ASSESSMENT OF SUSTAINABLE FARMING SYSTEM AND SOCIO-ECONOMIC ASPECTS OF SHIFTING CULTIVATION IN SELECTED MOUNTAINOUS AREAS IN MYANMAR

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ASSESSMENT OF SUSTAINABLE FARMING SYSTEM AND SOCIO-ECONOMIC ASPECTS OF SHIFTING CULTIVATION IN SELECTED MOUNTAINOUS AREAS IN MYANMAR

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The thesis attached hereto, entitled **"Assessment of Sustainable Farming System and Socio-economic Aspects of Shifting Cultivation in Selected Mountainous Areas in Myanmar"** was prepared under the direction of the chairman of the supervisory committee and has been approved by all members of that committee and the board of examiners as requirement for the Degree of Doctor of Philosophy.

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This thesis represents the original works of the author, except where otherwise stated. It has not been submitted previously for a degree at any other university.

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ABSTRACT

Myanmar is an agricultural country, and agriculture sector is the backbone of its economy. There is no denying that agricultural resources are not only an input into food production but also the major economic asset on which nearly three quarter of population in Myanmar depends for employment and income. Land resource will continue to be a major factor in the prospects for solving the food problem. There is evidence of resource degradation associated with shifting cultivating agricultural practices in mountainous areas of Myanmar. Therefore, to solve the problem of food security concern it is necessary to know the sustainable agricultural resource use in slope land area of Myanmar.

In this study, the household survey involved 84 respondents from seven villages in three townships in Muse district. The three income groups of analyses were important to evaluate the significance of different groups in a farming system. The farming systems approach was applied in this study in terms of analyzing the socio-economic characteristics, decision-making process and development potential of the farming systems. This involved comparative descriptive analyses and also parametric test to establish statistical differences. The approach of measuring sustainability and living standards was also applied using several criteria namely ecological sustainability, economic security, food supply and security, food expenditure, and education expenditure/level. Econometric methods and linear programming were used indifferent living standard measurements depending on what was being assessed.

The main results of farming system under shifting cultivating households have indeed soil degradation effects on their socio-economic situation in sustainable agricultural point of view. It has been found that on average all crops of yields of sampled households is still below the average yields of Muse district. This is due to the difficult access to innovations of HYV and other modern agricultural inputs. So far, agricultural income contributes most to the total income even though off-farm activities have started to play an increasing role. Although rice may not contribute the

largest share of agricultural income, this crop plays an important cultural role as the feeling of being food security which is closely linked to the perception of having access to it. Maize is an important cash crop and it contributes the largest share of agricultural income.

Crop diversification, integrated pest management, integrated nutrient management and balance use of inorganic fertilizers should be promoted to sustainable household income in this study area. Moreover, farmers must have better access to proven technologies, production inputs and services, and to markets for their products. Sustainable development in study area should introduce research development of legume-based relay, intercropping, soil conservation and other practices to raise family income of shifting cultivators.

According to the results, based on sustainable agriculture, government give attention to elaborate policies that recognize the first priority of many farmers is household food security and family welfare.

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LIST OF ABBREVIATIONS

ADB	Asian Development Bank
AE	Adult Equivalents
AISA	Adequate-Input Sustainable Agriculture
BGA	Blue Green Algae
CIRDAP	Centre on Integrated Rural Development of Asia and the Pacific
Co Ltd.	Company Limited
CSO	Central Statistical Organization
DAP	Department of Agricultural Planning
DP	Dependency ratio
FAO	Food and Agriculture Organization
FYM	Farm Yard Manure
Ha	Hectare
HH	Household
HL	Household Labour
HYV	High Yielding Variety
IFOAM	International Federation of Organic Agriculture Movements
INM	Integrated Nutrient Management
K	Potash
Kg	Kilogram
LISA	Low Input Sustainable Agriculture
MADB	Myanma Agricultural Development Bank
MAS	Myanmar Agricultural Service
MM	Milimeter
MOAI	Ministry of Agriculture and Irrigation
N	Nitrogen
OLS	Ordinary Least Square
P	Phosphorus
S	Sulphur
UNDP	United Nations Development Project
USG	Urea Coated Super Granules with Nimin
Zn	Zinc

LIST OF CONVERSION FACTORS

1 Basket of Paddy	= 20.9 Kilogram
1 Basket of Maize	= 25 Kilogram
1 Hectare	= 2.47 Acres
1 Kilogram	= 2.20 Pounds
1 Viss	= 1.63 Kilogram

CHAPTER 1
INTRODUCTION

As Myanma economy is based on agriculture, rural development is the priority sector for the national economy. The population of the country continues to rise rapidly at a growth rate of about 2.02 percent per annum and reached 55.4 million at the end of 2005, nearly three quarters of them living in rural areas (MOAI, 2007). As the population continues to increase, sustainable agriculture will depend largely on land resources, inputs and the efforts to use them.

About 10.1 percent (6.86 million ha) of total land area (67.69 million ha) still remain to be fallow and cultivable wasteland which can be utilized for expansion of farmlands for food and agricultural production. The area classified by type of land (CSO, 2006) is shown in Table 1.1. During the last decade (1995-2005), current fallow land was decreased by about 64 percent while 19 percent of cultivable waste land and 17 percent of other wood land were also declined. The area in reserved forests and net area sown were increased about 49 percent and 18 percent respectively.

Agriculture in developing countries including Myanmar has important characteristic with respect to sown area for majority of farmers. This characteristic is that farms are generally small size and they are threatened with the degradation of land resources and the environment. Some 85 percent of the total land areas were formed into small plots (less than 2 ha) and in various irregular forms (Tin Soe, 2004). The average land surface entitlement of small farmers has decreased, while the number of landless rural workers has increased. Farmers may inherit smallholdings, but often these are too small to be farmed economically. They then join the category of landless laborers or drift to urban area in search of a job (Rahman, 1995). As a result of population growth and urbanization, there is a pressure on the agriculture sector to increase production and shifting cultivation become intensified and still remain a major land use at the expense of forests.

1.1 Shifting Cultivation

Locally, shifting farming practice in upland area is known as taungya. It literally means hill cultivation or hill farming in Myanmar term. The shifting cultivation area in Myanmar amounted to 22.8 percent of the total land area (Figure 1.1). The Ministry of Forestry (1995) estimated that 1.5 to 2 million families practice shifting cultivation on an area of 2.43 million ha that constitutes mostly unclassified and degraded forests (San Win, 2005).

Shifting cultivation under its diverse forms of slash and burn system, is a traditional method of cultivating tropical upland soils mostly for subsistence purpose. There were many reasons of shifting cultivation practices in Myanmar. They are (i) insecured control over land; (ii) absentee ownership or unclear tenure status; (iii) land is common property; (iv) remote area with sparse population density; (v) deep rooted traditional land use practice; (vi) lack of capital investment; (vii) traditional taungya practice in Myanmar and (viii) livelihood activity of landless or marginal rural people.

Shifting cultivation was a cause of forest cover losses. Myanmar is now becoming one of the important deforesting countries within Southeast Asia region. Deforestation becomes environmental degradation to be serious in some regions of Myanmar and the local people of these regions are facing the scarcity of forest resources. The major causes of deforestation in Myanmar are (i) short-fallow shifting cultivation practices in hilly regions; (ii) expansion of permanent agriculture into forest lands particularly in dense populated regions; (iii) cutting of fuel wood and production of charcoal for daily cooking; (iv) associated trade of timber, and (v) infrastructure development and urbanization. One UNDP funded development project reported that the fallow period in the southern Shan state has been reduced to 3 years. In Chin state, the period has reduced from 10 years in the early 1960 (Maung Gale II, 1967) to 3-7 years and in northern Shan State from 10-12 years in 1970 to 0–5 years in 2000 (San Win, 2005).

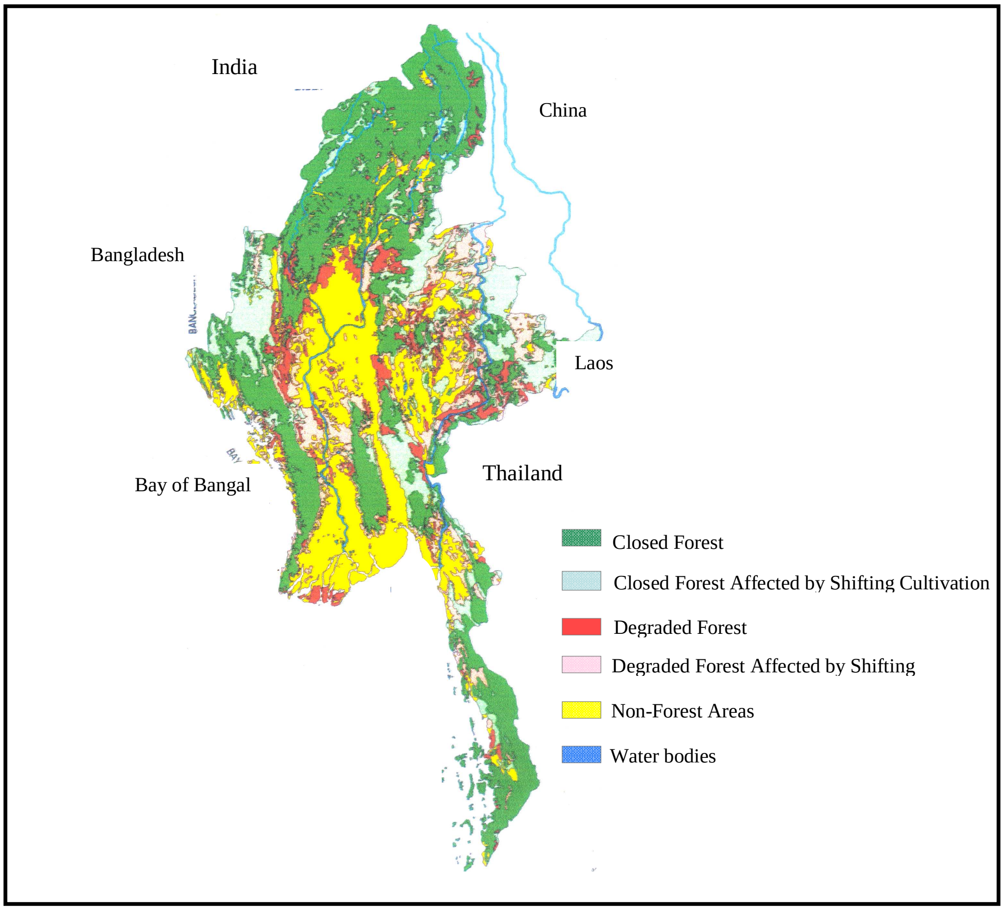
As shifting cultivation is practiced in hilly and sloping areas, the original fertile topsoil becomes very easily depleted through erosion; the remaining thin layer of soil is no longer suitable for cultivation in long term. This situation is compounded by the fact that the growing population continued to practice shifting cultivation. Although there is regrowth of young trees and bamboos in abandoned shifted land (commonly known as Phonzo), the land finally becomes infertile.

Bare hills without adequate soil cover can be found in hilly regions of Myanmar due to this practice (Figure 1.2). Table 1.2 shows the situation of shifting cultivation in the northern and western hills and Shan plateau.

Table 1.1. Area classified by type of land in million ha in Myanmar

Sr. no.	Year	Reserved Forests	Current Fallows	Net Area Sown	Cultivable Waste Other than Fallows	Other Wood Land	Others	Total Area
1	1995-1996	10.33	1.23	8.91	7.97	22.09	17.15	67.69
2	1996-1997	10.40	1.15	9.00	7.93	22.07	17.12	67.69
3	1997-1998	10.48	1.18	8.97	7.86	22.01	17.18	67.69
4	1998-1999	11.62	0.98	9.30	7.56	22.97	17.25	67.69
5	1999-2000	12.51	0.77	9.68	7.31	20.28	17.14	67.69
6	2000-2001	12.92	0.69	9.91	7.21	19.79	17.17	67.69
7	2001-2002	13.98	0.62	9.99	6.67	19.33	17.09	67.69
8	2002-2003	14.18	0.58	10.09	6.52	19.25	17.06	67.69
9	2003-2004	15.14	0.52	10.26	6.58	18.32	16.87	67.69
10	2004-2005	15.39	0.44	10.52	6.42	18.14	16.78	67.69

Source: CSO, 2006



Source: San Win, 2005.

Figure 1.1 Area affected by shifting cultivation in Myanmar

Figure 1.2 Denuded area in the study area of Muse district

Table 1.2. Situation of shifting cultivation in Myanmar (2002)

Sr. no.	Region	Total area (000 ha)	Shifting area (000 ha)	Percent
1.	Northern & Western Mountain			
	Kachin	9167.7	16.2	26.0
	Sagaing	9742.5	8.7	14.0
	Chin	3708.5	35.0	56.0
	Rakhine	3786.6	2.5	4.0
	Total	26405.3	62.4	100.0
2.	Shan Plateau			
	Shan (S)	3930	7.5	10.1
	Shan (N)	6126	37.4	50.5
	Shan (E)	5522	20.9	28.2
	Kayah	120.7	8.2	11.2
	Total	15698.7	74.0	100.0

Source: DAP, MOAI, 2002.

In these regions, in the absence of any other viable alternative for ecological setting, farmers regard their farming as an appropriate form of food production. Together with deforestation, steep slope farming without any soil conservation measure, shifting cultivation without proper fallow and uncontrolled grazing can result in serious degradation of land.

This study, therefore, attempts to examine the sustainability of farming system in the selected mountainous areas by using ecological indicators, economic indicators, and social indicators.

1.2 Problem Statement

Shifting cultivation proved as a poor form of land use even though it is regarded as a traditional way of life in mountainous area. Slash and burn farming of shifting cultivation in slope areas also led to soil degradation as the shifting cycle became shorter under population pressure (Kyi *et al*., 2000).

In coastal, eastern, and northern Myanmar, shifting cultivation has led to changes in the vegetation structure of the forest being transformed into degraded secondary shrubs without any production potential. The continuous depletion and exploitation of soil resource may threaten prospects for the sustainable economic growth. Soil degradation is a major cause of stagnating or even decreasing yields in some countries. Apart from widespread soil erosion, the major causes of soil degradation are: loss of organic matter resulting in reduced biological activity; nutrient depletion as a result of erosion, nutrient mining or inactivation of nutrient (absorption of phosphate); and reduced nutrient retention. High levels of soil acidity and aluminium (Al) toxicity are a problem in food production of Sub-Sahara Africa.

The estimated average nutrient depletion in 2000 was about 50 kg of nutrient ($N+P_2O_5+K_2O$) per year in this area. Without at least a medium level of plant nutrient input, many countries will not be able to meet their food needs, and some may not do so even with high inputs. Nutrient depletion from soil is a major form of soil degradation (FAO, 2003a). On a global scale, soil fertility depletion is far more widespread than soil fertility improvement. Soil nutrient depletion is caused primarily by negative nutrient balances, faulty nutrient management strategies and a lack of resources for investment in soil fertility-enhancing inputs.

In a survey conducted in 13 Asian countries (Bangladesh, China, South Korea, Singapore, India, Malaysia, Myanmar, Nepal, Pakistan, Philippines, Sri Lanka, Thailand and Vietnam), soil nutrient depletion coupled in imbalance in soil fertility was identified as environmental issue in land and water development (Table 1.3).

It was concluded that, on many soils, balanced and efficient use of nutrients lead to minimal adverse effects on the environment. This is made possible by combining balanced nutrient supplies with best management practices. Toward achieving this goal at field level farmers must have access to adequate resources, timely and quality advice, and remunerative market prices for their produce.

The issue of farm income vulnerability is important to the living standard of farmers in those mountainous area experienced by shifting cultivation farming system. Farm income is considered central to this study as it constitutes the most significant source of income while farming represents a major source of employment. Taking these two together as source of income and employment, the identified vulnerability which concerns brought about by narrow concentration on few farming activities, is critical to the living standard of the farmers in the study area.

Socio economic analysis can contribute significantly to the study of the relationships between low, medium and high income groups of shifting cultivators, sustainable land use, and living standard and therefore may provide solutions and policy direction particularly in those areas. The farming system approach offers a framework for understanding the needs of families within a system and the relative importance of strategies for development (FAO, 2001a).

1.3 Objectives of the Study

Based on the problems presented, the overall objective is to review current shifting cultivation practice and revise accordingly in order to improve social welfare status of shifting cultivators in study area. The specific objectives are as follows:

(i) To describe the socio-economic characteristics of shifting cultivating households

(ii) To investigate whether shifting cultivation is a sustainable land use in the study area

(iii) To find out economic and ecological sustainability of farming system and social acceptability of sampled shifting cultivating households, and

(iv) To suggest some recommendations based on resulting from the study.

Table 1.3. Environmental issues in land and water development to 13 Asian countries

Environmental issue	Frequency of occurrence
Low fertility and imbalanced nutrition	13 (all countries)
Population increase, water and wind erosion	12
Land use policies, sedimentation and siltation	11
Deforestation, water logging, shifting cultivation, land conversions	10
Salinization	9
Drought, acidity	8
Pollution, acid sulphate soils, organic matter depletion	7
Desertification, overgrazing, land slides	6
Poor crop management	5
Peat soils	4

Source: FAO/ RAPA, 1992.

1.4 Hypothesis of the Study

Three hypotheses, which are stated for this research, are as follows;

(i) Shifting cultivation is sustainable in terms of economics and ecological aspects.

(ii) Shifting cultivation still plays a major role in family income of the sampled households in the study areas.

(iii) Shifting cultivation is socially acceptable in the study areas.

1.5 Significance of the Study

Households of the study area dependent mainly on farm income are exposed to serious degradation of land and yield loss particularly due to deforested bare conditions. These related problems of sustainable farming system and household economy are of critical importance.

This thesis finds out the biophysical and socioeconomic conditions in the study area. Here, "12" indicators, representing ecological, economic and social dimensions of agricultural sustainability which have been selected for evaluation of the sampled households' farming systems.

More attention is given to consider the possible benefits of farm households, especially the contribution of more stable farming systems to resource conservation, environmental protection and the improvement in the quality of life that comes as a result of sustained farm income.

1.6 Organization of the Study

Chapter 1 outlined the degradation of land resources concerns related to shifting cultivation at steep slope farming and defined the objectives and hypotheses. It also includes the significance of the study and the organization of the study.

Chapter 2 discussed sustainable development in uplands and technological opportunities on the basis of literature review. It also explained optimizing nutrient management in diverse cropping systems. An overall strategy for sustainable development was described and sustainable agriculture on successful management of resources was highlighted.

Chapter 3 presented the empirical basis and research methodology applied in this study. The survey region was described, with its agro-ecological and socioeconomic characteristics. This chapter characterized the shifting cultivators as the target group of the study. Furthermore, in this chapter the design of the research and its theoretical framework is described.

Chapter 4 presented the research findings. The surveyed households were categorized according to annual income. This chapter described household structure, access to education, type of housing and luxury goods, own livestocks, land use and land resources, seasonal labour demand, off-farm activities, food supply and self-sufficiency, and the economic situation of the farm family household system.

Chapter 5 provided the information of the farming system used by shifting cultivating households in the study areas. Agricultural resource management and resource used by sampled households were discussed and the impact of shifting cultivating farming system was explored using indicators of ecological, economic and social dimensions of agricultural sustainability.

Chapter 6 examined the family income of shifting cultivating household for the living standard of those who lived in mountainous area. The analysis is carried out using linear regression model and linear programming model. The importance of agricultural activities and socio-economic factors that determine agricultural income are assessed.

In the last chapter, it included summary and conclusion in a brief of the whole study. The recommendations for improvement of sustainable farming systems were then provided.

CHAPTER 2
LITERATURE REVIEW

2.1 Concept of Sustainable Agriculture

"Sustainable agriculture" has emerged in the last 10 years to describe the varied field of agricultural practices that differ from conventional concepts of modern agricultural production (Bidwell, 1986; World Bank, 1981). The most prevalent definition of sustainable agriculture is "ecologically sound, economically viable, socially just and humane" (Gips, 1987). Most definitions of sustainable agriculture share two key elements: Use of farm chemical is minimized, especially pesticides and soluble fertilizers, and the farm system is viewed as a whole when making management decisions, even though specific decisions do not appear to have impact outside the area of use or application.

The focus and specific definitions of the subcategories of sustainable agriculture and its practices are many. Some practitioners choose to focus on the ecological aspects of the faming system, calling it organic (USDA, 1980), biological (Friend, 1981; Hodges, 1978), ecological, natural, or alternative (Crosson and Ostrow, 1988). Others focus more narrowly on resource dynamics of the agroecosystem, calling it low-input or resource-efficient agriculture. Some emphasize the social and ecological aspects (Berry, 1977), while others refer to a specific set of practices or management concepts combined with an ecological/social overview, such as biodynamic and permaculture (Mollison, 1988).

According to FAO (1995, p.426) sustainable agricultural development is a management of the natural resource to ensure attainment and continued satisfaction of human needs for present and future generations. It conserves or increases land capacity to produce agricultural goods, water availability and plant genetic resources. Sustainable agricultural development is environmentally non-degrading, technically appropriate, economically viable and socially acceptable.

In principle, sustainable agriculture can be carried out at low, medium or high yield levels. The appropriate level is the one that meets the needs and aspirations of the population. Sustainability at a low yield level, termed low input sustainable agriculture (LISA), means a system that many farmers may have no other choice but to adopt low-input, low-output cropping because it tends to cause human drudgery and risk of hunger. The preferred goal of sustainable production is a high level of productivity using adequate input. Adequate input means high or medium input depending on the production conditions and targets. Agriculture should not exploit the soil resource by "exhaustion cropping" for short-term profit, but rather maintain or even improve it for the benefit of future generations. The yield potential or resistance of crops to diseases may be greatly increased in future, but better crop nutrition management will remain a central component for production in sustainable agriculture.

2.1.1 Concept of low-input sustainable agriculture

A prominent concept for sustainable agriculture is low-input sustainable agriculture (LISA). LISA is supposed to optimize the management and use of internal production inputs (mainly on farm nutrient resources) in order to obtain satisfactory and sustainable crops yields and profitable returns. LISA is a subtype of organic farming. Low input agriculture and its associated low to medium productivity may be required for compelling natural and economic reasons. Extensive sustainable agriculture (low input, low output) in vast areas of developing countries is an example. It may also be deliberately promoted and practiced for ideological reasons such as bio-farming or eco-farming in developed countries.

Bio-farming and eco-farming are forms of organic farming. They refer to special farming systems that exclude the application of manufactured mineral fertilizers or pesticides, but use of plant residue, animal manure, compost and legumes as nutrients sources. The system is workable because of the higher produce prices realized, which compensate for the generally lower yields obtained.

The general features of permitted practice under organic farming as set by the International Federation of Organic Agriculture Movements (IFOAM, 1998) are:

- Inputs manufactured by chemical processes should not be used.
- Water-soluble N and P fertilizers are avoided as matter of principle.
- Soluble potassium sulphate and micronutrients are permitted provided that a threatening deficiency is documented through analysis.
- Plant residue and other natural minerals with a low solubility can be used.
- Weeds are removed or damaged by mechanical soil treatment or the use of flame.
- Extensive crop rotation and intercropping are adopted, while monocultures are avoided.

- Herbicides and synthetic pesticides are prohibited and genetic engineering is not accepted in practice.

However, organic agriculture faces the same environmental and sustainability problems with crop nutrient management due to emissions of ammonia and nitrous oxide, nitrate leaching, and depletion of plant residue resources (Lagreid, Bockman, and Kaarstad, 1999).

2.1.2 Concept of adequate-input sustainable agriculture

Sustainable agriculture cannot be equated with subsistence agriculture for the majority of crop land in the world. Sustainability is by no means confined to low-input conditions but can be achieved at any level of production where inputs and outputs are in balance and the best land-use practices are followed. Such systems could be called adequate-input sustainable agriculture (AISA).

As demonstrated in Western Europe and elsewhere, high but adequate rates of nutrient application result in sustainable production with high yields without significant adverse effects on soil fertility or the environment. Farming systems of this kind are rather diverse, ranging from rainfed to irrigated areas, but they have many similarities in terms of nutrient management. Even under rainfed dryland conditions, medium to high crop yields can be sustained through an integrated use of fertilizers and organic manures. Results of a nine-year field trial with dryland finger millet in the red soils at Bangalore, India showed that the best yields were obtained when recommended rates of fertilizers were applied in combination with 10 ton FYM/ha. It was only at this input level that grain yield of 3 ton/ha and above could be harvested in eight out of the nine years (Table 2.1). A considerable portion of the yield potential would have been lost if either of these inputs had been omitted.

The goal of intensive sustainable agriculture at high yields is to utilize, as far as possible, the yield potential of high yielding crops by eliminating all nutritional constraints through integrated nutrient management (INM) including fertilization and maintaining high soil fertility. Simultaneously crops are protected against disease and insect damage. However, there is a negative aspect of nutrient management under such systems. This happens where there is heavy reliance on the fertilizer input while neglecting the soil nutrient reserves and those available in various organic sources. This has led to the public misconception that intensive cropping is essentially a "nutrient-wasting" system.

Table 2.1. Effect of fertilizers and FYM on the productivity and stability of dryland finger millet over nine years of Bangalore, India.

Annual treatment	Mean grain yield (kg/ha)	Number of years in which grain yield (ton/ha) was			
		<2	2-3	3-4	4-5
Control	1510	9	0	0	0
FYM (10 ton/ha)	2550	1	6	2	0
Fertilizer 50-50-25 (kg/ha N-P_2O_5-K_2O)	2940	0	5	4	0
FYM (10 ton/ha)+25-25-12.5 (kg/ha N-P_2O_5-K_2O)	2900	0	6	3	0
FYM (10 ton/ha))+50-50-25 (kg/ha N-P_2O_5-K_2O)	3570	0	1	5	3

Source: Swarup, 2000

Sustaining crop productivity at a high yield level has proved possible in many progressive agricultural areas, even in parts of developing countries such as Punjab State in India. The dependence on fertilizers for adequate food and fibre production continues to remain because of continuous growth in human population and little expansion in the net cropped area. Food production can be enhanced by better nutrient cycling and prevention of losses. However, the food demands of an increasing population cannot be met only from organic sources or from fertilizers alone. They require an active pre-planned INM approach. As part of integrated crop production, INM will be a decisive factor in attaining the goal of "sustainable high yields" and "profitable crop production" without negative effects on the environments.

2.1.3 Concept of sustainable agriculture and shifting cultivation

Cropping without external nutrient application has been common in many parts of the world. Exploitation of soil nutrients basically means cultivating crops until available soil nutrients have been exhausted and the yields have declined markedly. In the end, such fields must be abandoned and left to return to natural vegetation for regeneration. A typical example of exploitation cropping is shifting cultivation used by subsistence farming in certain tropical forest areas.

This system is exploitive because nutrient losses are not compensated for by input. Nevertheless, it is stable to a certain extent as long as there has been no serious soil deterioration during the cropping period and there is sufficient land available for long regenerative phase under natural vegetation. The poor reputation of shifting cultivation as a misuse of soil resources is mainly a consequence of the deviation from the original concept by shortening the forest fallow period and, thus, not allowing the soil enough time for regeneration. This mostly occurs as a result of an increased population pressure. With increasing populations, such system needs to be replaced by more stable and productive types of farming systems.

