May 2005. Data from *Jhum* farmers was collected on a weekly basis during May-December, 2005. This was complemented with secondary information from the statistical bureau and earlier research reports.

4. Estimation of Costs and Benefits of Jhum and MSFO Farms

In this section, the costs and benefits associated with Jhum farming and MSFO are calculated. The role of the discount rate in motivating farmer adoption of new technologies is also examined. Further, exploratory analyses is undertaken to establish the impact of top soil loss on farm yield and to understand the implications of increasing fallow length on farm top soil.

4.1 Jhum Farming

The per hectare cost of *Jhum* farming was calculated by summing up all the costs incurred for various inputs like human labour, seed, and fertilizer (See Table 2). The gross return per hectare was calculated by summing up the value of different crops grown. The net return was estimated by deducting gross cost from gross return. In order to estimate future production from *Jhum* farming we assumed that the returns from the four different fallow periods considered here (3-, 4-, 5-, and 6-year fallows) would remain constant over the next 25 years. Therefore, based on different fallow periods, the estimated net benefits of Tk. 686 (3 year), Tk. 2,582 (4 year), Tk. 6,763 (5 year), and Tk. 9,811 (6 year) were considered fixed for up to 25 years (see Table 3).

4.1.1 Profitability of *Jhum* Farming

Jhum cultivation involves little cash expenses but relies largely on own inputs and the natural fertility of the soil. The survey found that about 80% of the total cost of production was domestically supplied in which 75% of the labour and 100% of the seed was from family sources. The net return per hectare was Tk. 17,786 ($ 289.72) per year and was found to increase with the lengthening of the fallow period. The average rate of return (BCR) of full cost and cash cost were 1.21 and 2.79 respectively implying that *Jhum* farming is profitable (see Table 2 & 3).

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[3] *Upazila* is an administrative unit that consists of several unions. A union comprises several villages

[4] However, in a few cases we had to change the sample household due to problems related to access to the farm for regular monitoring.

Table 5 shows that the average revenue received from two principal *Jhum* crops, namely, turmeric and rice, have gradually increased with the increase in the fallow period. A similar trend was also observed for other crops. Farms with longer fallow periods also showed higher TSD. Figure 2 presents the marginal effect of increasing the fallow period on the farm revenue. The gain in marginal revenue gradually declines as the fallow period increases. The maximum marginal gain is reached when farmers increase the fallow period to 4 years and the marginal gains are at their lowest when the fallow period is increased to 6 years. This implies that it is not desirable for *Jhum* farmers to increase the fallow period beyond the 5th year.

4.2 MSFO Farming

The project appraisal technique was adopted in estimating the cost and benefit of soil conservation technology (MSFO). The 1st year cost of setting up an MSFO in the hilly tracts included the cost of fruit sapling, pineapple and banana sucker, fertilizer, human labour, and intercrop cultivation. The maintenance costs of gardens for the 2nd to 4th years included the costs of human labour, fertilizer, hormone for pineapple fruiting, and pesticides. The initial cost and the maintenance costs up to four years of MSFO were calculated from cross section data collected from the interviews. Maintenance costs were estimated (based on field experience) to be 10% higher for the gardens aged from 5 to 10 years than the average cost incurred for the 1 to 4 year gardens. Again, the maintenance costs for 11 to 15 year gardens are assumed to be 15% higher than the maintenance cost for a 10th year garden. Similarly, maintenance costs for gardens aged 16 to 20 years and 21 to 25 years were assumed to be 15% higher than the costs incurred for the 15th and 20th year gardens respectively (see Table 4).

The gross benefit of MSFO included the benefits received from fruits, pineapple, intercrops and the salvage value of trees. The economic life was taken into consideration when estimating income from a fruit tree. For instance, the economic life of a litchi (*Litchi chinensis)* and mango (*Mengifera indica)* tree was assumed to be 25 years while for guava it was assumed to be 15 years. The whole fruiting period of a tree was divided into three stages: (i) increasing production, (ii) highest production, and (iii) decreasing production. The production periods and yields of different fruit trees were taken from published books and journals. The total benefits of a fruit tree was calculated by multiplying the total quantity of fruits produced per year with the length of fruiting period and local fruit price. Thus, the total benefit (undiscounted) per year of a sample garden was calculated by adding up all the returns produced from the different fruit trees. The salvage value of a fruit tree was calculated by multiplying the local price of timber with the total number of trees per hectare, and treated as previous year's income to the farmer.

