Chapter 2

LITERATURE REVIEW

2.1 Constraints of upland farming.

Upland farming is the activity deserving in-depth investigation since it involves solutions to the internal problems of the less privileged sector. An urging challenge facing scientists working on upland food-crop production in many parts of the humid and subhumid tropics is the need to find viable, sustainable, and environmentally sound alternatives to the ancient shifting cultivations. Reason of alternatives is because these systems which has main weaknesses: (1) The extravagant use of land resource and prolonged unproductive fallow will not be possible under high population pressure and low soil productivity (Kang et al., 1981). Potential and actual misuses of steep lands have caused worldwide concern about widespread deforestation, soil degradation and erosion. The most extensive limitation on slopes often encountered, and the stability of soil productivity after cleaning is often low. Calculation using the universal soil loss equation indicates soil losses of 500 tones per ha per year or more (Cook, 1988); (2) A second major concern on steep lands is a pronounced dry season. During the long dry season, plant cover is either sparse or nil, the soil exposed to the first intensive rains of steep lands, a perfect setting for erosion; (3) Steep lands also have soil fertility problems. Most of upland are high acidity, low nutrient reserves and high in exchangeable aluminum toxicity, and low in phosphorus.

The lack of soil organic matter content and the present of structurally inactive iron oxides in some soil made them susceptible to crust formation. The crust encourages water runoff overland that leads to gully erosion. Leak of a silt fraction in some tropical soils and amount of quart and skeletal materials make these soil structurally inert (Lal, 1978).

The effects of slope characteristics (length, gradient, and other aspects) on run off and soil erosion were shown by Lal (1976) in Table 1.

Table 1: Effects of slope aspects on water run off and soil loss on bare plowed soil

Time	Items	12.5 m long		37.5 m long	
		Slope 10.0 %	19.2 %	9.3 %	13.4 %
First season 1974	-Run off(mm)	320.7	260.4	175.6	357.3
	-Soil erosion (ton/ha)	77.3	34.6	114.3	68.6
Second season 1974	-Run off(mm)	162.4	140.7	52.3	52.7
	-Soil erosion (ton/ha)	32.3	14.0	40.2	26.8
	-Slope	Regular	Concave	Convex	Complex

(Source Lal, 1976)

In addition, in the tropics which expose to high temperature throughout the year affects soil erosion in both directly and indirectly. They cause rapid mineralization of soil organic matter, adversely affecting soil structure and other biotic activities, also increase evapotranspiration.

Constraints of upland farming are also caused by social factors as lack of information of soil conservation technologies, and suitable policies as well as farmers' poor knowledge and economics. All of the problems are causes to reduce productivity and sustainability of upland farming system.

2.2 Some methods for solving upland farming problems

Some key methods that have been researched and applied for soil conservation on steep land as follows:

1. Making terraces to avoid or reduce runoff.
2. Stripcropping and grass strips (contour planting, hedgerow, multiple cropping etc.)
3. Gully control.
4. Residue mulch.
5. Cover crops and *in situ* mulch.
6. Cropping patterns.
7. Soil condition, no-till farming.

To discuss these methods, we should consider that upland farming is in the low input condition. Although method of making terrace is good for soil conservation and it also requires more capital and labors that farmers can not afford to pay.

A cheaper and practical method which may be accepted by farmers is alley cropping with a suitable cropping pattern. This method is one of agroforestry system which has been introduced to improve the brush fallow system and has been extended to selected villages in many countries (Lal, 1988).

2.3. Alley cropping: the potential practice for soil conservation

Alley cropping is a known designed to optimize positive interactions among trees/shrubs and crops/animals and environment so as to obtain diversified and sustainable production (Lal, 1986)

Alley cropping is an attempt to integrate traditional forest management practices and natural nutrient cycling processes into a more intensive productive and sustainable farming system. It is also the simplest soil erosion control structure. This living wall of plants slows down the passage of rain water and traps soil to slowly form natural terraces.

Watson et al., (1988) have constructed the model of Sloping Agricultural Land Technology (SALT). It is combination of crops and woody leguminous species in which woody leguminous trees grown as hedgerows and crops grown in the alleys which combines the features of soil and water conservation, and crop diversity. SALT is one example of technology of alley cropping or contour farming.

