ASSESSMENT OF SUSTAINABILITY IN RAIN-FED CROPPING SYSTEM IN NATMOUK TOWNSHIP

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A THESIS SUBMITTED TO THE YEZIN AGRICULTURAL UNIVERSITY IN A PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF AGRICULTURAL SCIENCE
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The thesis attached hereto, entitled **"ASSESSMENT OF SUSTAINABILITY IN RAIN-FED CROPPING SYSTEM IN NATMOUK TOWNSHIP"** was prepared and submitted by Khaing Thandar Soe under the direction of the chairperson of the candidate supervisory committee and has been approved by all members of that committee and the board of examiners as a partial fulfillment of the requirements for the degree of **MASTER OF AGRICULTURAL SCIENCE (AGRICULTURAL ECONOMICS).**

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DEDICATED TO MY BELOVED PARENTS,

U AUNG SOE AND DAW TIN TIN AYE

DECLARATION OF ORIGINALITY

This thesis represents the original work 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

The dry zone in the central part of Myanmar is a region where agricultural productivity is not sustained by adverse weather condition and land degradation. The study area, Natmouk Township in the central dry zone is a resource poor area due to scarcity of water, thin vegetative cover and severe soil erosion.The objectives of the study were to describe the socio-economic characteristics, to investigate economic and ecological sustainability of cropping system, and social acceptability of sampled rain-fed cultivating households in Natmouk Township. The survey was conducted during December, 2010 and January, 2011. Simple random sampling procedure was used to select 96 respondents from 6 villages in Natmouk Township.

Among the sampled farm households, the numbers of small land holders were 33, medium land holders were 36 and large land holders were 27. All sampled farmers owned upland (Yar) and 54.2% of total farmers owned lowland (Le). The majority of the sampled households (77.1%) took credits from different credit sources. The average per capita income (91,278 Kyats/year) of food insecure households was significantly lower than the average income of food secure households (394,090 Kyats/year). There were three different cropping patterns in lowland such as monsoon paddy- fallow, monsoon paddy– chickpea, and monsoon paddy – green gram. The majority of farmers (72%) practiced monsoon paddy followed by fallow land. The common cropping pattern of upland was inter-cropping of sesame and pigeon pea in the early monsoon season. About 49% of farmers practiced the intercropping of sesame and pigeon pea followed by green gram or groundnut.

According to the gross marginal analysis, the sampled farmers who practiced intercropping of sesame and pigeon pea followed by cotton, chillies and onion cropping pattern received the highest benefit cost ratio (BCR) of (2.4) in upland. The farmers who practiced cropping pattern of monsoon paddy- chick pea received the highest benefit cost ratio of (1.59) in lowland.

Based on the regression results, household head’s schooling year, land holding size, crop intensification index and growing legume crop positively and significantly influenced on the sustainability score of the cropping system in low land at 5% significant

level. Income from livestock was also positively and significantly influenced on the sustainability score of the cropping system in low land at 10% level. But dependency ratio was inversely related to the sustainability score. On the other hand, household head's farm experience, number of livestock, crop intensification index and legume growing area positively and significantly influenced on the sustainability score of the cropping system in upland at 10% level. Crop diversification index positively and significantly influenced on the sustainability score of the cropping system in upland. But dependency ratio was negatively and significantly associated with the sustainability score of the cropping system in upland at 5% level.

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LIST OF ABBREVIATIONS

CDI	: Crop Diversification Index
CII	: Crop Intensification Index
DAP	: Department of Agricultural Planning
DDA	: Department of Development Affairs
FAO	: Food and Agriculture Organization
GOs	: Government Organizations
HDI	: Human Development Initiative
HNV	: High Nature Value farming system
INGOs	: International Non-Government Organizations
JICA	: Japan International Cooperation Agency
MAS	: Myanmar Agriculture Service
MOAI	: Ministry of Agriculture and Irrigation
MYA	: Myanmar
NGOs	: Non-Government Organizations
N,P,K	: Nitrogen, Phosphorus, Potassium
SARE	: Sustainable Agriculture Research and Education
SLRD	: Settlement and Land Records Department
UNCHS	: United Nations Center for Human Settlements
UNDP	: United Nations of Development Programme
UNESCAP	: United Nations Economic and Social Commission for Asia and the Pacific
UNESCO	: United Nations of Educational, Scientific and Cultural Organization
WHO	: World Health Organization

CHAPTER I
INTRODUCTION

Myanmar has a predominantly agricultural economy based on rice production. The country is suited to a large variety of crops such as cereals, pulses, oil seed crops, food legumes and industrial crops. The population of the country increased at a growth rate of about 1.1% per annum and reached 59.78 million at the end of 2010 (DAP, 2011). Among them, nearly 70% of the population lives in rural areas (MAS, 2011). Most of rural households are engaged in subsistence agriculture. Achievement of high food crop productivity in future is an important issue to meet the food demand created by the growing population, increased industrialization and urbanization.

Sustainable agriculture playsmajor rolein economic development of the country to consider as the population continues to increase. Its development is essential for alleviation of poverty because agriculture sector is the main livelihood of rural areas and poverty is largely a rural phenomenon.

In Myanmar land fragmentation is common, as well as land holding is small and average land holding size of a farm household is 2.3 ha (5.6 acres) at the country level (DAP, 2003). Agriculture in Myanmar has important characteristics with respect to the availability of water for the majority of farmers. Rain-fed cultivation system is a major cropping system which provides considerable amounts of crops, particularly cereals and legumes.

1.1. Cropping System and Production of Dry Zone

The dry zone in central part of Myanmar is a region where agricultural productivity is not sustained by adverse weather condition (drought, floods), land degradation and inaccessibility to markets due to poor infrastructure. The rainfall is high only in a few months of rainy season and almost no rainfall in other months. It leads to crop failure not only due to such frequent drought and erratic duration but also river floods during the mid-rainy season due to heavy rain. Therefore, the rural people who engage mainly in agriculture in the dry zone do not benefit the favor of good weather like others in different zones.

In dry zone, not only annual rainfall is low but also it has erratic duration in annual precipitation. The year-to-year variability of the rainfall in dry lands and of its distribution over the rainy season entail a great risk to the farmer, so that inputs applied at the start of the crop season such as fertilizer, or indeed seed or labor for land preparation, might not be repaid by the crop yield especially in low-rainfall years.

The dry zone, located in the central part of Myanmar, occupies approximately 87189 km^2 or around 12.9% of the country's total area. It is about 150 km (94 miles) from east to west and 500 km (313 miles) from north to south. About 34% of total population of the country resided in this region (DAP, 2010). Mandalay, Magway and the lower part of Sagaing Regions (total 13 districts and 58 townships) are included in the dry zone (SLRD, 2010). It has semi-arid climate with low and erratic annual rainfalls of less than 900 mm. The temperature is also very high in the dry zone and ranges from 19˚C to 40˚C.

The dry zone can be regarded as an important region for the country. Because the crops such as oil seeds and pulses which are the second and third most important crops in Myanmar are concentrated in that region. Because of the increasing population, the over-exploitation of land and natural resources has been increasing. Therefore, land has always been subjected to land degradation more and more and severe water and wind erosion are common in most parts of the dry zone, especially in MagwayRegion.

Undoubtedly, the main livelihoods of farmers in that region depend on agriculture with low-input subsistence farming. Magway Region is a resource poor area due to scarcity of water, thin vegetative cover and severe soil erosion. There has been decreasing crop productivity due to accelerated wind and water erosion and depletion of soil fertility.

According to MAS (2010), rice production of Magway Region is less than Mandalay and Sagaing regions. Although there are 47 dams and weirs for irrigation of agricultural land, it can only cover for 301484 acres of land. There are also many streams from which farmers can get water for their home consumption and for crops cultivation.

There were two main cropping systems practiced in Magway Region; (1) rice-based and (2) sesame-based cropping systems. Rice-based cropping system was practiced in low land (Le land) and sesame-based cropping system was practiced in upland. Livestock production was also much practiced in that area. Livestock which can resistant to drought such as drought cattle, cows, goats and sheep are mainly reared.

Table 1.1 shows the average growth rate percentage for harvested area, yield and production of the most widely grown crops; paddy, groundnut, sesame, sunflower, pigeon pea, green gram, chickpea and cotton in Magwayregion within ten years from 2000 to 2010. The growth rate for monsoon paddy harvested area and yield was 78.2% and 74.16%, respectively within ten years. The summer paddy harvested area and yield was increased by 55.23% and 86.08%, respectively. Groundnut, sesame and sunflower harvested areas werealso increased by 62.96%, 74.1% and 61.53%, respectively during 2000-2009.

In the study area, drought cattle were still using in land preparation for crops cultivation and in transportation since agricultural mechanization cannot be widely practiced. Although farmers were mainly practicing agricultural activities for their livelihood, the achievement of crop production was uncertain and they received low income. Therefore, in such situation, the farmers worked for additional income from rearing livestock since the livestock can be sold whenever they wanted money.

Table 1.1 Average growth rateof harvested area, yield and production of the most widely grown crops in Magwayregionduring 2000-2009

Crops	Growth rate (%)		
	Harvested area (%)	Yield (%)	Production (%)
Monsoon paddy	78.20	74.16	75.28
Summer paddy	55.23	86.08	79.37
Groundnut	62.96	84.98	83.44
Sesame	74.10	45.21	53.12
Sunflower	61.53	58.35	55.99
Pigeon pea	81.43	60.87	88.51
Green gram	76.25	94.72	82.29
Chickpea	70.88	73.27	90.25
Cotton	60.00	89.80	73.58

Source: MAS (2010)

Being in the central dry zone, Natmouk Township is one of the most pulses grown areas. Pigeon pea, green gram and chick pea are widely grown in that area. Oil seed crops are one of the most important crops which are widely grown in Natmouk Township.

Sown areas of major crops such as monsoon paddy, summer paddy, groundnut, sesame, sunflower, green gram, pigeon pea, chick pea and cotton in Natmouk Township during 2005-06 and 2009-10 are shown in Figure (1.1). Sown areas of monsoon paddy, sesame, sunflower and cotton were increased during 2005-2009. But sown areas of summer paddy, groundnut, pigeon pea and chick pea were the same during five years. Due to the drought condition, sown area of summer paddy was not increased that of monsoon paddy was increased from 9317 hectare to 19308hectare within five years. Although groundnut sown area was not increased, sown area of sesame was increased from 78947hectare in 2005-06 to 80921 hectare in 2009-10 and sown area for sunflower was also increased from 21637hectare to 24508hectare.

The production of nearly all crops in Natmouk Township was increased within five years. But the production of sunflower was decreased from 26504 ton/ha in 2005-06 to 25680 ton/ha in 2009-10. The production of monsoon paddy was significantly increased from 38504 ton per hectare to 86121 ton per hectare. Sesame production was also increased from 19344 ton per hectare to 49664 ton per hectare within five years. Moreover, cotton production was also increased from 6219 ton per hectare to 16759 ton per hectare Figure (1.2).

1.2. Rationale of the Study

In Myanmar, about 58 % of total rice grown area is under rain-fed cultivation whereas only 20% that of total is cultivated as irrigated rice (MAS, 2008). Although there are abundant water resource potentials, the present total water consumption in rice cultivation is generally high since rice is traditionally grown under continuous flooding in which the tremendous amount of water is used.

Although large strides made in improving productivity and environmental conditions in Myanmar, a great number of poor families in dry zone area still face poverty and food insecurity. These problems were exacerbated by adverse biophysical growing conditions and the poor socio-economic infrastructure in many rural areas (Kyaw Yee, 1998).

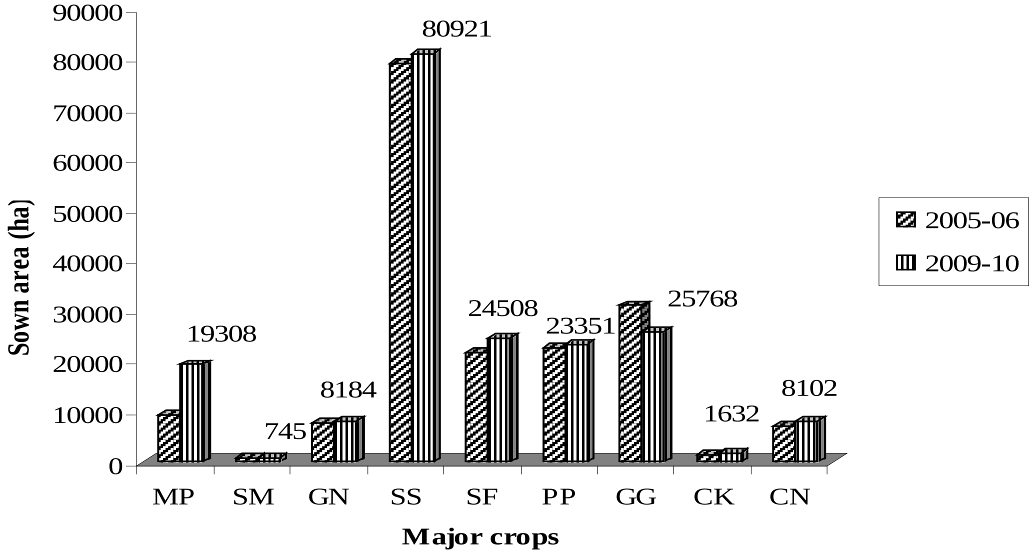

Figure 1.1 Sown areas of major crops in Natmouk Township (2005-10)

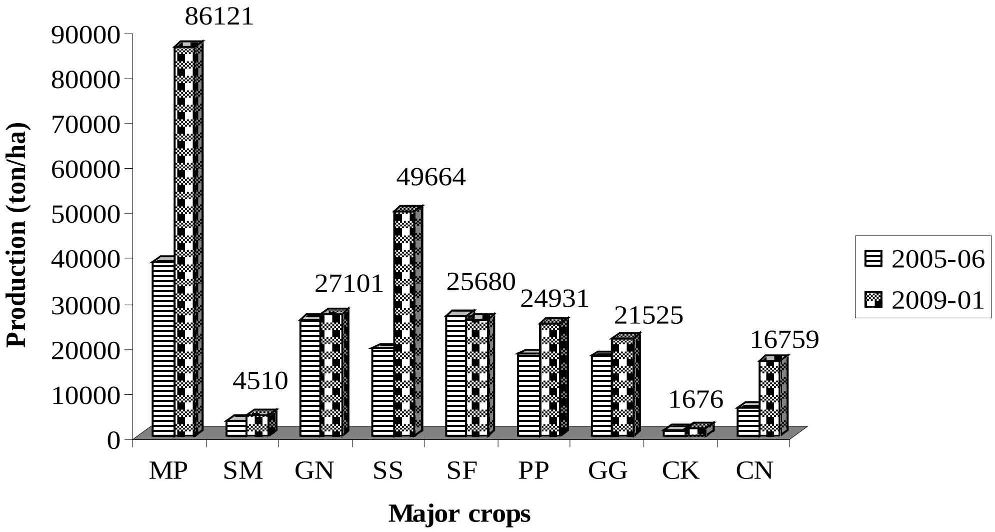

Figure 1.2 Production of major crops in Natmouk Township (2005-10)

Cropping without external nutrient application has been common in many parts of the country. Increasing population pressure pushes farming system to become more intensive and sedentary. It also creates imbalances in cropping patterns, reduced biodiversity and environmental problems which lead to threaten sustainability.

Using plant residues and other natural minerals with low solubility lead to sustainability of farms. Drought and degradation are interlinked in a cause and effect relationship, and the two combined are the main causes of poverty in farm households.

Rain-fed arable land in the dry zone is subject to; range of degradation hazards including erosion by water and wind, sandblasting of crops and emerging seedlings on arable land and rangeland, deposition of windblown sand, plant nutrient depletion in the soils, surface sealing or crusting, salinization in some areas. These hazards are generally more severe than in more well-watered regions, for several reasons.

Reduction in the producing capacity of land due to wind and water erosion of soil, loss of soil humus, depletion of soil nutrients, salinization, diminution and deterioration of vegetation cover as well as loss of biodiversity is referred to as land degradation leading to non sustainability (Volli, Carucci, 2001).

In Myanmar, increasing population promote to increase rice production more and more. The study area, Natmouk Township, has semi-arid climate with annual rainfall of ranging from 700 to 900mm per year. Therefore, farmers are facing to the serious ecological risk leading to low production. In these areas, the rainy season starts in later May and ends in October and the summer is from November to early May. In dry zone, the ratio of low land and upland is 1:3 and if the annual rainfall is high, the low land rice can be grown up to 30% (MAS, 2009).

Rice is the staple food of the country and rice production and post production activities could provide the main source of income and employment opportunities for millions of rural households. In Myanmar, development of economy is highly reliant on agriculture.An increase in population and the expansion of infrastructure in the central part of Myanmar has been lead tonon sustainable use of natural resources.

