ASSESSMENT OF ENVIRONMENTAL IMPACT OF JHUM BURNING ON AIR, SOIL AND HUMAN HEALTH IN LENGPUI AND THE ADJOINING AREAS OF MIZORAM.

A THESIS

SUBMITTED TO THE MIZORAM UNIVERSITY IN FULFILLMENT OF THE DEGREE OF DOCTOR OF PHILOSOPHY

IN

ENVIRONMENTAL SCIENCE

BY

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MIZORAM UNIVERSITY

TANHRIL, AIZAWL

2014

CERTIFICATE

This is to certify that Ms Hilda Lalrinpuii has submitted the Ph.D Thesis entitled, "**Assessment of Environmental Impact of Jhum Burning on Air, Soil and human health in Lengpui and the Adjoining Areas of Mizoram"** under our supervision, for the requirement of the award of the Degree of Doctor of Philosophy in the Department of Environmental Science, Mizoram University, Aizawl. The work is authentic, content of the thesis is the original work of the Research Scholar, and the nature and presentation of the work are the first own kind in Mizoram. It is further certified that no portion(s) or parts(s) of the content of the thesis has been submitted for any degree in Mizoram University or any other university or institute. She is allowed to submit the thesis for examination, and for the award of Doctor of Philosophy in Environmental Science.

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DECLARATION

I, Hilda Lalrinpuii hereby declare that the thesis entitled **Assessment of Environmental Impact of Jhum Burning on Air, Soil and human health in Lengpui and the Adjoining Areas of Mizoram** is a record of work done by me during 2008 to 2013 under the supervision and guidance of Dr. Lalnuntluanga, Associate Professor, Department of Environmental Science Department, Mizoram University. The thesis did not form basis of the award of any previous degree to me or to the best of my knowledge to anybody else, and it has not been submitted by me for any research degree in any other University/ Institute.

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ACKNOWLEDGEMENT

Completion of this doctoral dissertation was possible with the support of several people. Foremost, I would like to express my sincere gratitude to my supervisors Dr. Lalnuntluanga and Dr. A.S. Devi for their motivation, patience and scholarly input. The completion of this thesis was possible only because of their unconditional support and I consider it as a great opportunity to do my doctoral programme under their guidance.

I would like to gratefully and sincerely thank Prof. H. Lalramnghinglova, who was responsible in shaping this research title, consistently extended his research expertise throughout my work and I owe a lot to him for this achievement. I thank Prof U.K. Sahoo, for his valuable suggestions and concise comments on the research papers of the thesis.

Mr Lalpawimawha, Asst Professor, Pachhunga University College meticulously carried out the analysis of data, despite his busy schedules and I thank him for his contributions. My gratitude goes to my friend and colleague Dr. Lallawmkimi, for her suggestions and encouragement at various points of my research work. Mr Vanlalfela, laboratory assistant and other faculty members of the Department have been very kind enough to extend their help at various phases of this research, whenever I approached them, and I do acknowledge all of them.

I would like to take this opportunity to thank Mr. Lalnuntluanga (Hmunpui), Mrs Teresa Rothangpuii (Sairang) and Mr. Remruata VCP (Lengpui) for their hospitality and lending their services in all possible ways. I also express my gratitude to Mr Lalbiakdika, all the staffs of Primary health centres and health sub centres of the area for providing all the informations that was required. Mr. H. Lalhmachhuana Scientist, MIRSAC whose unselfish dedication amidst the tight routine to prepare the different maps for this thesis is deeply acknowledge. I would also like to extend my huge thanks to my loyal and reliable driver Mr. Lalrinpuia who assisted me in my field trip. Besides this, I am grateful to all the people who have knowingly and unknowingly helped me in the successful completion of this project. The completion of this thesis work would not have been possible without you.

I am very much indebted to my family, my husband Benjamin Lallianzova and daughter Faustina Zorinpuii, for their unconditional support, for having faith in me and allowing me to be as ambitious as I wanted. I owe a lot to my parents, who encouraged and helped me at every stage of my personal and academic life, and longed to see this achievement come true. A special thanks to my sister and brothers, their critics, encouragement and constant support has made me a tougher person and has given me the ability to tackle the challenges even at the worst moments. I also want to thank my in-laws who supported me in every possible way to see the completion of this work.

I gratefully acknowledge the financial assistance provided by the University Grant Commission, Govt. of India, privileged to be a recipient of Rajiv Gandhi National Fellowship.

Above all, I am deeply humbled to be a recipient of all the blessings of the Almighty God and for His Grace, granting me the wisdom, health and strength to undertake this research task and enabling me to its completion.

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Chapter- I

1. INTRODUCTION

1.1Concept and definition: According to Food and Agricultural Organization, shifting agriculture is defined as, “the custom of cultivating clearance scattered in the reservoir of natural vegetable (forest or grass or woodland) and of abandoning them as soon as the soil is exhausted and this includes in certain areas the customs of shifting homesteads in order to follow the cultivators, searching for new lands” (Das, 2001).

The term shifting cultivation describes systems of rainfed cropping with annuals, biennials or short-lived perennials in which a cropping period alternates with a longer rest or fallow period, during which the abandoned crop area is colonized by native herbaceous, shrub or tree species or by adventive species that find the ecological conditions favourable (Norman et al., 1995).

Jhum cultivation (*lo hal*) seems to have been well established during the Neolithic period more than 10,000 years ago. This cultivation is also known as slash and burn or swidden cultivation and represents a distinct stage in the history of man’s exploitation of his environment. It has been re-enforced as a system continually with experience of the people practicing it. It has been enriched by the exuberant spirit of the people living in close proximity with nature. This form of cultivation is still practiced in many parts of the world by several ethnic groups and tribal communities (Das, 2001), in some parts of the tropics and subtropics, especially in the humid tropics of west and central Africa, Southeast Asia and South/Central America, (Hillel et al., 2004). It has a rich traditional ecological knowledge base and remains an important component of forested landscapes in many parts of the Asian tropics. Ethnic minority groups have accumulated indigenous knowledge on cropping, as well as on the ecology and uses of secondary forests (Nakashima and Roué, 2002). Ganguly (1968) argued that unlike settled agriculturalists, who use manure and fertilizers to augment soil fertility, shifting cultivators, who are not conversant with soil conservation methods, shift to another fertile plot of land following loss of soil fertility on a particular jhum plot.

Shifting Cultivation is regarded as the first step in transition from food gathering and hunting to food production. It is considered as a primitive form of agriculture and the cultivators are usually identified as hill tribes or mountain people and are regarded as backward, serving on subsistence economy (Sachidananda, 1989). In the hilly regions of North East India, the nature of the land has forced the people to practice shifting cultivation by slash and burn method (Behera and Roy,1997). Though an agricultural state, the primitive method of shifting cultivation /jhuming is still practiced in Mizoram. Shifting cultivation and the mizo culture are closely inter-related. It is claimed that jhum was started by the mizo since the days they descended from the far east to the Lushai hills (now Mizoram) across Burma (Myanmar). The plots used in slash-and-burn agriculture are small, typically 1–1.5 acres (0.4–0.6 hectare). Unirrigated rice/ upland rice is the principal crop of shifting agriculture, with corn, beans, and root crops such as yams and cassava (manioc) also grown (Hobbs, 2009). They are also polycultural and polyvarietal; farmers plant more than one crop at a time, and each of these crops may be grown in several varieties. This helps control populations of agricultural pests. The cutting and burning involved in clearing the site releases nutrients which the cultivated crops can utilize, and the fallow period, which usually lasts at least as long as 15 years, allows these nutrients to accumulate again. In addition to restoring fertility, re-growth protects the soil from erosion. If shifting cultivation is being practised in a forested area, in the patch where crops are grown-weeds, diseases and insect-pests of the crop plants are likely to colonize and increase. This is one of the reasons why after a few years the patch is left for the occurrence of natural regeneration of forest, and the farmers clear another patch of forest. During the forest ‘fallow’ most crop pests decrease or disappear. The major disadvantage of shifting cultivation is that only a small proportion of the area is growing crops in any one year, and hence it can support only low densities of people (Newman, 2000). The practice of shifting cultivation will maintain soil fertility and reduce erosion to tolerable levels provided the associated conditions of low crop yields and low ratio of population to land area remain socially and economically acceptable. The critical factor in the system is the length of the fallow period (Morgan, 2005). The length of fallow period between two successive croppings has come down from a more favourable 20 years to about 5 years or even less because of increase in human population and diversion of a substantial jhum area to alternate uses such as commercial timber extraction and biodiversity conservation in the recent past (Rerkasem and Rerkasem, 1995). Shifting cultivation systems include a recovery fallow period of a few years (i.e. bush fallow) or for longer periods (secondary forest succession), (Nieder and Benbi, 2008). The transition from fallow field to secondary forest in jhum cultivation systems may depend upon the newly arrived fresh seeds, because burning after the clearing of a forest land could destroy most of the seeds stored in the soil, and/or root and stump sprouts and seedlings that appeared after clearing (Nepstad et al., 1991; Schmidt-Vogt, 2001).

1.2 Characteristics of shifting cultivation: Jhum in Mizoram is almost a uniform practice among the larger tribes like Mizos, Maras, Lais and Chakmas. The selection of the plot is done through the lottery system. By October each family has demarcated its plot and the village council is supposed to keep a record. Clearing the vegetation in the autumn allows for better decomposition, which increases the productivity. Since it coincides with the harvesting of early paddy, so normally clearing of new fields is done later between January and February. Although, jhum is a family -based operation, but the clearing of the forest is exclusively done by men. The cutting operation could last anywhere from a week to nearly two months, depending upon the nature of the forest. The right timing of burning is of utmost importance in jhumming. The timing is crucial in the sense that the felled trees and bamboos in the field are to be sufficiently dry, so that it burns very well. Generally most plots are fired by the 15th or 20th of March (as declared by the village council), depending on local weather conditions. The village elders from their traditional knowledge on cloud formation decide the suitable date of burning. Late burning as in April increases the risk of fire spreading to the surrounding dry vegetation, or early rain can upset drying and burning. If rain soaks the unburnt jhum land, ideal jhum cultivation is not possible (Rao et al., 2012). The respite between the completion of the jungle clearing operation and the burning of jhum is the time when the joyous festival ‘Chapchar Kut ’ is celebrated in Mizoram (Ralte, 2005).

Jha (1997) had mentioned shifting cultivation as an agricultural system which is characterized by a rotation of fields rather than of crops, by short period of cropping (1-3 years) alternating with long fallow periods (upto 20 and more years but often as short as 6 – 8 years) and by clearing by means of slash and burn.

In earlier days, forests were cut down for jhum, till the land for a few years, then abandons it, leaves it fallow for perhaps 3 to 5 years. The fallow period needs to be much longer, from 10 – 25 years, to regenerate the forest and restore soil fertility (Puro, 1996). The Oxisols in the year-round rainy climates,

Udox, are mainly in the tropical rain forests where a small human population is supported by shifting cultivation or slash-and-burn agriculture (Foth, 1990). Fire has been used intentionally to change soil properties, and both the release of nutrients by fire and the value of ash have long been recognized. Removal of natural vegetation for cropping interrupts natural mineral cycling between soils and plants, leaving the soil more vulnerable to wind erosion and water erosion. It loosens the soils and caused an increased rate of oxidation of organic matter and weaken soil structure. Increasing population in many parts of the developing world forces farmers into marginal areas for subsistence (Matthews, 2003). Nutrient losses are only part of the story. The removal of the forest cover exposes the soil to the direct impact of rain and this can break down its surface structure and carry loose material away (Morris, 2003). One may read a suggestive conclusion that shifting cultivation is an ancient, primitive system, today but a remnant of the past, not followed by civilized peoples (Spencer, 1988). In many developing countries where tropical rain forests occur, the majority of people do not own the land they live and work on. In Brazil, 5% of the farmers own 70% of the land. Most subsistence farmers have no place to go except into the forest, which they clear to grow food. Subsistence farmers often follow loggers' access roads until they find a suitable spot. Shifting cultivation is a form of subsistence agriculture in which short periods of cultivation are followed by longer fallow periods, in which the land is left uncultivated and reverts to forest. They first cut down the trees and allow them to dry, then they burn the area and plant crops immediately after burning**.** The yield from the first crop is often quite high because the nutrients that were in the burned trees are available in the soil. However, soil productivity declines at a rapid rate, and the yields of subsequent crops are poor. Slash and- burn agriculture is land-intensive; because tropical soils lose their productivity quickly when they are cultivated. In a short time, the people farming the land must move to a new part of the forest and repeat the process (Raven et al., 2010). Farmers using slash-and-burn agricultural methods are endangering the existence of the rain forest (Arreola et al., 2007).

The time frame for jhum is fairly critical, especially keeping in mind the heavy rainfall in the area, requiring the land to be cleared and seeds sowed in time for the monsoons (Ananthanarayanan, 2008). The clearance of forests is the prerequisite of shifting cultivation. The felling of trees and clearing of bushes, however, accelerate soil erosion and accentuate variability of rainfall which may lead either to droughts or floods. The overall impact is the decline in soil fertility. The ecosystems lose their silence characteristics. The dependant community on jhumming faces the shortage of food, fuel wood and fodder. Consequently, the nutritional standard goes down. These processes culminate into the social poverty and ecological imbalances (Momin, 2009). Jhum cultivation involves little cash expense but relies largely on own inputs and the natural fertility of the soil, about 80% of the total cost of production was domestically supplied in which 75% of the labour and 100% of the seed was from family sources (Miah and Islam, 2007).

1.3 Shifting cultivation and climate change: The current climate change discourse has taken the debate on shifting cultivation to another, a global level, reinforcing existing prejudices, laws and programs with little concern for the people affected by them. In today's world, shifting cultivation is bad because it causes carbon emission and thus contributes to climate change. The availability of high genetic diversity in agricultural plants has however been identified as a key element in adaptation strategies to climate change (UNFCCC, 2009). According to the UN-R E D D Framework Document "in many developing countries, deforestation, forest degradation, forest fires and slash and burn practices make up the majority of carbon dioxide emissions" (FAO, UNDP, UNEP, 2008). The transformations of swidden cultivation have a wide range of environmental consequences at the local and at the global level. The Intergovernmental Panel on Climate Change (IPCC) currently estimates that land use change accounts for 20% of global anthropogenic carbon emissions (IPCC, 2007). The UK based Forest Peoples Programme (FPP) and FERN have studied nine concepts for government programs on "Reducing Emissions from Deforestation and Forest Degradation" (REDD). Eight of these "identify 'traditional agriculture' or 'shifting cultivation' as a major cause of forest loss" (Griffiths 2008).

Coincidentally, the world's climate is changing and anthropogenic influences are strongly implicated (Houghton et al., 2001). Air pollution and climate change are two key factors comprising the global change threat to forest health and sustainability (Percy and Ferretti, 2004).

1.4 Ecological implications: Shifting cultivation has its own danger of soil erosion, soil degradation, loss of valuable forest products, climate changes and flooding in river valley down below (Deb and Ray, 2006). The brown haze, caused by dust from barren soils (by indiscriminate deforesting) and the blue haze from agricultural burning along with large dust concentrations, has led to a new air pollution problem known as particulate and aerosol pollution (Bannerji, 2005). Air pollution is a serious threat to the diversity of life. The human health is affected by air pollution mainly due to inhalation of gases and particulates during respiration (Liu and Liptak, 2000). CO has high affinity towards haemoglobin and reduces oxygen carrying capacity of blood, leading to damage of Central Nervous System. Asphyxiation is caused by CO_2 while SO_2 causes irritation of the respiratory tract and cough, and NO_2 causes inflammation of lungs (Rao, 2005). Personal discomfort is characterized by eye irritation and respiratory difficulties associated with asthma, bronchitis, emphysema, sinusitis, cardio–vascular damage and lung cancer, which are particularly associated with particulates (Khan and Zargar, 2004). Malaria is one of the oldest tropical diseases. *A. gambiae* requires stagnant water and the absence of shade in order to breed. By clearing the forests they removed the shade afforded by the trees and deprived the soil of much of its capacity to absorb water (Lauwerys, 1969).

In general, air pollution decreases the yield of all crops by affecting their photosynthetic activity and growth (Shukla and Chandel, 2006). Estimates have shown that hardly 12 to 15% of the total dust particulates released into the environment is man-made and the rest is by nature (Trivedi, 2000). The National Commission on Agriculture (1976) held that shifting cultivation cannot be considered as a balanced part of an ecosystem, and stated that both from the point of forest development and economic well being of the tribals, shifting cultivation should be regulated, contained and replaced as expeditiously as possible (Singh and Vishwakarma, 1997). Even the traditionally settled agriculture oriented society seems to have emerged as a result of neglect of people's needs in organized forest management which often favours timber trees over multipurpose trees valued by local people and ineffective enforcement of policy of restriction on conversion of forest land for agricultural land use (Rao et al., 2005).

1.5 Shifting cultivation and biodiversity: Extensive arrested succession of weeds over large areas, with invasive exotic species taking over as a consequence of shortened jhum cycles, has been one of the major problems affecting ecosystem level process (Ramakrishnan, 1991; Ramakrishnan and Vitousek, 1989). When traditional land use systems are abandoned, erosion of crop genetic diversity follows (Sutthi, 1990). With increasing external pressure on forest resources, larger populations, and declining soil fertility, forest cover is being rapidly lost (Kushwaha, 2006) and agricultural cycles shortened, causing marked reduction in crop productivity, reduced system stability and resilience, leading to serious social disruptions, biodiversity decline, biological invasion and large-scale site-level desertification (Ramakrishnan et al., 2006). Kleinman et al. (1995) documented the causes of yield decline in shifting cultivation with continuous cultivation are attributed to weed infestation and soil nutrient deficiencies and depend very much on the specific area studied. Shifting cultivation is a form of land use which enhances biodiversity. Severe declines in plant diversity have been observed in most areas when shifting cultivation is replaced by permanent land use systems. Particularly worrying is the decline in agrobiodiversity. Shifting cultivators have preserved agrobiodiversity through local rules, practices and the informal networks for exchange of seeds and knowledge, thus ensuring food security of their communities. Along with the replacement of shifting cultivation comes the collapse of these networks, which results in a substantial loss of crop genetic resources (UNFCCC Intersessional Meeting, 2009). The challenge for eco-agriculture is particularly evident in the practice of fallow- based (slash-and-burn) agriculture now practiced in the tropical forest margins, where over a billion chronically poor people depend on forest resources, and globally important biodiversity is threatened (Scherr and McNeely, 2007). The vegetation dynamics involved during secondary succession has implications also for soil fertility dynamics and nutrient cycling patterns and processes (Toky and Ramakrishnan, 1983).

1.6 Scope and Objectives:

Scope of Study : Positive impacts include the burning of slash returning nutrients to the soil through ash and kills microbes allowing relatively high yields. The belief that jhum has a detrimental impact on wildlife finds support in recent studies. Studies in Mizoram on rainforest birds, arboreal mammals, and plants have shown that second-growth habitats created by jhum, especially young fallows and dense, monotypic bamboo forests, support only a fraction of the species found in undisturbed primary tropical rain-forest, (Raman, 1996). Conklin (1963) stated that yields in shifting cultivation cannot be limited to a study of climate, soil and management practices, but must be seen in a wider ecological, socio-economic and cultural context to be fully understood. The people of North East India represent a fascinating variety of cultures. Jhum plays an important cultural role in local customs, traditions, and practices, besides offering economic security to farmers. Slash-and-burn agriculture is often effective for the farmer's economy in terms of security and productivity. It would be unfortunate if developmental programmes based on misguided opinions about jhum suppress this unique form of agriculture. There is urgent need of systematic studies on shifting cultivation in to provide result based recommendations to the government for its mainstreaming in national plans, policies and priorities.

Only occupations providing monetary and social benefits perceived by jhumias to outweigh the cultural and security benefits embodied by jhum are likely to gain acceptance. There is also a growing concern about the contribution of biomass burning, especially slash and burn agriculture, to both particulate and gaseous air pollution, (Murck, 2005). Air pollution is a serious threat to the diversity of life as they alter the physical and chemical environment. The objective of this paper is to summarize the overall possible impact of forest fire on physical and chemical properties of soil and air. A specific study on the impact of jhum cultivation on air, soil and the health status of the affected areas has not been carried out before particularly with reference to Mizoram. And since, the research proposed area, Lengpui is where the airport, an important commercial center of the state is situated. The airport is being disturbed often resulting in rescheduling of flights during the season of Jhum burning. So therefore a scientific studies on the impacts of jhum burning on the proposed areas is being suggested as a research title.

The objectives of study are:

1. To assess the environmental impact of jhum on the local atmosphere by analyzing Suspended Particulate Matter (SPM), Respirable Suspended Particulate Matter (RSPM), NO_2, SO_2 and CO.
2. To assess the environmental impact of jhum on the soil by analysing the physico-chemical properties of soil before and after jhum.
3. To assess the health status of the villagers in the adjoining areas of jhum.
4. To assess the air and soil quality and health status of villagers in a control area, not affected by jhum for comparison.

Chapter- II

2. REVIEW OF LITERATURE

2.1 An overview: Studies on shifting cultivation have been carried out by various authorities including social scientists, agronomists, forestry experts, soil scientists and ecologists from time to time. Jha (1997) has raised a question that if a change in farming system is brought looking at the entire terrain condition of the region, will it be acceptable to the local population and fit into their pattern of life. The economics and efficiency of shifting agriculture studied by Ramakrishnan (1992) and his team showed that far from being primitive and inefficient, jhum is an indigenious system of organic multiple cropping well suited to the heavy rainfall areas of the hill tracts. The economic and energetic efficiency of jhum is higher than alternative forms of agriculture such as terrace and valley cultivation. This is mainly because terrace and valley cultivation needs expensive external input such as fertilisers (which often get leached out or lost in the heavy rainfall hill slopes) and pesticides, besides labour for terracing. Energetic output-input ratio (MJ/ha/year) in jhum is twice that of valley cultivation and over five times that of terrace cultivation. In support to the above statement, Ninan (1992) mentioned that even gross returns (rupees/ha) from jhum are about 1.9 times higher than for terrace cultivation.

Sachidananda (1989) mentioned that the tropical region with a mean temperature of approximately 18.3^{o}C and a minimum of 24 inches (610mm) of rainfall per annum and with a thin population have been found to be favourable for shifting cultivation. Shifting Cultivation is normally confined to lower slopes as the ideal setting is provided by hot humid climate favouring faster growth of forest vegetation. The upper limit of height is around 2000 meter above sea level (Ramakrishna, 1992).

Ramakrishnan (1992) states that, shifting cultivation often dismissed as a primitive form of land use and waste of natural and human resources has now been recognized as a model of ecological efficiency. Mohapatro and Mohapatro (1997) opined that shifting cultivation is not always harmful to the forest and the land as it can very well be improved and evil effects minimized by introducing leguminous crops and nitrogen fixing plantations as well as planting fruit bearing trees by restricting jhum. Scientific studies have been consistent in suggesting that in many ways there is optimum utilization of natural resources in the shifting cultivation regime which is helpful for the stability and sustainability of agriculture in the mountains. By a perspective observance, Maithani (2005) stated that the correct approach to the shifting cultivation lies in not condemning it as an evil practise but regarding it as an agricultural practise evolved as a reflex to the physiographical character of land. The shifting agriculture not only shows the resilience to adjust to the changing situations but also points out how the scarce land resources can be used in most scarce manner.

The organizational model for collaborative research on integrated natural resource management is the ASB Partnership for the Tropical Forest Margins formerly known as the Alternatives to Slash-and-Burn program. The partnership focuses on landscape mosaics (comprising both forests and agriculture) where global environmental problems and local poverty converge at the margins of remaining tropical forests. Smoke pollution from burning of forest, grassland, and agricultural fields is a serious public health problem and disrupts livelihoods in large areas of the humid tropics. Byron (2004) pointed out that the ASB research has emphasized options to manage smoke from land clearing activities. Fires are not intrinsically harmful and if well managed can be a legitimate, low-cost technique for clearing unwanted vegetation. A number of site-specific alternatives to slash-and-burn agriculture, such as sustainable forest management, smallholder agroforestry, improved pastures, and *Imperata cylindrica* grassland reclamation have been proposed (Palm et al., 2005). Ramakrishnan (1992) suggests that traditional home gardens and plantation crop systems also complement shifting agriculture, and with varied ecological and economic efficiencies. According to Tawnenga et al., (1997) the material input in jhum is only through seeds, which again is in fact a product of preceding year's human labour input and the second established fact about jhum is that it is an efficient system of agriculture from the viewpoint of energy.

Myers (1984) cited “shifting cultivation” as the most important cause of deforestation. He continued to state that a destructive type of shifting cultivation was practised by non-indigenous colonizers who often knew little about farming, other than chopping down the forest, burning it, and planting corn or rice in the ashes. After 2 or 3 years, production gives out, and they are forced to move further into the wilderness. The length of shifting cultivation cycle observed in different states of North East suggests that the critical period had been transgressed in many areas causing irreparable loss to the ecosystem and subsistence economy of the mountain tribal communities (Maithani,2005).

2.2 Shifting cultivation at the global level: Jha (1997) had conclusively proved, through archaeological methods, that the Neolithic farmers of Formosa were shifting cultivators and identified the Neolithic farmers of the Dambe Valley as nomadic cultivators. In the savannas of Africa, for example, pastoralists and hunters gatherers have used fire to maintain the productivity of the ecosystem for livestock and game since millennia (McClanahan and Young, 1996). In North America as well, indigenous peoples have greatly modified the environment in pre-colonial times, creating and maintaining grasslands and open forest savannahs through controlled burning (Pyne, 1982, cited in: Schneider, 2000). In Asia, the majority of the people practicing shifting cultivation belong to ethnic groups that are generally subsumed under categories like ethnic minorities, tribal people, hill tribes, aboriginal people or indigenous peoples.