4.2.1 Net Present Values of the Two Techniques

Costs and benefits were discounted to calculate the net present value (NPV) of an MSFO. Since social discount rates are not known, ranges of values were used in this study for sensitivity analysis. The net gain from switching to MSFO was estimated by calculating the difference in the NPV of MSFO and *Jhum* farming using the following formula:

Net Gain from MSFO = $\sum_{t=1}^{n}\left[\frac{B_t - C_t}{(1+i)^t}\right]^{MFSO} - \sum_{t=1}^{n}\left[\frac{B_t - C_t}{(1+i)^t}\right]^{Jhum}$ Where, B_t = Benefit from farming (MSFO or *Jhum*) in year t; C_t = Cost of farming (MSFO or *Jhum*) in year *t*; *t* = 1, 2, to n; and *i* = interest (discount) rate.

The net gain from MSFO technology was calculated within the framework of both private and social benefits and costs. In the social BCA, the cost to society of keeping land fallow was included.

4.3 Discount Rate and Its Role

The discount rate plays an important role in determining the net present value of projects that have streams of benefits and costs over time. The literature on discount rate suggests that the appropriate rate of discount is the one that includes both the time value of money as well as a rate of growth in future consumption and the elasticity of marginal utility of consumption (known as the Ramsey equation). However, since it is difficult to determine these parameters within the scope of the present study and since most project analyses in Bangladesh use an arbitrary value of 10%, we too have used 10% for this analysis. At the same time, a sensitivity analysis is done using 8%, 12%, 15%, and up to 58% discount rates to understand the impact of the discount rate on the net present value of benefits (see Figure 3).

The adoption of any land use practice by farmers is dependent on the relative profitability of different options. This study finds that the farmers who adopted MSFO technology received negative net benefit in the first year due to the higher investment involved in the initial stage (see Table 5). The benefits however increase substantially from the second year due to pineapple and intercrop cultivation. The benefits from the MSFO garden are expected to continue up to the 25th year.

4.3.1 Discount Rate & Private Returns of *Jhum* Farmers

One of the objectives of this research was to find out when *Jhum* farmers are most likely to adopt the MSFO technology. In theory, it depends on a) the relative profitability of MSFO farming, b) the expected future prices of products, and c) the rate of discount of individual farmers. As discussed earlier in Section 4.2, the rate of discount of a farmer depends on a) the rate of interest, b) the rate of time preference, and c) the rate of growth in consumption. Assuming the rate of interest and growth in consumption is the same for all farmers; it is the rate of time preference of individual farmers that would determine the discount rate. The rate of time preference depends on the individual's perception of future outcomes. In this case, if two farmers have different expectations vis-à-vis the MSFO, then their discount rates are likely to differ. A farmer may switch to MSFO farming when his net gain from the switch is equal to or greater than that of *Jhum* farming.

Table 6 provides a comparative picture of net gains at different discount rates. It shows that a 3-year fallow *Jhum* farmer who earns about Tk. 686 ($11.17) per hectare will switch to the new technology only if his/her rate of discount is below 57.48%. Similarly, a 4-year fallow based *Jhum* farmer will switch at discount rates below 46.46%. The cut off rates of discount are 36.44% for a 5-year fallow and 32.58% for a 6-year fallow.

4.3.2 Reasons for lack of MSFO popularity

Even though our calculations indicate large NPV from MSFO technology for a wide range of discount rates, it has been observed that farmers do not readily switch to MSFO technology. Figure 3 shows the changes in the NPV of MSFO benefits at different rates of discount.

MSFO seems very lucrative economically but the high initial cost of adoption could be a deterrent for *Jhum* farmers. The initial cost of setting up a MSFO farm is Tk.1,06,254 ($1,730.80) per ha, which is beyond the capacity of the poor *Jhum* farmers (see Table 4). Jhum farmers who enjoy only customary rights on their land may find it too risky to spend such large amounts on land which they do not fully own thereby increasing the rate of discount. The long gestation period between initial expenditure and flow of returns could be a further deterrent for most *Jhum* farmers who find it difficult to sustain beyond one cropping season. Unless they have access to credit from NGOs or other formal credit institutions to finance their initial investment and their livelihood during the gestation period, they would not be able to adopt MSFO. Micro-finance institutions, which have been successful elsewhere in Bangladesh, would not work here since they depend on weekly repayment schedules to recover their loans while MSFO has long a gestation period. Finally, orchard farming is, by and large, a new type of farming with which *Jhum* farmers are not familiar. This further increases their risk perception.

