CHAPTER: 1
Introduction

1.1. Background statement

Any plant biomaterial cultivated in mass scale, primarily for food for human consumption and livestock population, followed, cloth, medicine: energy etc. is known as crop. It provides requisite nutrient and energy to the body so, man has been cultivating crop for self consumption initially since his course of civilization and gradually for earning cash in recent past. Just after nomadic life, the early man was not much aware of finding a food crop but has evolved with thousands of trial and error practices and keeps identifying the best for consumption based on the tastiness and abundance in quantity. He gradually started cultivating number of such plants in his field and accumulated knowledge on the management of such plants thereby he ensures his food security. Moreso, he meets his daily need through exchange program between crops and cash. In recent past, either by farmers' trial-error practices or by ex-situ experimentation programs led by farm scientists and academicians with sound knowledge on modern scientific technology, a vivid range of such useful crop plants are available in crop field. Subsequently, a wide range of crop gene pool has been managing at various levels irrespective of locational suitability and utility.

Crop biodiversity confers potential resistance to droughts and other environmental stresses and the cost of crop genetic uniformity can potentially be high. Therefore, the crop diversity has economic importance in production systems, regardless of whether crop populations are characterized predominantly by old varieties, modern varieties, or land races (Meng et. al., 1998). It is reported that knowledge of local crop is related to household crop diversity, probably because people with more knowledge of cultivated plants are better able to plant more crops than people with less knowledge of cultivated plant. Therefore, in recent past many studies on crop diversity have been taken which unfolded the strategy for conservation of genetic resources to the public, researcher and policy maker as concern grows over the loss of biological diversity (Vavilov 1994; Wood & Lenne, 1997). Next, crop diversity protects household food production against localised risks related to environmental and economic variability (Zimmerer 1996; Brush, 1992 b).

Agro biodiversity in any specific ecological context emerges through the interaction among human preferences, natural selection pressures and larger social and institutional considerations,
where major disastrous events might lead to not only extraordinary changes in the agro biodiversity conditions or the local agro ecological characteristics but also to major migrations. Human preferences have played a prominent role in selection but many times in highly ecologically stressed regions, the selection was made by nature and human beings adapted to whatever seeds or plants which survived (Gupta, 2001). Odum & Barret (2005) distinguished agroeconomies from natural of semi natural solar-powered ecosystems in three basic ways, (1) the auxiliary energy that augments or subsidizes the solar energy input is under the control of human kind and consists of human animal labour, fertilizer, pesticides, irrigation water, fuel powered machinery and so on; (2) the diversity of organisms and crops is greatly reduced (again by human management) to maximize yield of specific food crops or other products; and (3) the dominant plants and animals are under artificial selection rather than natural selection. In other words, agroeconomies are designed and managed to channel as much conversion of solar energy and energy subsidies as possible into edible or other marketable products by twofold process: (1) by employing auxiliary energy to do maintenance work that in natural systems would be accomplished by solar energy, thus allowing more solar energy to be converted directly into food; and (2) by genetic selection of food plants and domestic animals to optimize yield in the specialized, energy subsidized environment. Approximately 10% of the world’s ice free land area is crop land, converted mostly from natural grass lands and forests, but also from deserts and wetlands (Odum & Barret, 2005). Another 20% of the land area is pasture, designed for animals rather than plant production. Thus, about 30% of the terrestrial surface is devoted to agriculture production.

Like many tropical countries, India is characterized by a complex mosaic of diverse agroeconomies, differentiated by their climatic, soil, geological, vegetational and other natural features. A recent classification by the National Bureau of Soil Survey and Land Use Planning distinguishes 20 broad agro-ecological zones, separated by natural features and crop growing periods. Each of these agro-ecological zones is in turn comprised of myriad micro-habitats. It is within this diversity of habitats that an amazing variety of crops and livestock has been developed over the millennia of Indian farming (Kothari, 1994).