Differences in swidden farming practices of various ethnic groups in Thailand and Laos have also resulted in differences in the recovery rate of secondary forest in swidden fallows (Delang, 2007; Fukushima et al., 2008). Posey (1982) studies shows that some tribes like the Kayapo in Brazil, plant perennial crops and fruit trees in the fallow, managing the plot as a long- term rotation. According to Arreola et al. (2007) slash-and-burn farming is responsible for the nearly complete destruction of Madagascar’s rain forest. Experts estimate that over half of Africa’s original rain forest has been destroyed. In Lao People’s Democratic Republic (Laos) alone, it has been estimated that 6.5 million ha of forests are affected by swidden agriculture with an estimated 17% of the population (corresponding to 157 000 households) involved (Messerli et al., 2009).

Mertz (2009) in their assessment of existing data on the numbers of swidden cultivators at the global level and in Southeast Asia point at similar difficulties. According to them, the best estimate of the global population of shifting cultivators was done in a UNEP/FAO study in 1982. The figure of 500 million is a very rough approximation only, and the actual numbers must have changed considerably over the past 27 years.

Kato et al. (1999) studied rice and cassava yields in Brazil in two experimental plots with different fallow periods, 10 and four years, and under controlled traditional management. The study confirms the positive correlation between fallow length and rice yield and is the only study that provides almost exact soil conditions for both sample plots. Roder et al. (1995) sampled 190 fields in Laos and found no relationship between fallow length and upland rice yields. The reason could be that farmers maintain shorter fallow periods on more fertile land thereby neutralising the positive effect of increased soil organic matter after longer fallow. Wadley (1997) provides rice yield data for the 1979–1993 period in West Kalimantan based on interviews with all 14 households in an Iban community. Arnason et al. (1982) show that maize yields in Belize in an area with 50 years fallow were 1700 kgha^{-1} and in another area with 5 to 10 years fallow yields they were only 800 kgha^{-1}. Lambert (1996) does not indicate the time and method for measuring declining maize yields with shorter fallows in Mexico, but none the less both studies conclude that yields decline with reduced fallow length. Wey and Traore (1998) provide average rice yield and fallow period data from three regions in Guinea. In northern Thailand, Hansen (1995) found that first year upland rice yields after older secondary forest (5 fields) produced an average of 1960 kg ha^{-1} whereas yields after very short fallow (shrub or bamboo, 35 fields) produced only 856 kg ha^{-1} (forest age not provided). Finally, Pandey and van Minh (1998) concluded that shortening the fallow period on upland soils of Vietnam leads to reduced land productivity, but the data presented show that yields in two areas with different fallow periods are almost the same. In Peru, Denevan et al. (1984) found that farmers prefer fallow periods of 10 years for cassava cultivation, but most fallows are 20 years because the regrowth is used extensively for collection of forest products. Long settled Iban in Sarawak considered average fallow periods of five to seven years to be the minimum in order to avoid weeds (Mertz and Christensen 1997). There has been a long history in Southwest China to interplant a range of crops among Chinese fir (Cunninghamia lanceolata) during the cropping phase of the shifting cultivation, which is possibly the origin of the well-known taungya system (Brookfield, 2001). Liang et al. (2009) studies states that recent development of wet rice cultivation in China as well as improved access to market have enabled local farmers to reduce dependence on shifting cultivation for food security .

2.3 Shifting cultivation at the national level: According to the State of Environment report in 2009, an area of 18765.86 sq. km. (0.59 percent of the total geographical area) is under shifting cultivation. As per the statistics, Orissa accounts for the largest area under shifting cultivation in India. The area subjected to shifting cultivation reported 4.9 Mha. of eroded land. Government of India (1985) emphasized that it is natural to think of controlling shifting cultivation not only for improving the quality of life of the shifting cultivators but also for checking land degradation. Jha (1997), gave emphasis on introduction of all the three components i.e., agronomy, forestry and animal husbandry in hill farming system or for rehabilitation of shifting cultivators. According to Negi (1991), the main approach to solve problem of shifting cultivation is to bring in elements of Permanent cultivation by a gradual process.

The practice of shifting cultivation first came up for administrative review when the first forest policy was enunciated in 1894. It is clearly stated that “a system of shifting cultivation costs more to the community than it is worth and can only be permitted under due regulation”, but failed to analyse the problem related to shifting cultivators. Following the same approach the Indian Forest Act, 1927 laid down that “shifting cultivation was subject to control, restriction and abolition by the State Government". The National Forest Policy of 1952 concentrated attention to solve age-old injurious system stating that on the basis of persuasion, the participants would be induced to adopt alternative cultivation or occupation. It was admitted in paragraph 4.7 of the Forest Policy of 1988 that shifting cultivation affected adversely the productivity of the land as well as the environment. The National Forest Policy, 1988 laid guidelines and now the states of India will have to adopt suitable measures to tackle the problem (Jha, 1994).

2.4 Shifting cultivation at the northeast level: The Report of National Commision (NCA) Part IX of Forestry, 1976 reveals that in Assam hills, the total area affected by jhum is 4,98,000 hectares and area under jhum at one time is 69,000 hectares (Das, 2001). In North East India, the area and population involved in shifting cultivation during 1976 were recorded 2.7 million hectares and 2.5 million people respectively. According to the State of Forest Report (1997) in North Eastern States, the area under shifting cultivation has reduced from 73,410 sq. km. to 62,854 sq. km. during the period of 9 years, i.e. 1975 – 1984. In N.E. India, the Agro–Economic Research Center for North East, Jorhat; the North Eastern Council, Shillong and ICAR Research Complex for North East Hill Region, Shillong carried out studies of various aspects of shifting cultivation (Das, 2001). This farming is very closely interwoven with the social structure of the people in N.E. India that any dislocation in the setting may send shockwaves to the entire society. According to Acharyya et al. (2010) the most alarming zone is under Nagaland wherein about 83,000 hectares of land is under shifting cultivation and more than 30% of the total population still depend on the shifting cultivation.

Jha further states that, in a labour surplus, capital scarce economy like Assam more particularly in the Hill areas, the role of shifting cultivation is highly significant. According to Ramakrishnan (1992) at least 100 different indigenous tribes and over 620,000 families in the seven states of North East India depend on jhum for their subsistence. Das (2001) observed that shifting cultivation is not just an alternate form of land use or a set of agricultural practices, but it implies the whole nexus of people's religious belief, attitude, self-image and the tribal identity. In North-East India, increasing human population density has resulted in the practice of unsustainable form of slash-and-burn that includes shortening of the fallow period as well as permanent conversion of forest to permanent agricultural expansions (Yadav, 2013).

2.5 Shifting cultivation at the local level: Traditional jhum in Mizoram involves an alternation of a long resting period and a short cropping period (Tawnenga et al., 1997). Shifting cultivation and forest lands are governed by the Jhumming Regulation Act of 1954 and the Mizo District (Forest) Act, 1955 respectively. Jha (1997) mentioned that the nation is not in a position to afford shifting cultivation for a long time and needs to adopt a serious and practical approach to eradicate the system. Mizoram Pollution Control Board (MPCB) published in the State of Environment Report, Mizoram (2005), states that air pollution in Mizoram is largely contributed by Agricultural activities. According to Department of Agriculture, Government of Mizoram (1991), Mizoram shows a declining trend of jhum cultivation. Maithani (2005) have provided that Mizoram recorded remarkable progress with 44 percent families giving up Shifting Cultivation for other occupation. 80% of the population living in the rural areas of Mizoram are engaged in agricultural activities. The State Government has launched the programmes for the control of jhumming and the agricultural lands are being allotted to the farmers for taking up permanent type of cultivation (Dept of LR&S, 2011). Shifting cultivation of jhum is the major factor responsible for degradation and transformation of forests in Mizoram. Due to the shifting cultivation practices large tract of land is now covered by secondary forests of different seral stages, leaving few areas under primary forests (Lallianthanga et al.,1999).

Garbyal (1999) states that the Govt. of Mizoram in 1984 launched a programme called New Land Use Policy (NLUP) with an objective to put an end to the practice of jhuming by providing alternative land based permanent occupation and stable income to the families practicing jhuming (jhumias) in rural areas thereby raising their standard of living. The agricultural department reported that the area of jhum cultivation in Mizoram decreased by 36 per cent that of wet rice cultivation increased by 28.4 per cent during 2010 (The Shillong Times, 2011). Forest Survey of India, 2011 reported that Mizoram with 90.68 % has the highest forest cover percentage of forest cover with respect to total geographical area. However a loss of 66 km^2 has been detected during 2011 assessment for the state as compared to 2009 assessment, which is due to shortening of shifting cultivation cycle and biotic pressure. Dampa Tiger Reserve which contains 11 endangered mammal species and is the largest protected area in the state, lost 4% of its forest to fire last year due to slash and burn activities by adjacent villagers (Grogan et al., 2012).

2.6 Impact on air and soil: Mathews (2003) mentioned that profound modification of soils by agricultural activities can lead to their classification as anthrosols. As a consequence, Shifting Cultivation is often accused of being a prime cause of deforestation. The effects of fire on the soil resource are induced by soil heating, by removal of the protective cover of vegetation, litter and duff, or by the concentration of plant material substances in the soil (NWCG, 2011). Goudie (1993) estimated soil losses in different regions of North India, and concluded that the loss was the highest in the North Eastern States and in the hilly terrain. Researchers have studied the effect of shifting cultivation on soil fertility at high elevation of Meghalaya using 15, 10 and 5 years shifting cultivation cycle. Abdul et al. (2004) states that burning organic residues in shifting cultivation resulted in increased total content of most cationic micronutrients in soil. Soil nitrogen and phosphorus concentration under a 5 year cycle was significantly lower than that under the 10 and 15 years cycle. The reports of ICAR Research Complex has concluded that in slash and burn practices organic matter of the surface soil is also oxidized (Goudie,1993). He states that the amounts of phosphorus, magnesium, potassium and calcium released by burning forest and scrub vegetation are high in relation to both the total and available quantities of these elements in soils. The classic work of Nye and Greenland (1960) on shifting cultivation in West Africa suggested that P availability may be more critical than the total amount of P in the soil ash raises the pH, which in many tropical soils increases the availability of P (Nye and Greenland 1960; Jordan 1989). Davidson and Ackermann (1993) studies shows that the short-term consequences are release of C and N to the atmosphere and loss of a C sink in form of living biomass. Traditional slash and burn agriculture operates in small clearings for short cultivation periods so that reinvasion of the site by forest roots and organism is facilitated. The litter layer of the intact forest contains the majority of the active roots and symbiotic fungi, which recycle nutrients from litter decomposition directly to the vegetation. After slash and burn, fertility declines in parallel with the disappearance of the litter layer (Jordan, 1989). The destruction of the litter layer is sufficient to reduce nutrient availability to levels too low for agricultural use within 4 years of land clearing. Slash and burning such lands in the tropics having richer soils, usually under less humid or semi-arid moisture regimes, causes a rapid mineralization of SOM and release of organically held nutrients (Mueller-Harvey et al., 1985) as well as an immediate nutrient release by the fire (Kauffman et al., 1993). This not only supplies nutrients such as P for crop growth (Adepetu and Corey, 1976) but also generates a surplus (Agboola and Oko, 1976) which may be lost by leaching or by transformation into plant unavailable forms. The decrease in SOM as a consequence of cultivation is of the same order as that for temperate regions, averaging 25–30% of the initial SOM contents. Jordan (1995) reveals that when the plot is left fallow, the soil organic matter gradually builds up again, and the nutrients especially phosphorus, become available. There have been atleast two major hypotheses to explain the sharp decreases in growth of crops like corn and rice after 2 or 3 years of shifting cultivation. Uhl et al. (1982) explained one of the hypotheses of the decline in crop yield due to competition from vigorous weeds that have invaded the site. The other hypothesis was explained by Nye and Greenland (1960) stating that the decline was caused by nutrient losses due to leaching of calcium and potassium and volatilization of nitrogen.

In 1972, William H. Smith was asked to review the relationship between air pollution and forests for the annual meeting of the American Association for the Advancement of Science. This formidable assignment was approached by dividing the interactions between air contaminants and the forest ecosystem into three classes (Smith, 1990). The use of lichens and moss for air pollution level mapping in urban and industrial area of Europe and also in North America are the finest example of plant biomonitoring of air quality. The remark made by Hardy (2003) states that land clearing, much of it from agriculture, is the second largest source of CO_2 emissions after fossil-fuel combustion, accounting for 10 – 30% of net global CO_2 emissions.

Smith (1990) presented an overview on the various contaminants produced by forest burning. His results were based on data drawn from scanning electron microscope photomicrographs of particles which consisted largely of carbon. He further analyzed the pollutants produced by broadcast and pile fires set experimentally in Douglas Fir slash in Washington in order to explore the hypothesis that pile fires, because they are higher temperature fires, have more complete combustion and produce fewer emissions than the broadcast burns. The percentage of Douglas fir and western larch slash that was converted by controlled burns to various contaminants was determined in the field at the Lolo National Forest, Montana. His results showed that carbon dioxide is the highest emission with

1130 kg ton^{-1} of fuel followed by carbon monoxide, nitrogen dioxide and particulates. He has reported on field studies of particulate distribution from broadcast slash burns in the Flathead national forest, Montana. Daily 24 hour high volume suspended particulate concentrations measured were significantly higher at the three downwind sampling sites on prescribed fire days relative to non-fire days. Murck (2005) summarized that these forest fires can contribute locally and regionally significant amounts of particulates, carbon dioxide, and hydrocarbons to the atmosphere. It has been estimated that globally 8,000 people die every day from diseases related to air pollution exposure (CPCB, 2012). In the U.S., the National Morbidity, Mortality, and Air Pollution Study indicated a 0.41% increase in total mortality in response to a 10-µg/m^3 increase in PM_{10} in ambient air (Dominici et al., 2005).

The effects of fire on soils are a function of the amount of heat released from combusting biomass and the duration of combustion. As the cycle of shifting cultivation becomes shorter which is 4 to 5 years, the biomass that depends on the humus of soil declines and the biodiversity is considerably reduced. Reduction in the cycles of jhumming, adversely affects the recovery of soil fertility, and the nutrient conservation by the ecosystem. One of the most important impacts on soils results from the combustion of organic matter. Consumption of organics can range from scorching (producing black ash) to complete ashing (producing white ash) (DeBano et al., 1998), depending on fire severity, moisture content, and thickness of the organic layer. Recovery of soil nutrient levels after fires can be fairly slow in some ecosystems, particularly those with limited nitrogen, and in semi-arid regions where decomposition rates are slow (Neary et al., 1999).

2.7 Shifting cultivation and fallow periods: Commercialization and an increasing demand for cash crops provide incentive to growing commercial crops, intensively with shorter fallow periods or none at all. Although such land use offers almost immediate financial benefits to the farmers, it may have many long-term adverse environmental impacts, as a shortened fallow phases are often unsustainable (Wangpakapattanawong, 2001), allowing dominance of herbaceous weeds and grasses and eventually soil degradation (Ramakrishnan, 2006). Singh and Vishwakarma (1997) states that a serious problem concerning the tribals and forests is the practice of shifting cultivation. The cycle of shifting cultivation gets shorter and shorter, and erosion takes a heavier toll , resulting in deteriorating economic condition. Many studies have been conducted on the productivity aspects of shifting agriculture.

Jhum (shifting cultivation) was probably suitable for the Himalayan ecosystem when population pressure was low. It was practised in a cycle of 20–25 years (Sen and Chakrabarti, 2007). If the duration of fallow periods is long enough, shifting cultivation is a sustainable system. However, population growth as well as social and policy changes exert increasing pressure on shifting cultivators (Delang, 2002; Xu et al., 2009). The traditional shifting cultivation is under external and internal pressures to change and the circumstances needed for sustainable shifting cultivation systems with long forest fallow phase no longer exist in most regions (Cairns and Garrity, 1999). The essential ecological principles of swidden cultivation are that during the fallow phase nutrients are taken up by the recolonizing natural vegetation and returned to the soil surface as litter (Bruun et al.,2009). However, in many tropical developing countries, high population growth rates have led to an increased demand for arable land that has, in turn, resulted in shorter and shorter fallow periods for these systems. The shortened phase of fallow periods result in declining yields and would not allow forests to recover sufficiently for regeneration of soil fertility and control of weeds (Rasmussen and Jensen, 1999: Mansourian et al., 2005:). Ramakrishnan (2006) reported that in Northeast India, forests cannot recover if the length of the fallowing phase is shorter than 10 years.

Studies of succession by Lawrence (2004) shows that after cessation of swidden cultivation in tropical region have indicated that the diversity of woody species gradually increases with time since abandonment of fallow. Hooper et al. (2005) mentioned that it is likely that the frequent use of fire during repeated crop-fallow rotation cycles to prepare the fields favors grasses, which in turn limit seedling establishment due to competition. Tropical shifting cultivation systems employ a fallow period to help overcome weed infestations in addition to improving soil productivity and reducing other pest populations (Gallagher et al, 1999). The fallow phase allows soils to stabilize and gives forest vegetation an opportunity to re-grow, to accumulate biomass, and to provide various non-timber forest products. Moreover, if the fallow phase is long enough, there is considerable opportunity for both carbon sequestration and biodiversity conservation (Lawrence et al., 1998). Realizing the negative consequences of the shortening of the fallowing phase, sedentary agriculture (continuous cropping in the same fields and without fallowing) is often recommended by scientists and promoted through governmental policies as an alternative to replace and discourage shortened shifting cultivation (Brady, 1996; Cairns and Garrity, 1999; Fox, 2000; Borggaard et al., 2003).

Chapter-III

3. DESCRIPTION OF STUDY AREA

3.1 A brief information about Mizoram:

a) Location: Geographically, Mizoram is located in the northeastern part of India. Having 21,081 sq. km of land area, it lies between 21°58' – 24°35' latitude and 92°15' – 93°20' E longitude with the tropic of cancer passing through the state at 23°30'N latitude. The state stretches from 277 km (north-south) to 121km (east-west). Mizoram is internationally bordered with Myanmar to the east and south (404km) and

Bangladesh to the west (318km). The State has inter-state boundary with Assam (123km), Manipur (95km) and Tripura (66km). Administratively, there are 8 districts and 3 Autonomous Districts Councils having 719 villages. According to 2010 census, the total population of Mizoram is 10,91,014 of which 5,52,339 are male and 5,38,675 are female with the literacy percentage of 91.58% as given by Economics and Statistics department, Govt. of Mizoram.

b) Climate: Mizoram enjoys a moderate climate owing to its tropical location and falls under tropical monsoon type climate. The climate of Mizoram is neither very hot nor very cold; summer is warm and humid and winter is cold and dry. The whole state falls under the direct-influence of south-west monsoon and receives an adequate amount of rainfall. The climate of the state is humid-tropical, characterized by short winter, long summer with heavy rainfall. The fluctuation in temperature is not much and the highest temperature is observed during May to July and starts decreasing with the onset of monsoon. This fall of temperature continues with the span of monsoon and becomes more evident with the retreating monsoon. The temperature becomes minimum in December and January (Tiwari, 2006). In summer the temperature ranges between 18°C to 29°C. During winter season, the minimum and maximum temperature ranges between 11°C to 24°C (SFR, 2011).

Rainfall is not evenly distributed throughout the year. Mizoram receives an average annual rainfall of 2160 mm to 3500 mm (Ibid). The study of available rainfall data reveals that heavy rainfall starts from the second part of May and usually ends in the first part of October. Rainfall increases southward with the highest annual rainfall at

Lunglei district(315cm) followed by Saiha district(243cm) and Aizawl district (235cm).

c) Topography: Rugged hills and steep mountains characterize the topography of the State. The topography of Mizoram is dominated by mountainous terrain with parallel ranges forming deep gorges culminating into several streams and rivers. The hill ranges are steep, anticlinal, longitudinal and parallel to sub-parallel and are separated by rivers. The average height of the hills is about 900 metres. The hills run in the north south direction parallel to each other with valleys in between them. Dissected hills and hillocks are dominantly found in most of the river valleys in the western part of the state. The elevation ranges from 40 metres at Bairabi Valley to Phawngpui Mountain (Blue Mountain) where the height of its peak is 2,157 metres. The rock system is weak and loose and prone to frequent seismic influences. Less than 5 percent of the landmass is flat or in gentle slopes. Based on relief, drainage, lithologic and structural set-up, the landforms of the state are broadly classified as-

i)Mountainous terrain province- consists of the eastern part of the state with an altitude ranging from 40 to 2157 m asl. The ranges are aligned mostly in north-south direction.

ii)Ridge and valley province- consists of the western part of the state and covers about half of the area of the state. It is characterised by ridges and valleys with an average elevation of 700 m asl.

iii)The flat lands- mostly intermittent valley plains located in the midst of hills and narrow valleys. The largest plain in Mizoram is Champhai followed by North Vanlaiphai, Thenzawl and Chamdur in Lawngtlai district.

iv)The lakes- only few natural lakes are formed at places where hills and ridges serve as natural embankments on all sides. The important lakes of the state are Palak in the southern corner of the state and Tamdil in Aizawl district.

d) Soil: The soils of Mizoram are dominated by loose sedimentary formations. It is young, immature and sandy, and is still in the process of denudation in response to various exogenous forces. The soil is acidic and porous with poor water holding capacity, deficient in potash, phosphorous, nitrogen and even humus. The soil structure has exceptionally high rate of seepage. But in an uneroded soil, the content of Nitrogen is markedly high fostered by accumulation of organic matters. The soils in the valleys are heavier as they were brought down by rain water from the high altitudes. The soil of Mizoram can be classified into three orders of soil taxonomy, viz., Entisols, Inceptisols and Ultisols.

e) Drainage: Mizoram is drained by a number of rivers, streams and rivulets of various patterns and lengths. The northern part is drained by large rivers like Tlawng (with its tributaries namely Teirei and Tut), Tuivawl, Tuirial, Langkaih and Tuivai which eventually falls into the Tuiruang river in Cachar plains of Assam. The southern part is drained by much prominent rivers like Chhimtuipui (also known as Kolodyne) with its tributaries- mat, Tuichang, Tiau and Tuipui whereas river Khawthlangtuipui with its tributaries Kawrpui, Tuichawng, Kau and De drains the south-western part of the state eventually flowing into Bangladesh. These and a few more rivers, forms their respective watersheds in the path they flow giving rise to 25 watersheds in total for the whole of Mizoram.

3.2 Location of study sites: The study was carried out in and around Lengpui Airport (360m asl), 42 kms approx, from Aizawl, the capital city of Mizoram. The adjacent villages around the airport include Sairang (80m asl), Sihhmui (120m asl) and Hmunpui (840m asl). Shifting cultivation is a common phenomenon in these villages. The study was also stretched to the area that is not affected by jhum (control) which is Mizoram university campus (860m asl).

The study sites are indicated on the map with a marker (dark spots).

