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SOCIO-ECONOMIC CONDITION AND SOIL MANAGEMENT STATUS IN BANDARBAN HILLY AREA OF BANGLADESH

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Abstract

Jhum cultivation, a traditional shifting agricultural practice of small ethnic communities in the hilly regions, plays a central role in their livelihood but accelerates severe soil erosion and degradation. This study, conducted from March 2015 to February 2017 in Bandarban, assessed soil and nutrient losses, nutrient balance, and developed improved management practices to enhance long-term soil productivity. A comprehensive field survey evaluated soil fertility status and the socio-economic conditions of local tribal households. Results revealed that jhum cultivation induced substantial annual soil erosion ranging from 35 to 56 t ha^{-1}, while failing to meet the year-round food needs of the hill communities. The soils, inherently acidic (pH 4.6–5.3), exhibited more pronounced degradation in the surface layer (0–15 cm) compared to deeper horizons. Adoption of balanced fertilizer application combined with organic residue incorporation significantly reduced soil erosion and nutrient depletion, while improving crop yield. These findings highlight the urgent need for integrated soil fertility management strategies to sustain productivity and food security in the hilly landscapes of Bangladesh.

Keywords: Soil fertility, Chittagong Hill Tracts, Jhum cultivation, Soil erosion

1. Introduction

The soil is the greatest natural resource of Bangladesh. Physiographically, it has three categories of lands: floodplains (80%), terraces (8%) and hills (12%). Chittagong Hill Tracts (CHT), located in the south-east of Bangladesh, is endowed with natural beauty and economic potentiality (Chowdhury and Mallik, 2010). CHT region comprises about one tenth of the total area of Bangladesh. The area covers 13,295 sq. km consisting of about 77% upland (hill), 20% undulating bumpy land and 3% plain with high potential for agriculture development (BBS, 2008). It has three hill districts *viz*., Khagrachari, Rangamati and Bandarban with 25 upazilas, 110 unions, 380 mouzas and 3200 villages. The CHT's population is about 1.4 million with a density of 122 people per sq. km.

The CHT represents a very fragile hill ecosystem and is characterized by steep to extremely steep slopes with 90% of its landscape belonging to the upland category that limits its land use capabilities. The other characteristics are its land-based economy, high rainfall (2,000-3,800 mm), other than evapotranspiration and interception losses, most of these rainwater drains out of the hills through numerous creeks, streams, and rivers (Gafur *et al.* 2003a). The land of this region is susceptible to very high erosion and stagnant agricultural growth with high population growth. Presently, the area is becoming denuded due to the unplanned management of hills and agricultural practices at steep slope without any conservation measure. There are hills with altitudes of more than 1000 meter (Brammer, 1986) having the steep slope and long slope. Continuous depletion of soil fertility is a major constraint for crop production. Deforestation, sloppy land, soil erosion, inadequate irrigation facility, soil acidity, the limited volume of soil for root anchorage, nutrient leaching and low soil organic matter content are the main causes of poor crop yield. Because of unrest for decades, appropriate research and generation of technologies have not been duly advanced. Poor communication, poor marketing facilities, Bengali-Tribal people conflict, land ownership/tenure issues are the further constraints to the food security of the hilly people. Biodiversity and lack of proper soil management are the predominant forms of land degradation. In the past, land was left fallow for 15 to 20 years, which allowed the soil time to regenerate its fertility for jhum cultivation (the traditional multiple cropping system by the local tribal people taking little or no care of nutrient management of soil). These days however population pressure, coupled with acute land scarcity has forced that time frame to be reduced to a rotation cycle of between 2 to 3 years (CARE, 2000). Jhum cultivation is a traditional farming system, difficult to discard it. Rapid loss of soil fertility and toxicity of Al^{3+}, Fe^{3+}, and Mn^{4+} are the two major problems for achieving the satisfactory yield of jhum crops. The present challenge for the researchers is to restore the fertility of hill soils within a short period. Soil fertility is in declining trend due to loss of nutrients and organic matter. Upland soil loss and sedimentation are high during the cultivation period, but soil loss comes to near normal levels in the first-year fallow after one-year cultivation because secondary vegetation cover is established quickly (Gafur *et al.* 2003b).

