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Impacts of Forest Cover Change on Stream flow with reference to the Performance of Terrace Rice in Senapati, North East India

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ABSTRACT

Forests help to maintain favourable and stable conditions needed for sustained agricultural production. Human activities like clear-cutting or rotational felling of trees either for *Jhum* site or fuel-wood makes major influences on the hydrological regime of a given area. The problem can be viewed as the interrelation of two systems, the forests and the terraced farmland that lie side by side, the former natural and the latter anthropogenic. The goal is to identify the impacts of human-induced activities on seasonal streams flow at two selected streams of different source regions; controlled forest and degraded forest. The investigation is done for a period of two-year crop cycle. A Simple Bucket Method was employed to assess the flow variation. The flow volume data series were divided into two periods: wet season (2015 and 2016) and Dry season (2015 and 2016) respectively. The Purposive Sampling Technique was used in acquiring primary household domains, especially on rice production. The two years (2005 and 2015) digital satellite images are analysed for the forest cover mapping. A gradual shrinkage of the forest cover was detected over time. It is identified that the stream with the controlled forest as a source area remained with the flow. Notwithstanding, the stream of the degraded forest noticed completely dried out during the dry months. The rain-fed terrace fields of the district required a perpetual natural water storage mechanism to support marginal farmer folk in the long run if not the amount of food available to each person is a concern.

1. Introduction

As human beings learned farming some 9000-10000 years ago in semi-arid regions of Anatolia, Mesopotamia, Iranian Plateau and Indus Valley and departed from their foraging culture to the emerging agriculture, the easiest way to clear the land of bushes and weeds was to set it 'on fire', since Bronze Age culture was still 4-5 millennia ahead and without metallic implements clearing deep forests were not easy. The fire was the single most potent weapon against the unwieldy Nature and thus started the 'slash and burn' culture of agriculture ('shifting cultivation' or *Jhum*). However, in those early days, with the human groups being very small, there was hardly any noticeable imprint on the natural ecosystem. As human beings spread out colonising different areas around the globe and under different environmental conditions and as with agriculture, the population grew and technology changed to iron tools, the slash and burn changed to settled farming especially in river

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valleys that proved exceptionally productive. In wet and mountainous tracts, the 'slash and burn' tracts gave rise to 'terrace fields', especially in wet tropics for the conservation of both soil and water since rice farming needed a constant supply of water and rich soil.

In India, though terrace farming is not unknown, it is largely confined to the hilly terraces of Kashmir Valley, in mountainous regions along the Himalayas, the hill areas of the North East and also certain areas of the Western Ghats. In the hill districts of Manipur, nature rarely provides the opportunity of valley/plain based farming therefore, 'slash and burn' and terrace farming are the only possible options. The Senapati district is largely mountainous with the ridges in a north-south orientation. There are terraces along the ridges interspersed with forest tracts. Shifting cultivation is extensively practiced in uplands and crest areas. This traditional food production system, undulating terrain, and high and intense rainfall have further accelerated resource degradation and lessening processes leading to the whole forest ecosystem subside. Singh, (2007) evoked that; land, water and vegetation are the three basic resources of the life support system. These resources are under extreme pressure in North East India characterised by the permanent conflict between the need for conservation on one hand and constantly growing population and land-use change on the other. With this, large forests area is reported loss resulted in a disorder of community well being. For ecological stability, protection and conservation of forests are identified in the district.

The goal is to identify and document the present concept of the traditional ecological-based knowledge and practices of farmers regarding the environmental services of forest systems and its relation to the adjoining terrace fields. The research expected to help improve the management of forests and benefit the community by ensuring enhanced forest sustainability.

2. Statement of the Problem

The problem can be viewed as the inter-relation of two systems, the forests and the farmlands in terraces that lay side by side, the former natural and the later, anthropogenic. In these systems, the terraces receive water released from the forest system, both during the rains but more significantly during the dry seasons, through gullies, springs and streams, which then are restricted and managed in the terraces and released slowly to lower terraces. Only during rain, the terraces are directly exposed to rainfall; during the dry season, the terraces are dry but may or may not receive some flows from the adjacent forests. If the forests are of good canopy density, one may expect greater retention of moisture in the forest system, particularly through the mulches, root mass and soil absorption and then gradually released. Under clear-cutting or pronounced deforestation conditions, like shifting cultivation, the moisture retention is substantially reduced affecting any residual flow.

The two forest regimes - controlled and disturbed regime as natural and the adjacent ridges slope terraces act as a man-made system. The study quarry on how between these two systems are allied respects to moisture exchange through the stream. The study obliges to assess how crop (terrace rice) productivity on the terraces may be affected by flow variation within the systems, largely from the forests to the fields in respect of the flow volume, since a large literature exists augmenting the benefits of forests on agro-ecosystems, like terraces.

3. Objectives

(i) to assess the extent of forest cover loss;
(ii) to assess the volume of steam flow from forest systems to the terraces in respect of the rainy season as well as the dry season; and
(iii) to evaluate the impacts of *Jhum* activities on the streams flow with reference to the performance of terrace rice.

