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Important Traditional Soil and Water Conservation Techniques Practices for Sustainable Agriculture in North East India

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ABSTRACT

The North East Region lies between 21.5° to 29.5° N latitude and 89.4° to 97.5° E longitude. The average annual rain in the region is about 2450 mm. In spite of good rainfall region most of area faces the problems of water scarcity during the non-rainy seasons. The rapid increase in population of the region there is heavy pressure on land for food production and due to the population growth, the land holding size are reducing day by day and leads to reduction of *jhum* cycle. Indigenous technical knowledge could be the best option for successful management of *jhum* farming. Many of the *jhum* areas could be change into settle agriculture using traditional soil and water conservation measures.

1. Introduction

The North East India comprises of seven states namely Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland and Tripura (Figure 1). The region lies between 21.5° to 29.5° N latitude and 89.4° to 97.5° E longitude. The average annual rainfall in the region is about 2068 mm (Jain *et al.,* 2013). In spite of good rainfall region most of area faces the problems of water scarcity during the non-rainy seasons. Due to the hilly terrain most of the rainwater losses as runoff and very less amount of rainwater remained for utilization during the dormant periods. High amounts of runoff deplete the soil fertility and lead to imbalance the ecology of the region. Nearly 90% of the population of North Eastern Region (NEH) are rural and mostly dependant on agriculture. Shifting cultivation locally known as *jhum* cultivation is widely practised farming system in the hills areas of North Eastern India and provides livelihood to many of the tribal families in this region. In the process of *jhum* cultivation where first the land is cleared by cutting of trees, bushes, *etc.* up to stump level generally in December–January and kept the cut biomass for drying and final burning to make the land ready for planting of different crops before the onset of monsoon rains. The *jhum* cultivation generally takes place for two to three years and after three years the *jhum* cultivated land is left out for rejuvenation of natural forest and regaining its soil fertility until next cultivation takes place. The rapid increase in population of the region there is heavy pressure on land for food production and due to the population growth, the land holding size are reducing day by day and leads to reduction of *jhum* cycle (the period after which the farmer return to the same plot for cultivation). In the early days the *jhum* cycle use to be the 20–30 years and which is now reduced to 3–4 years (Borthakur, 1983), disturbing the entire ecosystem which leads to huge soil erosion and loss of flora and fauna. Different initiatives from the government and non-governmental organisation have been trying to eliminate the *jhum* cultivation in North East India. Most of the tribal societies in North East India are bind with the customary law, traditional and social system. Most of modern scientific technologies available for settle agriculture may not be easily acceptable to them. When we identify the traditional farming systems in terms of indigenous knowledge, skill, experiences used for sustainable natural resources management by farmers of north east India, it may be an option for the region to reduced *jhum* cultivation and move towards the sustainable agriculture. But it needs to provide awareness to the farmers in the right time and right place. Details and in-depth study of these indigenous farming systems are needed on how efficiently they used the soil and water management and their secret of success.