Local sufficient status of rice and pulses production in MagwayRegion during 2005 and 2010 are shown in Table (1.2) and Table (1.3). According to MAS (2010), MagwayRegionwas one of the rice insufficient divisions in Myanmar. Local sufficient status of rice production during 2005 and 2010 has been deficit. Being in the dry zone, NatmoukTownship was a resource poor area, scarcity of water, thin vegetative cover and severe soil erosion. And the soil was shallow with low fertility, erratic and low rainfall and high temperature of 40°C in several months. The productivity was decreasing due to accelerated wind and water erosion, and depletion of soil fertility. Simultaneously, use of chemical fertilizers and pesticides had been increasing tremendously.

The conservation and rehabilitation of rain-fed agriculture areas in dry lands should be part of a holistic approach to sustainable agriculture and rural development. Constraints occurred in dry zone areas are land degradation because of felling trees, shrubs and free grazing had intensified and added to the problems of excessive run-off and soil erosion. Nutrient depletion from soil is a major form of soil degradation (FAO, 2003).

The combined effects of increased population pressure and more relying on unsustainable farming practices resulted more land degradation, low soil fertility, and low production. Unfavourable weather conditions in Natmouk Township (in dry zone) such as late raining and receiving short rainy days cause crops failure due to receiving no rain at the sowing time and receiving less rain at the harvesting time. Although there has been severe-drought condition for one time within three years, it happens for one time within two years. Not only severe-drought condition but also heavy rain happens due to Alnino and Larnino. Because of climate change effect, the drought-prone lands are also subjected to flooding during the growing season due to erratic heavy rain.

Therefore, it is an urgent need to study sustainable cropping systems and to assess the sustainability of rain-fed cropping system in Natmouk Township.

Table 1.2Local sufficient status of rice production in MagwayRegionduring 2005-2010

Year	Production (ton)	Population(000')		Local consumption(ton)		Deficit (ton)	Sufficient (%)
		Urban	Rural	Consumption	Seed and Waste		
2005-06	616.65	979	4208	748.68	40.82	-173	78
2006-07	792.76	1000	4296	764.40	53.71	-25	97
2007-08	725.19	1019	4373	778.23	47.20	-100	88
2008-09	831.15	1037	4454	792.54	51.27	-13	98
2009-10	742.44	1052	4512	803.04	51.08	-112	87

Source: MAS, 2010

Table 1.3 Local sufficient status of pulses production in MagwayRegion during 2005-2010

Year	Production (ton)	Population (000')		Local consumption(ton)		Surplus (ton)	Sufficient (%)
		Urban	Rural	Consumption	Seed and Waste		
2005-06	19989.56	979	4208	2107.23	1278.42	527	874
2006-07	20809.84	1000	4296	2149.47	1302.00	551	603
2007-08	24026.04	1019	4373	2194.97	1407.84	649	667
2008-09	25923.34	1037	4454	2230.31	1460.16	706	702
2009-10	28064.89	1052	4512	2260.38	1529.11	771	741

Source: MAS, 2010

1.3. Objectives of the Study

The objectives of the study are:

1. To describe the socio-economic characteristics of sampled small, medium and large rain-fed cultivatingfarm households in the study area, Natmouk Township;
2. To investigate economic and ecological sustainability of cropping system and social acceptability of sampled farm households; and
3. To examine the influencing factors of sustainability score of the cropping system in rain-fed low land and upland in the study areas

CHAPTER II
LITERATURE REVIEW

2.1.Concept of Sustainable Agriculture

"Sustainable agriculture" is a topic which has received considerable attention in recent years from environmentalists, agriculturalists, and consumers. Sustainable agriculture has been given a number of different definitions, but the term implies three basic values: sustainable agriculture is ecologically sound, economically viable, and socially just and humane (Aiken 1983, Dahlberg 1986).

Sustainable agriculture is characterized by (a) sparse use of scarce raw materials and (b) no irreversible damage on the natural resource base. Low-input agriculture is claimed to be sustainable agriculture. Buttel et al. launched the term reduced-input agricultural systems in order to describe systems whose use of chemical fertilizers and pesticides is modest but significantly reduced in comparison to conventional systems (Buttel et al., 1986). The arguments are that inputs, like fertilizers and pesticides, may contribute to the pollution of surface and ground water. Therefore, sustainable agriculture could be considered agriculture of reduced inputs, which substitutes knowledge and management for polluting inputs.

Conway (1987) identified at least seven conceptualizations of sustainable agriculture and farming systems:

1. A sustainable farming system is a system in which natural resources are managed so that crop yields do not decline over time.
2. A sustainable farming system is a system in which natural resources are managed so that the stock of natural resources does not decline over time.
3. A sustainable farming system is one that satisfies minimum conditions of ecosystem stability and resilience over time.
4. A concept related to sustainable farming systems is HNV farming systems, which are likely to be of importance from a nature-conservation point of view.
5. Sustainable agriculture is organized so that the necessary support services (credit, extension, and input supply) are guaranteed.
6. Sustainable agriculture is a system guaranteeing equality, i.e. distributional and welfare aspects are given due attention through institutions that make

farmer participation possible, that are concerned about the poor and that are administered with a bottom-up approach.

7. A sustainable farming system is not unduly constrained by the socio-cultural environment or the policy-institutional environment.

Sustainable agriculture has been given a number of different definitions, but the term implies three basic values: sustainable agriculture is (i) ecologically sound, (ii) economically viable, and (iii) socially acceptable. Sustainable agriculture may be defined as an agricultural system which gives farmers a profitable livelihood while conserving agricultural resources and environmental quality. It makes efficient use of resources produced on the farm, reducing the need for commercially produced inputs (Haynes and Lamer, 1983). Ecological soundness refers to that it must be environmentally safe by the management and conservation of natural resource base. Economic viability refers to improving productivity and profitability of crops and livestock, and fair distribution of benefits and social acceptability refers to enhancing food security, equality, self-reliance and satisfaction of human needs.

According to USDA (1990), the term sustainable agriculture means an integrated system of plant and animal production practices having a site-specific application that will

- satisfy human food and fiber needs;
- enhance environmental quality and the natural resources base upon which the agriculture economy depends;
- make the most efficient use of nonrenewable resources and on-farm resources and integrate, where appropriate, natural biological cycles and controls;
- sustain the economic viability of farm operations; and
- socially acceptable and enhance the quality of life and for farmers and society as a whole.

USDA's Sustainable Agriculture Research and Education (SARE) Program (1990) stated that the primary goals of sustainable agriculture include:

(a) Providing a more profitable farm income

(b) Promoting environmental stewardship, including:

i. Protecting and improving soil quality

ii. Reducing dependence on non-renewable resources, such as fuel and synthetic fertilizers and pesticides, and

iii. Minimizing adverse impacts on safety, wildlife, water quality and other environmental resource

(c) Promoting stable, prosperous farm families and communities

According to FAO (1990), sustainable development is the management and conservation of the natural resource base and the orientation of technological and institutional change in such a manner as to ensure the attainment and continued satisfaction of human needs for the present and future generations. Such Sustainable development (in the agriculture, forestry and fisheries sectors) conserves land, water, plant and animal genetic resources, is environmentally non-degrading, technically appropriate, economically viable and socially acceptable.

Francis and Youngberg (1990) described sustainable agriculture as a philosophy, based on human goals and knowledge of impacts, which leads to "integrated, resource conserving, equitable farming systems which reduce environmental degradation, maintain agricultural productivity, promote economic viability in both the short and long term, and maintain stable rural communities and quality of life". The concept of sustainable agriculture is "agri-food systems that are economically viable, and meet society's need for safe and nutritious food, while conserving and enhancing natural resources and the quality of the environment for future generations" (Science Council of Canada, 1992).

Tilman*et al.*, (2002) defined sustainable agriculture as a practice that meets current and long-term needs for food, fiber, and other related needs of society while maximizing net benefits through conservation of resources to maintain other ecosystem services and functions, and long-term human development. This definition emphasizes multidimensional (economic, environmental and social) goals of sustainable agricultural development. The word "sustain" is derived from the Latin verb *sustinere* (to keep in existence or maintain) and implies long-term support or permanence.(Godfray*et al.,* 2010).

According to Zamora (1990), characteristics of sustainable agriculture are:

(1) Food Sufficiency

- Ability of agricultural systems to produce food in sufficient quantities to meet demand of the population over the long term;
- Similar to food security.

(2) Environmental Stewardship

- Environment should not be severely damaged by any agricultural activity;
- Maintenance of environmental quality essentially means preservation of the productive capacity of the land resource, no pollution of surface and ground water, loss of species habitat.

(3) Economic and Social Concerns

- Economic returns to farming
- Fair distribution of benefits
- Socially acceptable technology

To be sustainable, it must produce adequate food of high quality, be environmentally safe, protect the soil resource base, and be profitable (Reganoldet al. 1990). Sustainable agriculture and rural development has been defined by FAO as follow as:

"The management and conservation of the natural resource base, and the orientation of technological and institutional change in such a manner as to ensure the attainment and continued satisfaction of human needs for present and future generations. Such sustainable development (in agriculture, forestry, and fisheries sectors) conserves land, water, plant and animal genetic resources, and is environmentally non-degrading, technically appropriate, economically viable and socially acceptable" (FAO 1991).

While the definition of Conway is useful, it may be broadened to account for the economic and social aspects more appropriately. The definition has been followed and expanded by McConnell and Dillon (FAO, 1997). They have listed eight properties that need to be addressed when analysing farming systems. All of them, as follows, are given quantifiable measures:

1. Productivity
2. Profitability
3. Stability
4. Diversity
5. Flexibility
6. Time-dispersion
7. Sustainability
8. Complementarities and environmental compatibility

Sustainability rests on the principle that we must meet the needs of the present without compromising the ability of future generations to meet their own needs (Gail Feenstra et. al., 2002).

Sustainable agriculture integrates the goals of environmental health, economic profitability, and social and economic profitability, and social and economic equity. The overriding principle is to meet current food needs without compromising the rights of future generations (Heyzer N., UNESCAP, 2009).

2.2.Situation of Rain-fed Cultivation in Dry Zone Agriculture

The rain-fed cultivations are diverse and range from drought-prone lands to those subjected to flooding in excess of several meters during the growing season. The vast potential of rain-fed agriculture needs to be unlocked knowledge-based management of natural resources for increasing productivity and income to achieve food security in the developing world.

Myanmar is an agro-based country richly endowed with land and water resources and favorable climates. Sustainable agriculture development is essential to poverty reduction because agriculture sector is the main livelihood of rural people and poverty is largely a rural phenomenon in the country. Developing agriculture means developing the economy of rural people. Increased population and climate forces land use patterns to change and reassures upon farmers to produce more food on limited agricultural land.

While it will be necessary to develop sustainable irrigation systems, it will be even more important to reap greater benefits from rain-fed agriculture. This will mean, for example, developing varieties of seeds that are resistant to drought and pests, water-logging and salinity and creating market opportunities for dry-land farm products, such as pulses, oilseeds, millets, as well as vegetables, fruit and meat.

Rain-fed arable land in the dry lands is subject to; range of degradation hazards, including erosion by water and wind, sandblasting of crops and emerging seedlings on arable land and rangeland, deposition of windblown sand, plant nutrient depletion in the soils, surface sealing or crusting, salinization in some areas. These hazards are generally more severe than in more well-watered regions, for several reasons. The year-to-year variability of the rainfall in dry lands and of its distribution over the rainy season entail a great risk to the farmer, so that inputs applied at the start of the crop season such as fertilizer, or indeed seed or labour for land preparation, might not be repaid by the crop yield in low-rainfall years.

Much of land degradation results from over-intensive cultivation. In order to meet basic food needs, smallholders and the rural poor have been pushed into using ecologically fragile areas, forced to crop intensively on steep slopes that are vulnerable to erosion. FAO (1991) has reviewed some of the improved agricultural technology suitable for smallholders 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 (*Ananbaena*).
- Improved grazing management, including the use of fodder crops and temporary pastures in crop rotations.
- Increasing use of integrated pest management which avoids harming natural enemies and reduces the use of chemicals.
- Adaptation of mixed cropping for increasing productivity (FAO 1991).

2.3.Involvement of Developing Agencies in Agricultural sector in Dry Zone

In Myanmar, nearly 70 percent of cultivated land is under rain-fed cultivation, which is beset with numerous problems related to climate, soil, cropping and socio-economic aspects (MOAI, 2008).

To improve the living conditions of rural communities and to reduce the erosion hazards at the various project sites in the dry zone (Magway, ChaungOo and Kyaukpadaung Townships), the project with the title of “Agriculture Development and Environmental Rehabilitation in the Dry Zone” was implemented under the project of MYA/93/004 funded by UNDP/FAO and Human Development Initiative (HDI) (UNDP/FAO/HDI,1997). This two years project (1995-1997) was also strengthened through its interlinkage with parallel projects;

- UNDP/FAO MYA/93/003: Community Multipurpose Fuel wood Woodlots project
- UNDP/WHO: Primary Health Care
- UNDP/UNESCO: Primary Education Project
- UNDP/UNCHS: Water Supply and Sanitation Project

Under the projects, small-over flow dams and diversion weirs were built in Kyaukpadaung Township. In Magway and ChaungOoTownship, establishing agro-forestry and nurseries and making soil bunds and gully plugs were implemented. The vegetative barriers and the construction of physical structures on the upper slopes were made to reduce the soil and water runoff. Moreover, the 243 hectares of wind break plants were established in those townships as the achievements of the project activities of the Agriculture Development and Environmental Rehabilitation in the Dry Zone (Kyaw Yee, 1998).

To enlarge the genetic diversity of dry zone crop genetic resources in Myanmar Seed Bank, and to improve conservation and sustainable utilization of dry zone crop genetic resources for food and agriculture, collection and conservation of plant genetic resources from dry zone area of Myanmar has been carried out in collaboration with JICA of Japanese Government in Mandalay, Magway and Sagaing Regions. Among the collected samples in MagwayRegion, cereal crops showed the highest frequency (29.7%), and followed by food legumes (26.7%), vegetable crop samples (18.8%), oil seed crop (15.3%), industrial crops (5.4%), and rice (4.1%), respectively.

To maintain the dry land ecosystem and environment, and to protect the livelihoods of those living in dry land areas, sustainable agriculture development is very important. The Ministry of Agriculture and Irrigation participates and coordinates with International, Regional, INGOs and NGOs not only for the development of dry zone but also for the poverty reduction in rural area. Nowadays, the role of INGOs is gaining momentum in agriculture and rural development activities. The project of exploring approaches for agricultural sustainability and rural development for poverty reduction in central dry zone in Myanmar has been carried out by the cooperation of the Ministry of Agriculture and Irrigation with Japan International Cooperation Agency (JICA) under the five-year plan (2006-2010). The project activities such as mushroom culture, pig fattening and goat raising were established for landless as beneficiaries. Moreover, bio-gas (paddy husk) power generation which was benefiting all the people in the villages has been established.

In the dry zone, the annual rainfall, ranging from 700 mm to 900 mm, is concentrated in the wet season but is unstable and so harvest failures often occur. Most of the upland area of the Dry Zone suffers from various soil erosion and land degradation. The region is one of the rice deficit regions, having extreme weather and deforestation. As the residents in the dry zone mainly depend on the reservoirs where the rain stays within the village, when the water level of the reservoirs falls in the middle of the dry season, they have to go to wells several kilometers away and buy water.

To overcome such a situation, thousands of wells were formerly constructed by international organizations. The Government of Myanmar has planned and implemented various rural water supply projects, and one of the efforts is “A ten Year Project for Rural Water Supply by Development Committees of Sagaing, Magway and Mandalay Regions (From 2000-2001 to 2009-2010)”. However, the implementing organization, the Department of Development Affairs (DDA), Ministry of Progress of Border Areas and National Races and Development Affairs, have technical problems such as an insufficient technical capacity of the DDA and many defects with wells constructed by the DDA, which break down right after the construction or become out of use due to muddy water (Kokusai Kogyo 2007).

Therefore, construction, repair and maintenance of water supply facilities in the central dry zone under the four years project (2006-2009) of rural water supplytechnology were implemented in cooperation with the Japan International Cooperation Agency (JICA).

2.4. Previous Studies on Sustainable Farming System and Food Security in the Dry Zone

According to the experiment of NyaungOo Dry Zone Agricultural Research farm by Khin Lay Swe (2006), it showed that annual crop windbreaks showed significant affects on plant performance and yield of crops. Moreover, crops protected by windbreaks grew taller, produced more dry weight and yielded more seeds than control crops of without windbreaks.

Carucci (2001) pointed out that although soil and water conservation elements are part of the indigenous knowledge, and countless examplesare found in Myanmar dry zone. They are often not anymore sufficient to cope with the fast deterioration of the land-based resources.

Agronomic practices: mulching of crop residues, tie-ridging, compost application, contour ploughing and planting, ripping hard pans and sub-soil, intercropping, etc., are some of the most important biological measures that should be integrated with banding (J.W.F. Cools.1995).

Khin Lay Swe (2004) also showed that in the features of dry land farming in the dry zone, central Myanmar, subsistent farming system has been established with low input technology, together with more intensive land cultivation to secure a reliable income. Moreover, productivity levels cannot be sustained or increased with the current practices of under- application of nutrients and inefficient ways of utilizing crop residues.