Huxley (1986) built a hypothetical model of responses of surface soil fertility to change over time under 100 % tree cover or all ratios between hedgerows and crops. Model showed that one of three responses could occur, either a decrease in soil fertility under condition of agriculture (crop grown only); or a much greater improvement in soil fertility under the full cover of trees (fallow); or a relatively smaller decrease in soil fertility as a result of the mixture of trees and crop through the alley cropping (Figure 1).

In Figure 1, the vertical axis represents soil fertility status, it changes over time (years). Soil fertility decreases under condition of full crop cultivation (E to I) and improves under condition of full tree cover (H to J). As modeled, at the end of the time shown, the level of the soil fertility would be maintained by the ratio of 75 % tree cover, indicated by the arrow (1) on FG line. A 25 % tree cover (hedgerows) would give the fertility indicated at arrow (2).

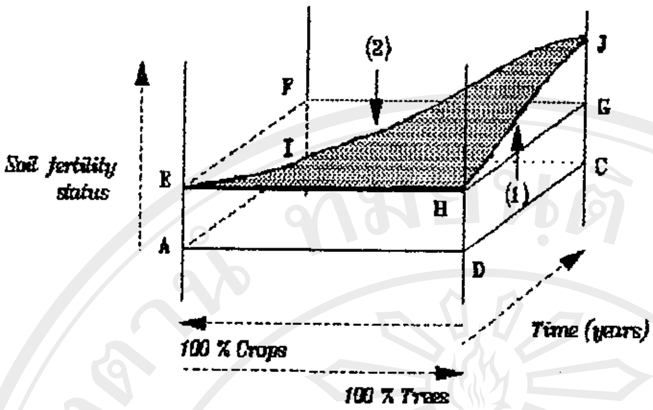

Figure 1 Hypothetical responses surface for changes with time in soil status under 100 % agricultural crops (left), 100 % tree cover (right), and all ratios between (Huxley, 1986).

In comparison, a brush-fallow system with a fallow period of 12-15 years followed by 3 or 4 years of cropping, is equal to rate of 80 % or more of tree cover (Huxley, 1986).

On research, however, the multi-faceted aspects of alley farming created what would appear to be a very complex management pictures. Much of experimental work has centered around tree-related variables as: tree species, alley width, tree population, tree establishment method, tree pruning height, tree pruning frequency, utilization of pruning, and the usual crop management variables as cropping patterns, field practices may also need to be reconsidered.

The success of alley farming depends on choice of hedgerow species. The basic characteristics required for an alley cropping tree species have been listed by Kang et al., (1984) i.e. ease of establishment, a deep root system, fast growth, tolerance to pruning, ability to coppice vigorously, high foliage productivity, nitrogen-fixing ability, completed with a high folio nitrogen content and a rapid decomposition rate are highly desirable for maintaining soil fertility.

Long term studies of alley cropping system on tropical Alfizol soil at natural slope of 12 percent have shown a positive effect on surface soil layer. Its soil moisture content, infiltration rate are higher (Lal, 1989), and less decline of soil organic matter than those of non-alley cropping. The runoff and soil erosion rate were reduced also from 4.3 to 0.1 tons/ha (Lal, 1989).

On the aspects of crop yield, the performance of crop yield have been widely studied on *Leucaena leucocephala* intercropped with maize in which maize yield is two tons per ha with continuous application of *L. leucocephala* pruning only.

However, in other research of Kang et al., (1981) showed that despite the high nitrogen yield from the pruning of leguminous hedgerows, the benefit from the nitrogen of pruning added to the food crop was less than 50 %.

On the aspect of economic evaluation of labor utilization for the management of alley cropping, Ngambexi (1985) showed that although the management of hedgerows (*L. leucocephala*) increased labor requirement by about 50 % but the system could increase maize yield by 60 %; reduced the use of nitrogen fertilizers; and increased marginal rate of return per cost of 1:23 to 1:32. These look promising especially for maize production in tropical area.

