CHAPTER II

LITERATURE REVIEW

2.1 Shifting cultivation

Shifting cultivation has been and continues to be practiced throughout the tropics. It is a land use system based on a traditional, year round, community wide, largely self-contained and ritual sanctioned way of life that is prevalent among tribal minorities in Southeast Asia and South America and a small, declining percentage of African farmers (FAO, 1991). Power and McSorley (2000) claimed that shifting cultivation or sometimes called slash and burn agriculture is a common subsistence method of agriculture. In addition, shifting cultivation is an indigenous technique which has been used on all of the continents which exists in various ecological conditions, from the upland to the plain, from the forest region to the grassland and in many countries around the world in the last thousand years (Spencer, 1966; Howard, 1996).

Linkham (2007) stated that shifting cultivation is a farming system where farmers move on from one place to another when the land becomes exhausted. The most common form is slash-and-burn agriculture: land is cleared by burning, so that crops can be grown. After a few years, soil fertility is reduced and the land is abandoned. A new area is cleared while the old land recovers its fertility. Rerkasem *et al.* (2009) confirmed that fallow improvement is managed to either (i) increase income from products harvested from the fallow or (ii) to improve soil fertility and weed suppression to increase productivity during the cropping phase, and often both at the same time.

Warner (1991) classified shifting cultivation into two types: (1) part time or partial shifting cultivation and (2) full time or integral shifting cultivation. In part time shifting cultivation or sometimes called as supplemental shifting cultivation, it has been done in both upland and highlands but mostly at the foot of mountains, with a lack of experience and lack of knowledge of sustainable agriculture. Full time shifting cultivation has been recognized as a major of occupation. The shifting cultivators rely on it for their livelihood. Furthermore, FAO (1984) mentioned that there are two distinct types of full time shifting cultivation: the rotation system and the abandonment type.

In rotation or established shifting cultivation system, it is normally done in secondary forests for 1-2 years, and then, cultivation moves to other places which have long been fallowed, and then, moves back to the same plots later. Farmers in this cultivation type do not need to move the whole village. This system is not harmful to the ecology or environment, but has a serious impact on the economy. In abandonment or pioneer shifting cultivation, it usually involves non-permanent villages that move into areas of primary forest and cultivated field intensively for a longer period, perhaps 10-15 years, fertility permitting or until most of the nutrients are severely depleted. In this case, fields and village sites are abandoned and moved to a new location in another area of primary forest. Typically, the loss of soil fertility and the intensity of cultivation greatly inhibit the natural process of the re-vegetation and succession, even after years of abandonment (FAO, 1984).

According to Pandey and Khiem (2002), in South eastern China and India there were more than 50 million peoples depend on shifting cultivation and use more than 100 million hectares of crops and fallow land. Moreover, Demaine (1994) stated that some 22 million peoples who were dependent on this form of agriculture cultivation on over 64 million hectares of which the largest concentrations were probably found in Indonesia, Vietnam and Myanmar. In Vietnam, three million people of fifty ethnic groups, but particularly Hmong, Dao, Bana, Ede and Giarai, practiced shifting cultivation on 3.5 million hectares where 2.3 million of these people are of non-integral shifting cultivators. The crops are grown in the field that purpose to produce staple food such as upland rice, maize, cassava, and taro. The majority is upland rice, and the area under uplands rice is reported to be 9 million ha; south Asia accounts for about 60%; the remainder being in south-east Asia. As upland rice is mostly grown in rotation with other crops, the actual area under upland rice based systems is much larger. Assuming a 3-year rotation, Pandey estimated the area under upland rice based systems in Asia to be about 15 million ha (Pandey *et al.*, 2005). The upland rice area in Asian countries ranges from 2% of the total rice area in Thailand and China, 11%-12% in Indonesia and India, and up to 36% in Lao PDR (Huke and Huke, 1997).