For the prevention of soil erosion, increasing the irrigation efficiency and investigation and improvement of water resources, the project which is funded by the Government of Myanmar and UNDP and implemented by FAO, has been carried out in Mayway, Kyaukpadaung and Chaung U Townships in 1995. The project has encouraged and helped some farmers to construct contour bunds, to assist in rain harvesting and reduce the top soil erosion. The results from this project described that there is not much surface water in the project area to develop. Therefore, the future of the agricultural development in the project area depends on the availability of ground water and how successfully it is explored. The analysis also showed that ground water can be used economically to irrigate most of the common crops grown in the area (R. T. Baban, 1995).

Under the pilot projects: improved paddy cultivation promotion programme, organic farming promotion programme, improved seeds regeneration project, pro-poor oriented mushroom culture promotion project, small-scale irrigation promotion project, crop storage depots promotion project, minimum tillage promotion project, new varieties adaptability trial project, pro-poor oriented goat revolving programme, pro-poor oriented piggery revolving programme, livestock feeding improvement programme, village revolving fund establishment project, firewood subsisting bio-fuel promotion, improved cooking stove promotion project, paddy husk power generation project and children’s nutrition improvement center established by JICA has been carried out in 2007 cooperated by MOAI.

CHAPTER III

RESEARCH METHODOLOGY

3.1 Description of the Study Area

3.1.1 Location, topography and climate of the study area

The study area, Natmouk Township, which is in the central dry zone, is located between 20˚ 7' N latitude & 20˚ 17' N latitude and 95˚ 10' E longitude & 95˚ 45' E longitude. It is at an elevation of around 570 feet or 174 meters. It is bounded by Pyawbwe, Yamethin and Meikhtila townships in the east, Yenangyaung and Magway townships in the west, Kyaukpadaung in the north and Myothit in the south. The people in Natmouk can go easily to the surrounding townships by car. The township also has access to railway as it is situated on Nay Pyi Taw-Bagan rail route. There are 73 village tracts including 237 villages in the study area.

In general, the topography is undulating to low. The township has high land in east and west sides of the township area. There are two dams and one large pond in the study area; Natmouk dam, Kyaukdagar dam and Pinn pond which can cover only 21 village tracts for irrigation of agricultural land (3389.07 hectares of total crop sown area). There are many streams across the township and streams have water only in rainy season. Therefore, many bridges are constructed for convenient of transportation.

Figure 3.1 shows that a maximum rainfall precipitation of 313.94 mm was found in October (2010) while a minimum precipitation of 7.87mm was found in March (2010). Although the average annual precipitation was 862.84mm and 913.89mm in 2008 and 2010, only 392.68mm of precipitation was found in 2009. Since there was a very low annual rainfall in 2009, farmers faced with crops failures. Farmers again faced with low production because of receiving unseasonal rain during harvesting time. The minimum average temperature was 16˚C and the maximum average monthly temperature was 40˚C within a year.

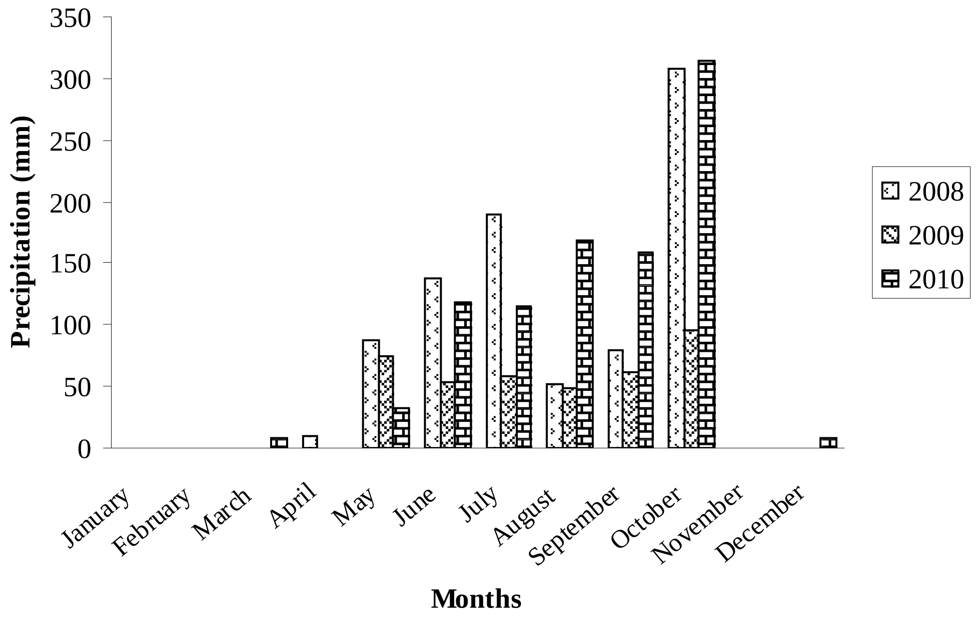

Figure 3.1 Precipitation (mm) in NatmoukTownship (2008-2010)

3.1.2 Area and population of the study area

The land area of NatmoukTownship was about 2310 km^2 (231022 hectares) with the population of 226858 in the year 2010. There were 73 village tracts and 237 villages in the study area. There were 7 wards in urban area with total 2560 households in 2009-10. The other households 37045 were in rural areas. The total population was 226858 in year 2010. The urban and rural population were 13015 and 212743, respectively. Therefore, the majority of total population 93.9% was living in rural area (MAS, 2010).

3.1.3 Land use pattern

Agricultural land or cultivated land which was the large share of total land was 55.53% including low land (Le), and upland (yar) (Table 3.1). In agricultural land, upland (yar) occupiedabout 50.04% (115613.4 ha) of the net sown area while low land (Le) was about 5.49% (12677.1 ha). Therefore, in the study area, yar (dry land) cropping was the major cropping system. About 8.18% of land use was classified as reserved and unreserved forest area which was about 18878.97 ha. Cultivable waste land occupied 5.36% and other land (residential area, river and streams area, etc) was about 30.94% in the study area.

Table 3.1Land use pattern in Natmouk Township (2009-10)

No.	Description	Area (ha)	% area
1.	Net Sown Area	128287.4	55.53%
	Le Land	12674.1	5.49%
	Yar Land	115613.4	50.04%
	Kaing Land	0	0
	Garden	0	0
2.	Reserved Forest	18147.8	7.86%
3.	Unreserved Forest	731.1	0.32%
4.	Cultivable Waste Land	12373.7	5.36%
5.	Uncultivable Waste Land	71482.2	30.94%
	Total	231022.2	100%

Source: MAS, NatmoukTownship (2010)

The dry zone is characterized by low and highly variable rainfall that has led to drought along with increased risks of rain-fed farming. Therefore, the farmers diversify the crops to reduce crop failure and to earn additional income. The farmers grow various crops such as oil seeds crops (groundnut, sesame and sunflower), pulses (pigeon pea, green gram, penauk), cotton, sorghum, chillies and vegetables in upland for their home consumption and cash income. In upland, rain-fed rice (monsoon rice), summer rice, chick pea, sunflower and green gram were usually grown.

In general, soil in Natmouk Township was sandy in the western part of the township and coarse and stony in the eastern part of the township. Being the sandy soil, rain water cannot be held for a long time and can run off easily. This is because soil moisture retention was low and vegetation cover was thin. Moreover, sandy textures and dry climatic conditions made soil highly erodible for most of the year leading to low productivity of land.

3.1.4 Cropping patterns, sown acreage and production of crops

In Natmouk Township, agricultural land was mainly planted with mostly drought resistant variety of crops such as pigeon pea, green gram, chickpea, sesame, groundnut, cotton, maize, sunflower and penauk. They were mainly grown often inter and mixed cropping to make efficient use of soil moisture. Being in the dry zone, the yield and production of crops were not as high as yields in other areas receiving favorable climate.

There were mainly three cropping patterns for which farmers were practicing in rain-fedlow land; (1) monsoon paddy-fallow, (2) monsoon paddy-chickpea, and (3) monsoon paddy-green gram. But in the upland, the main cropping pattern was intercropping of sesame and pigeon pea or green gram and pigeon pea in the early monsoon season. After harvesting of sesame, sorghum (for animal feeds) or groundnut was grown. After harvesting of groundnut, chillies, cotton, sunflower or onionwere grown as second crop. Other farmers practiced green gram or pigeon pea in the early monsoon season followed by cotton.

In 2009-10, total harvested area for monsoon paddyand summer paddy was 47.361 thousand hectares and 1.795 thousand hectares respectively. Table 3.2 shows that although the cultivation of monsoon rice was expanded significantly, the yield was only slightly increased by 8.68% while summer paddy was significantly increased by 26.18% within five years (2005-06 to 2009-10). The yield per hectare of groundnut and chickpea did not increase significantly within this period. However, although a few cultivation areas of sesame and cotton was expanded, their yields per hectare were highly increased by 48.03% and 77.98% within this period. The yields of sunflower were decreased by 14.49% because of their highly sensitive to drought although the areas were expanded. In the overall production, the yield level of crops (such as monsoon rice, summer rice, groundnut, sesame, pigeon pea, green gram, chickpea and cotton) except sunflower was increased during 2005-06 and 2009-10.

3.2 Data Sources and Data Collection Method

Data collection was based on a field survey and the collection of secondary information. The secondary sources of data which covered the information in the local sufficient status of rice production, annual rainfall, land use, sown area and yield of important crops in Magway Region and Natmouk Township were obtained for the period of 2005-06 to 2009-10 from the Government Organizations (GOs).

These informative data were obtained from Head Office Myanmar Agriculture Service (MAS) in Nay Pyi Taw, MAS in Natmouk Township, Department of Agricultural Planning (DAP) and Settlement and Land Records Department (SLRD).

Table 3.2Harvested area and yield of major crops in NatmoukTownship (2005 -2010)

No.	Description	2005-2006		2009-2010	
		Harvested Area(ha)	Yield (ton/ha)	Harvested Area(ha)	Yield (ton/ha)
1.	Paddy(monsoon)	23.01	67.74	47.36	73.62
2.	Paddy(summer)	1.76	80.69	1.79	101.83
3.	Groundnut	19.05	54.94	20.22	54.31
4.	Sesame	192.94	4.06	199.74	10.07
5.	Pigeon Pea	56.21	13.00	57.68	17.50
6.	Green gram	76.74	9.34	63.65	13.69
7.	Chickpea	3.74	15.11	4.03	16.84
8.	Sunflower	53.44	20.08	60.53	17.17
9.	Cotton	22.05	124.97	24.95	222.38

Source: MAS, NatmoukTownship (2010)

The household level survey was carried out in six villages (Nabuukwe, SaingGaung, Kyauk Tan, PadaukNgout, Sakhanma and YaeNgan) with a structured questionnaire by personal interview duringDecember 2010 and January 2011. A total of 96 households were selected and interviewed.

The household level survey covered the information about the background of the family, land use, cultivation and production of crops, availability of resources, agricultural assets and loans. Data of crop production practices, cropping patterns, labor allocation and the financial situation of the households were also collected. This study also included household information of household head’s age, education, occupation, family size, family labor and farmer’s experience.

3.3 Method of Data Analysis

3.3.1 Indicators for assessing agricultural sustainability

Figure 3.3 shows the conceptual framework for assessment of sustainable cropping system. There are many indicators to assess the agricultural sustainability. But they cannot cover all aspects of sustainability and they vary according to the country. However, to establish the long-term sustainable agriculture, three important topics; (1) economic viability (2) ecological soundness and (3) social viability must be considered. In Myanmar, majority of farmers are smallholders and average land holding size is less than two hectares. Therefore, farmers' perception for agricultural development is to increase crop yield, to obtain income and food security and reduce the risk of crop failure. Lacking the capital required for the purchase of necessary inputs is one of the crucial problems facing most of the farmers. In this study, "9 indicators" which represent the above three important topics were selected to evaluate the sampled farm households' cropping system.

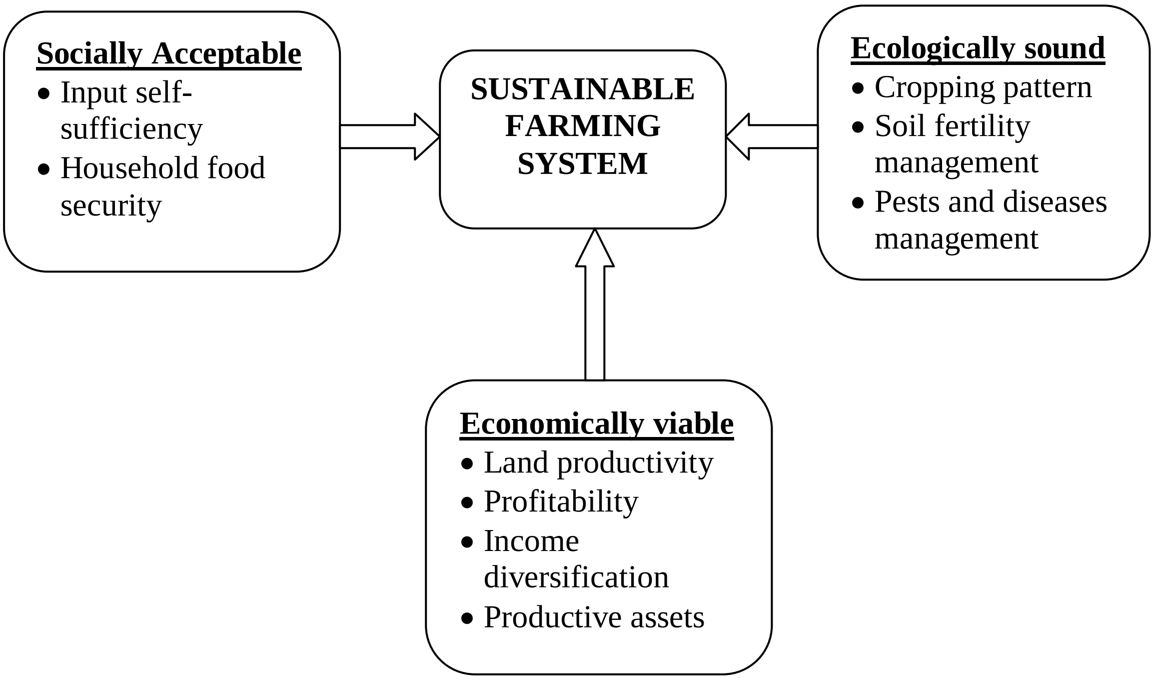

Figure 3.2 Conceptual framework for assessment of sustainable farming system

3.3.2 Framework for determining ecological indicators

There are three indicators which can assess the ecological sustainability namely (1) cropping pattern (2) soil fertility management and (3) pest and disease management.

(a) Two criteria were used to analyze the cropping pattern namely (1) cropping intensity and (2) crop diversification. Cropping intensity was measured through the following crop intensification index formula:

$$\mathrm{CII} = \frac{\text{Total cultivated area of crops for a year}}{\text{Owned cultivated area}} \mathrm{x100}$$

Where, CII = crop intensification index

Crop diversification was measured through crop diversification index using the following formula:

$$\mathrm{CDI} = \frac{\text{Proportion of sown area under crop}'\text{a}'}{\text{Total number of crops}} \mathrm{x100}$$

Where, CDI = crop diversification index

(b) Soil fertility management was evaluated based on farmers using inorganic and organic fertilizers, i.e., farmyard manure and cultivating legume crops and application rate of fertilizers (N,P,K) by crops. Moreover, proportion of area covered by each type of fertilizer including legumes and amounts of inorganic and organic fertilizers applied per unit of land was considered.

(c) Pests and diseases management was assessed based on farmers using mechanical and chemical methods and application rate of pesticides by crops.

3.3.3 Framework for determining economic indicators

To measure economic viability, four indicators; land productivity, farm profitability, income diversification and productive assets were examined. Land productivity was measured through yields of crops collected through the household survey.

Farm profitability was examined based on gross marginal analysis (gross margin per unit of land, gross margin per unit of capital, break-even yield, and break-even price). Income diversification was examined by collecting data based on on-farm, off-farm and non-farm income of sampled farm households.

3.3.4 Framework for determining social indicators

Social acceptability was assessed in terms of input self-sufficiency, and household food security.

Input self-sufficiency was determined on the basis of the ratio of local input costs to the total input cost. The higher the ratio of local inputs, the higher the input self-sufficiency. Household food security was examined firstly by analyzing percentage food from production, and percentage food from market. Then food security status of farm households was assessed by applying the national food poverty line of UNDP in 2010.