A rich diversity of traditional crops generally occurs in the eastern Himalaya which supports the sustenance of the entire region (Dollo & Sundriyal, 2003), and is identified by the Indian Council of Agricultural Research as a centre for rice germplasm, while the Forest Survey
of India reports that the region harbours a wide range of species with greater endemism. About 35 crop species are cultivated in a jhum cultivation system in the region (Ramakrishnan, 1985). The high crop diversity not only helps to sustain the nutrient requirement but also food security as it has been well adopted with diverse ecological conditions and, environmental and pathological stresses. Major share of crop diversity is contributed by the Arunachal Pradesh, as 616 numbers of rice germplasm were recorded from the state in between 1987 and 2002. Rice landraces collection from different tribal communities yielded 128 accessions processing the wide range of diversities (Hore, 2005) whereas a total of 245 accessions of cereals, pulses, oil seeds, fruits, vegetables, coarse cereals, spices and fibre crops were reported in both Changlang and Tirap districts of the state (Singh, et al., 2004). Many indigenous varieties of cereals (mainly paddy and millet crops), pulses, oil seeds, vegetables and spices are being conserved under the shifting cultivation system. There are 74 indigenous varieties of these crops, which are locally grown, conserved and used to fulfill the diversified needs in East Siang District of the state (Singh, 2007).

India is an agriculture-based country where more than 70% of the people are living in rural areas and agriculture is the principal source of subsistence for them. Traditionally Indian agriculture has been characterized by the use of extremely diverse crops and cropping patterns/methods. Traditional farming system provides the fuel, fodder and other ritual, cultural needs of the community and is intimately connected to social relations, festivals and other aspects of rural life (Choudhury, 2005).

The Himalayan highlands are the reservoir for a large number of crop genetic resources because of the preponderance of locally developed traditional crop varieties owing to high agro-climatic heterogeneity and local socio-cultural diversity. Traditional agro-ecosystems in the Himalayan regions are very diverse and crop husbandry, animal husbandry and forest constitute complex and interlinked production systems (Bisht, et. al., 2007).

Like other Indian Himalayan states, the state, Arunachal Pradesh which is popularly known as the land of rising sun, situated in eastern most corner of the country possesses diversified agro-ecosystem. The state share major portions of the Mega Biodiversity hotspot, the Eastern Himalaya, which have not only been known for its high biodiversity but also rich eco-cultural diversity having 26 major tribes and 110 sub/minor tribes. The majority of the population depends upon agricultural and forest based natural resources for their livelihood in Arunachal
Pradesh (Singh, et. al., 1994; Sundriyal, et. al., 1994), where more than 80% of the total populations are depend on it. Shifting cultivation popularly known as jhum is the predominant among agricultural practices for most of the tribal communities across the state with exceptions to the Apatanis and Monpas, who practice settled agriculture. Traditional communities of the region have well adapted and time tested agro-ecosystem management practices to sustain socio-ecological needs. The shifting cultivation not only provides rice but also more or less every needs of the farmer for its livelihood sustenance. Starting from the fuel wood collection to house construction materials, majority of the farmer depend on it.

Traditional ecological practices represent the experiences acquired over thousands of years of direct human contact with the environment as it has been experiencing from time immemorial. Traditional ecological practices are the essence of social capital of the poor people and plays significant role in conservation of biodiversity. By using inventive self-reliance, experiential knowledge, and locally available resources, traditional farmers have often developed farming systems with sustained yields. While looking at the local culture, spirit, social and ethical norms possessed by traditional people, it has often been determining factors for sustainable use and conservation of biodiversity. The traditional farmers, have given us an invaluable heritage of thousands of locally adapted genotypes of major and minor crops and they are habituated to survive under the risk-prone and harsh agro-ecosystems by using the local plants as well as they rely on the availability of crop biodiversity which they have conserved locally by their own informal experimental wisdom over the millennia (Singh, 2007).

One of the salient features of traditional farming systems throughout the developing world is their high degree of variability. These traditional farming systems have emerged over centuries of cultural and biological evolution and represent accumulated experiences of indigenous farmers interacting with the environment without access to external inputs, capital, or modern scientific knowledge (Grigg, 1969; Chang, et.al., 1977). Just in Latin America alone, more than two and a half million hectares of land remains under traditional agriculture in the form of raised fields, polycultures, agroforestry systems, etc. this signifies the relevancy of a successful adaptation to difficult environments by indigenous farmers (Altieri, 1991). Many of these traditional agroecosystems, still found throughout the Andes, Meso America and the lowland tropics, constitute major in-situ repositories of both crop and wild plant germplasm. From an agroecological perspective, these agroecosystems can be seen as a continuum of
integrated farming units and natural or semi-natural ecosystems where plant gathering and crop production are actively pursued. Plant resources are directly dependent upon management by human groups; thus, they have evolved in part under the influence of farming practices shaped by particular cultures and the forms of sophisticated knowledge they represent (Nabhan, 1983).