FAO (1984) specified about the advantages of shifting cultivation that it took less or even no external inputs like fertilizers and insecticides. It used only traditional technologies inherited from generation to generation, and used simple hand tools available in local areas that they try to use of available natural resources. This farming system includes hunting and fishing, which makes the livelihood sustainable, especially when rotational cultivation, is practiced with long fallow periods. In contrast, the shifting cultivation with the periods of fallow of more than five years, especially where the cultivation phase is about two to three years, may marginally rejuvenate the soil. But as the intensity of cropping increases, the various degradations above were set in, bringing to soil erosion, loss of fertility and productivities into a permanent decline.

Furthermore, it has been accused of causing deforestation and keeping farmers in poverty (Mertz *et al*., 2008). In addition, being a farming system that relies on field crop production, shifting cultivation cannot be expected to be more environmentally friendly than natural forest, but it would in most cases provide more and better environmental services than other more intensive farming systems (Neergaard *et al.*, 2008). Phouthone (2005) stated that shifting cultivation is the traditional farming system in the uplands in Lao PDR, occurring on some extreme slopes (of up to 120%), but usually confined to gradients of 15% to 60%. The practice was considered to be a permanent upland farming system in the past when fallow periods were of sufficient length. However, increased population density has contributed to shorter fallow periods, leading to widespread problems of weed infestation, soil erosion and declining yields.

Trenbath *et al.* (1985) attempted the model for shifting cultivation with respect to soil fertility and vegetation change. He stated that long fallow regeneration (10-20 years) would allow shifting cultivation to be sustainably functioning within mature forest domain and intensification of shifting cultivation due to shortening of fallow periods resulting from increasing population growth may threaten the system to collapse. As Bandy and Garrity, et al (1993) pointed out that under low population pressure, swidden-farming is a sustainable agricultural system, but under increased population pressure and shorted fallow periods the system becomes unsustainable. The critical duration of fallow regeneration is at least 8-10 years required to maintain soil fertility (Nye and Greenland, 1965; Sanchez, 1976; Zinke et al., 1978) and is more than 10-15 years to achieve a satisfactory level of weed control (Nye and Greenland, 1965; Ramakrishnan, 1992). However, Rerkasem (2001) reported that Karen community farmers have found a local pioneer tree species (*Macaranga denticulate*) that could contribute to the sustainability of shifting cultivation through productive regeneration of secondary forest and nutrient cycling of the system under 6 years of fallow re-growth. Ranjan and Upadhyay (1999) noted that the forest cover area was lost in the northeastern states in India was mainly due to the shifting cultivation with reduction in fallow cycle from 20–30 years to 2–3 years, the land under shifting cultivation looses its nutrients and the top soil. With reduction in crop yield, the families start moving to other virgin areas. Now, a stage has come that it has already affected 2.7 million ha of land, and each year 0.45 ha of land fall under shifting cultivation, in northeast India.

Since shifting cultivation has been conducted in different locations, altitudes, environments, and with various resources available, it is different from place to place and from country to country. Recently, shifting cultivation as a form of forest destruction is also becomes a social, economic and legal problem. In addition, since rotational slash-and-burn agriculture requires an abundant supply of forested land for cropping, forested areas have been encroached. In addition, Rasul (2006) also mentioned that the growing population and state control over forest have been shortening the fallow period in most parts of Asia that creating serious pressure on shifting cultivation systems, which destabilizes the system. Further, there were growing evidence shows that shifting cultivation with short fallow accelerates deforestation, soil erosion, soil nutrient depletion and biodiversity degradation and adversely affects the soil's physical and chemical properties. Therefore, this practice is no longer sustainable and needs to be replaced with dynamic farming systems. In order to reduce the problems associated with slash-and-burn agriculture, there have been increasing efforts to promote the adoption of agroforestry among smallholders.

Power and McSorley (2000) argued that there are some steps that can be taken to improve productivity and sustainability of the system and some of these steps can actually lead the growers away from a shifting cultivation system to agroforestry system, which may be more sustainable in the long run, e.g. planting crops that will improve the soil and nutrient level of the land, reduce the need of fallow through keeping the ground covered by multiple cropping to reduce weeds and to keep diversity high, and use tree crops or multiple-story crops to intercrop with food crops.