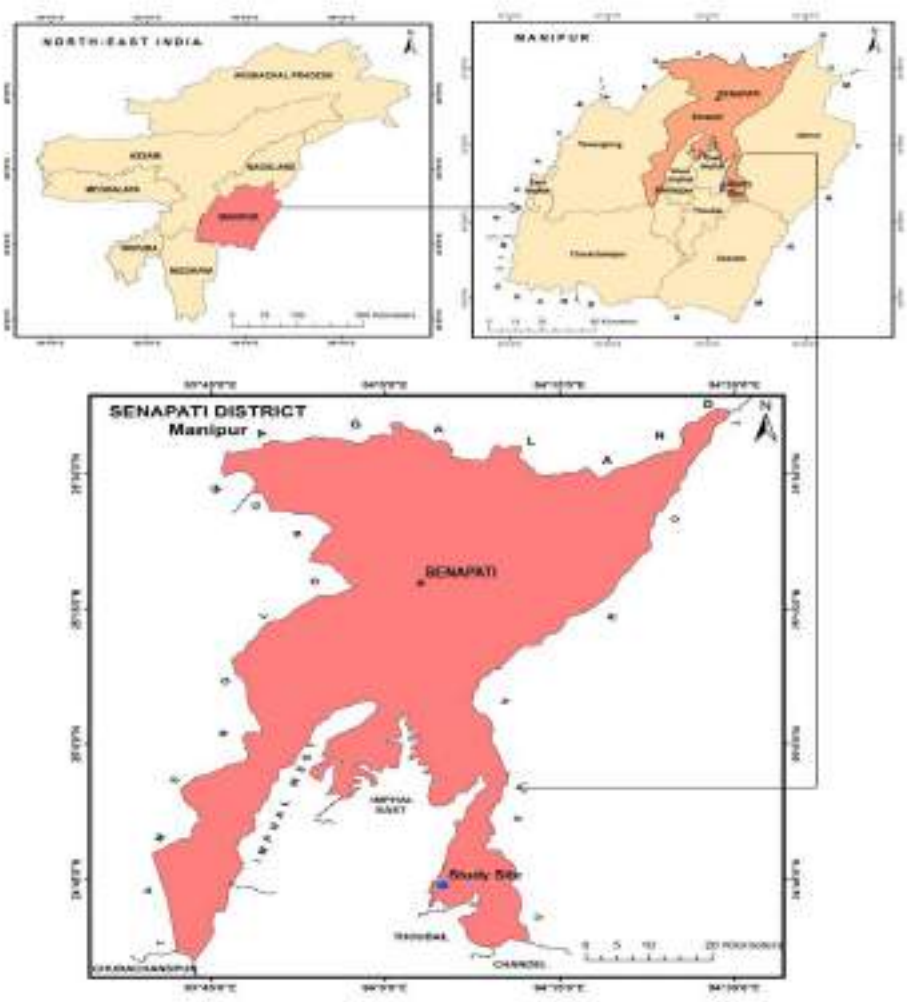
4. Research Questions

(i) The first issue relates to the process of deforestation and its relation to the variation in the seasonal stream flow.
(ii) Secondly, it may be of significance to assess the impacts of anthropogenic disturbance *(Jhumming*) in a forest to possible decline or failure of crops in the terraces.

5. Study Area

Senapati district is situated in the northern part of Manipur, bounded by Phek district of Nagaland in the North, Tamenglong district in the West, Ukhrul in the East and Imphal East and West in the South. It is located between 93°29' and 94°15' East Longitude and 24°37' and 25°37' North Latitude. It has a total geographical area of 3,271 sq km lies at an altitude between 1,061 m to 2,994 m above MSL.

The district is under a humid subtropical, climate with a temperature ranges from a minimum of 4°C to a maximum of 34°C. The annual rainfall ranges from 670 to 1,450 mm. The district is home to many ethnic minorities with a population of 4, 79,148 persons and a density of 146 persons per sq km (2011 Census). They are traditionally and culturally mosaic with the distinct social systems of organisation and cultural beliefs. Agriculture is the main occupation and it is entirely rural by economy



6. Data Source

Both primary and secondary data from the diverse sources and types are employed. Collection of primary household data and empirical fieldwork database are the principal constituent module of this study.

6.1 Secondary Data

Forest Survey of India (FSI) 2005 and 2015 report; Manipur State Forest Department statistical data are incorporated to assessed district forest cover loss.

Estimation of forest covers loss due to *Jhum* was done with data from the Forest Department and District directory.

Statistical Year Book, 2015 published by the Directorate of Economic & Statistic, was the source of district decadal population growth, and decadal growth variation. The total area under terrace rice (paddy) cultivation, production and yield data (2006-2016) was extracted from the Agriculture Directorate, Manipur.

6.2 Primary Data

From 6 terrace cultivators' dominant villages, 100 households were surveyed for primary data. The traditional structured questionnaire method as well as Participatory Rural Appraisal (PRA) was used to obtain information on economic pursuits undertaken by the terrace farmers in particular. A questionnaire with 36 questions is placed on every sample household/farmer. The socio-economic database was developed through interviews with key informants, including traditional village chiefs, community leaders, older people who could provide holistic histories of land-use dynamics in the field area. Stream flow data are collected through fieldwork.