2.2 Holistic Approach to Implementing Sustainable Agriculture

Sustainability agriculture should involve the successful management of resources for agriculture to satisfy changing human needs while maintaining or enhancing the quality of the environment and conserving natural resources.

Sustainability involves the complex interactions of biological, physical, and socioeconomic factors and requires a comprehensive approach to research in order to improve existing systems and develop new ones that are more sustainable (Plucknett, 1990).

These biological considerations will be important for future sustainability:

- Conservation of genetic resources must be continued and strengthened.
- Yields per unit of area and per unit of time must be substantially increased to meet the needs of rapidly increasing populations.
- Long-term pest control must be developed through integrated pest management and built-in resistance because intensified production will tend to encourage build-up of pests and break down the effectiveness of pesticides and host-plant resistance.
- Improved methods for disease and parasite control will also be important to sustain animal production.
- A balanced production system involving both crops and livestock will be needed to enhance productivity and avoid overgrazing.

These physical factors and constrains are deemed most important:

- Soil is the most important resource for ensuring sustainability; loss of topsoil through erosion and a reduction in soil fertility by not replacing nutrients both turn a renewable resource into a nonrenewable one.
- Agriculture is the principal user of water globally; inefficiently using fossil water and overdrafting rechargeable aquifers can result in another renewable resource being eroded.
- Poor soil and water management in rainfed agriculture can cause severe land degradation.
- Misuse of agricultural and industrial chemicals can contribute to the accumulation of toxic substances in soil and water.
- Atmospheric changes brought about by human activities will adversely affect agricultural production.
- Energy consumption required by high-yielding production systems will probably be justified in the foreseeable future as using a nonrenewable resource, oil, to protect soil from being reduced to a nonrenewable resource.

These socioeconomic and legal constraints also affect long-term sustainable strategies:

- Weak infrastructure in many developing countries is a major constraint to delivering inputs and transporting farm products.
- Financial and administrative programs often are biased toward urban consumers.
- Land tenure systems can discourage farmers from conserving natural resources and investing in future productivity; many countries do not have law to protect forests and rangelands from indiscriminate exploitation.

To achieve sustainability, the constraints must be alleviated, and major efforts must be made in increasing productivity to meet the immediate demands of a growing global population.

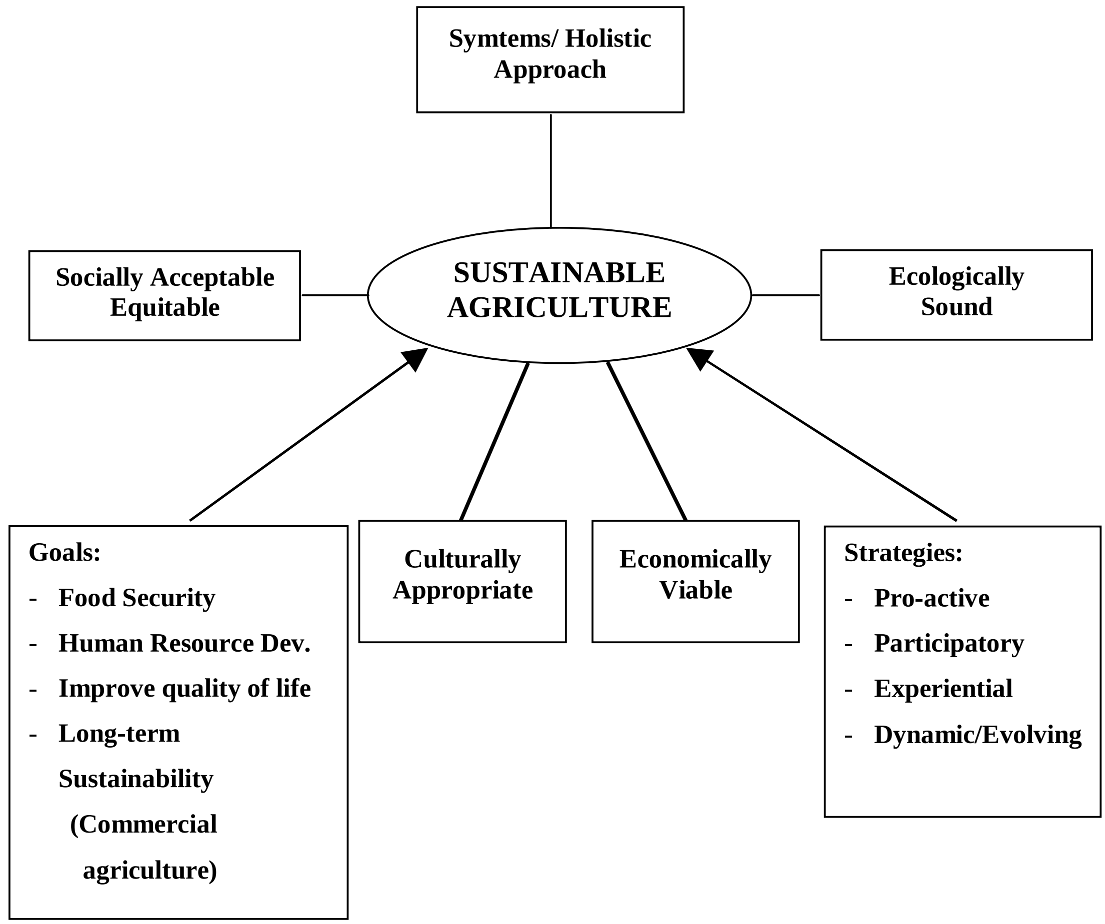
If the goal of sustainable agriculture is to meet the changing needs of people, research must clearly consider both short-term and long-term needs. Yet, stability of the environment should not be consciously sacrificed for short-term gains. Research center's aim should be to devise technologies that can meet short-term requirements while at the same time maintaining or enhancing ability to meet long-term needs. The overall conceptual framework of the study therefore can be laid out as the (Figure 2.1).

2.3 Sustainable Agriculture Development in Upland Areas of Southeast Asia

Uplands in Southeast Asia account for about 50 million hectares having about 100 million people directly dependent on them. Rice is a major food crop in the uplands, and the food security of upland people depends on its production. The total rice area in the uplands of Southeast Asian countries (Cambodia, Laos, Myanmar, the Philippines, Thailand, and Vietnam) is estimated to be 4 million hectares in 2000. Population density in these countries varies from 20 per square kilometer in Laos to 225 per square kilometer in the Philippines (Pandey, 2000).

Uplands are highly heterogeneous with the climate varying from humid to sub humid and the soil varying from fertile to highly infertile. Uplands also include steeply sloping areas. Cultivation practice ranges from shifting to permanent cultivation.

The crops grown in the uplands also vary across these environments. Despite this diversity, a general feature of the upland system is that it is inhabited by very



Source: Donaldson & Scannel, 1986

Figure 2.1 Framework for sustainable agriculture indicators poor farmers who grow food crop mainly for subsistence using very few inputs other than labor. Upland areas are often remote with poor access to markets.

In important lowland areas, great improvements in yield have been significant due to intensification of cropping. However, this is not true everywhere and it is not true in most of the many upland parts of Southeast Asia. A shortening of fallow periods has been noted in several of these upland areas, with potentially serious consequences for sustainability of production and environment. The traditional system of slash-and-burn based on fallow periods in excess of 20 years has been replaced by a short fallow period in some cases owing to increased population pressure. Moreover, the current agricultural productivity is low. For example, the yield for rice, an important food crop in the uplands of Asia, is only 1.1 metric ton per hectare compared with 4.9 metric ton per hectare for irrigated areas. Thus, technological and institutional interventions to improve the yields of major staples are needed to increase overall food production.

Increasing population pressure pushes farming system to become more intensive and sedentary. Increasing market access moves the systems toward more commercial production of non-rice crops. In areas with low population pressure and limited market access, the traditional farming system was shifting cultivation with long natural fallow, but these areas are declining because of increasing population pressure and political reactions against unsustainable slash-and-burn cropping practices.

Integrated rice-based system, where upland rice is grown in rotation with a range of annual crops in permanent field, is found as the dominant farming system in Asia with high population pressure and limited market access. In areas with greater access to markets, opportunities exist for development based on cash-cropping although food production may still be an important component of the farming systems. Improving the productivity of upland rice can be an important starting point for addressing the problem of food poverty. In most type of upland system, plantation crops and other cash crops are likely to be the dominant components of farming systems even though rice will remain important for food security.

Finally, any strategy for achieving sustainable food security and alleviating poverty in upland environments must stimulate growth in agricultural productivity, raise incomes, and conserve resources to sustain long-term development (Pandey, 2000).

2.4 Technological Exploration for Upland Rice in Southeast Asia

The major biophysical constraints to the growth of rice yields in the uplands of Southeast Asia are drought, weeds, blast (a fungal disease), nematodes, and infertile soils, which are deficient in phosphorus and are generally acidic. In addition, soil erosion is an important problem, especially in sloping uplands.

Technology research for germplasm improvement at the International Rice Research Institute and collaborating partners in various countries is focused on developing varieties that escape, tolerate and resist drought. Short-duration varieties that mature before the end of the rainy season escape the damaging late season drought that occurs in some areas. Varieties that tolerate and resist drought are needed for areas where intermittent drought can occur anytime during the growing season. Researchers are studying physiological mechanisms for drought resistance and using molecular tools to identify genes that impart such resistance. While this prebreeding work should ultimately reduce production losses to drought, most of the modern varieties currently being adopted in Asian uplands are shorter-duration varieties that escape drought. The adoption of these varieties has, however, remained somewhat limited because of other constraints including the unavailability of seeds.

Weeds and blast are the two other major constraints on the production of upland rice. Manual weeding is extremely labor intensive, but most farmers cannot afford chemicals for weed control. As most of the losses to weeds occur during the early stages of crop growth, rice varieties with high seedling vigor that establish themselves rapidly are being developed to reduce the competitive effects of weeds .

For tackling soil fertility problems, the focus of research is on understanding long-term nutrient dynamics in upland soils, with particular emphasis on phosphorus. Researchers are also focusing on nutrient management in drought-prone soils, particularly the effects of nutrients on alleviating drought-induced yield reductions. Scientists are developing nutrient management strategies that rely on biological principles of nutrient cycling and assessing how such strategies can complement or substitute for external sources of nutrients. Research has shown that rice can yield three to five metric tons per hectare if adequate quantities of nutrients, particularly phosphorus, are provided in these poor soils (Pandey, 2000). Similarly, technologies for controlling soil erosion are being developed and evaluated. Contour hedgerows were found to be effective in controlling soil erosion and increasing farmers' incomes in places that are more accessible to markets. The use of contour hedgerows for controlling soil erosion has, however, not been widespread as its profitability is somewhat location-specific. A socioeconomic study of adoption of contour new hedgerows for soil erosion control identified several factors, such as the security of tenure, farm size, and educational status of farmers, as critical determinants of adoption.

2.5 Some of Improved Agricultural Technologies Suitable for Smallholders in a Sustainable System

Several points should be emphasized regarding the development of technology, in particular the limited land holdings and capital of smallholders, and their rising populations. Farmers should not have to invest heavily into inputs to improve yields or maintain the productivity of their farms. Because the environment and socio-economic situation of each farmer are location specific, farmer-based technology should be developed, particularly Asian and Pacific smallholders. FAO 1991, has reviewed and recommended some of improved agricultural technologies in a sustainable way.

- Exploitation of biological nitrogen fixation, through increasing use of leguminous plants or non-symbiotic ferns (Azolla) and nitrogen-fixing blue-green algae.
- Improved grazing management, including the use of fodder crops and temporary pastures in crop rotations.
- Increased use of integrated pest management which avoids harming natural enemies and reduce the use of chemicals.
- Increased use of rhizobium inoculation on legume crops grown before or after rice.
- Adaptation of mixed cropping, or the use of varietal mixtures, to create the diversity of natural ecosystems. Increased productivity based upon the combined yield of crops is also important.

2.6 Optimizing Nutrient Management in Diverse Cropping Systems

There is a great variety of cropping systems with plant nutrition problems which require different system of nutrient management. All cropping systems have limitations imposed by natural and economic conditions. The objective of optimizing nutrient management is to make the best use of soil and apply nutrients within the characteristics and demands of specific farming systems with minimal depletion of soil nutrient status.

2.6.1 Annual crops in different rotations

Short rotations that include crops such as rice, wheat, maize, oilseed rape, barley, vegetables and fodders are highly nutrient demanding and, therefore, rely mainly on high external nutrient input. Except for N, especially where no legume is involved, nutrient management is more concerned with the whole rotation than with individual crops. Fertilizers are applied to maintain a high nutrient supply utilizing both the direct (fertilized crop) and the residual effects. This is sometimes referred to as "rotation fertilization" (Roy *et al*., 2006).

According to Yadav *et al*., 2000, one of the most intensive and nutrient-demanding rotations in parts of south Asia is the rice–wheat rotation. In India, this rotation is practiced on more than 10 million ha, primarily in the northern alluvial plains. Under optimal management, grain yields of 8-12 tons/ha/year can be harvested. Optimizing nutrient management in this system includes the application of NPK and other required nutrient such as S and Zn. The wheat crop must receive its optimal rate of P application while rice can benefit to a considerable extent from the residual effect of P applied to wheat. On highly P-deficient soils, P must be applied to both crops. Incorporation of greengram residues after picking the pods before planting rice is an effective green manuring practice in this system. In general, research recommendations provide for application of the fully recommended rates of fertilizer to the wheat crop, while 25-50 percent of the recommended fertilizer to rice can be saved through the use of 10 ton/ha FYM, *sesbania* green manure and crop residues (Yadav *et al*., 2000). Information is also becoming available on integrated nutrient management (INM) in this intensive systems (Table 2.2).

Table 2.2. Examples of Integrated Nutrient Management packages and their comparison with fertilizer recommendations for rice-wheat cropping in different agro-climatic regions of India

Region	Mineral fertilizer recommendation (kg/ha)	"INM" recommendation (kg/ha)
Trans Gangetic Plain	Rice: 120 N+ 60 P_2O_5+ 60 K_2O+ 20 Zinc Sulphate Wheat: 180 N+ 60 P_2O_5+ 30 K_2O	Rice: 60 N+ 30 K_2O + 10 ton/ha FYM or poultry manure Wheat: 150 N+ 30 P_2O_5 (through SSP) + 30 K_2O + Azotobacter or Azospirillum + PSB
Upper Gangetic Plain	Rice: 120 N+ 60 P_2O_5+ 40 K_2O + 20 Zinc Sulphate Wheat: 120 N+ 60 P_2O_5+ 40 K_2O + 40S	Rice: 90 N+ 30 K_2O +10 ton/ha FYM or green manuring with *Sesbania Leucaena* Wheat: 90 N+ 60 P_2O_5 (through SSP) + 30 K_2O
Middle Gangetic Plain	Rice: 100 N+ 60 P_2O_5+ 40 K_2O Wheat: 120 N+80 P_2O_5+ 40 K_2O	Rice: 50 N+ 30 P_2O_5 + green manure (greengram stover) + 20 Zinc Sulphate in calcareous soils Wheat: 90 N + 60 P_2O_5 + 30 K_2O +10 ton/ha FYM or Rice: 75 N+ 45 P_2O_5 + 30 K_2O +15 kg/ha BGA +10 ton/ha FYM + 20 Zinc Sulphate in calcareous soils Wheat: 100 N + 65 P_2O_5 + 30 K_2O
Lower Gangetic Plain	Rice: 80 N+ 60 P_2O_5 + 40 K_2O Wheat: 120 N +60 P_2O_5 + 60 K_2O	Rice: 40 N+ 45 P_2O_5 + 30 K_2O + 10 ton/ha FYM or green manure + 10 ton/ha Azolla or 10kg/ha BGA + 20 Zinc Sulphate Wheat: 90 N+ 45 P_2O_5 (through SSP) + 45 K_2O

Source: Sharma and Biswas, 2004

2.6.2 Annual crops in monoculture

In several tropical and subtropical areas, high-intensity monoculture is practiced wherever the rainfall is well distributed or where adequate irrigation is available.

Extensive on-farm trials suggest that the adoption of appropriate crop and nutrition management practices can minimize the effects of diminishing returns at increasing N application rates mainly on account of N losses. In order of importance, the limiting factors that small holder rice farmers using prill (or granular) urea can address are: (i) too few split applications, resulting in substantial N losses and consequent inadequate N supply to meet crop requirements at various growth stages; (ii) cultivars that may be insufficiently N responsive; and (iii) inadequate initial plant population. A multi-location on-farm trial/demonstration project on irrigated rice (1995-98), funded by Japan and implemented by FAO in Indonesia, the Philippines and Malaysia, demonstrated that deep-placed supergranules made with nimin-coated urea (USG) enables a 21-percent N saving in comparison with 70 kg/ha N applied as prill urea in three splits (FAO, 20003b). Urea coated with Nimin, a commercial extract from neem (*Azadirachta indica*) seed, has been widely tested, especially in India. This reasonably inexpensive biological product shows great promise for resource poor farmers, with an average yield increase of 5-10 percent over uncoated prill urea. Supergranules made with nimin-coated urea and placed deep show further improvement over the USG technology.

In many rice-growing areas, wherever the climate permits, 2-3 rice crops can be raised in succession within a year. For example, in India, rice-rice annual rotation is practiced on almost 6 million ha. Supply of N through Blue Green Algae (BGA) and Azolla/Anabaena symbiotic systems has some promise and could potentially replace of N fertilizer.

2.6.3 Annual crops with short-term fallow

Fallowing may be required for weed control in humid climates or for water storage in the soil in dryland farming. In the absence of crop removal, fallowing also conserves mobilized soil nutrients, thus providing an extra nutrient supply for the next crop. Fallows can be bare or with a plant cover, depending on main purpose. Bare fallow is a period of nutrient and water accumulation. In overpopulated, land-scarce countries, land is rarely left fallow by choice. It is more a consequence of the farmer's inability to raise an additional crop under rainfall or inadequate stored soil moisture. The vegetation cover during that fallow period can be used effectively as mulch or even as a green manure.

2.6.4 Multiple cropping systems

Multiple cropping refers to the cultivation of two or often more than two crops on the same field in a year. The concept of multiple cropping includes cropping practices where sole or mixed crops are grown in sequence, simultaneously after another, or with an overlapping period. A distinction is made between sequential cropping and intercropping. Sequential cropping can involve growing two, three or four crops a year in sequence or ratoon cropping. Intercropping involves mixed/row/strip intercropping (simultaneously) or relay intercropping (overlapping).

Optimizing plant nutrition in multiple cropping systems revolves around;

- adjusting for residual effects of nutrients such as P, S and micronutrients (e.g. applying P on priority to wheat and green manure to rice in a rice-wheat rotation, and FYM on priority to maize in the maize-wheat rotation);
- prioritizing the application of fertilizers to those crops in the system that have a poor users of applied nutrients (eg. potato in a potato-maize system);
- planning for a short-duration catch crop that can feed on residual fertilizer in between two main crops (eg. greengram in a maize-wheat-greengram annual rotation);
- practising INM keeping in view crop characteristics (eg. green manure where possible before planting rice or inoculation of the rice field with BGA and Azolla in rice-based cropping systems);
- phasing of fertilizer application among crops in a rotation so that maximum direct plus residual gains are obtained (eg. P application on priority wheat in rice-wheat, maize-wheat or sorghum/millet-wheat rotation application to an oilseed crop in an oilseed-cereal rotation);
- in mixed cropping, such as with cereals and legumes, the fertilizer application is primarily determined by the cereal, and the legume seed can be inoculated with Rhizobium culture;
- nutrient management in multiple cropping systems should be finally decided by the economics of the yield response to various nutrient applications, particularly where the component crops fetch different

market prices (eg. a yield response of 1 ton oilseed is more valuable than a yield response of 1 ton cereal).

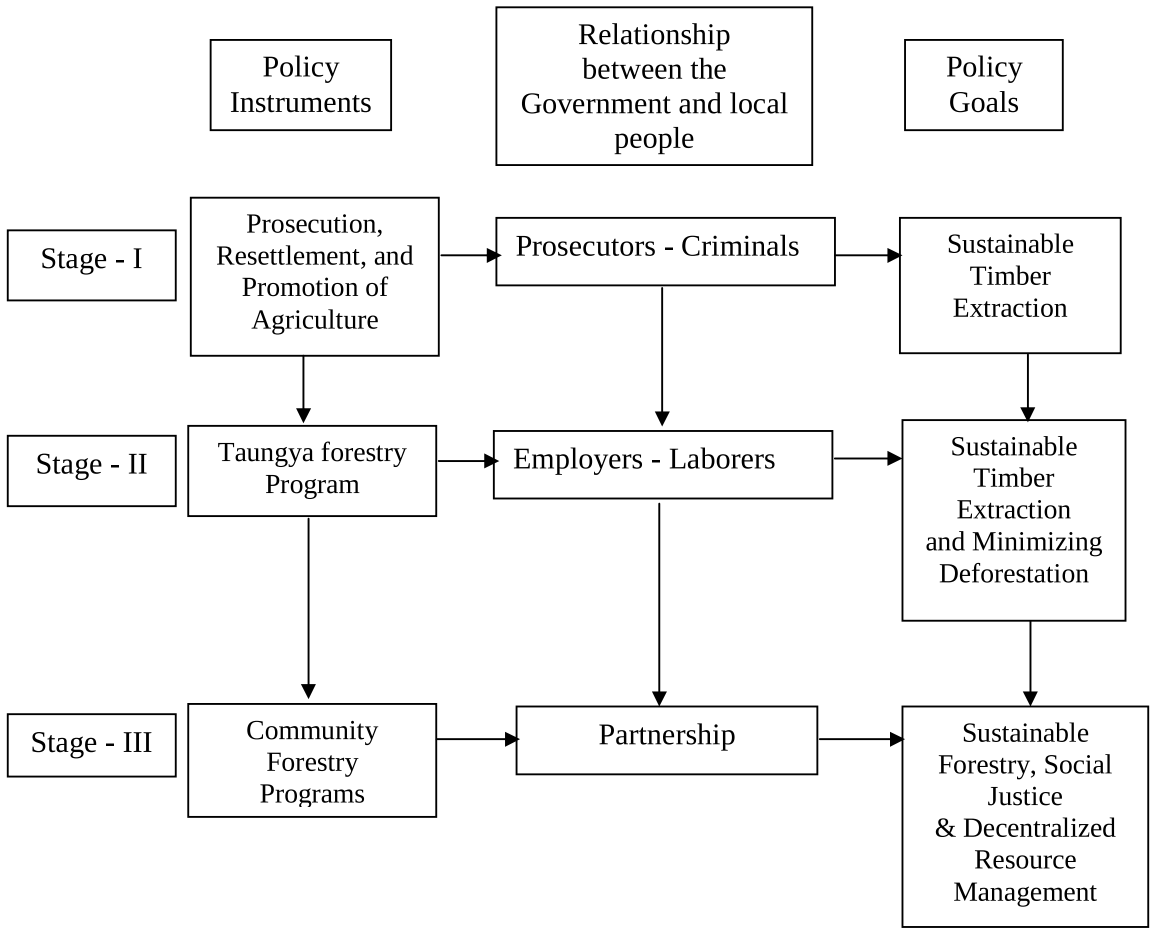
Depending on the strategy of nutrient management used, the gains from multiple cropping can vary considerably. Results from several long-term experiments employing multiple cropping rotations, for example, have shown that: (i) intensive cropping with only N input is a short-lived phenomenon; (ii) sites that were initially well supplied with P, K or S became deficient over a period of time when continuously cropped using N alone or S-free fertilizers; (iii) in most situations, optimal fertilizer application 10-15 ton FYM/ha/year was required in order to sustain crop yields; (iv) soil fertility status was improved or depleted depending on input-output balances as well as by soil properties; and (v) fertilizer rates considered as optimal still resulted in nutrient depletion from the soils at high productivity levels and in the process themselves became suboptimal application rates (Nambiar, 1994).

2.7 A Strategy for Sustainable Development of Upland Areas in Myanmar

While improved crop and resource management technologies are important for the development of Asian uplands, institutional and policy interventions also play critical roles. Upland areas must develop effective economic linkages with the national economy to enhance food security and income growth. Enabling policy and institutional environments are needed to encourage activities such as horticulture and agroforestry for which the uplands have a comparative advantage. Therefore, an important technological intervention with high potential for impact in the uplands is agroforestry. A suitable combination of annual and perennial plants can help maintain soil fertility, because perennial crops help recycle nutrients and reduce soil erosion. In addition, perennial plants such as fruit trees can be an important source of cash income to poor farmers. Such policy interventions include development of infrastructure and marketing institution and reform of property rights institutions. Much of the degradation of upland environments can be maintained.

In Myanmar the new Forest law was enacted in November 1992 to replace the 1902 Forest Act. Although the new law replicates much as in the old colonial law, it emphasizes community participatory approach in managing the forest resources, particularly to satisfy the basic needs of the local people (Forest Department, 2000). Moreover, 1995 Myanmar Forest Policy highlights the importance of people's participation in the conservation and utilization of forest resources and public awareness of the vital role of forest in socioeconomic development of the country as policy imperatives. It is a major shift from the old concept of reservation, revenue generation and restriction to community-based forestry.

Community forestry programs have been implemented as policy instruments with the provision of land use arrangements and property regimes for local communities. During this decade, the sustainable development view is shaped in national forest policy while broadening policy goals into new dimensions of social justice and decentralized resource management. The relationship between the local people and government also improved towards partnership (Figure 2.2). Thus, it can be recognized that policies and technologies encourage diversification to exploit the agroclimatic condition in these heterogenous environments for sustainable land use of Myanmar's uplands.



Source: Than Naing Win, 2005

Figure 2.2 The development process of community forestry in Myanmar

CHAPTER 3
RESEARCH METHODOLOGY

3.1 Study Area

A brief overview of the bio-physical characteristics, land use and soil type of Muse district in the north east of Myanmar were given. The chapter also outlines the methods used to collect data and information and introduces the methodological framework applied in the analytical part of the work.

3.1.1 Location and choice of study area

The study area, Muse District, which is in the northern part of Shan State, is located between latitude 22° 45' and 24° north and 97° 53'and 98° east longitudes. It is bordered by the People’s Republic of China on the north, Kunlong District on the east, Lashio District on the south, Kyaukme District and Banmaw District on the west. The land area of the District is 3018.37 sq miles (1,931,744 acres) with the population of 456,789 in the year 2005-2006 (Figure 3.1).

The choice of Muse district as a study area was made based on the following criteria:

The study area, Muse District, is situated as a transit point, 69.11 miles far west of the People’s Republic of China. Being one of the border areas of the country, Muse district plays an important socio-economic role. Muse district is dominated by mountains with steep slopes. Agricultural land is scarce in this region. Land degradation due to agro- ecological conditions is severe in this area.

Additionally, of the states in the country, the Shan State is the largest area with the largest population and the largest shifting cultivation areas due to pressure on agricultural land resources. The existing land degradation due to the growing population and inappropriate cultivation methods is, furthermore, a typical problem for mountainous regions. From this point of view, it is considered as representative of all mountainous regions in Myanmar.

With a view to the availability of sufficient food, the rice production of mainly agricultural production townships in this district for the year 2001 met only 73.13 percent of its home consumption. Over the region as a whole, rice production increased by 126.4 percent of its sufficient between 2001-2005 with a break in growth only in 2001 (Table. 3.1)

During this period, this region changed from being the rice deficit area to being self-sufficient and the food needs of growing numbers of people have met.