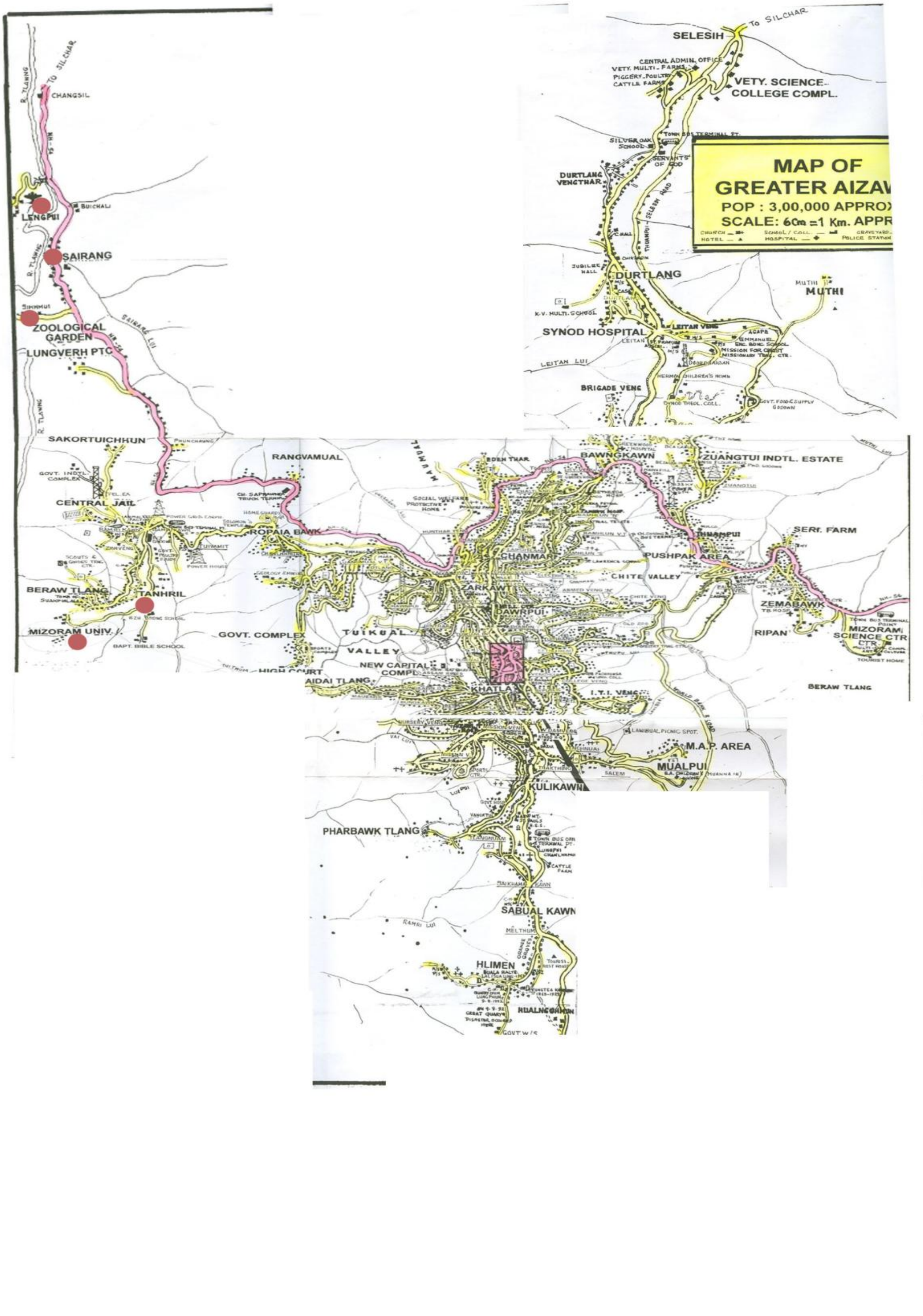


Fig 3.1: Map Of Aizawl Showing The Study Sites

MAP OF MIZORAM

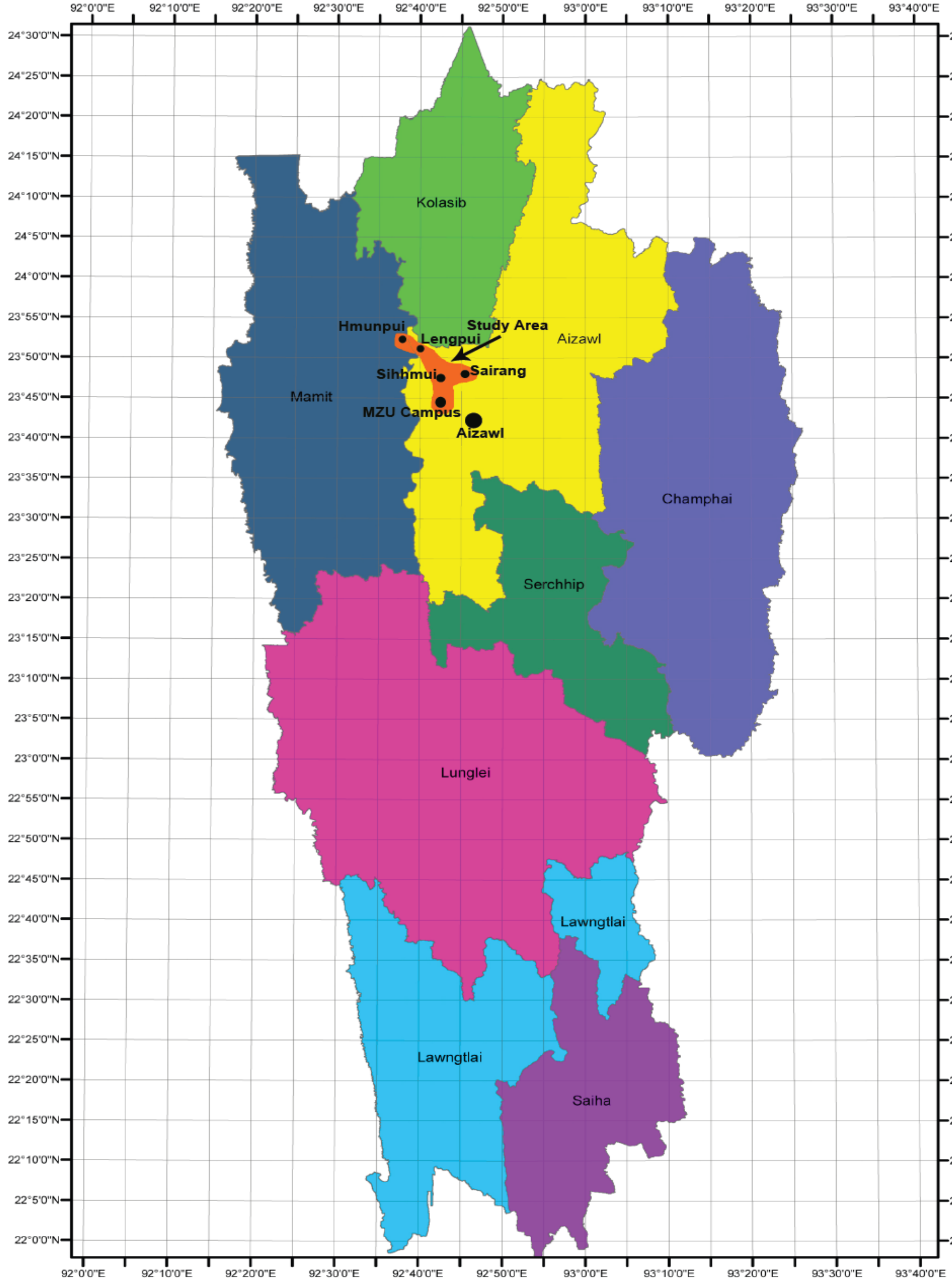


Fig 3.2 : Map of Mizoram showing study sites

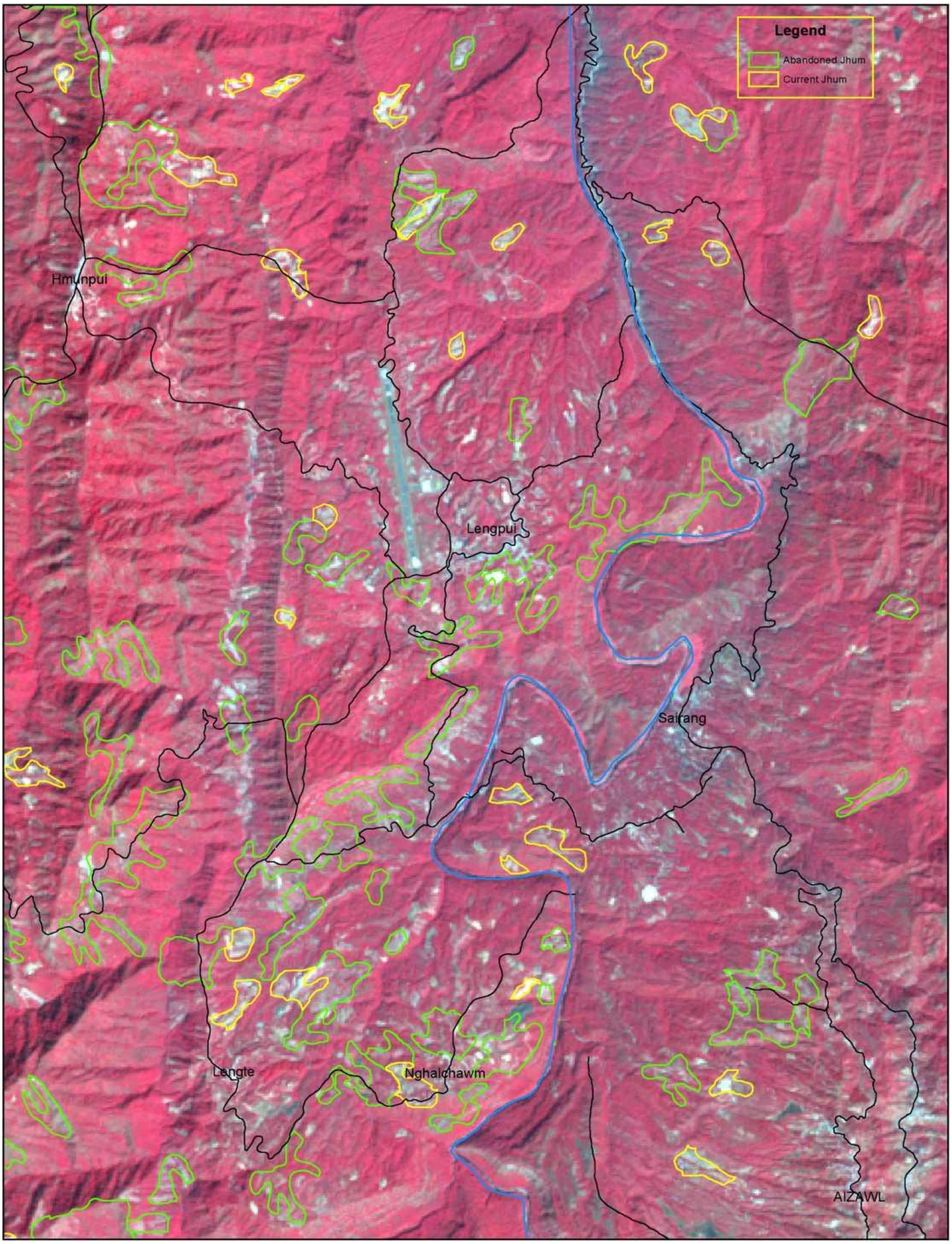


Fig 3.3: Jhum Affected area of the Study Sites

Chapter- IV

4. MATERIALS AND METHODS.

The monitoring of ambient air quality was carried out during jhum burning season from the 25th of February to 25th of March, 2010 and from 24th of February to 24th of March, 2011. The soil samples were collected from five different locations namely Hmunpui, Lengpui, Sihhmui, Sairang and Tanhril (MZU Campus). The soil was collected and analyzed twice i.e. prior to jhum burning (February to mid-March) and after jhum burning (March end till April). High Volume Air Sampler was used for monitoring of air quality stationed near Lengpui Airport. The monitoring of ambient air quality was also done prior to jhum burning, during jhum and after jhum burning and was taken to the laboratory for analysis. Analysis was done at a weekly interval and each sample was monitored for 8 hours using standard method. The data were properly recorded.

4.1 Estimation of Ambient Air Quality.

4.1.1. Estimation of Suspended Particulate Matter

Suspended Particulate Matter (SPM) in the atmosphere was analysed by using **High Volume Method** for which Respirable Dust Sampler, Envirotech Model APM 460 BL was used .

Prior to the data collection, a known weight the filter paper having an ID number was installed in the sampler with the rough side of the filter paper facing upwards. The timer was set for the desired start and stop time. The flow control sampler was done manually and the motor was turn on for five minutes and the exhaust pressure with a rotameter was measured. The motor was turned off and the timer was kept in its automatic mode. After sampling was completed, the final flow rate and the elapsed time was recorded. The filter paper was folded in half lengthwise by handling it along its edge with the exposed side inward. It was then kept inside the envelope. The exposed filter weight was recorded after it was taken back to the laboratory. The ambient concentration of Suspended Particulate Matter was calculated as follows.

(a) Calculation of volume of air sampled:

$$\text{Air Volume Sampled (V), } m^3 = \frac{Q_1 + Q_2 \times T}{2}$$

Where, Q_1 = initial air flow rate, m^3 / min

Q_2 = final air flow rate, m^3 / min

(b) Calculation of mass concentration of SPM :

$$\text{SPM } (\mu g/m^3) = \frac{(W_f - W_t) \times 10^6}{V}$$

Where, W_t = initial weight of filter, g.

W_f = final weight of filter, g.

V = Volume of Air sampled in m^3

10^6 = Conversion of g to µg ($1g = 10^6$ µg)

4.1.2. Estimation Of Respirable Suspended Particulate Matter (PM_{10})

The method for determination of Respirable Suspended Particulate Matter in the ambient air is the **Cyclonic Flow Technique** which is inbuilt in Respirable Dust Sampler, Envirotech Model APM 460 BL.

The filter cup was inspected and assigned an ID number. The weight of the filter paper was recorded and shipped to the field in a heavy paper folder or envelope. The filter cup was installed in the sampler with the rough side of the filter paper facing upwards. The timer was set for the desired start and stop time. The flow control sampler was done manually and the motor was turn on for five minutes and the exhaust pressure with a rotameter was measured. The motor was turned off and the timer was kept in its automatic mode. After sampling was completed, the final flow rate and the elapsed time was recorded. It was then kept inside the envelope. The exposed filter weight was recorded after it was taken back to the laboratory. The ambient concentration of Respirable Suspended Particulate Matter was calculated as follows.

(a) Calculations of volume of air sampled :

$$V = QT$$

Where, V = Volume of air sampled in m^3

Q = Average flow rate in m^3 / minute

T = Total sampling in minute

(b) Calculation of PM_{10} in ambient air :

$$PM_{10} = \frac{(W_f - W_i) \times 10^6}{V}$$

Where, PM_{10} = Mass concentration of particulate matter less than 10 micron diameter in mg / m^3

W_i = Initial weight of filter in g

W_f = Final weight of filter in g

V = Volume of air sampled in m^3

10^6 = Conversion of g to mg

4.1.3. Estimation of Nitrogen Dioxide

Nitrogen Dioxide in the atmosphere was determined by **Jacob & Hochheiser modified (Sodium Arsenite) Method** (Merryman *et. al.*, 1973).

10 ml of the collected sample from the impinger was pipette out in 50 ml volumetric flask. To this sample 1 ml of diluted H_2O_2, 10 ml of Sulphanilamide solution and 1.4 ml of NEDA solution was added. After thorough mixing with addition of each reagent, distilled water was added to make the volume upto 50 ml. A blank solution was prepared in another 50 ml volumetric flask by taking 10 ml of absorbing media(viz. 4g of sodium hydroxide and 1g of sodium arsenite dissolve in 1 litre of distilled water). Also, 1 ml of diluted H_2O_2, 10 ml of Sulphanilamide solution and 1.4 ml of NEDA solution was added and the volume was made upto 50 ml with distilled water. After 20 minutes, the absorbance was recorded at 540 nm in a spectrophotometer. The Spectrophotometer was run for 30 minutes before operating.

Calculation :

NO_2 concentration in air sample was calculated as -

$$\mu g\ NO_2 / m^3 = \frac{\mu g/NO^-_2 \times V_S \times D}{Va \times 0.82 \times V_t}$$

Where **,** $\mu g/ NO^-_2$ = NO^-_2 concentration in analyzed sample

Va = Volume of air sample, m3

0.82 = Sampling efficiency

D = Dilution factor (D=1 for no dilution; D=2 for 1:1 dilution)

V_S = Final volume of sampling solution

V_t = Aliquot taken for analysis

4.1.4. Estimation of Sulphur Dioxide

Sulphur dioxide (SO_2) in air was determined by the **Modified West and Gaeke Method** (1956).

20 ml of the collected sample from the impinger was pipette out in 50 ml volumetric flask. 20 ml of SO_2 absorbing media (i.e. 10.86g of mercuric chloride, 0.066g of EDTA and 6 g of potassium chloride dissolve in 1 litre of distilled water) was again pipetted out in another 50 ml volumetric flask for blank solution. To both the flask- the collected sample and the blank solution, 1 ml of Sulphamic acid, 2 ml of Formaldehyde and 2 ml of PRA was added with thorough mixing after addition of

each reagent. The volume was made upto 50 ml with distilled water in both the flask. After 30 minutes and before 60 minutes, the absorbance was recorded at 560 nm in a spectrophotometer. The Spectrophotometer was run for 30 minutes before operating.

Calculation :

The concentration of SO_2 in $\mu g/m^3$ in the sample was calculated as follows :

$$C\ (SO_2\ \mu g/m^3) = \frac{(A - Ao) \times 10^3 \times B}{V}$$

Where, A = Sample absorbance

Ao = Reagent blank absorbance

10^3 = Conversion litres to cubic meters

B = Calibration factor, µg / absorbance

V = Volume of air sampled in liters

4.1.5. Estimation of Carbon Monoxide

Carbon Monoxide (CO) in air was determined by using **Lutron Digital Meter**

Calculation:

No calculation is necessary. CO concentration in mg /m^3 are converted to ppm as follows :

$$CO \ ppm = CO \ mg/m^3 \times 0.873 \ at \ 25^oC \ and \ 760 \ mm \ Hg$$

4.2 Analysing the Physical Properties of Soil

The physical properties of the soil were analysed by the following methods:

4.2.1. Soil Moisture Content (Hot Air Oven method)

The soil moisture content was calculated by using the method given by **Anderson and Ingram (1993).**

10g of freshly collected soil sample were kept in a hot air oven at 105°C for 24 hours and the oven-dried soil are weighed again. For each sample three replicates were maintained.

Calculation:

The percentage of the soil moisture content is calculated by the following formula:

$$\text{Moisture content (\%)} = \frac{W_1 - W_2}{W_2} \times 100$$

Where, W_1 = Initial weight of soil

W_2 = Final weight of soil

4.2.2. Soil pH

Soil pH was estimated by using pH meter.

10g of freshly collected soil sample were taken in a beaker containing 50 ml of distilled water. The soil water mixtures were stirred for 20 minutes on a magnetic stirrer. The solutions were left overnight and the pH readings were taken with the help of pH meter.

4.2.3. Soil Bulk Density and Total Porosity

The bulk density and total porosity was estimated by the method given by **Anderson and Ingram (1993).**

With the help of a hollow cylinder, the known volume of soil was collected in a polythene bag by hammering the core of known volume in the soil. After reaching the laboratory, the collected soils were put on the petriplates separately and kept in the oven at 105°C for about 24-48 hours. Then the weight of the dry soil is taken and recorded.

Calculations:

The bulk density was calculated using the formula

$$\text{Bulk density } (g/cm^3) = \text{Mass/Volume}$$

$$= \frac{\text{weight of oven dried soil (g)}}{\text{Volume of soil corer}(cm^3)}$$

Where, volume of the corer = $\pi r^2 h$ (π=3.14; r =the radius of the corer; h =the height of the corer).

$$\text{Porosity } (\%) = \frac{S-D}{S} \times 100$$

Where, S = Particle density

D = Bulk density

4.2.4. Soil Water Holding Capacity

The soil water holding capacity was calculated by using the method outlined by **Anderson and Ingram (1993**).

A filter paper was placed in a container box of an appropriate dimension so as to cover the whole perforated bottom. The weight of the container plus the filter paper is then taken. The crushed soil sample dried in an oven at 105^{o}C was placed inside the perforated bottom of the container box and weighed. The box containing soil was placed in a petridish of 10cm diameter containing water and was kept overnight to allow the water to enter the box and saturates the soil. The soil box was taken out from the water the next day, was whipped off excess water and the weight was recorded.

Calculations:

The water holding capacity was calculated using the following formula.

A. Mass of dry soil = (weight of container + filter paper + dry soil) – (weight of container + filter paper).

B. Mass of saturated soil = (weight of container + filter paper + saturated soil) - (weight of container + filter paper).

C. Mass of water contained in saturated soil = Mass of saturated soil – mass of dry soil.

Water holding capacity (%) = C/B x 100

4.3 Analysing the Chemical Properties of Soil

The chemical properties of the soil were analysed by the following methods:

4.3.1 Soil Organic Carbon Content

The soil organic carbon was determined by **Walkey and Black Method (1934).**

The oven dried soil is ground completely, passed to 0.2mm sieve (80-mesh) and 0.5g soil sample is placed at the bottom of dry 500ml conical flask. 10 ml of 1N potassium dichromate was added in the conical flask and the flask is swirled gently to disperse the soil in the dichromate solution. The flask is kept on asbestos sheet. 20ml of conc. Sulphuric acid was carefully added from a measuring cylinder and was swirled 2-3 times. The flask was allowed to stand for 30 minutes. 20 ml of distilled water and 10 ml of ortho-phosphoric acid is added to get a sharper end point of titration. After the addition of 1 ml diphenylamine indicator, the content is titrated with ferrous ammonium sulphate solution till the colour flashes from blue violet to green. Simultaneously, a blank is run without soil.

Calculation:

Organic carbon content and organic matter was calculated using the following formula:

(a) Organic carbon content (%) = $\frac{10(B-T)}{B} \times 0.003 \times \frac{100}{S}$

Where, B = volume of ferrous ammonium sulphate for blank titration in ml.

T = volume of ferrous ammonium sulphate for soil sample in ml

S = weight of soil sample.

(b) Organic matter (%) = % organic carbon x 1.724

4.3.2 Soil Total Nitrogen Content

The soil total nitrogen content of the soil sample was determined by **Kjeldhal Digestion Method** (Anderson and Ingram, 1993).

Procedure:

Digestion – 5g of soil sample is weighed and transfer to the digestion tube. 10-15 ml of conc. Sulphuric acid (H_2SO_4) and 5-7g of catalyst mixture is added to the soil sample. The digestion tubes are loaded into the Digester and the digestion block is heated to410oC till the sample colour turns colourless or light green colour.

Distillation – The main AC power and the rear side green colour of the distillation unit is switched on. The distillation water tap is kept in ON condition. The power is switched on control panel. The Digestion Tube Large (DTL) is taken with digested sample. The DTL is well-shaken after the addition of 10ml distilled water and is loaded in the Distillation Unit using the slider mechanism. 25ml of 40% Boric acid plus 3 drops of Methyl Red and 3 drops of Bromocresol green is taken in a 250ml conical flask and is kept in the Receiver end of the machine.

40ml of 40% NaOH is added by using the control panel. The timer is set at 20 sec. on the upper button. After the distillation process is over, the Boric acid turned colourless. After the READY signal glows, the tap water inlet is opened for condensation. The required process time is set at 6 minutes for distillation on the lower button. The run key is pressed at the lower button. After the process time is over, steam was automatically cut off and the condensation tap water inlet was closed. The conical flask containing boric acid was taken out from the receiver end and the sample was ready for titration.

Titration – The solution of boric acid was titrated against 0.1N HCl. Or 0.1N H_2SO_4 until the boric acid turned pink. The burette reading was taken.

Calculation:

The calculation for the percentage of total nitrogen in the sample was calculated using the formula-

$$\text{Total nitrogen (\%)} = \frac{14\text{x normality of acid x titrant value x } 100}{\text{Sample weight x } 1000}$$

4.3.3 Available Phosphorus

The available phosphorus was estimated by **Olsen's Method (1965)**.

Procedure:

Preparation of extractant – 2.5g of soil and 50 ml of extracting solution ($NaHCO_3$) were added in a 250ml conical flask. The flask was shaken for 30 minutes with a suitable shaker. The suspension was filtered through Whatman filter paper No. 40. Activated carbon (free of phosphorus) was added to obtain a clear filtrate. Again the flask was shaken immediately before pouring the suspension into the funnel.

Colour development – 5ml of extract was taken into a 25ml volumetric flask, to which 5ml of Dickman's and Bray's was added drop by drop with constant shaking till the effervescence due to CO_2 evolution ceases. The neck of the flask was washed down and the contents were diluted to about 22ml /9acidification to be checked, pH 5.0; if less acidify with 5N H_2SO_4 to pH 5.0). Then 1ml of dilute $SnCl_2$ was added and the volume was made upto the mark. The colour was stable for 24 hours and maximum intensity was obtained in 10 minutes at 660nm ($SnCl_2$: 2.5g in 100ml glycerol heat in water bath for mixture).

Preparation of Standard Curve – For preparation of standard curve different concentration of phosphorus (1, 2, 3, 4, 5 and 10ml of 2ppm of phosphorus solution) were taken in 25ml volumetric flask. The standard concentration of phosphorus was prepared in the range of 0.08µg/ml to 80µg/ml with the help of Spectrometer at 660nm.

The curve was plotted taking the colorimeter reading on the vertical axis and the amount of phosphorus (in µgP/ml) in the horizontal axis.

Calculation:

$$\text{Olsen's phosphorus (kg/ha)} = R \times V/v \times 1/S \times (2.24 \times 10^6)/10^6$$

$$= R \times (50/5) \times (1/2.5) \times 2.24$$

$$= \mu g\ P \times 8.96$$

Where, V = total volume of extractant (50 ml)

v = volume of aliquot taken for analysis (5 ml)

S = weight of soil (2.5 g)

R = weight of P in the aliquot in μg (from standard curve)

4.3.4 Exchangeable Potassium

The soil exchangeable potassium was determined by flamephotometry (Maiti, 2004).

Extraction - 5g of soil was shaken with 25ml of neutral normal ammonium acetate solution (soil extract = 1:5) for 5 minutes and was filtered immediately through a dry filter paper (Whatman filter paper No. 1). The first few drops of the filtrate were rejected. The potassium concentration was determined in the extract by flame photometer by using K – filter.

Preparation of Standard Curve – 10 to 60 ppm potassium solutions was prepared from the stock solution by adding ammonium acetate solution. After attaching the appropriate filter, gas and air pressure in the flame photometer were also adjusted. The reading was adjusted to zero for the blank in the flame photometer. The readings at the different concentrations for K solution were noted. The flame photometer readings were then plotted against the different concentrations of K.

Calculation:

(1) Available potassium (mg of K/g of soil)

$$= \frac{A \times V}{W \times 100}$$

(2) Available K (Kg/ha)

$$= \frac{R \times V}{W} \times \frac{224 \times 10^6}{10^6}$$

= ppm of K x 11.2

Where, A = K content of soil extract from standard curve, mg/L

V = Volume of the soil extract, ml

W = Weight of air dry sample taken for extraction in g (5g)

R = ppm of K in the extract 7(obtained from the standard curve)

= ppm of K x 11.2

K meq/L = K mg/L x 0.02558

K mg/L = K meq/L

4.4 Socio-Economic Study:

The socio-economic condition and the health status study was done in the village communities in the study area by employing the methods of Participatory Rural Appraisal (PRA). The methodology involves in PRA are interacting with villagers, understanding them and learning from them. Because of its participatory nature, it is an useful methodology to focus attention on people, their livelihoods and their interrelationships with socio-economic and ecological factors (Mukherjee, 1993). Information were gathered through personal and group interviewing with the local villagers, the village council members, the YMA office bearers, the health workers and nurses, government employees of Hmunpui, Lengpui and Sihhmui village.