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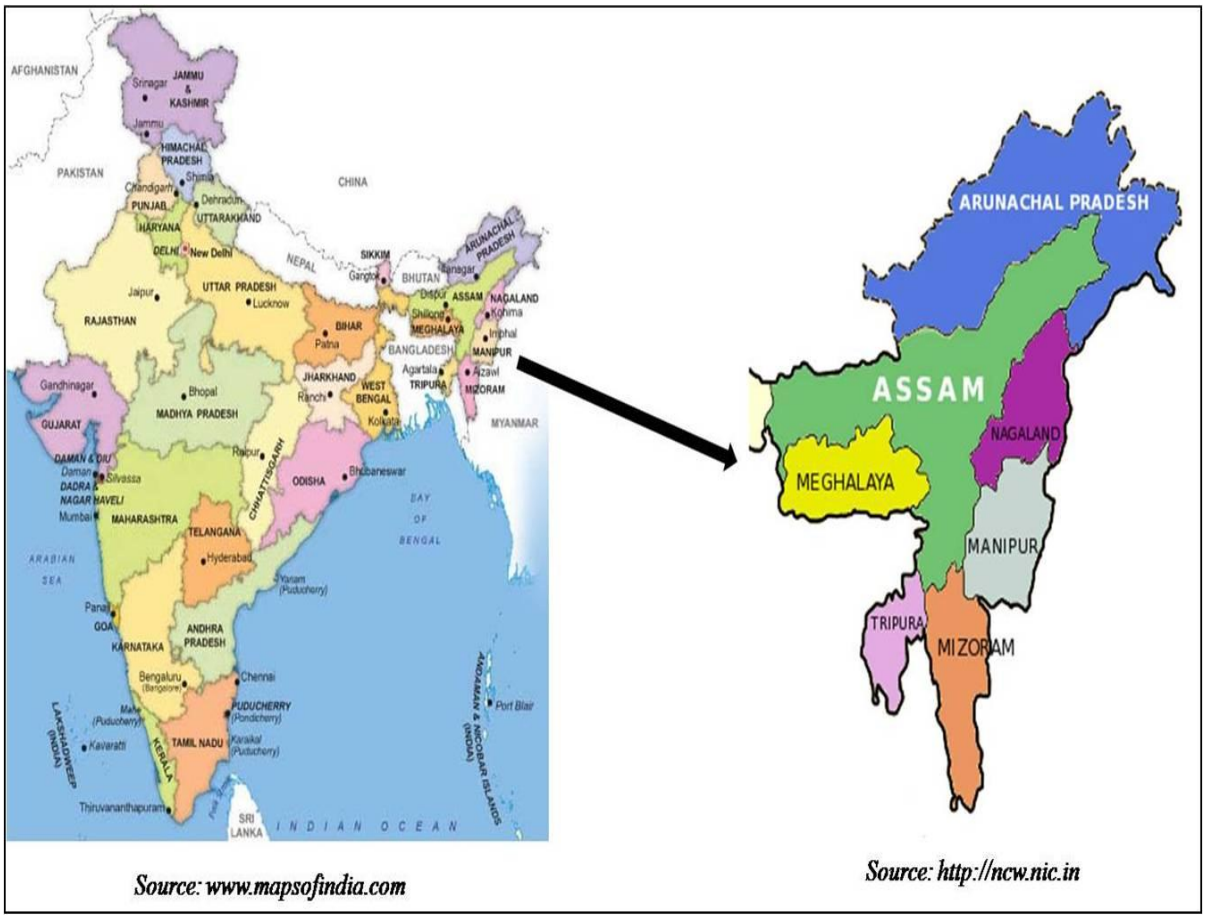

Figure 1. Location of the north eastern region of India showing the seven states

2. Zabo system of farming system

The '*Zabo*' word relates to water. *Zabo* system of traditional soil and water conservation is practiced by *Chakhesang* tribes in Phek district of Nagaland (Figure 2). It is an integrated farming system combination of silviculture, animal rearing and paddy cultivation on the hill slopes. Kikruma village of Nagaland is the example village still practicing *zabo* system of soil and water conservation (www.rainwaterharvesting.org). Silviculture or forest area is kept in the upper most portion of hill slope. Forest area protects the hilltop portion of the *zabo* system by defending from rainfall striking over its surface by its vegetation. The presence of vegetation intercepts more amount of rainfall during the rainy days. Plant rooting and netting system helps to infiltrate more rainwater into the soil, which reduces runoff. The infiltrate water which flows down the slope as sub-surface flow, which makes water available in the downstream even during the non-rainy seasons. Below the forest area there are constructions of terraces for storage of water. The livestock are reared below the forest area, which increases the soil fertility through manuring. Paddy is cultivated below livestock area at the foothills. Paddy fields located at the foothills helps to retained maximum water due to seepage and sub-surface flow from higher elevation to lower elevation by gravitational forces. Paddy fields get organic manure from livestock. The stored water at the upper terrace area is used for livestock and irrigation of paddy cultivation. In some location it is difficult to get a suitable location for construction of terrace as water reservoir then the runoff from the watershed area is taken directly to paddy fields for irrigating the crops. Rice husk is used on shoulder bunds of the terrace and puddling is done thoroughly in paddy fields (Dabral, 2002).

3. Cheo-ozihi

Ozihi means water in Angami tribal dialect of Nagaland. *Cheo* is the name of person, who was responsible for laying long channel and many of its branches from river *Mezii* flowing in the Angami area of Kwigema in Nagaland (www.rainwaterharvesting.org). Water is diverted from the river *Mezii* through long channels and their branches to terrace paddy fields of Kwigema village. Villages are further divided into sub-villages, which are known as *khels* in the Angami tribal dialect. Water flowing through diverted channels are distributed among the *khels*.

