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MODIFIED *ECHO* AS AN OPTION FOR LOW COST SOIL CONSERVATION MEASURES FOR SETTLE AGRICULTURE IN WOKHA, NAGALAND - A CASE STUDY

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ABSTRACT
The goal of this study is to assess soil erosion losses after implementation of ITK with modern scientific technology from the shifting cultivated hilly sloping areas. For the first time, this study demonstrates *Echo* as soil conservation measures along with scientific technology such as contour bunding and none of the researchers had evaluated such kind of work earlier. *Echo* is one of the farmers' friendly indigenous technical knowledge practiced by farmers in Wokha district of Nagaland. Soil erosion problems cause due to jhum cultivation could be solved through mechanical measures, but the cost will be very high.*Echo* is constructed by placing randomly across the slope in jhum field and generally last up to 3 years or sometimes up to five years. Proper installation of *Echo* ensured to check the soil erosion. Studied carried on *Echo* with scientific method could be retained soil about 229.5 t ha^{-1} yr^{-1} in the first year, about 153.0 t ha^{-1} yr^{-1} in the second year and about 91.8 t ha^{-1} yr^{-1} in the third year. *Echo* with scientific method could save vast jhum area of Wokha, Nagaland and will help to bring it to sustainable agriculture.

INTRODUCTION

Physical degradation of soil is the major limitation among the soil erosion (Singh and Ratan, 2008). In many developing countries, shifting cultivation remains an important agricultural system (van Vliet *et al*., 2012).About 5334 million tonnes of soil is eroded every year in and out of the total 29%soil is lost permanently to the seas (Narayana and Babu, 1983).Shifting cultivation is an agricultural system where forests land is cleared and cultivated for a short period and subsequently left to the longer period for a regenerate (Conklin, 1961).Shifting cultivation locally known as *jhum* cultivation is widely practiced farming system in the hills areas of northeastern India. The *jhum* cultivation generally takes place for two or three years, and the cultivated *jhum* land is left fallow for regeneration of forest vegetation and soil fertility to be used again after some years. The rapid increase in population 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 a 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 has reduced to 3–4 years disturbing the entire ecosystem which leads to tremendous soil erosion and loss of flora and fauna (Borthakur *et al*., 1983). The present practice of *jhum* cultivation, which gives the least period to rejuvenate the *jhum* area and leads to soil erosion, later the land becomes unsuitable for agriculture.

Agriculture continues to be the primary source of livelihood in Nagaland and food production is still not self-sufficient in the state. Rice cultivated in *jhum* area according to Statistical Handbook (2008), was 99980 ha for the year 2006–2007 and production from this *jhum* area were 160000 metric tonne. If those big *jhum* areas are not adequately taken care then in the later stages many of the areas may become unproductive due to massive soil erosion and may lead to the wasteland. The economic and agricultural settings into which they are introduced highly influence successful replacement of shifting cultivation with commercial crops (Vongvisouk *et al*., 2014).To build a layer of 2.5 cm of topsoil thickness it takes 600–1000 years and there is loss of about 6000 million tonnes of productive soil from about 80 million hectares of cultivated land in India and also observed that there have been losses of soil from unprotected land at about 120 t ha^{-1} yr^{-1} to 300 t ha^{-1} yr^{-1} (Yadav, 2006). The losses of the soil generally flow with runoff water and some get deposited on the surface, some get deposited at river bed reducing flow capacity of the river, which sometimes lead to flood occurrences and remaining soil generally flows to the sea. Such problems cause due to *jhum* cultivation could be solved through mechanical measures like contour bunding, bench terracing, contour

trenching, half-moon terraces, diversion drains *etc.*, but the cost will be very high which the farmer may not be in the position to implement such measures. The aim of this study is to assess soil erosion losses in local practice (ITK,Indigenous technical knowledge) soil conservation in collaboration with modern scientific technology in the Wokha district of Nagaland, North Eastern India.. The objective of the study was to study locally available ITK in the field of soil conservation and to study find out the outcome of the study on ITK with scientific method

MATERIALS AND METHODS

Study Area

The study was carried out at Lungshachung village, Wokha district, Nagaland (Figure 1) and in the research farm of Krishi Vigyan Kendra, Wokha, Nagaland (http://wokha.nic.in/). About 1.5 ha area was considered for the front line demonstration (FLD) program as a study area. Wokha district is one of the districts, out of 11 districts of Nagaland. Wokha district has the population of 166,343 with the geographical area of 1628 km^2 (Census, 2011). The district shares its borders with Zunheboto on the East, Kohima on the South, Assam on the West and Mokokchung on the North. Out of the total population, 78.96% of the population live in rural areas consisting of 135 villages and rest 21.04% live in towns. The district is divided into five blocks namely, Wokha Sadar, Chukitong, Sanis, Wozhuro-Ralan and Bhandari blocks.