7. Research Design

Large numbers of papers have been documented on the significances of forests in regulating or providing stream water qualitatively or quantitatively worldwide. The present study is designed to investigate the functions of forest systems in the performance of terrace farms taking the two as separate systems. The study involved the assessment of forest roles under two (controlled and *Jhum* or degraded forest) land-use systems to that of terrace farms adjoining them.

To validate answers to the research questions or objectives, the forests system and terrace system are treated as separate systems. To further, accomplished adding of water to terrace farms, two sets of terrace farms with similar physical environments are chosen at different locations. They are *(i) Hatheipham loukon/*controlled forested set and *(ii) Ningthoirok loukon/*degraded or *Jhum* set. The total sample terrace farm under rice interspersed forested area is 43.2 ha (108 acres) and that of degraded or *Jhum* area is 67.4 ha (168.5 acres). The flow of water from the forest system to terrace system was studied herein taking consideration of two identical rivulets of the forested and degraded forests source area. The important research aspects are comparing streams flow volume and evaluation of rice production/yield for a two-year crop cycle.

8. Methodology

A simple histogram was used to represent the trend in the forest cover. The changes or loss in the forest cover was evaluated with the help of USGS district's satellite images (2005 and 2015) using ArcGIS's applications for NDVI mapping. Simple Buckets method was used to assess flow volume. Separate monthly records were maintained for each stream for both the wet and the dry season. Presentable data was prepared through SPSS and Microsoft Excel's statistical techniques.

In assessing the flow perturbations on crop yield, departmental data were integrated with household data. Purposive Technique of Sampling was used in selecting among the terrace cultivators covering every single village. The procedural steps involved in field data collection are repeated. This helps to deliver rise and fall in crop productivity. Line graphs are used to evaluate production and yield trend. Besides these variables, all farming inputs utilised by farmers were scheduled to assess crop productivity dynamics.

9. Forest Cover Change Scenario

Ethnic tribal communities in North East India are traditional forest dwellers. Forests play a significant role in their economy. It is commonly believed that the tribal community lives in harmony with nature and protects forests by considered as their livelihoods provider. As the time changes, population increase and need of people amplify escalating tremendous pressure on forest resource. The belief in protecting nature and conserving forests resources becomes no longer feasible. In North East India at least two-thirds of the forests are officially under the legal authority of local communities, while perhaps 90 percent or more are physically controlled by rural communities. As in the hills of Manipur, the forest is governed by ancestral customary beliefs and practices. Illegal logging and forest conversion is more widespread where tenure rights over the forests are weak or unclear. This often linked to the absence of forest mapping and registration, as well as aggravated by laws and policies that are conflicting and constantly being challenged by private sector interests, government agencies, and even from within the communities themselves. With this fact, assessment of forest covers in tribal areas, therefore, acquires a special significance.

From Table.1: a gradual loss of forest area is noticed in which moderately dense forest areas degraded the most (FSI, 2015). Between 2005 and 2015, 2.29 percent (114 km^2) moderate, 2.03 percent (67 km^2) dense and 3.82 percent (125 km^2) un-classed open forest area loss respectively. Due to the high rate of degraded un-classes open forest, the district's land under scrubs increased tremendously. Geographically, 2,483 km^2 (75.91 percent) was under forests cover during 2005 and was reduced to 2,177 km^2 (66.55 percent) in 2015. The highest forest loss was recorded in 2011 that the district lost 120 km^2 and loss10 km^2 of its forest cover in the subsequent year. Increased in forests area has been detected between 2013 and 2015. Assessing gain and loss data, the district loss 9.34 percent (306 $km^{2)}$ of its precious forests cover at the rate 1.23 percent (30.6 km^2) per year

Table .1: Forest Cover Change Matrix of Senapati District

Year(s)	Total GA (Km^2)	VDF (%)	MDF (%)	O.F. (%)	Total (Km^2)	% of total GA	Net Change (%)
2005	3,271	9.04	28.61	38.24	2,483	75.91	
2009	3,271	7.12	28.73	34.54	2,303	70.41	-5.50
2011	3,271	7.12	26.59	33.01	2,183	66.74	-3.66
2013	3,271	7.09	26.32	33.01	2,173	66.43	-0.30
2015	3,271	7.01	26.32	34.42	2,177	66.55	0.12
Total		-2.03	-2.29	-3.82	-306		-9.34

Source: FSI, India State of Forest Report, 2005-2015

GA-Geographical Area, VDF-Very Dense Forest, MDF-Moderately Dense Forest, OF-Open Forest

For a clearer picture, two years (2005 and 2015) NDVI satellite images on forest cover change were given below:

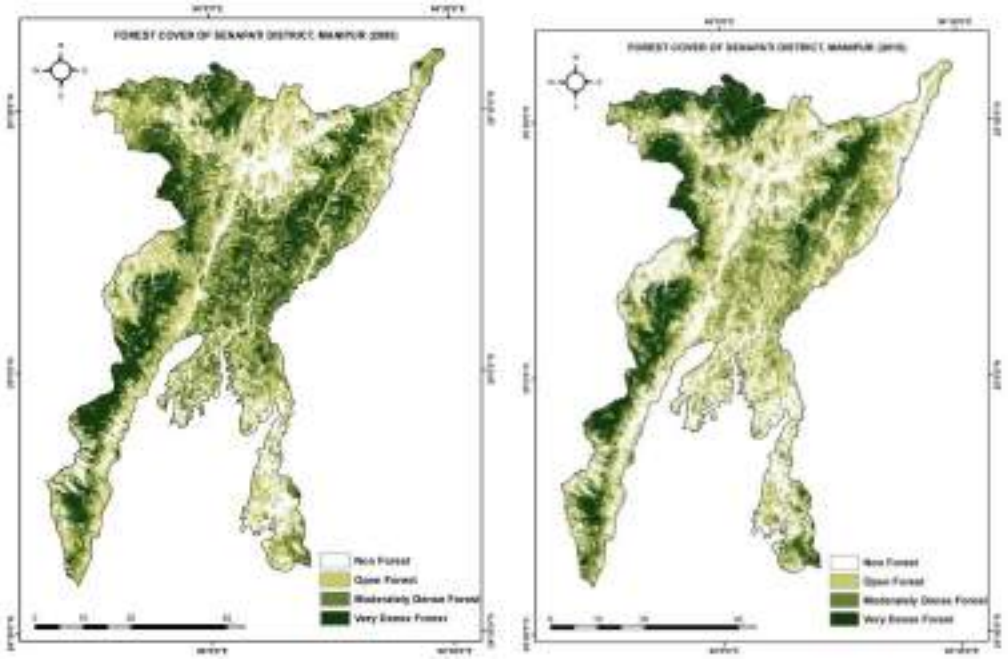


Fig.3: Satellite Images showing trend in Forest Cover (2005 and 2015)

Table.2: NDVI data on Depletion of Forest Cover in Senapati

Variables (%)	Year (s)		Change (in %)
	2005	2015	
Non-Forest Area	24.09	33.41	+9.32
Total Forest	76.39	66.89	-9.5
Open Forest	50.3	51.6	+1.3
Moderately Dense Forest	37.7	37.7	-2.1
Very Dense Forest	11.9	10.6	-1.2

Source: Analysing Satellite image

Similar to that of FSI output data, NDVI data provide more or less a similar depiction of forest loss (Table.2). District forest area declined from 76.39 percent to 66.89 percent indicating the loss of 9.5 percent between 2005 and 2015. The district Non-Forest Area and Open Forest area increased substantially. The study reveals that, from 2005 to 2015, the district losses 2.1 percent MDF and 1.2 percent VDF respectively. A gradual decline in forest area is noticed from the generated database. Hence, overall, the district lost 9.5 percent (311km^2) of its forest area in ten years at a pace of 0.9 percent (31km^2) per year.

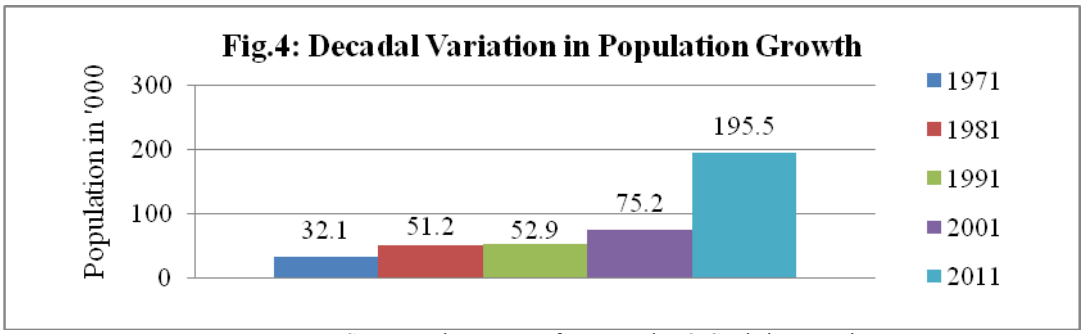
10. Causes of Forest Cover Loss

Population growth and economic development lead to trade-offs between different land uses. A growing population implies a growing demand for agricultural land and forest products, particularly in the hilly regions. Shah (2005); Yadava *et al.*, 2002 stated, indiscriminate cutting and destruction of trees and vegetation for the purposes of firewood, timber and *Jhum* plots causes maximum loss of forests cover and eco-degradation in Manipur.

In the past decades, a scarcity of land coupled with population growth has led to increasing pressure on forests. Senapati district is the smallest hill districts of Manipur yet recorded the highest decadal population growth. As the population exploit, peoples start looking for new land or space for settlement and agriculture, eventually resulted to unprecedented attacks on existing forest areas. To begin with, the district forests are not under the purview of the Manipur Land Records and Land Revenue Act, 1960, which was enacted to put certain geographical areas under the government legal domain. The entire forest resource is owned and governed by individuals or community leaders according to their customary laws and beliefs. Authority on legal or approval utilization of forest resources or lands is vested upon the Chief's wisdom or village authority. This absence of rightful authority remains a stumbling block for state or central government agencies to restrict the exploitation of forests resource. The distinction or geographical demarcation of hills area and non-hills area for political administration under certain constitutional provisions pave ways to granting people's right to control over the land resources. Privatization of lands or forests resource endorsed the people to act promptly without hesitation to large scale mistreatment of forest areas. The age-old debates between the naturalists or the environmentalists with that of traditional chiefs remain futile in efforts to preserve the forest covers in the district. From this factual situation, we can say that human-induced activities are the culprits for losing forest covers. Hence, it compelled me to investigate and assess the forest cover change in the recent decade.

