Shifting cultivation practiced by the upland communities of India is a common phenomenon not only in Northeast India, but also of the whole world particularly in Latin America, South Asia and South East Asia. It is their intrinsic system of cultivation and resource management which is intricately interwoven with their socio-economic, cultural and environmental conditions. For the majority of the upland communities of Northeast India, shifting cultivation popularly known as jhum is the primary – and often the only – agricultural practice available to address their need for food security. Many anthropologists, sociologist, environmentalist and ecologist, have given detailed account of shifting cultivation practiced by the ethnic upland communities in India, Asia and Latin America (Conklin, 1961; Spencer, 1966; Gohain, 1954; Guha, 1955; Elwin, 1959; Sharma, 1976; Ramakrishnan, 1993; Fox, 2000). Ramakrishnan and his co-workers extensively worked for about three decades on the shifting cultivation practices in Northeastern Indian region particularly in Arunachal Pradesh and higher and lower altitude areas of Meghalaya. Growing mixtures of as many as 35 to 40 crops or sometimes up-to 60 crops is the salient characteristics of shifting cultivation that enabled the villagers to meet diverse food requirement.

Shifting agriculture, once considered being an efficient system of resource management and food production in the mountainous terrain is besieged with conflicting views. At the same time, better agricultural practices with settled cultivation that fulfilled the basic requirements of the shifting cultivators are not available. On the other hand, viable options or alternatives acceptable by these upland communities in the difficult mountain areas are yet to be designed. Therefore, these communities are still continuing to practice shifting cultivation as the most suitable and available forms of agriculture or resource management that has social connotation in their livelihood. With the increasing pressure on land, shifting cultivation fallows have been diverted for other activities as well and therefore
available land for shifting cultivation has reduced. Even in the Northeast region of India, shifting cultivation cycles are now reduced from 15-20 or more years to as low as 4-7 years (Ramakrishnan, 1993; Darlong, 2004). This has lead to economic and ecological constraints including vigorous weed growth, low yield of the cultivating plots as well as non-availability of several resources from the fallow. It is with the rational that increasing fallow length could be a solution to sustain this agricultural practice which could be possible by increasing the cropping phase. Stretching cropping phase has impact in rendering not only a higher degree of sustainability in the agricultural practice, but also ensures sufficient time for regeneration of the native vegetation in the fallow phase thereby reducing the environmental impacts. The immediate attribute of significance is the “two plus” years of cropping, hence by implication, the “semi-sedentarisation” and added implication that it has in terms of increasing the fallow phase in an incremental manner, proportionate to the number of years of cropping. The present thesis therefore elucidate how Tangkhul shifting cultivators of Ukhrul district, Manipur enabled to cultivate their fields for more than two years without reducing yield in the latter years of cropping. This piece of work also highlighted the approach for optimization of the practice and issues towards fulfillment of the resource dependency of the farmers’ requirement of resource as discussed bellow.

9.1 Crop combination and cropping pattern: to strengthen cropping phase

As many as 51 crop species are grown during the entire cropping phases by the Tangkhuls. These crops including various cereals, legumes, spices, tubers and vegetables create an intimate mixture in the field. These mixtures created different canopy that has implications in terms of efficient light captures. At the same time all the crops can optimally use nutrient from varying soil profile (Ramakrishnan, 1993) which could prevent from nutrient exhaustion. Not only prevention of soil exhaustion through mix cropping, high crop diversity is also reported to have a role in high organic matter content in the system as a whole (Trenbath, 1974). Understanding these processes of soil-plant and organic matter interactions, the Tangkhul shifting cultivators might possibly be influenced to continue cropping for 3 to 4 years.
Growing different crop varieties during 4 years of continuous cropping, the Tangkhuls enable sequential harvesting of different crops throughout the year except March and April of the entire period of cropping. Harvests of certain crops from the field also provide humus and nutrient for the remaining crops (Ramakrishnan, 1984a) that could help the farmers to obtain good yield. Maintaining sequential sowing and harvesting for the entire cropping phases, the Tangkhuls are endowed food security for longer period of time and therefore continues cropping.