Traditional farmers constantly search for and promote novel variation in their crops. They acquire new varieties by exchange, while travelling, through purchase from markets and natural hybridization. This is actually one of the key features of traditional farming systems: the interaction between domesticated varieties and their wild relatives. The promotion of natural hybridization and introgression has, over time, increased the genetic diversity available to farmers.

Agriculture is the major important economic activity for a large populace in the developing world (Ramakrishnan, 1985). The view held a few decades ago that an over-emphasized industrialization as the main hope for the developing countries has undergone remarkable changes in more recent times (Grigg, 1969). Today economists emphasize agriculture and rural development as the main parts of the national development, while, the agronomists focus on conservation and development of agriculture including indigenous crop variety being conserved by traditional communities living in less disturbed habitat. Tribal communities are mainly dependent on a large variety of landuses for their sustenance (Ramakrishnan, 1993). Shifting agriculture is one of the most complex and multifaceted forms of agricultural landuse in the world (Grigg, 1969; Ramakrishnan, 1993), which is also known as ‘Slash and Burn’ or ‘Bush Fallow’ agriculture (Husain, 1997). It consists of highly diverse land use systems, which has a wide range of distinct socio-economic and ecological conditions, from montane to low land ecosystems, and from tropical forest to grasslands (Spencer, 1966). In the hilly tracts of the Northeast India, shifting agriculture is the most dominant landuse practice (Ramakrishnan, 1993) prevailing since time immemorial. It may be referred as a unique forest ecosystem largely depends on its fertility maintenance where a fallow cycle of less than ten years is considered crucial for maintaining soil status (Ramakrishnan, 1993). Over the last hundred years, there have been a variety of attempts to find a solution to the vexed problem of shifting cultivation in the northeastern region. On the basis of earlier researches conducted in the region, it is being increasingly realized that building upon shifting agriculture, rather than finding
alternate to shifting agriculture is the best strategy to conserve the rich natural resources of the North Eastern region of India (Anonymous, 2001).

The shifting agriculture is also a predominant and age-old agricultural practice of Arunachal Pradesh, it is practiced between 200-2700 m elevation, and nearly 54000 families are involved with this cultivation. The shifting agriculture has been a subject of debate for last few decades (Anonymous, 2002) although recent reports suggested that the practice of shifting agriculture ensures subsistence crop and provides most of the energy in diets (Dufour, 1994). Crop diversity in shifting agricultural systems is maintained as strategy to ensure food security against variability in market conditions, such as fluctuations in the price of crop.

In the North-East Himalaya, the shifting agriculture was once considered to be an efficient system of cultivation being sustainable both ecologically and economically (Ramakrishnan, 1992), is gradually becoming untenable under pressure from a number of factors and besieged with conflicting views in regard to the degradation/conservation of ecosystem and the way of life for the upland people. This situation led to a number of dialogues; one section perceives the practice as ecologically destructive, uneconomical and, therefore undesirable, hence advocates to ban or replace the practice by other alternatives and land use practices such as agro forestry based farming system (Borthakur, et. al., 1979; Ingyt & Goswami, 1979; Borthakur, 1992; Mokopathy, 2000). Alternatives like horticultural, floriculture, coffee or rubber plantations, etc" are being introduced to prevent deterioration of environment, soil erosion and forest cover loss (GOI, 1983; Syiem, 2002).