There is very little information on the farming system in CHT, specifically on current jhum cultivation and how people cope in order to maintain their livelihood under declining productivity. It is important to know the views of farmers regarding their farming practices as well as improvement of their livelihood. Before the initiation of hill researches the present survey, study was carried out to investigate the socioeconomic conditions of the tribal people and potential effects of jhum cultivation in hill soils. The findings would help in developing improved technology to minimize soil erosion, improve soil fertility and ensure sustainable increased productivity in hill soils of Bangladesh. The present research program was, therefore, designed to identify the problems in hill farming, with respect to the educational, cultural and other socio-economic conditions of the local people of Chittagong Hill Tracts (CHT).

2. Materials and Methods

A survey work on livelihood of jhum farmers was done in 2015 in two upazilas of Banderban district of CHT to know the jhum cultivation and soil management practices and determine the changes in soil fertility. The two upazilas where the survey was done were Bandarban sadar and Roangchori under Bandarban district. Fifty respondents from each area were interviewed through a pre-tested structured questionnaire to get basic information of the households including livelihood activities, soil fertility, fertilizer use and soil management.

2.1 Data collection procedure

In-situ soil samples were collected from the gentle slope (0-15%), moderate slope (15-30%), steep slope (30-50%) and very steep slope (>50%) at 0-15 cm and 15-30 cm depths from 12 hills before and after jhum cultivation in 2015-2016. About 48 composite soil samples were collected from 12 hills from two different depth in two times. The samples were collected from nine different spots for each site, before sowing and after harvest of jhum crop. After collection of soil samples, sampling sites were marked by labelling plates for easy identification during future work. The collected soil samples were air-dried, ground and sieved to pass through a 2-mm sieve and then mixed thoroughly to make a composite sample for each of 12 hills. Dry roots, grasses, and other unwanted substances were removed from the samples. About 250 g of soil for each site was kept in plastic containers for analyses. Hillslope was measured by Slope Meter (Abney's Level). Elevation, longitude, and latitude were determined by the GPS meter. Information on soil loss under jhum practice was also collected. Standard methods were followed for soil analyses. The data of socio-economic survey on jhum cultivation was analyzed by Statistical Package for the Social Sciences (SPSS) program.

3. Results and Discussions

About 63% male and 37% female farmers were interviewed for the survey purpose. Farmers' ages were ranged from 21 to 76 years. Mostly middle-aged farmers (64%) were interviewed, 17% were young aged, and the rest 19% of farmers were old aged. Out of 100 farmers, 77 were illiterate, that is they have never gone to school, 20 farmers have primary and the rest 03 farmers have a higher secondary level of education. The survey showed that the maximum jhum farmers were illiterate who had no academic background. Recent improvement of transport and infrastructural facilities in the hilly areas may have favored the young generation for inclination to education. Ahmed (2015) stated that the rate of education in hilly area is increasing day by day. In fact, the rate of literacy is only 2% in 1970 to 35.9% in 2015 (Banglapedia, 2023). Even though, the exact rate is not available in 2024, which is certainly will be higher than that of 2015, but below the national average rate of 78%.

Family size ranged from 2 to 7 members. Most of the family size varied within a range of 3-4 members and 63 farmers (63%) belonged to this range, 36 respondents have family sizes varying from 5-7 members and the rest single farmer (1%) have two members in his family. According to BBS (2008) report, the growth rate of population in Bandarban district was 2.02% in 2001.

Out of 100 farmers, 10 farmers (10%) had only 5-49 decimal land, 19% had 0.50-2.50 acres, 57 farmers (57%) had 2.51-7.50 acres and the rest 14% farmers had more than 7.50 acres of land (Fig. 1). The survey information revealed that marginal, small and medium farmers traditionally grow jhum crops for fulfilling their food requirements. But the large farmers having more than 7.5 acres land are inclined to grow high valued fruit trees like pineapple, mango, litchi, guava, banana, coffee etc. commercially in orchards. It was reported that the daily food demand of the jhum people especially rice is 0.5 kg per capita. Most of the family informed that they face food deficit. Usually, they buy their rice and other food items from the nearest shop. Jhum culture is a continuous and traditional agricultural practice to supply daily food requirement of the hilly people. Six to 12 crops were grown in jhum cultivation to meet up the livelihood.