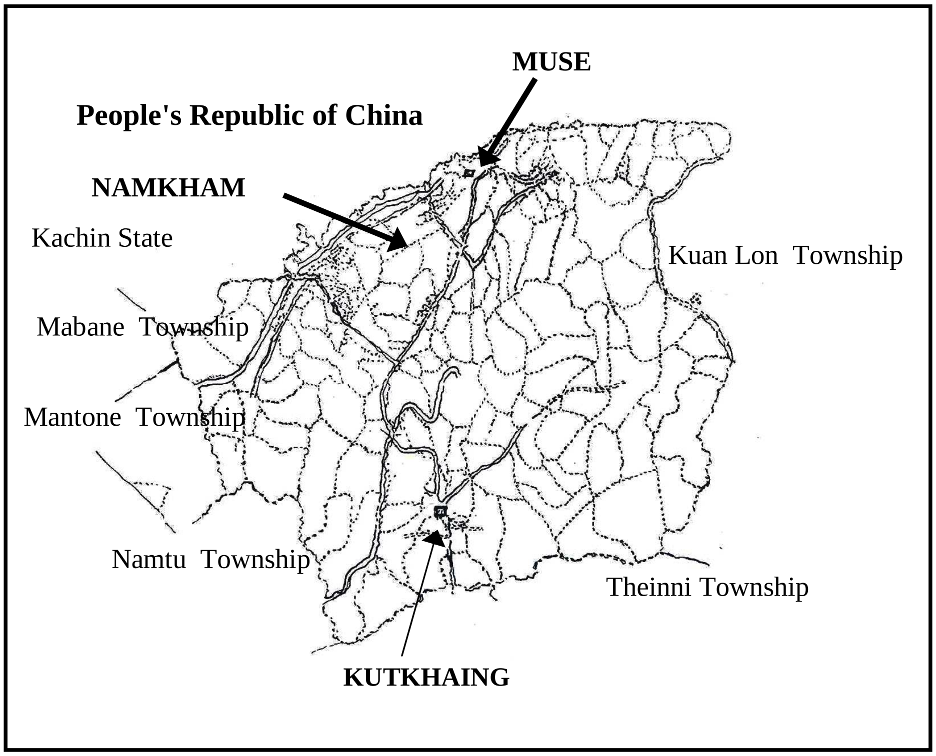


Figure 3.1 Location map of the study area in Muse District

Table 3.1. Local sufficient status of rice production in Muse district during 2001-2005

Year	Production (ton)	Population		Local consumption (ton)			Surplus (or) deficit	Suffi-cient %
		Urban	Rural	Urban	Rural	Seed and Waste		
2001	102156	148263	271024	37184	84966	7452	- 27446	73.13
2002	139397	92694	333253	23247	104474	8034	+ 3641	102.61
2003	153168	152744	279216	38308	87534	7935	+ 19391	112.7
2004	163218	167054	284242	41897	89109	8195	+ 24018	114.7
2005	184850	181669	261501	45562	81980	8326	+ 48980	126.4

Source: MAS, Muse District 2001-2005.

Great improvement in yield has been achieved and there has been significant intensification of cropping and utilization of modern rice varieties (eg. Sin Shwe Le and other HYVs) mainly in low land areas. However, it is not true in most of the many upland parts of the region. Moreover, fallow period has been shortened in several of these upland areas, with potentially serious consequences for sustainability of food production and environment. In term of future land use management, this study will provide sustainable land use practices to fulfill sufficient food and family needs of households who mainly depend on the shifting cultivation.

3.1.2 Bio-physical (agro-ecological) characteristics of Muse District

Muse district is lying with elevation between 1350 meter (Kutkhaing township) and 759 meter (Namkham township). The elevation of Muse township is 823 meter. The district is defined as being in the agro-ecological zone with low temperature and sub-tropical climate as a hilly region. Mainly agricultural production in this district can be found in Muse township, Kutkhaing township and Namkham township. Due to this reason, the climate of these townships was emphasized in this study. Figure 3.2 showed that a maximum precipitation of 389.5 mm was found in July in Kutkhaing township while a minimum precipitation of 6.03 mm was found in December in Muse township on five years average value (2000-2004)). Among the three townships, the lowest minimum temperatures were 10.93°C in monsoon, 1.19°C in winter and 6.96°C in summer respectively in Kutkhaing. In these townships, the highest maximum temperatures were 35.06°C in monsoon, 26.86°C in winter and 33.4°C in summer respectively in Muse (2004-2005) (Figure 3.3).

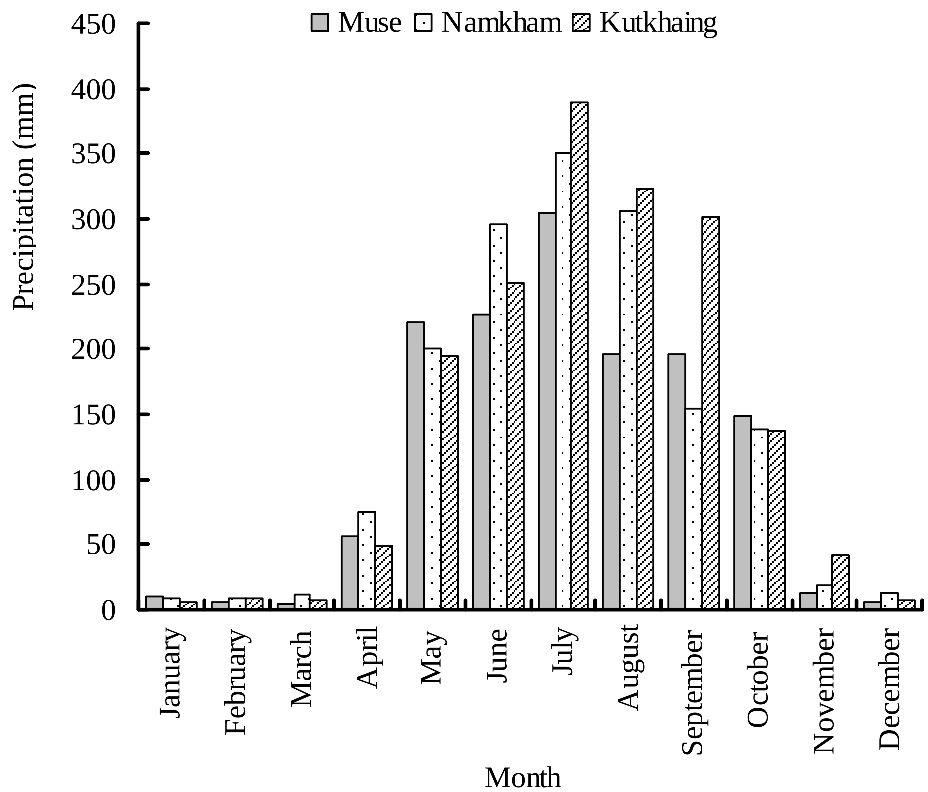


Figure 3.2 Precipitation (mm) in Muse District, five years average value (2000-2004)

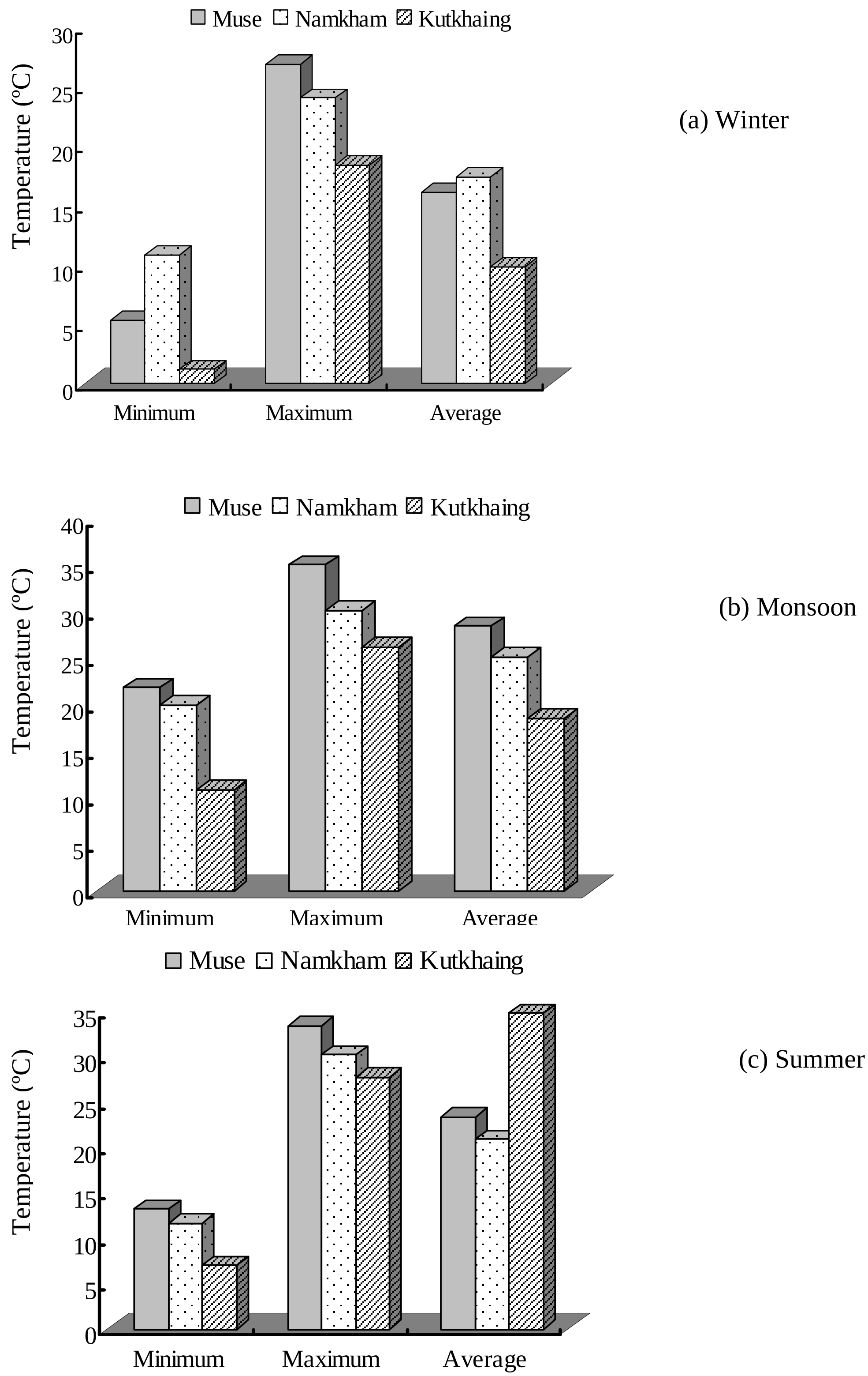


Figure 3.3 Temperature (ºC) in Muse district (2004-2005)

3.1.3 Land use and soil type

Dried mixed deciduous forests and wild forest covered in the areas with an altitude of 914.4 meter above sea level in Shan State. Pine woods forest was found in the areas with an altitude of above 1219.2 meter. Bamboo grows in the forest with trees. Kyun (teak), Pyingadoe, Padauk, In, Kanyin and other hardwood trees grow in the forest in low areas. Table 3.2 showed that forest area occupied a very large portion of the total land area. About 43.2 percent of land use was classified as reserved and unreserved forest which was about 338,678 ha in area. Agricultural land was 7.6 percent which was included rainfed paddy growing area, ya land, kaing land, garden and taung ya. Taung ya was only 0.5 percent and fallow land was 1.9 percent in this area (2005). At present, forest plantation in reserved forest area was reduced to 3990 ha due to fire, shifting cultivation and other factors during 1981 to 2003 in Table 3.3.

In general, soil in Shan State is classified as Acrisol which is reddish and has deep soil depth. It is suitable for growing of both seasonal and perennial crops. Forest soil type in Shan state is identified as Acrisol and Cambisol. The Acrisol was found in Shan Plateau with high elevation, composed of evergreen and pine forest. It was red brown in colour. Cambisol was also found in Shan plateau where dry forest and mixed deciduous forest were established (Phyu Phyu Swe, 2002).

3.1.4 Sown acreage and crops produced

Shan State has over 0.6 million hectare of cultivated areas consisting of over 202,347 ha each for paddy and crops cultivation, about 80,939 ha for hill-side cultivation, over 3238 ha of land formed by the process of shifting for cultivation and over 80,939 ha for gardens. There are about 182,113 ha of irrigated areas for cultivation in the state. Terrace-fields are seen in Shweli Valleys and on smooth hill-sides. Crops cultivated in Muse district are rainfed paddy, upland rice, taung ya rice, maize, pulses, edible oil crops, industrial crops, kitchen crops, Virginia tobacco, tea, coffee, fruit trees and other vegetables (Myanmar facts and figures, 2002).

The proportion of agricultural land in Muse district is 58630 ha in 2005 or 7 percent of the land area of state (Table 3.4). The land area related to agriculture was increased by 12 percent within five years. In Muse district, agricultural land is mainly planted with rainfed paddy, ya rice, maize, soybean, tea, groundnut and taungya rice. The rate of rainfed paddy yield improvement was increased by 14.7 percent within five years.

Table 3.2. Land use in Muse district in 2005

No	Description	Area in hectare	% area
1.	Rainfed paddy growing area	17299	2.0
2.	Yaland	24493	3.0
3.	Kaing land	582	0.7
4.	Garden	11288	1.4
5.	Taung ya	4217	0.5
6.	Fallow land	15390	1.9
6.	Reserved forest area	6569	0.8
7.	Unreserved forest area	332109	42.4
8.	Cultivable waste land	66459	8.5
9.	Others (town, village, road .etc)	303357	38.8
	Total	781763	100

Source: MAS, Muse District 2005.

Table 3.3. Percentage destruction of reserved forest area in Muse district during 1981 to 2003

No	Township	Area in hectare			Causes			Dest-ruction
		origin (1981)	present (2003)	decrease ha	Shifting cultivation	Fire	others	
1.	Muse	3103	2481	622	171 (6%)	294 (9%)	157 (5%)	20.0%
2.	Namkham	263	109	154	40 (15.2%)	-	114 (43.3%)	58.5 %
3.	Kutkhaing	3104	1400	1704	516 (16.6%)	8 (0.2%)	1180 (38%)	54.8%
	Total	6470	3990	2480	727 (11.2%)	302 (4.7%)	1451 (22.4%)	38.3%

Source: Facts for Muse district, 1981–2003, Forest Department

Table 3.4. Area and yield of important crops in Muse District in 2001 and 2005

No	Description	2001		2005	
		Area (ha)	Yield (ton/ha)	Area (ha)	Yield (ton/ha)
Agricultural land		52437		58630	
1.	Rainfed paddy	16946	5.5	17299	6.3
2.	Ya rice	5827	2.6	7545	2.9
3.	Taung ya rice	3728	2.5	4216	2.5
4.	Maize	8317	2.3	10200	3.3
5.	Soybean	1926	1.13	2143	1.2
6.	Groundnut	778	1.01	1040	1.3
7.	Tea	6881	0.97	7399	1.02

Source: MAS Muse District, 2001 and 2005

The yield per acre of ya rice, soybean, tea and taung ya rice did not increase significantly in this period. In contrast, the cultivation of maize expanded significantly and yields per acre was increased by 41.5 percent because of using fertilizer which was provided by private lenders. In upland cultivation the yields in Muse district are comparatively low, mainly due to declining soil fertility.

3.1.5 Data collection and household level survey

The collection of data was based on a field survey and the complementary collection of secondary information. The use of secondary information covered agricultural and forestry statistics on the district level. It also includes a review of literature on concept of sustainable agriculture, improved agricultural technology suitable for small holders in a sustainable system and optimizing nutrient management in diverse cropping systems.

A comprehensive review was executed from two national institutions which are Myanmar Agriculture Service (MAS) and Forestry Department in Muse District.

The household level survey in Muse District was carried out in seven villages with a standardized questionnaire, during the period of August 2005 (Table 3.5). A total of 84 households were selected and interviewed with a structured questionnaire.

The household survey covered information about the background of the family, land use, soil fertility and availability of resources, agricultural activities as well as the financial situation of the household. The data covered for cropping seasons in 2005.

Table 3.5. Information base of the farm-household survey in 2005 in Muse District

Village	No. of HH (interviewed)	No of family members	Total agricultural land area (ha)
Kaung Khar	4	28	10.31
Shee Voke	5	29	8.09
Namt taung	6	27	9.39
Maw Taung	40	265	61.96
Hin Lon	13	66	31.76
Nant Phat Khar	9	49	18.51
Kho Mone	7	37	6.98
Total	84	501	147

Source: Own data, 2005

3.2 Analytical Framework

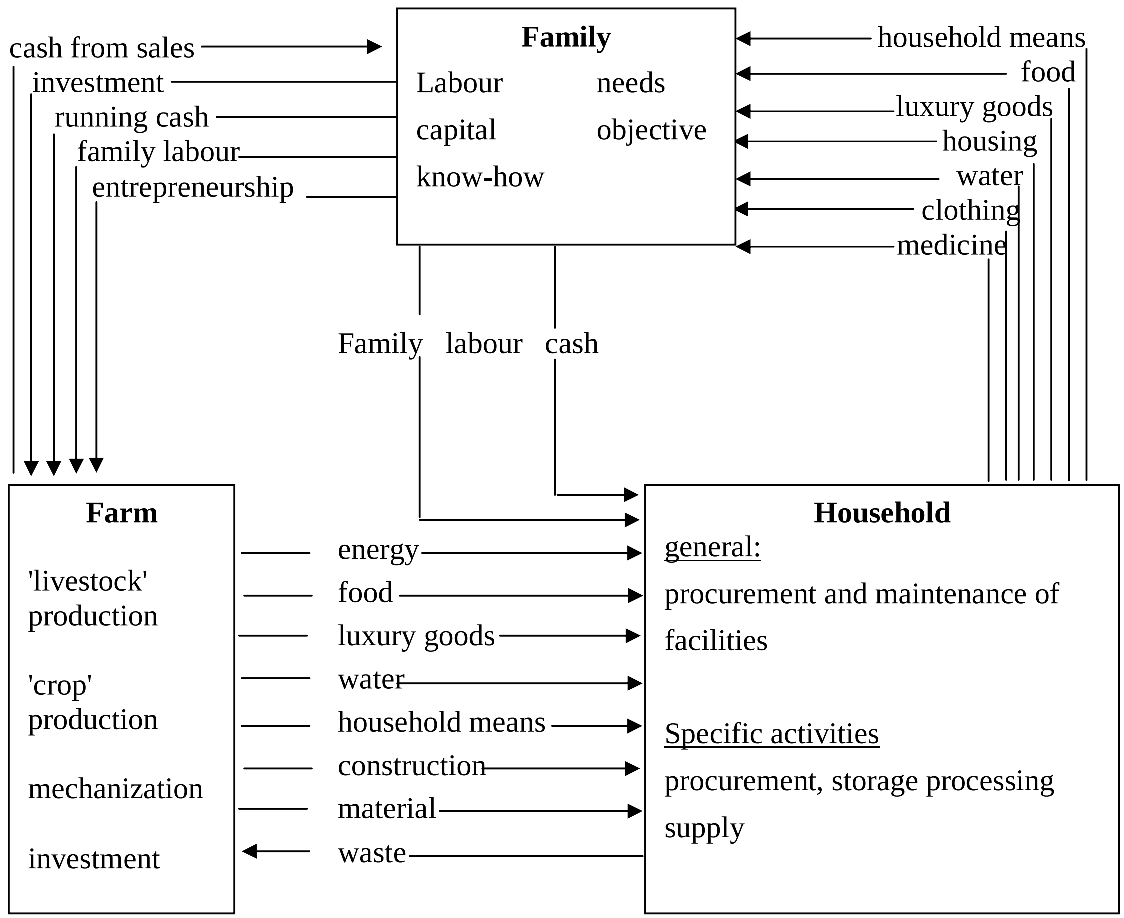
The basic concept used in the analysis was the farming system approach, which looks at the farm household in the wider context of its environment. The unit of analysis was farm-household. Further analysis involved features of productivity in farm activities. Household incomes were calculated to determine the level of income of the farm household under investigation in relation to other farms in Muse District. The importance of a range of factors determining household was analysed using regression analysis. Subsequently, linear programming was applied in order to investigate optimum farming system in agricultural production.

3.2.1 The farming system approach

A farming system is a natural resource management operated by a farm household, and includes the entire range of economic activities of the family members (on-farm, off-farm agricultural as well as off-farm non agricultural activities) to ensure their survival as well as their social and economic well-being (Wattenbach and Friedrich, 2001). Farming systems analysis deals with the constituent elements of farming systems, their characteristics, and their embedding in the environment. The FS approach recognizes that the system and the surrounding environment is not only complex but also influenced by many factors, both internal and external (Figure 3.4 and Figure 3.5).

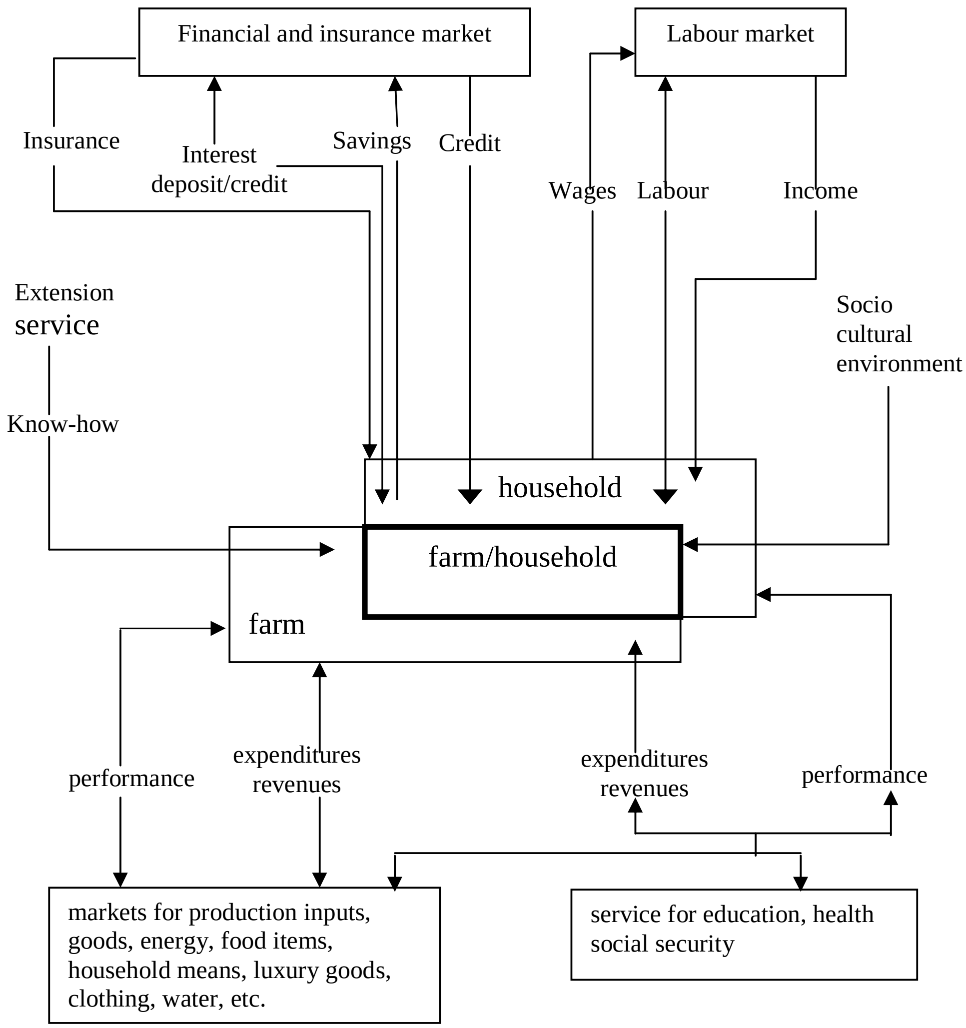
In this study the univariate method was used and farm types were designated on the basis of the income of the household, which reflects the livelihood of the farm household. Viewing the family, the household and the farm as a single economic unit, total family income comprises all net contributions of the farm and of the family/household during the period of time under consideration. The three income groups of analyses are important to evaluate the significance of different groups in a farming system. The first group included high-income, the second medium-income and the third low- income farmers.

This work applies a basic farm income formula cited by Müller (1996) in order to calculate the disposable net family income in equation 3.1. The calculation of the disposable net family income starts from deducting variable costs from farm revenues. This represents the economic performance of the farm, or in other words, the gross margin.



Source: Doppler, 1994

Figure 3.4 Internal relationship within the family unit



Source: Doppler, 1994

Figure 3.5 External relationships to the farming systems

Net farm income + Net off-farm income + Net income from off-farm capital investments + Credit + income in kind -Transfers to others - Interest payments

= Net disposable family income equation 3.1

Source: Müller, 1996

The farm revenues consist of revenues from crop cultivation and livestock production, and revenues from renting out work animals, while farm expenses, in this formula, consist of the variable costs for inputs, hired labour, rent for work animals, expenditures for maintenance and repair of equipment.

Off-farm income from independent or wage labour, net credit (gross credit minus interest and installments), income from capital investment and income in kind valued at the farm-gate price complete the family cash/kind inflow. In addition to expenses of production activities, costs such as transfers to others, mainly family members need to be deducted to reach the disposable net family income. This amount can be either consumed or invested/saved.

According to Müller (1996) net disposable family income was calculated and income clusters were formed. Within the three income clusters identified through the discriminant analysis the following variables were analysed separately; household structure, cropping pattern, livestock activities, off-farm activities, household labour demand for agriculture, earning, and expenses of the household. Furthermore, attitudes towards optimal farming system and conserve resources were analysed.

3.3 Framework for Assessing the Agricultural Sustainability

3.3.1 The concept of sustainable agriculture

The concept of agricultural sustainability has emerged in response to concern about the adverse environmental and economic impacts of conventional agriculture (Hansen, 1996). The excessive and imbalanced use of agro-chemicals has led to increased production costs and dependence on external inputs and energy, a decline in soil productivity, contamination of surface and ground water and adverse effects on human and animal health (Biswa, 1994; Conway, 1985; Edwards, 1989). Overuse or imbalanced application of agrochemicals has led to degradation of natural resources, thereby undermining their productive capacity (Ikerd, 1993). Sustainable agriculture is often viewed in contrast with conventional agriculture as low input and regenerative (Lockeretz, 1989; Re-ijntjes, Bertus, and Water-Bayer, 1992), making better use of farm's internal resources through incorporation of natural processes into agricultural production and greater use of knowledge and skills of farmers to improve their self-reliance and capacities. It uses external and nonrenewable inputs to the extent that these are deficient in the natural environment (Pretty, 1995).

Despite the diversity in conceptualizing sustainable agriculture, there is a consensus on three basic features of sustainable agriculture: (i) maintenance of environmental quality, (ii) stable plant and animal productivity, and (iii) social acceptability. Consistent with this, Yun-long and Smith (1994) have also suggested that agricultural sustainability should be assessed from ecological soundness, social acceptability and economic viability perspectives. Ecological soundness refers to the preservation and improvement of the natural environment, economic viability to maintenance of yields and productivity of crops and livestock, and social acceptability to self-reliance, equality and improved quality of life.