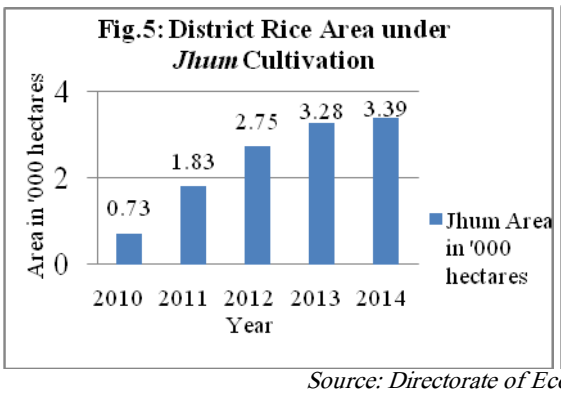
11. The District Demographics Dynamic

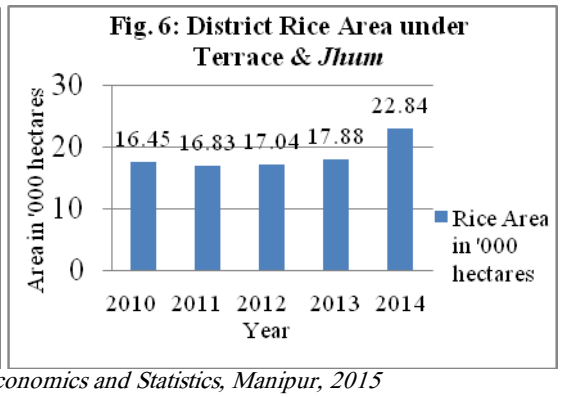
The Senapati district is the most populace hill district of Manipur. It has a total population of 4, 79,148 persons with a density of 146 persons per km^2 (2011 census). The highest decadal population growth was recorded in the district for the last five decades. Considered as one of the pushing factors for extensive loss of forest cover, revised of district's demographic dynamic and nature turn out to be significant. High population growth and pressure on the forest resources have plagued the district. The district once inhabitant by 72,039 persons (1961) become the house of 4, 79,148 persons (2011) at the average annual growth rate of 95,829 persons per year.



Source: Directorate of Economics & Statistics, Manipur

12. Area under Rice by types of Cultivation





Source: Directorate of Economics and Statistics, Manipur, 2015

Fig.5: Estimation of the area under rice by types of cultivation shows a gradual increase in the area under *Jhum* cultivation. The district total *Jhum* area of 0.73 thousand hectares during 2009-2010 was increased to 3.39 thousand hectares in 2013-2014. At the rate of 7 km^2 annually, district forest covers have been degraded by *Jhum* activities.

Not only increased in *Jhum* area, Fig.6 shows adding more land under terrace cultivation. Together 16.45 thousand hectares during 2010 increased to 22.84 in 2014 at an average increment of 4.5 thousand ha/year. With no option, peoples invade forest lands to fill their empty stomachs. It is clearly noted that, the demand for farmlands to feed a growing population acts as the main factor for rampant forest area degradation in Senapati district.

12.1. Terrace Farming Scenario in Senapati District

Terrace farming is one of the oldest types of land and water resource management system engaged for crop farming. Essentially, the main purpose of terracing land is to reduce the water velocity and thereby soil erosion by breaking the length of the slope. The natural formation of terraces consumed time and due to the shortage of viable farmland in the hill districts of Manipur, farmers convert the slope areas into terrace fields by the cut-level method. Farmers used cow and buffalo to till the land with the help of traditional wooden plough with an iron head. The chances of using tractor, harvester and other modern agricultural machinery are limited due to poverty, slope and inaccessible roads. All farm operation is done manually; bullock power is used for field preparations. Scrubs lands intersperse with forests area were converted into a terrace to grow rice crops. This has taken many forms over the course of agriculture's long history and continues to be a prominent method for crop cultivation. The effects of different forest land-use systems prevail in the district to the performance of closed terrace fields are little-known. The importance of a healthy forest ecosystem in ensuring water resource and soil fertility in mountainous agriculture is discussed worldwide. For example, the century-old terrace agriculture practiced by the Inca and Mayan of South America, the Hani of Southern China and the Angami of Nagaland (India). But, '...the challenges that mountain farmers must overcome are many: short vegetation periods, steep slopes, shallow soils and the occurrence of landslides' (FAO, 2015).

12.2. Forests: Sustainers to Terrace cultivators

The first water function of the forest is to trapped rain and releases it down towards the valley. The forest acts as a natural green dam. As it is in Senapati district, the influence of surrounding forests in providing water is commendable. In higher slopes, peoples practice *Jhum* or shifting cultivation on a large scale. All farming-related activities come to alive on the onset of *monsoon*. Thus, during farming season, farmers depend on small streams or rivulets that flow from the surrounding hill areas. The hill streams are tapped as soon as they emerge from the forests and the water is channelled to accommodate a series of the terrace. Construction of bamboo and stone check dams in gullies, brushwood dams and gabions in stream sides to protect rice fields are some mechanism used by farmers to get rid of overflow and shortage of water. Generally, terraces adjoining controlled forested areas received a regular and uniform supply of water. However, the degree of significance is unknown. On the other hand, it is also well established that partial or complete removal of tree cover may accelerate water discharge and increase flood risk and may reduce stream flow or even cause river beds to be dry out. Harmonizing such micro-level linkage of experiences, initiatives and mechanisms in the context of sustainable forest and water management can be taken as a priority.