The other section, considering the social and economic dependency of the ethnic communities on this practice, considers it as a way of life that integrates both material and immaterial culture and discards the opinion of the former labeling it as a top down approach that neglects the very basic needs of the shifting cultivators and their inherent knowledge with respect to conservation (Brown & Schreckenberg, 1998). They emphasize on the unique resource ownership and utilization pattern of the shifting cultivators, which according to them, makes the system ecologically and economically sustainable (ICIMOD, 2006). They also opined that the efforts to wean farmers away from shifting agriculture and to replace shifting agriculture have not been successful (Das, 2006) and such projects encroached the cultivable land ultimately shortening the shifting agriculture cycles while most of the upland communities are still continuing to practice shifting cultivation (Darlong, 2004).
Ironically, efforts of the government to find solutions through settled agricultural practices have been responsible for the increased marginalization of the practice and thus resultant vulnerability of the practitioners (Choudhury & Sundriyal, 2003). Further, ecologists who made extensive studies on shifting cultivation in Northeast India opined that any development in the region should be shifting agriculture centered as the region is not having any viable alternative to replace shifting cultivation (Ramakrishnan, 1987). It is also suggested that the beneficial spin-off of shifting agriculture in terms of societal gains, chiefly in terms of equitable gains to the members of the village community and the maintenance of the societal norms of harmony and equity should not be lost sight of (Task Force on Rehabilitation of Jhum (Shifting Cultivation) Lands, 2006 MoEF, GOI).

Nevertheless, in the present global context, documentation of country's traditional ecological knowledge (TEK) particularly those associated with natural resources has assumed high priority. Over the centuries, the tribal and other forest dweller communities have accumulated a rich and time tested traditional knowledge on the management of natural resources for their livelihood sustenance. The management practices adopted by these ethnic communities are ecologically and culturally suited to their habited.

More so, the entire North-Eastern region of India is well acknowledged for its 'Mega Biodiversity Hot Spot' zone of the world. The region is not only known for biological diversity but also has tremendous significant in evolutionary history of biological resources. Besides, it has high cultural diversity, as reports suggest that approximately one third of the ethnic groups of the nation are found in it. The rich cultural heritages of the region are well entranced with diverse traditional ecological knowledge, which help to manage the resource sustainability.

Irrespective of the conflicting opinions, shifting agriculture, which is densely woven with the socio-cultural fabric of the region, continues as the predominant land use system and primary livelihood option and often the only agricultural practice available to address the need for food security of the majority of the upland communities. Further, the amount of genetic material in terms of crop being maintained in shifting agriculture is tremendously higher than any other recognized agricultural systems that ensure dietary need of farmers in one hand and balancing soil ecosystem through various agronomic practices and at the same time the risk of genetic erosion has been reducing in a massive way. Therefore, it is imperative for synchronizing the traditional resource management strategies and customary practices of the shifting cultivators
with appropriate low cost, interventions and government policies, respectively, to make it ecologically, economically and socially viable.

Biomass assessment is important for national development planning as well as for scientific studies of ecosystem productivity, carbon budgets, etc. (Pandey, et. al., 2010; Parresol 1999; Zheng, et. al., 2004; Zianis & Mencuccini 2004). The analysis of biomass productivity especially on carbon stock is an important element in the carbon cycle especially, carbon sequestration. Recently biomass is being increasingly used to help quantify pools and fluxes of greenhouse gases (GHG) from terrestrial biosphere associated with land use and land cover changes (Cairns, et. al., 2003). The importance of terrestrial vegetation and soil as significant sinks of atmospheric CO₂ and its other derivatives is highlighted under Kyoto Protocol (Wani, et. al., 2010). Vegetation especially, forest ecosystems store carbon in the biomass through photosynthetic process, thereby sequestering carbon dioxide that would otherwise be present in the atmosphere. Undisturbed forest ecosystems are generally highly productive and accumulate more biomass and carbon per unit area compared to other land use systems like agriculture. It is estimated that the carbon stored globally in the forest biomass amounts to 2, 40,439 Mt with an average carbon density of 71.5 t ha⁻¹.