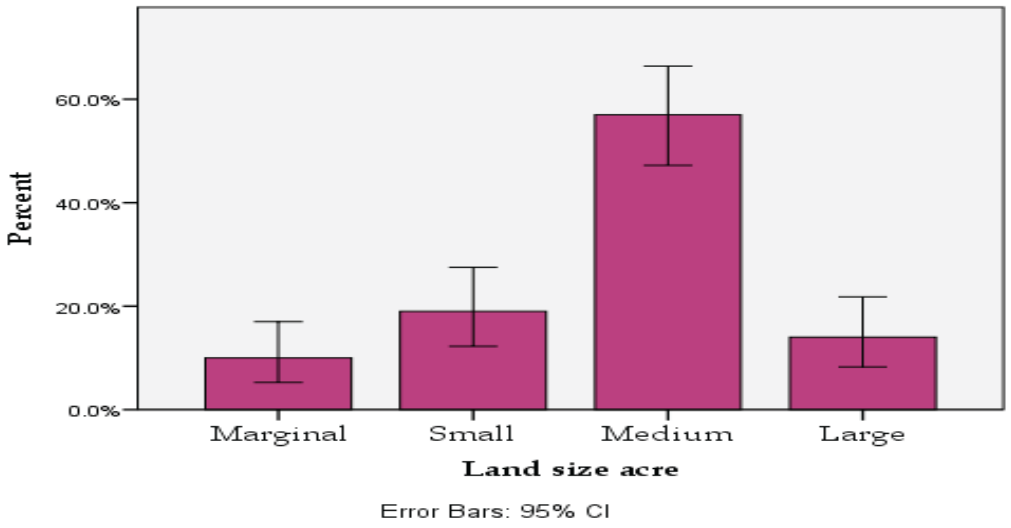

Fig. 1 Land size of the jhumias in the study area of Banderban

3.1 Information on jhum cultivation in the hilly area

Most of the farmers had 40-200 decimal of jhum cultivation, few farmers had more than 200 decimals under jhum culture. About 69% of farmers opined that rice production from jhum cultivation is not sufficient to fulfill their food requirement, while 31% respondent have a positive opinion. Out of 100 respondents, 14% reported to have been involved in jhum cultivation for the last 10 years, 31% farmers for 20 years, 34% farmers for more than 30 years and the rest 21% engaged in jhum culture for more than 40 years (Fig. 2). In hilly areas, population has increased tremendously for the last few decades and the cultivable land has decreased as well due to habitats and infrastructural development. On the other hand, soil fertility and productivity deteriorated with time due to mishandling of the cultivated land. To

meet up the food crises, hilly farmers are recently motivated to grow other seasonal vegetable crops commercially within short period of time, reducing the jhum area.

3.2 Variation of jhum cycle

It was observed that jhum cycle in most cases (52%) was 3 years, 37% farmers adopted a jhum gap of two years, 5% respondents reduced the jhuming gap to only one year and the rest 6% maintained the jhum cycle of 4 years or more (Fig. 3). After some 15 years when the fallow land regains fertility, the farmer comes back to the same land for jhum cropping. This cycle from farming till fallowing and back to farming the land is known as one complete jhum cycle. Jhum cycle means the fallow period of shifting cultivation. In the past most of the farmers followed a cycle of more than six years (Chakma and Ando, 2008). In the present survey, 64 % farmers mentioned the causes of reduction of jhum cycle to be the decrease of jhum cultivable land in the hilly area, about 10% respondents opined that they need for more food, 5% reported that due to increased population and the rest 21% people mentioned due to all of these similar causes.