The diversity and mixture of crops grown by the Tangkhuls have several factors for enabling continuous cropping. As pointed out, maize—an emergent cereal and ricebean—a legume cover crop together with runners like cucurbits are the main dominating crops throughout the cropping phases by the Tangkhuls. These combinations of mixtures could help the farmers to control and manage their fields particularly in the latter years of cropping in terms of weed control and nutrient management for longer period of time since emergent crops can withstand and compete weed proliferation. Not only easy endurance of maize against weeds, larger spacing of this crop is helpful in weeding operations to clod with spade. Similar practice of longer cropping in maize dominating fields are also reported (Momose, 2002). At the same time legume cover crops throughout the cropping phases help to suppress weed seed germination rates (Teasdale, 1993), ensure risk minimization by protecting the field from agents of wind and rain erosion to some extent. Through inputs of cover crop biomass, possibility for enhancing soil structure as well as water and nutrient holding and buffering capacity of soil have also been reported earlier (Patric et al., 1957; Lu et al., 2000; Vanlauwe et al., 2000). With these crops during the entire cropping phases, Tangkhuls possibly enable to maintain nutrient status and counter weed competition for a longer period of time and therefore cropping can continue.

9.2 Weed and weeding regimes: key to maintain soil status

Even though 30-36 weed species are found in the present study, larger number of individuals belonging to few species dominates the system. *Ageratum conyzoides* and *Imperata cylindrica* are thus found to be the most dominating species in the shifting cultivation fields of the Tangkhuls. Similar observations of dominating the
system by few species have also been reported from other parts of tropics (Zimdahl et al., 1988; Ekeleme et al., 2004). Weeding operations and their biomass retention in the field is of paramount importance in terms of soil health maintenance in shifting agriculture and is more critical in the present study since the cultivation phases last for 3 to 4 years. During the weeding operations, piling uprooted weeds and spread over in the field allows using them as mulching material, which could help in sustaining soil health for longer period through the slow release of nutrients. Moreover, weeds heaping around the stem bearing crops could benefit the crops directly. While practice of 20% weed retention by the shifting cultivators in the northeast have been reported (Ramakrishnan, 1984, 1988; Swamy and Ramakrishnan, 1988b), Tangkhuls practice of allowing uprooted weeds to put around the crop stems or heaping between crops could allow to conserve soil.

Weeding is happening to be the most laborious and difficult task for shifting cultivators in different parts of the globe (Moody, 1974; Nye and Greenland, 1960, Sanchez, 1976; Warner, 1991) and in the present study is no exception. Inspite of these facts of constraining shifting cultivators due to increasing weed proliferation, Tangkhuls are still pleased to manage labour for weeding. In the process of cultivating their fields weeding operations for 3 to 4 years, they could bring back more than 150 to 270 kg ha$^{-1}$ weed biomass into the system. The increasing weed biomass with increasing year of cropping could mean more nutrient back into the system in the latter years of cropping. The perceived nutrient deterioration in the latter years of cropping for any ecosystem where external fertilizers are not applied, such weed biomass that has increased with increasing year of cropping could be the only source to maintain soil health for longer period.

Implication of weed management on the nutrient maintenance for longer period is clearly reflected in the shifting cultivation practice of the Tangkhuls in the present study. Nutrient status of shifting cultivation fields does not have pronounced variation during the entire phases of 4 years of continuous cropping as against the perception of declining nutrient contents with increasing year of cultivation in other parts of the world (Lemenih et al., 2005). Nutrients do not deplete or show significant decrease after cropping within a cropping year as against the perception of declined nutrient status at the end of cropping as reported from other parts of the
region (Ramakrishnan, 1993). Even nutrient contents do not vary significantly along the slope. The farmers in Ukhrul district therefore are able to continue cropping for more than three years, probably an outcome of their efficient management of weeds, crop residues and other erosion control measures to sustain nutrient status for longer period.

Further, ethnopedological knowledge of the Tangkhuls as the basis for fine attunement of cropping systems to the agricultural capabilities of the site, and adjusting soil conservation practices (Weinstock, 1984; Marten and Vityakon, 1986; Pawluk et al., 1992) the farmers could sustain their agricultural systems. With age old experience of the farmers on the shifting cultivation practices and their understanding of soil plant interaction procedures, there seems that the farmers of the study area enable to produce good yield at satisfactory level continuously for a longer period of time (4 years).