Table 4.1: Demographic and Occupation Data

Name of the village	No. of house hold	Population			BPL Family	Occupation					
		Male	Female	Total		Cultivators	Piggery	Poultry	Industry	Govt.	Business
Hmunpui	240	521	437	958	160	235	-	-	-	31	5
Lengpui	945	1914	1892	3798	172	150	10	10	8	132	113
Sairang	1051	2895	2653	5548	130	400	-	-	-	38	60

Table 4.2: Educational and Local Institutional level

Name of the Village	Educational Level				Local Institutional level					
					H/S		M/S		P/S	
	P.G.	Graduate	10+2	Std-X		Teachers/ Students		Teachers/ Students		Teachers/ Students
Hmunpui	5	26	25	80	1	8/39	1	3/115	2	3/100 2/204

Lengpui	15	102	350	900	1	8/90	2	9/122 9/73	3	4/64 4/70 4/104
Sairang	2	50	380	950	4	8/164 6/118 8/133 8/175	4	6/36 6/104 3/29 4/70	4	4/119 2/42 4/141 4/84

Table 4.3: Standard of living and Social Welfare Services

Name of the Village	Houses electrified	Houses with LPG	Houses with Chullah	Tin roof building	RCC building	Public Water point	Road Communication
Hmunpui	140	160	10	229	1	8	Fair weather jeepable
Lengpui	837	812	32	776	106	32	All weather
Sairang	850	600	2	700	110	10	All weather

Chapter- V

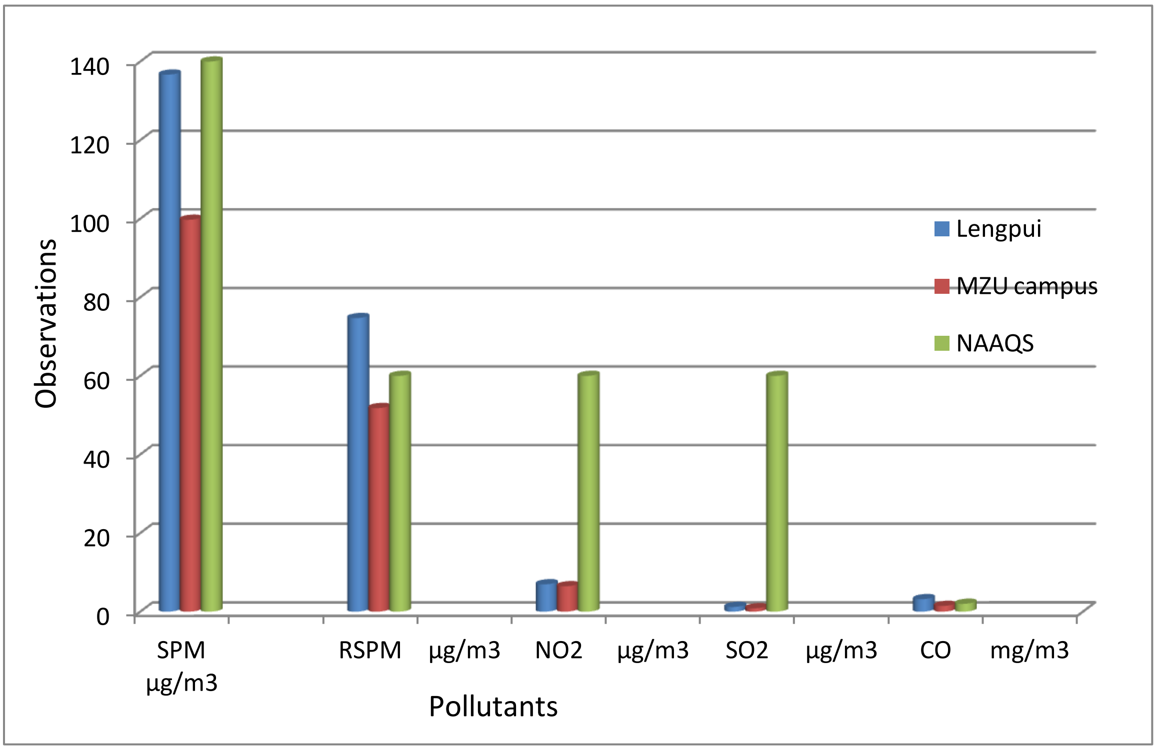
5. RESULTS AND DISCUSSION

5.1 Effect of jhum on Air quality- The average concentration of gases and particulates are weighted against the National Ambient Air Quality Standards (NAAQS) laid down by Central Pollution Control Board. The average concentration of the estimated particulate and gases is given below :

Table 5.1: The average concentration of various air pollutants at Lengpui airport and MZU Campus.

Pollutants	Station				NAAQS
	Lengpui		MZU campus		Residential, rural & other areas
	Mean	SE ±	Mean	SE ±	
SPM µg/m^3	136.68	19.388	99.735	4.423	140
RSPM µg/m^3	74.72	6.546	51.817	2.318	60
NO_2 µg/m^3	6.96	2.656	6.463	0.890	60
SO_2 µg/m^3	1.2	0.425	0.853	0.129	60
CO mg/m^3	3.17	0.5	1.456	0.232	2

Fig 5.1: Average concentration of various air pollutants at Lengpui airport and MZU Campus compared with NAAQS



The results reveal that the average concentration of Respirable Suspended Particulate Matter and Carbon monoxide is quite high, while Nitrogen dioxide and Sulphur dioxide are very low as compared with the National Ambient Air Quality Standards (NAAQS) in Lengpui. Suspended Particulate Matter, however, was at par with NAAQS guideline at Lengpui and is well within the permissible limits at MZU. These particulates and gas pollutant have proven pathological effects on human health; they also reduce visibility, and increase atmospheric turbidity besides these particulates are reported to have adverse effects on vegetation, animal, materials and buildings. A forest fire is reported to release maximum particulate matters which gets transported and diffuse within the atmosphere. The SPM having an average concentration of 136.68 µg/m^3 (SE± 19.388) in the present study at Lengpui is comparatively high even though they are within the permissible limits while the RSPM exceeds the standard limits with the average concentration of 74.72 µg/m^3 (SE± 6.546) as compared to

NAAQS standard of 60 µg/m^3. MZU Campus has a mean of 99.735µg/m^3 (SE± 4.423) SPM and 51.817µg/m^3 (SE± 2.318) RSPM. The pathological effects such as chronic bronchitis, bronchial asthma, emphysema and lung cancer are particularly associated with SPM. The size of the particles determines the site in the respiratory tract that they will deposit: PM_{10} particles deposit mainly in the upper respiratory tract while fine and ultra-fine particles are able to reach lung alveoli (Kampa and Castanas, 2008). RSPM (PM_{10}) can be inhaled through the upper respiratory airways, and deposited in the lungs thus causing serious respiratory problems and in the long term an increased likelihood of respiratory death. They get retained in the respiratory system causing chronic respiratory diseases, cardio-vascular damage, etc. Pollutants release in the form of gases like NO_2 and SO_2 having 6.96 µg/m^3 (SE± 2.656) and 1.20 µg/m^3 (SE± 0.425) respectively are detected at Lengpui which are well below the standards limits while CO have an average concentration of 3.17mg/m^3 (SE± 0.5) which is above the permissible limits of NAAQS. Whereas MZU Campus has a mean concentration of 6.463 µg/m^3 (SE± 0.890) for NO_2, while SO_2 and CO have an average concentration of 0.853 µg/m^3 (SE± 129) and 1.456 mg/m^3 (SE± 0.231). NO_2 causes inflammation of lung tissue and pulmonary edema, an accumulation of excessive fluid in the lungs. The main hazards of SO_2 on health are intense irritation, contribution to respiratory diseases and cardiac ailments. Significant relationships were found between this pollutant and bronchitis-like symptoms such as usual cough, sputum and breathlessness specifically in adults (Bentayeb et al., 2010). Sulphur dioxide is an irritant gas, particularly for breathing apparatus. CO combines with the oxygen carrying haemoglobin of the blood to form carboxyhemoglobin (COHb)**,** it displaces oxygen and causes symptoms including death from asphyxiation, or lack of oxygen to the bloodstream and therefore to the brain. Carbon monoxide produces symptoms such as mild headaches, nausea and shortness of breath. Thus, jhum burning can have a very serious impact on the society by deteriorating the health status of the local people. Air pollution directly influence every human activities and weather-sensitive economic sectors such as land, marine ecosystems, banking and insurance, health, food security, agriculture, water resources management, communication, tourism and recreation activities. There is a problem of flight scheduling and cancelling because of the smog caused by slash burning, specifically around the airport every year due to jhum burning. The variation in different air pollutants may be attributed to the quality and quantity of vegetation burned in that area.

Table 5.2: Data/ Records on SPM, RSPM, NO_2, SO_2 and CO of Lengpui and MZU, 2010

Pollutant	Sites	Date					Mean
		25/2/'10	4/3/'10	11/3/'10	18/3/'10	25/3/'10	
SPM	Lengpui	136.37	132.58	132.58	227.28	151.52	156.07

μg/m^3	MZU	95	98	104	113	74	96.8
RSPM	Lengpui	56.82	37.88	75.76	94.7	75.76	68.18
μg/m^3	MZU	45	48	62	43	56	50.8
NO_2	Lengpui	6.3	7.7	14.4	16.2	3.5	9.62
μg/m^3	MZU	5.6	11.9	9.3	8.4	9.1	8.86
SO_2	Lengpui	0.5	0.3	0.8	1.6	0.7	0.78
μg/m^3	MZU	0.37	1.2	0.7	0.16	0.8	0.646
CO	Lengpui	4.583	3.436	4.583	4.583	1.146	3.67
mg/m^3	MZU	0.95	1.2	0.7	1.4	1.1	1.07
Temperature / Weather		30.2^{o}C /clear	31.4^{o}C /clear	30.8^{o}C /sunny	32.1^{o}C /sunny	28.8^{o}C /clear	

Table5.3: Data/ Records on SPM, RSPM, NO_2, SO_2 and CO of Lengpui and MZU Campus, 2011

Pollutant	Sites	Date						Mean
		24/2	3/3	10/3	17/3	24/3	31/3	
SPM	Lengpui	92.3	105.9	108.3	127.8	117.1	152.6	117.3

µg/m^3	MZU	84	98	117	104	124	89	102.67
RSPM µg/m^3	Lengpui	59.6	69.5	80.4	89.5	80.4	108.2	81.27
	MZU	42	53	66	52	48	56	52.8333
NO_2 µg/m^3	Lengpui	4.2	3.85	3.85	6.45	3.85	3.66	4.31
	MZU	2.7	4.2	4.5	4.1	3.5	5.4	4.06667
SO_2 µg/m^3	Lengpui	2.1	1.6	1.3	0.8	1.45	2.55	1.63
	MZU	0.4	0.6	1.6	0.8	1.1	1.2	1.06
CO mg/m^3	Lengpui	3.436	4.582	1.146	4.582	1.146	1.146	2.67
	MZU	0.852	1.205	1.116	2.228	2.911	2.74	1.842
Temperature / Weather		34.9^{o}C /Sunny	37.4^{o}C /Sunny	36.5^{o}C/ Sunny	34.4^{o}C /Sunny	37.4^{o}C/ Sunny	34.3^{o}C/ Cloudy	

5.2 Effect of jhum on soil parameters- The result of the physico- chemical analysis of pre- jhum and post-jhum soil shows that - physically the impacts of fire on soil include breakdown in soil structure, reduced moisture retention and capacity, and development of water repellency, all of which increase susceptibility to erosion.

Chemically, fire-impacted soils experience changes in nutrient pools cycling rates, loss of elements to the atmosphere, and loss of organic matter. One of the most important impacts on soils results from the combustion of organic matter. Campbell et al. (1977) found that moderately burned areas maintained 38 percent of the vegetative and litter cover, while severely burned areas had none to 23 percent retention. Soil structure degradation can persist for a year to decades after a fire and is often responsible for reduced infiltration and increased runoff. Horizons not subjected to thermal shock can retain most of the elements leached from above (Soto and Diaz-Fierros,1993).

5.2.1. Soil Moisture Content- The data on the tables shows that pre-jhum soil moisture content are higher than post-jhum in all the three years, except Tanhril, the area unaffected by jhum. Tanhril has recorded an increased in the soil moisture content in post-jhum. Sihhmui has the highest content of soil moisture as compared to the other study sites in all the three years. Reductions in soil moisture occur when increased soil temperatures decrease water viscosity, thus allowing more water to percolate through the soil profile. In addition, reduced shade, combined with increased soil temperatures, also results in higher evaporation rates, which in turn, restricts the movement of water into the soil profile. The impact of fire on soil moisture is important, since it facilitates both seed germination and plant development.

Table5.4 (a): Soil Moisture Content (%)

2009				
Study sites	Pre-Jhum	Post-Jhum	Change	Change%

Hmunpui	16.9	12.23	4.67	16.631
Lengpui	18.2	13.2	5	17.806
Sihhmui	23.6	20.19	3.41	12.144
Sairang	22.25	13.51	8.74	31.125
Tanhril	23.04	29.3	-6.26	-22.293

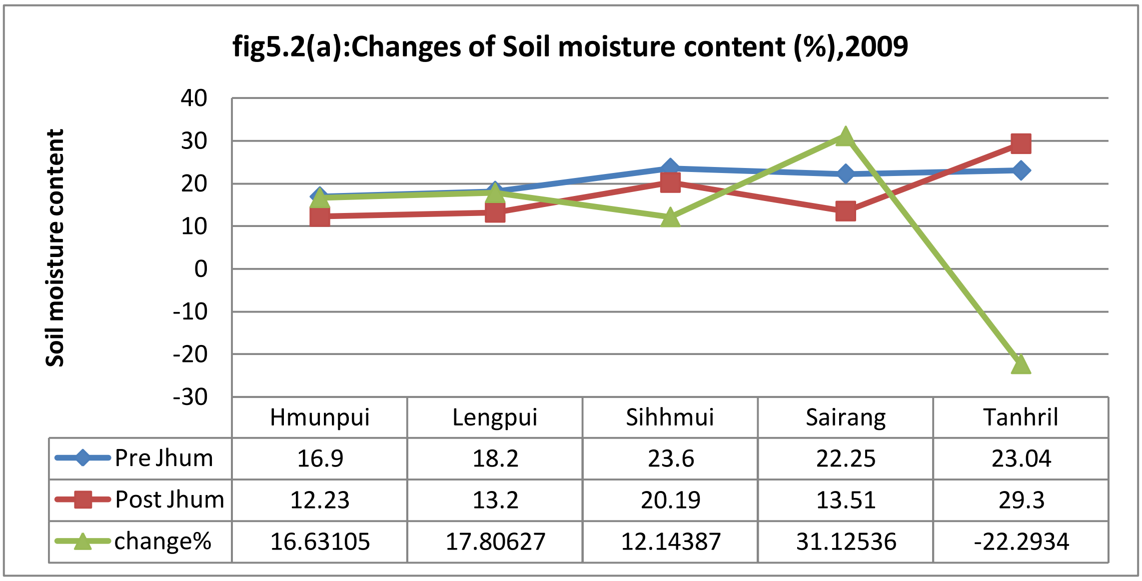


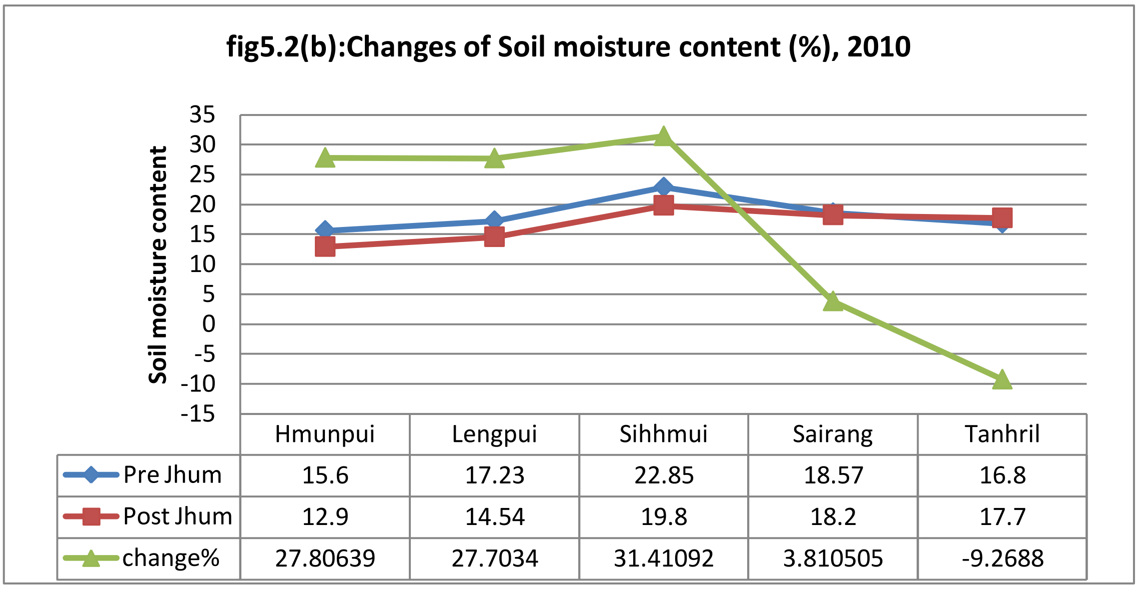
fig5.2(a):Changes of Soil moisture content (%),2009

The data and figure of the soil moisture content in 2009 shows that, the pre-jhum soil moisture content is highest in Sihhmui having 23.6% and the lowest in Hmunpui with 16.9%. The post jhum soil mositure content is also the higheat in sihhmui (20.19%) and lowest in Hmunpui (12.23%). The changes (%increase or decrease) of soil moisture content at Hmunpui, Lengpui, Sihhmui and Sairang are 4.67%, 5%, 3.41% and 8.74% respectively. The changes of soil moisture content at Tanhril having a negative value, i.e. -6.26%, is due to the area not being affected by jhum.

Table5.4 (b): Soil Moisture Content (%)

2010

Study sites	Pre-Jhum	Post- Jhum	Change	Change%
Hmunpui	15.6	12.9	2.7	27.806
Lengpui	17.23	14.54	2.69	27.703
Sihhmui	22.85	19.8	3.05	31.411
Sairang	18.57	18.2	0.37	3.811
Tanhril	16.8	17.7	-0.9	-9.269



	Hmunpui	Lengpui	Sihhmui	Sairang	Tanhril
Pre Jhum	15.6	17.23	22.85	18.57	16.8
Post Jhum	12.9	14.54	19.8	18.2	17.7
change%	27.80639	27.7034	31.41092	3.810505	-9.2688

In 2010, Sihhmui has the highest soil moisture content (22.85% & 19.8%) and Hmunpui has the lowest having 15.6% and 12.9% respectively, in pre-jhum and post jhum. However, the change percentage is lowest in Sairang having 0.37% and highest decrease in Sihhmui with 3.05% . Tanhril on the other hand has an increase of moisture content in post-jhum and gave a negative value of 0.9%.

Table5.4(c): Soil Moisture Content (%)

2011

Study sites	Pre-Jhum	Post-Jhum	Change	Change%
Hmunpui	10.9	10.1	0.8	21.333
Lengpui	14.9	14.2	0.7	18.667
Sihhmui	19.2	18.3	0.9	24
Sairang	11.7	10.8	0.9	24
Tanhril	13.85	14.3	-0.45	-12

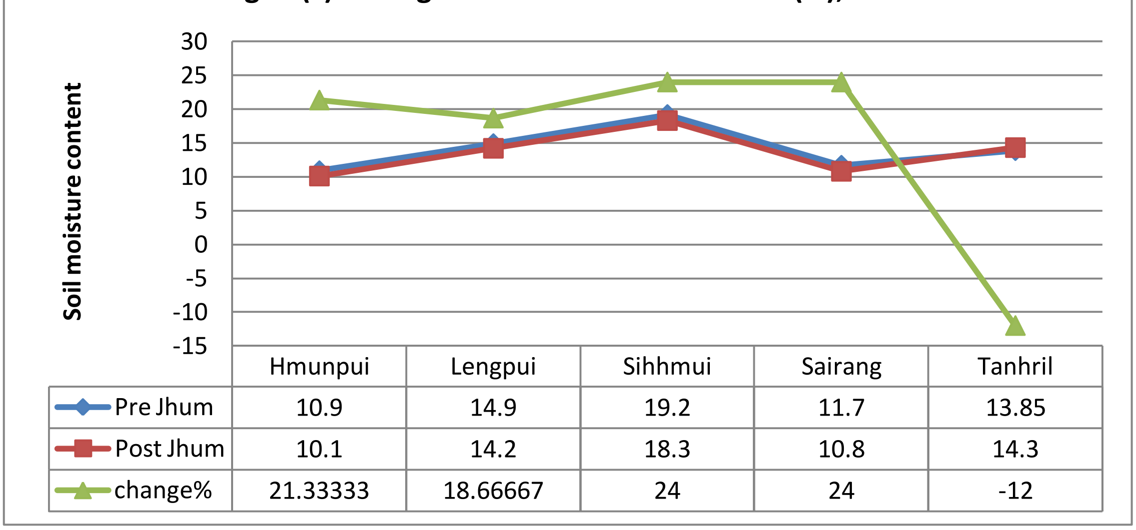


fig5.2(c): Changes of Soil moisture content (%), 2011

Again in 2011, the highest moisture content was observed in pre-jhum and post- jhum at Sihhmui(19.2% & 18.3%) study site and the lowest was observed in Hmunpui (10.9% & 10.1%). The percentage increase or decrease in moisture content are more or less similar in all study sites except Tanhril which has a value of -0.45%.

5.2.2 Soil pH- Soil pH is generally increased after forest fire (Aref et al., 2011; Boerner et al., 2009). The presence of ash may increase soil pH due to high pH of ash (Molina et al., 2007; Schafer and Mack, 2010).However significant increase occurs only at higher temperature (450-5000°C) (Certini, 2005). In the ash form they are subsequently leached into the soil where they exchange with H+ ions; the resulting increase in H+ ions in solution increases the pH. A higher pH typically increases the nutrient cycling of various elements critical for plant growth. Ash deposited after a fire is composed mostly of salts. If exchange sites are available, these salts can effectively increase soil pH by capturing the salt cations as they leach through the soil profile. Ulery et al.(1993) found that the topsoil pH could increase as much as three units immediately after burning; this rise was essentially due to the production of K and Na oxides, hydroxides, and carbonates, which did not persist through the wet season. From the data obtained during three years i.e., from 2009-2011, the overall pH analysed in 2009 was comparatively higher than the other two consecutive years. From the results given on the table, the soil analysed are mostly acidic in nature and shows an increase in post jhum.

Table 5.5(a): Soil pH

2009				
Study sites	Pre jhum	Post jhum	Change	Change%
Hmunpui	5.09	6.08	-0.99	-19.336
Lengpui	5.25	7.31	-2.06	-40.234
Sihhmui	6.95	7.2	-0.25	-4.883

Sairang	5.97	7.71	-1.74	-33.984
Tanhril	6.86	6.94	-0.08	-1.563

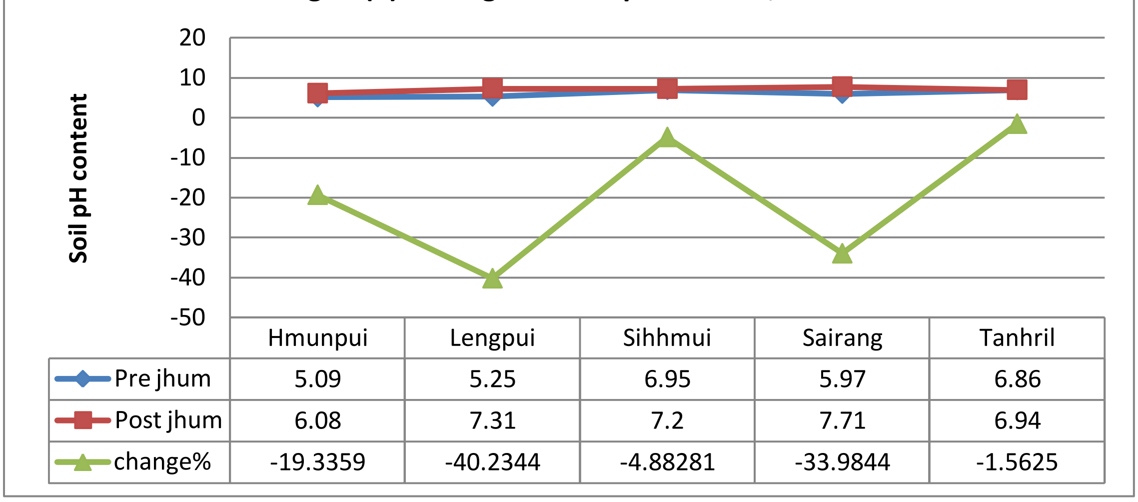


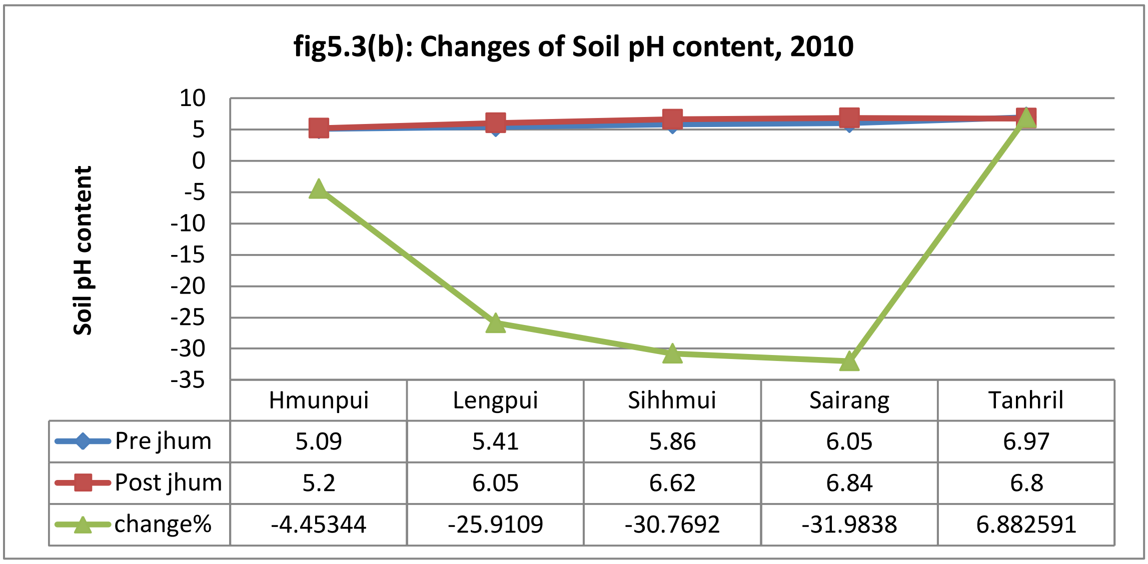
fig5.3(a): Changes of Soil pH content, 2009

In 2009, an increase of soil pH is observed in post jhum with the highest change in Lengpui which is -2.06. The pH value ranges from 7.71 (highest) at Sairang to 6.08 at Hmunpui which is the lowest compared to other sites.

