2. LITERATURE REVIEW

2.1 Conservation practice on the steep land

Many agencies in the Northern Thailand have tried to develop vegetation conservation practice on the steep land. The concept of agricultural development is to integrate the soil-water conservation into the cropping systems. The practice will protect soil erosion, enrich soil fertility, use less external inputs and stabilize crop yields in short term and long term. Strip cropping is first introduced with leguminous crops as crop rotation along the contour. This practice was found to be less effective on conservation because field crops could only provide 4 to 5 months ground cover after which the soil would be subject to erosion. It is therefore suggested that growing the row of perennial crops would be more suitable. (Inthapan, 1988).

Grass strip cropping is the method developed by Thai-German Highland Development Project (TG-HDP) and Department of Land Development (DLD). Grass strip can stand over years, be used for animal feed and has been proved to be most effective in reducing soil loss when compared with farmers' own practice on upland rice fields. But it needs proper management to control grass growth otherwise it can turn to be a weed problem (Inthapan et al., 1988).

Alley cropping is the most recent introduction for rehabilitation of steep land agriculture. This system is first introduced by non-governmental organizations (NGOs). There are at least 13 NGOs working on alley cropping for rehabilitating steep land which cover many areas of Chiang Mai, Chiang Rai, Lampoon, Tak and Nan Provinces. The pioneer organizations are the Mckean Rehabilitation Institute, Care-Mae Chaem Agroforestry Project and Project for Ecological Recovery. Most of them have studied on the species of trees or shrubs and the management of hedgerows. The studies also include the cropping pattern management such as crop rotation with legumes, relay cropping maize and black bean and integrated fruit trees in the system. The DLD is the leading governmental agency to conduct the alley cropping research which is at present being conducted in 4 sites in Chiang Mai and 2 sites in Lampang and Mae Hong Son Provinces. Part of the DLD research work is to collaborate with other development agencies particularly Thai-German Highland Development Project which conducts extension work on alley cropping since 1988 in Mae Hong Son after grass strip was found to be not so successful. Thai-Australia World Bank Land Development Project (TAWLD) and Thai-Norwegian Project have also adopted alley cropping as one of their conservation farming practices.

There are also other agroforestry practices which are conducted by the Royal Forestry Department whereby the perennial crops or forest trees are integrated into the agricultural systems. Backyard gardening systems, growing coffee or tea in the forest or with the fast growing trees and the multi-purpose trees are shown to be the suitable agroforestry practice in the northern Thailand.

2.2 Role and function of alley cropping

Shifting cultivation or the bush fallow system is widespread and important to the livelihood of so many people in the Tropics (Nair and Fernandes, 1984). It will be virtually impossible to dispense with it completely. The system which has two main weaknesses, the extravagant use of land resources and the prolonged unproductive fallow (Kang et al., 1981) will not be possible under high population pressure and low soil productivity. It needs a crop to fallow time ratio of at least 1:5 for effective restoration or 3 year of cropping following by 15 years of fallow (Lal, 1986). Therefore the alley cropping is designed to optimize positive interactions among trees/shrubs and crops/animals and environment so as to obtain diversified and sustainable production.

Alley cropping or hedgerow intercropping is essentially an agroforestry system. It refers to cropping system where arable crops are grown in the interspace (or alley) between rows of planted trees or woody shrubs, which are pruned periodically during the cropping season to prevent shading and to provide green manure and/or mulch to the arable crop. When there are no crops, these planted trees are allowed to grow freely to cover the land (Kang et al., 1984; Nair, 1984).

An important aspect of alley cropping is its effect on sustaining crop production and the role that it can maintain and improve soil productivity. An essential component of the system is the woody species particularly the leguminous tree species such as *Leucaena leucocephala*. The perennial woody species has deep-rooted system that can uptake nutrients from subsoil and store them in above ground biomass (Nair, 1984). Leguminous species such as *Leucaena leucocephala* can also supply nitrogen through fixation from the air. Part of these nutrients will return to the surface soil through litter fall and hedgerow pruning which are often used as green manuring and mulching. It has been claimed that by maintaining a ground surface cover of 60% or more through the period of erosion by a combination of living plant cover, crop residues and tree pruning will give effective soil erosion control (Young, 1988). Decomposition

of this organic matter will release plant nutrients to benefit companion crops, has effect on increasing microorganisms' activity in the root zone and has associated effects on soil physical properties for being a better medium for plant growth (Avery, 1987; Nair, 1987).

Effective slope length can be reduced by the hedgerows barriers to runoff. Litter fall against the upper soil will form an effective filter for the soil. Hedge barriers differ from ditch and bank structures in being partly permeable because of spacing between plants, so the hedges will not be damaged and over time, when soil eroded from the clear strips between contour rows lodge against this living fence such that, natural terrace will form. An important advantage of the hedgerows over man made terrace is that the hedgerows use fewer capital and manpower inputs to establish, operate and maintain (Vergara, 1987; Young, 1988).