2.2 Agroforestry systems

Lundgren (1982) and ICRAF (1993) claimed that the agroforestry refers to land-use systems in which trees are grown on the same land as agricultural crops and/or animals, either in a spatial arrangement or a time sequence, and in which there are both ecological and economic interactions between the tree and non-tree components. Houmchitsavath *et al.* (2005) stated that agroforestry practice is the integrated trees or woody perennials with crop and/or animal production fields. These techniques include hedgerows, intercropping, home-gardens, alley cropping, silvopastoral systems, and improved fallows. In addition, agroforestry is perceived to be a system that promotes high and sustainable crop production and reduces soil erosion (Tamubula, 2000).

Agroforestry system combines agriculture and forestry technologies to create more integrated, diverse, productive, profitable, and sustainable land-use systems. It also can help eradicate hunger through basic systems of poor-resource farmer production by soil fertility replenishment and land regeneration (NAFRI, 2006) as follows:

- Reduce rural poverty through market-driven, locally led tree cultivation systems that generate income and build assets;
- Advance the health and nutrition of the rural poor through agroforestry systems;
- Conserve biodiversity through integrated conservation and development solutions based on agroforestry technologies, innovative institutions and better policies;
- Protect watershed services through agroforestry-based solutions that reward the poor for their provision;
- Enable the rural poor to adapt to climate change and to benefit from emerging carbon markets, through tree cultivation; and
- Build human and institutional capacity in agroforestry research and development

In the mountainous mainland Southeast Asia region, forest management skills are gradually adapted and incorporated as the cropping systems evolve (Rerkasem, 2009). Rasul (2006) verified that agroforestry is considered to be environmentally suitable for the mountainous areas of Bangladesh as the rate of soil erosion under such systems is considerably less than slash-and-burn agriculture. Therefore, he suggested that agroforestry, a land use system characterized by growing different species of woody perennials in association with field crops, is an alternative land use suitable specifically for the mountainous regions where shifting cultivation is widely practiced.

Beetz (2002) claimed that agroforestry is a farming system that integrates crops and/or livestock with trees and shrubs. The resulting biological interactions provide multiple benefits, including diversified income sources, increased biological production, better water quality, and improved habitat for both humans and wildlife. Agroforestry involves combining a tree planting with another enterprise, such as grazing animals or producing mushrooms or managing a woodlot for a diversity of special forest products e.g. an agroforestry system might produce firewood, biomass feed stocks, pine-straw mulch, fodder for grazing animals, and other traditional forestry products. At the same time, the trees are sheltering livestock from wind or sun, providing wildlife habitat, controlling soil erosion, and in the case of most leguminous species for fixing nitrogen to improve soil fertility.

According to Beetz (2002), agroforestry practices in use in the United States include alleycropping, silvopasture, windbreaks and shelterbelts, riparian buffer strips, and forest farming (special forest products)

a) Alley-cropping

Alley-cropping involves growing crops (grains, forages, vegetables, etc.) between trees planted in rows. The spacing between the rows is designed to accommodate the mature size of the trees while leaving room for the planned alley crops. In most alleycropping systems, trees are planted in straight rows, sometimes with no regard for slope or contour. There are, however, advantages to planting the trees in curves or on the contour because of it can help for the slowing of surface water movement and the reduction of soil erosion.

b) Silvopastoral

Tree-animal systems or forest and livestock grazing include the intensive management of forages grown with trees. This practice can yield economic benefits as well as improve wildlife habitat, soil protection and forest management. Grazing livestock on silvopasture eliminates some of the costs of tree maintenance. With good grazing management, grazing also enhances nutrient cycling and reduces commercial fertilizer costs i.e. the animals remove few nutrients, and their waste is a valuable input for the trees. Well-managed grazing will increase organic matter and improve soil conditions.

c) Shelterbelts or Windbreak systems

Trees are planted in single or multiple rows along the edge of a field to reduce wind effects on crops or livestock. The purposes are to protect soils from wind erosion, enhance production of crops and animals and stabilize microenvironments. Windbreaks can be designed specifically for sheltering livestock. Many Studies in use of windbreaks have shown the economic advantages of providing protection from wind chill, a major stress on animals that live outside in the winter. Likewise, reduced feed bills, increases in milk production, and improved calving success.