9.3 Fallow management: role in enhancement of system recovery, jhum optimization and livelihood sustenance

Fallow functions of ecosystem services and provision for livelihood items were well studied. With increasing population pressure, the fallow cycle is shortening in South East Asia and elsewhere. To counter the problems of increasing population pressure several workers have also suggested to shorten the jhum cycle to certain level (Ramakrishnan, 1993) by modifying the fallow. While workers suggested modifying the fallow through improvement or enriching approaches (Brookfield and Padoch, 1994; Cairns and Garrity, 1999; Sanchez, 1999; Burgers et al., 2000), the fallow management practised by the Tangkhuls covers both improvement and enrichment approaches. These practices therefore could help in system recovery in enhancing soil fertility, to speed up vegetation recovery of fallows thus Tangkhuls are able to continue cropping for more than two years.

Not only the ecosystem services of these species, sustainability or success of such management strategies can be visualized only when varied requirements of the communities are fulfilled. The farmers in the study area infact obtain provision for 11 different use values of the species including edibles, fuel, fodder, construction materials, timber, and medicinal items. So in order to address the livelihood needs of
the farmers, the potential of the species with multi value functions will also be of paramount importance.

One very important consideration that needs to address for improving or enriching the fallow is the management of such species in the field during cropping phase, particularly in cases where fields are cultivated for longer period. The practice of management approaches adopted by the Tangkhuls by lopping, slashing at trunk height and thinning/ or removing profuse root sprouts ensure well growth of the remaining branches and reduce shade effect of these retained fallow vegetations on the crops growing belowground.

9.4 Traditional knowledge system: to optimize land use and agricultural practices

As defined by the Convention on Biological Diversity, traditional knowledge refers to the knowledge, innovations and practices of indigenous and local communities around the world. Developed from experience gained over the centuries and adapted to the local culture and environment, traditional knowledge is transmitted orally from generation to generation. It tends to be collectively owned and takes the form of stories, songs, folklore, proverbs, cultural values, beliefs, rituals, community laws, local language, and agricultural practices, including the development of plant species and animal breeds. Traditional knowledge is mainly of a practical nature, particularly in such fields as agriculture, fisheries, health, horticulture, and forestry. The exploitation or use of the physical environment that nature provides in any region depends upon the social environment of the people in the region. The traditional societies looked upon nature as a resource and took certain steps, consciously or unconsciously to conserve and replenish the nature or its environment. It also creatively modified nature so as not to disturb the natural balance; it sought to put nature to better social and economic use (Asraf, 1994). Traditional knowledge thus is an attribute of societies with historical continuity in resource use practice (Dei, 1993; Williams and Baines, 1993) which has been acquired from their ancestors with trials and errors.

With years of co-existence, interactions with forest and experience earned in the process, the Tangkhuls also adopt to make use of their physical environment
(forest) for the purpose of shifting cultivation from time immemorial. In the process, steps were taken up for sustainable utilization of the resources (environment) so that their action or practices can ensure optimum returns that could support their livelihood. Observation and preference of certain species as vegetation indicators before selecting a plot by the Tangkhuls is an excellent example in this regard. Presence (or absence) of certain indicators help them in their decision-making during plot selection. Preference given by the community at sites with species like *Alnus nepalensis*, *Artemisia* spp. and *Albizia* spp. suggest about the rich ecological knowledge of the farmers and understandably so due to the nitrogen fixing capacity of the two non-leguminous trees. Ecology of these species particularly *Alnus nepalensis* and *Albizia* spp. were well studied for their capability to enrich soil and were recommended as potential fallow species (Ramakrishnan, 1993; Changkhija et al. 2000, Darlong, 2001; Cairns, 2004; Cairns et al., 2004). Moreover, farmers’ rejection of sites with certain species like *Quercus* spp., *Pinus* spp. also logical since litters from both species (Oak and Pine) are rich in tannins and phenols; secondary metabolites that cause a slow down of leaf breakdown and also result in acidic soil. In case of pine, the litter increases surface run-off discouraging undergrowths and hence makes the soil poor in both nutrients as well as moisture. But communities in Bhutan prefer pine seedlings and ferns to yield sufficient biomass for burning in case of Phenzing type of shifting cultivation (ICIMOD, 2006). Monpa and Sherdukpan tribes of West Kameng district in Arunachal Pradesh also use Oak leaves as mulching material in their home gardens and terraces by bringing them from their Oak forests that could help their farms in enhancing soil fertility, moisture and suppressing weed and soil erosion (Dollo et al., 2006; Dollo, M., 2007).