4.4 The Social Perspective

In the above sections, we have discussed the critical rate of discount that would prompt a *Jhum* farmer to adopt MSFO technology. However, what we did not bring into the calculation was the amount of land that is used by the different technologies. A 3-year fallow *Jhum* farm would typically use 3 times the amount of land in comparison to a MSFO farmer using the same net-cropped area. If the gross cropped area is used to compare between the two technologies, the total gain from switching to MSFO would be much higher (Table 7). Hence, the net social gains are much greater than the net private gains calculated earlier.

4.5 Farmers' Perceptions on Shifting Cultivation and MSFO

Jhum farmers are aware of the harmful effects of shifting cultivation as it depletes and degrades soil, among other environmental problems and the need to stop shifting cultivation. They opined that it causes huge soil loss from the hillsides, which in turn degrade soil quality, and causes other environmental problems. Traditional farmers know these harmful effects from the experience of decreasing crop yield over time. Despite this knowledge, they have continued *Jhum* farming partly due to historical reasons and partly due to poverty-related reasons such as lack of alternatives, awareness, and technical know-how (see Table 8).

Interviews reveal that most hill farmers realise the importance of soil conservation and wish to adopt the new MSFO technology. About 90% of them were willing to set up MSFO on their hill but the technology is unknown to them. Of those willing to accept MSFO, 36% said that they need financial support, 39% want free supply of saplings, and 25% need training (see Table 9).

5. Conclusions and Policy Recommendations

This study compares the benefits of MSFO farming with the current practice of shifting cultivation (*Jhum*) as a means of ensuring soil conservation and enhancing farm incomes in the Chittagong hills. The study reveals that MSFO farming is highly beneficial and the net return for shifting from *Jhum* depends on the fallow period practiced in *Jhum* farming. However many farmers do not want to switch to MSFO farming due to various reasons such as a) insufficient knowledge of MSFO farming practices, b) risks and uncertainties associated with MSFO farming, c) high initial cost of adoption, d) uncertain property rights and e) unavailability of seed money. Some of these problems could overcome if financial support and technical assistance are made available by the state authorities.

The following policy interventions may be socially desirable and also enable *Jhum* farmers to adopt MSFO technology:

Awareness: Create awareness among hill farmers by the help of NGOs, the hill development authority, and other socio-cultural organizations.

Financial support: Given the high initial cost of setting up MSFO farms by provision long-term and short-term loans at reduced rates of interest to enable wider acceptance of this technology.

Pest control: MSFO farmers complained of pest-related problems on their farms. Scientists could help identify and provide curative measures for the farmers.

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Table 1: Socio-Economic Profile of *Jhum* Farmers

Socio-economic Characteristics	
1. Family size	5.10 persons/household
2. Literacy rate	37.5%
3. Population dependent on wage labour	65.0%
4. Population dependent on agriculture	30.0%
5. Land holdings	Hill- 2.80 ha; Plain- 0.59 ha
6. Dwelling house (made of CI sheet & bamboo)	1.1 Nos.
7. Households without modern amenities	82.0%
8. Households with livestock & poultry	55-65%
9. Source of drinking water	Natural springs

Source: Field survey, 2005

Table 2. Annual Cost and Return from Jhum Farming

(Tk per ha)

Particulars	Length of Fallow Period of Hill				All year
	Three year	Four year	Five year	Six year	
1. Human labour	15551 (74)	19637 (78)	16973 (75)	17493 (76)	17414 (75)
Family labour	10817 (52)	16271 (65)	12419 (55)	12589 (55)	13024 (56)
Hired labour	4734 (22)	3366 (13)	4554 (20)	4904 (21)	4390 (19)
2. Seed	5113 (24)	5200 (21)	5262 (23)	5161 (22)	5184 (23)
3. Fertilizers	4.25 (0)	5.42 (0)	3.81 (0)	-	4.32 (0)
4. Interest on OC*	344.8 (2)	300 (1)	343.7 (2)	352.3 (2)	335.24 (2)
A. Gross costs:					
Full cost	21013	25142	22583	23006	22938
Variable cost	10196	8871	10164	10417	9914
B. Gross benefit	21699	27724	29346	32465	27700
C. Net return					
Over full cost	686	2582	6763	9811	4762
Over cash cost	11503	18853	19182	22048	17786
D. Rate of return					
Over full cost	1.03	1.10	1.30	1.43	1.21
Over cash cost	2.13	3.13	2.89	3.12	2.79