3.3.2 Indicators for assessing agricultural sustainability

For any study on sustainable agriculture, the question arises as to how agricultural sustainability can be measured. Some argue that the concept of sustainability is a "social construct" (David, 1989; Webster, 1999) and is yet to be made operational (Webster, 1997). Although precise measurement of sustainable agriculture is not possible, if specific parameters or criteria are selected, it is possible to say whether certain trend are steady, going up or going down (Pretty, 1995, p.11).

Although a large number of indicators have been developed, they do not cover all the three aspects of sustainability as ecological, economic and social. Due to variation in biophysical and socioeconomic conditions, indicators used in one country are not necessarily applicable to other countries. Therefore, indicators should be location specific, constructed within the context of contemporary socioeconomic situation (Dumanski and Pieri, 1996). In Myanmar, where the majority of farmers are smallholders, and average landholding size is less than two hectare, their immediate concern for agricultural development is how to increase crop yield, income, and food security and reduce the risk of crop failure. The overwhelming majority of farmers lack the capital required for the purchase of inputs, but normally have an adequate labor force. Thus, in view of biophysical and socioeconomic conditions in the study area, "12" indicators, representing ecological, economic and social dimensions of agricultural sustainability, have been selected for evaluation of the sampled households' farming systems. The relevance of the indicators to assess sustainability and their usefulness both from societal and farmers' perspective were considered in selecting them (Figure 3.6).

3.3.3 Framework for determining indicators

3.3.3.1 Framework for determining ecological indicators

Ecological sustainability was assessed based on five indicators namely land-use pattern, cropping pattern, soil fertility management, pest and disease management and soil fertility status. These indicators provide insight about cropping systems and land management practices which influence agricultural sustainability. Normally, there is a higher chance of agricultural sustainability with increasing cropping diversification, mixed cropping and use of organic fertilizers (Altieri, 1995; Edwards and Grove, 1991; Hossain and Kashem, 1997). On the other hand, increased land-use intensity, and application of inorganic fertilizers and pesticides jeopardize sustainability (Biswas, 1994; Conway, 1990; Repetto, 1987).

a) Land-use pattern was examined through proportion of land under field crops, homestead and orchard. F test was employed to see the difference in land-use patterns among the sampled households.

b) Cropping patterns were analyzed using three criteria: cropping intensity, crop diversification and mixed cropping. Crop diversification was measured through crop diversification index using the following formula:

$$ICD = 1/ [(P_a + P_b + P_c + \ ... + P_n)/ N_c]$$

Where, ICD = Index of crop diversification;

P_a = proportion of sown area under crop a;

P_b = proportion of sown area under crop b;

P_c = proportion of sown area under crop c;

P_n = proportion of sown area under crop n;

N_c = number of crops.

Source: Rasul and Thapa, 2003

Crops occupying less than three percent of cropped area were excluded from the analysis. The seven major crops, namely rice, maize, sugarcane, wheat, fruit tree, groundnut, and tea were taken into consideration.

c) Soil fertility management was evaluated based on proportion of farmers using inorganic and organic fertilizers, i.e. farmyard manure and cultivating legume crops. In addition, proportion of area covered by each type of fertilizer, including legumes and amounts of inorganic and organic fertilizers applied

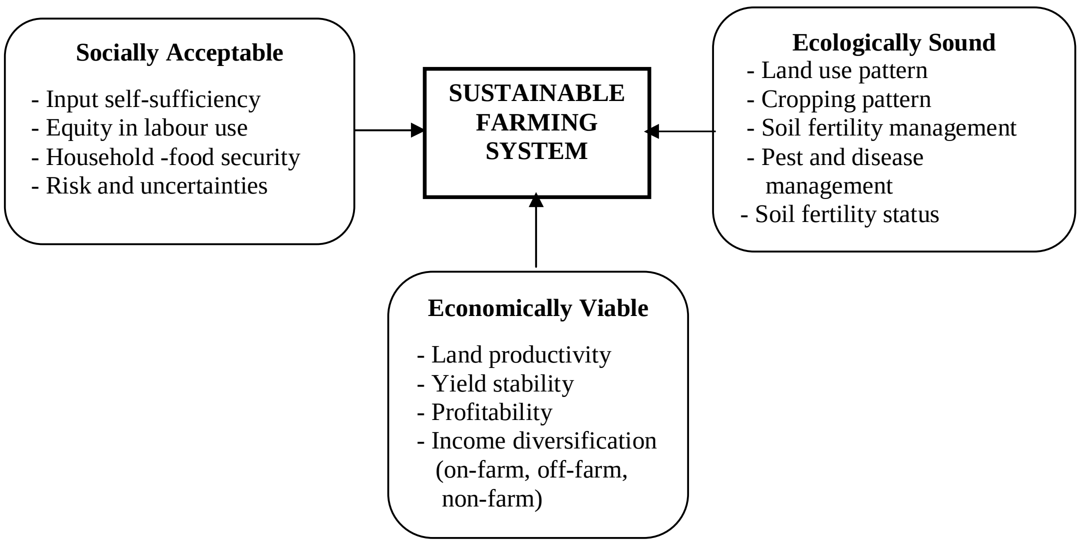


Figure 3.6 Conceptual framework for assessment of sustainable farming system

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per unit of land were considered. F test was employed to test the differences between the different income groups of households.

d) Management of pests and diseases was assessed based on proportion of farmers using mechanical and chemical methods. F test was also used to test differences.

e) Soil fertility was examined through chemical analysis of soil samples collected from study area.

3.3.3.2 Framework for determining economic indicators

Economic sustainability was measured based on three indicators: land productivity, yield stability and profitability. These three indicators reflect the financial condition of an agricultural system. If an agricultural system does not provide sufficient food and income, farmers will not adopt it. System may have ecological benefits that will not be too complicated to consider as an indicator in the study.

a) Land productivity was measured through physical yield of crops. Crop yield data were collected through a household survey. The F test was employed to test the differences in income groups of sampled households.

b) The stability of crop yield was examined by constructing an index based on farmers' subjective responses to a question related to yield trend.

The index was constructed based on the following formula:

$$ITY = (f_i * 1 + f_d * -1 + f_c * 0)/N$$

Where, ITY = index of trend yield

f_i = frequency of responses indicating increasing yield,

f_d = frequency of response indicating decreasing yield,

f_c = frequency of responses indicating constant yield,

N = total number of responses

Source: Rasul and Thapa, 2003

c) Farm profitability was determined based on financial return, economic return and value addition per unit of land. Financial return was analyzed through gross margin per unit land area, gross margin per unit capital and gross margin per unit of labor. As suggested by APO (1994), value added per unit of land was calculated by deducting the value of intermediate goods such as inorganic fertilizers, pesticides, diesel and agricultural equipment from the gross revenue.

3.3.3.3 Framework for determining social indicators

Social acceptability was assessed in terms of input self-sufficiency, equity, food security, and the risks and uncertainties involved in crop cultivation. These indicators are relevant both from societal and individual perspectives. As for long-term agricultural sustainability it is necessary to reduce dependency on external inputs, to minimize risks and uncertainties in farm production, and to attain food security and equity in the society (Ikerd, 1993; Pretty, 1995; Tisdell, 1996). Input self-sufficiency was determined on the basis of the ratio of local inputs cost to the total inputs cost. The higher the ratio of local inputs, the higher the input self-sufficiency. In view of the pervasive unemployment in rural areas of Myanmar, the ability to generate within the system was considered as an indicator of equity effect. Family food security was assessed in terms of adequacy of food grain produced as well as farm households' ability to purchase food grain required for consumption. Risks and uncertainties were examined based on cropping diversification and diversity of agricultural income.

An index of risks and uncertainties was constructed using the following formula:

$$Ir = \sum_{i=1}^{3} (Xi - \bar{X})$$

Where, I_r = index of risks and uncertainties,

X_i = amount of income from the i^{th} source,

$\bar{X}$ = size of income at minimum risk level.

Σ = summation of absolute deviation of i^{th} income from the minimum risk level.

Source: Rasul and Thapa, 2003

The index value is zero when all agricultural enterprises contribute equally. The higher the degree of deviation, the higher the risk involved.

3.4 Maximization of Family Income in Farm-Household System

Profit maximization was determined by using linear programming. There are three quantitative components in LP model. They are:

(1) an objective function

(2) resource requirements; and

(3) resource availability.

Algebraically it is stated in compact form as;

Maximize $\pi = C'X$ (1)

Subject to $$AX \underset{\leq}{\geq} B$$

$$X \geq 0 \qquad (2)$$

Where, A is m x n matrix of technical coefficients

C is n x 1 vector of prices or other weights for the objective function

X is n x 1 vector of activities (crops and livestock to be produced which are unknown decision variables)

B is m x 1 vector of resources or other constraints, availabilities, in physical units, such as labour, credit, land, etc.,

π is gross margin

In expanded form it is written as:

$$\text{Maximize} \quad \pi = c_1x_1+c_2x_2+ \ldots +c_nx_n \qquad (3)$$

Subject to

$$a_{11}X_1 + a_{12}X_2 + \ldots + a_{1n} X_n \leq b_1$$

$$a_{21}X_1+ a_{22}X_2 + \ldots + a_{2n} X_n \leq b_2$$

$$\vdots$$

$$a_{m1}X_1+a_{m2}X_2 + \ldots + a_{mn} X_n \leq b_m \qquad (4)$$

and X_j (column 1 to n) all should be specified in positive values starting from zero or any positive value ($X_j \geq 0$), a_{ij} = i^{th} resource required to produce one unit of j^{th} crop or livestock activity. π is gross margins from the whole farm.

With Σ notation it is written as:

$$\text{Maximize} \quad \pi = \sum_{j=1}^{n} C_j X_j \qquad (5)$$

Subject to

$$\sum_{j=1}^{n} a_{ij} X_j \leq B_i \qquad (6)$$

$$\sum_{j=1}^{n} X_j \geq 0 \qquad (7)$$

B_i = i^{th} resource available with farm for use in the production of crops and livestock. i ranging from 1 to m denoting the numbers of rows (constraints) in the problem. j ranging from 1 to n indicating the number of columns (crop and livestock activities) in the problems.

3.5 Determinants of Family and Agricultural Income

The goal of a regression analysis is to obtain estimates of the unknown parameters, β_0 to β_k which indicate how a change in one of the independent variable affects the values taken by the dependent variable. Normally two methods are used to estimate these parameters, the ordinary least square method (OLS) and the maximun likelihood estimate.

The OLS procedure minimises the sum of squared differences between the actual Y and the estimated Y. The estimation is carried out by means of a linear relationship and the given residuals are the difference between the actual and the estimated Y.

This can be formulated by

$$\hat{Y}_i = \beta_0 + \beta_i x_{i1} + \ldots + \beta_k x_{ik} + u_i \quad (3) \quad \text{and:}$$

$$\hat{Y}_i = \beta_0 + \beta_1 x_{i1} + \ldots + \beta_k x_{ik} \quad (4)$$

Where is the estimated value of Y

$$Y_i = \hat{Y}_i + u_i \quad \Rightarrow \quad u_i = Y_i - \hat{Y}_I \quad (5),(6)$$

It shows that u_i is simply the difference between the actual and the estimated Y.

With the least square criterion:

$$\Sigma\, u_i^{\,2} = \Sigma(Y_i - \hat{Y}_i)^2 \quad (7)$$

it can be said that

$$\Sigma u_i^2 = f(\beta_{1,\ldots,}\, \beta_k) \quad (8)$$

OLS chooses β_1, ..., β_k in such a way that, for a given sample or set of data, the sum of squared residuals is as small as possible. The estimators obtained are known as the Least Square Estimators.The estimators have to be unbiased, linear, and the variance between the real and the eatimated β as small as posssible. In the present study, the OLS is used to estimate the parameters of the regression model.

In order to evaluate the family and agricultural income of the sample households multiple regression analysis was used. In the linear regression model, the dependent variable is assumed to be a linear function of one or more independent variables. The model is characterized as non-stochastic if one corresponding value for each value of the variable X can be identified.

$$Y_i = \beta_0 + \beta_1 x_{i1} + \ldots + \beta_k x_{ik} \quad (1)$$

Where: Y_i = dependent variable

$x_{i1}, \ldots, x_{ik}$ = a set of independent variables

β_0 to β_k = the intercept and a set of parameters related to the independent variables to be estimated

If an error is introduced which accounts for all other factors the model is characterized as stochastic.

$$Y_i = \beta_0 \quad \beta_i \quad x_{i1} + \ldots + \beta_k \quad x_{ik} + u_i \qquad (2)$$

With u_i = disturbance or error term.

The errot term is included for the following reasons:

- Not all explanatory variables are included in the model, for example due to lack of knowledge, difficulty in measurement, etc.
- Measurement errors cannot be absolutely avoided
- Errors of aggregation over time and space may occur

All these points are captured with the error term. But certain assumptions about the error term have to be fulfilled. The mean value of u_i conditional upon the given x_i has to be zero ($E(u_i / x_{i1,} \ldots x_{ik}) = 0$). The variance of u_i, given the value of x_i, has to be the same for all observations ($Var.(u_i) = \sigma^2$). An autocorrelation between the disturbance terms has to be avoided ($Cov.(u_i, u_j) = 0$). No covariance between u_i and each variable x is allowed. Furthermore, there is no exact linear correlation between the variables x_i.

CHAPTER 4

SOCIO-ECONOMIC CHARACTERISTICS, LAND USE AND ECONOMIC SITUATION OF SHIFTING CULTIVATING HOUSEHOLDS

This chapter firstly presents the detailed socio-economic characteristics of shifting cultivators such as annual household income, household structure, labor availability, education level of household head, access to education, housing and luxury goods, own livestock, land resource, seasonal labour demand in crop production and off-farm activities. The household consumption expenses, inflow and outflow of cash and goods, credit and deficit or surplus of household income are provided to study the economic situation of shifting cultivating households.

4.2 Categorizing of Shifting Cultivating Households Based on Annual Household Income

In a given study area, farm-family-households can never in actual fact be considered a homogeneous group. To evaluate activities of farm-family-household, the approach usually taken is to group the households in relatively homogeneous clusters. In an iterative process, classes are defined as a possibly small variability in key variables within the group and high variability between the groups. A study concerning the development of the livelihood of smallholders requires a classification reflecting the economic situation of the small-scale farmers. Disposable income per farm-household was chosen as a criterion for stratification. The sample shifting cultivating's households were classified into three groups: (1) low-income households whose annual household income was below 0.5 million kyats; (2) medium-income households whose annual income was between 0.51 and 1 million kyat; and (3) high-income households whose annual households income was above 1 million kyats.

Based on annual household income, 45.2 percent of the total sample households can be classified as 'low-income households', 29.8 percent of sample households as 'medium-income households', and 25 percent of sample households as 'high-income households'. The average annual households income of 'low-income household' was 395,924.89 kyats, and 'medium-income household' was 726,588.08 kyats, and 'high-income household' was 1,537,368.50 kyats (Table 4.1).

Table 4.1. Categories of shifting cultivation households based on disposable annual income

Category	Number and %	Average annual income (standard deviation)	Maximum income	Minimum income
Low-income household	38 (45.2%)	395,924.89 (84,799.17)	492,970	202,960
Medium-income household	25 (29.8%)	726,588.08 (132,904.91)	994,600	570,660
High-income household	21 (25.0%)	1,537,368.50 (572,247.83)	3,061,740	1,000,910
Total household	84 (100%)	779,697.45 (548,403.21)	3,061,740	202,960

Source: Own data, 2005

4.2 Household Structure

A household is defined as a group of people who permanently live together in one house. It is the basic unit in which decision on the allocation and utilization of resources was made in order to fulfill the objectives of the household members.

The household is characterised by family size, age composition, family labour endowment and the educational level of male and female adults of the household. Family size and age mainly influence the family's needs with regard to food, cash, and clothing but also the availability of labour for farm, household and off-farm activities. The total availability of household labour (HL) in adult equivalents (AE) is calculated as follows.

$$HL = MW + 0.5 * C + 0.5\ E$$

where: MW Total number of men and women living in the family $\geq$ 15 years old and $\leq$ 65 years old

C Children >5 years old and <15 years old

E Elderly $\geq$ 65 years old

Source: Luibrand, 1999

Table.4.2 shows the household structure of different types of shifting cultivating households. The average household size was 5.84 for all income groups. The high-income household possessed the highest household size (6.5) while the low-income household had the lowest household size (5.1).

Household size in the study area ranged from 2 to 11 persons. The high-income households have a slightly larger family size and labour capacity than the medium or the low-income households. Two main types of households can be characterised as followed: (1) a couple living with their children (2) the extended family, where two or three generations are living together, including unmarried sisters and brothers of the head of the household.

In the medium and high-income clusters, a higher percentage of extended families can be found, which leads to a higher average number of family size. This also results in a slightly higher availability of labour in the high and medium-income clusters. The labour capacity on average is 5.01 AE. In a high-income household, 5.54 persons are of working age, while in a low-income household 4.42 persons are of working age and in a medium-income household the figure is 5.46. The dependency ratio (DP) is lower in the low-income households than it is in the high and medium ones.

Table 4.2. Household structure of shifting cultivating household

Characters	High-income HH (N=21)	Medium-income HH (N=25)	Low-income HH (N=38)	Total HH (N=84)
Household size (no)	6.50	6.40	5.10	5.84
Household labour (no)	5.54	5.46	4.42	5.01
Dependency ratio (%)	50	51	41	47
Age of farmer (yr)	48	47	44	46
Age of wife (yr)	42	40	39	40
No. of children (no) (>5 <15 years)	1.47	1.20	1.10	1.22
No. of older person (no) (≥65 years)	0.29	0.56	0.23	0.33

Source: Own data, 2005

A high DP means that the percentage of non-working persons is high. The DP in a low-income household was 41 percent compared to 51 percent in a medium-income and 50 percent in a high-income household.

The head of a household is usually male. The age distribution of the farmers showed that nearly 40 percent of men and 63 percent of women are under 40 years of age (Figure 4.1).

Labour availability is the highest in families with a household head who is between 41 and 50 and lowest in families whose household head is less than 40 years old (Figure 4.2). A difference in the household structure between income groups is the number of children between 5 and 15 years. Children are often to feed the cattles of the family and thus labour availability is increased. In the high-income families the share of youngsters was 1.47 and in the medium-income families it was 1.20, whereas in the low-income families the figure is only 1.10. In low-income households, a young couple has small children who need to be to take care of or who have to go to school and, therefore labour for farm activities is scarce. Thirty one percent of the low-income and 32 percent of medium-income farmers are under 30 years of age, whereas the percentage is smaller in high-income households which was about 19 percent.

4.3 Access to Education

Farmers and their wives in the high-income families went to school longer than in the low or medium-income families (Table 4.3). In this group, 24 percent of farmers and 10 percent of their wives finished high school and one farmer had been to university. Of the medium-income group, farmers attained lower education than the two other groups. In this group, 36 percent of the household head and 24 percent by the wife had finished primary school. However, 37 percent and 39 percent by household head and wife respectively of the low-income farmers went to primary school. Of the high-income farmers, 42 percent of the household head and 52 percent by the wife did not attain primary education. Of the medium-income farmers, 44 percent of the household head and 76 percent by the wife did not go to school. Of the low-income farmers, 39 percent and 51 percent household head and wife did not finished primary school. It is observed that there is no connection between education and choice to get married.

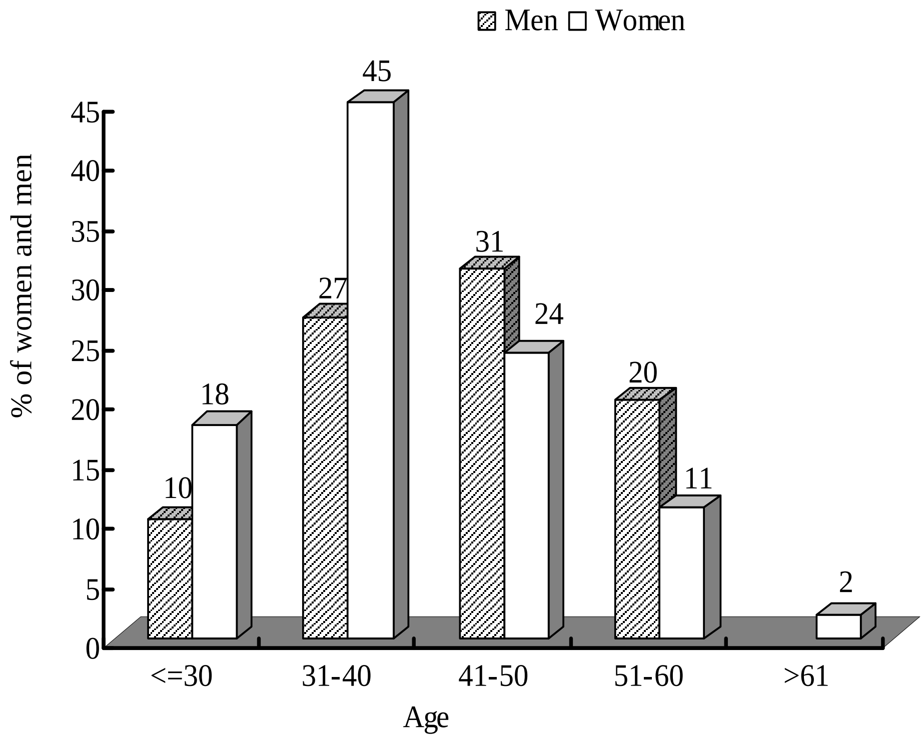


Figure 4.1 Age distribution of the farmers and their wives

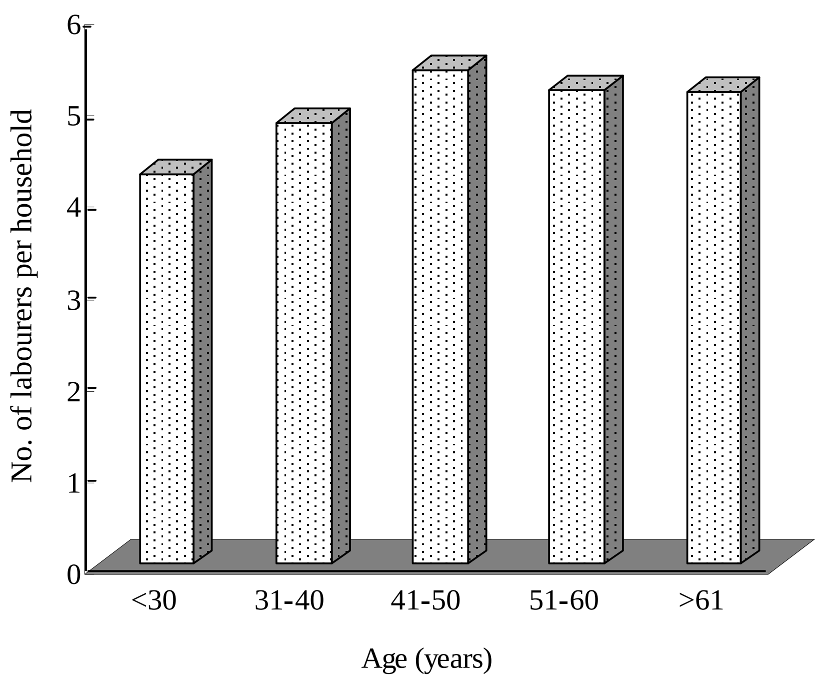


Figure 4.2 Labour availability in relation to the age of the household head

Table 4.3 Education level of the farm family

Characters	High (N=21)	Medium (N=25)	Low (N=38)	Total (N=84)
Finished high school by farmer (%)	24	-	8	10
Finished high school by wife (%)	10	-	5	5
Finished middle school by farmer (%)	24	20	16	19
Finished middle school by wife (%)	19	-	5	7
Finished primary school by farmer (%)	10	36	37	30
Finished primary school by wife (%)	19	24	39	30
Did not go to school by farmer (%)	42	44	39	41
Did not go to school by wife (%)	52	76	51	58

Source: Own data, 2005

In 2002, the overall adult illiteracy rate in Myanmar was 19 percent for men and 11 percent for women. Compared to the survey results, the average illiteracy rate of 41 percent for men and 58 percent for women is higher in the study area than in survey of 2002. Also, according to ADB (2004) access to primary education level of 91 percent in Myanmar 2000, is comparatively higher than the survey in all three clusters.

Nevertheless, education is an important tool to reduce poor living standard in three ways. (i) it gives future workers to be skillful through which they can escape low-wage labour trap and increase the wage-rate; (ii) more skilled labour force improve the international competitiveness of country's products, boosting exports and economic growth; (iii) improvement of basic education level of labour force reduces the income gap. Thus, literacy and access to education is becoming a major determinant of household income (CIRDAP, 2005).

The majority of families recognizes the importance of school attendance and assumes a positive correlation between children's education and their future. On average 69 percent of the households are satisfied with the school system and there is no major variation concerning satisfaction among the three clusters (Table 4.4).

On average household expensed 53,214 kyats per year for education. High-income households have more expenses for education (145,095 kyats) because they usually send more than one child to school and make to get more education for their children. School expense for primary school is mainly for text books and stationary.

The most preferred education for children is a graduation after tertiary school (Figure 4.3). Discrimination between boys and girls depends on different ideas on attitudes of household heads respectively but not on gender issue.

Children generally left school after primary school (at least five years). Usually most of the boys and girls rarely went to secondary and tertiary school.

4.4 Type of Housing and Luxury Goods

The type of housing and possession of luxury goods in study area provides evidence regarding the status of the household. Household usually lives in simple houses with brick or bamboo walls and thatch or corrugated metal roofs.

Nowadays, arising number of solid houses with corrugated metal roof have been built in the studied villages. In the high-income cluster 81 percent of farmers live in houses with a corrugated metal roof, while in the medium-income cluster and

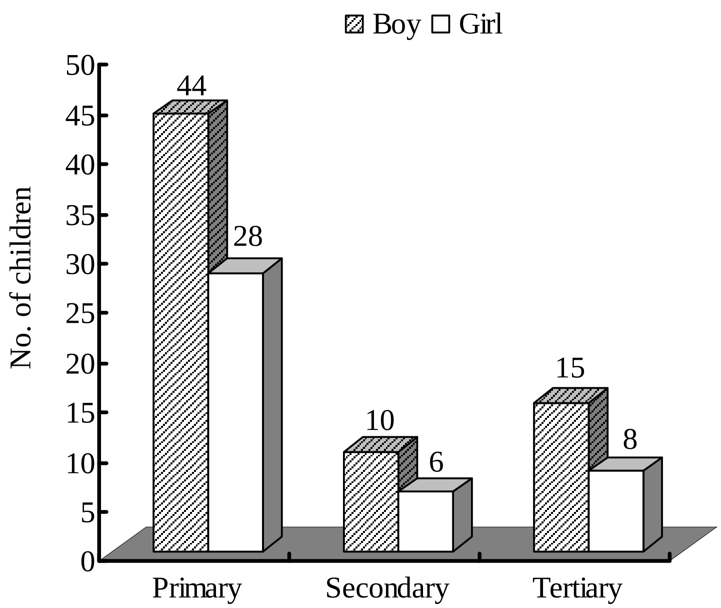


Figure 4.3 Number of children with respect to level of education

the low-income cluster the figure are 64 percent and 32 percent respectively (Table 4.5). Only 19 percent of the high-income, 36 percent of the medium and 68 percent of the low-income households have the conventional grass thatched roofs and bamboo walls.

There is a difference between the clusters in the percentage of farmers who have luxury goods which are television, VCD player, Cassette/Radio, and motorcycle. It varies between 62 percent in a high-income household, 48 percent in a medium-income household and 29 percent in a low-income household. One can say that the livelihood of the farmers as regards housing and possession of luxury goods still has slow improvement.