Table 5.5(b): Soil pH

2010				
Study sites	Pre- jhum	Post- jhum	Change	Change%
Hmunpui	5.09	5.2	-0.11	-4.453
Lengpui	5.41	6.05	-0.64	-25.911
Sihhmui	5.86	6.62	-0.76	-30.769

Sairang	6.05	6.84	-0.79	-31.984
Tanhril	6.97	6.8	0.17	6.883

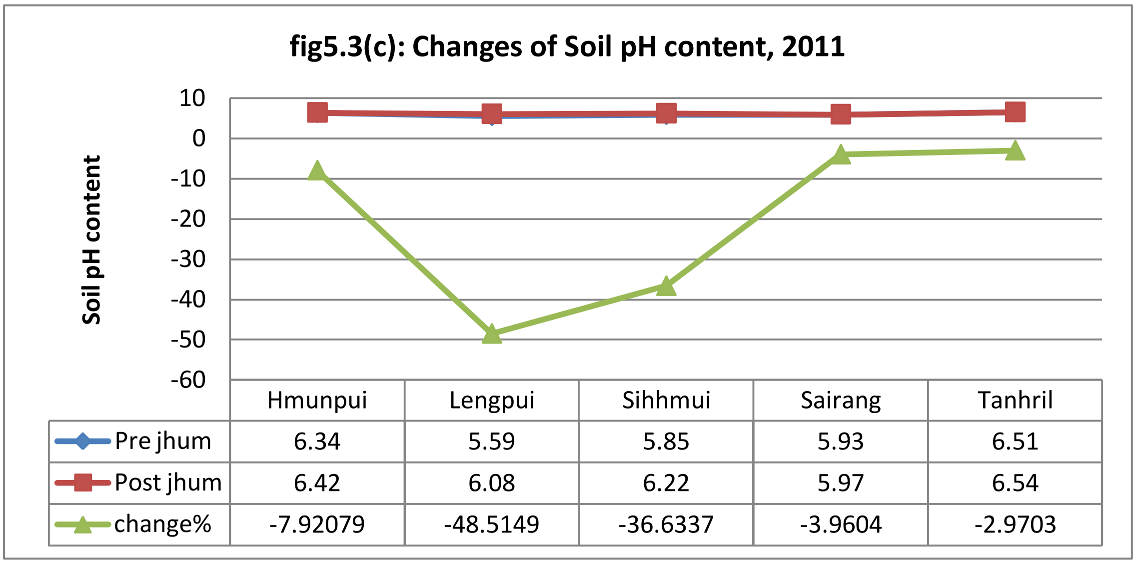


Sairang again has the highest pH with 6.84 (post jhum) in the year 2010 and the lowest value was observed in Hmunpui with 5.09. Tanhril (unaffected area) has shown a decrease of pH with a value of 0.17.

Table **5.5(c)**: Soil pH

2011				
Study sites	Pre -jhum	Post- jhum	Change	Change%
Hmunpui	6.34	6.42	-0.08	-7.921
Lengpui	5.59	6.08	-0.49	-48.515
Sihhmui	5.85	6.22	-0.37	-36.634

Sairang	5.93	5.97	-0.04	-3.960
Tanhril	6.51	6.54	-0.03	-2.970



In 2011, pH is highest in Tanhril (post jhum) which is 6.54 and lowest in Hmunpui which is 5.34. An increase of -0.03 was observed, the lowest change of pH value.

5.2.3. Bulk Density- Bulk density of forest soils increase significantly as a result of forest fire (Boerner, et al., 2009). It increases because of collapse of aggregates and clogging of voids by the ash and dispersed clay minerals; as a consequence, soil porosity and permeability decreases (Certini, 2005). Bulk density increases with ash depth (Cerdà and Doerr, 2008).

Table 5.6(a): Bulk Density (g/cm^3)

2009				
Study sites	Pre Jhum	Post jhum	Change	Change%
Hmunpui	1.08	1.19	-0.11	-7.639

Lengpui	1.02	1.2	-0.18	-12.5
Sihhmui	0.9	1.87	-0.97	-67.361
Sairang	1.26	1.36	-0.1	-6.944
Tanhril	0.88	0.8	0.08	5.556

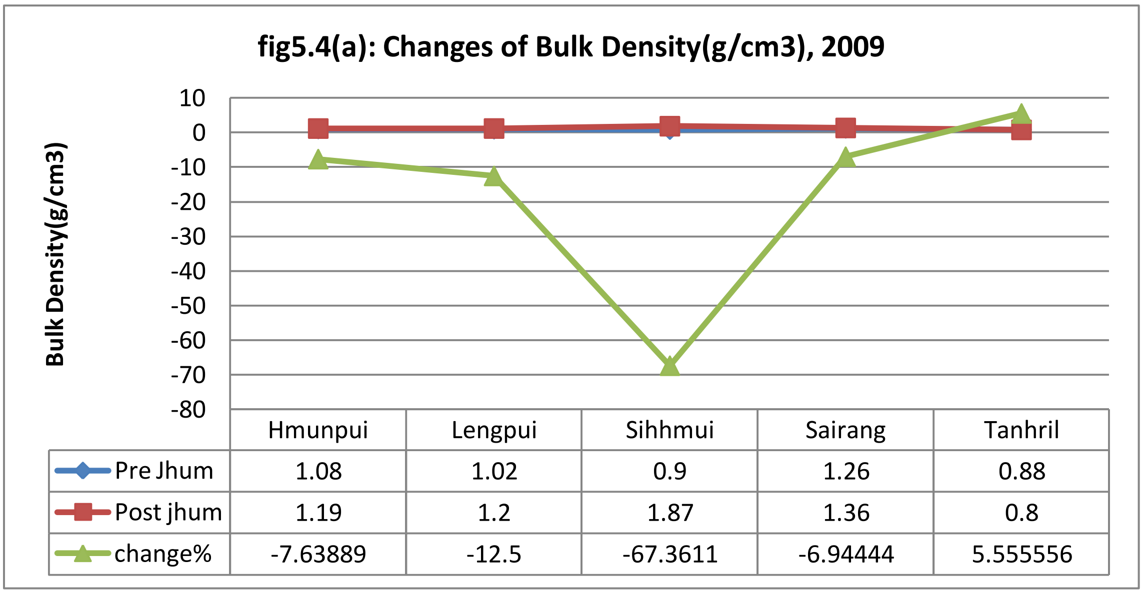


fig5.4(a): Changes of Bulk Density(g/cm3), 2009

The result showed that bulk density increases at post-jhum in all the four study sites whereas in Tanhril it decreases, which could be the area not being affected by jhum with little or no human interference. During three years, bulk density ranges from 0.61 to 1.26 g/cm^3 in pre jhum soil and in post jhum it ranges from 0.68 to 1.87 g/cm^3.

Table 5.6(b): Bulk Density (g/cm^3)

2010				
Study sites	Pre jhum	Post jhum	Change	Change%

Hmunpui	1.14	1.76	-0.62	-31.313
Lengpui	1.09	1.66	-0.57	-28.788
Sihhmui	1.2	1.75	-0.55	-27.778
Sairang	0.9	1.11	-0.21	-10.606
Tanhril	0.97	0.94	0.03	1.515

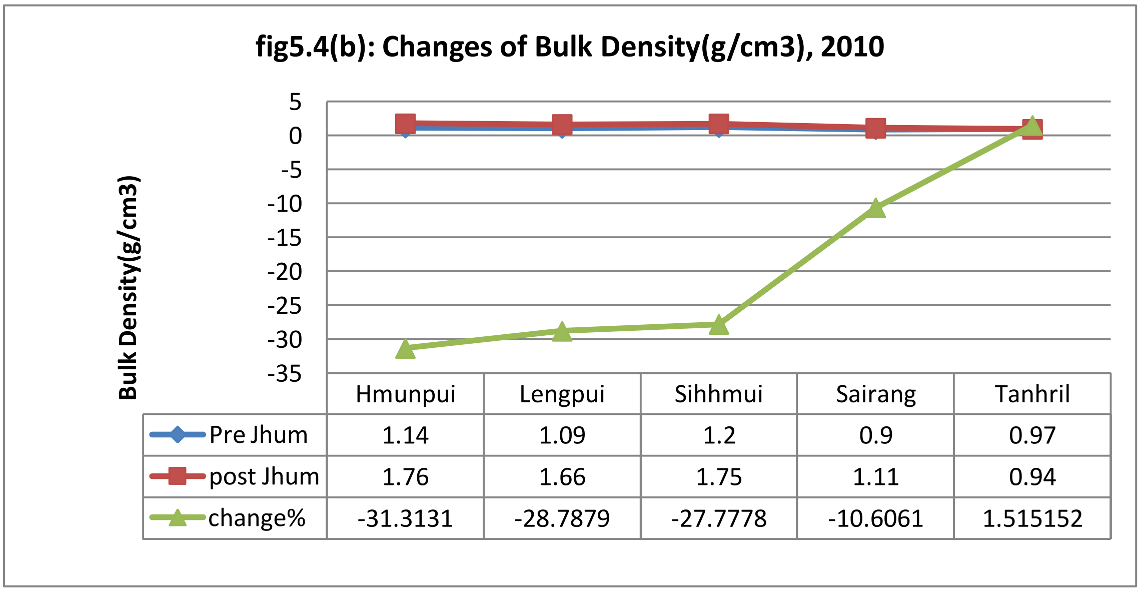


Table 5.6(c): Bulk Density (g/cm^3)

2011				
Study sites	Pre jhum	Post jhum	Change	Change%
Hmunpui	0.98	1.12	-0.14	-22.581
Lengpui	0.61	0.68	-0.07	-11.290
Sihhmui	0.75	0.97	-0.22	-35.484

Sairang	1.04	1.15	-0.11	-17.742
Tanhril	1.06	0.98	0.08	12.903

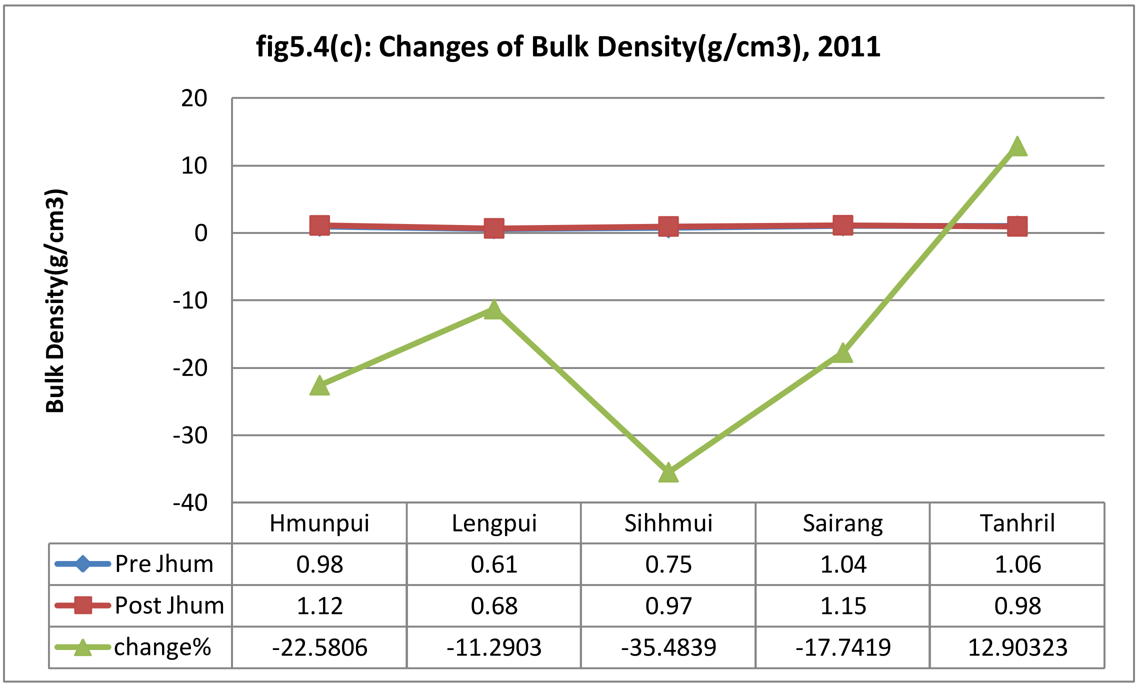


fig5.4(c): Changes of Bulk Density(g/cm3), 2011

5.2.4. Soil Porosity- The consequences of increased bulk density results in decrease in soil porosity in post jhum soil. The change in porosity from pre jhum to post jhum ranges from 3.02% at Sairang to as high as 23.4% in Hmunpui. Tanhril showed an increase in soil porosity in all the three years with -1.89%, -2.26% and -3.02% in 2009, 2010 and 2011 respectively.

Table 5.7(a): Soil Porosity (%)

2009

Study sites	Pre Jhum	Post Jhum	Change	Change%
Hmunpui	59.25	55.09	4.16	16.693
Lengpui	61.51	54.72	6.79	27.247
Sihhmui	66.04	56.98	9.06	36.356
Sairang	52.45	49.43	3.02	12.119
Tanhril	69.43	71.32	-1.89	-7.584

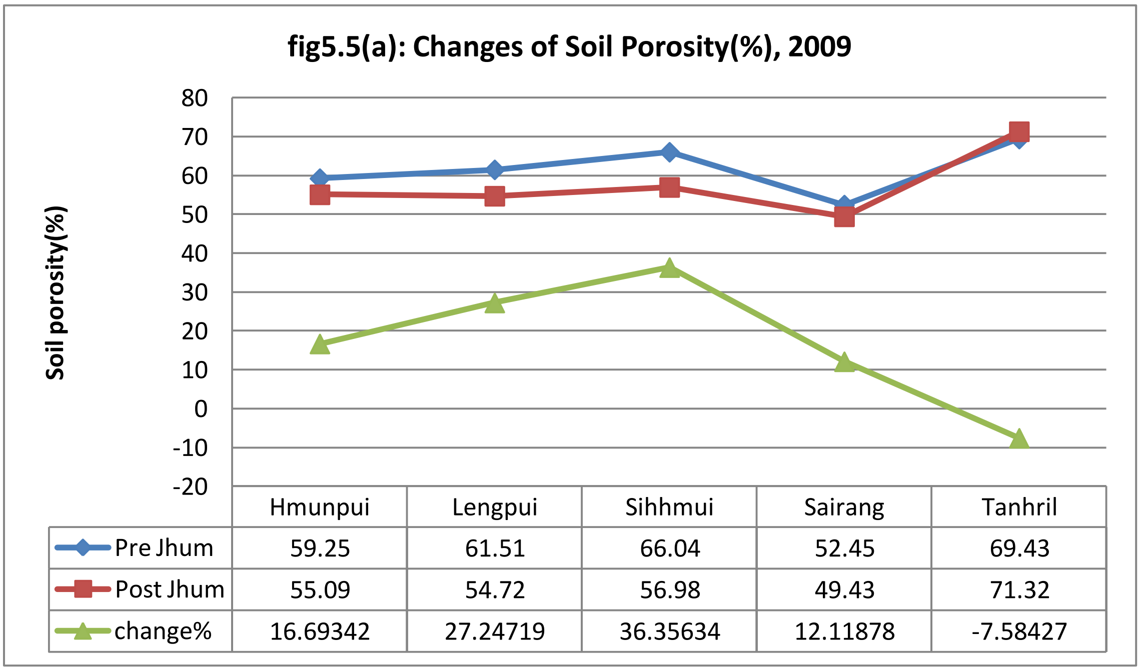


Table 5.7(b): Soil Porosity (%)

2010				
Study sites	Pre Jhum	Post Jhum	Change	Change%
Hmunpui	56.98	33.58	23.4	30.846
Lengpui	58.87	37.36	21.51	28.355
Sihhmui	54.72	33.96	20.76	27.366

Sairang	66.04	58.11	7.93	10.453
Tanhril	63.4	65.66	-2.26	-2.979

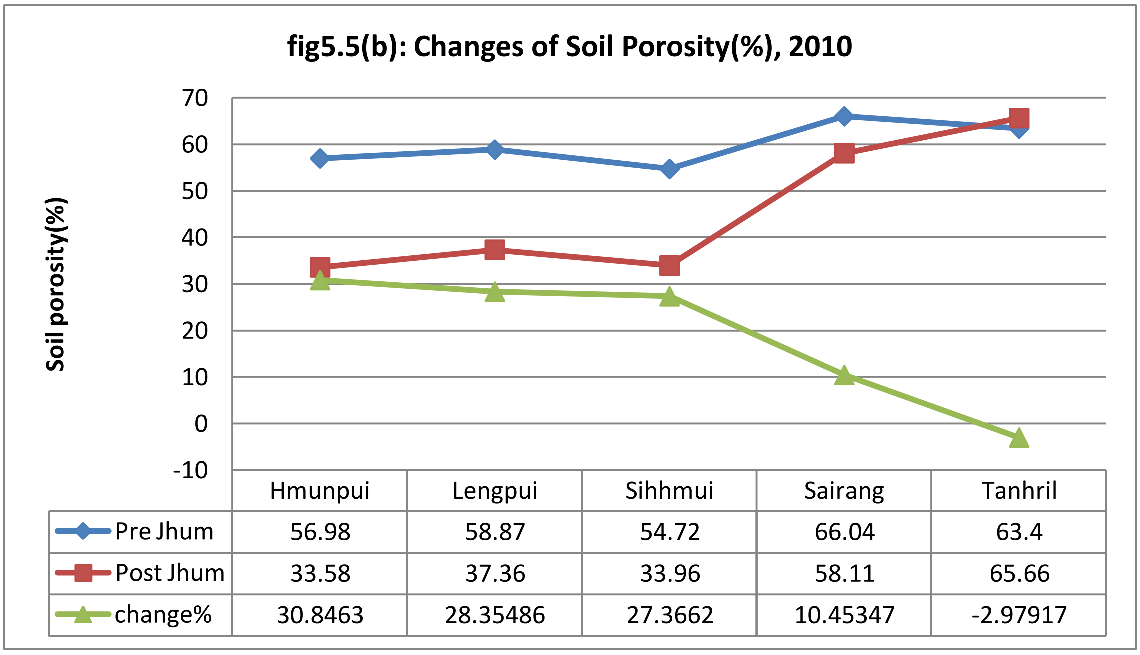
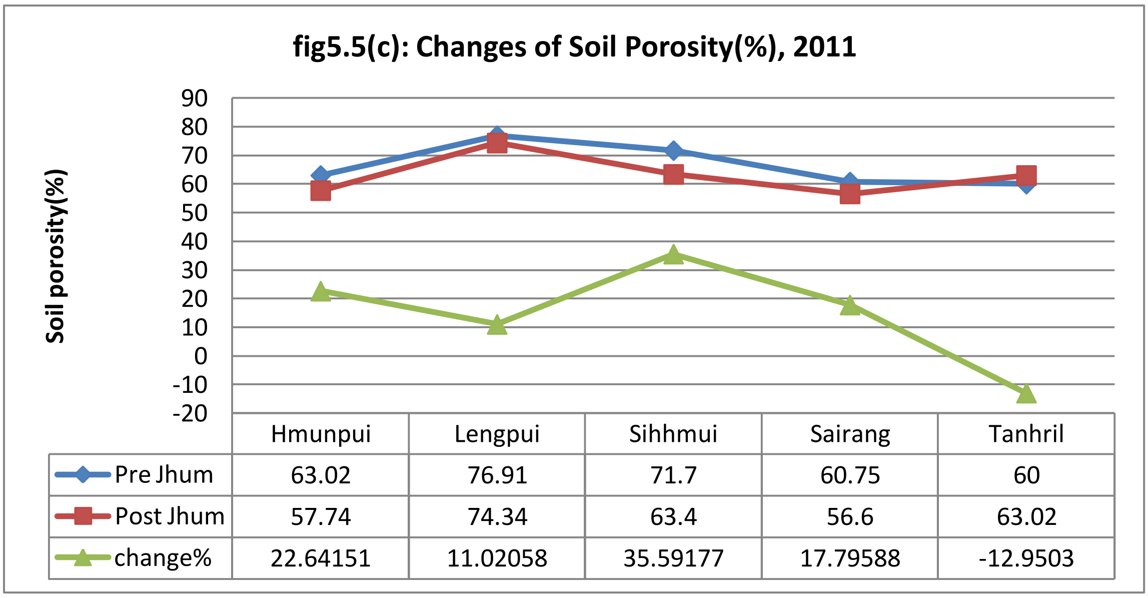


Table 5.7(c): Soil Porosity (%)

2011				
Study sites	Pre Jhum	Post Jhum	Change	Change%
Hmunpui	63.02	57.74	5.28	22.642
Lengpui	76.91	74.34	2.57	11.021

Sihhmui	71.7	63.4	8.3	35.592
Sairang	60.75	56.6	4.15	17.796
Tanhril	60	63.02	-3.02	-12.950



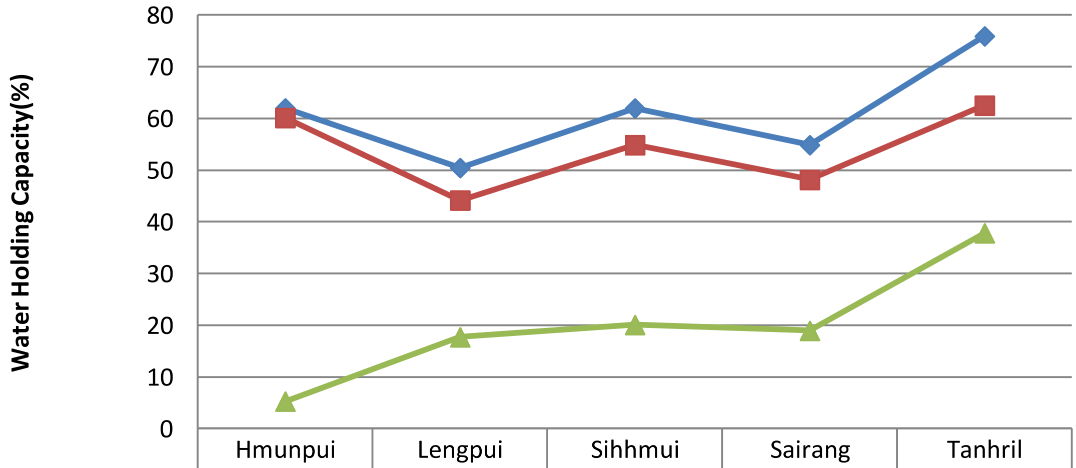
5.2.5. Water Holding Capacity- The result from the table shows that water holding capacity of soil decreases in post jhum in all the study sites. In pre jhum the highest recorded was 68.5% at Hmunpui in 2011 and lowest was found in Lengpui (2009) with 50.47%. Whereas in post jhum, 64.35% at Hmunpui (2010) was the highest at Lengpui (2009) having 44.19% is the lowest in the area affected by jhum. The unaffected area, Tanhril recorded a higher value during three years as compared to the affected area.