d) Riparian buffer strip systems

This combines vegetative types in areas alongside streams and rivers. These systems may be used to regulate microenvironments and protect fish habitats or to regulate waterway pollution from nonpoint sources. This is accomplished by reducing summer water temperature, trapping sediment and filtering and storing nutrients. In addition, these areas protect and enhance the aquatic environment as well. Shading the water keeps it cooler, an essential condition for many desirable aquatic species. Buffer strips also provide wildlife habitat and can be managed for special forest products

e) Forest farming and special forest products

Natural forest specialty crop systems and/or forest farming provide suitable microenvironments in managed natural forest stands for growing specialty crops. Besides producing saw timber and pulpwood, woodlands can generate income from many other products. Established forests offer many non-timber "special forest products" that contribute to cash flow without requiring the one-time harvest of old trees e.g. fruits, nuts, berries, honey and other hive products, mushrooms, herbs and medicinal plants, materials for basket-making or chair-caning, pine straw, boughs, pinecones, bamboo, aromatics, fencepost, firewood, decorative or odd wood (e.g. burls, dye materials

2.3 Assessment of adoption in agroforestry

Farmers adopt agroforestry practices for two reasons. They want to increase their economic stability and they want to improve the management of natural resources under their care (Beetz, 2002). There were some findings from many countries by many researchers regarding the assessment of agroforestry adoption.

McGinty *et al.* (2008) in their study for agroforestry adoption in Brazil found out those socio-economic factors especially the issues of money and other resources affecting farmers to the adoption of agroforestry. The logistic model that they used indicated that age and income significantly contributed to farmers' intentions to adopt or maintain agroforestry. Addressing young, low-income farmers in agroforestry development programs proves to be the key in this context holding everything else constant. Younger farmers may be more risk taking even though older farmers may have more experience. However, the more complex, multi-dimensional socio-psychological variables, attitudes and self-efficacy, capture subtleties of personality that play into land-use decisions. They have proven to contribute more significantly to farmers' decisions to adopt agroforestry than other socio-economic factors. The resulting models of this study indicate that attitudes about conservation and perceived behavioral control play an important role in farmers' intentions to adopt or maintain agroforestry.

Kiptot *et al.* (2007) presented a study of the dynamics of improved tree fallow use by farmers in Siaya and Vihiga districts of western Kenya over a period of eight years. Both qualitative and quantitative data to critically discuss the motivations of adopters, testers/rejecters and re-adopters were used. The results showed that the process of adoption was highly dynamic and variable with farmers planting improved fallows and discontinuing or re-adopting them due to a whole range of factors such as incentives from projects, the tying of adoption to credit programs, prestige, participation in seminars/tours and the availability of a seed market from projects promoting improved fallows. Farmers planting improved fallows for such reasons may be termed 'pseudo-adopters'. This has some important implications for research and development. For improved fallow technologies to be attractive to farmers, they must provide other tangible economic benefits besides soil fertility improvement. This presents a challenge to researchers who must better attune themselves to the needs and demands of farmers if they wish to see their research findings widely adopted.

Rasul (2006) assessed the financial and economic benefits of agroforestry and slash-and-burn agriculture in Bangladesh based on three criteria such as: benefit–cost ratio, net present value, and return to labor. To make the cost-benefit analyses of slash-and-burn agriculture and agroforestry comparable, a 12-year time horizon was considered with three slash-and-burn agriculture cycles, and with 3–4 years for each cycle. Costs and benefits were analyzed based on inputs used and farm-gate prices of produce sold. The cost of labor was estimated based on the opportunity cost of labor, which was based on the prevailing rates of payment for male and female wage laborers.

Shrestha *et al.* (2004) analyzed the prospects and challenges for silvopasture agroforestry adoption in south-central Florida, USA, by using the strengths, weaknesses, opportunities, and threats approaches (SWOT) in combination with analytic hierarchy process (AHP) methods. It was found that land stewardship and diversification of income as major strengths of agroforestry and environmental benefits and government support for agroforestry practices as important opportunities. While long-term investment requirement and poor-quality soils are identified as weaknesses for the adoption of agroforestry, government regulation relating to land-use practices is considered as a critical threat.