4.5 Own Livestock

Livestock production is also an important part of the farming systems. It is mostly small-scale and primarily for household consumption and work; furthermore, large ruminants are regarded as a form of savings. The average value of all animals in all the households is 166,458 kyats. There are differences in the average value of animal between high and medium-income, also between high and low-income group in which the value difference was around 0.76 million and 0.86 million respectively (Table 4.6). In the total animal assets, cattle predominate, followed by buffaloes in high-income and medium-income household while buffaloes predominate, and followed by cattle in low-income household.

Buffaloes and cattle are kept as draught animals for land preparation, manure production and breeding. Buffaloes are sold at marketable adult age of 4-5 years with up to 0.2 million kyat. For cattle it is marketable at the adult age of 3-4 years and can be sold at up to 0.15 million kyat. There is a difference between the clusters in terms of cattle in a household. Low-income farmers have on average 0.26 cattle per household and medium-income farmers have on average 0.64 cattle per household whereas high-income ones have over four cattle.

Pigs are quite attractive to households because they grow and multiply rapidly and require only a small start-up investment. They are used for meat consumption and for manure production, as well as can easily be sold on the local markets to generate cash. Poultry rearing is a quick source of cash income. Chicken are easy to sell in the local markets. Chicken meat and eggs are an additional source of cash.

Table 4.4. Farmers' perception of the education system and annual education expenses

Items	High (N=21)	Medium (N=25)	Low (N=38)	Total (N=84)
Satisfaction with school system (% of HH)	72	68	69	69
Expenses for school (kyats per year)	145,095	37,680	12,658	53,214

Source: Own data, 2005

Table 4.5. Distribution of corrugated metal roof houses and luxury goods, percent of households

Items	High (N=21)	Medium (N=25)	Low (N=38)	Total (N=84)
HH with corrugated metal roof houses (%)	81	64	32	54
HH with luxury goods (%)	62	48	29	43

Source: Own data, 2005

Table 4.6. Animal assets of livestock holdings per household

Characters	High (N=21)	Medium (N=25)	Low (N=38)	Total (N=84)
Assets of animal per HH (kyats)	1,030,000	267,900	164,605	166,458
No. of Buffaloes	1.28	0.56	0.36	0.65
No. of Cattle	4.3	0.64	0.26	1.39
No. of Pigs	1.57	0.72	0.60	0.88
No. of Poultry	8.57	3.8	3.6	4.9

Source: Own data, 2005.

4.6 Land Use and Land Resources

According to the 1992 land use act, any citizen was allowed to use land at the disposal of the government for growing of perennial and seasonal crops, and livestock rearing. In general in survey area, the land size, including the total farm, paddy and upland, was larger in high-income household than in the medium-income households, where in turn it is still larger than in the low ones. The average farm size per household is 1.75 ha and a significant difference can be seen between the low-income households (1.03 ha) and the high-income households (3.05 ha) (Table 4.7).

Eighty percent of the medium-income and 84 percent of the low-income families do not have any rainfed paddy land, whereas 58 percent of the high-income families possessed paddy land. The per capita upland area owned by low-income household was 0.18 ha but that owned by high-income household was 0.39 ha which differ nearly double in area owned by high-income in the study area. In this study, the upland fields of sampled households can be classified into Ya and TaungYa field.

Rice is cultivated on rainfed paddy land, on Yaland and taungya fields (Figure 4.4). Twenty three percent of the farmers cultivated rice only on lowland fields, 8 percent on Yaland fields, 36 percent on taungya field and 6 percent of the farmers combine rainfed paddy land and taungya fields.

The area of rainfed paddy is declining to 29.5 percent of the total cultivated area (Figure 4.5). It is important for households to meet their requirements in rice consumption from their yaland rice and taungya rice. Although there is declining area in rice cultivation at the rainfed paddy field, stagnation was found in yaland and taungya rice area. The land is now increasingly substituted by maize crop. Maize area increased from 15.8 percent to 18.0 percent in the last five years. Maize has now become one of the most important cash crops for farm households.

In this survey, shifting cultivation had changed from rotational to sedentary farming practice, and from subsistence cropping to commercial cropping. They produce commercial crops and various kinds of food crops and small–scale livestock rearing are made in their home compound. They practice composite swiddening, which is a farming system defined by Jamieson *et. al.* (1998). It is a system of agriculture in which households combine cultivation of rainfed paddy in the valleys with rotational swiddening on the hillsides, although rotational swiddening is increasingly being replaced by permanent cultivation. Besides the main crops of rice, maize, groundnut and soybean, the farmers also grow fruit trees, tea, sugarcane, sesame, wheat, potato and vegetables, although on a small scale. Such crops are usually grown in home-gardens or on upland fields (Figure 4.6).

Table 4.7. Agricultural land resources in the study area, in ha

Characters	High (N=21)	Medium (N=25)	Low (N=38)	Total (N=84)
Average farm size per HH	3.05	1.76	1.03	1.75
Average farm size per capita	0.47	0.27	0.20	0.30
Paddy area per HH	0.47	0.13	0.07	0.19
Paddy area per capita	0.07	0.02	0.01	0.03
Upland area per HH	2.57	1.63	0.95	1.56
Upland area per capita	0.39	0.25	0.18	0.26

Source: Own data, 2005

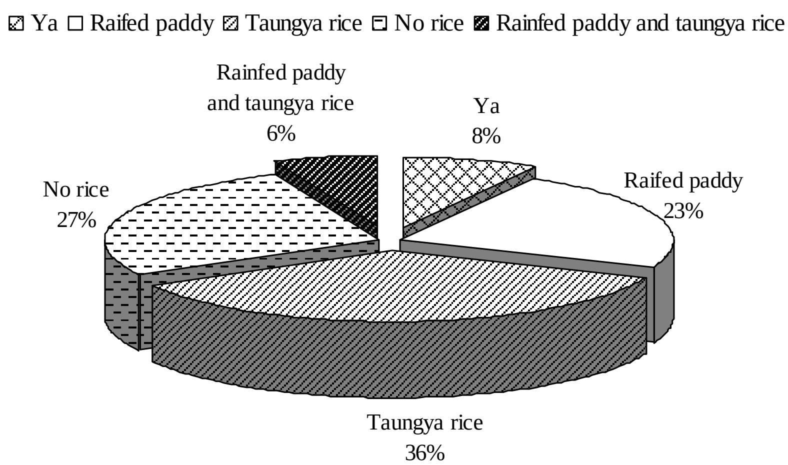


Figure 4.4 Rice production systems in the study area

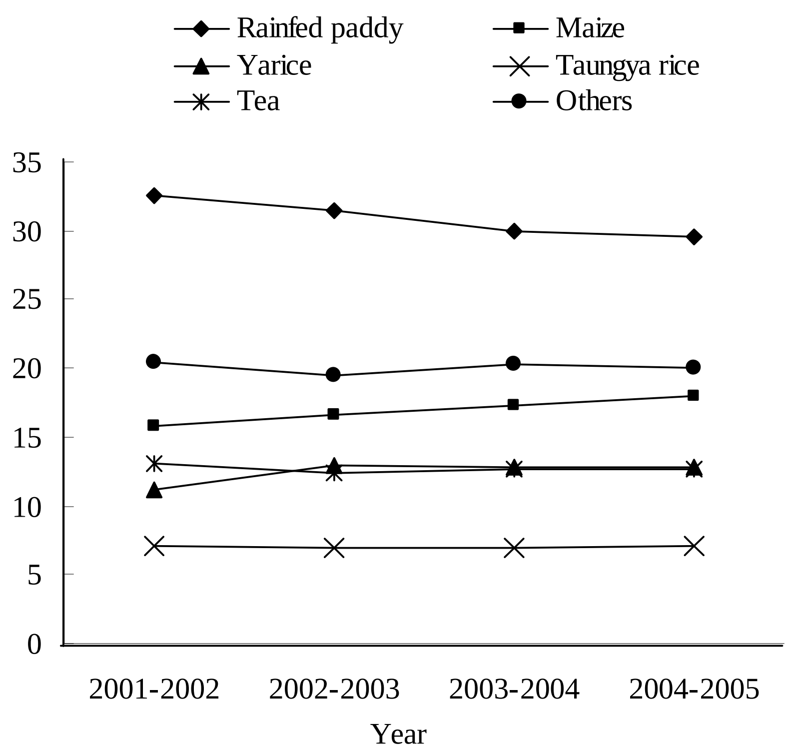


Figure 4.5 Changes in rainfed paddy and upland cultivation in study region between 2001-2002 and 2004-2005, growing in percentage of total cultivated area in Muse district.

Figure 4.6 Upland cultivation practices in the study area

4.7 Seasonal Labour Demand in Crop Production

Two distinct periods with respect to labour distribution can be noticed in the study region (Figure 4.7). One distinct period belongs to during the period of November up to February in which the working days per household was at ten to thirteen days per month. The other was found in March and October where labour use was at 21 to 30 days per month.

Peaks of working days are in March and April, when the upland crops and monsoon paddy fields are prepared for planting. In January and February, upland fields are slashed and burned to clear weeds and shrubs. At the beginning of April, before coming the first rain, sugarcane is planted when tea, potato and winter wheat are harvested. In May, monsoon paddy fields are prepared for cultivation and summer paddy is harvested. In June a second peak can be noticed due to sowing of monsoon paddy and upland crops. In July monsoon paddy is transplanted from the seed-beds to the paddy fields. Fertilization, the application of pesticides, hoeing and weeding took place two to three times between July and September.

The main task of October is upland crops harvesting. The working days from November to February is planting summer paddy, winter wheat, mustard and harvesting of sugarcane and sesame. Additionally, sugarcane is an annual crop which needs work between December and February.

4.8 Off-farm Activities

Off-farm activities play an important role in the development of FS (Hazell and Haggblade, 1993). In the study region households' livelihoods are still agriculture in nature. Households with off-farm activities were found to be 86 percent in the high-income, 88 percent in medium-income cluster and 89 percent in low-income households (Table 4.8).

However, 48 percent in the medium-income cluster and 34 percent in the low-income cluster of households was found where off-farm income is the predominant income source. In the high-income households, income from off-farm activities presented the major income source in 19 percent of the households. Most of the farmers would like to pursue off-farm activities in months when there is less farm work. Off-farm income activities are included two activities such as non-agricultural off-farm activities and agricultural off-farm activities (Figure 4.8).

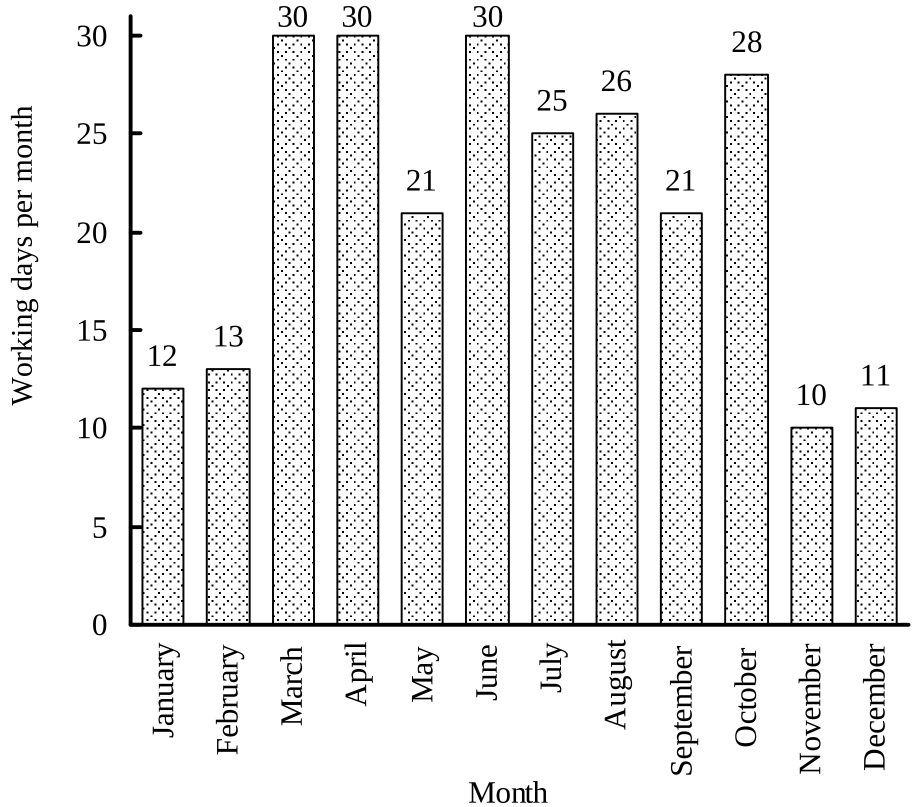


Figure 4.7. Monthly distribution of working days for crop production per household in the study region.

Note: Data about the different activities were collected in hours. From this base, working days are calculated with eight working hours per day.

Table 4.8. Off-farm income by three different income households

Characters	High (N=21)	Medium (N=25)	Low (N=38)	Total (N=84)
Households with off-farm income (% of HH)	86	88	89	87
Off-farm activities as main source of income (%of HH)	19	48	34	35
Off-farm income (Kyats)	517,397	357,809	171,844	310,545
Share of agricultural off-farm (% of income)	4	20	30	14
Share of non-agricultural off-farm (% of income)	25	21	9	20

Source: Own data, 2005.

Figure 4.8 Agricultural off-farm and non-agricultural off-farm activities

Non agricultural off-farm includes grocery shop, slipper store, tea shop, selling cattle, transportation services, handicraft production, baking charcoal, and selling forest products (mushroom, firewood, and medicinal plants). Employment can be found as a government servant in one household of high income farmers and as a local teacher in one household of low-income farmer. Agricultural off-farm income plays a minor role in high-income farmers. Only 4 percent of agricultural off-farm income of high-income farmers was found whereas 20 percent in medium-income farmers and 30 percent in low-income farmers was found in survey area. In general, farmers help each other in agricultural activities on a mutual basis and most low-income farmers employ laborers on a wage basis in forest-plantation.

The average annual income from off-farm activities is 310,545 kyats. The contribution of non agricultural off-farm income to average total income and agricultural off-farm income to average total income are 20 percent and 14 percent respectively. In the cluster of the high-income households, grocery shops and transportation services were found to be responsible for non agricultural off-farm income. In the cluster of the medium-income households, baking charcoal and transportation services were found as the main source of non agricultural off-farm income. Only 9 percent of non agricultural off-farm income of low-income farmers was from baking charcoal which is a main source of such income.

4.9 Food Supply and Self-Sufficiency

The main staple foods in the investigated farming systems are rice, oil, vegetables and meat. A high percentage of rice in the meal and the frequent consumption of meat are regarded as a sign of wealth. Vegetables originate either from home-gardens or they are collected in the fields or in the forest or bought from the market.

In general, the requirements of an individual are influenced by gender, age, body weight, activities and climate. The total food requirement of a household depends on family size and structure. Two World Bank living standards surveys (1993 and 1998) were carried out in Vietnam for extensive analysis of the livelihood of the population, and the analysis in these was based on consumption per capita. In this study, therefore, consumption is also calculated on a per capita basis to make it easier to compare results across studies. In this study, rice, oil and meat were chosen as examples to describe the food supply of a household. In fact, rice and oil are the main components of the daily diet, while the consumption of meat indicates the wealth of the family. On daily average a household consumes 1.97 kg of rice, 0.09 kg of oil and spends around 209 kyats for meat and fish per day (Table 4.9). In medium-income households the consumption of oil (0.12 kg per day) is slightly higher than in the other two clusters. It was found that usage of oil in cooking is in a small amount, according to tradition of the people in mountainous regions.

The results show that high-income households consume more meat and rice than low and medium-income households. Calculated on a per capita basis, a high-income household uses 0.38 kg of rice, 0.019 kg of oil and spends 50 kyats for meat. The consumption of rice in a medium-income (0.33 kg/capita and day) and a low-income household (0.34 kg per capita and day) are nearly the same.

Self-sufficiency of household needs refers to goods deriving from the farm itself. The survey results showed that in rice production farmers are not at being self-sufficient.

The percentage of rice purchasing from the market is on average 36 percent. The medium-income farmers have the highest share of 51.1 percent for rice in their consumption, compared to 43 percent or 7.2 percent in the case of the low and high-income farmers. The average amount of rice that households buy on the market is 121 kg per year. Low and medium-income farmers purchase annually at 122 kg rice and 199 kg rice which is more than nearly four to six times of the rice purchased by high-income farmers (28 kg rice per year). Market food includes rice expenses for food a household spends in the market. Subsistence food consists of rice only, valued at farm-gate price (Table 4.10). The value of market food does not differ from the value of subsistence food in low and medium-income farmers.

The expenses for market food vary between 29,982 kyats per year for the high-income up to 214,510 kyats per year for the medium-income households. The value of the subsistence food on average for all the households is 234,593 kyats per year, although this varies between 171,552 kyats per year for the low-income households, 204,588 kyats per year for the medium-income households and 384,389 kyats per year for the high-income households. On average total subsistence level in all classes of households is about 58 percent which is still low in the study area. In general, high-income farmers are more food self-sufficient in rice consumption than low-income and medium-income farmers. Concerning rice consumption, farmers in all three clusters are needed to get full subsistence level because it is the staple food crop.

Table 4.9. Daily consumption of rice, oil and meat and fish by three income groups

Items	High (N=21)	Medium (N=25)	Low (N=38)	Total (N=84)
Rice consumption (kg per HH)	2.2	2.14	1.74	1.97
Rice consumption (kg per capita)	0.38	0.33	0.34	0.35
Oil consumption (kg per HH)	0.109	0.12	0.067	0.09
Oil consumption (kg per capita)	0.019	0.02	0.012	0.016
Meat and fish consumption (ks per HH)	300	180	178	209
Meat and fish consumption (ks per capita)	50	32	34	37

Source: Own data, 2005

Table. 4.10. Comparison of the subsistence level for rice for total food supply

Items	High (N=21)	Medium (N=25)	Low (N=38)	Total (N=84)
Self-sufficiency in rice (% of HH)	90	28	39	49
Rice from the market (% of total rice consumption)	7.2	51.1	43.0	36
Rice from the market (kg per year)	28	199	122	121
Value of market food (kyats)	29,982	214,510	139,894	197,908
Value of subsistence food (kyats)	384,389	204,588	171,552	234,593
Total subsistence level	92.8	48.8	45.0	58.0

Source: Own data, 2005

4.10 Economic Situation of the Farm-Family-Household System

The economy is an important feature of describing the success of a farm-family-household system. This section analyses farm and family income and outlines the farmer's behaviour towards borrowing and saving.

4.10.1 Composition of income

Income can be described as the flow of cash or goods accruing to an individual, a group of individuals, a firm, or the economy over some time period (Bartels, 1993). Farm household is the economic unit on which the analysis is based. Cash flows can be divided between cash receipts and cash disbursements. Cash receipts are the money received by the farm household and disbursements are money spending by the farm household for consumption and operating the farm. Flows of goods are goods for home consumption, valued at farm-gate prices. The household income is calculated using cash flows and home consumption from plant production, livestock rearing, agricultural off-farm activities, non-agricultural off-farm activities and orchard income.

In general, cash inflow mainly stems from agricultural activities, credit received, off-farm and non agricultural off-farm activities. Cash inflow from plant production is generated through selling of maize, rice, groundnut, tea, soybean, sugarcane and orchard. The predominant share of cash flow in plant production stems from maize production followed by rainfed paddy and upland rice. The average share of plant production was about 58 percent of the total for all clusters. Rainfed paddy and upland rice play a minor role because it is mainly grown for family consumption. In animal production, farmers receive cash from selling chicken meat or eggs, pig meat and sometimes meat from large ruminants. Forest products collected from the forest were taken as an additional source of income, including non-agricultural off-farm income, even though these products are primarily used for home consumption. Forest products like mushroom, firewood, and medicinal plants were sold out by some farmers. The composition of off-farm income activities is described in section 4.8.

On average, the cash inflow of a farm household is around 1.5 million kyats per year (Table 4.11). It ranges from 0.67 million kyats for a low-income household to 1.3 million kyats for a medium-income household and 2.8 million kyats for a high-income household. Variation in cash inflow between farms was very high, with a minimum of 202,960 kyats per year and a maximum of 3,061,740 kyats per year.

The highest share of income stems from plant production. On average, cash from plant production was around 0.5 million kyats per year. The lowest value observed was 0.06 million kyats and the highest 2.6 million kyats. Maize is the main source of cash income in a farm household. The higher income of the high-income farmers can therefore mainly be explained by the larger size of maize area and higher maize yields. The second most important income source in plant production is rainfed paddy production and upland rice production. Income from orchard production accounts for only 4 percent of the total cash income. The highest cash inflow can be found in high-income household by the larger size of orchard area than in the other two clusters.

The average cash inflow from animal production is 0.12 million kyats. High-income households do have on average more large ruminants than the low and medium-income farmers having the higher cash inflow. Low and medium-income households normally need their large ruminants for work.

Income from agricultural off-farm activities accounts for around 14 percent of the total cash inflow. The low share is due to a low demand for off-farm labourers. The contribution of non-agricultural off-farm income to the total cash inflow is around 20 percent. The lowest value observed was 0.02 million kyats and the highest 1.09 million kyats. Grocery shop, transportation service and baking charcoal from forest are the main source of such income.

The average amount of credit was 0.12 million kyats per household. The amount of credit in a high-income household (0.31 million kyats) is higher than in a low-income (0.042 million kyats) or medium-income household (0.067 million kyats).

Home consumption consists mainly of rice, with smaller share of eggs, meat and goods collected in the forest such as vegetables and bamboo. The total value of consumption varies between 0.26 million kyats in a low-income household and 0.5 million kyats in a high-income household. Average annual inflow per household is 1.8 million kyats. The variation between a low and a high-income household is different. The total inflow in a high income household is 3.3 million kyats per year while for a low-income household, it is 0.9 million kyats per year.

Per capita annual inflow is on average 0.32 million kyats. It varies between 0.51 million kyats for a high-income household and declines to 0.18 million kyats in a low-income household.

The outflow of cash and goods is due to expenses for farm activities and for household consumption (Table 4.12). Expense for farm activities includes expenses for plant and animal production and for farm tools. In animal production farmers make heavy use of feed stuffs deriving from plant production. Rarely, farm households buy animal fodder supplements. For plant production, expenses for agricultural inputs such as fertilizer, pesticides and seeds, expenses for non-family labour are considered.

Cash outflow for agricultural activities is on average 0.13 million kyats and expenses for plant production have the highest share in three clusters. The expense for agricultural activities in high-income households (0.63 million kyats) is higher than in the other two clusters due to larger farm size. Therefore a high-income household is spending the amount of 0.34 million kyats for plant production which is more than a low (0.05 million kyats) or medium-income household (0.07 million kyats).

Expenses for the household include the purchase of food, clothes, education, medical care and expenses for other household needs such as expenses for weddings, funerals and house-building. Additional expenses for interest on current credits are also included. On average the household expenses for consumption are 0.85 million kyats. The total outflow per household is 1.1 million kyats per year and the highest cash outflow per capita can be found in the high-income cluster. The per capita expenses for a low-income household are around 50 percent lower than that for a high-income household.

Table 4.11. Inflow of cash and goods in household, kyats per year

Items	High (N=21)	Medium (N=25)	Low (N=38)	Total (N=84)
Cash				
Plant production	1,194,050	426,113	259,237	542,606
Animal production	237,143	88,000	23,667	124,556
Agricultural off-farm activity	160,593	279,769	152,450	188,093
Non-agricultural off-farm activity	541,267	258,467	79,325	288,374
Orchard production	387,500	266,667	114,000	243,333
Credit	312,778	67,222	42,038	127,952
Total cash inflow	2,843,331	1,386,238	670,717	1,514,914
Goods used as home consumption				
Crop production	424,852	300,863	260,759	323,046
Animal production	77,273	16,667	5,833	32,000
Total value of HC	502,125	317,530	266,592	355,046
Total inflow per HH	3,345,456	1,703,768	937,309	1,869,960
Total inflow per capita	514,686	266,214	183,786	320,199

Source: Own data, 2005

Table 4.12. Outflow of cash and in kind, kyat per year per household

Items	High (N=21)	Medium (N=25)	Low (N=38)	Total (N=84)
Expenses for farming activities				
Plant production	342,318	67,448	49,105	127,867
Animal production	177,500	41,429	16,875	80,217
Farm tools	110,719	31,268	12,863	42,805
Total expense for farming activities	630,537	140,145	78,843	250,889
Expenses for household				
Food	644,075	729,067	488,533	591,713
Clothes	81,190	47,860	33,526	49,708
School and medical care	222,905	72,958	44,743	99,975
Other	113,190	29,988	24,632	48,365
Interest	101,233	50,666	38,954	60,435
Total expense for household	1,162,593	930,539	641,390	850,196
Total outflow per HH	1,793,130	1070,684	720,233	1,101,085
Total outflow per capita	275,866	167,294	141,222	188,542

Source: Own data, 2005

Due to the fact that the farm-family-household systems are more subsistence than market-oriented, the balance of inflow minus outflow was calculated on a household and on a per capita basis (Figure 4.9 and Figure 4.10). In study area, the net balance was around 0.76 million kyats for the sampled farm family household. Balance of a low-income household was 0.2 million kyats per household while that of a high-income household was 1.5 million kyats per household.

Moreover, the per capita balance is higher for a high-income household (0.24 million kyats) than for a low (0.041 million kyats) or medium-income household (0.09 million kyats). On average, high-income households have more land and more animals and therefore the balance of cash and in-kind inflow and outflow is higher than in the other two clusters.

To identify the cash surplus or deficit obtained in a given period, the cash balance is calculated taking only cash flows into considerations. The difference between cash inflow and outflow can be used by the household for borrowing or savings. On average the cash balance is 0.23 million kyats per household or 0.04 million kyats per capita (Table 4.13).

The average cash balance for a high-income household (0.33 million kyats) is more than three times cash balance of a low-income household (0.10 million kyats). In the three clusters, 5 households, 9 households and 19 households with a negative cash balance were found in high, medium and low-income households respectively.

4.10.2 Credit, deficit and surplus

Institutional credit in the rural areas is provided by Myanma Agricultural Development Bank (MADB) for the farmers. MADB is administrating target-oriented credit programme at subsidised interest rates with 1.5 percent per month for crop production. Other sources for credit in the study area were from family members and "101 Co. Ltd." run by the American project. About 39 percent of the households took the loans from family member source with 20 percent interest rate per month mainly for home affairs. For 61 percent of the households, "101 Co. Ltd." was the main source of credit with 5 percent interest rate per month mainly for maize crop production. "101 Co. Ltd." provided seed and fertilizer as advance in kind or cash with 20,000 kyats per acre.