Table 5.8(a): Water Holding Capacity (%)

2009

Study sites	Pre -Jhum	Post-Jhum	Change	Change%
Hmunpui	62.02	60.14	1.88	5.311
Lengpui	50.47	44.19	6.28	17.740
Sihhmui	62.01	54.89	7.12	20.113
Sairang	54.89	48.17	6.72	18.983
Tanhril	75.94	62.54	13.4	37.853

fig5.6(a): Changes of Water Holding Capacity(%), 2009



	Hmunpui	Lengpui	Sihhmui	Sairang	Tanhril
Pre Jhum	62.02	50.47	62.01	54.89	75.94
Post Jhum	60.14	44.19	54.89	48.17	62.54
change%	5.310734	17.74011	20.11299	18.98305	37.85311

Table 5.8(b): Water Holding Capacity (%)

2010				
Study sites	Pre- Jhum	Post- Jhum	Change	Change%
Hmunpui	67.1	64.35	2.75	17.038

Lengpui	55.1	52.54	2.56	15.861
Sihhmui	54.1	49.17	4.93	30.545
Sairang	53.19	50.57	2.62	16.233
Tanhril	70.5	67.22	3.28	20.322

fig5.6(b): Changes of Water Holding Capacity(%), 2010

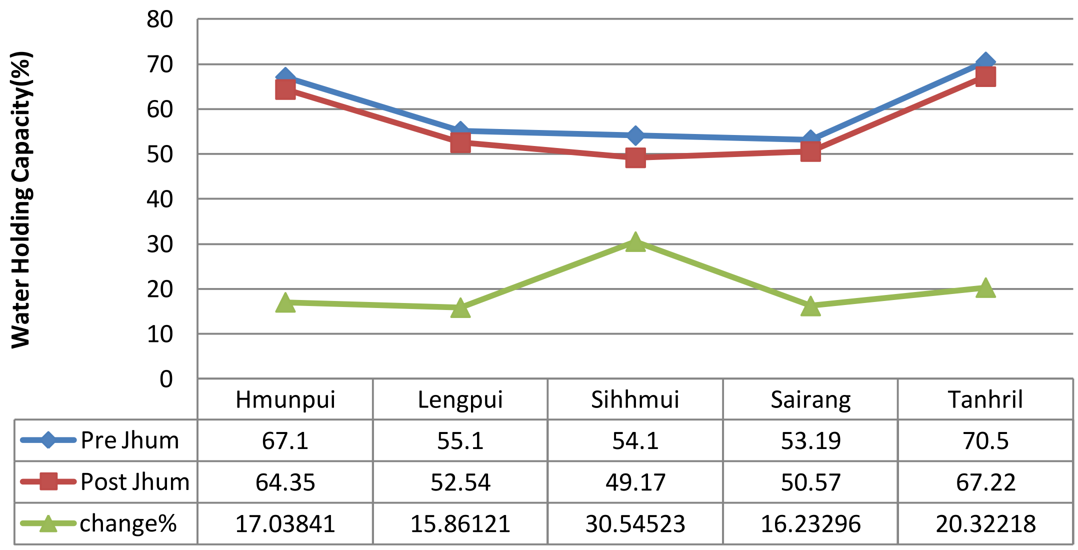
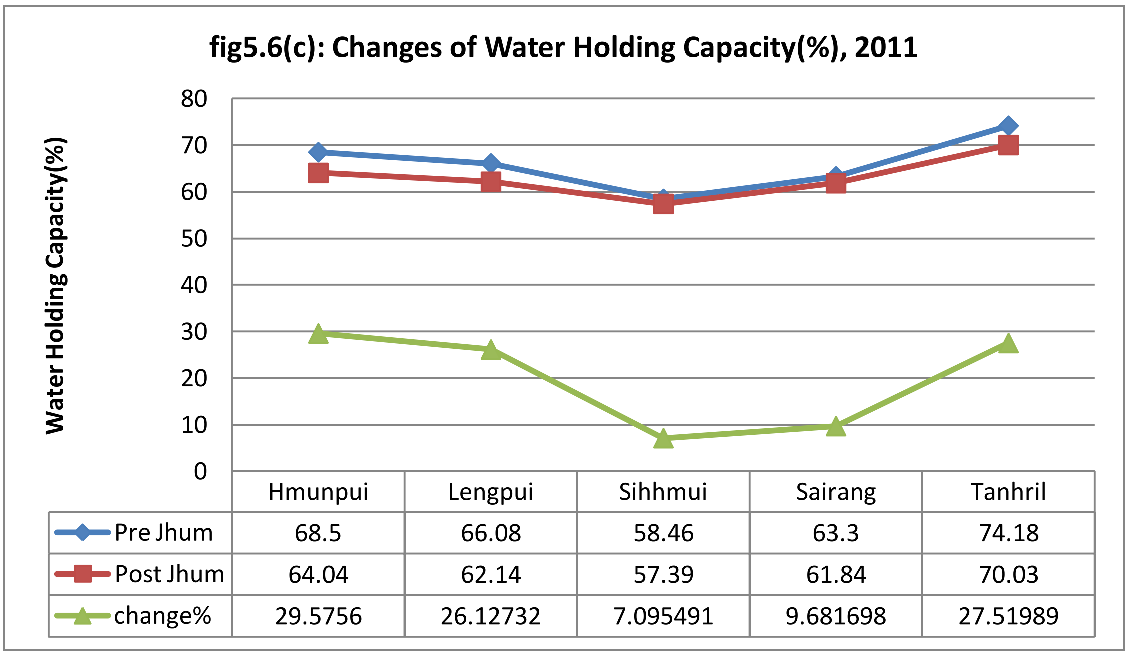


Table 5.8(c): Water Holding Capacity (%)

2011				
Study sites	Pre -Jhum	Post -Jhum	Change	Change%

Hmunpui	68.5	64.04	4.46	29.576
Lengpui	66.08	62.14	3.94	26.127
Sihhmui	58.46	57.39	1.07	7.095
Sairang	63.3	61.84	1.46	9.682
Tanhril	74.18	70.03	4.15	27.519



5.2.6. Soil Organic Matter and Organic Carbon- The effect of fire on SOM is highly dependent on the type and intensity of the fire, among other factors, soil moisture, soil type, and nature of the burned materials (Verma and Jayakumar, 2012).

The effect of fire on SOM is highly variable from total destruction of SOM to partially scorching depending on fire severity, dryness of the surface OM and fire type (Neary et al., 1999; Gonzalez-Perez et al., 2004). Greater accumulation of organic carbon in the surface layer is due to slow microbial decomposition of litter in acidic soils as reported by Nayak and Srivastava (1995) from humid sub-tropical soils under shifting cultivation in north east India. The result from the analysis shows the decrease of soil organic carbon and organic matter content in the four study sites whereas an increase in the unaffected area, Tanhril with a change of 5.787%. In pre jhum and post jhum, organic carbon was recorded lowest with 1.87% and 0.91% respectively in 2011 at Sihhmui; and the highest at Hmunpui (2010) with 3.33% and 2.88% in 2011. Similarly organic matter in pre jhum is the highest in Hmunpui (2010) with 5.74% and lowest in Sihhmui(2011) having 3.22%; whereas in post jhum, Hmunpui(2011) has the highest organic matter content with 4.97% and Sihhmui(2011) has the lowest OM content which is 1.57%. Organic matter acts as the primary reservoir for several nutrients and, therefore, is the source for most of the available phosphorus (P) and sulfur (S), and virtually all of the available nitrogen (N).

Table 5.9(a): Soil Organic Carbon Content

2009				
Study sites	Pre-Jhum	Post-Jhum	Change	Change%
Hmunpui	2.56	2.37	0.19	7.639

Lengpui	1.91	1.88	0.03	22.222
Sihhmui	1.98	1.72	0.26	10.417
Sairang	2.34	0.99	1.35	53.935
Tanhril	4.38	4.53	-0.15	-5.787

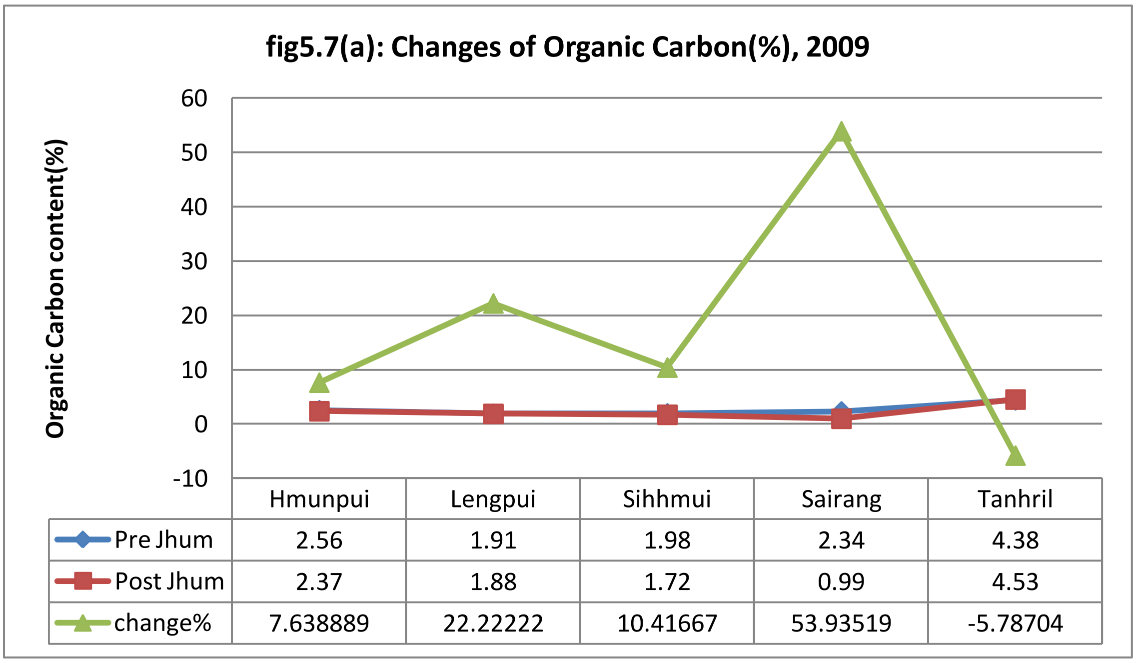


Table 5.9(b) : Soil organic matter content

2009

Study sites	Pre-Jhum	Post-Jhum	Change	Change%
Hmunpui	4.42	4.09	0.33	9.596
Lengpui	3.3	2.34	0.96	1.515
Sihhmui	3.42	2.97	0.45	13.131
Sairang	4.04	1.71	2.33	68.182
Tanhril	7.55	7.8	-0.25	-7.576

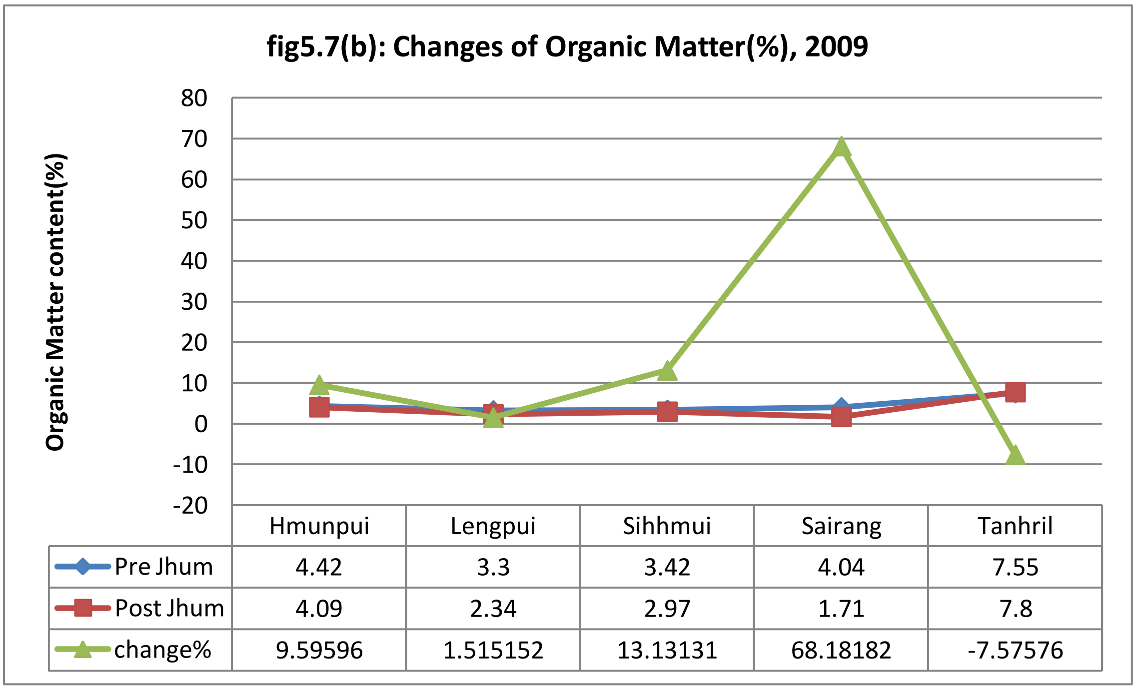


Table 5.9(c): Soil Organic Carbon Content

2010

Study sites	Pre-Jhum	Post-Jhum	Change	Change%
Hmunpui	3.33	2.32	1.01	34.314
Lengpui	2.85	2.79	0.06	2.157
Sihhmui	2.07	0.96	1.11	37.451
Sairang	2.52	2.46	0.06	1.961
Tanhril	3.42	4.14	-0.72	-24.118

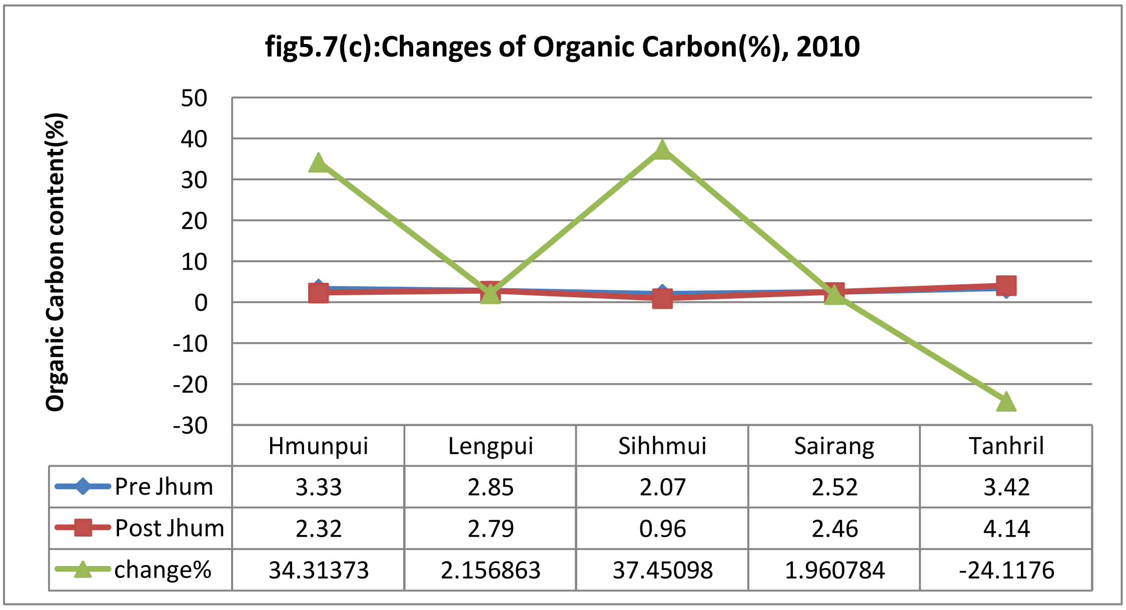


Table 5.9 (d):Soil Organic Matter Content

2010				
Study sites	Pre-Jhum	Post-Jhum	Change	Change%
Hmunpui	5.74	3.99	1.75	34.122
Lengpui	4.91	4.8	0.11	2.027
Sihhmui	3.57	1.66	1.91	37.5
Sairang	4.34	4.24	0.1	2.027
Tanhril	5.9	7.13	-1.23	-24.324

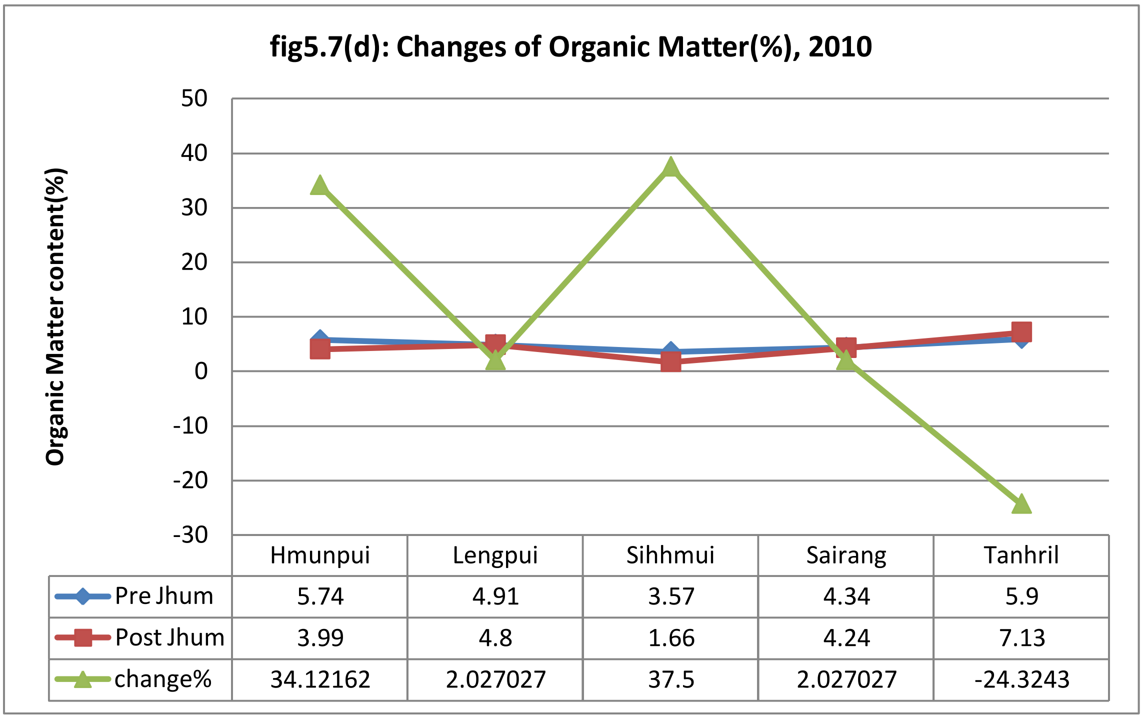


Table 5.9(e): Soil Organic Carbon Content

2011				
Study sites	Pre-Jhum	Post-Jhum	Change	Change%
Hmunpui	3.18	2.88	0.3	9.239
Lengpui	2.28	1.44	0.84	26.268
Sihhmui	1.87	0.91	0.96	29.891
Sairang	2.43	1.53	0.9	27.899
Tanhril	4.08	4.29	-0.21	-6.703

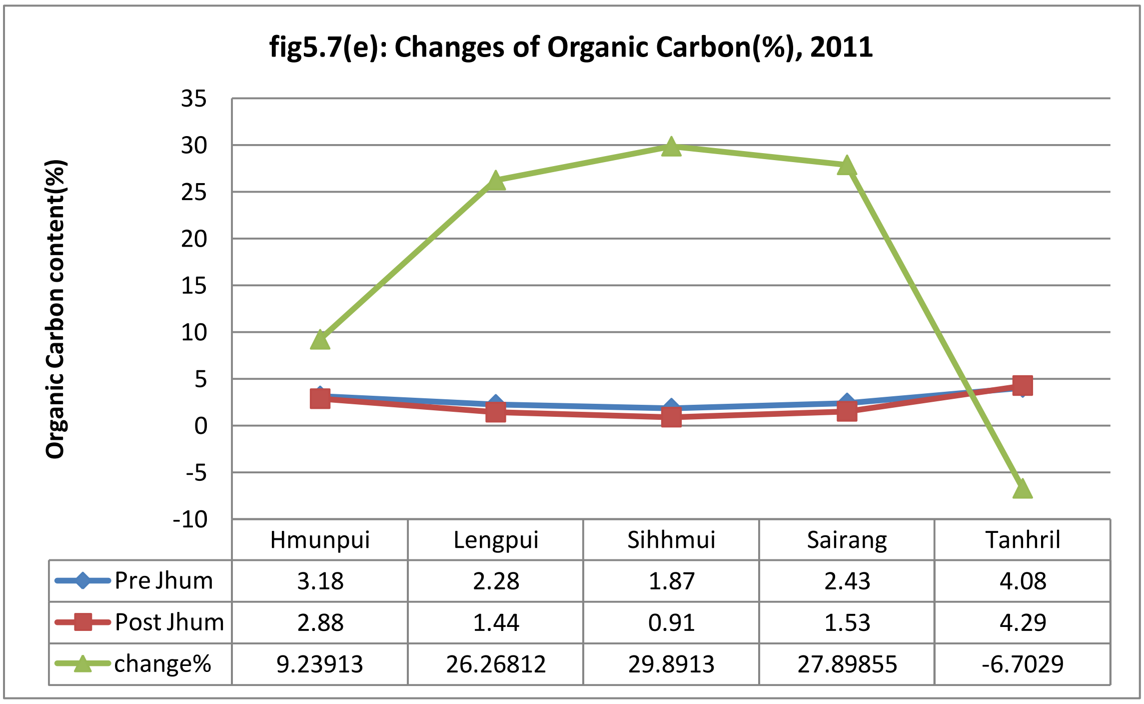
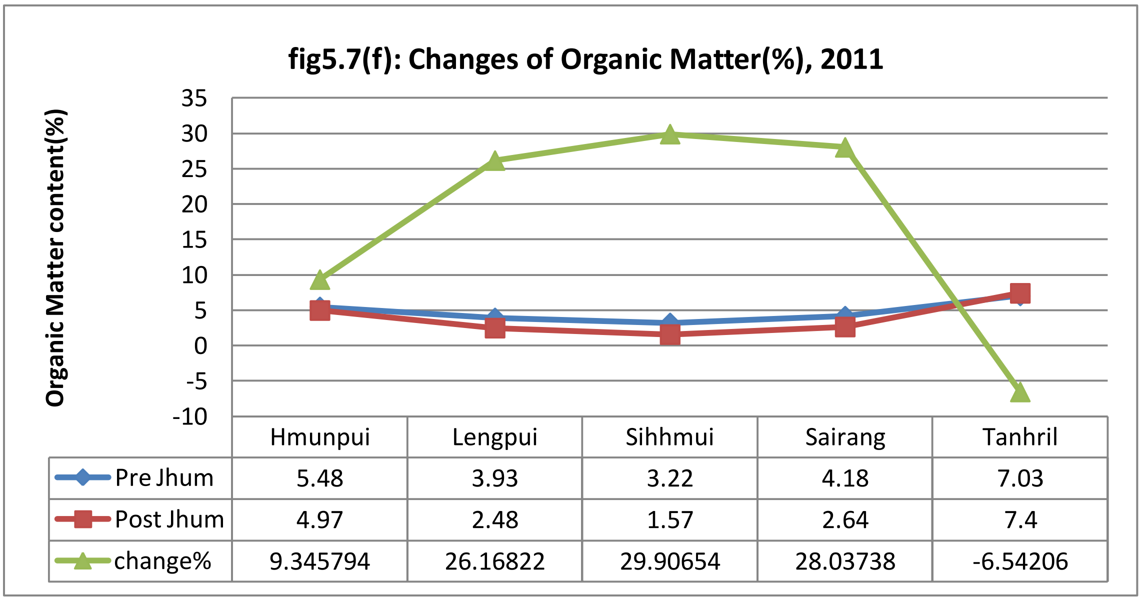


Table 5.9(f): Soil Organic Matter Content

2011				
Study sites	Pre-Jhum	Post-Jhum	Change	Change%
Hmunpui	5.48	4.97	0.51	9.346
Lengpui	3.93	2.48	1.45	26.168
Sihhmui	3.22	1.57	1.65	29.906
Sairang	4.18	2.64	1.54	28.037
Tanhril	7.03	7.4	-0.37	-6.542



5.2.7. Soil Nitrogen- Nitrogen volatilization during prescribed fire is the dominant mechanism of Nitrogen loss from these systems (Caldwell et al., 2002). After burning, soil nitrogen content was highest in Sairang (2009) and Hmunpui (2010) which has 0.24% and lowest in Lengpui (2009) which has 0.12%. Burned soils have lower nitrogen than unburned soils (Neff et al., 2005). The observation shows that nitrogen content decreases after jhum burning with a level of 0.12% and below. Nitrogen is often converted to the more available form ammonium, during the volatilization process.