Benefit of alley cropping has long been recognized and it has been practiced in various forms over the ages. These are also the results of long term efforts in integrating traditional and modern emerging technologies. However, we also have to consider constraints of alley cropping techniques as how competition between trees (hedgerow) and crops is in growing process? What is optimal alley width or pruning schedule and so on. Specially, two kinds of issue must be considered: Which basic components of technology can be used to work, and how technology can become valuable to farmers. It is important to understand the conditions under which trees can be successfully established as well as soil related factors of soil, established year, crop combination and time of planting.

2.4 *Tephrosia candida* as potential woody leguminous species in alley cropping

T. candida has been researched in some places of tropical region. It is about 200 to 250 cm high at maturity. *T. candida* can tolerate well to drought and cold conditions. Kang et al., (1981), Wilson and Kang (1981) tested some leguminous trees for hedgerow of which *T. candida* was showed as potential leguminous tree (Table 2). On the other aspect, *T. candida* needs more time for decomposition than other crops. This can help increase its role in controlling soil erosion.

In Viet Nam, *T. candida* has been commonly grown in the mountainous areas. It can grow well in acid, and poor soil. *T. candida* can also tolerate pruning because of its good ability to coppice. After establishment in the hedgerow it takes a role as barriers to prevent water runoff at high rainfall condition (about 1800 mm to 2400 mm per annum).

Table 2 Nitrogen contribution by various leguminous-woody species interplanted with maize in alley cropping trials at IITA.

Spices	Leaf yield dry weight (kg/ha)	N content %	N content (kg/ha)
Gliricidia sepium	2300	3.7	84
Tephrosia candida	3067	3.8	118
Cajanus cajan	4100	3.6	151
Leucaena leucocephala	5000-8000	3.2-3.5	180-250

(Source: Kang et al., 1981, Wilson and Kang, 1981)

T. candida is often grown with tea, cassava, fruit trees as intercropping in Bac Thai, Vinh Phu, Lang Son and other provinces of

North Viet Nam. Its leaves and branches are used as green manure.

Advantage of growing *T. candida* as alley crop was reported by Dau and Tien, (1991). *T. candida* intercropping with cassava and peanut (at Bac Thai) can supply over 10 tons of green materials per ha and increase peanut, cassava yield of 15 % and 32 %, respectively.

2.5 Cropping patterns on upland in the northern mountainous region of Viet Nam

Farming in the upland of the North mountainous region of Viet Nam has been self-sufficiency driven. The long struggle for subsistence in these regions have resulted in disastrous environmental degradation. So far most government efforts were concentrated in assisting the indigenous people in their traditional cultural practice of monocropping food gain and tubers such as upland rice, cassava, yam, sweet potato, peanut and mungbean. These crops are highly adopted to condition of the upland weather and soil. Simultaneously, they are also very necessary for farmers in self-efficiency and low input condition.

In the past, research and development for upland regions had received low priority, most research so far were concentrated on varietal adaptation of rice, coffee and tea, and application of *in situ* irrigation methods for high yield rice production in the terraces. Compared with lowland rice yield in the terraces which is about 3.0 to 5.0 tons per ha, upland rice yield is low i.e. 0.7 to 1.5 tons per ha.

Recently, some methods of cropping systems have been researched such as SALT model; intercropping cassava-peanut, corn-peanut and cassava-legumes, those have shown as potential cropping systems.

In almost all the provinces surveyed by Xuan (1991), farmers practiced some kinds of integrated farming as upland rice was directly broadcasted or drilled in furrows. A number of household cultivated crops mixed with their exotic tree (cassava, tea, under cinnamon plantation in Bac Thai, Quang Ninh, Lang Son provinces); some farmers planted upland rice with corn, peanut, mungbean, sesame, millet, or cassava in intercropping in Quang Ngai, Song Be, Lai Chau provinces (Xuan, 1991).

In summary, complexity of biology, geography and society of upland region needs high efforts of scientists in order to find appropriate agricultural technology for mountainous and upland regions. Particularly, those involving technology for sloping land agriculture should be given more emphasis to provide scientific bases to exploit dominant diversity of plants. Cropping systems must take the lead in order to improve productivity and maintain sustainability in upland farming of the area.