Figures within parentheses are percentages of full cost, OC = Operating capital

Table 3: Cost and Benefit Streams of MSFO and *Jhum* Farming

Year	Cost and Return from MSFO Farming (Tk/ha)			Net Benefit from *Jhum* Farming (Tk/ha)			
	Cost Stream	Benefit Stream	Incremental Benefit	3 year *Jhum*	4 year *Jhum*	5 year *Jhum*	6 year *Jhum*
1	106254	0	-106254	686	2582	6763	9811
2	9678	49093	39416	686	2582	6763	9811
3	12773	70478	57706	686	2582	6763	9811
4	10237	103742	93505	686	2582	6763	9811
5	36802	55596	18794	686	2582	6763	9811
6	36802	157093	120291	686	2582	6763	9811
7	36802	121489	84687	686	2582	6763	9811
8	36802	164885	128083	686	2582	6763	9811
9	36802	129742	92940	686	2582	6763	9811
10	36802	164550	127748	686	2582	6763	9811
11	42322	981198	938876	686	2582	6763	9811
12	42322	1270102	1227780	686	2582	6763	9811
13	42322	981198	938876	686	2582	6763	9811
14	42322	1270102	1227780	686	2582	6763	9811
15	42322	981198	938876	686	2582	6763	9811
16	48671	1701247	1652576	686	2582	6763	9811
17	48671	1318362	1269692	686	2582	6763	9811
18	48671	1701247	1652576	686	2582	6763	9811
19	48671	1318362	1269692	686	2582	6763	9811
20	48671	1701247	1652576	686	2582	6763	9811
21	55971	1680950	1624978	686	2582	6763	9811
22	55971	2168258	2112286	686	2582	6763	9811
23	55971	1680950	1624978	686	2582	6763	9811
24	55971	2168258	2112286	686	2582	6763	9811
25	55971	1680950	1624978	686	2582	6763	9811
26	0	445120*	445120	0	0	0	0

Notes: * Salvage value of tree

The cost of intercrop cultivation is excluded from the cost stream of MSFO

Table 4: Initial and Maintenance Costs of MSFO

Inputs	1st year cost		2nd year cost		3rd year cost		4th year cost	
	(Tk/ha)	%	(Tk/ha)	%	(Tk/ha)	%	(Tk/ha)	%
1. Human labour	36950	34.8	8691	89.8	11630	91.1	9394	91.8
Family labour	10773	10.1	8691	89.8	11630	91.1	9394	91.8
Hired labour	26177	24.6	-	-	-	-	-	-
2. Sapling/sucker	25927	24.4	-	-	-	-	-	-
Fruit sapling	6900	6.5	-	-	-	-	-	-
Banana sucker	608	0.6	-	-	-	-	-	-
Pineapple sucker	18419	17.3	-	-	-	-	-	-
3. Fertilizers	34205	32.2	638	6.6	802	6.3	541	5.3
Urea	5916	5.6	-	-	-	-	-	-
TSP	13500	12.7	-	-	-	-	-	-
MP	14789	13.9	-	-	-	-	-	-
4. Hormone	-	-	300	3.1	265	2.1	169	1.7
5. Pesticide	-	-	49	0.5	76	0.6	133	1.3
6. Intercrops	9172	8.6	-	-	-	-	-	-
Total	106254	100	9678	100	12773	100	10237	100

Note: Price of inputs: Pineapple sucker= Tk.0.50 (including transportation cost); Mango= Tk.50; Litchi= Tk.25; Jackfruit= Tk.10; Guava= Tk.5; Coconut= Tk.20; Betel nut= Tk.10; Papaya= Tk.2; Lemon= Tk.10; Golden apple= Tk.10; Indian Olive= Tk.10; Sapota= Tk.10; Banana= Tk.5; Urea= Tk.6; TSP= Tk.14; MP= 15; Wage Rate = Tk.110 (including meal).