4. *Apatani* land and water management

Apatani tribe are most advanced agricultural community of Lower Subansiri district of Arunachal Pradesh. *Apatani* plateau consist of 48.38% under paddy-cum-fish cultivation, forest area occupies 32.64%, bamboo forest shares 16.41% and remaining 2.75% are under home garden (Rai, 2005). Paddy-cum-fish cultivation is one of the advanced integrated farming systems practiced by *Apatani* tribe. Integrated farming system not only improved the agricultural production, but also provides employment opportunity to the rural farmers. Paddy-cum-fish cultivation practiced is based on the organic agriculture, where pig excreta, poultry dropping, cow dung, rice husk, left out products of local beer and other domestic waste products are used as organic manure. The organic manure provides fertility to the soil and also provides feeds to the fishes. Paddy field has strong bund around paddy fields locally known as *Agher*, which obstructs water to flow from the paddy field. Common carp (*Cyprinus carpo*) are most common fish reared along with rice in *Apatani* plateau. Two different paddy varieties are generally cultivated, short duration crop (*Mipya*) and long duration crops *(Emo)*. Water stagnant between the bunds at desired depth and provides facility for paddy cultivation and suitable for fish culture. Bamboo matings are provided at the base of the bunds for its strength and support. Generally millets are grown on bunds of paddy fields leaving no portion of paddy plots are left unutilised. Field channels are provided at the middle of the paddy fields locally known as *Parkho*, which provides rearing space for fishes and also provide shelter during the sunny days. The paddy field has two outlets (*Hubur*) and one inlet (*Hubur,* Figure 3). Upper outlet is used for removal of excess water and lower one is mean for draining of the field water for harvesting paddy crops and fishes.

5. Contour trench farming system

It is constructed along contours having slope above 15% to prevent soil erosion and retaining of more rainwater. It improves moisture status of soil and increased water yield of spring water during the non-rainy seasons. Eroded soils are trapped into contour trench and it also helps in breaking the kinetic energy of the runoff water. The trapped soils into the tranches reduced the volume of trench and have to be removed annually before onset of monsoon. The soils trapped in the trenches are found to be very fertile and can be used for area lower to the contour trenches. The flowing runoff over the slope is collected in the trenches, which reduces the runoff and gives more time for soil to infiltrate. Because of more infiltration into the soil the lower portion of the area under the contour trenches gets enough water for the growth of horticultural plants or silviculture. Contour trench farming system is practices in most of the north eastern state. Pineapple plantation in Mizoram using contour trench farming system is shown in Figure 4.

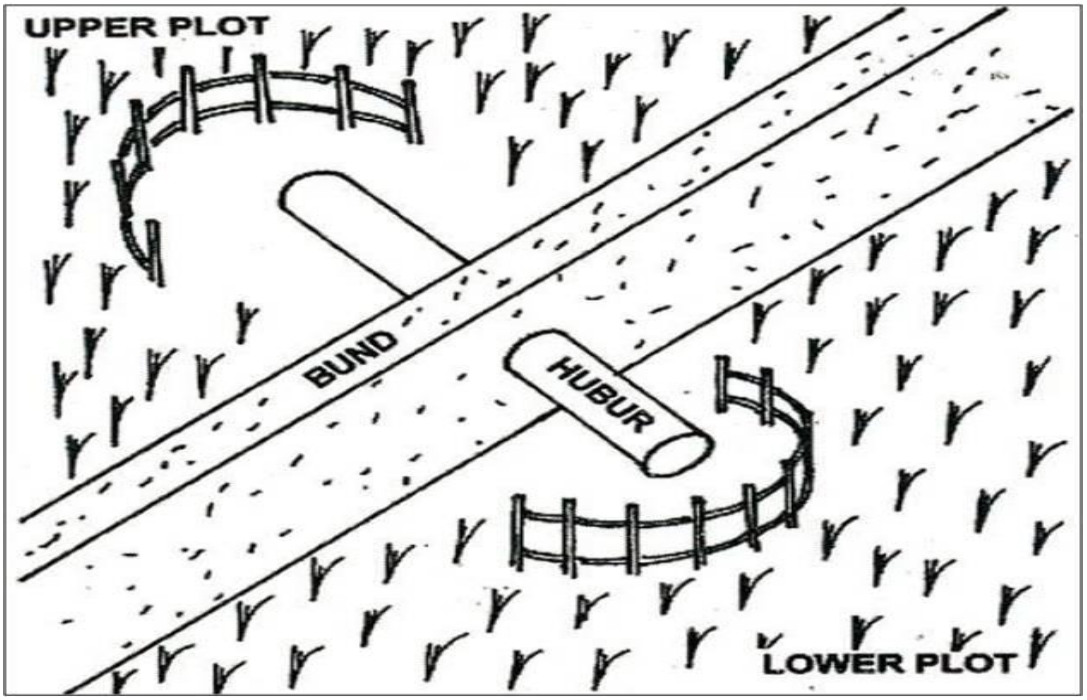

Figure 3. Water management in paddy-cum-fish culture in *Apatani* plateau (Rai, 2005)