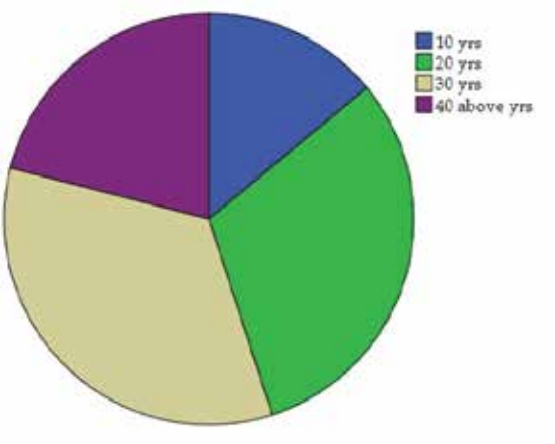

Fig. 2 Period of involvement of the farmers with jhum culture

Sachianda (1989) reported that the higher the density of population the shorter the jhum cycle. No major research focuses on the key issues of jhum farming in CHT. Long time ago, the vegetation in the fallow land regenerates during the fallow period. There are many reasons for decreasing jhum cultivation in hilly land. Poor yield of jhum crops can't meet the food demand of hilly people. Food is not the only item for livelihood of the people. Cost of clothing, education and other necessary requirements can't be met from jhum harvests. Degradation of jhum soil due to mismanagement has led to decreased soil productivity and poor yield of crops.

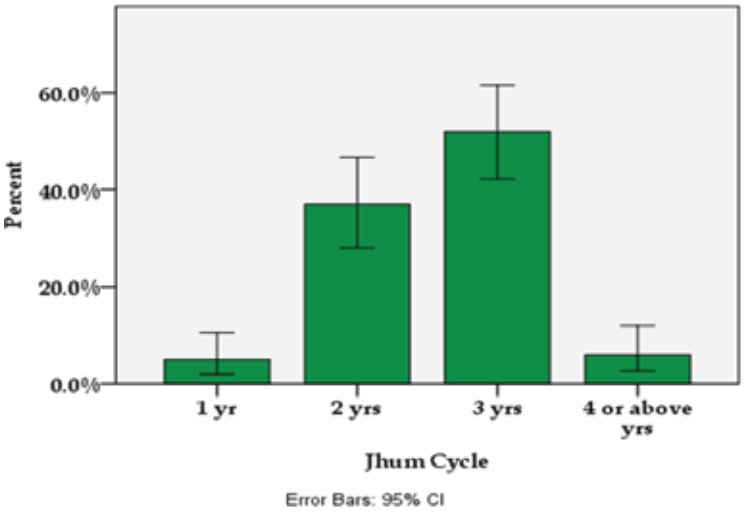

Fig. 3 Variation in Jhum cycle adopted by different farmers

The new young generation are motivated to be educated and trained on advanced technologies of hill agriculture and thus some of the hilly people started commercial cultivation of fruit trees in orchards leaving the traditional jhum cultivation. In some cases, farmers often choose short duration jhum crops to accommodate commercial cultivation of winter vegetables. Now-a-days farmers in many cases are compelled to reduce the time-break period in shifting agriculture for recharging the land for jhum cultivation. Therefore, they use same jhum land within short period of time like one or two-year's interval.

3.3 Crops grown in jhum and their yields

Farmers select jhum crops based on their own need and the availability of seeds. The number of crops varies from 2 to 10 mostly (more than 90%) covered by rice. Other common jhum crops were maize (Makka), sesame, chilly, sweet gourd, ash gourd, *marpha* (cucurbit), turmeric and zinger. Paddy, chilies, maize, sesame, sweet gourd, ash gourd, marpha (cucurbit), yard-long bean, pigeon pea and vegetables were sown by dibbling method in jhum field. Rice, maize (Makka), sesame, chili, sweet gourd, ash gourd, marpha (cucurbit), turmeric and zinger are the dominant species of jhum crops. Several crops like paddy, maize, sesame, chili, sweet gourd, ash gourd, marpha (cucurbit), yard-long bean, pigeon pea and vegetables are sown by a dibbling method in jhum field. The crops mature at different times of the year. Farmers mainly use seeds of local variety that is why they could seldom harvest a good crop. Most of the family is reported to have smaller homestead area (1-33 decimal) with a few having larger homestead area (>33-80 decimal). Most of the farmers have fewer fruit and timber trees in homestead area for their own consumption and use.