Fig.5: Estimation of the area under rice by types of cultivation shows a gradual increase in the area under *Jhum* cultivation. The district total *Jhum* area of 0.73 thousand hectares during 2009-2010 was increased to 3.39 thousand hectares in 2013-2014. At the rate of 7 km^2 annually, district forest covers have been degraded by *Jhum* activities.

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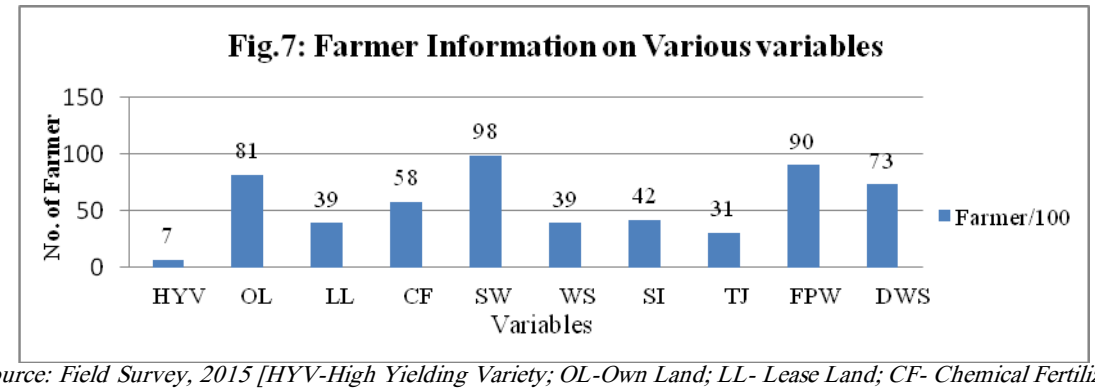
Forests help to maintain favourable and steady conditions needed for sustained agricultural production. Deep reaching roots help mobilize nutrients far below ground level added to groundwater for use by food crops. The bio-diversity of plant species accelerates and maintains the rainfall level and, in turn, protects the water resources Sunder, (2003). Thus, bio-resources are regarded as the backbone of agriculture. Basso, *et al*, (2013) due to forest removal in some parts of Kansas and Texas, farmers can no longer pump sufficient water to meet crop demand due to aquifer depletion. Fisher, *et al.,* 2009 so, 'as long as forest degradation is allowed to continue as it has been in the past, the amount of food available to each person is a concern'. A gradual depletion of forests and consequential degradation of soil and water resources of the traditional tribal habitat is stripping off their life-supporting capacities (Dash, 2005). The Senapati district of Manipur, inhabitants by various ethnic tribal communities represents a typical example, wherein, under such circumstances, the cultivated hill slope productivity bulks vary. Fangyi and Jiading, (2013) asserted that forest acting as sponges that soak up water during the monsoons and gradually release it (Maes, *et al.* 2009) also purify water and regulate its flow into agricultural systems, providing sufficient quantities at the appropriate time for the plant growth.

12.3. Effects of Jhum on Terrace Farms

During rain, a farmer who cultivate terraces close to the *Jhum* site encounter inconveniences as there is no enough vegetation to hold the soil, rain or gully water easily carried away pebbles and sediment along the slope that ingress to the terrace causing damage to the crops. Windrowing slashes burnt during *Jhum* site preparation destroyed the soil structure, compact nature and humus composition making it vulnerable to soil erosion. The run-off water discharge heavier half-burnt wood pieces, pebble, gravel and many other unfertile materials to the terrace indirectly affecting the crops yield/production. As a result, abandonment of large terrace farms happened every year. The forests system which generally provides water to terrace farms fails to comply in the case of *Jhum* land use.