In order to evaluate the low land and upland sustainability score of the sampled farm households, Ordinary Least Square regression model was used.

$$\mathbf{Y_i = \beta_0 + \beta_i x_{1i} + \beta_i x_{2i} + \beta_i x_{3i} + \ldots + \beta_k x_{ik} + u_i}$$

Where, Y_i = low land sustainability score

- x_{1i} = household head's age
- x_{2i} = household head's schooling year
- x_{3i} = household head's working experience
- x_{4i} = dependency ratio
- x_{5i} = low land area (ha)
- x_{6i} = per capita income of migration (thous.Kyat/yr)
- x_{7i}= per capita income of livestock (thous.Kyat/yr)
- x_{8i} = owned livestock quantity
- x_{9i} = application rate of farm yard manure (ton/ha)
- x_{10i} = crop intensification index (%)
- x_{11i}= crop diversification index (%)
- x_{12i}= rice insufficient month per year
- x_{13i}= Dummy variable (growing legume in low land=1, and not growing legume=0)
- u_i= disturbance or error term

$$\mathbf{Y_i = \beta_0 + \beta_i x_{1i} + \beta_i x_{2i} + \beta_i x_{3i} + \ldots + \beta_k x_{ik} + u_i}$$

Where, Y_i = upland sustainability score

- x_{1i} = household head's age
- x_{2i} = household head's schooling year
- x_{3i} = household head's working experience
- x_{4i} = dependency ratio
- x_{5i} = upland area (ha)
- x_{6i} = per capita income of migration (thous.Kyat/yr)
- x_{7i}= per capita income of livestock (thous.Kyat/yr)
- x_{8i} = owned livestock quantity
- x_{9i} = application rate of farm yard manure (ton/ha)
- x_{10i} = crop intensification index (%)
- x_{11i}= crop diversification index (%)
- x_{12i}= legume growing area (ha)
- x_{13i}= intercropping area (ha)
- u_i= disturbance or erro

CHAPTER IV
RESULTS AND DISCUSSION

4.1 Socio-economic Characteristics of Selected Farm Households in Natmouk Township

4.1.1 Land holding size of farm households in the study area

Farm households wereclassified as three groups according to their land holding size. The farm households who own the land less than 2.024 ha were denoted as small farm households. The farm households holding the land between 2.025 ha and 4.058 ha were denoted as medium farm households and those who hold the land more than 4.058 ha as large farm households (Table 4.1).

4.1.2 Comparison of land ownership by type and farm size distribution of households

All farm households in the selected sampled villages owned the upland (Yar land). About 36.4% of small farm households, 55.6% of medium farm households and 74.1% of large farm households owned the low land (Le land). About 63.6%, 44.4% and 25.9% of small, medium and large farm households owned upland only (Table 4.2).

Table 4.3 shows the average farm size of three farm households. The average farm sizes of small, medium and large farm households were 1.56 hectare, 3.36 hectare and 5.92 hectare respectively. The F-test shows that total farm size, the average low land area and the average upland area were highly significant at 1% level among three farm households.

Table 4.1 Categories of rain-fed cultivated farm households based on their own farm size

H/H groups	Number	Average farm size(ha)	Minimum farm size(ha)	Maximum farm size(ha)
Small farm households	33	1.56	0.2	2.02
Medium farm households	36	3.36	2.43	4.05
Large farm households	27	5.92	4.45	15.38
Total	96	3.46	0.2	15.38

Source: Field survey (2011)

Table 4.2 Number and percentage of farmers having land ownership by type for different farm size groups

(Number and percentage of farmers)

	Ownedlow land	Owned upland	Owned Both Types of Land
Small farm households (N=33)	11 (36.4%)	33 (100%)	11 (36.4%)
Medium farm households (N=36)	20 (55.6%)	36 (100%)	20 (55.6%)
Large farm households (N=27)	19 (74.1%)	27 (100%)	19 (74.1%)
Total	50 (54.2%)	96 (100%)	50 (54.2%)

Source: Field survey(2011)

Table 4.3 Mean value of land holding size of different farm size groups

Items	Small farm households	Medium farm households	Large farm households	Total farm households
	(N=33)	(N=36)	(N=27)	(N=96)
Average farm size (ha)	1.56	3.36	5.92	3.50
-Std. deviation	0.58	0.61	2.23	2.18
-Minimum	0.20	2.43	4.45	0.20
-Maximum	2.02	4.05	15.38	15.38
F-test	**F=90.687, p=0.000***,df=2**			
	(N=11)	(N=20)	(N=19)	(N=50)
Average low land size (ha)	0.29	0.58	1.09	0.63
-Std. deviation	0.41	0.62	0.96	0.74
-Minimum	0.00	0.00	0.00	0.00
-Maximum	1.21	2.02	3.24	3.24
F-test	**F=10.466,p=0.000***, df=2**			
	(N=33)	(N=36)	(N=27)	(N=96)
Average upland size (ha)	1.27	2.78	4.95	2.87
-Std. deviation	0.64	0.92	1.90	1.89
-Minimum	0.20	0.81	2.83	0.20
-Maximum	2.02	4.05	12.15	12.15
F-test	**F=68.553, p=0.000***, df=2**			

Source: Field survey (2011),

Note: ***significant at 1% level

4.1.3 Comparison of the social characteristics of farm households

The social characteristics of the farm households were described for three main groups; small farm households, medium farm households and large farm households (Table 4.4). The average age of small, medium and large farm householdswere 48.64, 55.93 and 57.14 years, respectively. Thus, the household head’s age was significantly different at 5% level.

The average household head's schooling years for small, medium and large farm households were 3.42, 3.31 and 4.07 years. Therefore, the average household head's schooling year was not significantly different among small, medium and large farm households. The average family members were about 6.42, 6.89 and 6.78. The average family size was not significantly different among three farm groups. Most of family members in rural areas engaged in their own farm to reduce labor cost. There was no significantly difference among three groups because the average family labors for three groups of farm households were 2.06, 2.03 and 1.78,respectively. The F-test showed that the average number of farm worker was not significantly different among small, medium and large farm households.

Farmers' working experience also plays an important role in agricultural farming activities. The average household head's working experiences were 24.61, 33.07 and 33.25 years respectively for small, medium and large farm groups.

4.1.4 Comparison of productive assets and types of house condition of selected farm households

The medium farm households significantly owned more bicycle and bullock cart than small and large farm households. The majority of farm households, 81.8%, 86.1% and 96.3% of small, medium and large farm households owned both plow and harrow. About 41.7% of medium farm households possessed bicycle for transportation and 80.6% of them owned bullock carts for transporting crops from fields to village, and from village to market. About 21.2%, 38.9% and 48.1% of small, medium and large farm households owned sprayers.

About 9.1% of small farm households owned horse cart but about 2.8% of medium farm householdsowned horse cart. More percentage of small farm households engaged in non-farm employment to earn extra income. There were no farmers who owned tractor in the selected sampled villages even among large farm households. Therefore, it can be concluded that farmers in the selected sampled villages were still practicing traditional methods in land preparation. However, about 5.6% of medium and 11.1% of large farm households owned generators (Table 4.5).

About 55% and 56% of small and medium farm households lived in the house with bamboo wall and corrugated iron roofing (Table 4.6). The majority of large farm households about 41% lived in on storied house with wooden wall and corrugated iron roofing.

Table 4.4 Socio-demographic characteristics of selected farm households

Items	Small farm households (n=33)	Medium farm households (n=36)	Large farm households(n=27)	Total farm households(n=96)
Average head's age	48.64	55.93	57.14	53.87
F-test	**F= 4.407, p= 0.015**, df= 2**			
Average head's schooling year	3.42	3.31	4.07	3.52
F-test	**F= 0.774, p= 0.464^{ns}, df= 2**			
Average living together family size	6.42	6.89	6.78	5.1
F-test	**F= 0.224, p= 0.8^{ns}, df=2**			
Average family labor	3.91	3.81	3.63	3.79
F-test	**F= 0.166, p= 0.848^{ns}, df=2**			
Average farm worker	2.06	2.03	1.78	1.97
F-test	**F= 0.792, p= 0.456^{ns}, df= 2**			
Average head's experience	24.61	33.07	33.25	30.23
F-test	**F= 4.422, p= 0.015**, df= 2**			

Source: Field survey (2010),
Note:**significant at 5% level, ns= not significant

Table 4.5 Productive and luxury assets of selected farm households

(Number and percentage of households)

Assets	Small farm households(n=33)	Medium farm households (n=36)	Large farm households(n=27)	Totalfarm households (n=96)
Own sprayer	7(21.2%)	14(38.9%)	13(48.1%)	34(35.4%)
Own water pump	2 (6.1%)	1 (2.8%)	2 (7.4%)	5 (5.2%)
Own plow	27(81.8%)	31(86.1%)	26(96.3%)	84(87.5%)
Own harrow	27(81.8%)	31(86.1%)	26(96.3%)	84(87.5%)
Own bicycle	5(15.2%)	15(41.7%)	12(44.4%)	32(33.3%)
Own motorcycle	6(18.2%)	3(8.3%)	6(22.2%)	15(15.6%)
Own horse cart	3(9.1%)	1(2.8%)	0(0%)	4(4.2%)
Own bullock cart	22(66.7%)	29(80.6%)	26(96.3%)	77(80.2%)
Own TV	2(6.1%)	1(2.8%)	2(7.4%)	5(5.2%)
Own sewing machine	3(9.1%)	4(11.1%)	5(18.5%)	12(12.5%)
Own generator	0(0%)	2(5.6%)	3(11.1%)	5(5.2%)

Source: Field survey (2011)

Table 4.6 Types of house conditions of selected farm households

(Number and percentage of households)

Types of house	Small farm households (n=33)	Medium farm households (n=36)	Large farm households(n=27)	Total farm households (n=96)
Thatch roofing& bamboo wall	11(33.3%)	8(22.2%)	6(22.2%)	25(26.0%)
Corrugated iron roofing& bamboo wall	18(54.5%)	20(55.6%)	5(18.5%)	43(44.8%)
One storied, wooden & corrugated iron roofing	2(6.1%)	3(8.3%)	11(40.7%)	16(16.7%)
Two storied, wooden & corrugated iron roofing	2(6.1%)	4(11.1%)	3(11.1%)	9(9.4%)
Pucca house	0(0%)	1(2.8%)	2(7.4%)	3(3.1%)

Source: Field survey (2011)

4.1.5 Comparison of livestock ownership of sampled farm households

Farm households in the study villages reared livestock for extra income such as drought cattle, cows, pig, goat, sheep and poultry. Since farmers in these villages were still practicing traditional methods in agricultural activities, drought cattle were their main reliance not only for land preparation but also for transportation of crops.

The rearing of livestock such as cattle, pig, poultry, goat and sheep can make extra income if there were any failure in crops production due to uncertain weather conditions and other risks. Large farm households significantly owned more drought cattle and poultry than any other two group farmers. The F-test shows that the average numbers of drought cattle and poultry owned by the farm households were significantly different at 1% and 5% level. The average number of sheep was significantly different at 10% level among small, medium and large farm households. Large farm households reared more sheep than others. The F-test shows that the average numbers of cows, goat, pig and poultry were not significant among three groups (Table 4.7).

Table 4.7 Comparison of livestock ownership of sampled farm households

Livestock	Small farm households (n=33)	Medium farm households (n=36)	Large farm households (n=27)	Total farm households (n=96)
No. of cattle	2.12	2.69	4.67	3.05
F-test	**F=7.071, p = 0.001***, df = 2**			
No. of milk cow	0.48	0.78	0.81	0.69
F-test	**F= 0.432, p = 0.650ns, df = 2**			
No. of goat	5.33	2.69	2.78	3.62
F-test	**F= 0.897, p = 0.411ns, df = 2**			
No. of sheep	0.91	1.03	4.48	1.96
F-test	**F= 3.078, p = 0.05**, df = 2**			
No. of pig	0.24	0.19	0.19	0.21
F-test	**F= 0.108, p = 0.898ns, df = 2**			
No. of poultry	9.61	9.94	14.67	11.16
F-test	**F= 2.416, p = 0.09*, df = 2**			

Source: Field survey (2011)
Note: ***, **,*significant at 1%, 5% and 10% level, ns= not significant

However, small farm households reared more goats than other holders. Since goats are very prolific, income from goats are certain in a short period. This is the main fact why small farm households reared more number of goats than others.

4.2 Rain-fed Cropping System in the Study Area

4.2.1 Croppingpatterns practiced by the sampled farm households

Due to drought and without irrigation, some of the farmers in the study area did not grow any crop after harvesting monsoon paddy. But some of them grew monsoon paddy followed by chickpea or green gram. In the study area, there were three types of low land (Le) cropping patterns practiced by sampled farm households. They were (1) monsoonpaddy-fallow, (2) monsoon paddy – chickpea, and (3) monsoon paddy – green gram (Table 4.8). About 63.6% of small farm households, 75% of medium farm households and 73.7% of large farm households grew monsoon paddy only in low land. They practiced only mono cropping pattern. About 36.4%, 25% and 15.8% of small, medium and large farm households grew chickpea after harvestingmonsoon paddy. But only 10.5% of large farm households grew green gram after harvesting of monsoon paddy.

The common cropping pattern of upland (Yar land) was inter-cropping of sesame and pigeon pea in the early monsoon season. After harvesting of sesame, some farmers grew green gram or groundnut. There were only 5.6% medium farm households who grew only sesame. About 51.5%, 44.4% and 51.9% of small, medium and large farm households grew green gram or groundnut after intercropping of sesame and pigeon pea. Intercropping of sesame and pigeon pea followed by cotton or chillirs or onion was practiced by 12.1%, 25% and 33.3% of small, medium and large farm households. Sunflower or groundnut was grown as the second crops by 3% of small, 11.1% of medium and 3.7% of large farm households (Table 4.9).

Table 4.8 Low land cropping pattern of the sampled farm households

(Number and percentage of farmers)

No.	Low land Cropping Pattern	Different farm size group			Totalfarm households (n=50)
		Small farm households (n=11)	Medium farm households (n=20)	Large farm households(n=19)	
1.	Monsoon paddy-fallow	7 (63.6%)	15 (75%)	14 (73.7%)	36 (72%)
2.	Monsoon paddy – Chickpea	4 (36.4%)	5 (25%)	3 (15.8%)	12(24%)
3.	Monsoon paddy – Green gram	0 (0%)	0 (0%)	2 (10.5%)	2(4%)

Source: Field survey (2011)

Table 4.9 Upland cropping pattern of the sampled farm households

(Number and percentage of farmers)

Upland Cropping Pattern	Small farm households (n=33)	Medium farm households (n=36)	Large farm households (n=27)	Total farm households (n=96)
Sesame only	0 (0.0%)	2 (5.6%)	0 (0.0%)	2 (2.1%)
Sesame +Pigeon pea- Green gram or Groundnut	17 (51.5%)	16 (44.4%)	14 (51.9%)	47(49%)
Sesame +Pigeon pea-Chillies-Tomato	2 (6.1%)	4 (11.1%)	2 (7.4%)	8 (8.3%)
Sesame +Pigeon pea-Groundnut-Sunflower	1 (3%)	4 (11.1%)	1 (3.7%)	6(6.2%)
Sesame +Pigeon pea-Cotton-Chillies or Onion	4 (12.1%)	9 (25%)	9 (33.3%)	22(22.9%)
Pigeon pea-Green gram	2 (6.1%)	1 (2.8%)	1 (3.7%)	4 (4.2%)
Sesame +Pigeon pea-Onion	7 (21.2%)	0 (0%)	0 (0%)	7(7.3%)

Source: Field survey (2011)

4.3 Resource Used in the Study Area

4.3.1 Sources of production credits for farm households

In crop production, production credit is essential for farm households. Although MADB waspaying loans to farmers for monsoon rice production, the amount was too small to cover the requirements of crop production. Therefore, farm households had to take credit from other sources such as money lenders and relatives. According to the survey data, about 48.5%, 50% and 51.9% of small, medium and large farm households borrowed money from MADB/ MAS (Table 4.10). About 50% of farmers took credit from MADB and MAS, 8.3% of farmers borrowed money from money lender and 11.5% of farmers borrowed money from both MADB and money lender and 6.2% farmers borrowed money from relatives.

The farm households in the study area also engaged in the off-farm and non-farm activities to earn extra income. Small, medium and large farm households earned about 50.62%, 68.98% and 74.09% of income from crop production, respectively which is the highest among their income sources. Small farm households also received 13.58% of income from migration jobs, and 11.49% of income from livestock rearing. Medium farm households received 7.73% of income from migration jobs and 7.55% of income from working as farm labors. Large farm households also received 11.35% of income from livestock rearing and 7.47% of income from migration jobs (Table 4.11).

4.3.2 Inputs used by sampled farm households in low land

The farm households who practiced the cropping pattern of monsoon paddy followed by fallowed land used 78.2 kilogram of seed, 123.3 kilogram of compound fertilizer and 2.2 liter of pesticide per hectare. Compound fertilizer cost was about 37,664 Kyats per hectareand pesticide cost was about 11,856 Kyats per hectare. The application rate of FYM is about 5.4 ton per hectare and the opportunity cost of FYM was about 2,9042 Kyats per hectare. The number of hired man labor was 32 man day and hired animal labor was 6 animal day per hectare. The price of hired man labor was about 1,171 Kyats per man day and that of hired animal labor was 3,500 Kyats per animal day (Appendix 2).