If leaving the hill for ten years, it regenerates and regains soil fertility. But nowadays

farmers come back to jhum within 1-2 years which is not enough time for the forest and soil fertility to regenerate. On the other hand, tons of biomass get lost due to the burning of trees and natural vegetation by jhum farmers. Due to heavy rainfall, the minerals of the surface soil (plant nutrients) get washed off causing fertility declination of jhum soils thus, makes the soil unproductive.

Yields of different crops grown under tillage and jhum system are provided in the Fig. 4. It was found that rice yields under well tilled with jhum, and minimum tilled with jhum were 1.85 and 1.78 t ha^{-1}, respectively. The yield of jhum crops were found much lower compared to plain land crop yields. Most of the farmers (53%) opined that the cause of low yield of jhum crops might be due to low soil fertility, 19% told that the soil is low in organic matter content and the rest 19% respondents was unaware about causes of low yields of jhum crops. The yield of jhum crops is very poor to meet up the food demand of the jhum farmers. This is because of continuous use of surface soil and fertility loss due to soil erosion, poor soil management, improper or imbalanced fertilizer application, lack of water during the dry season, use of low yielding local varieties of crops, lack of pest management facilities etc.

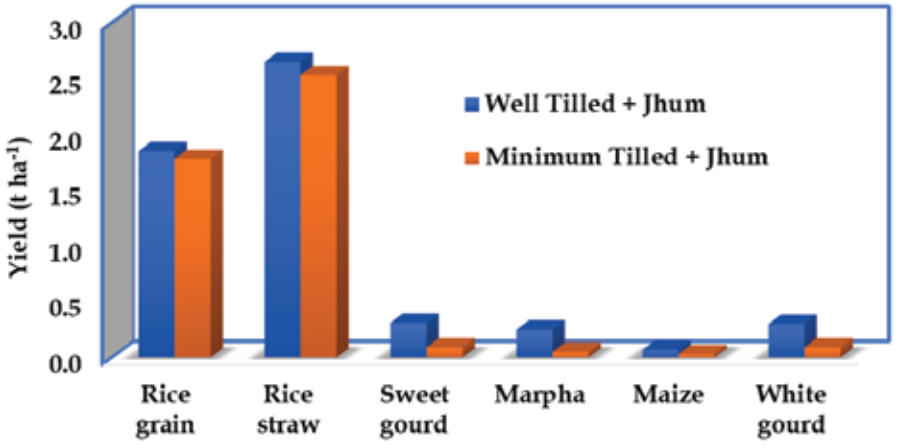

Fig. 4 Yields of different crops under tillage with jhum cultivation system

3.4 Knowledge about soil fertility level

Eighty-one percent respondents reported that the soil fertility status is decreasing day by day. Only 2% of farmers opined that soil fertility status is improving. About 17% of people had no idea regarding soil fertility of jhum field. Out of 100 respondents, 16% farmers viewed that the cause of declined soil fertility may be due to heavy rainfall, 45% people reported that loss of nutrient from soil may be due to soil erosion, and 28% people had no idea on the causes of soil fertility reduction of jhum land. Only 2% stated that loss of soil fertility may be due to the loss of moisture from the soil and about 9% opined that low organic matter could be the cause of reduction of soil fertility (Fig. 5).