Table 5: Effect of Increased Fallow on TSD and Productivity (*Jhum*)

Type of *Jhum* Farm	Average Revenue (Tk/ha)	Average TSD (cm)	Change in Revenue (Tk/ha)
A. Turmeric			
3 years fallow	12448.80	5.63	1,977
4 years fallow	14444.35	7.30	1,415
5 years fallow	17279.71	7.93	1,299
6 years fallow	18993.27	8.43	1,151
B. Rice			
3 years fallow	3525.93	5.63	560
4 years fallow	3907.75	7.30	383
5 years fallow	4245.31	7.93	319
6 years fallow	4574.13	8.43	277
C. All Crops			
3 years fallow	21698.79	5.63	3,445
4 years fallow	27724.12	7.30	2,716
5 years fallow	29345.99	7.93	2,205
6 years fallow	32464.80	8.43	1,967

Table 6: Gains from Switching to MSFO Technology

Rate of Discount	Annual Net Gain Taka per ha from MSFO Farmers			
	From 3 year *Jhum*	From 4 year *Jhum*	from 5 year *Jhum*	from 6 year *Jhum*
8%	232458	231649	229863	228562
10%	170895	170207	168689	167582
12%	127283	126688	125376	124420
15%	83706	83216	82135	81347
25%	24480	24177	23511	23025
32.58%	10930	10698	10185	9811*
36.44%	7430	7222	6763*	
46.46%	2746	2582*		
57.48%	686*			

Note: *equivalent of foregone benefits from *Jhum* farming

Table 7: Social Gains from MSFO Technology

Rate of Discount	Annual Net Gain Taka per ha from MSFO When Switching			
	From 3 year *Jhum*	From 4 year *Jhum*	From 5 year *Jhum*	From 6 year *Jhum*
8%	232666	232481	232141	231980
10%	171071	170911	170612	170463
12%	127433	127292	127025	126885
15%	83829	83707	83475	83347
25%	24552	24466	24296	24192
33.39%	10120	10049	9904	9811*
37.16%	6967	6900	6763*	
46.96%	2641	2582*		
57.71%	686*			

Note: * foregone benefits from *Jhum* farming

Table 8. Reasons for Jhum Cultivation

Type of problem	Percentage
Reasons for *Jhum* Cultivation (*N=40*)	
1. *Jhum* farming is an inherited practice	93
2. For livelihood/poverty	90
3. Other cultivation method is unknown	53
4. Lack of plain land	10
5. Lack of awareness	10
6. Labour scarcity	5

Table 9: Farmers' Responses to the Adoption of MSFO Technology

Reasons for not Adopting	Percentage
A. Willingness to Adopt *(N=40)*	
Yes	90
No	10
B. Reasons for not Adoption	
1. Technique of establishing MSFO is unknown	58
2. Require higher investment	42
C. Facilities Demanded	
1. Provision for supplying fruit saplings free of cost	39
2. Provision for full financial support to set up MSFO	36
3. Provision for providing training on MSFO	25

Figure 1: Map of the Study Area

Figure 2: Marginal Revenue with Respect to Length of Fallow Period

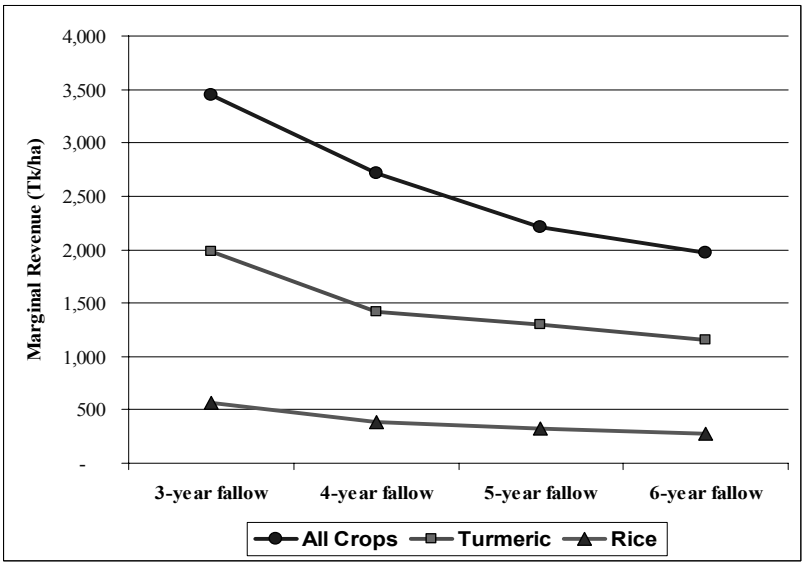

Figure 3: Annual Net Gain from Switching to MSFO Technology at Different Discount Rates