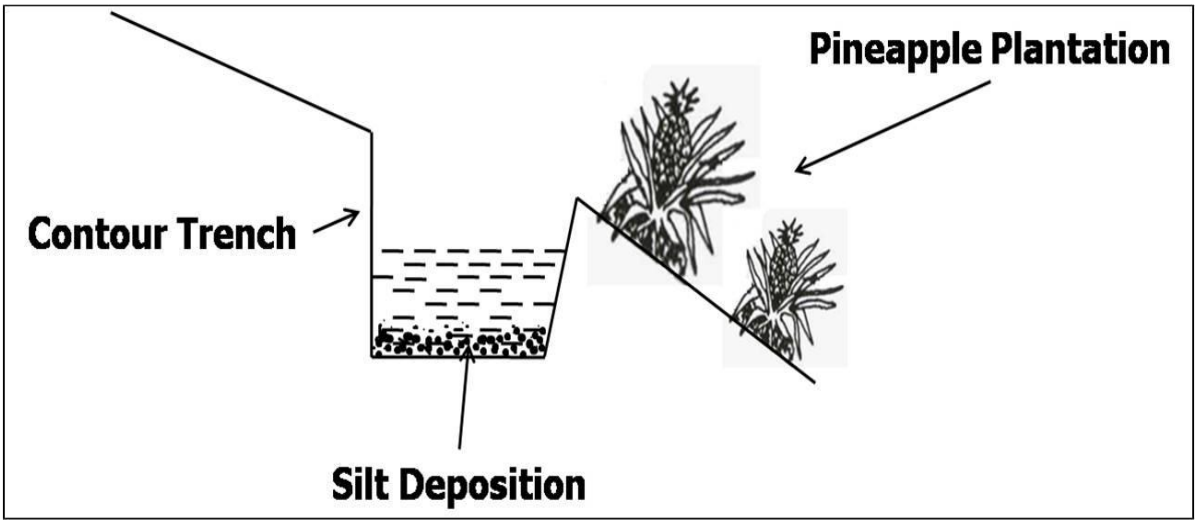

Figure 4. Contour trench farming system in Mizoram

Figure 5. '*Echo*' the traditional soil conservation system practiced by farmers

6. '*Echo*' the traditional soil conservation system

Echo is the traditional soil conservation system practiced by farmers of Wokha district as well as other districts of Nagaland. It is an age old practiced and *Echo* is the local name used by *Lotha* community. *Echo* is constructed by using locally available materials like bamboo or wood log *etc*. It is constructed by placing randomly across the slope in *jhum* field and generally last up to 3 years or sometime upto 5 years (Figure 5). The logs are placed across the steep slope at an average vertical interval of 3.00 m or depending on the degree of the slope. *Echo* as locally practiced to reduced soil erosion and conservation of moisture. Proper installation of *Echo* ensured to check the soil erosion and the runoff water. In the field condition the crop can grow at better rate besides of *Echo* installed area, which results the capture more moisture and nutrients by the *Echo* farming system (Singh et al., 2016).

7. Bamboo Drip Irrigation

Bamboo drip irrigation is 200 years old irrigation system practiced in *Khasi* and *Jaintia* hills of Meghalaya (www.rainwaterharvesting.org). The sources of water for bamboo drip irrigation are through stream and spring water (sub-surface flow). Water is diverted to the bamboo channel from the spring water through bamboo pipe. Water flows in the bamboo pipe on the hill slope due to occurrence of gravitational force from higher elevation to lower elevation. It is used for irrigating plantation crops like black pepper, areca nut plantations, *etc*. About maximum of 18 to 20 litres of water entering the bamboo pipe system per minute gets depleted and transported several hundred metres to different plantation through bamboo conveyance system. The conveyance water finally reduced to 20 - 80 drops per minute at the time of delivering to the plant (www.rainwaterharvesting.org).