Table 5.10(a): Soil Nitrogen Content (%)

2009				
Study sites	Pre -Jhum	Post- Jhum	Change	Change%
Hmunpui	0.23	0.18	0.05	16.667
Lengpui	0.2	0.12	0.08	26.667
Sihhmui	0.21	0.18	0.03	10
Sairang	0.36	0.24	0.12	40
Tanhril	0.33	0.31	0.02	6.667

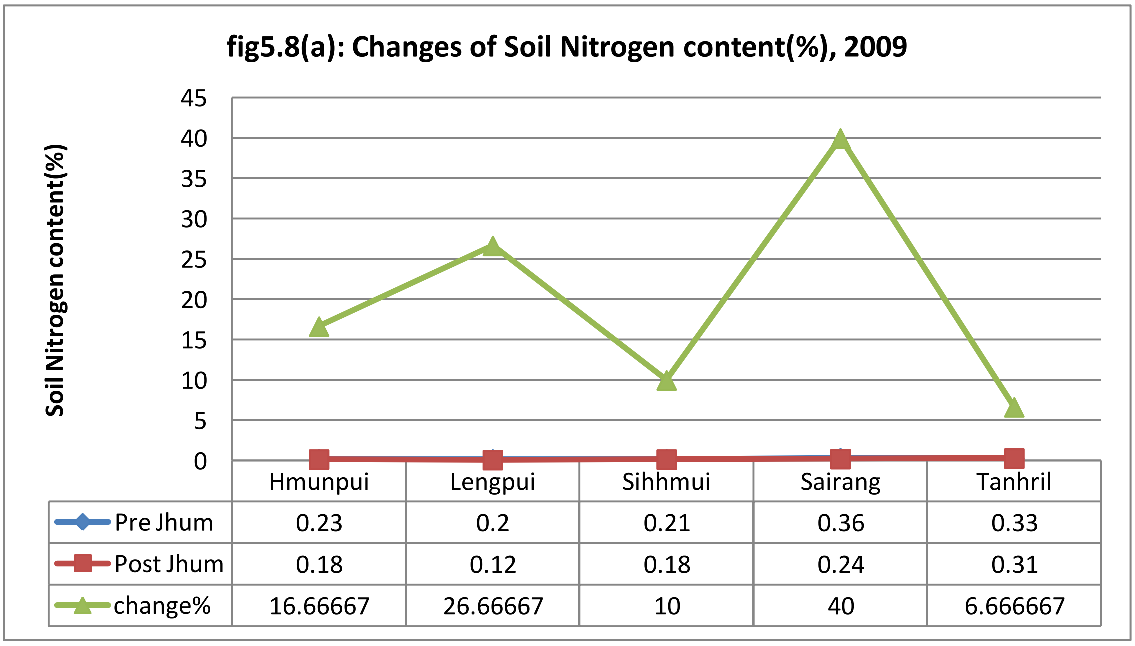


Table 5.10(b): Soil Nitrogen Content (%)

2010				
Study sites	Pre-Jhum	Post-Jhum	Change	Change%
Hmunpui	0.29	0.24	0.05	20.833
Lengpui	0.25	0.19	0.06	25
Sihhmui	0.19	0.17	0.02	8.333
Sairang	0.28	0.22	0.06	25
Tanhril	0.35	0.3	0.05	20.833

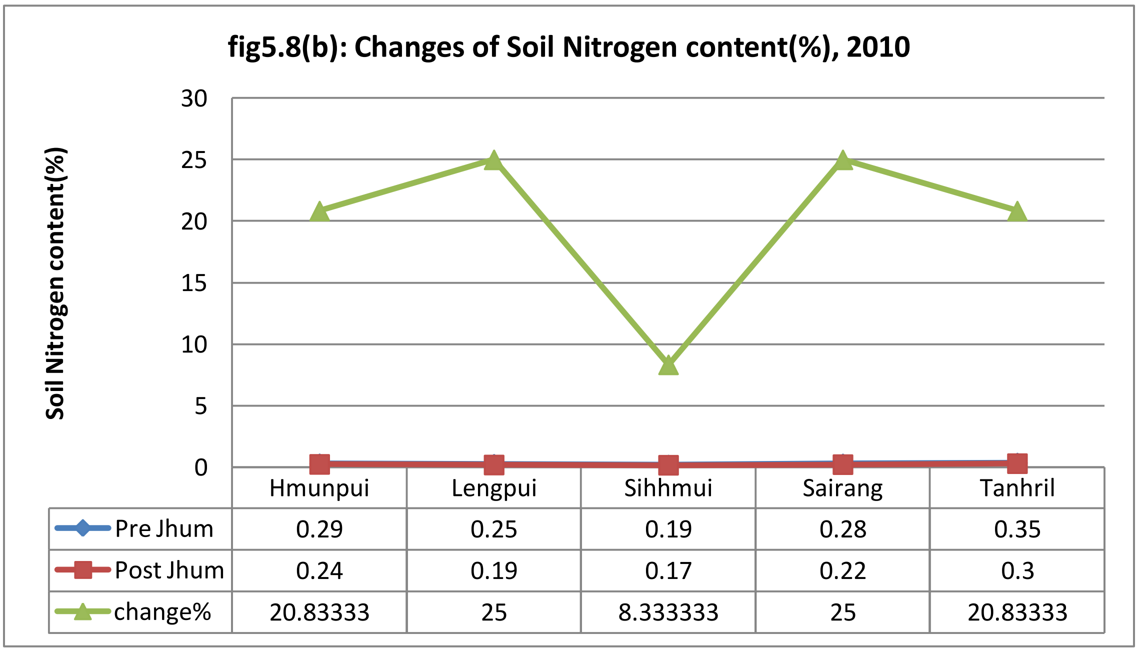
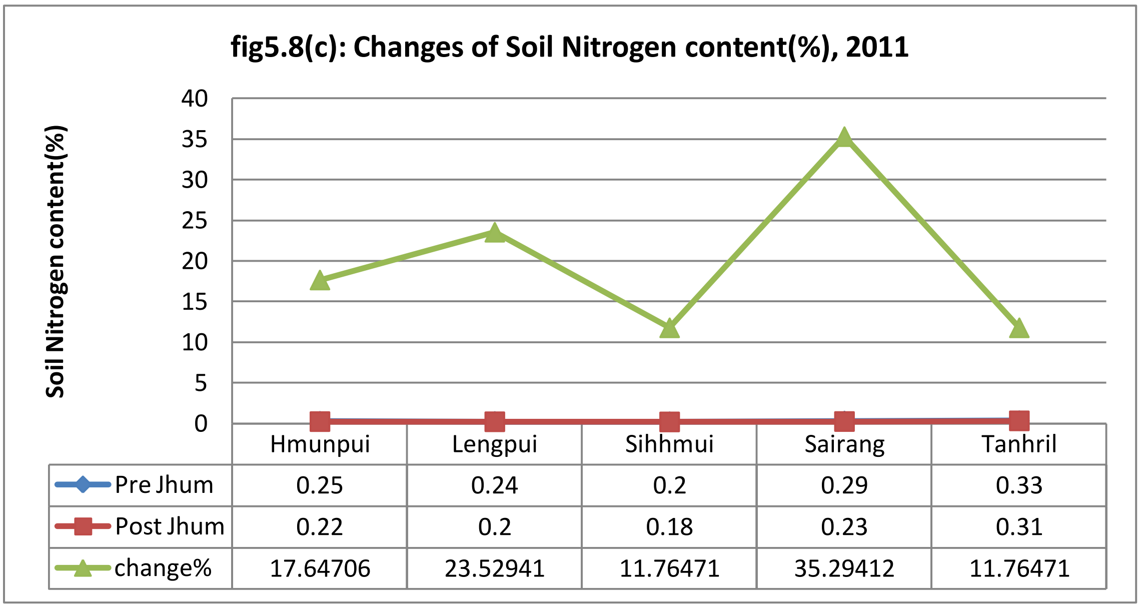


Table 5.10(c): Soil Nitrogen Content (%)

2011				
Study sites	Pre- Jhum	Post- Jhum	Change	Change%
Hmunpui	0.25	0.22	0.03	17.647
Lengpui	0.24	0.2	0.04	23.529
Sihhmui	0.2	0.18	0.02	11.765
Sairang	0.29	0.23	0.06	35.294
Tanhril	0.33	0.31	0.02	11.765



5.2.8.Soil Phosphorus- the results shows that soil phosphorus are comparatively higher in the area unaffected by jhum which ranges from 1.07 kg/ha to 1.43 kg/ha. The soil analysed from study sites affected by jhum ranges from 0.26 kg/ha to 0.53 kg/ha in pre jhum and 0.44 kg/ha to 0.98 kg/ha in post jhum. The result of change showed an increase in soil phosphorus content from pre jhum to post jhum and ranges from 0.17 kg/ha to 0.54 kg/ha.

Table 5.11(a): Soil Phosphorus Content (kg/ha)

2009				
Study sites	Pre Jhum	Post Jhum	Change	Change%
Hmunpui	0.44	0.98	-0.54	-30.509
Lengpui	0.36	0.78	-0.42	-23.729
Sihhmui	0.26	0.53	-0.27	-15.254
Sairang	0.35	0.8	-0.45	-25.424
Tanhril	1.16	1.25	-0.09	-5.0848

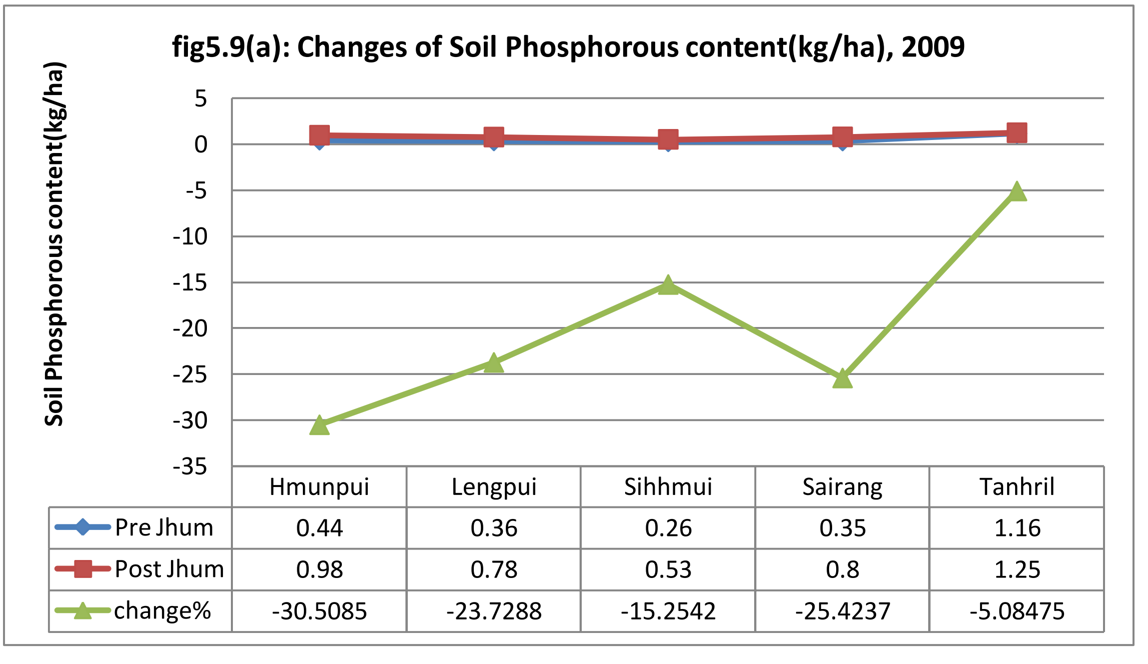


Table 5.11(b): Soil Phosphorus Content (kg/ha)

2010				
Study sites	Pre Jhum	Post Jhum	Change	Change%
Hmunpui	0.36	0.71	-0.35	-26.923
Lengpui	0.27	0.44	-0.17	-13.077
Sihhmui	0.29	0.63	-0.34	-26.154
Sairang	0.41	0.58	-0.17	-13.077
Tanhril	1.07	1.34	-0.27	-20.769

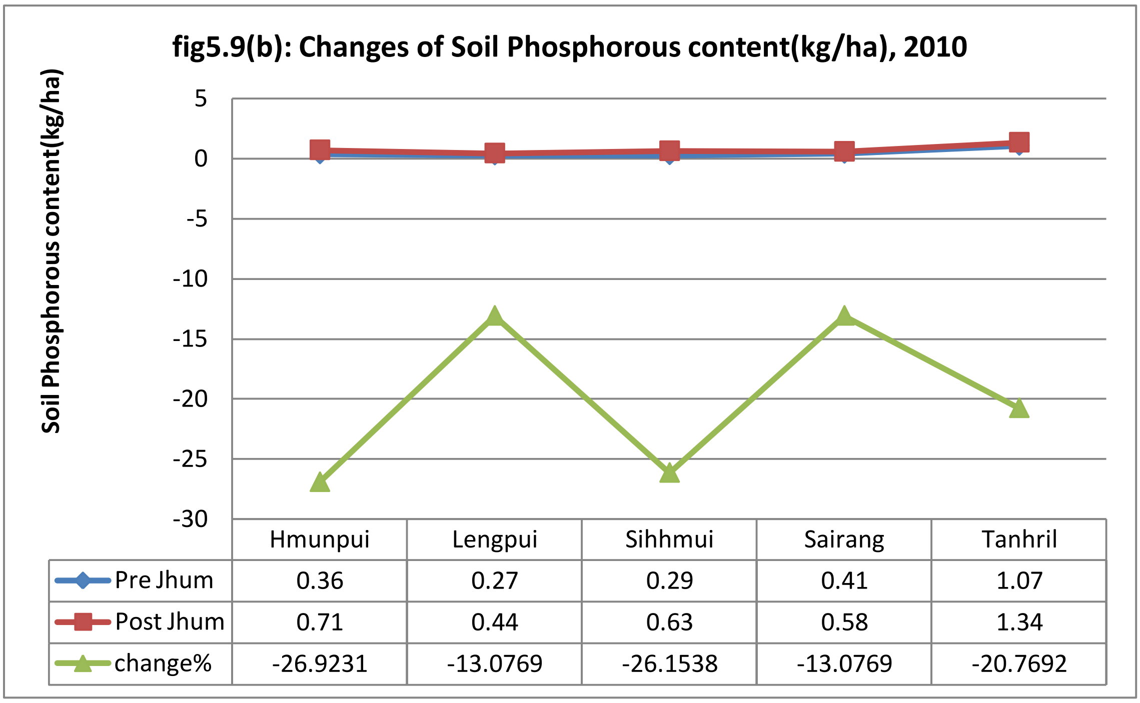
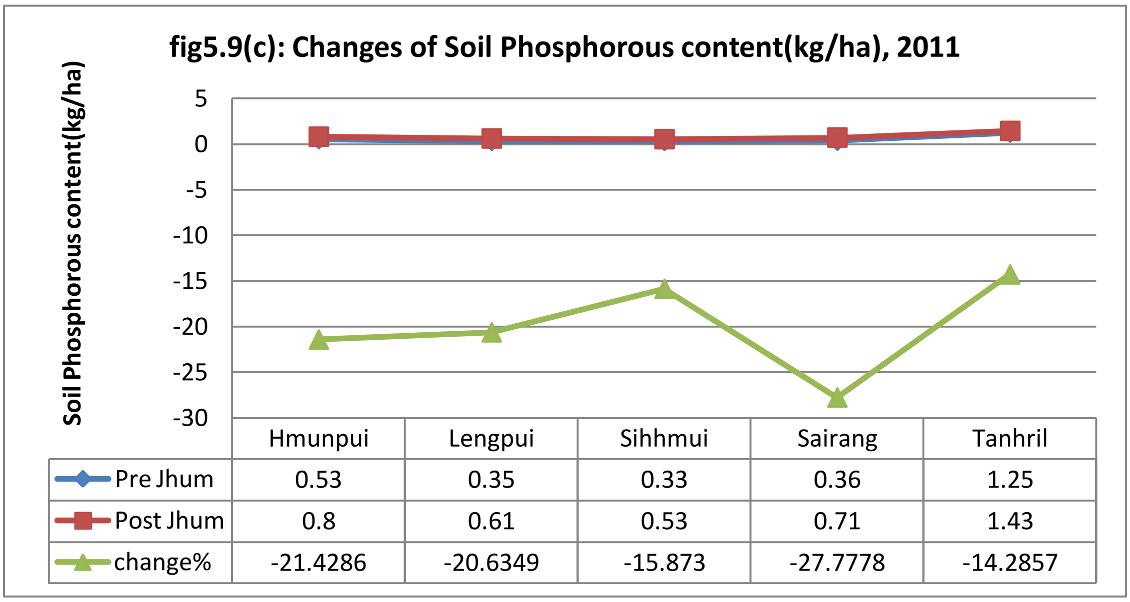


Table 5.11(c): Soil Phosphorus Content (kg/ha)

2011				
Study sites	Pre Jhum	Post Jhum	Change	Change%
Hmunpui	0.53	0.8	-0.27	-21.429
Lengpui	0.35	0.61	-0.26	-20.635
Sihhmui	0.33	0.53	-0.2	-15.873
Sairang	0.36	0.71	-0.35	-27.778
Tanhril	1.25	1.43	-0.18	-14.286



5.2.9. Soil Potassium- In pre-burned soil, Sairang (2011) has the highest potassium content with 1.53 mg of K/g of soil and the lowest was 0.56 mg of K/g of soil at Hmunpui (2009), which also have the lowest potassium content after post burned (0.97 mg of K/g of soil). The highest potassium in soil was found in Lengpui (2010) having 1.91 mg of K/g of soil.

Table 5.12(a): Soil Potassium Content (mg of K/g of soil)

2009				
Study sites	Pre Jhum	Post Jhum	Change	Change%
Hmunpui	0.56	0.97	-0.41	-30.147
Lengpui	0.77	1.12	-0.35	-25.735
Sihhmui	1.07	1.37	-0.3	-22.059
Sairang	1.06	1.24	-0.18	-13.235
Tanhril	1.23	1.35	-0.12	-8.8235

fig5.10(a): Changes of Soil Potassium content(mg of K/g of soil), 2009

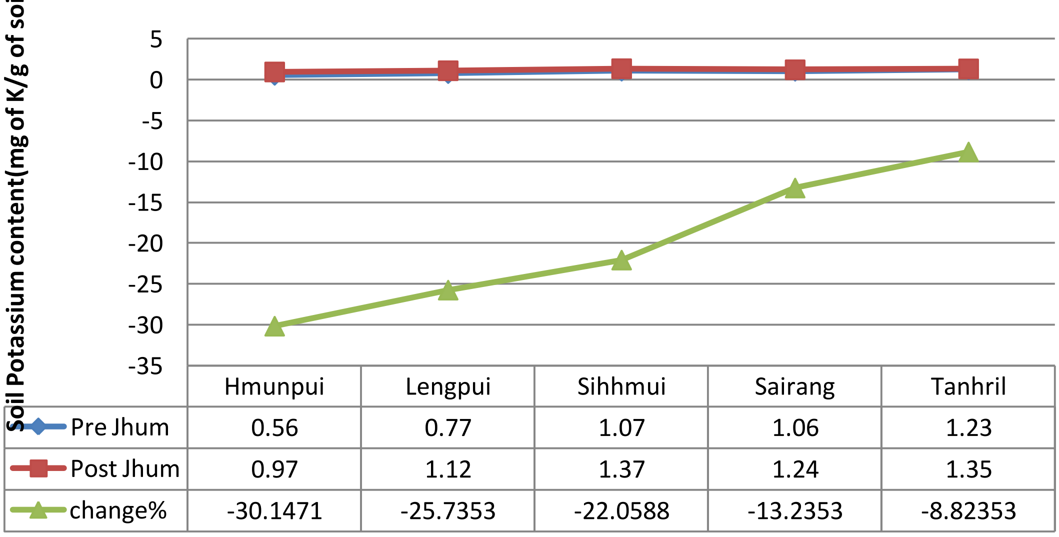


Table 5.12(b): Soil Potassium Content (mg of K/g of soil)

2010				
Study sites	Pre Jhum	Post Jhum	Change	Change%
Hmunpui	1.24	1.46	-0.22	-14.966
Lengpui	1.53	1.91	-0.38	-25.850
Sihhmui	1.12	1.41	-0.29	-19.728
Sairang	0.84	1.18	-0.34	-23.129
Tanhril	1.25	1.49	-0.24	-16.327

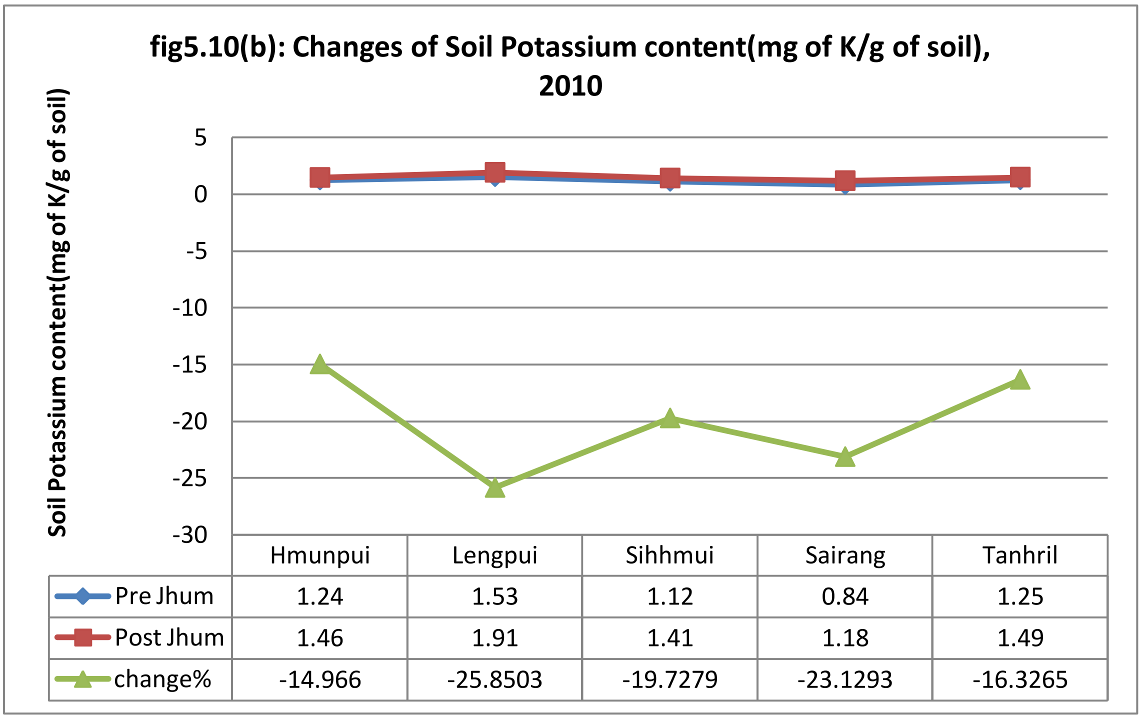
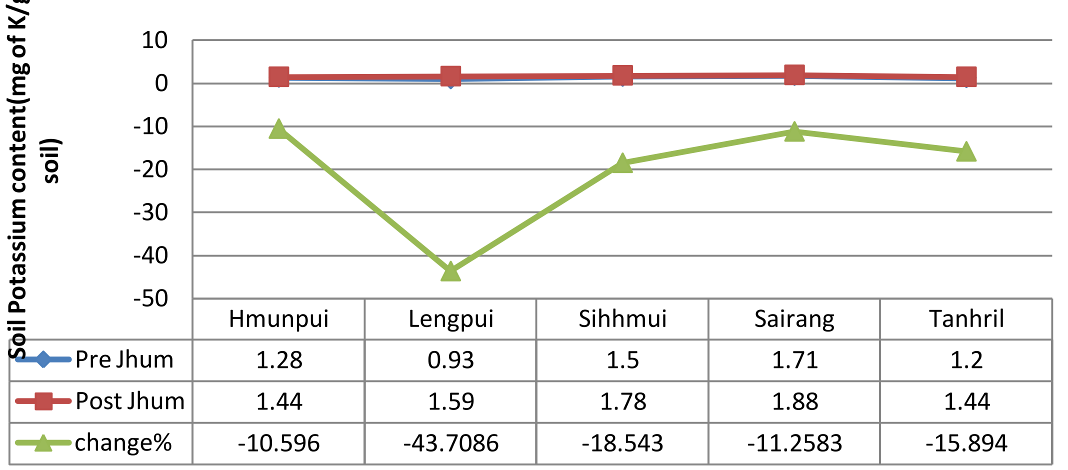


Table 5.12(c): Soil Potassium Content (mg of K/g of soil)

2011				
Study sites	Pre Jhum	Post Jhum	Change	Change%
Hmunpui	1.28	1.44	-0.16	-10.596
Lengpui	0.93	1.59	-0.66	-43.709
Sihhmui	1.5	1.78	-0.28	-18.543
Sairang	1.71	1.88	-0.17	-11.2589
Tanhril	1.2	1.44	-0.24	-15.894

fig5.10(c): Changes of Soil Potassium content(mg of K/g of soil), 2011

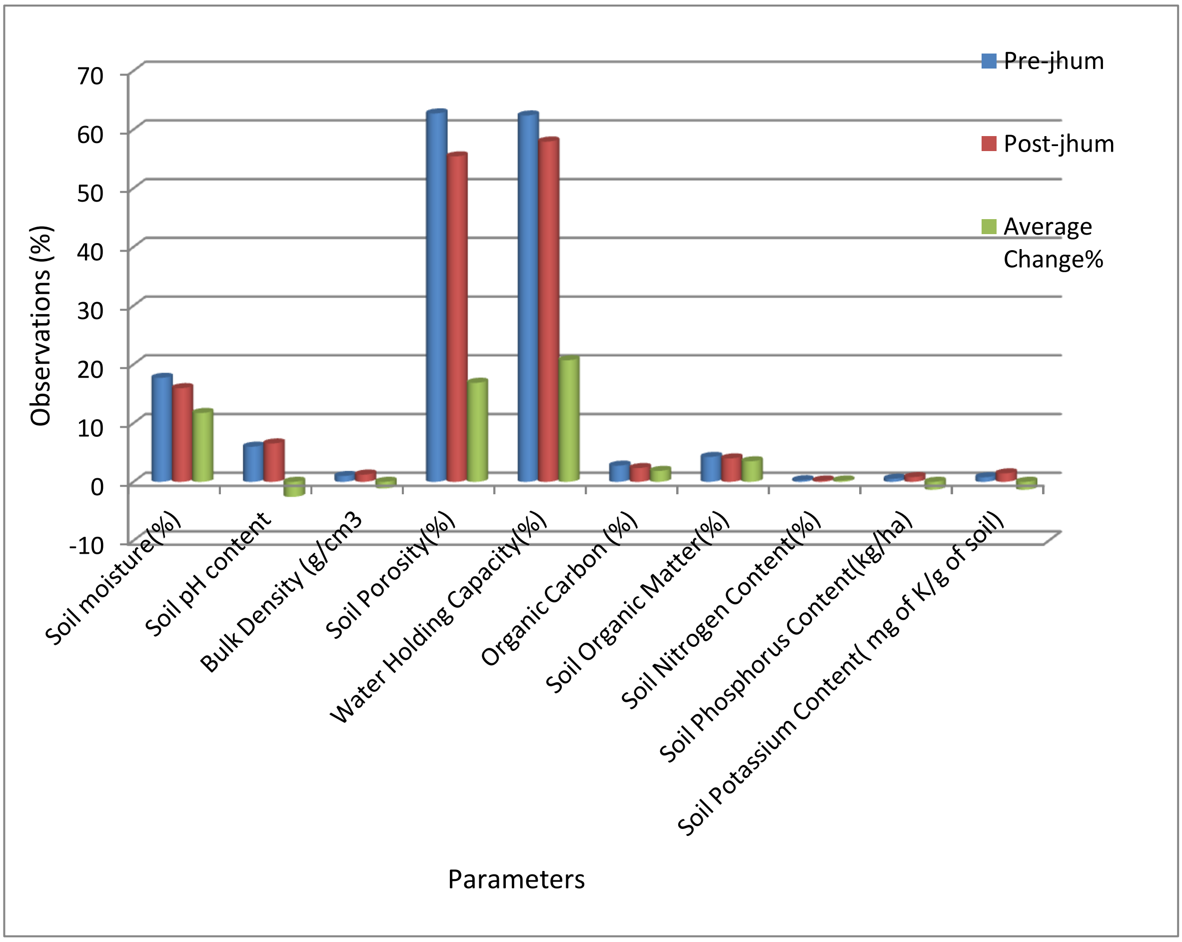


Numerous exchangeable cations including P and K typically increase following a fire. This results in an abrupt release of elements, which in the absence of fire, would only have become gradually available through the slow decay of plant litter. These cations are generally released during various combustion stages with the total amount released being dependant on fire severity, intensity and fuel type. Overall, in most cases, a fire increases the amount of nutrients available, and as a result nutrient cycling is increased.