Not only the vegetation indicators, farmers also use certain belowground characters of the field that are thought to be suitable with some basic reasons. Thus their preference of black and soft coloured soils over red and hard understandably could be the presence of organic matter, high permeability and higher chances of root penetration and spreading. Availability of earthworm casts increases the preference – again, as this help to increase the qualities outlined above. Selection of sites for cultivation by the Chakma community in Bangladesh is based on the soil texture, test, soil colour and presence of certain species giving preference to black
soils with burrows of earthworm and covered with vegetation, preferably bamboo (Allam and Mohiuddin, 2001). Characteristics of soil preferably blackish and breakable with a fist are regarded to be indicator of workability among shifting cultivators in Bhutan (ICIMOD, 2006). Farmers understanding and preference of black/dark soils are also supported in many studies (Marten and Vityakon, 1986; Tylor-Powell et al., 1991).

Farmers understanding is not only with the physical environment but also with their age old experience can further strengthen optimum exploitation of the resources. Farmers minutely determine the fine characteristics of the soil characters that can work best for the particular crops they grow. Planting groundnut on loose soils by the Tangkhuls seems most pragmatic as groundnut needs soft soil for rooting and for the nuts to form fully. On the other hand, selection of rice bean and soyabean for the stony, gravelly and loose soil with lesser depth is plausible. Both these legumes (ricebean and soyabean) are shallow rooted and the paucity of soil and organic matter would mean that nitrogen fixation by the symbionts will not be constrained. On their basis of experience and knowledge of soil types/ or characters, farmers thus decide varieties of crops to be planted or vice versa (or on the basis of crops to be planted, they select or search for suitable soil types). Maintaining distinct crop zones by the Tangkhuls, they optimize the available space in their fields. Planting specific crops at specific locations further utilize their in-depth understanding of the micro variations of the field situation in order to produce a wide variety of crops within the limits of resource available. For instance, planting chilly in the high intensity burning zone could perhaps be instrumental since potassium requirement for this crop was expected from the ashes after burning. While Tangkhuls prefer chilly in the demolished termite mound, their Thai counterparts put tobacco and tomato plants on the same (Spencer, 1966). Farmers minimize the labour requirement of putting poles for climber crops by planting such crops at the locations where poles or trunks are already available and thus acts as trellis.

Shifting cultivation is regarded to be prone to soil erosion and soil nutrient depletion since the practice involves cropping in sloppy land. However, traditional shifting cultivators are aware of the dangers of soil erosion and take measures to
prevent or reduce serious impairment of their cropland ranges (Spencer, 1966). Different mechanical and biological structures prepared and maintained by the Tangkhuls along the contour indicate farmers understanding for importance of soil and water conservation measures in this regard. These structures have multiple implications not only in terms of erosion control mechanisms but also crop-soil interaction/ nutrient demand of the crops etc. Biological barriers/ or live bunding crops particularly maize and jobstear on contour can withstand against the soil and water coming down from the upper portion of the field since these crops carries stem and have good rooting. Further, colocasia and ginger on the contours not only allows to act as contour support, the most interesting proposition is that the farmers understand the accumulation of nutrient on to these contours and therefore those crops that require higher nutrients to form bigger rhizomes are planted. Similar practice of soil conservation measures using boulders, logs, bamboos etc. are also reported among the jhumias of Nagaland (Sanchothung, 1999). Such structures of physical and biological barriers have been identified as important soil and water conservation strategies for farming the slopes (Morgan, 1986; REST and NORAGRIC, 1995; Gebremedhin et al., 1999; Herweg and Ludi, 1999; Nyssen et al., 2000; Nyssen et al., 2001; Jagger and Pender, 2003). Experimental analyses of the effectiveness of these structures carried out by NEPED during 2001-2003 have proven results in Nagaland. The experiment showed more than 2.5 times lesser quantity of soil loss in plots with logs and stone barriers when comparing to plots with no barriers whereas crops as barriers reduces soil loss more than two times than that of plots with no barriers (Ngullie, et al., 2006). The invariant nutrient status at different slopes observed in the present study further logically suggest the effectiveness of these soil and water erosion control measures of the Tangkhul by which they could continue longer cropping.