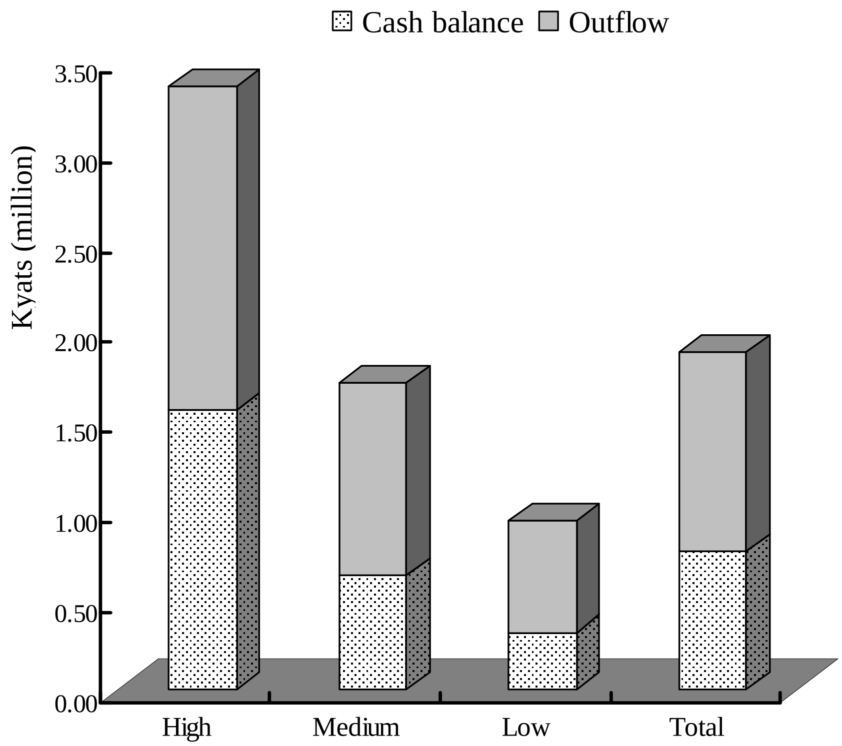


Figure 4.9 Balance per household and outflow, million kyats per year

Note: The sum of the cash balance and the outflow is the inflow

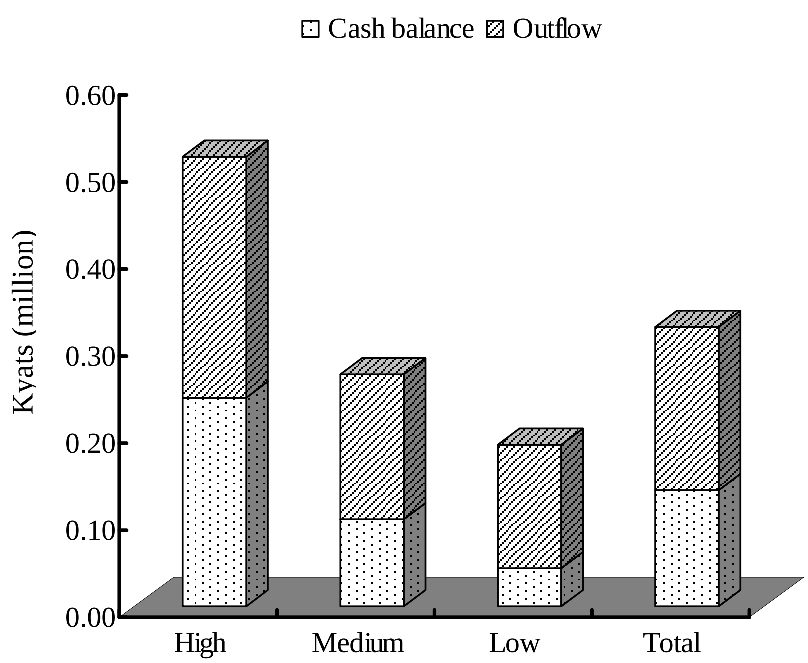


Figure 4.10 Balance per capita inflow and outflow, million kyat per year.

Table 4.13. Cash balance of family farm households in 2005, in kyats

	High (N=21)	Medium (N=25)	Low (N=38)	Total (N=84)
<u>Cash inflow</u>				
Total inflow per HH	1,644,269	814,495	386,819	915,486
Total inflow per capita	252,965	127,265	75,847	156,761
<u>Cash outflow</u>				
Total outflow per HH	1,312,298	520,049	285,249	681,123
Total outflow per capita	201,892	101,970	55,931	116,631
<u>Cash balance</u>				
Cash balance per HH	331,971	294,446	101,570	234,363
Cash balance per capita	51,073	25,295	19,916	40,130

Source: Own data, 2005

Note: Some farmers in the "three" clusters had a negative cash balance. In the calculation of the cash balance per HH and per capita a zero was assigned to these negative cash balance.

High-income farmers only have credit from "101 Co. Ltd." source having about 94 percent and the family member source having about 6 percent. For the medium-income cluster, 53 percent of sampled household was provided by "101 Co. Ltd." and 47 percent of the sampled household was supported by family member source. About 34 percent of low income farmers obtained their credit from "101 Co. Ltd." and about 66 percent from the family member source. For low-income farmers it is more difficult to obtain a loan from "101 Co. Ltd." than two clusters because of little access to land.

The average amount of credit by households was 0.13 million kyats. About 43 percent of the high-income farmers had taken out a loan of about 0.31 million kyats. Only 34 percent of the low-income and 36 percent of the medium-income cluster borrowed the money of 0.048 million kyats and 0.067 million kyats. Medium-income households have more potential to invest in their farm while for the low-income farmers the fulfilment of basis needs is more urgent. The main problems mentioned with regard to obtaining credit were the lack of collateral in the households (Table 4.14).

Saving mobilization in rural areas is still a problem. Most of the farmers keep their money at home, large ruminants as their source of savings. About 61 percent of the farmers in the sampled household have cash surplus for savings. High-income households have more cash surplus than other two clusters, however, low-income households have cash deficit (Table 4.15).

4.10.3 Willingness to stop farming and to change a new job in percent of households

In this study area, farmers are very closely linked to their environment and to their villages. The farmers are aware that life in the villages is hard and that the future, with the existing problems, is insecured. However, 80 percent of the farmers are pleased with shifting cultivation. Despite this, farmers were also asked if they would like to stop farming activities if they could earn more money in a job elsewhere. About 51 percent of the farmer claimed that they would like to do so (Table 4.16). But half of the household had no intention to change new job due to difficulty in employment, language problems, and the strong bond of them to the farming tradition. From the low-income cluster, 61 percent would like to change their job, whereas 48 percent of the high-income and 40 percent of the medium-income cluster wanted to change their livelihood.

Table 4.14. Credit situation of farm households

Items	High (N=21)	Medium (N=25)	Low (N=38)	Total (N=84)
Households with loans (% of HH)	43	36	34	37
Amount of loan (kyats)	312,777	67,222	48,962	130,854
Credit for farm activities (% of loan)	94	53	34	79
Credit for consumption (% of loan)	6	47	66	21

Source: Own data, 2005

Table 4.15. Situation of income surplus and deficit in the farm households

Items	High (N=21)	Medium (N=25)	Low (N=38)	Total (N=84)
Households with surplus (% of HH)	76	64	50	61
Households with deficit (% of HH)	24	36	50	39

Source: Own data, 2005

Table 4.16. Willingness to stop farming and to change a new job, percent of households

	High (N=21)	Medium (N=25)	Low (N=38)	Total (N=84)
Are you pleased with shifting cultivation?	76	80	82	80
Would you like to have another job?	48	40	61	51

Source: Own data, 2005

CHAPTER 5

SUSTAINABLE FARMING SYSTEM

This study examined the sustainable farming system based on sample households regarding environmental soundness, economic viability and social acceptability. Ecological sustainability was assessed based on five indicators: land-use pattern, cropping pattern, soil fertility management, pest and disease management and soil fertility status. As reduced land holdings caused by steadily growing population, it is required to make additional efforts to increase agricultural production. Therefore agricultural system which is both economically and environmentally suitable should be adopted.

5.1 Ecological Sustainability

5.1.1 Land-use pattern

Field crop production is the dominant type of land-use in three clusters of household. Nearly 90 percent of the agricultural land in all sample households has been utilized for crop production while remaining area is utilized as homestead and orchard. The average number of trees grown per household was found to be insignificantly different among income groups (Table 5.1). However, the mean value of number of tree in the high-income (110) is higher than in the medium-income (80), where in turn it is higher than in the low-income group (34).

The greater number of trees in the high-income households is partially attributed to the need for biomass to prepare compost to apply to the crop land and to diversify household income. Relatively more trees on the homestead and orchard help farm households not only to meet biomass requirement but also to fulfill households' fruit and fuel wood requirements and earn cash income.

5.1.2 Cropping system practiced by different income groups

Self-sufficiency in rice is still a predominant objective of the farm households (Figure 5.1). It is the main source of food for people and constitutes the basis of the daily diet. Majority of farmers grew rice, in which high-income group of farmers cultivated about 86 percent which is more subsistence than the other two groups. Though food crops are still important for the farmers, maize becomes more important in all three clusters as a cash crop. Thus, rice and maize occupy over two-thirds of the cropped area.

On the upland fields households grow mainly upland rice, maize, groundnut, soybean, fruit tree, tea and sugarcane (Figure 5.2). The average area of upland rice is 0.0675 ha per capita in which high-income group took the area of (0.0847 ha) followed by low-income group households (0.0658 ha) and medium-income household (0.055 ha) (Table 5.2). Maize is the most important cash crop for households and is cultivated as a mono-crop or mixed with banana or rice. The average area of maize is 0.1162 ha per capita. High-income household possesses almost two times more land than the medium and low-income households in growing of maize.

Groundnut is included as one of the cash crops. All of the farmers cultivated groundnut, however, their fields are relatively small, with an average size of 0.0249 ha. Soybean is only favourable for their home-consumption with a small average size of 0.0036 ha.

Other important sources of cash are generated by tea and fruit trees. Medium-income households have the largest land share of the tea with an average size of 0.0405 ha. Fruit trees include orange, banana, mango, lichee, jujube, jackfruit and peach. The area of fruit tree orchards is nearly three times greater for the high-income families (0.0342 ha) than it is for low-income families (0.0136 ha). Sugarcane is only cultivated in one of the high-income household group with an area of (0.0179 ha). There is a higher chance of agricultural sustainability with increasing cropping diversification, mixed cropping and lower cropping intensity.

In general, the results point to fact that rice and maize dominate in land use for all income clusters. The high diversification for the high-income groups is due to land use for sugarcane. This crop constitutes about 4 percent of all land cultivated for nearly 10 percent of high-income farmers compared to zero percent of sugarcane in total land area cultivated in medium and low-income groups. Hence, sugarcane is the source of higher diversification in term of area cultivated for high-income group, while no growing of soybean in low-income farmers causes the low diversification in relation to other two income groups.

The lower cropping intensity is attributed to the practice of mono crop of sugarcane and fruit trees. These crops constitute 10.9 percent of cropped area for about 29 percent of high-income farmers. Fruit trees is cultivated in about 9 percent of the land by 12 percent of medium-income farmers compared to 7 percent of the land grown by 16 percent of low-income farmers.

In the case of mixed cropping, maize with taungya rice is cultivated by 5 percent of high-income, 8 percent of medium-income farmers and 13 percent of low-income farmers respectively. Maize with banana is grown by 5 percent of high-income and 3 percent of low-income farmers. Only 4 percent of medium-income farmers grow maize with sesame and soybean.

Subsistence agricultural crops such as pumpkin, gourd, lady finger, eggplant, mustard, potato, sesame, chilly and beans (including soybean, and cowpea) are grown in all household's compound for their own consumption and the surplus are sold out for cash in near market.

There are three different ways of shifting cultivation practices in the upland fields of the surveyed area (Table 5.3). In the first way, 19 percent of the high-income households, 20 percent of the medium-income and 26 percent of the low-income households are doing shifting cultivation in their ancestral land by rotational places. The cycles consisted of cultivation periods of average 3 years of upland rice/maize/groundnut followed by around 3 years of fallow period. With increases in population, introduction of new maize variety and other cash crops, cycle became decreased. Shifting cultivation changed from rotational to sedentary farming practice. Maize and other cash crops (groundnut, sugarcane, fruit tree, tea) are used as a substitute for fallow periods which stay every year in the field.

In second way of shifting cultivation practice, 48 percent of the high-income, 44 percent of the medium-income and 32 percent of the low-income of ancestral landowners make shifting cultivation within place by small area expansion in a particular year. Recently, the average area expansion varies from 0.04 ha to 4.04 ha depending on labor, crop and place situation during 1 to 3 years. The crop rotation in these years consisted of upland rice/maize/groundnut left by average fallow periods of 1 to 3 years. Presently, the area expansion per year has reduced and stopped when there is no more land.

Table 5.1. Number of trees grown among the income clusters

Income group	HH %	Number of trees per household
High	19	110
Medium	12	80
Low	13	34
Significant		ns

ns - not significant

Table 5.2. Distribution of upland area per capita in the study area, in ha.

Items	High (N=21)	Medium (N=25)	Low (N=38)	Total (N=84)
Forest land	0.1335	0.1093	0.1012	0.1133
Fallow	0.0149	0.0051	0.0000	0.0058
Upland rice	0.0847	0.0550	0.0658	0.0675
Maize	0.1889	0.0823	0.0929	0.1162
Groundnut	0.0476	0.0330	0.0021	0.0249
Soybean	0.0030	0.0083	0.0000	0.0036
Tea	0.0089	0.0405	0.0136	0.0211
Fruit tree	0.0342	0.0253	0.0136	0.0232
Sugarcane	0.0179	0.0000	0.0000	0.0050

Source: Own data, 2005

Table 5.3. Percentage of farmers using different ways of shifting cultivating practices in Upland fields

Shifting cultivating practices	High (N=21)	Medium (N=25)	Low (N=38)	Total (N=84)
Rotational places	19	20	26	23
Within place by small area expansion	48	44	32	39
Old fallow land	33	36	42	38

Source: Own data, 2005

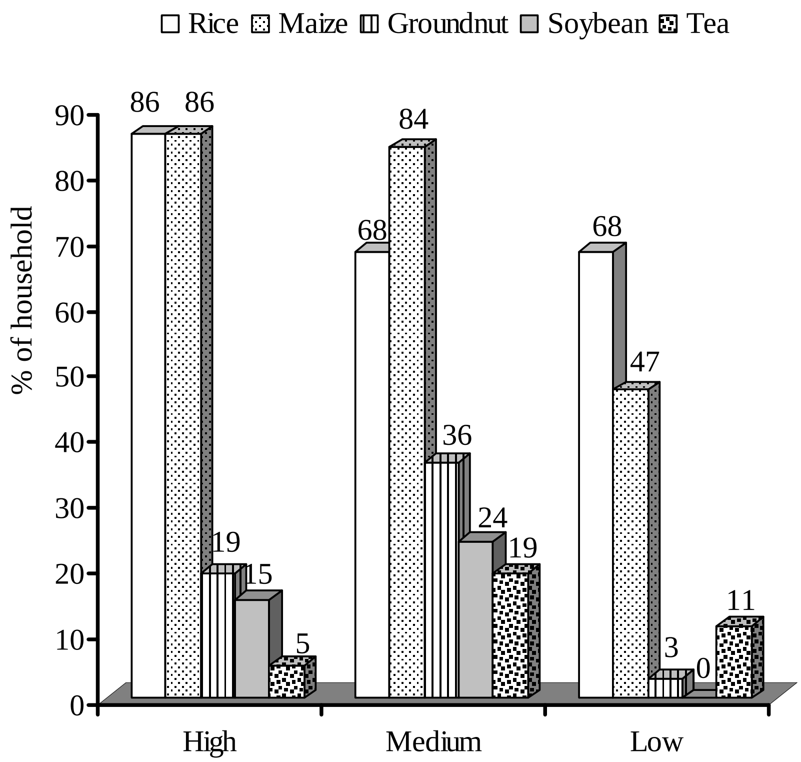


Figure 5.1 Crops cultivated by different income groups in the study area

Maize cultivation

Banana and Rice cultivation

Sugarcane cultivation

Maize and Seame cultivation

Groundnut cultivation

Soybean cultivation

Tea plantation

Figure 5.2 Crops cultivation by different income groups

In the third way, 33 percent of the high-income, 36 percent of the medium-income and 42 percent of the low-income households are working as new cultivators in places where previous owners are absent which are old fallow land.

Households can apply lease land for 30 years for farming even in reserved forest areas according to the "instructions of 1995 Myanmar Forest Policy. If the applicant does not breach the rules prescribed there in, he/she can extend his/her land tenure for next 30 years, and his/her successor can inherit the land.

Recently, under the reforestation project, 50 percent of the forest land is reforested with new established plantation in the study region. Forty-eight percent each of the high-income and medium-income households and 53 percent of the low-income households have forest land, with an average area of 0.1133 ha. Farmers with high and medium-income clusters have 3 percent and 1.8 percent under fallow respectively in their upland fields, whereas those with low-income cluster have no fallow land.

5.1.3 Use of local and high yielding varieties (HYV) for paddy, maize and groundnut

As farmers increasingly confront with declining per capita land holdings caused by steadily growing population, they are required to make additional efforts to increase agricultural production by the use of HYV varieties.

Considerable variation was found in the cropping practices of the sampled households. More than 25 percent of the cropped area is occupied by HYV paddy, HYV maize and HYV groundnut in high-income households compared to about 8 percent of the cropped area in medium-income households. HYV maize and HYV groundnut in low-income households is cultivated about 12 percent of the cropped area. The average land use of HYV paddy was found to be significantly different among income groups at 1% level while low-income farmers did not use HYV paddy. Local variety of paddy area was not significantly different among the household income clusters.

HYV maize accounts significantly difference among the income groups at 1% level. Mean value of HYV maize area in high-income (1.2 ha) is higher than other two income groups, while mean value of HYV maize area in medium-income (0.46 ha) is higher than mean value of HYV maize area in low-income (0.35 ha).

Local maize area was represented significantly different among the income groups at 1% while farmers with low-income did not cultivate local variety of maize.

Small farmers in study area who are struggling for food security adopt HYV maize for increasing crop yields to make sufficient income. The average land use for HYV groundnut was also found to be significantly different among the income clusters at 10% level. The mean value of land use for HYV groundnut in high-income farmers (0.2 ha) is higher than in the medium-income (0.081 ha), where in turn it is higher than in the low-income (0.01ha). The average land use for local groundnut area was not significantly difference among the income clusters (Table 5.4).

5.1.4 Cropping intensity, crop diversification and mixed cropping

Variation was also found in cropping intensity, crop diversification and mixed cropping (Table 5.5). Crop diversification index in high-income was found to be higher than other income groups due to growing of sugarcane. The cropping system practices by different income groups are described in section 5.1.2. Cropping intensity in the high-income households was found to be lower than in the medium-income and low-income households. The lower cropping intensity is attributed to the practice of mono crop of sugarcane and fruit trees, as well as cultivation of these crops in an entire cropping season. Relatively more cropped area under sugarcane, legume, maize, fruit trees and rice facilitates farmers to practice sequential cropping.

Crop diversification and mixed cropping suggest that cropping patterns are relatively superior in high-income households. In particular, cultivation of legume crops contributes nitrogen, organic matter and other plant nutrients to the soil, and helps restore phosphorous and potassium extracted by crops (Islam, 1989; Mahmud, Rahman, and Johir, 1994). Sugarcane which possesses large amounts of leave left biomass on the field and they represent a large and valuable nutrient source. On the other hand, modern varieties of crops use relatively greater amount of nutrients than traditional varieties (BARC 1997; Gowda and Jayaramaiah, 1998; Hossain and Kashem, 1997). The relatively greater portion of land under sugarcane, legume, maize and fruit trees is an indication of relatively large amounts of biomass and plant nutrient to the soil in the high-income households.

Like wise, the relatively high degree of cropping diversification in this type of system is conducive to making efficient use of different types of nutrients available in soil and to increasing bio-diversity (Dahal, 1996). Crop diversification reduces the risk of crop failure, thereby making farms less vulnerable to food shortage. Mixed cropping, which is found relatively more frequently in the high -income households, enhances bio-diversity, in terms of both habitat structure and species, and soil quality, and helps to control pests and diseases (Stinner and Blair, 1990).

Table 5.4. Percentage of household and land use area of local and HYV of paddy, maize and groundnut among the income clusters

Income group	Paddy		Maize		Groundnut	
	HH %	Land use (ha)	HH %	Land use	HH %	Land use (ha)
HYV						
High	52	0.41	80	1.2	14	0.21
Medium	16	0.09	48	0.36	20	0.08
Low	0	0	63	0.46	2	0.01
Significant		***		***		*
Local						
High	4	0.05	4	0.01	4	0.09
Medium	4	0.03	28	0.16	12	0.11
Low	15	0.07	-	-	-	-
Significant		ns		***		ns

* Significant at 10%; *** significant at 1%; ns – not significant

Table 5.5. Cropping intensity, crop diversification and mixed cropping

Indices[a]	Index value		
	High	Medium	Low
Cropping intensity	1.001	1.04	1.06
Crop diversification	0.08	0.07	0.05
Mixed cropping	0.12	0.11	0.07

[a] The higher the index values, the higher the cropping intensity, crop diversity and mixed cropping

5.1.5 Use of organic fertilizer

Declining soil fertility has been the major concern for agricultural sustainability in Myanmar. It is believed that declining land productivity can, to a considerable extent, be attributed to the lack of adequate amounts of organic matter in soil (BARC, 1997; Hossain and Kashem, 1997). Traditionally, farmers used to apply farmyard manure (FYM) and mulch crop residues to land to enhance soil fertility. This tradition has been abandoned gradually due to reduced livestock herd size and increased use of dung and crop residues as fuel. A significant variation was found among three income households at 1% level, in the land use of organic fertilizers. Nearly all farmers in the high-income households are applying 81 percent of their land holdings, while 52 percent of the medium-income households are applying organic fertilizers to about 68 percent of their farmlands and only 32 percent of the low-income farmers are applying organic fertilizers to about 38 percent of their farm lands (Table 5.6).

Additionally, the amount of FYM used by high-income household is greater than that by other two households and significantly different among the three income clusters at 1% level. This combined with mulching practice in high-income farmers has led to the relatively high amount of organic matter content in soil.

Organic matter in the soil contributes to improve soil structure and productivity (Poincelot, 1986), as well as enhances the disease resistant capacity of crops (Kotschi, Adelhelm, and Ann Hoesle, 1989). Average, well-rotted FYM contains 0.5-1.0 percent N, 0.15-0.20 percent P_20_5 and 0.5-0.6 percent K_2O. The desired C:N ratio in FYM is 15-20:1. In several tropical and subtropical area such as South Asia, the FYM is applied preferentially before the rainy season crop such as rice, maize and pearl millet rather than to wheat in the dry post-monsoon season. FYM is also frequently applied to potato, groundnut, sugarcane and vegetable crops in preference to crops such as wheat (Roy, Finck, Blair and Tandon 2006).

5.1.6 Use of inorganic fertilizers

Most of the farmers in the high-income households, 64 percent in the medium-income households, and 45 percent in the low-income households, are applying inorganic fertilizers to their farmlands. The amount of inorganic fertilizers used is significantly different among the income groups (Table 5.6). The rest of medium and low-income farmers are not applying inorganic fertilizers, as a lack of credit may influence their use which in turn may badly affect crop yield, there by jeopardizing their livelihood. According to inorganic fertilizer users of sampled households, however, they have available credit to apply low amounts of inorganic fertilizers. Average N, P and K were found to be lower (173.6, 96.1 and 46.5 kg/ha respectively) in high-income household than the recommended does of rice (185, 132 and 61 kg/ha respectively) and those of maize (247, 123, and 61 kg/ha). In addition, it was rather low in medium and low-income households.

Evidence from Bangladesh (Hossain and Kashem, 1997), China (Wu, Xu, and Wu, 1989), Kenya (De Jager *et al*., 2001), Madagascar (Stoop, Uphoff, and Kassam, 2002), West Africa (Ouedraogo *et al*., 2001) and the United States (Pimental, Culliney, Buttler, Reineman, and Beekman, 1989) suggests that soil fertility and productivity can be maintained and even improved by substantially reducing the external inputs if soil, water and biological resources are managed properly. Organic fertilizers though contain low percentage of energy, but they provide a variety of micro-nutrients to the soil contributing to good soil structure. Improved structure helps to increase water-holding capacity of soil, improve root development of crops, enhance biological activities in soil, and prevent nutrients leaching. In addition; good soil structure acts as buffer against acidity, alkalinity, and other toxicity in soil (Altieri, 1995; Conway, 1990; Hossain and Kashem, 1997; Ouedraogo et al., 2001; Repetto, 1987).

5.1.7 Justification of sustainable agriculture in study area

Except for desert soils that have inherently low organic matter contents, placing new land under cultivation without the use of fertilizers results in a gradual but pronounced decline in crop yield, usually within a few years (Thorne and Throne, 1978). There is no denying that the supplementary nutrients are needed in the soil-crop ecosystem if sustained or increased yields are to be produced.

Regarding resource use for farming, farmers manage their resources as they do because they must make decisions based on the probability of a given outcome, and unknown probability determined by the vagaries of weather, insects and disease pressure, weed competition, rooting zones stresses, and market fluctuations.

Table 5.6. Use of organic and inorganic fertilizers by sampled households

Sampled Households	Organic fertilizers	Inorganic fertilizers			
	FYM used in percentage of land (Amt t/ha)	N (Amt kg/ha)	P (Amt kg/ha)	K (Amt kg/ha)	Total (Amt kg/ha)
High	81 (1.4)	173.6	96.1	46.5	316.2
Medium	68 (1.3)	96.5	45.3	33.5	175.3
Low	38 (1.06)	112.1	38.4	36.1	186.6
Significant	***	***	***	***	***

*** Significant at 1%
Source: Own data, 2005

Farm households who apply recommended and/or no/low rate of N fertilizer are categorized as sustained use of N fertilizer. Most of the farmers in low and medium-income groups did follow the recommended N fertilizer application rate or use no/low rate of N fertilizer in rice and maize production. However, about 58 percent and 67 percent of farmers in high-income group could be categorized in the same category (Table 5.7 and 5.8).

The use of mineral fertilizers is necessary to apply with organic manures and other biological inputs as a part of an integrated plant nutrition system. There was no significant variation in using organic manures for rice production but significant difference at 1% was found in maize production. In rice production, nearly 20 percent of high-income farmers, and about 90 percent of the medium and more than 80 percent of low-income farmers were not applying organic manures resulting their farming towards unsustainable land resource situation. By contrasts, nearly 80 percent of high-income farmers, about 60 percent of the medium and nearly 20 percent of the low-income farmers were using organic manures and they would face sustainable productive farming in future (Table 5.9).

About 72 percent of the farmers in the high-income households, 52 percent in the medium-income households, and 25 percent in the low-income households, were applying organic fertilizers for maize production, enhancing sustainable soil fertility. The rest of the sampled households were not applying organic fertilizers in maize production because unavailability of organic manure may influence crop yield to decline (Table 5.10).