Table 5.13: **Changes (%) in various physico-chemical properties of soils during a 3-yr period**

Sl.no	Parameters	Pre-jhum	Post-jhum	Average change	Average Change%
1.	Soil moisture(%)	17.706	15.951	2.516	11.723
2.	Soil pH content	5.981	6.532	-0.551	-2.567
3.	Bulk Density (g/cm^3)	0.992	1.236	-0.244	-1.138
4.	Soil Porosity(%)	62.738	55.421	7.317	16.865
5.	Water Holding Capacity(%)	62.389	57.948	4.441	20.706
6.a	Organic Carbon (%)	2.747	2.347	0.399	1.862
6.b	Organic Matter(%)	4.232	3.986	0.749	3.493
7.	Soil Nitrogen Content(%)	0.267	0.219	0.047	0.221
8.	Soil Phosphorus Content(kg/ha)	0.519	0.808	-0.289	-1.346
9.	Soil Potassium Content(mg of K/g of soil)	0.780	1.442	-0.289	-1.349

Fig 5.11: Pre-jhum, Post-jhum and average change% in various parameters of soil during 3-years.



During the three year period of study the soil properties shows significant changes, with maximum percentage of average change in soil porosity and water holding capacity. The results shows that the pre-jhum soil or rather the virgin soil were known to have a higher content of moisture, water retention, organic carbon and organic matter, nitrogen and soil porosity. Whereas the average post-jhum soil contents was higher in pH, bulk density, phosphorus and potassium. The negative average change percentage shows an increase in soil content during post-jhum, while the positive average change percentage shows an increase in soil content during pre-jhum. The results of the interaction between sites and year which is given in table 5.14 shows that the interaction does not affect the physico-chemical properties of soil. Since **p** value is greater than 0.005, this confirms that there is no interaction between sites and year.

Table5.14: Analysis of variance (ANOVA, 2-ways, fixed effects model) on changes in physico-chemical properties of the soil due to jhum.

Sources of Variation	**D.F**	**S.S**	**M.S**	**F**	**p**
Sites	4	222.372	55.593	8.267	.001
Years	2	151.947	75.973	11.298	.001
Sites*Years	8	102.538	12.817	1.906	.134
Error	15	100.870	6.725		
Total	30	9073.848			

5.3 Effect of jhum on human health-

Table 5.15: Different diseases caused by jhum related air pollution on human and the number of people affected (scoring out of 10)

Sl. No.	Diseases	No of people affected		
		Hmunpui	Lengpui	Sairang
1.	Cough	***	********	***
2.	Cold	********	*****	**
3.	Sinusoities	*	**	***
4.	Emphysema	-	-	-
5.	Heart disease	-	-	-
6.	Lung Cancer	-	-	-
7.	Asthma	*	**	**
8.	Bronchitis	***	****	***

The table shows the different diseases caused by jhum burning on the three villages, the data are recorded/collected during jhum burning which is from January to June of 2010 and 2011. Ranks are given on the basis of fixed scoring which is done out of ten and data are obtained from mutual sharing, questionnaires and records from the Primary Health Sub-Centre and Community Health Centre of their respective village. There is one Health Sub-Centre (HSC) at Hmunpui, One Community Health Centre and Primary Health Sub-Centre at Lengpui and one Primary Health Sub-Centre at Sairang. The Primary Health Sub-Centres are looked after by one or two Health workers while the Community Health Sub-Centre by three doctors. The most number of diseases reported/recorded are cough and cold and a few cases on bronchitis. Keeping in mind the limitations of the sources of data obtained, jhum related health impacts are not as serious as anticipated, rather, the effect of jhum on human health are fortunately mild cases. One of the village council member mention the discussion with the doctor stating that jhum burning does not effect much of the human health since there are less cases reported during jhum burning. Reservations need to be made as this health problems are also related with air-borne diseases other than pollution made by jhum burning.

5.4 Effect of jhum on flight scheduling-

Table 5.16: Flight scheduling, their status and remarks from 2009-2011

Date (Jan-June, 2009)	Flight Number	Status	Remarks
7.01.2009	IC211/213 CCU IC7759/7758 GAU	Delayed Cancelled	Due to poor visibility
20.01.2009	IC211/213 CCU	Delayed	Due to poor visibility
21.01.2009	IC211 CCU IC7704/03 GAU	Cancelled Delayed	Due to poor visibility over Lengpui Airport
23.01.2009	IC211/213 CCU IC7759/7758 GAU	Cancelled Cancelled	Due to poor visibility
25.01.2009	IC211/213 CCU	Cancelled	Due to poor visibility
26.01.2009	IC211/213 CCU	Cancelled	Due to persistent bad weather & poor visibility over Lengpui Airport

12.02.2009 16.02.2009 24.02.2009 27.02.2009	IC211/213 CCU IC211/213 CCU IC7704/03 IC211/213 CCU	Cancelled Cancelled Cancelled Cancelled	Due to poor visibility Due to poor visibility Due to operational reason Due to poor visibility
1.03.2009 2.03.2009 4.03.2009 5.03.2009 7.03.2009 9.03.2009 11.03.2009	IC211/213 CCU IC211/213 CCU IC211/213 CCU IC7703/04 CCU IC7757 GAU IC7757 GAU IC211 CCU A319/320 IC211/213	Delayed Delayed Cancelled Cancelled Delayed Delayed Cancelled (diverted to IMF) Cancelled (not operated/	Due to operational reason Due to operational reason Due to persistent bad weather & poor visibility. Due to operational reason Due to operational reason Due to persistent bad weather & poor visibility Poor visibility due to Jhum Burning

		withdrawn from 11th – 15th March)	
12.03.2009	IC7757 GAU	Cancelled (diverted back to GAU)	Due to poor visibility
15 – 26.03.2009	All flights	Cancelled	Poor visibility due to Jhum Burning
31.03.2009	IC7703/04 IC213	Cancelled Delayed	Due to operational reason
1.04.2009	IC7703/04 IC213	Cancelled Delayed	Due to operational reason
2.04.2009	IC7703/04 IC213	Cancelled Delayed	Due to operational reason
3.04.2009	IC211	Delayed	Due to operational reason
7.04.2009	IC213	Delayed	Due to operational reason

8-14.04.2009 15.04.2009 17.04.2009 21.04.2009	IC7704/04 IC211 IC211 IC7757/58 IC213	Cancelled Cancelled Cancelled Cancelled Cancelled	Due to operational reason Due to poor visibility Persistent bad weather Persistent bad weather & poor visibility
18.05.2009 25.05.2009	IC211 IC7759 IC211	Cancelled Cancelled Cancelled	Persistent bad weather Persistent bad weather & poor visibility
1.06.2009 4.06.2009 6.06.2009 7.06.2009	IC211 IC213 IC7757 IC213 IC7704	Cancelled Cancelled Delayed Cancelled Cancelled	Bad weather & poor visibility Bad weather & poor visibility Bad weather & poor visibility Bad weather & poor

18.06.2009	IC211 IC213	Cancelled Cancelled	visibility Bad weather & poor visibility
Date (Jan-June, 2010)	Flight Number	Status	Remarks
1.01.2010 5.01.2011 6.01.2011 11.01.2010 22.01.2010 31.01.2010	IC211 IC7703/04 IC7703 IC213 IC211 IC7757/58 IC7703/04	Cancelled Delayed Cancelled Delayed Delayed Delayed	Poor visibility over Lengpui Airport. Poor visibility Poor visibility Operational reason Operational reason Operational reason
1.02.2010	IC7757/58 IC7703/04	Delayed	Operational reason

10.02.2010 23.02.2010 25.02.2010	IC211 IC7703 IC7757/58	Cancelled Delayed Delayed	Poor visibility over Lengpui Airport. Poor visibility over Kolkatta Airport. Operational reason.
2.03.2010 4 & 5.03.2010 13.03.2010 21.03.2010 22.03.2010 31.03.2010	IC7757/58 IC7757/58 IC213 IC211 IC213 IC7703/04	Delayed Delayed Cancelled Cancelled Cancelled Delayed	Operational reason Operational reason Poor visibility over Lengpui Airport. Poor visibility over Lengpui Airport. Poor visibility over Lengpui Airport. Poor visibility over

			Lengpui Airport.
1.04.2010	IC7703/04	Delayed	Poor visibility over Lengpui Airport.
2.04.2010	IC211	Cancelled	Bad weather & Poor visibility over Lengpui Airport.
19.04.2010	IC7757 IC211 IC7704	Delayed	Poor visibility
26.04.2010	IC7757	Delayed	Operational reason
29.04.2010	IC8704 IC213	Delayed	Persistent bad weather & Poor visibility over Lengpui Airport.
2.05.2010	IC7758 IC211	Delayed	Persistent bad weather & Poor visibility
7.05.2010	IC213 IC7757	Cancelled Delayed	Persistent bad weather & Poor visibility

19.05.2010	IC7757	Delayed	Operational reason
21.05.2010	IC7757/58 IC211	Cancelled	Persistent bad weather & Poor visibility
24.05.2010	IC213 IC7757/58	Cancelled	Persistent bad weather & Poor visibility
26.05.2010	IC7703 IC211	Cancelled	Persistent bad weather & Technical problems
30.05.2010	All flights	Cancelled	Persistent bad weather & Poor visibility
31.05.2010	IC3211 IC7757	Delayed	Persistent bad weather & Poor visibility
3.06.2010	IC205 IC213	Cancelled	Persistent bad weather & Poor visibility
4.06.2010	IC211 IC7757/58	Cancelled Delayed	Persistent bad weather & Poor visibility
5.06.2010	IC213	Cancelled	Persistent bad weather &

			Poor visibility
10.06.2010	IC7703 IC213	Delayed Cancelled	Persistent bad weather & Poor visibility
12.06.2010	IC7757 IC213	Cancelled	Persistent bad weather & Poor visibility
14.06.2010	All flights	Cancelled	Persistent bad weather & Poor visibility
18.06.2010	All flights	Cancelled	Persistent bad weather & Poor visibility
19.06.2010	IC7757	Cancelled	Persistent bad weather & Poor visibility

Date (Jan-June, 2011)	Flight Number	Status	Remarks
2.01.2011	IC211	Cancelled	Persistent bad weather & poor visibility
11.01.2011	IC213	Cancelled	Due to poor visibility

	IC7719		Over Lengpui Airport
16.01.2011	IC211 AJL/IMF Sector	Cancelled	Bad weather & poor visibility
17.01.2011	IC7757/58 IC213	Cancelled Cancelled	Persistent bad weather & poor visibility
22.01.2011	IC213	Cancelled	Persistent bad weather
23.01.2011	IC211	Cancelled	Bad weather & poor visibility
28.01.2011	IC211	Cancelled	Bad weather & poor visibility
1.02.2011	IC7758 IC213	Cancelled	Bad weather & poor visibility
8.02.2011	IC213	Cancelled	Bad weather & poor visibility
9.02.2011	IC211 (AJL/IMF Sector)	Cancelled	Bad weather & poor visibility
16.03.2011	AI711	Delayed	Low Visibility
19.03.2011	AI713	Cancelled	Bad weather (strong wind) & poor visibility

26.03.2011	AI713	Cancelled	Bad weather & poor visibility
28.03.2011	AI713	Cancelled	Bad weather & poor visibility
29.03.2011	AI9757	Cancelled	Bad weather & poor visibility
30.03.2011	AI711	Cancelled	Bad weather & poor visibility
4.04.2011	AI9703	Cancelled	Poor visibility
2.05.2011	AI9703/04	Cancelled	Bad weather & poor visibility
4.05.2011	AI9757	Cancelled	Bad weather & poor visibility
17.05.2011	AI713	Cancelled	Poor visibility
18.05.2011	AI711 (AJL/IMF sector)	Cancelled	Persistent bad weather & poor visibility
23.05.2011	AI9757 AI713	Cancelled	Bad weather & poor visibility

As shown on the table above the weather plays a very important role in flight scheduling. Delayed or cancellation of flight were due to poor visibility mainly caused by bad weather. However, in the first year of study, i.e. 2009, all flights were cancelled (not operated/ withdrawn) from 11th– 26th of March, as this periods are the peak season of jhum burning in Mizoram and as mentioned on the table, the reason was poor visibility due to jhum burning. After 2009, the government issued a notification that jhum burning should be done only in the evening after all the flights have taken off, specifically for Lengpui Airport area and the surrounding villages. As per the standing of the government rules, the village council of Lengpui issued a notice that burning of slashed vegetation should be done on a specific day at a specific time within their area which was announced at the public meeting. A monetary fine was even imposed to the people who do not obey/follow the rules. This rule was strictly followed by the cultivators and is highly effective in that it does not disrupt the flight scheduling even during the peak season. The villages in and around the airport still depends on the subsistence farming of slash and burn agriculture. In 2010 and 2011, delayed or cancellation of flight were mostly due to persistent bad weather, and the consequences of reduced/ low visibility.

Lengpui Airport is included among the 11 critical airports in India due to the geographical location. There were no regular flights to Mizoram due to issues related to bad terrain, Civil Aviation Security concerns and lack of ILS. Frequent cancellation of flights was leaving many air travellers in Mizoram grounded. More than the inclement weather and jhum burning, the absence of Instrument Landing System (ILS) in the state's airport is the problem (Karmakar, 2010). Lengpui Airport has installed

Cat-I Instrument Landing System and is in function from 2nd August, 2011, which has helped planes land safely during low visibility conditions and increase the frequency of regular flights to and from Mizoram.

Chapter- VI

6.1 SUMMARY

Shifting cultivation is one of the very first forms of agricultural practiced by humans and its survival into the modern world suggests that it is a flexible and highly adaptive means of production. It was a sustainable land use when population pressure is low and fallow period between two cropping phases is long enough for recovery in ecosystem structure and function disturbed by slashing, burning and cropping (Sundriyal & Jamir, 2005). Throughout human history, forests have been cleared in response to such pressures for more farming land. Most type of forest encroachment involve clearing the land of trees and vegetation by burning, and then cultivating it as long as it will produce crops. Once the forests is cleared, their fertility rapidly decline as nutrients tied up in the vegetative layer are leached away, resulting in soil laterisation and erosion of wind and water. Therefore crops chosen should be able to help reduce the degradation of soil. On the contrary with the soils suitable for farming, the transition from forest to agriculture can be achieved without such problems.

First Chapter deals with the introduction which contain the concept, definition and characteristics of shifting cultivation, ecological implications, biodiversity and climate change, scope and objectives.

Second Chapter deals with review of literature which consist of an overview of shifting cultivation, the cultivation done at the global level, national level, northeast level and at the local level, its impact on air and soil and fallow periods.

Third Chapter consist of the description of study area- location, climate, topography, soil and study sites.

Fourth Chapter deals with the materials and methods of the research work which are estimation of ambient air quality, analysis of physical and chemical properties of soil and socio-economic study.

Fifth Chapter deals with results and discussion which shows the important findings of the research work done. The findings of the present study are summarized as under:

1. Air pollutants like RSPM and CO at Lengpui have an average concentration higher than the NAAQS which are 74.72 µg/m^3 and 3.17 mg/m3 respectively exceeding the standard limits given by NAAQS. However the concentration of SPM is the highest in 2010 with an average concentration of 156.07 µg/m^3 exceeding the NAAQS permissible level. Other pollutants such as NO_2 and SO_2 are within the permissible level, quite low as compared with the standards. On the other hand, the average concentration of all the air pollutants under study at MZU Campus is well within the standards.

2. Soil moisture content ranges from 10.9% to 23.6% in pre-jhum and 10.1% to 20.19% in post jhum in the jhum affected areas. It experienced an average change of 11.723% during three years i.e. from 2009-2011.

3. Soil pH shows a value of 5.981 in pre-jhum and 6.532 in post-jhum and an average change of -2.567% which indicates the increase of soil acidity after jhum burning. Hmunpui has the most acidic soil as compared to the other study sites.

4. The average value of bulk density are 0.992 g/cm3 and 1.236 g/cm3 for pre-jhum and post-jhum was observed during three years. The average change percent is -1.137. In pre jhum it was highest in Sairang (1.26%) and highest in Sihhmui having 1.87% in 2009.

5. Soil porosity had an average of 53.883% and 55.421% in pre jhum and post jhum respectively. The average change with an increase of 55.596% was observed during three years.

6. The average organic carbon content was found higher in pre jhum soil (2.747%) than in post jhum soil (2.347%). Therefore the average change resulted in a decrease of 1.862% from pre jhum to post jhum.

7. Soil total nitrogen averages 0.267% in pre jhum and 0.219% in post jhum, thus resulting in an average decrease of 0.2203%.

8. The average range of available phosphorus in soil was 0.519 kg/ha in pre jhum and 0.808 kg/ha in post jhum. The average change results in an increase of 1.3458% during three years of study.

9. Exchangeable potassium has an average of 0.748 mg/g and 1.442 mg/g in pre jhum and post jhum respectively. During the three years of study it results in an average change of -1.3489%, showing an increase from pre jhum to post jhum.

10. Among the jhum affected area under study, Sairang has the highest population recorded (5036) while Hmunpui has 958 inhabitants, the lowest recorded.

11. Hmunpui village have the highest number (98%) of jhum cultivators. Two third of the number of household are registered under below poverty line and they still depend on the subsistence farming of jhum cultivation. The approachable road to their village is only fair weather and jeepable.

12. The health effect of jhum burning on the villagers are not as serious as anticipated. The most number of cases reported are cough and cold and a few cases of bronchitis, asthma and sinusoities.

13. The flight scheduling was affected much by jhum burning in the early years of study. However there was improvement with the notifications and rules of the state government which was strictly enforced by the village council.

6.2 CONCLUSION:

Shifting cultivation systems as perceived both by numerous scientists and the general public as primitive, backward, wasteful, unproductive, and exploitative and the cause of widespread environmental degradation. Frequent shifting from one land to the other has affected the ecology of that region; and as a consequences, the area under natural forest has declined and results in fragmentation of habitat, local disappearance of native species and invasion by exotic weeds and other plants. However, many casual observers misunderstood this practice, they cannot see past the clearing and burning of standing forest and do not perceive often ecologically stable cycles of cropping and fallowing. The superiority of jhum cultivation over other forms of agricultural practices/cultivation explains the persistence of this form of agriculture in North East India. Other reasons include the economic security provided by jhum and its cultural importance to indigenous tribes. Poor access to markets, capital, and technical knowhow of more commercially rewarding alternatives such as horticulture and cash crop cultivation also hinders the transition to other occupations.

Cultivators rarely have the knowledge or skills necessary to manage the land and neither have the resources needed to practise modern agriculture. Often the land is farmed to exhaustion, leaving it permanently degraded and useless either for agriculture or productive forestry. Cultivators are then forced to move deeper into the forest and clear new plot of land to farm. Converting steep slopes/ hillsides to permanent agriculture requires a variety of measures such as contour ploughing, the construction of terracing, the selective retention of trees in critical areas, and a careful choice of crops and ground cover plants to protect the soil. There is lack of awareness among the farmers in areas where gentle slopes exist and where contour terraces can be adopted, only few terraces exist.

Eventhough the villagers have the resources and other business, they have a preconceived idea that every family should work on the field and have the food supply enough to last a year atleast. They consider it a shame if a family do not have a cultivable land. Clearly, one cannot do away with jhum assuming it to be a primitive and inefficient system, as attempted in governmental jhum control programmes and new land use policies. Instead, an unbiased understanding of the advantages of jhum is required for proper design and implementation of developmental programmes (Singh, 1996).

The changes in soil properties after fire produces varying responses and the wide range of effects may be due to the inherent pre-burn variability in these resources, fire behaviour characteristics, season of burning, and pre-fire and post-fire environmental conditions such as timing, amount, and duration of rainfall (Clark, 2001). In response to increased competition for land which is due to population pressures, shifting cultivators are being forced to change their traditional patterns of activity: fallow periods are being reduced, with the result that trees and other vegetation have less time to regenerate, thus undermining their vital role in restoring soil fertility. Therefore, careful land clearance is required with the necessary investments in terracing and other soil conservative measures.

The different composition of air pollutants, the dose and time of exposure and the fact that humans are usually exposed to pollutant mixtures than to single substances, can lead to diverse impacts on human health. Human health effects can range from nausea and difficulty in breathing or skin irritation, to cancer. They also include birth defects, serious developmental delays in children, and reduced activity of the immune system, leading to a number of diseases. Moreover, there exist several susceptibility factors such as age, nutritional status and predisposing conditions. Efforts should be intensified by taking the appropriate measures, in order to reduce the possibility of human pollutant exposure.

The transition from shifting cultivation to permanent agriculture can be achieved successfully, provided the additional inputs such as fertiliser and soil conservation measures are supplied (Foley and Barnard, 1984). Since indigenous people tend to be very poor, they are not in a position to adopt high input agricultural technologies. Hence there is a need for scientific interventions adapted to socio-cultural specificities of the region to control soil erosion, restore soil fertility and to improve efficiency of agricultural production (Choudhury and Sundriyal, 2000). Certain social, cultural and even religious functions are linked with various operations carried out in the jhum system. Approaches such as replacement of traditional jhum by altogether new agricultural practices are not likely to succeed easily (Dhyani and Chauhan, 1994).

In any project that aims for collaborative natural resource management, government officials must undergo a well-prepared process so that they realize that indigenous and local people can be efficient protectors and users of protected areas; and that indigenous knowledge can be used in the management of natural resources, even in protected areas. The prejudice that indigenous agriculture is a major cause of deforestation must be reversed, not only among politicians and government officials but also among the general public.

SUGGESTIONS AND RECOMMENDATION:

1. Social and economical aspects need to be considered, pollution problems cannot be tackled by technology alone. Each individual should understand his/her responsibility towards the society and take an active part in a fight against the pollution

2. The formulation and enforcement of laws and regulations for the control strategy are a must as the society cannot be governed without law.

3. Awareness on modern technologies like SALT, agroforestry, land use planning like terrace cultivation, contour bunding/ trenching, growing of cover crops and organic manuring, settled farming system namely orchards, nurseries, rice cultivation.

4. Public awareness and education which can be imparted through newspapers, journals, AIR, community meeting, etc. Jhum burning can have a very serious impact on the society by deteriorating the health status of the local people and educating the community of the extent of its effect and recommend remedial measures.

5. Emissions and corresponding air quality impacts from prescribed fires can be reduced by adopting smoke reduction techniques and choosing better dispersion conditions for burning, as suggested by both U.S. Environmental Protection Agency (EPA) and U.S. Forest Service.

6. Introduction of hedgerows in jhum. This will increase land and labour productivity and also reduce threats to the existing forest resources and associated ecosystem services (Tacio,1992).

7. Market development and commercialization: By encouraging cooperative efforts for carrying out traditional and forest-based activities, i.e. basket making, rope making, cane furniture processing of minor forest produce, honey collection, etc. can be made commercially viable by providing proper marketing facilities. This will give an alternative income to the tribals and discourage them from practising shifting cultivation.

8. Plantations should be promoted by governments and extension agencies in a bid to find alternatives to shifting cultivation that provide farmers with a livelihood,

while at the same time maintaining forest cover. Selecting species that are indigenous to the area, marketable and could give economical stability to the cultivators.

9. Investment in research and extension to document and scientifically validate traditional shifting cultivation practices to increase their productivity, profitability, and enhance ecological and social benefits, providing formal recognition of the innovations practiced by farmers.

10. An ecodevelopment plan like farm- forestry can be taken up in some selected fallow sites. Tree plantations cause minimal soil disturbance and does not require frequent ploughing, the above-ground primary productivity of forests is notably greater and could enhance the soil biota than that of agricultural crops and by providing fodder and firewood, the farm forestry would create a favourable situation for the revival of the natural forests.

11. Provision of livelihood for Asset-less families: The Asset-less families will be provided with a scope of micro-entrepreneurship, they will be assisted and trained to take up those activities identified under the project. Livestock farming, handicraft, mechanics, black smithy, Tin smithy, Petty trade etc. will be encouraged for this Asset-less people. Necessary financial and technical support will be provided from the project fund.

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Plate 1: A plot of land showing jhum burning

Plate 2: Reburning the unburnt jhum

Plate 3: Collecting soil from jhum burned land

Plate 4: Picture showing jhum field with banana plantation at the adjacent fields

Plate 5 : Jhum burned fields at the research site-Hmunpui

Plate 6: Fallow lands showing regeneration