About 24% of total farm households practiced the cropping pattern of monsoon paddy followed by chickpea (Table 4.8). In this cropping pattern, the application rate of monsoon paddy seed was about 90.8 kilogram per hectare and that of chickpea was about 154.6 kilogram per hectare. The application rate and cost of compound fertilizer for monsoon paddy was about 123.5 kilogram per hectare and 44,011 Kyats per hectare and that of chickpea was about 66.2 kilogram per hectare and cost of compound fertilizer for chickpea was about 18,746 Kyats per hectare. The application rate of pesticide for monsoon paddy was about 2.1 liter per hectare and that of chickpea was about 1.9 liter per hectare. The application rate of FYM for monsoon paddy was about 4.5 ton per hectare and that of chickpea was about 4 ton per hectare. The number of hired man labor for monsoon paddy was 26 man day per hectare and the cost was about 33,298 Kyats per hectare. Hired animal labor dayfor monsoon paddy was 5 animal day per hectare and the cost was about 17,125 Kyats per hectare. The number of hired man labor for chickpea was 22 man day per hectare and the cost was about 29,079 Kyats per hectare. Hired animal labor day for chickpea was 5 animal day per hectare and the cost was about 14,820 Kyats per hectare (Appendix 3).

Only 4% of total farm households practiced the cropping pattern of monsoon paddy followed by green gram (Table 4.8). These farm households used 129.7 ton of monsoon paddy seeds and 161.4 ton of green gram seeds per hectare. The costs were 23,465 Kyats per hectare for monsoon paddy seeds and 22,230 Kyats per hectare for green gram. The application rate of compound fertilizer was about 237.7 kilogram per hectare for monsoon paddy and 123.5 kilogram per hectare for green gram. The cost of compound fertilizer was about 85,462 Kyats per hectare for monsoon paddy and about 44,460 Kyats per hectare for green gram. The hired man labor was 44 man day per hectare for monsoon paddy and 32 man day per hectare for green gram. The hired man labor cost was about 63,580 Kyats per hectare for monsoon paddy and 33,345 Kyats per hectare for green gram. The hired animal labor was 10 animal day for monsoon paddy and the cost was about 31,616 Kyats per hectare (Appendix 4).

4.3.3 Inputs used by sampled farm households in upland

About 2.1% of total farm households cultivated sesame followed by fallow land. The application rate of seed was about 154.6 kilogram per hectare and the cost was about 12,350 Kyats per hectare. The application rate of compound fertilizer was about 123.5 kilogram per hectare and the cost was about 51,870 Kyats per hectare. The application rate of FYM was about 4.3 ton per hectare and the cost was about 25,935 Kyats per hectare. The hired man labor was 33 man day per hectare and the cost was about 37,544 Kyats per hectare (Appendix 5).

The majority of total farm households (about 49%) practiced the intercropping of sesame and pigeon pea followed by green gram or groundnut (Table 4.9). The application rate of sesame seed was about 171.3 kilogram per hectare and that of pigeon pea was about 160.3 kilogram per hectare. The application rate of green gram seed was about 254.6 kilogram per hectare and that of groundnut was about 50.1 kilogram per hectare. The application rate of compound fertilizer for the intercropping of sesame and pigeon pea was 97 kilogram per hectare and the cost was about 25,693 Kyats per hectare. Moreover, the application rate of pesticide was about 2.9 liter per hectare and the cost was about 13,278 Kyats per hectare. The hired man labor was 33 man day per hectare and the cost was about 37,207 Kyats per hectare. The hired animal labor was 5 animal day per hectare and the cost was about 19,529 Kyats per hectare. The application rate of FYM was about 4.7 ton per hectare and its opportunity cost was about 23,312 Kyats per hectare. The application rate of compound fertilizer was about 101.3 kilogram per hectare for green gram and 122.3 kilogram per hectare for groundnut. The application rate of pesticide and cost was about 2.3 liter and 11,347 Kyats per hectare for green gram and 4.3 liter and 19,423 Kyats per hectare for groundnut (Appendix 6).

About 8.3% of total farm households practiced the intercropping pattern of sesame and pigeon pea followed by chillies and tomato (Table 4.9). The application rates of chillies seeds and tomato seeds were 4.3 kilogram per hectare and 16.1 kilogram per hectare, respectively. The application rate and cost of compound fertilizer was about 89.5 kilogram and 19,050 Kyats per hectare for chillies cultivation and that for tomato was 46.3 kilogram and 11,733 Kyats per hectare, respectively. The application rate of pesticide for chillies was 2.2 liter per hectare and the cost was about 15,360 Kyats per hectare. The application rate of pesticide for tomato was about

1.9 liter per hectare and the cost was about 11,115 Kyats per hectare. The application rate of FYM was about 3.6 ton per hectare for chillies and about 1.9 ton per hectare for tomato. The hired man labor was 21 man day per hectare for chillies cultivation and 11 man day per hectare for tomato cultivation (Appendix 7).

About 6.2% of total farm households practiced the intercropping of sesame and pigeon pea followed by groundnut and sunflower (Table 4.9). The application rate of sunflower seed was about 113.4 kilogram per hectare and the cost was about 7,822 Kyats per hectare. The application rate of compound fertilizer was about 61.8 kilogram per hectare and the cost was about 16,302 Kyats per hectare. The application rate of pesticide was about 1.5 liter per hectare and the cost was about 10,198 Kyats per hectare. The application rate of FYM was about 3.3 ton per hectare and the cost was about 16,467 Kyats per hectare. The hired man labor was 39 man day per hectare and the hired animal labor was 4 animal day per hectare (Appendix 8).

About 22.9% of total farm households practiced the intercropping of sesame and pigeon pea followed by cotton and chillies or onion (Table 4.9). The application rate of cotton seed was 12.6 kilogram per hectare and that of onion was about 5.9 kilogram per hectare, respectively. The application rate of compound fertilizer for cotton was about 177.2 kilogram per hectare and the cost was about 18,797 Kyats per hectare. The application rate of compound fertilizer for onion was about 121.4 kilogram per hectare and the cost was about 40,673 Kyats per hectare. The application rate of pesticide for cotton and onion was about 2.5 liter per hectare, respectively. The hired man labor for cotton was 29 man day per hectare while that for onion was 43 man day per hectare. The hired animal labor was 5 animal day per hectare for cotton and 7 animal day per hectare for onion (Appendix 9).

About 4.2% of total farm households practiced the cropping pattern of pigeon pea followed by green gram (Table 4.9). The application rate of pigeon pea seed was about 132.6 kilogram per hectare and that of green gram seed was about 254.6 kilogram per hectare. The application rate of compound fertilizer for pigeon pea was about 27.8 kilogram per hectare and the cost was about 8,954 Kyats per hectare. The application rate of compound fertilizer for green gram was about 101.3 kilogram per hectare and the cost was about 14,678 Kyats per hectare. The application rate of FYM was about 4.9 ton per hectare for pigeon pea and 2.9 ton per hectare for green gram. The hired man labor was 23 man day per hectare for pigeon pea and 31 man day per hectare for green gram, respectively. The hired animal labor was 3 animal day per hectare and the cost was about 13,585 Kyats per hectare for green gram (Appendix 10).

About 7.3% of total farm households practiced the intercropping of sesame and pigeon pea followed by onion (Table 4.9). The application rate of onion seed was about 5.9 kilogram per hectare and the rate of compound fertilizer was about 121.4 kilogram per hectare. The application rate of pesticide was about 2.5 liter per hectare and the cost was about 6,176 Kyats per hectare. The hired man labor was 43 man day per hectare and the cost was about 56,810 Kyats per hectare. The hired animal day was 7 animal day per hectare and the cost was about 3,705 Kyats per hectare (Appendix 11).

Table 4.10 Sources of credit for sampled farm households

(Number and percentage of households)

Sources of Credit	**Small farm households(n=33)**	**Medium farm households (n=36)**	**Large farm households(n =27)**	**Totalfarm households (n=96)**
MADB/MAS	16 (48.5%)	18 (50.0%)	14 (51.9%)	48 (50.0%)
Amount (Kyats/yr)	82188	82778	98214	87083
NGO/WFP	1 (3.0%)	0 (0.0%)	0 (0.0%)	1 (1.0%)
Amount (Kyats/yr)	50000	0	0	50000
Money Lender	3 (9.1%)	1 (2.8%)	4 (14.8%)	8 (8.3%)
Amount (Kyats/yr)	60000	50000	325000	191250
Own Capital	10 (30.3%)	9 (25.0%)	3 (11.1%)	22 (22.9%)
MADB/Money Lender	2 (6.1%)	5 (13.9%)	4 (14.8%)	11 (11.5%)
Amount (Kyats/yr)	105000	296000	163750	213180
Relatives	1 (3.0%)	3 (8.3%)	2 (7.4%)	6 (6.2%)
Amount (Kyats/yr)	50000	566670	52500	309170
Total	33(100%)	36(100%)	27(100%)	96(100%)

Source: Field survey (2011)

Table 4.11 Income composition of sampled farm households

Income sources	Small farm households (n=33)	Medium farm households (n=36)	Large farm households (n=27)	Total farm households (n=96)
Crop income composition (%)	50.62%	68.98%	74.09%	64.11%
F-test	F=5.697,P=0.005**			
Livestock income composition (%)	11.49%	7.11%	11.35%	9.81%
F-test	F=0.777,P=0.463^{ns}			
Farm labor income composition (%)	7.08%	7.55%	0.99%	5.54%
F-test	F=4.576,P=0.013**			
Causal income composition (%)	9.14%	1.14%	0.68%	3.76%
F-test	F=3.607,P=0.031**			
Migration income composition (%)	13.58%	7.73%	7.47%	9.67%
F-test	F=0.879,P=0.419^{ns}			
Selling income composition (%)	8.09%	7.48%	5.42%	7.11%
F-test	F=0.243,P=0.785^{ns}			

Note: ** significant at 5% level

ns = not significant

CHAPTER V
SUSTAINABLE CROPPING SYSTEM

5.1.Ecological Sustainability

5.1.1.Cropping pattern

Table 5.1 shows crop diversification and crop intensification indices of sampled farm households in low land. The F-test shows that crop diversification index and crop intensification index in low land were not significantly different among different farm households. But crop diversification index of large farm households (128.42%) was higher than other farm households. Moreover, small farm householdstook the highest crop intensification index of 136.36% among different farm households.

In Table 5.2, crop diversification and intensification indices of sampled farm households in upland were described. Large farm households took the highest crop diversification index of 363.25% while small and medium farm households took 234.33% and 270.49% of crop diversification index, respectively. Moreover, crop intensification index for small farm households was 120.74% while crop intensification indices for medium and large farm households were 115.02% and 88.61% respectively. The F-test shows that crop diversification and crop intensification indices were highly significantly different among different farm households.

5.1.2. Soil fertility management

Table 5.3 shows utilization of organic and inorganic fertilizers by sampled farm households. Among three groups, about 22.2% of large farm households used only organic fertilizers while 12.1% of small and 11.1% of medium farm households were using only organic fertilizers. Moreover, about 57.6% of small, 75% of medium and 66.7% of large farm households used both organic and inorganic fertilizers. But there was no large farm households who did not use fertilizers.

Table 5.4 shows utilization of both organic and inorganic fertilizers in low land and upland. While 40% of medium and large farm households were using both organic and inorganic fertilizers in low land, only 20% of small farm households used both fertilizers. About 32.5% of small, 39% of medium and 28.6% of large farm households used both organic and inorganic fertilizers in upland.

Table 5.1 Crop diversification and crop intensification of sampled farm households in low land

Cropping strategy in low land	Type of households			Total farm households (N=50)
	Small farm households (n=11)	Medium farm households (n=20)	Large farm households (n=19)	
Crop diversification index (%)	100%	100%	128.42%	110.80%
F-test	**F= 1.811, p= 0.175^{ns}, df= 2**			
Crop intensification index (%)	136.36%	125%	113.38%	123.08%
F-test	**F= 0.885, p= 0.42^{ns}, df= 2**			

Note: ns=not significant

Table 5.2 Crop diversification and crop intensification of sampled farm households in upland

Cropping strategy in upland	Type of households			Total farm households (N=96)
	Small farm households (n=33)	Medium farm households (n=36)	Large farm households (n=27)	
Crop diversification index (%)	234.33%	270.49%	363.25%	284.15%
F-test	**F= 14.48, p= 0.000***, df= 2**			
Crop intensification index (%)	120.74%	115.02%	88.61%	109.56%
F-test	**F= 5.63, p= 0.005**, df= 2**			

Note: ***,**significat at 1% and 5% level

Table 5.3 Utilization of organic and inorganic fertilizers by sampled farm households

(Number and percentage of farmers)

Type of households	Organic fertilizer only	Inorganic fertilizer only	Both fertilizers	Without fertilizers
Small farm households(n=33)	4 (12.1%)	7 (21.2%)	19 (57.6%)	3 (9.1%)
Medium farm households(n=36)	4 (11.1%)	3 (8.3%)	27 (75.0%)	2 (5.6%)
Large farm households(n=27)	6 (22.2%)	3 (11.1%)	18 (66.7%)	0 (0.0%)
Totalfarm households (n=96)	14 (14.6%)	13 (13.5%)	64 (66.7%)	5 (5.2%)

Table 5.4 Utilization of both organic and inorganic fertilizers in low land and upland

(Number and percentage of farmers)

Different farm size groups	Use both organic and inorganic fertilizers in low land	Use both organic and inorganic fertilizers in upland
Small farm households	9 (20%)	25 (32.5%)
Medium farm households	18 (40%)	30 (39%)
Large farm households	18 (40%)	22 (28.6%)
Total farm households	45 (100%)	77 (100%)

5.1.3. Pests and diseases management

Table 5.5 shows management of pests and diseases by sampled farm households in low land. According to this table, About 27.3% of small, 30% of medium and 26.3% of large farm households used chemical control method and 72.7% of small, 70% of medium and 73.7% of large farm households used manual control method for the management of pests and diseases in low land.

But in upland, 42.4% , 33.3% and 44.4% of small, medium and large farm households used chemical control method, respectively. About 57.6% of small, 66.7% of medium and 55.6% of large farm households used manual control method for the management of pests and diseases (Table 5.6).

Table 5.5 Management of pests and diseases by sampled farm households in low land

(Number and percentage of farmers)

Different farm size groups	Chemical Control Method	Manual Control Method
Small farm households (n=11)	3 (27.3%)	8 (72.7%)
Medium farm households (n=20)	6 (30%)	14 (70%)
Large farm households (n=19)	5 (26.3%)	14 (73.7%)
Total (n=50)	14 (28%)	36 (72%)

Table 5.6 Management of Pests and Diseases by sampled farm households in upland

(Number and percentage of farmers)

Different farm size groups	Chemical Control Method	Manual Control 1 Method
Small farm households (n=33)	14 (42.4%)	8 (57.6%)
Medium farm households (n=36)	12 (33.3%)	14 (66.7%)
Large farm households (n=27)	12(44.4%)	14 (55.6%)
Total (n=96)	38(39.6%)	36 (60.4%)

5.2.Economic Viability

5.2.1.Farm profitability

5.2.1.1.Gross margin analysis of low land cropping patterns

Gross marginal analysis is based on variable costs including costs of human labor, animal power, seed, fertilizers, pesticides and interest rate on operating capital. Break-even yield and break-even price were also calculated.

Gross margin per unit of land in low land cropping pattern was shown in Figure 5.1. The results showed that only medium farm householdstook benefit with the gross margin per unit of land of 65,608 Kyats per hectare by practicing the cropping pattern: monsoon paddy-fallow land. Small and large farm households did not keep benefit because yields of monsoon paddy were 825.5 kg/ha and 974.3 kg/ha which were lower than that of medium farm households. Moreover, price of monsoon paddy for small and large farm households was also lower than that of medium farm households. Small farm households can profit only if yield was more than 907.1 kg/ha and selling price of paddy was more than 209 Kyats per kilogram. Large farm households can profit only if yield was more than 1102.6 kg/ha and selling price was more than 206 Kyats per kilogram (Appendix 12).

Among different farm households who practiced the cropping pattern: monsoon paddy-chick pea, large farm householdsreceived the highest gross margin per unit of land of 251,289 Kyats per hectare. This is because monsoon paddy yield of large farm households was 2244.4 kg/ha and price was 217 Kyats/kg and the yield of chick pea was 470.2 kg/ha. Small and medium farm householdskept the gross margin per unit of land of 71,938 Kyats per hectare and 65,686 Kyats per hectare, respectively. The monsoon paddy yields for small and medium farm households were 1186.5 kg/ha and 1407.9 kg/ha and the yields of chick pea were 376.8 kg/ha and 357.1 kg/ha, respectively (Appendix 13).

Monsoon paddy-green gram cropping pattern was practiced by large farm households and the gross margin per unit of land was 163,951 Kyats per hectare (Appendix 14). Among three low land cropping patterns, the farm households who practiced the cropping pattern of monsoon paddy-chick pea kept the highest gross margin per unit of land.