Table 5.7. Percentage of farmers using inorganic nitrogen for sustainable agriculture in rainfed paddy by the income clusters

Category	Income group			Total
	Low	Medium	High	
Unsustained use of N	1 16.7%	1 20.0%	5 41.7%	7 30.4%
Sustained use of N	5 83.3%	4 80.0%	7 58.3%	16 69.6%
Total	6 100.0%	5 100.0%	12 100.0%	23 100.0%

Source: Own data, 2005

Table 5.8. Percentage of farmers using inorganic nitrogen for sustainable agriculture in maize by the income clusters

Category	Income group			Total
	Low	Medium	High	
Unsustained use of N	0 0%	3 15.8%	6 33.3%	9 14.8%
Sustained use of N	24 100.0%	16 84.2%	12 66.7%	52 85.2%
Total	24 100.0%	19 100.0%	18 100.0%	61 100.0%

Source: Own data 2005

Table 5.9. Percentage of farmers using organic matter for sustainable agriculture in rainfed paddy by the income clusters

Category	Income group			Total
	Low	Medium	High	
Unsustained use of organic matter	5 83.3%	2 40.0%	2 16.7%	9 39.1%
Sustained use of organic matter	1 16.7%	3 60.0%	10 83.3%	14 60.9%
Total	6 100.0%	5 100.0%	12 100.0%	23 100.0%

Source: Own data 2005

Table 5.10. Percentage of farmers using organic matter for sustainable agriculture in maize by the income clusters

Category	Income group			Total
	Low	Medium	High	
Unsustained use of organic matter	18 75.0%	9 47.4%	5 27.8%	32 52.5%
Sustained use of organic matter	6 25.0%	10 52.6%	13 72.2%	29 47.5%
Total	24 100.0%	19 100.0%	18 100.0%	61 100.0%

Source: Own data, 2005

5.1.8 Soil fertility status

As mentioned above, soil fertility in the study area is evaluated on the basis of soil pH, and organic matter content (OM), available nitrogen (N), phosphorus (P), potassium (K) and Zinc (Zn). Soils of the high-income households contain higher pH, organic matter, nitrogen, phosphorous, and Zinc, whereas those of medium-income households have higher amounts of potassium, calcium, magnesium and those of low-income farmers have lower pH, organic matter, nitrogen, phosphorous, potassium, calcium, magnesium and Zinc (Table 5.11). Thus, soil fertility in the high-income households' farming system is better than other two clusters of households. Organic matter content not only influences soil productivity but also improves its texture and structure. It helps to reduce leaching of nutrients, increases water holding capacity. Supports the activities of microorganisms, improve drainage, reduces erosion and promote plant hormones (BARC, 1997; Dahal, 1996). Nitrogen also is an indicator of soil fertility as its requirements for most of the crops are high and considered as a major determinant of growth and yield of crops (Hossain and Kashem, 1997).

5.1.9 Pests and disease management

Since medium and low-income households are smallholders with limited capital or unavailability of credit for the purchase of costly inputs, they cannot use much pesticides and weedicides. However, farmers with the high-income households' agricultural system were found to use insecticide and weedicides than those with other income households.

Nearly 70 percent of high-income and more than 80 percent of medium-income are not controlling pests and disease using agrochemicals, while more than 90 percent of low-income farmers are not applying agrochemicals to control pests. In contrasts, more than 30 percent of high-income and nearly 20 percent of medium-income are using agrochemicals, while about 5 percent of low-income farmers are controlling pests using agrochemicals (Table 5.12).

Table 5.11. Soil fertility status by sampled farmers' agricultural systems

Soil properties	Soil test value			Interpretation		
	High	Medium	Low	High	Medium	Low
pH	5.51	5.47	4.07	Slightly acid	Slightly acid	acid
Organic matter (%)	5.31	4.37	3.56	High	Medium	Medium
Nitrogen (%)	0.0066	0.0054	0.0036	Medium	Low	Low
Phosphorous (kg/ha)	21.1	7.1	3.6	Low	Very low	Very low
Potassium (%)	0.0064	0.0218	0.0071	Low	Medium	Low
Calcium (me/100gm soil)	4.88	5.07	0.16	Low	Low	Very low
Magnesium (me/100gm soil)	2.81	4.63	0.17	Medium	High	Very low
Zinc (ppm)	0.45	0.03	0.31	Low	Low	Low

Source: Own data, 2005

Table 5.12. Percentage of household using pesticide and weedicide by income clusters

Income group	Pesticide % of Household	Weedicide % of Household
High	33	33
Medium	16	12
Low	5	0

Source: Own data, 2005

5.2 Economic Viability

Economic sustainability was measured based on three indicators: land productivity, yield stability and profitability.

5.2.1 Productivity

Over the past decade, paddy yields have increased steadily in Myanmar. Study region produces rice in two seasons, the monsoon crop, which is harvested generally around, October-November and the summer crop, which is generally harvested around May-June. Almost all of paddy land owner households cultivate wheat as a winter crop followed by monsoon for their home consumption in study region.

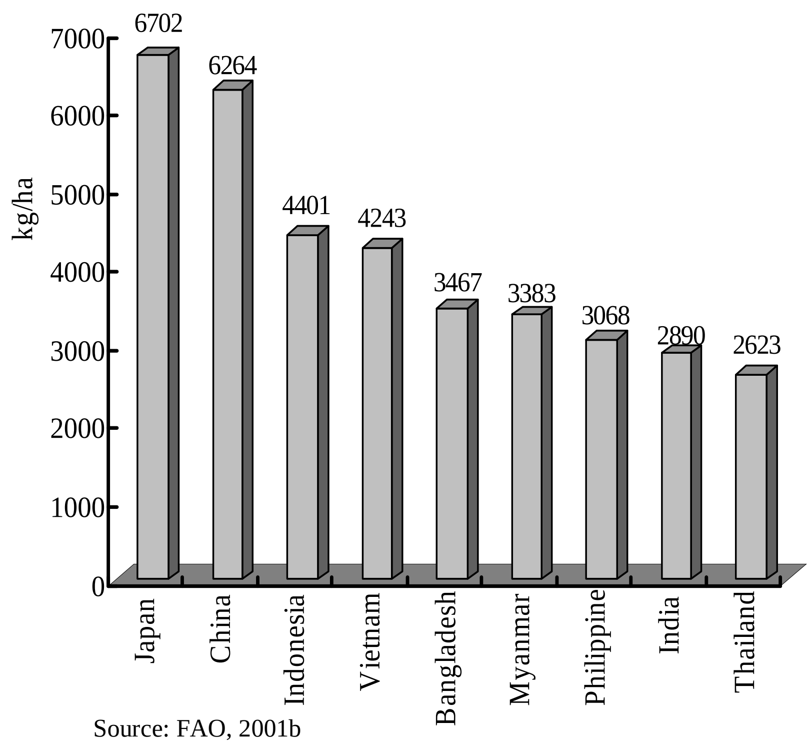
In Myanmar, paddy yields per ha are quite low compared to those in Japan and China (Figure 5.3). However, it is higher compared to Philippines, India, and Thailand. Technologies of fertilizer and irrigation management in Myanmar have led to increase yield over recent years.

The average yield of paddy in Muse district was 5,154 kg/ha (MAS, Muse, 2005). Paddy yield per ha for the sample household is calculated as the mean of monsoon rice and summer rice. About 4,244 kg/ha by high-income farmers and 4,029 kg/ha by medium-income households are about 1000 kg/ha lower the average yield of Muse district, whereas low-income farmers kept 3,408 kg/ha which is nearly 2000 kg/ha below the average paddy yield in Muse district (Table 5.13). Per household annual output for a high-income household (2,020 kg/year) is more than four times that for a medium-income households (516 kg/year) and more than eight times that for a low-income household (251 kg/year).

There is a significant difference among the income clusters in the average yields of rainfed paddy and maize. Yield is higher in high-income than in the medium-income households, where in turn it is higher than in the low-income ones (Table 5.13). This can be attributed to the application of significantly higher amounts of inorganic fertilizers and pesticides by farmers in the high-income farmers than the medium and low-income farmers. Yield of the upland rice is not significantly different among the income clusters.

5.2.2 Stability of the yield

The index of yield stability constructed following the method described in section 3, the index of HYV and local rice revealed a negative trend for all sampled households. But HYV maize in high-income and in medium-income has positive index.



Source: FAO, 2001b

Figure 5.3 Yield of paddy in selected Asia-Pacific region.

Table 5.13. Average yields of the most important crops in the study area, in kg/ha

	High (N=21)	Medium (N=25)	Low (N=38)	Total (N=84)	F value
Paddy yield (per ha)	4,244	4,029	3,408	4,576	8.49***
Paddy production (per year and HH)	2,020	516	251	322	
Upland rice (per ha)	2,343	2,340	2,162	2,255	0.09^{ns}
Upland rice production (per year and HH)	1,286	824	723	894	
Maize yield (per ha)	2,378	2,087	2,067	2,168	4.33**
Maize production (per year and HH)	2,910	1,102	979	2,269	
Groundnut yield (per ha)	1,088	928	982	981	-
Groundnut production (per year and HH)	337	197	10	147	
Sugarcane yield (per ha)	61,777	-	-	61,777	-
Sugarcane production (per year and HH)	7,060	-	-	7,060	

Source: Own data, 2005
Note: *** = significant at 1%; ** = significant at 5%; ns = not significant; - not available

The index value for HYV rice in high-income farmer was found to be -0.08, as against -1.0 in medium-income indicating higher rate of yield decline in medium-income households' agricultural system. The index value for local rice in low-income farmers showed the highest rate of yield decline among the sample households.

The index value for HYV maize in high-income farmer was found to be + 0.23, whereas it was + 0.33 in medium-income indicating lower rate of increase in the high-income households' agricultural system, it may be use of inorganic fertilizers and pesticides. But the index value for HYV maize in low-income farmers was found to be -0.45 showing negative trend, it can be insufficient use of inorganic fertilizers (Table 5.14).

5.2.3 Profitability

Profitability was analyzed from both individual and society perspectives. Because of time and budget constraints, it was not feasible to analyze the profitability of all crops. Instead, upland rice and maize were used for the profitability analysis, as they are the major crops in three clusters of sample households.

Gross margin analysis is based on variable costs, including costs of human labor, animal power, seed, fertilizers, pesticides, weedicides and machinery use and interest on operating capital. Costs of inputs were computed on the basis of respective market price whether they have supplied from home or purchased. The cost of family labor was calculated on the basis of the prevailing wage rate. Gross return was determined based on reported crop yield and the farm gate price.

Financially, the medium and low income farmers are performing better than the high-income farmers (Table 5.15 and Table 5.16). The gross margin per unit land area of high-income groups differs from medium and low-income groups in upland rice cultivation. Gross margin per unit land area of high-income farmers was found to be lower in maize than that of medium and low-income farmers respectively (13 percent and 15 percent). The total variable cost was found to be the highest for the high-income farmers in both crops, due to relatively higher use of agrochemicals. As a result, both gross margins per land and per labor unit in the high-income farmers are lower than in the medium-income and low-income farmers. The gross margin per unit capital is the lowest in the high-income one, indicating that the return per unit of investment in the high-income farmers is not as attractive as normally thought. But investment in maize cultivation is found to be more attractive for all household groups, as increasingly available credit for agrochemical.

To assess economic viability, it is necessary to look into both tangible and intangible costs and benefits (Williams, 1992). If intangible costs of declining crop yield for all sampled households' agriculture and intangible benefits of improvement in quality of soil for all sampled households' agriculture are taken into account, the medium-income and low-income farmers' farming system would be economically superior to the high-income farmers' farming system.

5.2.4 Value addition

The agricultural sector uses inputs from industrial and services sectors, including inorganic fertilizers, pesticides and agricultural equipment. To determine the net contribution of agriculture to the whole economy, the value of inorganic fertilizers, pesticides and other inputs from outside the agriculture sector has to be discounted from the value of the agricultural output (A.P.O, 1994). Accordingly, the value of intermediate good such as inorganic fertilizers, pesticides, and other inputs from outside the agriculture sector were deducted from the gross returns to determine the amount of value addition per hectare of land. In fact, if the benefit of the value addition to the local society is considered, the medium-income farmers and low-income farmers turn out to be better as it utilizes more local resources that generate income and employment opportunities for local people than high-income farmers.

5.3 Social Acceptability

5.3.1 Input self-sufficiency

The high dependency on external inputs, such as inorganic fertilizers, pesticides and charge of agricultural machinery used increases farmers' vulnerability to reduce profit, as they have no control over supply and price of inputs. Sustainable agriculture should seek to minimize the dependency on external inputs (Altieri, 1995; Ikerd, 1993; Pretty, 1995). There is considerable variation among the three clusters of sampled households in terms of dependency on external inputs. In the medium and low-income farmers, there is a tendency to use more local input, i.e., labor, draught power, seed than in high-income farmers.

Table 5.14. The index of yield stability for paddy and maize

	HYV			Local		
	High (n=21)	Medium (n=25)	Low (n=38)	High (n=21)	Medium (n=25)	Low (n=38)
Rainfed paddy	-0.08	-1.0	-	-	-	-
Maize	+0.23	+0.33	-0.45	-	-	-0.8
Upland rice	-	-	-	-0.66	-0.5	-0.84

Source: own data, 2005

Table 5.15. Profitability of upland rice by sampled households' agricultural system

		High (N=21)	Medium (N= 25)	Low (N=38)
	Financial analysis			
1.	Gross return (Kyat/ha)	339,735	339,300	313,490
2.	Total variable cost (Kyat/ha)	279,937	199,916	195,697
3.	Gross margin per land (Kyat/ha)	59,798	139,389	117,793
4.	Gross margin per unit labor (Kyat)	1,254	1,690	1,607
5.	Gross margin per unit capital	1.2	1.69	1.60
	Value addition (Kyat/ha)			
6.	Cost of inorganic fertilizers	21,130	5,342	2,450
7.	Cost of Pesticides	1,235	288	-
8.	Cost of Weedicides	1,676	-	-
9.	Charge of machinery used	6,103	1,030	823
10.	Cost of intermediate goods[1]	30,144	6,660	3,273
11.	Value addition per ha (1-10)[2]	309,591	333,220	310,217

[1] Cost of inorganic fertilizers, pesticides, weedicides and agricultural machinery hired.
[2] Gross return – cost of intermediate goods.

Table 5.16. Profitability of maize by sampled households' agricultural system

		High (N=21)	Medium (N=25)	Low (N=38)
	Financial analysis			
1.	Gross return (Kyat/ha)	339,198	297,689	294,837
2.	Total variable cost (Kyat/ha)	309,242	240,644	245,576
3.	Gross margin per land (Kyat/ha)	29,956	57,045	49,261
4.	Gross margin per unit labor (Kyat)	1,050	1,222	1,176
5.	Gross margin per unit capital	1.09	1.24	1.2
	Value addition (Kyat/ha)			
6.	Cost of inorganic fertilizers	58,788	28,422	22,698
7.	Cost of Pesticides	172	-	-
8.	Cost of Weedicides	220	-	-
9.	Charge of machinery used	7,262	1,176	2,660
10.	Cost of intermediate goods[1]	66,442	29,598	25,358
11.	Value addition per ha (1-10)[2]	272,756	268,091	269,479

[1]Cost of inorganic fertilizers, pesticides, weedicides and agricultural machinery hired.
[2] Gross return – cost of intermediate goods.

Contribution of local input cost to cost of all variable inputs was about 96 percent by medium-income farmers and 98 percent by low-income farmers in upland rice while it was about 88 percent and 90 percent respectively for maize. Farmers with high-income utilized local inputs for upland rice by 89 percent and those for maize by 79 percent. Hence, the dependency on external inputs, i.e., inorganic fertilizers, pesticides and charge of agricultural machinery used, is greater in the high-income farmers, accounting for about 11 percent for upland rice and about 21 percent for maize of the total input cost than medium and low-income farmers, accounting for about 4 percent, 2 percent for upland rice and about 12 percent, 10 percent for maize of total input cost respectively (Table 5.17 and 5.18). When all these above mentioned facts are taken into account, the medium and low-income farmers' farming clearly appear to be more self-sufficient in inputs than the high-income farmers' farming.

5.3.2 Equity

Employment determines the economic participation of people in productive activities and determines economic growth and incomes, which is one of the major causes of poverty. Any activity that creates employment opportunities will have a higher equity effect, through a process of chain reactions across the rural economy. Thus, it is reasonable to consider labor requirements and labor cost per unit of output as indicators of the equity effect of any farming system. Upland rice and maize are the most important crops in all sampled household groups' agricultural systems. The cultivation of upland rice is labor intensive (Table 5.19 and Table 5.20). As a consequence, both labor cost per unit of production and labor cost per unit of capital are higher in the medium-income and low-income agricultural systems. This implies that the medium-income and low-income agricultural system has provided more equitable benefits to local people.

Table 5.17. Input self-sufficiency by the three clusters of sampled households for upland rice

Attribute	High (N=21)	Medium (N=25)	Low (N=38)
1. Cost of all variable inputs (Kyats/ha)	279,937	199,916	195,697
2. Cost of local inputs (Kyats/ha)[1]	249,793	193,256	192,424
3. Cost of external inputs (Kyats/ha)[2]	30,144	6,660	3,273
4. Input self-sufficiency ratio (2/1)	.89	.96	.98

[1] Local inputs include labor, draught power, seed, and organic fertilizers.
[2] External inputs include inorganic fertilizers, pesticides, and agricultural machinery.

Table 5.18. Input self-sufficiency by the three clusters of sampled households for maize.

Attribute	High (N=21)	Medium (N=25)	Low (N=38)
1. Cost of all variable inputs (Kyats/ha)	309,242	240,644	245,576
2. Cost of local inputs (Kyats/ha)[3]	242,800	211,046	220,218
3. Cost of external inputs (Kyats/ha)[4]	66,442	29,598	25,358
4. Input self-sufficiency ratio (2/1)	.79	.88	.90

[3] Local inputs include labor, draught power, seed, and organic fertilizers.
[4] External inputs include inorganic fertilizers, pesticides, and agricultural machinery.

Table 5.19. Labor requirement for cultivation of upland rice

Attribute	High (N=21)	Medium (N=25)	Low (N=38)
Labor requirement to produce 1 kg upland rice (in man day)	0.075	0.078	0.085
Labor cost per kg output (in kyat)	75	78	85
Labor cost per kyat of return	0.52	0.54	0.59

Source: Own data, 2005

Table 5.20. Labor requirement for cultivation of maize

Attribute	High (N=21)	Medium (N=25)	Low (N=38)
Labor requirement to produce 1 kg Maize (in man day)	0.073	0.087	0.09
Labor cost per kg output (in kyat)	73	87	90
Labor cost per kyat of return	0.52	0.61	0.63

Source: Own data, 2005

5.3.3 Risks and uncertainties

Crop diversification helps farmers to minimize risk arising from natural hazards. In a situation of failure or damage to one crop farmers will be able to gain some income from other crops in a diversified cropping system.

As reflected in the relative income from different agricultural enterprises, including field crops (Table 5.21), the high-income farmers' agricultural system is more diversified than the medium and low-income farmers' agricultural system. Consistent with this, the risk analysis based on the method mentioned in chapter 3 revealed an index value of 0.79 for the high-income farmers' farming, 1.04 for the medium-income farmers' and 1.11 for the low-income farmers' farming, implying that the low-income farmers' farming is the most vulnerable to the risk of economic loss.

5.3.4 Food security

Food security has remained one of the important concerns in Myanmar due to limited land for agricultural use and an ever increasing population. Food security at the farm household level, according to FAO (1997), is a matter of individual households having able to meet their daily food from off-farm sources. Overall, farmers' own food grain production in the high-income farmers' farming can meet food requirements for 721 days as opposed to 287 days in medium-income farmers and 256 days in low-income farmers, although land quality are almost identical in these three clusters of farmers (Table 5.22). It should be noted, however, that the shortage of food grain in the medium and low-income farmers can offset by not only income from other agricultural enterprise, including livestock and orchard but also income from off-farm and non-farm sources. If the overall family income is considered, food will be secured in all clusters of sampled farmers.

Table 5.21. Average on-farm income[1] and risk index by income clusters

Enterprises	High (N=21)		Medium (N=25)		Low (N=38)	
	Income in kyat	% of total income	Income in kyat	% of total income	Income in kyat	% of total income
Field crops	362,360	71.9	281,385	85.5	272,018	89.3
Livestock	79,047	15.7	17,600	5.3	3,737	1.2
Orchard	62,366	12.4	30,282	9.2	29,046	9.5
Total Income	503,773	100	329,267	100	304,801	100
Risk index	0.79		1.04		1.11	

[1] Income is calculated based on household reported income of different enterprises.

Table 5.22. Food security especially based on food grain production by three income clusters in study area, 2005.

Attribute	High (N=21)	Medium (N=25)	Low (N=38)
Fulfillment of food (days)	721	287	256
Surplus or shortage of food	surplus	shortage	shortage

Source: Own data, 2005

CHAPTER 6

INCOME DETERMINANT FACTORS AND MAXIMIZING FAMILY INCOME

6.1 Factors Determining Family Income

The household income of survey area is composed of income from three different sources. They generate income through farming activities including crop production, orchard and livestock production. Additional income comes from agricultural off-farm activities and non-agricultural off-farm activities. Looking at the relative contribution of these three sources it can be seen (Figure.6.1) that crop production contributes about 58 percent to household income, while 4 percent each of household income comes from livestock production and orchard. Agricultural off-farm activities contribute about 14 percent to household income, while 20 percent of household's income from non-agricultural off-farm activities.

Based on the output of the contribution of the five alternative activities to the household income, the study tries to examine whether these relative contributions are affecting family income. The determinants of family income are therefore investigated by means of a regression model. A Cobb-Douglas household model is used.

The model used for investigation is specified in equation No.1.

$$\text{In } y_1 = \beta_0 + \beta_1 \text{In } x_1 + \beta_2 \text{In } x_2 + \beta_3 \text{In } x_3 + \beta_4 \text{In } x_4 + \beta_5 \text{In } x_5 + \beta_6 \text{In } x_6 + \beta_7 \text{In } x_7 + \beta_8 \text{In } x_8 + \mu_i \qquad (1)$$

Where:

y_1 is the family income

x_1 is the income from crop production

x_2 is the income from live-stock production

x_3 is the income from orchard

x_4 is the income from agricultural off-farm activities

x_5 is the income from non-agricultural off-farm activities

x_6 is the age of the household

x_7 is the level of education of the household head

x_8 is the dependency ratio of the farm family

μ_i is the disturbance term

The hypothesis behind this model formulation is defined as “crop, livestock, orchard, off-farm and non-farm incomes are hypothesised to have a positive contribution to the family income”, since it represents the most important activity in the study region. Economic activities are not the only determinants of family income generation, the socio-economic characteristics of farmers, for instance their age and level of education attainment may influence income generation at the household level.

The result of the regression model indicates clearly that the contribution of four activities considered namely crop production, livestock production, orchard, and non-agricultural off-farm activities to the family income is significant to family income (Table 6.1).

A 1 percent improvement in crop production may contribute to improve family' income by about 0.52 percent. For the livestock production and non-farm activities, 1 percent increase in these activities will generate the income by 0.03 percent improvement while for orchard, 1 percent improvement may provide family income by 0.02 percent increase. The variation in family income explained by the variation in the independent variables included in the model can be considered satisfactory. The value of adjusted R squared is about 71 percent.

The socio-economic characteristics of the farmers included in the model (education, and dependency ratio) do not play an important role in income generation of households. However, there is a tendency of an inverse relationship between the dependency ratio and the family income. In addition, age of the household head is significant at 10% level in the model, meaning that more experience persons may generate to improve the income. The family income explained by the variables included in the model is highly significant, as indicated by the results of the Analysis of Variance (ANOVA) (Table 6.2). Because of the relatively high contribution of crop production to family income, it is useful to investigate the structure of the income from crop production. Therefore, the contribution of different crops to crop income will be analysed in the next step of the study.

6.2 Evaluating the Farm Income Structure of Sampled Households

The income of sampled households from farm income is composed of income from crop production, livestock production and orchard. They cultivate rainfed paddy, upland rice, maize, groundnut, soybean, tea, sugarcane and vegetables in home gardens.

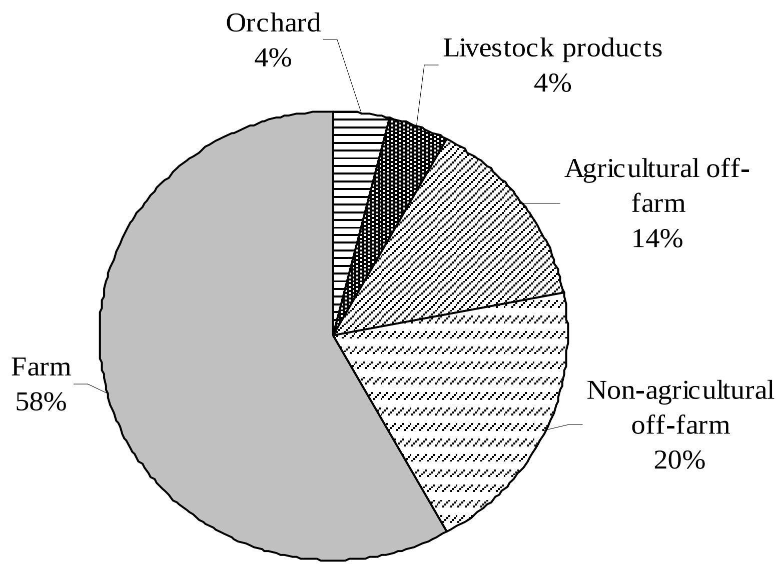


Figure 6.1 Relative contribution of the individual components to the household income

Table 6.1. Results of regression analysis for factors determining family income

	Non standardised coefficients Beta	Standard error	Standardised coefficients Beta	T	Significance
(Constant term)	5.466	0.875	-	6.244	0.000
Income from crops	0.528***	0.048	0.784	10.904	0.000
Income from livestock	0.028***	0.008	0.214	3.421	0.001
Income from orchard	0.022***	0.009	0.155	2.501	0.015
Income from agr: off-farm activities	0.010	0.007	0.099	1.341	0.184
Income from non-agri:off-farm activities	0.032***	0.006	0.330	5.155	0.000
Age of the head	0.240*	0.133	0.110	1.804	0.075
Level of education of HH head	0.020	0.079	0.017	0.259	0.797
Dependency ratio of the farm family	- 0.032	0.022	- 0.090	- 1.482	0.143
Adjusted R^2	0.708				

Note: * Significant at 10%; *** Significant at 1%

Table 6.2. ANOVA for the regression analysis for the family income

	Sum of Squares	df	Mean Square	F	Significance
Regression	21.606	8	2.701	26.174	0.000
Residual	7.739	75	0.103		
Total	29.345	83			

Considering the relative contributions of these alternative enterprises one can see that maize production contributes about 35 percent to farm income, while farm income share 19 percent each from rainfed paddy production and upland rice production (Figure.6.2).

Maize is cultivated for market and rice for home consumption, therefore the share of maize in the household farm income is relatively high as compared to rainfed paddy production and upland rice production.

In order to know whether the contribution of the different crops to agricultural farm income is significant or not the investigation is done by means of a regression analysis.

The model used for investigating which crops are determined for agricultural income generation is specified in Equation No.2.

$$\text{In } y_1 = \beta_0 + \beta_1 \text{ In } x_1 + \beta_2 \text{ In } x_2 + \beta_3 \text{ In } x_3 + \beta_4 \text{ In } x_4 + \beta_5 \text{ In } x_5 + \beta_6 \text{ In } x_6 + \beta_7 \text{ In } x_7 + \beta_8 \text{ In } x_8 + \mu_i \quad (2)$$

Where:

y_1 is the income from agriculture

x_1 is the income from live-stock production

x_2 is the income from paddy production

x_3 is the income from upland rice production

x_4 is the income from maize production

x_5 is the income from groundnut production

x_6 is the income from soybean production

x_7 is the income from tea production

x_8 is the income from other crop production

μ_i is the error term

Seven crops are considered in the model namely rainfed paddy, upland rice, maize, groundnut, soybean, tea, and other crops which comprise sugarcane and orchard. Among these crops, the contribution of soybean and tea is found to be non-determinant in terms of agricultural farm income (Table 6.3). The positive signs and significant values were obtained for rainfed paddy, upland rice, maize, groundnut and other crops. The variation in agricultural farm income is explained by 48 percent in the model.