The performance of crops has been wildly studied on leucaena species with maize and other crops. Maize-leucaena alley cropping systems can be operable as a low nitrogen input system, in which maize yield can be sustained about 2 t/ha with continuous application of leucaena pruning only. To obtain higher maize yields, supplementation with

nitrogen fertilizer, though at the low rate, is still needed (Kang, 1981; 1985).

The various pruning intensities of hedgerow species will affect biomass production and alley crop yields. Biomass from the hedgerows pruning will increase with decreasing pruning frequency and increasing pruning height while higher grain yields of alley crops will be obtained with increasing pruning frequency and decreasing pruning height (Duguma et al., 1988; Mittal et al., 1989). Leucaena hedgerow intercropping will give dry matter yield between 1.6-8.0 t/ha/year with nitrogen yield between 114-250 kg N/ha/year at 2-5 m. row spacing with 25 cm. between plants and one-two monthly pruning at 25 cm.-1.5 m. height (Kang et al., 1981; Duguma et al., 1988; Gutteridge, 1988). The nutrient levels of leucaena leaves are contained with 3.0-3.7% nitrogen, 0.22% phosphorus, 1.52% potassium, 0.92% calcium and 0.31% magnesium (Budelman, 1989).

Economic evaluation of labor utilization for the management of leucaena hedgerow was studied by Ngambeki (1985). The result showed that although the management of leucaena tree increased labor requirements by about 50%, the system could sustain and increase maize yield by 60%, reduce the use of nitrogenous fertilizers and give an attractive net income and marginal rate of return per unit

cost. It gave a reasonable benefit-cost ratio of 1.23 to 1.32 and seen promising especially for maize production in tropical area.

2.3 Key Issues for alley cropping development

The alley system is attractive because of its inherent flexibility and many apparent advantages. It can accommodate a wild range of farmers' goals and objectives, which may vary from farmers to farmers and from different environment conditions. However, this alley farming will create a complex management picture because it consists of at least two components, trees and crops which will have an interaction. Therefore, the relative management variable is needed to be considered such as choosing appropriate crops and tree species, management of trees and soil, crop management practices for annual food crop and the proportion of land area needed to be allocated to trees so that ecological stability is maintained with intensive use of the remaining land as an arable area (Sumberg et al., 1988 ; Lal,1989).

An important aspect for farmers and researchers for further development is to understand the range of alley farming management options, and the ways in which these options can be used to fulfil a variety of objectives. In

detail, the kind of issues which needed to consider for this understanding are related to the conditions under which the basic components of the alley farming can be made to work and the condition under which this alley system as a whole becomes interesting or valuable to farmers (Sumberg et al., 1988). Therefore, the local specific research is needed to develop appropriate alley cropping for different soils, crops and ecological environment. Furthermore, the assessment of farmers' interest in this technology will help design a better and manageable alley cropping system.

2.4 Phosphate requirement to sustain high crop yields on the highland soils

Phosphorus fixation in an unavailable form has always occurred in many tropical soils, and phosphorus is commonly found to be deficient under shifting cultivation area (Sunchez, 1976). Hiranburana (1986) found that under upland condition, soil containing less than 15 ppm. extractable phosphorus should be supplied with phosphate fertilizer according to the degree of deficiency.

Legume crops such as soybean and peanut are often grown by the northern Thai farmers as component crops in alley system. However, legume crop yields on the sloping land are still lower than that of lowland. The critical

content of phosphorus for peanut was found to be 0.21-0.22 % while for soybean, it was 0.35-0.36% (Hiranburana et al., 1989 ; Hiranburana, 1990). The data of upland and highland soils have shown that available P is low (DLD, 1985). It seems that to sustain productivity of leguminous crops at higher level, additional phosphorus fertilizer is needed.

2.5 Farmers' opinion on conservation farming practice

Soil erosion is usually seen by the development agencies as the major problem on the upland-highland environment. Many research work has developed appropriate conservation farming practices to the farmers, but only a few has adopted the practice.

The case study by Cantor (1990) in Nan Province revealed that of 240 farmers from 8 different upland villages, 43 % of sample farmers did not perceive they had a soil erosion problem. The remaining 57 % perceived they had this problem and 60 % of this farmer rated the problem as moderate. Only 31 % of all farmers considered that erosion trend on their own fields over ten years period was increased because of a decline in the amount of tree and soil cover, and increase in cultivation. The primary possible solution for soil erosion which was designed by the farmers are tree planting because it can reduce erosion and

has more suitability on their farm than making terraces or alley cropping or contour farming. The fruit trees could also be used for home consumption and increasing farmers' income.

In case of alley cropping, the interview found that this system was not easily understood or visualized by sample farmers, and it was obvious that some aspects of alley cropping such as growing rows of trees with only marginal economic benefit seemed strange and irrational to many of these farmers. Alley cropping was not considered to be a very suitable conservation measure with the reason on lack of information, lack of resources, time consuming and the alley rows would lead to a reduction in the yields of main food crops through competition for nutrients, sunlight and/or water.