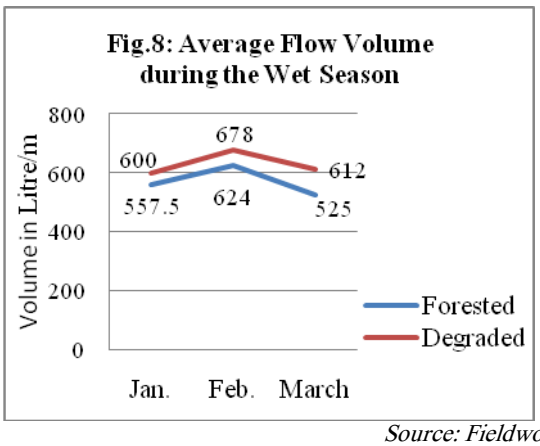


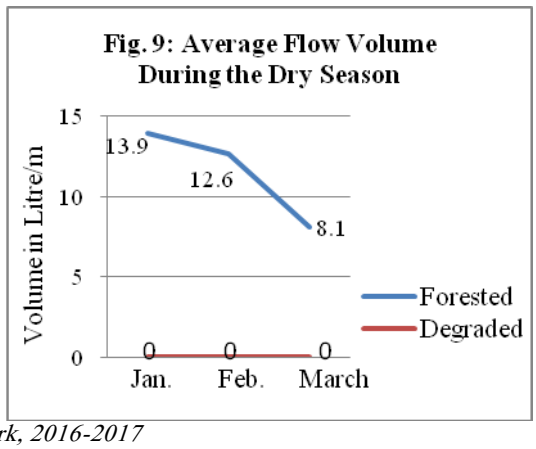
Source: Field Survey, 2015 [HYV-High Yielding Variety; OL-Own Land; LL- Lease Land; CF- Chemical Fertilizer; SW- Stream Water; WS-Water Shortage; SI-Soil Ingress; TJ- Terrace & Jhum; FPW- Forest Provide Water; DWS-Deforestation cause Water Scarcity]

The questions were prepared to draw the traditional knowledge and implications on forests which are significant to the study. Importantly, out of the total 100 farmers, 98 percent used stream water for farming purposes, 90 percent 'yes' with forests as a source of water especially during the dry season and 73 percent agreed with deforestation cause water shortage. The impacts of deforestation are manifolds, though, in the study area, the terrace farmers agreed/believed that soil erosion, shortage of water, streams dried out, infertility

13. Evaluation of Stream Volume from the Forests to the Terrace

To recognise the implications, the experiment was conducted upon two rivulets of similar features with unlike source region; controlled forested stream and *Jhum* or degraded forests stream. Three months flow variation records were maintained both for the wet and the dry season. Comparative average flow volumes for both the seasons were given in the figures

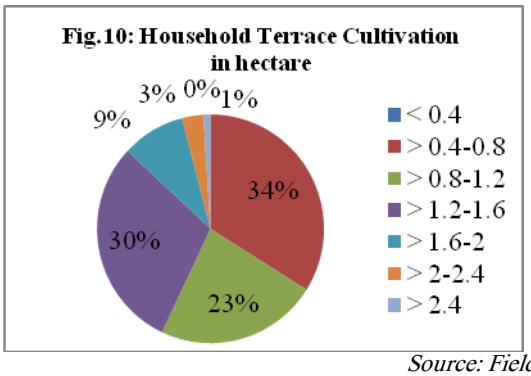


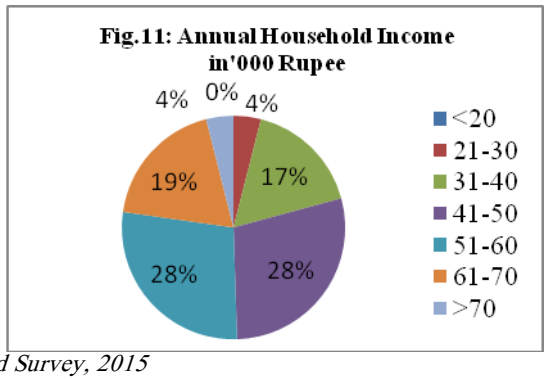


Source: Fieldwork, 2016-2017

[To avoid any discrepancy, flow measurement during the wet season was done on the same date i.e. 22nd of June, July and August, 2015. The Dry season measurement was conducted on the 9th of January, February and March, 2016/17. The stream volume was collected for 5 sec and calculated for 1 minute in an analysis. In the dry season 2016/17, the degraded forest stream is completely dried out]

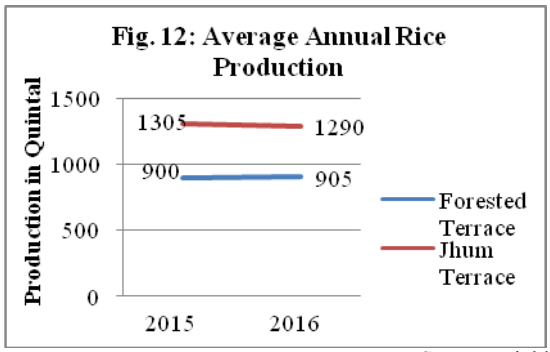
It is clear from (fig: 8 and 9) that, the two streams emit different flow pictures. Dry season measurement on the same streams gave diverse information in which only forested stream coupled with a flow. In comparing average flow volumes of two-year-cycle considerable flow variation was observed in both the cases. It is identified that the forested stream with an average volume of 557.5 L/m during the month of June (2015) recorded 13.9 L/m during January (2016). In the same fashioned, the average flow of 624 L/m during July (2016) reduced to just 12.6 L/m in February (2017) and so on. According to (fig: 7), the average volume of a degraded stream during the wet months recorded 600, 675 and 612 L/m respectively. The unusual striking experience was that the degraded forest stream which was records higher turbidity flow during the wet season is seen without flow during the dry season. It is assumed that the availability of flow in the forested stream continued to discharge flow even during the dry months. Hence, the terrace fields close to forested tracts believed to be more sustainable and productive.