Agricultural income explained by the variables included in the model is highly significant, as indicated by the results of ANOVA (Table 6.4).

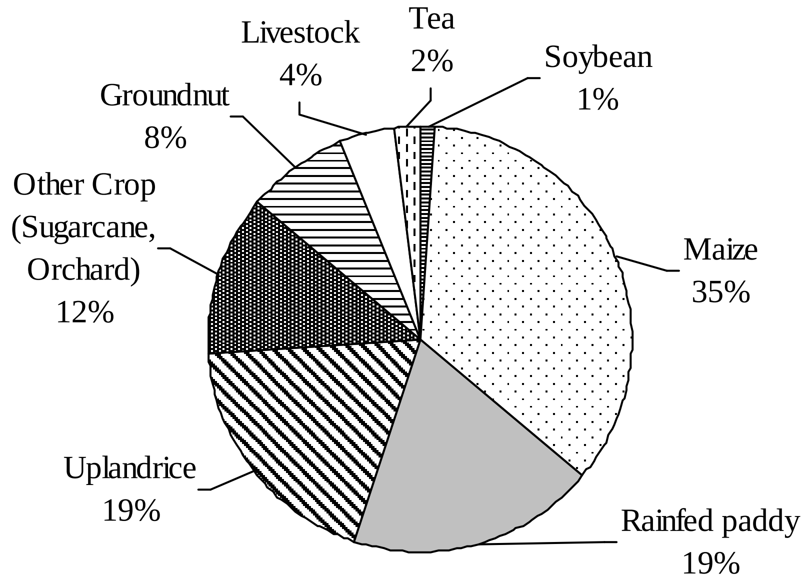


Figure 6.2 Relative contribution of the individual components to the agricultural income

Table 6.3. Results of regression analysis for factors determining agricultural income

	Non-standardised coefficients B	Standard error	Standardised coefficients Beta	T	Significance
(Constant)	11.442	0.230		49.758	0.000
Income from livestock	0.017	0.017	0.084	1.002	0.319
Income from rainfed paddy	0.087***	0.015	0.530	5.861	0.000
Income from upland rice	0.046***	0.015	0.296	3.158	0.002
Income from maize	0.058***	0.016	0.318	3.588	0.001
Income from groundnut	0.060***	0.018	0.292	3.287	0.002
Income from soybean	0.016	0.031	0.045	0.520	0.604
Income from tea	0.008	0.023	0.028	0.329	0.743
Income from other crops	0.071***	0.017	0.350	4.189	0.000
Adjusted R^2	0.48				

Note: *** Significant at 1%

Table 6.4. ANOVA for the regression analysis for agricultural income

	Sum of squares	df	Mean Square	F	Significance
Regression	38.777	8	4.847	10.505	0.000
Residual	34.607	75	0.461		
Total	73.384	83			

6.3 Determination of Optimum Family Income

Simple Linear programming approach is used to select an initial plan and move to more profitable plans to determine the optimum family income. Linear programming enables one to determine the best plan of allocating scarce resources to make the maximum family income. This study considers only the optimum plan in upland crops with the most determinants of agricultural income, namely upland rice, maize and groundnut, which have the limited nature of resources use.

The model use for determination of optimum family income is specified in question no. 3.

$$\text{Max } Z = \sum_{t=1}^{y} \sum_{j=1}^{n} (P_{jt} X_{jt} - C_{jt} X_{jt})$$

Subject to

$$\sum_{j}^{n} \alpha_{ijt} X_{jt} \leq b_{it}, \text{ all } i = 1 \text{ to m and all } t=1 \text{ to } y$$

$$X_{jt} \geq 0, \text{ all j=1 and all } t = 1 \text{ to } y$$

Where:

Z = the objective function (family income)

X_{jt} = the level of activity j in period t

P_{jt} = the price of per unit of the j ouput activity in period t

C_{jt} = the cost per unit of j input activity in period t

y = number of periods

n = number of possible activities

m = number of resources and constraints

a_{ijt} = technical coefficient (amount of i^{th} input required to produce one unit of j^{th} activity in period t)

b_{it} = amount of i^{th} resource available in period t

Objective function

The objective function is to maximize the family income subject to family resource availability and other constraints. The family income is maximized thorough maximization of value of crop and livestock products, and off-farm income and minimization of production cost. The components of the objective functions are:

1) The variable costs of crops of crop and livestock production per unit of land or livestock unit, excluding hired labour costs.

2) The average sales prices of crops and livestock products which are used to calculate the revenue of farm products.
3) An average off-farm wage rate for each family group in the study area is used for off-farm and hired labour activities.
4) Interest for credits from formal and informal credit.

6.3.1 **Validation of the model**

Modeling a system requires a certain level of abstraction and simplification of reality, which is expressed in a matrix of main activities and constraints (Katwijukye, 2005). Obtaining model results identical to reality therefore requires complete knowledge and information about farmers' behaviour and decision-making (Pape-christiansen, 2001). To test how realistic the basic model is and how suitable it will be for future strategy testing, validation is necessary (Praneetvatakul, 1996). A good model should present the results which are close to reality (Regassa, 2000) and which behaves in its main components like the real system (Maerz, 1990). Despite the fact that the basic models were designed as close to reality as possible, a gap between the basic model and reality still exists due to the complexity of the real world (Kitchaicharoen, 2003). The mathematical basic model gave the results through optimal use and integration of resources in farm and family. It is assumed that the model quality can be accepted if the model results are close to reality. Validation of the model was done through (1) comparison of farm, off-farm and family income and, (2) comparison of their resource use (land and labour) in farming.

6.3.2 **Resource allocation in actual survey and the model**

The results of land area allocation by linear programming are presented in Table 6.5 to keep the higher incomes of the household for all income groups. The simulation results of area cultivated for crops were reasonable estimates compared with the actual survey. In low-income group, the model allocated more land of 1.03 ha to groundnut compared to 0.31 ha of upland rice, 0.47 ha of maize, 0.01 ha of groundnut and 0.24 ha of other crops in the actual survey. However, the model shift the land allocated to groundnut because of high price incentive in those area. Both high and medium-income group, the model allocated more land to groundnut due to profitable growing in the study area.

6.3.3 Family income in actual survey and the model

In order to maintain higher return from the farm in the basic model, the model allows hiring labours in income groups to compensate for lack of labour when the crops are growing and for providing work on the farm. The optimal solution helps farmers to reduce dependency on external resources, such as external capital.

Comparative analysis of family income between basic model and actual survey was done to judge the ability of the model to predict actual farmer behavior. The basic model showed differences in the family income which is higher than the actual survey but off farm work has not been done due to more concentration of farm work and profitability of farming itself.

Table 6.6 gives an overview of farm, off-farm and family income resulting from the model, compared with survey data in 2005. In terms of farm income the basic model results were substantially higher in all income groups. This could be attributed to the optimization of scale and level of farm portfolio given the constraints in the model. Regarding family income, the results of basic model were much closer to that of the survey data. The results of Table 6.6 suggest an important observation; portfolio selection in the model was based on optimal return given the constraints while portfolio selection in the case of survey data was lower in family income. The model suggests allocating more land to groundnut to get higher family income for all household clusters.

There is still to think that it is necessary to consider whether the model is sustainable in allocating more land to groundnut in mountainous area because sole cropping of groundnut would cause monoculture system and food will not be secured. Family income would be maximized due to the high price of groundnut but price instability will affect the family income in long run. Therefore, it is needed to encourage the farmers, to practice intercropping with groundnut in their farming systems.

Table 6.5. The comparison of resources use of land between actual survey and basic model by income groups

Crops	High (N=21)		Medium (N=25)		Low (N=38)	
	Actual (ha)	Model (ha)	Actual (ha)	Model (ha)	Actual (ha)	Model (ha)
Upland rice	0.55	-	0.35	-	0.31	-
Maize	1.22	-	0.53	-	0.47	-
Groundnut	0.31	3.00	0.20	1.76	0.01	1.03
Other crops	0.92	-	0.68	-	0.24	-
Total	3.00	3.00	1.76	1.76	1.03	1.03

Source: Own data, 2005

Table 6.6. Farm, off-farm and family income results from model compared with actual survey for different income groups

Income	High (N=21)		Medium (N=25)		Low (N=38)	
	Actual	Model	Actual	Model	Actual	Model
Upland	62,972.28	-	28,942.94	-	27,479.56	-
Maize	141,819.10	-	46,263.05	-	45,777.82	-
Groundnut	31,967.62	393,505.63	9,741.80	86,556.45	1,714.29	83,005.26
Other	173,941.72	173,941.72	72,246.86	72,246.86	21,520.84	21,520.84
Livestock	31,989.88	31,989.88	15,216.51	15,216.51	1,511.94	1,511.94
Off-farm	23,012.55	23,012.55	58,874.95	58,874.95	48,707.00	48,707.00
non-farm	156,462.57	156,462.57	62,760.02	62,760.02	13,516.79	13,516.79
Family income	622,164.51	778,912.34	294,046.14	295,654.80	160,228.25	168,261.84

Source: Own data, 2005

CHAPTER 7

SUMMARY, POLICY IMPLICATION AND CONCLUSION

7.1 Summary

7.1.1 Objectives of the study

A Survey on farming system and socioeconomic aspects of shifting cultivators was conducted in Muse district during 2005. This study aimed at addressing the socio-economic situation and living standard of farming families in mountainous areas through linkages and interrelationships within the system. The socio-economic, sustainability and living standard measurement analyses led to identification of strategies that could improve the living standards of shifting cultivating households while still using their available resources.

The household survey involved 84 respondents from seven villages in three townships. The three income groups of analyses were important to evaluate the significance of different groups in upland farming system. The farming systems approach was applied in this study in terms of analysing the socio-economic characteristics, decision-making processes and development potential of the shifting cultivating households. This involved comparative descriptive analyses and also parametric tests to establish statistical differences. The approach of measuring sustainability and living standards using several criteria namely ecological sustainability, economic security, food supply and security, food expenditure, and education level/expenditure was also used. Econometric methods and linear programming were used to recommend agricultural practices for promoting living standard of shifting cultivating households.

7.1.2 Major findings of the study

This section summarizes the major findings emanating from the analyses undertaken in the study.

7.1.2.1 The socio –economic situation of shifting cultivating households in Muse District

The sampled farm households were clustered into three groups: low, medium and high-income farmers. Based on the annual household income, 45.2 percent of the total sample households can be classified as 'low-income households', 29.8 percent of sample households as 'medium-income households and 25 percent of sample households as 'high-income households'. The average annual family income of 'low-income household was 395,924.89 Kyats, and the medium-income household was 726,588.08 Kyats, and high-income household was 1,537,368.50 Kyats, respectively.

The study pointed out that shifting cultivation system has changed from rotational to sedentary farming practice, and from subsistence cropping to commercial cropping. The land is now increasingly substituted by maize, and it has now become one of the most important cash crops for the farm households. The average farm size for overall household was 1.75 ha and difference was found between the low-income (1.03ha) and high-income (3.05 ha) households. Eighty percent of the medium-income and 84 percent of the low-income households did not have rainfed paddy land, whereas 58 percent of the high-income family possessed rainfed paddy land. The per capita upland area owned by low-income was 0.18 ha but that owned by high-income household was 0.39 ha which differ nearly double in land area owned by high-income household.

In general one can say that the high-income farmers have more land, more animals and better access to capital than the farmers in low and medium-income groups. They also live in better houses, are more educated and have higher balance of cash and in-kind inflow and outflow.

The rice consumption of farmers in all three clusters is needed to reach self sufficient level because it is the most important food crop. High-income farmers have the highest level of self sufficiency in rice consumption.

The income structure of farmers is still dominated by agricultural production. But here too, off-farm income has started to play an increasing role. The percentage of off-farm income in the total income is the lowest in the high-income households and the highest in medium-income households. Households who engaged in off-farm activities were 86 percent in the high-income, 88 percent in medium-income cluster and 89 percent in low-income household, respectively.

Farmers in all three clusters are awareness of environmental problems like erosion and declining soil fertility and do not want to leave the villages. Despite this, about half of the households would like to stop farming activities and want a new job outside agriculture. They expect that they could earn more money from a new job.

7.1.2.2 Assessment of sustainable farming system based on ecological, economic and social indicators

Type of agriculture is not different among three clusters of households, particularly in terms of land-use patterns. The high-income farmers have the greater number of trees than the farmers in the other two clusters. Relatively more trees on the homestead and orchard help farm households not only to meet biomass requirement but also to fulfill households' fruit and fuel wood requirements and cash income.

Regarding cropping patterns, there was no variation in terms of types of crops, as the major percentage of land holdings are still being cultivated with upland rice and maize in all three clusters. Significant variation was found if varieties of crops cultivated are taken into consideration, particularly in rain-fed paddy, maize and groundnut. The high-income farmers' farming system is more diversified, mixed cropping and has a lower cropping intensity than the other two clusters, which is a step toward sustainable agricultural system.

Significant variation among three clusters of households was reflected in the use of inorganic fertilizers, which are the primary causes of land, water and atmospheric pollution, as well as degradation of food quality.

Although the majority of low and medium-income households are still applying inorganic fertilizers, the amount that they used was significantly lower than the amount that high-income households used. As the low and medium-income farmers' system less depended on the external inputs, their farming system was more sustainable than high-income farmers' farming system.

Relatively higher yields and gross returns in the high-income households' farming system accrues through the application of much higher amounts of inorganic fertilizers and pesticides, which have resulted in severe costs on the environment and society. If these costs and benefits are taken into account, the low and medium income households' farming systems would be financially better.

There is a significant difference among the income clusters in the average yields of rainfed paddy and maize. The yield index of HYV and local rice revealed a negative trend for all sampled households. But most of the farmers in low and medium-income and more than half of high-income farmers applied recommended N application rate or low rate which favours sustainable agricultural system. Likewise, HYV maize in medium and high-income has positive index due to modern varieties as well as relatively greater amount of nutrients than traditional varieties. They are more easy to obtain a loan from "101 Co. Ltd." because of possessing higher access of land than low-income cluster. Therefore, the high and medium-income farmers have compensating effect of increasing applications of plant nutrients as the yields have been increasing on their degrading land.

The high-income farmers' farming system is more diversified than the medium and low-income farmers' farming system and their farming system was less vulnerable to the risk of economic loss.

7.1.2.3 Factors influencing family income and farm income of shifting cultivators

Farmers' basic socio-economic characteristics such as education and dependency ratio did not play an important role in the variation in household income. One reason for this may be that the level of formal education is generally relatively low in the region. However, there tends to be an inverse, although not significant, relationship between the dependency ratio and the household income. In addition, age of the household head is significant at 10% level, meaning that more experience persons may generate to improve the income.

Agriculture's still the main source of income for farmers and contributes for around 70 percent to the total income in the sampled households. A relatively high contribution, 58 percent came from crop production in which maize, rainfed paddy and upland rice were the most important crops. Maize is cultivated for market and rice for home consumption, thus the share of maize in the household farm income is relatively high as compared to rainfed and upland rice production.

Livestock contributes around 4 percent and agricultural off-farm activities around 14 percent to the household income, while 20 percent of household's income from non-agricultural off-farm activities. Off-farm activities are still quite a source of income for the sampled farmers.

About 50 percent of the variations in agricultural income are explained by variation in crop yield and livestock production. Nevertheless, absolute agricultural income could be increased significantly if efficiency in resource allocation were enhanced. A better rural infrastructure is required. However, it is not only the transportation system that must be improved but also access to markets (input, output, credit, etc.).

7.1.2.4 Estimation of the determinants of optimum family income

The linear programming model allocated land to groundnut because of high price incentive for farmers. Among the three clusters of households, the model allocated more land to groundnut due to getting a high profit in the study area.

Comparative analysis of family income between basic model and actual survey was done to judge the ability of the model to predict actual farmer behavior. In terms of farm income the basic model results were substantially higher in all income groups. The results suggested an important observation; portfolio selection in the model was based on optimal return given the constraints while portfolio selection in the case of survey data was lower in family income.

There is still to think that it is necessary to consider whether the model is sustainable in allocating more land to groundnut in mountainous area because sole cropping of groundnut would cause monoculture system and food will not be secured. Therefore, it is needed to encourage the farmers, to practice intercropping with groundnut in their farming systems.

7.2 Policy Implications

7.2.1 Improvement of food security

The most serious challenge for policy-makers to achieve sustainable agricultural development in mountainous regions is how to maintain soil fertility to provide sufficient food and income to farmers without degrading environmental quality. Possessing very small land holdings, on average less than 0.12 ha per capita in study area, farmers have to at least maintain the present level of crop yield.

Degradation from nutrient mining is a serious problem, particularly in the agriculture in slope lands where livestock manure is in short supply and use of mineral fertilizer is seldom economic. Where soil fertility is mainly concentrated in the surface layers, soil erosion can lead to greater yield losses in tropical soil than the temperate zones. At the same time, however, the effects of land degradation are often marked by the compensating effects of improvements in agricultural technology or increasing implication of plant nutrients so that yields may have been increasing even on degrading land.

Moreover, the shortening of fallows and prolonged crop harvesting without adequate technological response to replace the soil nutrient take out by crops with organic or mineral fertilizer inputs, leguminous crops, nitrogen-fixing algae and so on, is lowering the nutrient status of soils and the actual or potential crop yields. It consequently threatens the sustainability of agricultural production. However, the important thing should be for policies to recognize that the first priority of many farmers is household food security and family welfare. Thus efforts to minimize trade-off between more production and the environment must be centered on actions that improve household food security and are profitable on time scales which meet the farmers' differing circumstance or risk perceptions.

7.2.2 Sustainable agricultural practices for promoting household income

The challenge for policy makers is how to implement and regulate policies, programs and support services in favor of shifting cultivators contributing to resources conservation and providing sufficient food by practicing ecological farming systems. Therefore, government should provide credit/loan, extension education, and promoting rural infrastructure for sustainable agricultural practices especially small and medium-income farmers. The extension of the cultivated area may not be a sustainable solution to increase the income of farm household in this degraded upland area. The strategy such as integrated pest management (IPM), crop diversification, integrated nutrient management, and balanced used of inorganic fertilizers, etc. should be promoted to sustain household income.

The soil conservation techniques that concentrate on measure with no or low external capital requirements will be more appropriate for the resource-poor shifting cultivators in this degraded area. The focus should be on biological rather than mechanical approaches to soil conservation which, as with vegetative barrier techniques or with systematic crop and residue management.

Provision of alternative sources of energy, efficient use of biomass fuel through the promotion of improved stoves, and promotion of multipurpose agroforestry species will help control the use of biomass and manure, and increase the supply of FYM required to maintain soil structure and fertility. Compost is considered to be better than FYM in terms of nutrient contents. Shifting cultivators should therefore be trained and encouraged to make compost-utilizing biomass and animal wastes available in their farms.

The groundnut – rhizobium symbiosis can fix about 110-150 kg N/ha (Roy *et al.*, 2006). Production of high-value leguminous crops, therefore may lead to higher household incomes than production of food crops, simply because the profitability of such crops may be greater than that from food crops. In addition they may also promote greater productivity, land improvement and increased income for farmers.

7.2.3 Improvement of rural institution and infrastructure

Greater applications of organic and mineral fertilizers are essential to prevent soil nutrient mining and raise crop yields, but in many developing countries application like Myanmar will remain below that amount. Most of the farmers do not follow recommended N application rates and apply lower amounts due to lack of credit and provision of inadequate extension services. Provision of credit on inorganic fertilizers along with effective extension services will help to improve the rate from lower use and imbalanced use of inorganic fertilizers. In particular there is need for better and less costly intergraded plant nutrient systems (IPNS) and improved transport and marketing systems to lower relative mineral fertilizer price.

Although pulses and oilseeds appear financially superior to rice and maize these two cereal crops are being cultivated continuously year after year due to inadequate extension, research, marketing and credit facilities, and farmers' concern about food security. Since so far cereals have been the main thrust of research and extension programs, little attention has been paid to other crops, despite their great potential to increase farmers' income and maintaining soil fertility.

At the operational level, the research effort should be directed at promoting sustainable increase in productivity in the higher potential areas as well as at targeting marginal and fragile environments where current degradation must be reversed and production stabilized or raised. Sustainable development in many marginal areas should introduce research development of legume-based relay, intercropping, soil conservation and other practices to raise the family income of farmers.

Given the small land holdings and increase population, it is necessary to diversify the farming systems comprising livestock, agroforestry to make better use of available resources and to gain their synergetic effect. Livestock and agroforestry also have potential to improve farmers who have not adopted these practices much due to limited knowledge and skill, and unavailability inputs credit and other support services. Proper policy and institutional support along with coordinated efforts with NGOs will help to promote diversified ecological farming, resulting in increased high-value products and farmers' income.

Sustainable agriculture, indeed, demands intimate knowledge and information about crop, soil, pest, insects, market, price and environment. Dissemination of knowledge and other information through existing government extension agencies does not seem to be efficient and effective, because of lack of motivation and inadequate number of extension staff, arising from a number of factors, including low salary. Therefore, attempt should be made to build and enhance social capital by organizing farmers in groups, encouraging farmers to farmers extension and sharing information conducive to build cooperation, trust, reciprocity and cohesiveness among farmers, which facilitate social institutions, common rules, norms and sanctions of behavior (Pretty and Ward, 2001).

Therefore, the economic and institutional environment must also be favourable. Farmers must have better access to proven technologies, production inputs and services, and to markets for their products. They must be secured in their rights to access to land and other resources so that they have the stability and confidence to take up the technological opportunities and make the necessary investments.

7.3 Conclusion

Given the theme of the study "Assessment of Sustainable Farming System and Socio-economics Aspects of Shifting Cultivation in Selected Mountainous Areas in Myanmar", much of the analysis was centered on sustainable farming system, socio-economic situation and household economy in Muse district, and subsequently to consider the possible benefits of farm households especially the contribution of more sustainable farming system. From the main results of the dissertation it can be concluded that farming system under shifting cultivation have indeed soil degradation effects on their socio-economic situation of agricultural sustainable point of view.

It has been found that on average all crops of yields of sampled households is still below the average yields of Muse district. This is due to the difficult access to innovations of HYV and other modern agricultural inputs. So far, agricultural income contributes most to the total income even though off-farm activities have started to play an increasing role. Although rice may not contribute the largest share of agricultural income, this crop plays an important cultural role as the feeling of being food security which is closely linked to the perception of having access to it. Maize is an important cash crop and it contributes the largest share of agricultural income.

The results of land area allocating by linear programming, all income groups in the model allocated more land to groundnut due to profitable growing in the study area. However, there is needed to consider with the sole cropping of groundnut. Instead, farmers should encourage to practice intercropping with groundnut in their farming system. The Myanmar Government should elaborate policies that help to promote the sustainable agricultural practices in research, education, rural infrastructure etc. in the soil degraded area. Otherwise, shifting cultivating households will be unable to exist unsustainable farming system in the long term and stay slow improvement in their livelihood.

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Appendix 1. ANOVA for number of trees by sampled household

Items	Sum of square	df	Mean square	F	Sig.
Between income groups	85388.47	2	42694.23	1.02	0.363
Within groups	3374135.3	81	41655.99		
Total	3459523.8	83			

Appendix 2. ANOVA for land use area of HYV and local variety of paddy, maize and groundnut among the income clusters

	Sum of square	df	Mean square	F	Sig.
HYV Paddy					
Between income groups	2.41	2	1.20	16.39	0.00
Within groups	5.95	81	0.07		
Total	8.35	83			
Local paddy					
Between income groups	0.03	2	0.01	0.29	0.745
Within groups	3.61	81	0.05		
Total	3.63	83			
HYV maize					
Between income groups	9.74	2	4.87	8.94	0.000
Within groups	44.14	81	0.55		
Total	53.88	83			
Local maize					
Between income groups	0.45	2	0.22	5.37	0.006
Within groups	3.36	81	0.04		
Total	3.81	83			
HYV groundnut					
Between income groups	0.55	2	0.27	2.63	0.07
Within groups	8.39	81	0.10		
Total	8.94	83			
Local groundnut					
Between income groups	0.23	2	0.12	1.19	0.31
Within groups	7.96	81	0.09		
Total	8.20	83			

Appendix 3. ANOVA for FYM use in percentage of land and amount of FYM among three income clusters

	Sum of square	df	Mean square	F	Sig.
FYM used in % of land					
Between income groups	53.59	2	26.79	15.16	0.00
Within groups	143.15	81	1.77		
Total	196.74	83			
Amount of FYM					
Between income groups	1.15E+08	2	57594729.79	7.54	0.001
Within groups	6.19E+08	81	7642382.85		
Total	7.34E+08	83			

Appendix 4. ANOVA for amount of inorganic fertilizers use among the income clusters

	Sum of square	df	Mean square	F	Sig.
N					
Between income groups	2697782.90	2	1348891.43	17.39	0.00
Within groups	6280273.90	81	77534.25		
Total	8978056.80	83			
P					
Between income groups	610579.91	2	305289.95	12.29	0.00
Within groups	2011024.80	81	24827.47		
Total	2621604.70	83			
K					
Between income groups	78571.83	2	39285.91	11.63	0.00
Within groups	273514.40	81	3376.72		
Total	352086.22	83			

Appendix 5. Percentage of household cultivating local and HYV of paddy among the income clusters

Count (Household)	Income group			Total
	Low	Middle	High	
Not grow	32	20	9	61
	84.2%	80.0%	42.9%	72.6%
Grow	6	5	12	23
	15.8%	20.0%	57.1%	27.4%
Total	38	25	21	84
	100.0%	100.0%	100.0%	100.0%

Source: Own data 2005

Appendix 6. Chi-Square Test for growing of local and HYV paddy by household

	Value	df	Asymp. Sig (2-sided)
Pearson Chi-Square	12.608[a]	2	.002
Likelihood Ratio	11.767	2	.003
Linear-by-Linear Association	10.154	1	.001
N of Valid Cases	84		

[a] 0 cells (0%) have expected count less than 5. The minimum expected count is 5.75.

Appendix 7. Percentage of household growing local and HYV of maize among the income clusters

Count (Household)	Income group			Total
	Low	Middle	High	
Not grow	14	6	3	23
	36.8%	24.0%	14.3%	27.4%
Grow	24	19	18	61
	63.2%	76.0%	85.7%	72.6%
Total	38	25	21	84
	100.0%	100.0%	100.0%	100.0%

Source: Own data, 2005

Appendix 8. Chi-Square Test for growing of local and HYV maize by household

	Value	df	Asymp. Sig (2-sided)
Pearson Chi-Square	3.666[a]	2	.160
Likelihood Ratio	3.823	2	.148
Linear-by-Linear Association	3.601	1	.058
N of Valid Cases	84		

[a] 0 cells (0%) have expected count less than 5. The minimum expected count is 5.75.

Appendix 9. Chi-Square Test for amount of organic matter application in maize among the income clusters for sustainable agriculture

	Value	df	Asymp. Sig (2-sided)
Pearson Chi-Square	9.484[a]	2	.009
Likelihood Ratio	9.867	2	.007
Linear-by-Linear Association	9.245	1	.002
N of Valid Cases	61		

[a] 0 cells (0%) have expected count less than 5. The minimum expected count is 8.56.