The results showed that only medium farm households hadbenefit cost ratio of 1.29 by practicing the cropping pattern of monsoon paddy-fallow land (Figure 5.2). Small and large farm householdshad higher total variable costs of production which were about 172,340 Kyats per hectare and 200,670 Kyats per hectare respectively so that cost were higher than their value of production(Appendix 12).

Among different farm size groups who practiced the cropping pattern of monsoon paddy-chick pea, large farm householdsattained the highest benefit cost ratio of 1.59 while small and medium farm householdshad the benefit cost ratio of 1.19 and 1.17, respectively (Appendix 13). This is because although total variable cost of production for monsoon paddy of large farm households was about 271,535 Kyats per hectare, value of production was higher than other two farm households because of high yield. Only two large farm households practiced the cropping pattern ofmonsoon paddy-green gram. But they can benefit the high benefit cost ratio of 1.37 (Appendix 14).

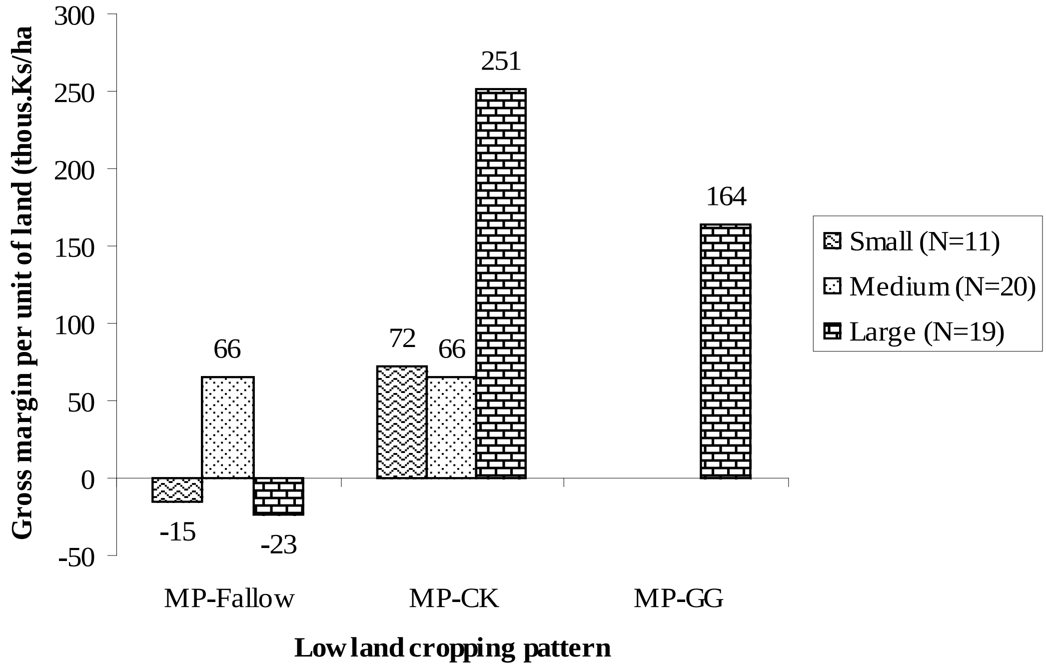

Figure 5.1 Grossmarginper unit of land in low land cropping pattern among different farm size groups

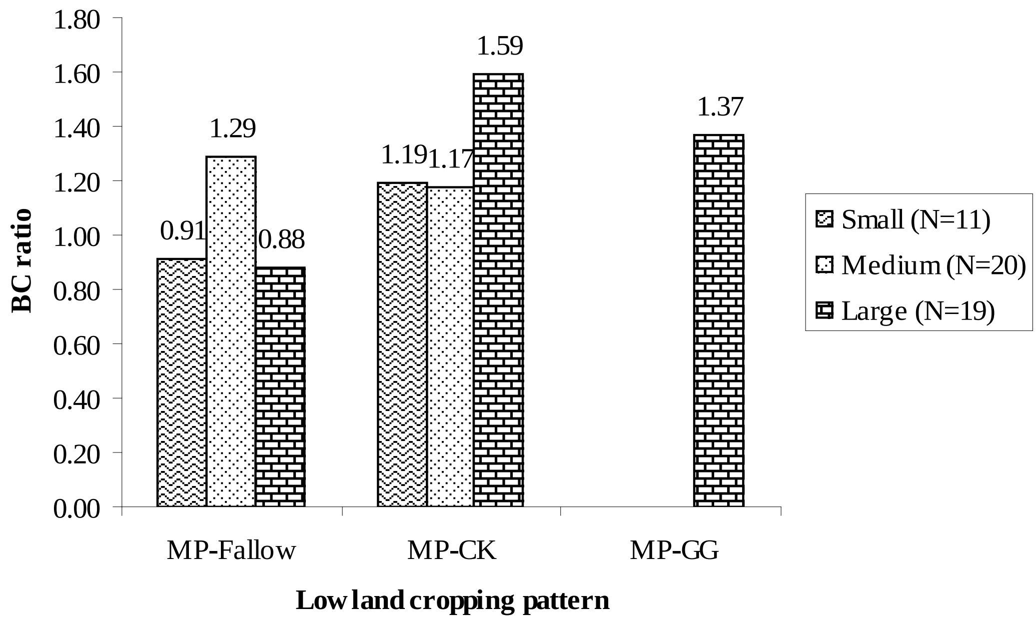

Figure 5.2 Benefit cost ratio of low land cropping pattern among different farm size groups

5.2.1.2. Gross margin analysis of upland cropping patterns

Figure 5.3 showed gross margin per unit of land of upland cropping pattern among different farm size groups. The intercropping of sesame and pigeon pea followed by green gram or groundnut was practiced by most of farm households receiving the higher profit. Only medium farm households practiced the cropping pattern of sesame-fallow. And they took the gross margin per unit of land of 11,800 Kyats per hectare (Appendix 15).

Among different farm households who practiced the intercropping of sesame and pigeon pea followed by green gram and groundnut, large farm householdsreceived the highest gross margin per unit of land of 562,173 Kyats per hectare (Appendix 16). And the gross margin per unit of land of small farm householdswas 406,674 Kyats per hectare which was higher than that of 179,571 Kyats per hectare of medium farm households. Mean yield of sesame for small, medium and large farm households were 313 kilogram per hectare, 306 kilogram per hectare and 376.3 kilogram per hectare, respectively. Small farm householdsrecieved mean yield of 533.9 kilogram per hectare for pigeon pea, 387.5 kilogram per hectare for green gram and 604.6 kilogram per hectare for groundnut. Mean yield of medium farm households were 350.9 kilogram per hectare for pigeon pea, 366.1 kilogram per hectare for green gram, 498.2 kilogram per hectare for groundnut. Large farm householdsreceivedthe highest mean yield of 627.3 kilogram per hectare for pigeon pea, 672.7 kilogram per hectare for green gram and 631.2 kilogram per hectare for groundnut, respectively.

The results showed that large farm householdsreceived the highest gross margin per unit of 560,079 Kyats per hectare by practicing the intercropping of sesame and pigeon pea followed by chilliesand tomato (Appendix 17). Small and medium farm householdsreceived about 229,717 Kyats per hectare and 382,580 Kyats per hectare, respectively.

Medium farm households who practiced the intercropping of sesame and pigeon pea followed by groundnut or sunflower and the intercropping of sesame and pigeon pea followed by cotton and chillies or onion recieved the highest gross margin per unit of land of 253,313 Kyats per hectare and 1,159,789 Kyats per hectare (Appendix 18 and 19). And small farm householdsreceived the lowest gross margin per unit of land 144,983 Kyats per hectare and 749,063 Kyats per hectare in both cropping patterns. This is because mean yield for sesame, pigeon pea, groundnut, sunflower, cotton, chillies and onion were lowest among three groups. Moreover, gross margin per unit of land of large farm households were also lower than that of medium farm households. This is because large farm households did not grow groundnut and onion although they practiced the same cropping pattern.

Small farm householdstook the highest gross margin per unit of land of 289,410 Kyats per hectare by growing pigeon pea followed by green gram (Appendix 20). Medium and large farm householdstook about 147,820 Kyats per hectare and 166,896 Kyats per hectare, respectively although the yield of pigeon pea was higher than that of small farm householdsbecause they grew only pigeon pea.

Only small farm households practiced the intercropping of sesame and pigeon pea followed by onion. And they received gross margin per unit of land of 569,416 Kyats per hectare which was the second highest among different cropping patterns for them (Appendix 21).

Figure 5.4 showed the benefit cost ratio of upland cropping pattern among different farm size groups. Among seven cropping patterns, farm households who practiced the intercropping of sesame and pigeon pea followed by cotton, chillies or onion took the highest benefit cost ratio. Medium farm households who practiced this cropping pattern got the highest benefit cost ratio of 2.4. They took gross margin per unit of land of 144,715 Kyats per hectare for sesame, 214,467 Kyats per hectare for pigeon pea, 266,524 Kyats per hectare for chillies and 548,874 Kyats per hectare for onion (Appendix 19). But they did not benefit from cotton cultivation. They can benefit only if the yield of cotton was higher than 246.45 kilogram per hectare and the selling price was higher than 609 Kyats per kilogram. Although large farm householdstook high yield for pigeon pea, cotton and chillies, they took lower benefit cost ratio of 2.25 than medium farm households since they did not grow onion.

Among different cropping patterns small farm householdstook the highest benefit cost ratio of 2.2 by growing pigeon pea followed by green gram. This is because value of production of pigeon pea was 243,210 Kyats per hectare and that of green gram was 290,610 Kyats per hectare which can cover total variable cost of production (Appendix 20).

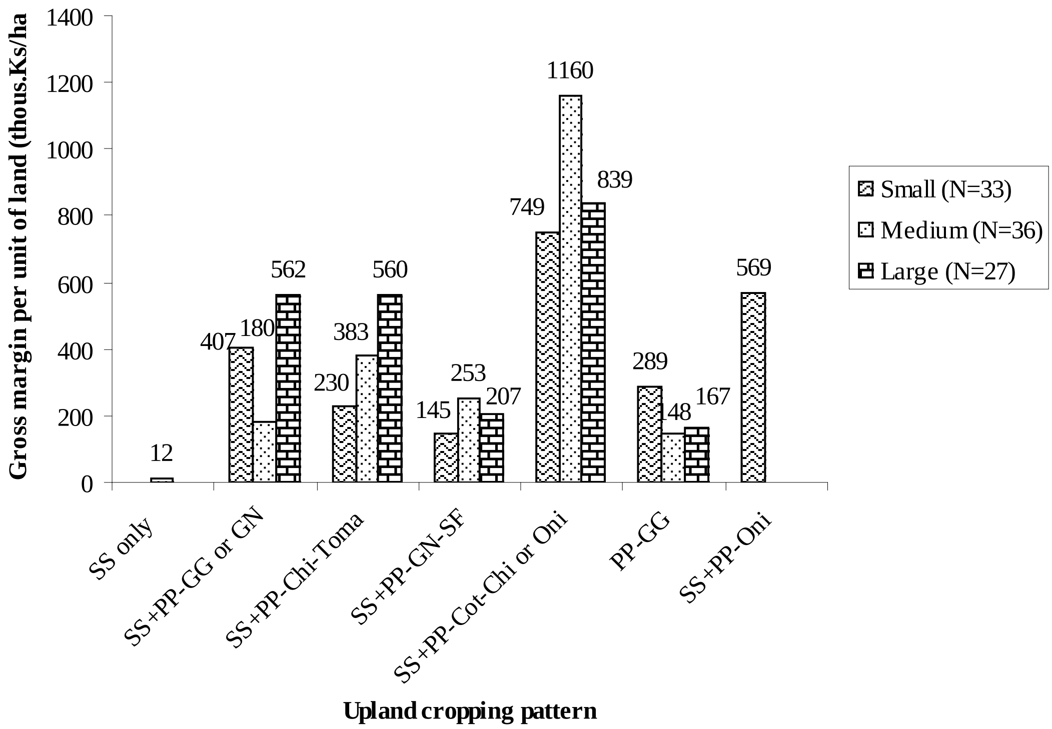

Figure 5.3 Gross margin per unit of land in upland cropping pattern among different farm size groups

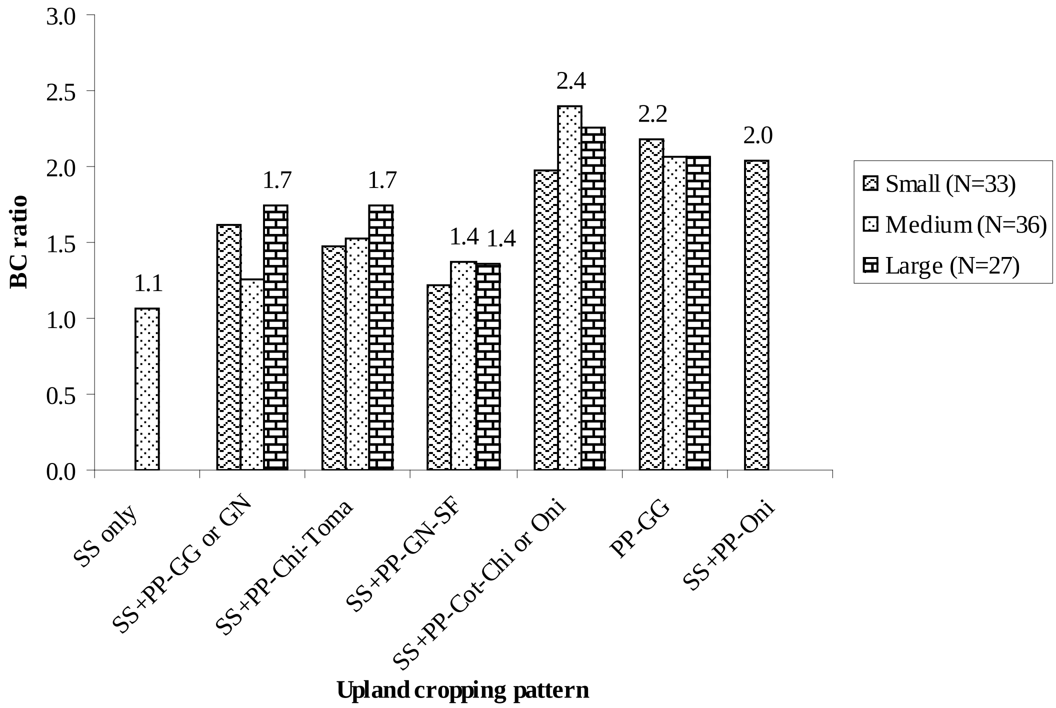

Figure 5.4 Benefit cost ratio of upland cropping pattern among different farm size groups

5.3.Social Acceptability

5.3.1. Input self-sufficiency

Input self-sufficiency was calculated based on the ratio of local input cost to total input cost. If the farm households highly depended on the external inputs, the input self-sufficiency ratio will be high. And the profitability of their farm will also decrease due to the cost of external inputs such fertilizers and pesticides. Small farm households had more tendencies to depend on local inputs such as labor, drought power, seed and farm yard manure (Table 5.7).

The results showed that small, medium and large farm households who practiced the intercropping of sesame and pigeon pea followed by chillies and tomato had higher input self-sufficiency ratio than other cropping patterns.In low land, small farm households who practiced monsoon paddy followed by fallow land possessed the highest input self-sufficiency ratio.

Table5.7 Input self-sufficiency of sampled farm households

Cropping patterns	**Input self-sufficiencyindex of farm households**		
	Small farm households(n=33)	**Medium farm households(n=36)**	**Large farm households (n =27)**
MP-fallow	0.57	0.45	0.47
MP-CK	0.48	0.44	0.48
MP-GG	-	-	0.59
SS only	-	0.50	-
SS+PP-GG or GN	0.48	0.47	0.54
SS+PP-Chi-Tomato	0.61	0.62	0.61
SS+PP-GN-SF	0.40	0.35	0.55
SS+PP-Cot-Chi or Onion	0.55	0.52	0.49
PP-GG	0.55	0.52	0.67
SS+PP-Oni	0.53	-	-

5.3.2.Food security

Food is a basic daily need for growth and sustenance of life and access to food is deemed as a basic human right.

Household food security was calculated based on annual income of farm households with food poverty line (274,990 Kyats/yr) (UNDP, 2010). The farm households whose annual income less than 274,990 Kyats were denoted as food insecure households. In the study area, about 75.8% of small, 61.1% of medium and 37% of large farm households were food insecure (Table 5.8). On average, 59.4% of the farm households were food insecure. Among the sampled farm households, 63% of large, 24.2% of small, and 38.9% of medium farm households were food secure.

Food sufficiency was also calculated based on percentage of food from own production and market and food insufficient months (Table 5.9 and 5.10). The F-test showed that percentage food from own production was significantly different at 10% level among three groups. While small farm households received 14.38% of food from own production, medium farm households received 19.86% and large farm households received 23.77% of food from own production. The F-test also showed that percentage food from market was also significantly different among three groups.