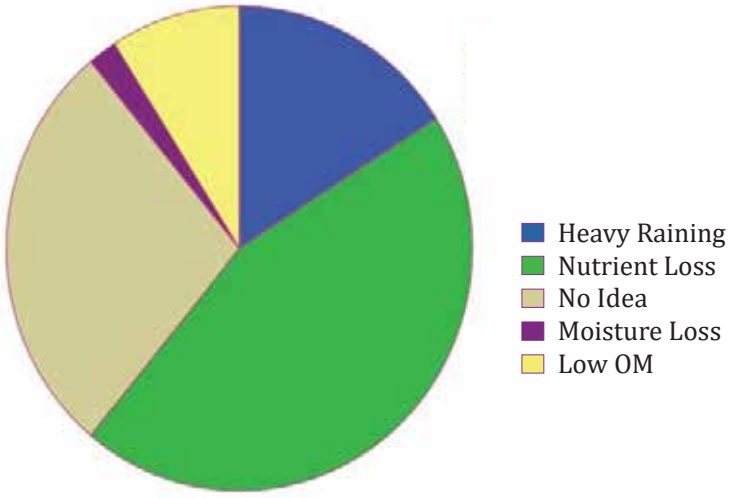

Fig. 5 Causes of soil fertility decline in jhum land

The yield of jhum crops decreased continuously with time due to decreased soil fertility of jhum soil. *Salahin et al., (2013)* stated that the adaptation of the indigenous method of jhum cultivation has created a negative impact on fertility and productivity of hill soils. Burning of natural vegetation just before initiation of jhum cropping leads to a remarkable reduction of soil organic matter, significant loss of nutrients through soil erosion along with improper management of cultivated soil have contributed to the severe decline in productivity of the hilly land. It was reported earlier that there was no use of chemical fertilizer in the jhum culture in the hilly areas of Bangladesh. Degradation of upland soils is widespread in CHT and continues to accelerate due to gradual intensification of crop production without applying balanced fertilizers or manures (Miah *et al.* 2008). But the current survey revealed that farmers in some cases are motivated in applying chemical fertilizer mostly urea by top-dressing, most of which is lost by surface runoff. Due to lack of knowledge, jhum farmers do not have any idea on balanced fertilizers and micronutrients. Most of the farmers use urea fertilizer and a few used urea in combination with triple super phosphate and muriate of potash having no scientific basis. Most of the applied chemical fertilizers may be lost through heavy rainfall.

3.5 Use of chemical fertilizers in jhum cultivation

Only 2% of respondents, reported that they did not use chemical fertilizer. The rest of 98% farmers informed that they used chemical fertilizer in their jhum culture to increase jhum yield. The farmers (98%) who are using chemical fertilizer opined that 44% of them used only urea fertilizer, 29% people used urea and TSP fertilizer and the rest 27% farmers used urea, TSP and MOP fertilizers in their jhum field by top dressing method. About 71% of farmers viewed that the chemical fertilizer was not available in the remote hilly area. About 25% told

that the price of fertilizer was high and not affordable. The remaining 4% respondents did not comment on the use of chemical fertilizer. The present survey study revealed that only about 12% of farmers know about balanced fertilization and the rest of the respondents (88%) do not have any idea about fertilizer application on soil test basis.

Chemical fertilizer was not available everywhere in the remote area of hills. In most cases, it may be available at the Upazila or the district town too far away from the hill villages of the jhum farmers. Due to lack of proper transport facility, hilly people can't go to collect chemical fertilizer in time for their jhum crops. Jhum farmers are mostly poor and, in many cases, can't afford to buy costly fertilizer. The Government should assist the poor jhum farmers by providing chemical fertilizers and other cultivation inputs at low cost. Ignorance of the illiterate farmers about the balanced use of chemical fertilizers and other necessary inputs is also a problem. Soil test-based fertilizer is the latest technology for sustainable land management and retaining soil fertility. But most of the hilly people are not aware of this idea. They didn't get any training on balanced fertilizer application on soil test basis. Only a few farmers apply chemical fertilizer on the basis. In fact, Soil Resources Development Institute (SRDI) provides training to farmers on soil test-based fertilizer application through Mobile Soil Testing Laboratory, but in some cases it may not reach the remote hilly areas.

3.6 Use of organic fertilizers in jhum cultivation

Out of 100 respondents, only 11% people used organic residues to their jhum or homestead garden. Most of the respondents (84%) did not use any organic fertilizer or organic residues in their cultivation in the hilly area. Another 5% farmers had no knowledge on organic fertilizer. Most of the jhum farmers (68%) did not have any idea about the organic matter or organic fertilizer. About 12% people used cow dung, 11% people applied compost fertilizer and only 9% of farmers used poultry litter as organic fertilizer to their homestead garden. About 60% of farmers reported that they do not know how to make organic fertilizer. About 25% told that the sources of organic fertilizer like cow dung and poultry litterwere not available in their locality. Only 4% of farmers reported that the price of organic fertilizer is high which is not affordable and the rest 11% farmers opined that organic fertilizer increases weed infestation in the arable land. The 12% of farmers had idea about fertilizer application on soil test basis (STB), only 2% of them apply chemical fertilizer on STB, but the remaining (98%) do not apply fertilizers on STB.