Collection of matured and healthy seed and proper preservation for next years’ planting have implications for better yield in any agricultural system but more importantly in the uplands where seeds are managed by the farmers themselves with no external fertilizer and pesticides are applied in their farms. Poor seed quality due to ineffective means of preventing pest attacks during storage, deteriorating knowledge of seed management practices and lack of access to quality seeds are
identified to be the root causes of food shortage among the Kirats (Gurung and Gurung, 2002). After harvest considerable amount of food grains is also lost due to lack of sufficient storage and processing facilities (Singh and Satapathy, 2003) which can be up to 10% worldwide annual losses as estimated by FAO (Solomon et al., 2006). Hanging the harvested Zea mays and Vigna umbellata by the Tangkhuls inside the kitchen but not over direct flame could mean for drying the seeds properly and implications in protecting them from fungal contamination. Moreover, villagers sitting around the kitchen and which are noisy most of the time possibly are avoided by rats. At the same time, the smoked seeds and pods are alkaline and might have protective effects to the pests. The same procedure and techniques of hanging maize and beans has also been practiced by the communities in Toimatai, Bangladesh (ICIMOD, 2006). Many communities in Northeastern Hill region generally maintain indoor storage for obtaining seed, whereas the grains for consumption are in separate structures that are constructed away from the residence (Jain et al., 2004). Several studies also reported to contain this loss through routine management of stored produce by fumigation (Page and Lubatti, 1963), chemical pesticides (Lemon, 1967) and plant based deterrents (Schmutterer, 1990). Traditional experience and understanding of the study communities in seed sourcing and storage techniques thus could arrest their crop or grain losses and should be similarly helpful to other upland communities.

With culturally assigned role and their importance in maintaining the basic needs of their families, seed selection and storage for next year plantation is entirely women's duty among the Tangkhuls, even these women exchanged their seeds, ensuring quality seed among themselves. Similar practice of managing household seed systems among the Kirats of Nepal has been reported (Gurung and Gurung, 2002). Among these Kirats, the role of women in managing seed is perceived as synonymous with feminine fertility and, as a result, it is classified within the domestic space of the household. In absence of women the success or sustainability of this agricultural system is questionable and therefore due recognition for their contribution and properly harnessing of their knowledge is also very important. With their major role in shifting cultivation practice and efficient seed sourcing
techniques, the Tangkhul women thus ensure agro-diversity conservation and future food security.

From the foregoing discussions, it is clear that shifting cultivation practice of the Tangkhuls could have a role in improving the upland agriculture and livelihood improvement as well in the region. It can be mentioned that, fallow management practices adopted by the Tangkhuls during different phases of shifting cultivation in fact exemplify sound attributes of an agricultural and adaptive forest management practice asserted during the 2004 Shillong Declaration. The fact that these villagers of Ukhrul district maintain a good harvest through out the cropping phase demonstrates the significance and implication of the ‘two year plus’ shifting cultivation in terms of sustainability in the agricultural practice which can potentially contribute to systems recuperation, fallow forest regeneration and hence, enhanced productivity.

Shifting cultivation produces are recognized to be organic in nature and is exemplified in the present study as well. Recognizing the importance of organic food; organizations (such as International Federation of Organic Agriculture Movement and Organic Farming Association of India etc.) are working to expand the horizon of organic crops. With the increasing market demand for organic crops and efforts of the organizations in certifying jhum products as “organic” (Darlong et al., 2008), farmers could be benefited for higher returns from shifting cultivation.

It is observed that, traditional shifting cultivators regulate their practices, including the location and size of the field, length and species composition of fallows through customary norms and religious beliefs (Conklin 1957; Schmidt-Vogt 2007). The rich traditional ecological knowledge and practices adopted by the shifting cultivation communities and women in particular have a magnificent role in improving the livelihood of the poor. In this context, these traditional women shifting cultivators are empowered in the process of their agricultural practices and can even have a role in achieving Millennium Development Goal 3 of the United Nation (Promote gender equality and empower women). Shifting cultivation indeed can have direct contributions to achieve 1st MDG (Eradicate extreme poverty and hunger) – through marketing of organic produces and through sequential harvesting
of fresh and nutritious produces from the shifting cultivation system. Not only the 1\textsuperscript{st} and 3\textsuperscript{rd} Millennium Development Goal, reports highlighted that all MDGs have a direct or indirect linkages with agriculture (World Bank, 2008). It is also clear that by increasing food availability and incomes, contributing to a range of assets and economic growth, higher agricultural productivity and supportive pro-poor policies allow people to break out of poverty, hunger-malnutrition (Braun et al. 2008). Therefore, in the mountainous terrain of the Northeastern region, livelihood improvement attempts of the upland communities and sustainable agriculture as well have to be based on the traditional frameworks of shifting cultivation practice.