Table 5.8 Food security of farm households based on food poverty line

(Number and percentage of farmers)

Type of households	Food secure households	Food insecure households
Small farm households	8(24.2%)	25(75.8%)
Medium farm households	14(38.9%)	22(61.1%)
Large farm households	17(63.0%)	10(37.0%)
Total farm households	39(40.6%)	57(59.4%)

Note: H/Hs annual income > 274,990 Kyats/yr= food secure households

H/Hs annual income < 274,990 Kyats/yr= food insecure households

Table 5.9Sources of food for the sampled farm households

Type of households	Food from own production (%)	Food from market (%)
Small farm households (N=33)	14.3%	85.7%
Medium farm households (N=36)	21.8%	78.2%
Large farm households (N=27)	24.7%	75.3%
F-test	F=2.943, p=0.058*, df=2	F=3.563, p=0.032**, df=2

Note: **, * significant at 5% and 10% level

5.4.Level of Sustainability

5.4.1. Assessment of level of sustainability in low landand upland

About 27% of small, 50% of medium and 32% of large farm households suffered soil problem such as erosion, water logging and low soil fertility and saline soil in their low land (Table 5.10). Only 36% of small, 25% of medium and 26% of large farm households grew legume in low land. About 95% of large farm households used farm yard manure while less percentage of small and medium farm households applied farm yard manure. It was noted that less percentage of farm households (average 24.3% of total sampled households) applied pesticides in low land.

Table 5.11 showed percent of farm households who used both organic and inorganic fertilizers, practiced intercropping, grew windbreak trees, pesticide utilization and their soil fertility in upland. About 76% of small, 83% of medium and 82% of large farm households used both organic and inorganic fertilizers in upland. Nearly all sampled farmers (about 80.3%) used both organic and inorganic fertilizers and 38.6% of total farm households used pesticides. Moreover, about 15% of small farm households owed poor soil while 14% of medium and only 4% of large farm households owned poor soil.

Level of sustainability was analysed based on sustainability score. Sustainability score in low land was calculated based on farmers who suffered soil problem or not, who grew legume or not and who used manure and pesticides or not.

The highest sustainability score in low land was four and the score less than three was denoted as low level of sustainability and the score greater than or equal three was denoted as high level of sustainability (Table 5.12).

The farm households who did not suffer soil problem, grew legume, used manure and did not use pesticide got the highest score of four and they were in high level of sustainability. The farm households who suffered soil problem, did not grow legume but used manure and did not use pesticide got the score of 2 and they were in low level of sustainability.

According to Table 5.12, the results showed that about 72.7% of small, 70% of medium and 73.7% of large farm households were at low level of sustainability. Only 27.3% of small, 30% of medium and 26.3% of large farm households were at high level of sustainability.

Sustainability score in upland was calculated based on farmers who used both organic and inorganic fertilizers or not, who practiced intercropping or not, who grew windbreak trees or not, who used pesticides or not and the soil fertility. The highest sustainability score in upland was six and the score less than or equal four was denoted as low level of sustainability and the score greater than four was denoted as high level of sustainability(Table 5.13).

The farm households who used both organic and inorganic fertilizers, practiced intercropping, grew windbreak trees, did not use pesticide and owned good soil fertility got the highest score of six and they were at high level of sustainability. The farm households who did not use both organic and inorganic fertilizers, but practiced intercropping, did not grow windbreak trees, did not use pesticide and owned medium soil fertility got the score of 3 and they were at low level of sustainability in upland(Table 5.13).

Table 5.12 also showed that about 78.8% of small farm households were at low level of sustainability while 75% of medium and 66.7% of large farm households were at low level of sustainability. Only 21.2% of small, 25% of small and 33.3% of large farm households were at high level of sustainability.

Table 5.10Soil condition and farm practices affecting sustainability score of the low land cropping system

Practices affecting sustainability	Type of farm households			
	Small farm households (n=11)	Medium farm households (n=20)	Large households (n=19)	Average farm households (n=17)
Soil problem (erosion, saline, water logging)	27%	50%	32%	36.33%
Legume growing	36%	25%	26%	29%
Manure utilization	82%	85%	95%	27.33%
Pesticide utilization	27%	25%	21%	24.33%

Table 5.11 Soil fertility condition and farm practices affecting sustainability score of the upland cropping system

Practices affecting sustainability	Type of farm households			
	Small farm households (n=33)	Medium farm households (n=36)	Large farm households (n=27)	Average farm households (n=32)
Used both organic and inorganic fertilizer	76%	83%	82%	80.33%
Practicing intercropping	97%	92%	100%	96.33%
Growing windbreak trees	39%	44%	41%	41.33%
Pesticide utilization	27%	33%	56%	38.67%
Poor soil	15%	14%	4%	11%
Medium soil	61%	67%	67%	65%
Good soil	24%	19%	30%	24.33%

Table 5.12 Level of sustainability in low land among different farm households

(Number and percentage of farm households)

Level of sustainability in low land	Type of farm households			Totalfarm households (N=50)
	Small farm households (n=11)	Medium farm households (n=20)	Large farm households (n=19)	
Low level of sustainability (score 0 to 2)	8(72.7%)	14(70.0%)	14(73.7%)	36(72.0%)
High level of sustainability (score 3 to 4)	3(27.3%)	6(30.0%)	5(26.3%)	14(28.0%)

Note: Score 0-2 = low level of sustainability
Score 3-4 = high level of sustainability

Table 5.13 Level of sustainability in upland among different farm households

(Number and percentage of farm households)

Level of sustainability in upland	Type of farm households			Totalfarm households (N=96)
	Small farm households (n=33)	Medium farm households (n=36)	Large farm households (n=27)	
Low level of sustainability (score 0 to 4)	26 (78.8%)	27 (75%)	18 (66.7%)	71 (74%)
High level of sustainability (score 5 to 6)	7 (21.2%)	9 (25%)	9 (33.3%)	25 (26%)

Note: Score 0-4 = low level of sustainability
Score 5-6 = high level of sustainability

5.4.2. Relationship between cropping strategy and level of sustainability

Table 5.14 showed the relationship between cropping strategy and level of sustainability in low land. The F-test showed that crop diversification index and crop intensification index were significantly different in level of sustainability at 5% and 1% level, respectively. Therefore, it can be concluded that the farm households who diversified more crops got high level of sustainability in low land. And the farm households who intensified only one crop got low level of sustainability.

According to Table 5.15, the F-test shows that crop diversification and crop intensification indices were significantly different in level of sustainability at 5% level, respectively. Low sustainable farm households occupied 267.77% of crop diversification index while high sustainable farm households occupied 331% of crop diversification index. Moreover, the farm households with 102.08% of crop intensification index were in low level of sustainability and farm households with 130.75% of crop intensification index were in high level of sustainability.

Table 5.14Crop diversification and intensification by different levels of sustainability in low land

Cropping strategy in low land	Sampled farm households		Average level of sustainability (N=50)
	Low level of sustainability (N=36)	High level of sustainability (N=14)	
Crop diversification (%)	100.56%	137%	110.80%
F-test	**F=5.42, p= 0.02**, df= 1**		
Crop intensification (%)	102.43%	176.19%	123.08%
F-test	**F= 52.658, p= 0.000***, df= 1**		

Note: ***,** significant at 1% and 5% level

Table 5.15Crop diversification and intensification by different level of sustainability in upland

Cropping strategy in upland	Sampled farm households		Average level of sustainability (N=96)
	Low level of sustainability (N=71)	High level of sustainability (N=25)	
Crop diversification (%)	267.77%	331%	284.15%
F-test	**F=6.8, p= 0.01**, df= 1**		
Crop intensification (%)	102.08%	130.75%	109.56%
F-test	**F= 10.03, p= 0.002**, df= 1**		

Note: ** significant at 5% level

5.4.3. Relationship between households income and level of sustainability

Farm households were also classified into low and high income groups according to their annual income based on food poverty line (274,990 Kyats per year) (UNDP, 2010). Farm households whose annual income more than 274,990 Kyats per year were denoted as high income group and farm households with annual income less than 274,990 Kyats per year were denoted as low income group.

Table 5.15 showed the relationship between household income and level of sustainability. About 70.15% of low income farm households were in low level of sustainability while only 27.59% of high income farm households were in low level of sustainability. Moreover, while 29.85% of low income group were in high level of sustainability, 72.41% of high income group were in high level of sustainability. Therefore, it can be concluded that high income farm households used more farmyard manure, more practiced intercropping, grew windbreak trees and diversified more crops than low income farm households to be in high level of sustainability.

Table 5.16 Level of sustainability in low and high income groups

(Number and percentage of farmers)

Level of sustainability	Income group	
	Low income farm households	High income farm households
Low level of sustainability	47(70.15%)	8(27.59%)
High level of sustainability	20(29.85%)	21(72.41%)
Total	67(100%)	29(100%)

5.5.EstimatedResults from the Ordinary Least Square Regression Model for Low land and Upland

5.5.1 Factors influencing sustainability score of the cropping system in low land

Table 5.16 showed the results of sustainability score of cropping system in low land. Sustainability score of cropping system in low land was estimated by using 13 variables; household head's age, household head's schooling years, head's experience, dependency ratio, low landsize, per capita income of migration, per capita income of livestock, livestock quantity, amount of FYM, crop intensificationindex, crop diversification index and rice insufficient months. Dummy variable of growing legume in low land (growing legume=1, not growing=0) was also included.

Household head's schooling year played one of the major roles in determining low land sustainability score. Generally, farm households with high schooling year can make suitable decisions in their farm activities which will lead to sustainability score of cropping system.

Household head's schooling year was positively and significantly influenced on sustainability score of cropping system. If household head's schooling year increases by 1%, sustainability score of cropping system will be increased by 0.122. Dependency ratio was negatively and significantly influence on sustainability score of cropping system. If dependency ratio increases by 1%, sustainability score of cropping system will be decreased by 0.013.

There were on-farm and off-farm employment opportunities within and outside the village. Outside the village, the laborers could also find jobs in road construction, other townships, and some went abroad to Malaysia. In the study area, since weather condition was erratic and irregular, the benefit from crops production was also unsure. Therefore, the farm households also reared livestock for their additional income. One percentincreased in per capita income of livestock may contribute to increase sustainability score of cropping system by 0.003. In addition, 1% increased in low landsize and crop intensification index may improve sustainability score of cropping system by 0.25 and 0.005, respectively. Growing legume in low land was also significant at 5% level.

Among the variables, household head's schooling year and dependency ratio more influenced on the sustainability score of cropping system in low land. The F-value showed that the selected model was significant at 1% level. The adjusted R square pointed out that the model was significant and it can explain the variation in sustainability score of the cropping system in low landby 90.2 % (Appendix 5.11).

Table 5.17Factors influencing sustainability score of cropping system in low land

Variables	Unstandardized coefficients		Standardized coefficients	t-value	Sig.
	B	Standard error	ß		
(Constant)	1.183	0.669		1.77	0.085*
HH head's age (year)	-0.007	0.004	-0.082	-1.592	0.12^{ns}
HH head's schooling year	0.122	0.043	0.288	2.86	0.007**
HH head's farm experience (year)	0.012	0.015	0.145	0.802	0.428ns
Dependencyratio (%)	-0.013	0.005	-0.288	-2.774	0.009**
Low land size(ha)	0.25	0.09	0.172	2.775	0.009**
Per capita incomeof Migration (Kyats/yr)	0.002	0.002	0.071	1.033	0.308^{ns}
Per capita income of Livestock (Kyats/yr)	0.003	0.002	0.111	1.939	0.06*
No. of livestock	0.004	0.007	0.052	0.504	0.617^{ns}
Used FYM (ton/ha)	0.006	0.02	0.02	0.292	0.772^{ns}
Crop intensification index (%)	0.005	0.002	0.21	2.837	0.007**
Crop diversification index (%)	0.001	0.001	0.056	0.895	0.377^{ns}
Rice insufficient months (month)	-0.033	0.023	-0.085	-1.419	0.164^{ns}
Growing legume (0=not growing, 1 = growing)	0.448	0.14	0.199	3.197	0.003**

R^2=92.8%

Adjusted R^2=90.2%

$F_{13,36}$=35.671,

Sig=0.000***

Dependent variable: Low land sustainability score

***,**, * significant at 1%,5% and 10% level, respectively, ns= not significant

5.5.2 Factors influencing sustainability score of the cropping system in upland

Table 5.17 showed the results of sustainability score of cropping system in upland. Sustainability score of cropping system in upland was estimated by using 13 variables; household head's age, household head's schooling years, head's experience, dependency ratio, upland land size, per capita income of migration, per capita income of livestock, livestock quantity, amount of FYM, crop intensification index, crop diversification index, legume growing area and intercropping area.

Household head's farm experience positively and significantly influence on the sustainability score of the cropping system in upland meaning that more experience farm households may improve the sustainability score. If household head's farm experience increases by 1%, the sustainability score will be increased by 0.063. The sustainability score was also negatively and significantly influenced by dependency ratio. If dependency ratio increases by 1%, the sustainability score will be decreased by 0.041.

Growing legume and crop diversification were the practices leading to the sustainable cropping system. Legume growing area and crop diversification were also positively and significantly influenced on the sustainability score of the cropping system in upland. If legume growing area and crop diversification index increase 1%, the sustainability score will be increased by 0.098 and 0.003, respectively. The owned livestock quantity and crop intensification index were also significant at 10% level. But household head's age, head's schooling year, upland land size, per capita income of migration, per capita income of livestock, amount of FYM and intercropping area were not significant.

Among the variables, household head's farm experience and dependency ratio more influenced on the sustainability score of cropping system in upland. The F-value showed that the selected model was significant at 1% level. The adjusted R square pointed out that the model was significant and it can explain the variation in sustainability score of the cropping system in upland by 70.4 % (Appendix 5.12).

Table 5.18 Factors influencing sustainability scoreof cropping system in upland

Variables	Unstandardized coefficients		Standardized coefficients	t-value	Sig.
	B	Standard error	ß		
(Constant)	1.907	0.569		3.353	0.001***
HH head's age (year)	-0.004	0.006	-0.047	-0.743	0.46^{ns}
HH head's schooling year	0.016	0.03	0.035	0.546	0.587^{ns}
HH head's farm experience (year)	0.063	0.036	0.759	1.75	0.084*
Dependency ratio (%)	-0.041	0.013	-0.831	-3.152	0.002**
Upland land size (ha)	0.072	0.072	0.119	1.009	0.316^{ns}
Per capita income of Migration (Kyats/yr)	0.000	0.002	0.004	0.069	0.945^{ns}
Per capita income of Livestock (Kyats/yr)	0.001	0.001	0.057	0.976	0.332^{ns}
No. of livestock	0.014	0.008	0.144	1.902	0.061*
Used FYM (ton/ha)	0.046	0.036	0.348	1.27	0.208^{ns}
Crop intensification index (%)	0.004	0.002	0.131	1.644	0.104*
Crop diversification index (%)	0.003	0.001	0.237	2.87	0.005**
Legume growing area (ha)	0.098	0.054	0.117	1.827	0.071*
Intercropping area (ha)	0.133	0.088	0.144	1.515	0.134^{ns}

R^2=74.4%

Adjusted R^2=70.4%

$F_{13,82}$=18.34,

Sig=0.000***

Dependent variable: Upland sustainability score

***,**, * significant at 1%,5% and 10% level, respectively, ns= not significant

CHAPTER VI
CONCLUSION AND POLICY IMPLICATION

6.1 Conclusion of the Study

In this study, socio-economic characteristics of the rain-fed cultivating households in Natmouk Township were firstly described. In addition, to be economically viable, ecologically sound and socially acceptable, the indicators; cropping intensity, crop diversification, soil fertility management, pest and disease management, land productivity, farm profitability, income diversification, productive assets, input self-sufficiency and household food security which can represent these three topics were calculated.

In the study area, about 36.4% of small, 55.6% of medium and 74.1% of large farm households owned low land (Le land) and all sampled farm households owned upland (Yar land). Small farm households were younger, lesser experience and higher family labor than other farm households. Large farm households owned more number of cattle, sheep and poultry. But small farm households owned more number of goat and pig because goat rearing can earn quick return of income. Since mechanized farming was not practiced in the study area, about 81.8% of small, 86.1% of medium and 96.3% of large farm households owned plow and harrow. About 54.5% of small and 55.6% of medium farm households lived in the house of corrugated iron roof and bamboo wall while about 40.7% of large farm households were living in the wooden house with corrugated iron roof.

The farm households in the study area also engaged in the off-farm and non-farm activities to earn extra income. Small farm households earned 50.62% of income from crop production and 13.58% of income from migration income which stands for the second highest composition of income source for them. Medium farm households also earned 68.98% of income from crop production and 7.73% of income from migration income. Large farm households earned 74.09% of income from crop production and 11.35% of income from livestock rearing. The majority of sampled farm households (about 69.7% of small, 75% of medium and 88.9% of large farm households)took credits from MADB, MAS, money lender and their relatives.

About 63.6% of small farm households grew monsoon paddy and fallowed land in low landwhileabout 75% of medium and 73.7% of large farm households grew monsoon paddy and fallowed land.While 15.8% of large farm households were growing monsoon paddy followed by chickpea, about 36.4% of small and 25% of medium farm households also practiced this cropping pattern.