The survey revealed that the farmers were not aware of the benefits of the use of organic fertilizers like cow dung, poultry manure or compost, green manure in their jhum or horticultural crops. It might be due to ignorance and unavailability of cow dung, poultry manure or other farmyard manure in that area. Generally, hilly people are not habituated in using fertilizer, or organic manure. Nowadays, some people have started in applying chemical fertilizers, but they don't have any idea on the importance and preparation of organic fertilizers. Farmers are not aware of the benefits and preparation of OM or manures.

They were never trained before for preparation and use of OM in cultivated soils. Lack of availability of organic inputs such as cow dung, poultry litter etc. are also the problems of using organic manures to the cultivated hill soils. Due to the remote hilly area and poor communication facility, farmers have little or no access to modern high yielding varieties of seeds. More than 60% of the farmers mainly use the locally produced low yielding local varieties of seeds. Other farmers buy seeds from the neighbored or the market. Due to poor communication in the remote hilly villages, there is less opportunity of the jhum farmers to interact with extension workers or the NGOs for getting knowledge on modern technology on hill soil conservation and increment of soil fertility. Farmers have little or no access to the institutional credit facility. Most of the time farmers face huge loss due to attacks by rodents/animal within the jhum area. Farmers also responded that they get poor yield due to loss of soil fertility due to loss of top soils.

3.7 Soil erosion

Most of the respondents (88%) of the survey viewed that soil erosion causes due to jhum cultivation, but 11% of the respondent do not agree on it. Only 1% farmer has no idea regarding soil erosion or soil loss. Most of the respondents (91%) do not use any control measure to protect soil erosion during jhum cultivation, and only 2% of the farmers had no idea on soil erosion control. Jhum cultivation contributes in disintegrating soil particles and ultimately results severe erosion of top hill soils. The intensity of soil erosion depends on hill slopes, the more the slope the higher the erosion. More tillage and deforestation accelerate soil erosion leading to declining of soil fertility and siltation of rivers and lakes. Due to lack of knowledge or ignorance, people of hilly areas do not take any measure to protect soil erosion. Tillage operations and jhum practice exert severe effects on soil erosion where well tilled without jhum contributed to the highest soil loss of over 56 t ha^{-1} (Table 1).

Soil erosion supplies large quantities of sediments to rivers of Southeastern Asia. It reduces soil fertility of agro-ecosystems located on hill slopes, and it degrades, downstream, water resource quality and leads to the siltation of reservoirs (Ribolzi *et al.* 2017). Soil erosion due to rainfall could be minimized significantly by growing cover crops or adopting contour plowing, terrace farming and plowing of gullies in the hilly areas.

Table 1. Effects of minimum tillage on the reduction of soil erosion in relation to a well -tilled condition in the hilly area

Treatments	Soil loss (t ha^{-1})	Erosion reduction compared to no crop condition (t ha^{-1})	The efficiency of conservation practices (%)
Well tilled, no jhum	56.4	-	-
Well tilled, jhum	39.6	16.8	30.0
Minimum tilled, jhum	35.2	21.3 & 4.4	38 & 11.2

4. Conclusions

Sustainable crop production in the hill regions demands judicious and science-based soil management. Adopting improved practices such as minimum tillage, cultivation in short-length plots, and mulching with crop residues or weeds can significantly reduce erosion and conserve soil moisture. Consistent application of recommended, balanced fertilizers in combination with organic residues, coupled with timely irrigation during dry periods and effective plant protection measures, is essential to maintain soil fertility and optimize crop performance. Implementing these integrated management strategies will not only safeguard the productivity of fragile hill soils but also ensure sustained high yields from jhum cultivation, contributing to food security and livelihood resilience of the hilly communities.

Conflicts of Interest

The authors declare no conflicts of interest regarding publication of this paper.

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