Biomass is an integral part of agro-ecosystem which is the dry weight of material produced by living organism or collection of organisms. Measuring biomass in crops is important for yield prediction, nutrient management and analysis of carbon sequestration. Studying crop phenology via biomass can also provide insight into not only the state of the ecosystem but also environmental factors which may affect crop growth. After harvesting of crop, the unused biomass left in the field will either be decayed fully by microbial activity (Prasad, et. al., 1985; Puri & Ashman, 1998; Bordoloi, et. al., 2013) or remain as humus content. The partially decomposed dead organic matters which not only maintain the soil health but also make soil more fertile (Puri & Ashman, 1998; Bordoloi, et. al., 2013). Carefully managed soils with a high proportion of humus offer essential advantages with respect to physico-chemical qualities in soil (Madgwick, 1981). Further high proportion of humus in the soil helps in uniform distribution of nutrients and also promotes plant hygiene (Sharma, 2002). The larger the quantity of biomass produced, the faster the cycling and decay processes take place (Gupta, et. al. 2009; Chauhan, et. al. 2011). A healthy, biologically active soil is the basis of this recycling process, requiring the replenishment of organic matter and nutrient removed by crop harvesting. A
nutrient deficiency problem therefore be solved by assessing and amending the physical and biological condition of the soil, the balance of rotation, and the suitability of farming practice before “imported” fertilizers, whether mineral or organic, are used (Sharma, 2002). A significant portion of terrestrial ecosystem, the biomass of which is studied for assessing the environment, are cultivated systems and agricultural/crop lands which cover at least 24% of the earth’s total land area (Reid, et al., 2005; DeFries, 2008). Monitoring and measuring biomass of agricultural crops is important because agricultural crops play a significant and unique role in the environment as a result of the management practices employed for agriculture.

Farmer’s wisdom of pedology and management dynamics is based on trial and error, problem solving and group approach to manage the natural resources. The farmer’s knowledge of defining the soil and fertility maintenance practices are compatible to their adaptive skills and rich source of location specific ecological information (Singh & Singh, 2005). Further farmer’s wisdom of soil classification and fertility management is one of the oldest concepts which have been used by local farmers from time immemorial. However, in the recent past, the changes in agriculture scenario and greed of getting high and quick yield through intensive cultivation by resource rich farmers have resulted in the decline of the fertility management dynamics in many pockets of Indian Himalaya. One of the major tailbacks for crop production faced by the resource poor farmer is the inappropriate location specific fertility management technology (Singh, 2001).

Sustainable development of rural area involves conservation of lands and management of water resources. With the increasing pressures of ever growing human and cattle population, increased living standards and the concomitant economic activities are exerting tremendous pressure on the finite natural resources. Due to lack of advance planning and non-judicious use of natural resources, ground water levels are getting depleted resulting lands are getting either degraded or turning in to waste land (Reddy & Vekateshwarlu, 2002).

Degradation of land and denudation of forest resources, instability in production, erosion of soil, and depletion of native fertility status necessitates a thorough understanding for sustainable agricultural development (Banik, et. al., 2006) for conservation of natural resources primarily the crop genetic materials for present and future generations. Further, report says that in recent past, the habitat of crop diversity has declined due to various developmental activities and also due to the introduction of HYV in Eastern Himalayan region (Dollo, 2007).
In view of the above, there is a necessity to understand comprehensively various issues related with crop diversity and biomass productivity in upland agriculture, practiced by tribal communities of Arunachal Pradesh. Through study of the Adi community living in Upper Siang, East Siang and West Siang districts of Arunachal Pradesh, an attempt has been made in this dissertation to understand the above stated issues through formation of various hypotheses.

1.2. Introduction of hypothesis

Since, there is no work on crop diversity assessment and biomass productivity estimation as well as the area is inhabited by ethnic community, hence it is imperative to prepare an account how environmental factors and local population is governed by the local ecosystem. Keeping these factors in mind the present study has been envisaged and designed the following hypotheses along with objectives.

Objectives of the study

Hypothesis: I

*Upland agriculture is known for its high agro-biodiversity*

Objective to the hypothesis: I

➢ To assess crop diversity of upland agriculture.

Hypothesis: II

*Agriculture is the principal livelihood sustenance for majority of the upland communities and it is known for ecologically efficient cultivation practices, when involving innovative TEK in agro-ecosystem management.*

Objective to the hypothesis: II

➢ To estimate the agronomic yield and biomass productivity of selected crop(s).
➢ To analyze the economic and energy efficiency of the agro-ecosystem.

Hypothesis: III

*Soil is an important component for better agronomic yield and biomass productivity in agriculture. Nutrient optimizations in upland agriculture manage the temporal nutrient requirements of the crop species.*

Objective to the hypothesis: III

➢ To analyze the nutrient optimizations practices and temporal variation in physico-chemical properties of soil.