Shifting cultivation and wet rice cultivation (WRC) in Wokha district

Jhum is widely practiced across Wokha district. This practice has threatened the very existence of the tribal themselves by causing degradation of land and its environment and ecological imbalance affecting even the flora and fauna of the region to such an extent that the tribal have progressively become economically poorer with the passage of time. The average annual area under *jhum* and WRC cultivation are 13900 ha and 9590 ha respectively (Anonymous 2008). The area under WRC is located in the plain areas of Wokha district bordering Assam under the Baghty sub-division.

Front line demonstration programme under KVK, Wokha district, Nagaland

Frontline demonstration program was conducted on the construction of '*Echo*' with the modern scientific method in the *jhum* practice areas of Longsachung village and KVK farm in Wokha, Nagaland in June 2007. The *Echo* traditional soil conservation knowledge have been practicing in Wokha and adjoining districts of Nagaland. The term *Echo* has taken from Lotha dialect of Lotha community, Wokha, Nagaland for naming the traditional soil conservation knowledge, otherwise name varies from district to district of Nagaland depending upon the dialect of particular tribes. For this study, the *Echo* was considered for naming the traditional soil conservation knowledge. With the soil and water, conservation measures could assure sustainable agricultural production attracting villagers to go forward for settled agriculture. The system can be adopted on hill slope up to 50% gradient where soil depth is greater than 1.0m. In-situ conservation of rainfall is one of important objective of settled agriculture and at the same time in high rainfall areas where in addition to the in-situ conservation of rainfall, safe disposal of runoff is also one of the essential objectives (Singh *et al.*, 2006).

Conversion of contour bunding into bench terrace for sustainable agriculture

Bench terraces are constructed across the hill slopes by half cutting and half filling which gives the shape of flatbeds and serve as barriers to break slope length and reduce the degree of slope.The risers are provided as shoulder bund for the stability of the terraces and perennial grasses are planted on the riser for its stabilization and help in filtering the silt particles. A well-established bench terrace can retain up to 98% of rainfall (Singh, 2006). To stabilizing and stepping up of crop yields in drylands rainwater conservation is a critical factor (Mathukia *et al.*, 2016). The costs of a construct of bench terraces are very high and every farmer cannot afford to construct bench terraces in their field. The alternative low-cost way to obtain bench terrace is through the construction of contour bunding. Contour bunding is one of the simple, low-cost engineering structures constructed for the conservation of soil and water in the sloppy or hill areas. Bunds are made across the slope and filling of the earth as bund along the contour. The concept of a contour is to trap the water during rainy days and safely disposal of excess water. Cultivation is done between the two contour bund intervals. Contour bund intervals spacing can be adjusted depend on the percentage of slope. Channels are provided along the contour and excavated soil is placed in the form of bund in downstream to divert excess runoff during rains to grassed waterways and retain the eroded soil. During the cultivation process, the scouring of soil particle takes place from higher elevation area and gets deposited in the lower elevation area within the two bunds. Because of scouring and siltation process, the area within the two bunds gets leveled up and in due course of time area takes in the shape of terrace, provided some maintenance of bund structures are necessary like increasing the height of the bund in order to capture the siltation (Figure 2). The area between the two bunds can take the shape of terrace in about 4-8 years' time (Singh, 2006).

Echo' the traditional soil conservation system

Echo is the traditional soil conservation system practiced, by farmers in all districts of Nagaland. It is an age old practice 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 sometimes up to 5 years (Figure 3). The logs are placed across the steep slope at an average vertical interval of 3–4m or depending on the degree of the slope 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 from the capture more moisture and nutrients by the *Echo* system (Singh, 2012).