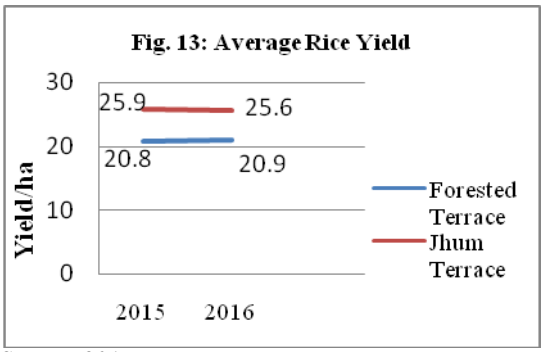




Source: Field Survey, 2015

From (fig: 10) it can easily be understood that the maximum numbers of the farmer were cultivating a land of 0.4 to 0.8 ha. They correspond to 34 percent of the farmers. Only one farmer cultivates land more than 2.4 ha. Fig.11: shows the distribution of the household's annual income from all types of sources. Out of the total 100 households, 29 generate ₹41-50 thousand; 28 generate ₹ 51-60 thousand respectively. None of the farmers earned below ₹ 20 thousand and 4 farmers earned above ₹ 70 thousand. The farmer's annual income is said to be highly irregular.





Source: Field Survey, 2015

Despite of smaller terrace proportions interspersing forested area (i.e. 43.2 ha), it is found that the performance is more worth than the fields closed to the *Jhum* or degraded area (i.e. 50.2 ha). This is the most significant finding of field data analysis. The annual rice production in 2016 is increased by 5 quintals from 2015. The maximum households harvest between 31-40 quintals of rice. A single farmer harvest below 15 quintals, 4 harvested 15-20 quintals, 14 between 21-30 quintals, 27 harvested 41-50 quintals, 18 between 51-60 quintals, 4 harvested 61-70 quintals and 3 farmers harvested more than 70 quintals. In the two-year crop cycle, production in the degraded terrace farm record declined by 15 quintals in average. However, (fig: 12) in the forested terrace an average increase of 5 quintals is observed. Accordingly, the average rice yield per ha has increased in the forested farmland and turn down in the case of the degraded terrace.

According to the state government data, the district total land under terrace rice cultivation in 2015 was 3.22 thousand ha and produced a total of 4.51 MT rice. The yield was recorded at 1.40 MT/ha. In 2014 and 2015, the area under terrace rice was increased though production and yield are against it. The terrace rice productivity is recorded drop down in the district as a whole.

14. Finding

a) A gradual loss of forest cover was noticed in the district losing at the rate of 30.6 km^2 annually (FSI, 2005 – 2015).
b) The traditional *Jhum* cultivation, rotational felling, population pressure and uncertain land tenure system are the major factors causing forest degradation in the district.
c) The stream originated from the forested area remained with the flow even during the dry season which was not in the case of the stream of disturbs area.
d) There was a drastic drop in the rice yield from terrace fields adjacent to degraded forest.
e) The production and yield in rice has remained more or less the same in the forested terrace farms.
f) A controlled forest ecosystem is able to provide water needs in the interspersed terrace farm throughout the year.

15. Discussion and Conclusion

Senapati district is the most populated hill district in Manipur. The high population growth and unprecedented pressure on the forests resource have plagued the district. As peoples required 'land' for homesteads and varied economic activities, clearing of the forests area for the new village, *Jhum*, timber, firewood, terrace farming, hill slope gardening, orchards and other non-timber forest products become very prominent all over the districts. The forests today are more threatened than in the past; owing to the increasing population pressure. The district which is blessed with heavy annual rainfall every year faced an extreme shortage of potable water/drought- like situations during the dry season. The district suffered from flood, mudslide, and landslide during the wet season. These environmental-related problems are the outcome of an ecological imbalance creates by human actions. So, community responsiveness and adopting conservation measures will only help in fighting these environmental crises.

Agricultural production cannot be sustained without ecosystem resilience and integrity. Food availability depends on the productivity of both cultivated and natural systems. Ecosystem degradation and natural disasters that reduce the availability of food sources will also have a large impact on the food security of the peoples. In poor rural societies, therefore, resource degradation particularly forest resources can make the difference between having food and going hungry. Katerere and Smith, (2013) local communities are often the custodians of ecosystems and the managers of food production from both wild and farmed resources and therefore are critical actors in sustaining natural resources and managing conflict over them. To this context, the greatest threat to the preservation of the forests ecosystem comes from marginal farmers in the Senapati District of Manipur. Arguably the only sure way of stopping deforestation is to minimize, and eventually, to eliminate, the territorial demands made upon the forests by thousands of small terrace farmers and *Jumias.* The study found out that, lack of proper institutional and legislative framework in managing forests and lack of control of territories in the hills areas has posed a threat to the maintenance of the forest covers. Lack of definition of rights, the vague ownership over forests, and lack of survey and settlement operations are seen as the root cause of forests shrinking in the district.

To conclude with few measures to coup the deforestation scenario were suggested below:

a) Alternative livelihoods or incentive must be provided to the farmers/*Jhumia*/villagers those who depend on forests to minimise the degree of dependency on forests resource.
b) Awareness programs must be conducted at a village level to disseminate the ecological significances of forests.
c) Identification of the degrade areas and regenerating such notified areas through Joint Forest Management programmes should be made compulsory.
d) Annual state budget sanction on protection and conservation of the forest must be increasing on a yearly basis.

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