The channels diversions, conveyance, distributions without leakage are all made of bamboo only. There is system created to control the flow of water into the lateral pipes. At the last stages of application where water is to deliver to the specific plant, the channel section and diversion units are reduced to control the flow of water. Different types of locally available bamboos of different diameters are used for laying the channels. Local farmers are well expert in fabrication and fitting of bamboo for bamboo drip irrigation using locally available axe, called '*Dao'* and other simple device like chisel are used. From intake of water to the delivery to the plants, about four to five stages of distribution systems are involved (Figure 6).

8. Bamboo channel water harvesting system

Bamboo is abundantly available in most part of Manipur. Water is harvested from hilly stream and spring water (sub-surface flow). During the monsoon season water is harvested from hilly stream for irrigating in the paddy fields when water level goes down due to non-rainy days. During non-monsoon seasons water are generally harvested from spring water and mainly used for domestic and livestock. Good quality bamboos of different sizes are used as channel for water conveyance. Cost involved in construction of bamboo channel is very low as compared to the PVC pipe. Bamboo channel is constructed locally using locally available axe, called '*Thangjou'*. The water harvested from stream is conveyance through bamboo channel and brought down to water tank or reservoir. The sizes of bamboo channel generally ranges from 8 cm to 15 cm. From this reservoir water is transfer to the agricultural field or uses of domestic and livestock. Bamboo channel generally last up to one year or sometime last more than one year. For better efficiency of the channel, generally bamboos are replaced annually.

9. Roof top water harvesting in Mizoram

Most of the hilly terrains in Mizoram are more than 50 percent and due to the steepness of hilly slopes it is very difficult to stored water in top hills of Mizoram. Even though Mizoram received good monsoon rains people face acute water problems every year during the dormant seasons. Due to the exhaustive deforestation and soil condition in state, most of the rainfall goes as quick runoff and could not retained much water into soil, hence springs (sub-surface) dries up very fast during the non-rainy seasons. Because of water scarcity problems during the dormant seasons, people in Mizoram have learnt how to solve the problems of water by rooftop rainwater harvesting system. The harvested rooftop rainwater are used for domestic, livestock and sometime for kitchen gardening. Most of houses in Mizoram have sloping roofs cover with GI sheets, which help in collecting rooftop rainwater runoff. Rainwater from rooftop is conveyance through gutter made of GI sheet or PVC pipe and collected in reinforced cement concrete tanks or container made of plastic (polyethylene). The average capacity of rainwater storage in Mizoram generally ranges from 3000 to 5000 litres and some houses could maintain rainwater storage structure capacity more than 10000 litres capacity. The details of rooftop rainwater harvesting are given in Figure 7.