Echo with scientific method

Echo the traditional soil conservation practices, it can be supplemented with the scientific method or modern soil

conservation technique like contour bunding. With the same input, *Echo* can be constructed by placing the wood log or bamboo along the contour line. This *Echo* method is scientifically modified so that logs are now placed across the slope along the contour line at a vertical interval of 3–4m or depending upon the degree of the slope. When *Echo* is constructed along the contour rather it becomes contour bunding system and it can provide the permanent solution to check soil erosion and water conservation. Advantages of *Echo* along the contour is that it cannot be easily washed away by the flash flood, scoured soil particle are captured by *Echo*, by the time *Echo* becomes contour bunding it gets to stabilized and decomposes of wood log or bamboo added nutrients to the soil and also another advantage of scientific method with *Echo* is that when *Echo* stabilized to contour bunding, it does not need to put again the same bamboo or wood log, which can save lots of bamboos as well as wood logs.

Bulk density and soil texture

Most of the soils under study are falls under the loamy soil. Bulk density values have been used from the Table 1 for calculation of soil masses (http://hort.ifas.ufl.edu). The soil scouring takes place during the rainfall periods and is deposited in the cut area bellow the *Echo* contour bunding. The deposited soil has been measured in the terms of volume and later on volume of soil has been converted into soil masses using a bulk density of the soil texture.

RESULTS AND DISCUSSION

Unlike past studies, for the first time, this study demonstrates *Echo* the traditional soil conservation practices along with the scientific method such as contour bunding. None of the researchers had taken up such kind of studies earlier. Studied carried on soil erosion and found out that by practicing *Echo* contour bunds could divert excess runoff during rains to the bottom channel drain of *Echo* contour bunds and retained eroded soil. The excavated soil for the provision of the channel is provided along the *Echo* contour bunds in the downstream. The eroded soil retained by *Echo* contour bund in the first year was 229.5 t ha^{-1} yr^{-1}. This retained soil at the excavated area required to maintain for the next year in the same way by excavating the soil and placed in the downstream. Due to this maintenance of eroded soil yearly, development of terraces takes place in area between two bunds. The eroded soil retained by *Echo* contour bunds in the second year was about 153.0 t ha^{-1} $yr^{-1}$and about 91.8 t ha^{-1} yr^{-1} in the third year (Table 2). Usual cultivation practices continued between two bunds and siltation process continues between the bunds to takes the shape of terrace in 3–5 years. Use of contour bunding technology (CBT) could reduce gullies at a rate of 73%, soil fertility was maintained at a rate of 84% at a very high or high rate and 82% of farmland responded with success stories mainly to do with better water availability, improvements in

Table 1: Bulk density values for difference soil textures

Soil Texture	Critical bulk density range (g/cc)
Clay, silt loam	1.4–1.55
Silty clay, silty clay loam, silt	1.4–1.45
Clay loam	1.45–1.55
Loam	1.45–1.60
Sandy clay	1.55–1.65
Sandy clay loam	1.55–1.75
Sandy loam	1.55–1.75
Loamy sand, sand	>1.75