Fischer and Vasseur (2002) in their study regarding smallholder perceptions of agroforestry projects in Panama, found that smallholders' attitudes, needs, preferences and traditional knowledge are crucial factors in determining the success of adoption of agroforestry with a participatory approach in project planning and implementation.

Franzel *et al.* (2001) assessed the agroforestry adoption in sub-Saharan Africa by profitability indicator with methods of partial budget, enterprise budget, sensitivity analysis, farm model; and acceptability indicator that assessed by using resource budget, evaluation of quality of practice, survey of farmer problems, farmer assessment survey, risk assessment, monitoring expansion, matrix scoring, and decision tree methods.

2.4 Farming system assessment and decision making

An understanding of the household and farming situation is important, because it serves as a basis for judging whether a technical change represents an improvement, and to assess this, three types of analysis are important, i.e. technological, economic and social analysis (Norman *et al*., 1995)

- ***Technological analysis*** is used to determine if the new technology is practical in a technical sense.
- ***Economic analysis*** is used to determine if the farmer will receive a greater economic and more stable return from adopting the technology. Part of the economic evaluation is an assessment as to whether the farmer has enough resources available to adopt the technology or can acquire them by borrowing or receiving a government subsidy to facilitate adoption.

Zandstra *et al.* (1981) commended that the profitability of both technologies will be used to assess economic viability. The net return or gross margin of farm households will be used to measure the profitability of each technology. These average net returns then can be compared between technologies; some scientists believe that the return for a new technology must be at least 30 percent higher than that for the traditional technology before farmers will adopt it.

- ***Social analysis*** is used to determine if the technology is acceptable within the household (i.e., intra-household) and overall village (i.e., inter-household) situation. Socio/cultural analysis looks at the technology in a whole farm, analyzes acceptability for the various members of the household who are involved with the technology, determines if there are cultural factors that influence acceptability, examines consumption/ nutrition implications, etc.

Edwards-Jones (2006) claimed that the decisions made by farmers may have large influences beyond the farm boundary, and they are often of interest to government and the public. The process of adoption of new technologies and policies has received considerable academic attention over many years, and this has highlighted the role of social influences in decision-making.

Janssen and van Ittersum (2007) determined that the farmer decision making can be classified as operational, sequential and strategic decision making, with an increasing time horizon of the decision at stake. **Operational decisions** are the day-by-day management decisions during the growing season, such as deciding whether to mow a pasture or spray a crop depending on the weather forecast. **Sequential or tactical decision making** relates to decisions within a growing season and to the fact that decisions on crop choice and technology are of a sequential nature. For example, a farmer may decide to use relatively more inputs on his onions during the growing season than foreseen at the start of the growing season, if he notices during the growing season that onion prices are increasing. **Strategic decision making** has an impact on the structure of the farm over many years, such as the choice between conventional and organic farming and investment decisions.

On the other hand, Backus et al. (1997) claimed that, a decision in general involves four steps: (1) perception of needs or opportunities; (2) formulation of alternative courses of action; (3) evaluation of the alternatives; and (4) choice of one or more alternatives. People face decision problems when they have alternatives in choosing, each with significant consequences, and when they are unsure about which particular choice is best.

Shinawatra *et al.* (1987) and Calavan (1970) argued that farmers were economically rational and their decision to plant crops which will yield the highest cash return, which can be 1) the highest return per land unit or 2) the highest return per labour unit. Farmers with limited amount of land would choose the crop which provided the highest returns per land unit while farmers with limited amount of labour would choose the crop which would provide the highest return per labour unit. In addition, a household's decision on which crop to be grown will have to be related to the household's resources, namely, land, labour, capital, cash, skills, and other social factors.

Several researches and classification of both the shifting cultivation and IRFS system were reviewed in this chapter from many countries. Shifting cultivation was presented as the suitable practice for upland area in the past with a long fallow period, but increasing population and recent factors have shown that it is no longer sustainable, nor friendly environmental practices. On the other hand, agroforestry has been verified a good practice for upland agricultural system in many countries depending on appropriated conditions. The assessment of agroforestry adoption in several points of views as well as farming system assessment and decision making were reviewed in the chapter.