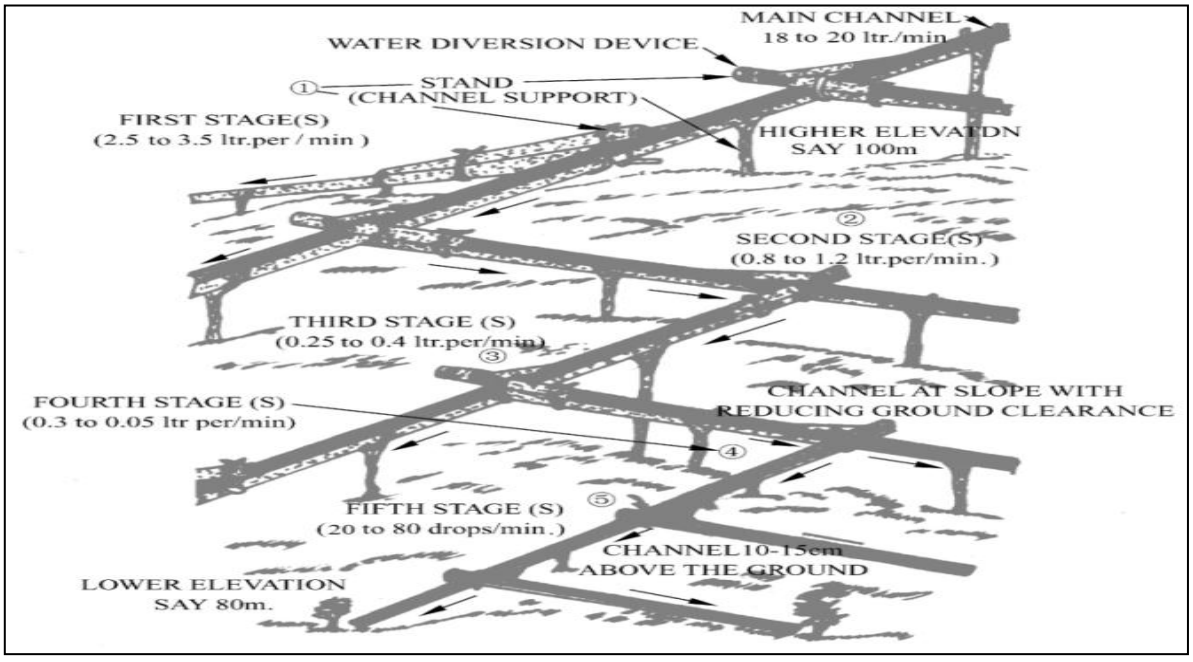

Figure 6. Sketch showing the bamboo drip irrigation water distribution system (Borthakur, 1992, Dabral, 2002)

Figure 7. Rooftop rainwater system

Figure 8. Wet rice terrace cultivation (*pani kheti*) in Nagaland

10. *Pani Kheti*

Wet rice terrace cultivation is also known as *pani kheti* in Nagaland. *Pani kheti* is the cultivation of paddy on the terrace area of hill slope. *Pani kheti* is successfully practiced in the district of Kohima, Nagaland. Terrace cultivation is very old agriculture practice in Nagaland. Wet rice terrace cultivation is done in the Nagaland since the time of immemorial. Terrace mostly constructed in the area having clay soil of good water holding capacity. Good quality terraces are constructed even on the high steep terrain up to 100% slope and even more. Terraces could retained water level between 8 to 12 cm depth depend upon the high of the shoulder bund. Paddy cultivation needs to maintain optimum water level. When water level goes down in the terrace, water from the stream is channelized to irrigate in terrace for obtaining optimum water level. Very good system of water channels are constructed at the upper ridge of the stream, where water flows down into the terrace located at the lower elevation. Most channels are generally constructed as unlined and in some area lined channels are also constructed. Stone patching are done on the downstream of the bund of the terraces for its stability and strength (Figure 8). Generally cultivation of paddy started in the month of June and harvesting is done in the month of October and continues till mid November.

11. Alder based farming system

The alder based farming system is a unique self sustainable farming practiced by *Angami* tribes of Khonoma village, Kohima district, Nagaland. It is about 200 years old farming system. Alder (*Alnus nepalensis*) planted in the field provided not only fuel wood to the farmers, but also a nitrogen fixing plant which provides nutrients to the agricultural crops. It can rejuvenate the vegetation and soil fertility at the faster rate in *jhum* land as compared to the normal *jhum* land. Alder tree can grow in the degraded land that is the reason it is one of best suitable tree species for rejuvenating *jhum* areas. The shaded tree leaves from alder tree helps in mulching the soil and retained moisture naturally. Alder nursery is available in wild and used for planting.

Alder trees about 10 years old are pollarded at the average height of 1.7 to 2.0 m from the ground level. The cutting process is done before the starting of the *jhum* cultivation. After slash and burnt process is over paddy and other vegetable crops are planted. Alder *jhum* cultivation continues upto 3 to 4 years depending upon the productivity of land, otherwise in some areas cultivation is done only upto 2 years. Since alder tree is cut at the trunk, it still exists and helps in biding of soil to prevent soil erosion. The alder tree also helps in infiltrating more rainwater into the soil, because of its rooting system. The field is also kept fallow for 3 to 4 years to regain more soil fertility and for growth of alder branches and other vegetations. Alder based *jhum* cultivation can reduced fallow period and increased yield of production as compared to the normal *jhum* cultivation.

Conclusions

North eastern region receives adequate rainfall and mostly received during the monsoon season. Due to the hilly terrain and concentrated rainfall huge soil are eroded annually from the region. Soil erosion mostly affects in *jhum* cultivated areas. Various indigenous technical knowledge available in the region in terms of soil and water conservation could be explored and can be utilized for solving various soil erosion problems in entire north east region and in other hilly areas of India. Indigenous technical knowledge could be the best option for successful management of *jhum* farming. Many of the *jhum* areas could be change into settle agriculture using traditional soil and water conservation measures. If many of the *jhum* areas are converted to settle agriculture, there could be solutions to the soil erosion, food production and conservation of flora and fauna, which alternately leads to sustainable agriculture.

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