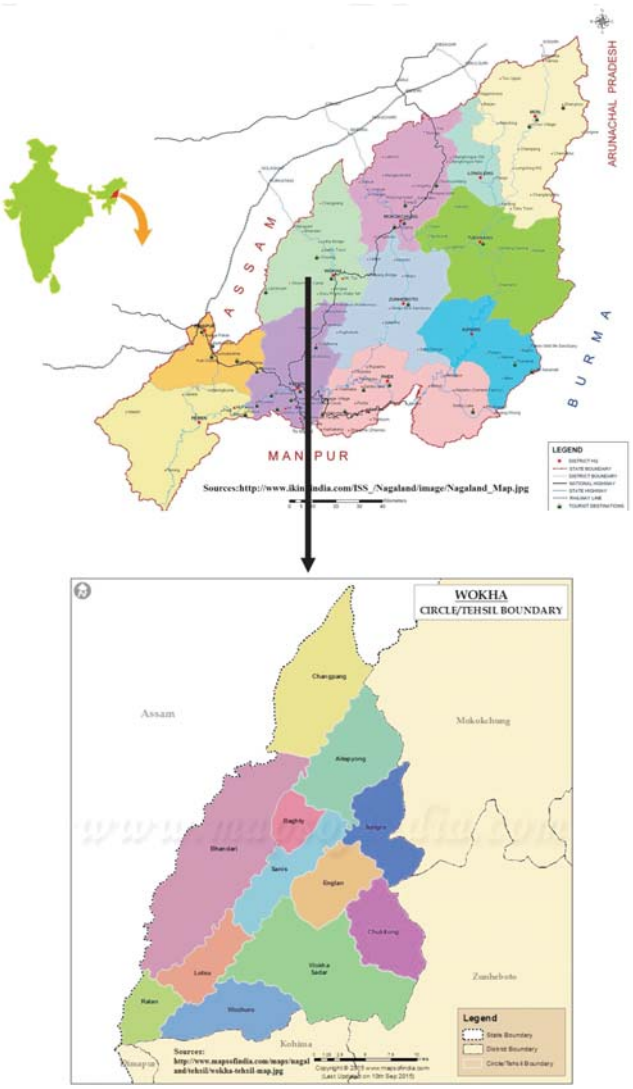

Figure 1: Location of the study area

Table 2: Year-wise soil retained at the *Echo* contour bunding

Month-year of construction and maintenance of bund	Month-year of measurement of soil retained at the bund	Average soil retainedat the bund (tonnes $ha^{-1}year^{-1}$)
June 2007	November 2007	229.5
March 2008	November 2008	153.0
March 2009	November 2009	91.8

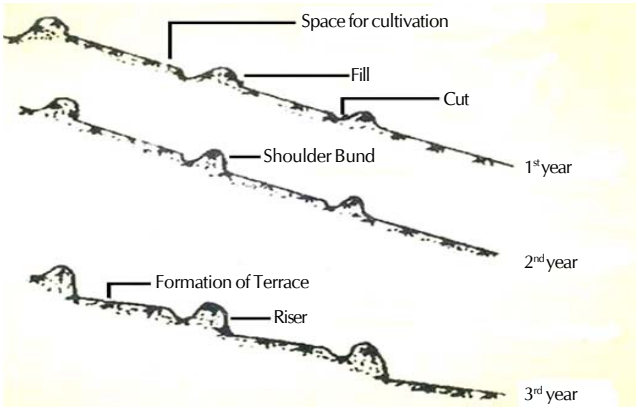

Figure 2: Contour bunding for slow conversion terraces

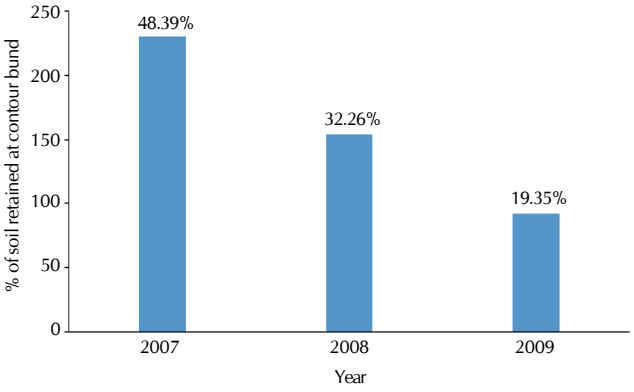

Figure 4: Year wise percent of soil retained at contour bund during 2007-2009

Figure 3: *Echo'* the traditional soil conservation system practiced by farmers

Figure 5: *Echo* with scientific method

crop yield and soil fertility (Zemadim *et al*., 2014). The modified contour bunds with gated-outlets provide better control of ponded water and found that the development cost of structures was quickly repaid (Belguami, 1994).Contour bunding provides positive effectiveness of soil and water conservation in the watershed which prevent soil erosion and nutrient losses (Mishra and Rai, 2013).

The percent of soil losses retained at contour bunding during 2007-2009 is shown in Figure 4. In the first year (2007) soil losses retained was the highest with 48.39% followed by 32.26 and 19.35% in second (2008) and third (2009) year respectively. The above results revealed that the *Echo* with contour bunds could reduce soil losses drastically year by year and the technology could retain the huge amount of soil losses from the field. *Echo* is widely practicing in Wokha districts of Nagaland and successful *Echo* with the scientific method in Wokha district, Nagaland is shown in Figure 5.

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