On the other hand, about 51.5% small, 44.4% of medium and 51.9% of large farm householdspracticed the intercropping of sesame and pigeon pea followed by green gram or groundnut. Only small farm households about 21.2% practiced the intercropping of sesame and pigeon pea followed by onion. In addition, about 12.1% of small, 25% of medium and 33.3% of large farm households practiced the intercropping of sesame and pigeon pea followed by cotton and chillies or onion.

About 50% of medium farm households suffered from soil problems while only 27% of small and 32% of large farm households suffered from soil problems in low land. Only 36% of small, 25% of medium and 26% of large farm households grew legume in low land. In addition 82% of small, 85% of medium and 95% of large farm households used manure. But about 73%, 75% and 79% of small, medium and large farm households did not use pesticides in low land.

Moreover, 76% of small, 83% of medium and 82% of large farm households used both organic and inorganic fertilizers in upland. Only 27% of small farm households used pesticide in upland while 33% of medium and 56% of large farm householdswere using pesticides. Almost all sampled farm households or about 97% of small, 92% of medium and 100% of large farm households practiced intercropping in upland.

According to the gross margin analysis, small and large farm households who practiced the cropping pattern of monsoon paddy followed by chick pea received the highest benefit cost ratio of (1.19) and (1.59), respectively. Medium farm households who practiced the cropping pattern of monsoon paddy and fallow land received the highest benefit cost ratio of (1.29) in low land.

In upland, medium and large farm households who practiced the cropping pattern of sesame and pigeon pea followed by cotton, chilies, and onion received the highest benefit cost ratio of (2.4) and (2.25), respectively. Small farm households who practiced the cropping pattern of pigeon pea followed by green gram received the highest benefit cost ratio of (2.2) in upland.

About 73%, 70% and 74% of small, medium and large farm households were at low level of sustainability in low land. And about 55%, 50% and 33% of small, medium and large farmers were at low level of sustainability in upland. About 70% of low income farmers were at low level of sustainability while only 30% of high income farmers were at low level of sustainability.

The majority of small farm households about 76% were food insecure while 61% of medium and 37% of large farmers were food insecure.Crop diversification and crop intensification were higher at the high level of sustainability in both low land and upland. Crop diversification index was 100.56% in low level of sustainability and 137% in high level of sustainability in low land while crop intensification indices were 102.43% and 176.19% in low and high level of sustainability in low land, respectively. But about 267.77% and 331% of crop diversification indices were found in low and high level of sustainability in upland. Crop intensification index was 102.08% in low level of sustainability and 130.75% in high level of sustainability in upland.

According to the regression results from the Ordinary Least Square Model, household head's schooling year, land holding size, crop intensification index and growing legume positively and significantly influenced on the sustainability score of the cropping system in low land at 5% level. Income from livestock was also positively and significantly influenced on the sustainability score of the cropping system in low land at 10% level. But dependency ratio was inversely related to the sustainability score. If dependency ratio increases by 1%, the sustainability score of cropping system in low land will be decreased by 0.013.

The results also show that household head's farm experience, number of livestock, crop intensification index and legume growing area positively and significantly influenced on the sustainability score of the cropping system in upland at 10% level. Crop diversification positively and significantly influenced on the sustainability score of the cropping system in upland. But dependency ratio negatively and significantly influenced on the sustainability score of the cropping system in upland at 5% level.

6.2 Recommendations and Policy Implications

6.2.1 Provision of sustainable cropping practices

Today's agricultural industry contributes significantly to environmental and resource degradation, undermining the basic of people's food security. Choosing suitable cropping practices plays one of the major roles in agricultural sustainability. Cropping practices such as intercropping, growing green manure, crop rotation, application of adequate amount of manure and chemical fertilizers should be promoted.

The availability of adequate water resources for agriculture is essential for increased production. However, efficient use of this resource in the study area does not imply large scale. Generally Natmouk Township depends solely on rain water for crop production. This has limited agricultural activities to the rainy periods. Therefore, water saving cultivation practices should be promoted.

6.2.2 Crop diversification and intensification

Achieving food security in the study area requires increasing the productivity and sustainability of the cropping system. This involves increasing the intensification of production and diversification. In low land, crop intensification should be promoted to increase sustainability of cropping system of sampled farm households. On the other hand, it is needed to promote crop diversification and crop intensification for increasing sustainability of cropping system of sampled farm households in upland.

6.2.3 Non-farm activities

More income diversification is needed to reduce food insecurity of farm households in rain-fed cropping system. Due to erratic and unseasonal rainfall, profitability of crop production is unsure in the study area. To overcome this situation, non-farm employment opportunities such as rearing livestock should be created. On the other hand, low productivity of the land and underemployment has led to low annual income in the study area. Moreover, since dependency ratio is negatively related to the sustainability of cropping system, non-farm employment opportunities should be promoted to reduce this.

6.2.4 Involvement of developing agencies

Since about 59% of the total sampled farm households were food insecure, involvement of developing agencies should be promoted for development of agriculture sector in the study area.Much need education, training and the technology for sustainable resource management, economic growth and self-sufficiency. Sampled farm households will be required to acquire skills, knowledge and farm experience needed to sustain income generating activities.

Therefore, technology dissemination by means of provision of training, demonstration plots and extension services should be promoted to increase sustainability of rain-fed cropping system. Moreover, the economic and educational empowerment of resource poor rural farm households should be improved through environmentally sustainable means, thus contributing towards the attainment of sustainable development.

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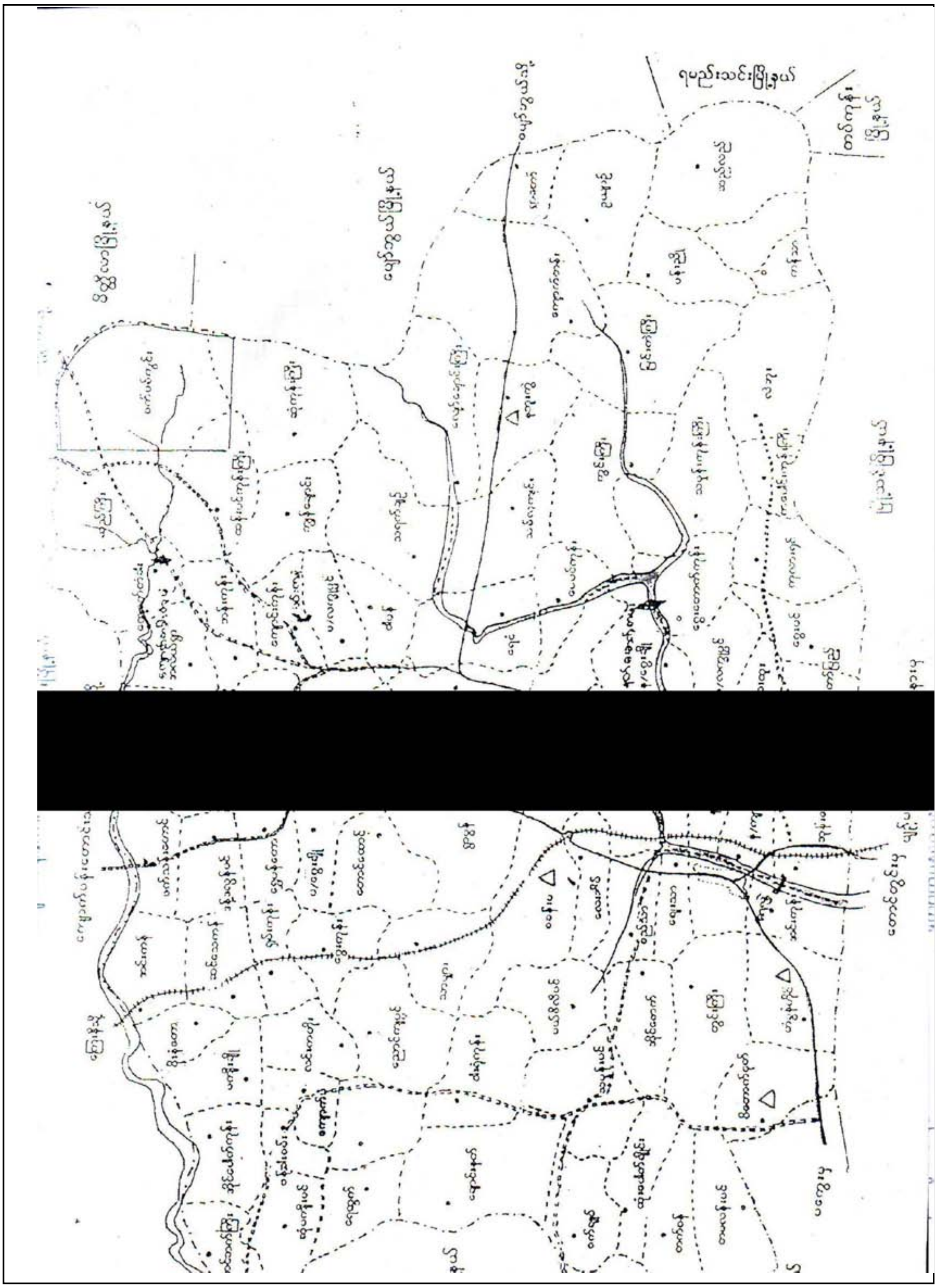
Appendices

Appendix -1 Map of Natmouk Township



Appendix 2 Inputs used in monsoon rice-fallow cropping pattern

Item	Monsoon Rice			
	Unit	Level	Effective cost/unit	Total cost
Variable Cost				
(a) Non Labor Input Cost	**Ks/ha**			
Seed	Kg/ha	78.2	250.8	19622.8
Compound Fertilizer	Kg/ha	123.3	305.5	37663.5
Pesticide	li/ha	2.2	5485.7	11856
Sub-total (a) Cash Cost	**Ks/ha**			69142.3
(b) Labor-input (Family)				
Man labor	md/ha	33	1516.5	50728.6
Animal labor	ad/ha	7	4137.5	26942.4
FYM	ton/ha	5.4	5380.1	29042.4
Sub-total (b) Opportunity Cost	**Ks/ha**			
(c) Labor-input (Hired)				
Man labor	md/ha	32	1170.9	37422.8
Animal labor	ad/ha	6	3500	21612.5
Sub-total (c) Cash Cost	**Ks/ha**			59035.3
(d) Interest on Cash Cost				
Interest on subtotal (a)		0.2	69142.3	13828.5
Interest on subtotal (c)		0.2	58015.9	11603.2
Total Interest on Cash Cost				25431.7

Appendix 3 Inputs used in monsoon rice- chickpea cropping pattern

Item	Monsoon Rice				Chickpea		
	Unit	Level	Effective cost/unit	Total cost	Level	Effective cost/unit	Total cost
Variable Cost							
(a) Non Labor Input Cost							
Seed	Kg/ha	90.8	247.7	22487.3	154.6	123.8	19142.5
Compound Fertilizer	Kg/ha	123.5	356.4	44010.9	66.2	283.3	18745.5
Pesticide	li/ha	2.1	6600	13585	1.9	11441.6	21760.7
Sub-total (a) Cash Cost Ks/ha				80083.2			59648.7
(b) Labor-input (Family)							
Man labor	md/ha	27	1498.7	40412.3	29	1822.7	52899.2
Animal labor	ad/ha	6	4382.6	27062.6	5	4145.8	22342.3
FYM	ton/ha	4.5	6800	30538.2	4	5000	20068.8
Sub-total(b)Opportunity Cost Ks/ha				98013.1			95310.2
(c) Labor-input (Hired)							
Man labor	md/ha	26	1278.4	33298.3	22	1321.4	29078.6
Animal labor	ad/ha	5	3466.7	17125.3	5	3000	14820
Sub-total (c) Cash Cost Ks/ha				50423.6			43898.6
(d) Interest on Cash Cost							
Interest on subtotal (a)		0.2	80083.2	16016.6	0.2	59648.7	11929.8
Interest on subtotal (c)		0.2	61151.2	12230.2	0.2	43898.6	8779.7
Total Interest on Cash Cost				28246.9			20709.5

Appendix 4 Inputs used in monsoon rice- green gram cropping pattern

Item	Monsoon Rice				Green gram		
	Unit	Level	Effective cost/unit	Total cost	Level	Effective cost/unit	Total cost
Variable Cost							
(a) Non Labor Input Cost							
Seed	Kg/ha	129.7	180.9	23465	161.4	137.7	22230
Compound Fertilizer	Kg/ha	237.7	359.5	85462	123.5	360	44460
Pesticide	li/ha	0	0	0	5.6	3333.3	18525
Sub-total (a) Cash Cost	**Ks/ha**			108927			85215
(b) Labor-input (Family)							
Man labor	md/ha	28	1170.4	33244.7	26	1404.8	36432.5
Animal labor	ad/ha	4	1760.9	6524	5	3125	15437.5
FYM	ton/ha	4.3	6571.4	28405	0.00	0	0
Sub-total (b) Opportunity Cost	**Ks/ha**			68173.7			51870
(c) Labor-input (Hired)							
Man labor	md/ha	44	1430.1	63580.1	32	1038.5	33345
Animal labor	ad/ha	10	3200	31616	0	0	0
Sub-total (c) Cash Cost	**Ks/ha**			95196.1			33345
(d) Interest on Cash Cost							
Interest on subtotal (a)		0.2	108927	21785.4	0.2	85215	17043
Interest on subtotal (c)		0.2	64220	12844	0.2	33345	6669
Total Interest on Cash Cost				34629.4			23712

Appendix 5 Inputs used in sesame-fallow cropping pattern

Item	**Sesame**			
	Unit	**Level**	**Effective cost/unit**	**Total cost**
Variable Cost				
(a) Non Labor Input Cost				
Seed	Kg/ha	154.6	79.9	12350
Compound Fertilizer	Kg/ha	123.5	420	51870
Pesticide	li/ha	0	0	0
Sub-total (a) Cash Cost	**Ks/ha**			64220
(b) Labor-input (Family)				
Man labor	md/ha	30	1508.3	44707
Animal labor	ad/ha	5	4000	19760
FYM	ton/ha	4.3	6000	25935
Sub-total (b) Opportunity Cost	**Ks/ha**			
(c) Labor-input (Hired)				
Man labor	md/ha	33	1125.9	37544
Animal labor	ad/ha	0	0	0
Sub-total (c) Cash Cost	**Ks/ha**			37544
(d) Interest on Cash Cost				
Interest on subtotal (a)		0.2	64220	12844
Interest on subtotal (c)		0.2	37544	7508.8
Total Interest on Cash Cost				

Appendix 6 Inputs used in sesame+ pigeon pea- green gram or groundnut cropping pattern

Item	Sesame+ Pigeon pea				Green gram		
	Unit	Level	Effective cost/unit	Total cost	Level	Effective cost/unit	Total cost
Variable Cost							
(a) Non Labor Input Cost							
1st Crop seed	Kg/ha	171.3	81.5	13961.1	254.6	89.9	22895
2nd Crop seed	Kg/ha	160.3	72.4	11599.6			
Compound Fertilizer	Kg/ha	97	264.8	25692.8	101.3	144.9	14677.9
Pesticide	li/ha	2.9	4524.9	13277.9	2.3	4947.1	11346.6
Sub-total (a) Cash Cost	**Ks/ha**			64531.5			48919.5
(b) Labor-input (Family)							
Man labor	md/ha	33	1511.2	49670.8	35	1491.9	52820.2
Animal labor	ad/ha	6	3996.3	22412.4	5	3749	19677.7
FYM	ton/ha	4.7	4996.6	23311.9	2.9	4928.6	14202.5
Sub-total (b) Opportunity Cost	**Ks/ha**			95395.1			86700.3
(c) Labor-input (Hired)							
Man labor	md/ha	33	1123.1	37207.3	31	1318.2	41326.7
Animal labor	ad/ha	5	3986.5	19529	3	4125	13585
Sub-total (c) Cash Cost	**Ks/ha**			56736.3			54911.7
(d) Interest on Cash Cost							
Interest on subtotal (a)		0.2	64531.5	12906.3	0.2	48919.5	9783.9
Interest on subtotal (c)		0.2	56736.3	11347.3	0.2	53122.6	10624.5
Total Interest on Cash Cost				24253.6			20408.4

Appendix 6 Continue: Inputs used in sesame+ pigeon pea- green gram or groundnut cropping pattern

Item	Sesame+ Pigeon pea				Groundnut		
	Unit	Level	Effective cost/unit	Total cost	Level	Effective cost/unit	Total cost
Variable Cost							
(a) Non Labor Input Cost							
1st Crop seed	Kg/ha	171.3	81.5	13961.1	50.1	604.4	30271.2
2nd Crop seed	Kg/ha	160.3	72.4	11599.6			
Compound Fertilizer	Kg/ha	97	264.8	25692.8	122.3	231.1	28256.8
Pesticide	li/ha	2.9	4524.9	13277.9	4.3	4493.5	19423.2
Sub-total (a) Cash Cost	**Ks/ha**			64531.5			77951.2
(b) Labor-input (Family)							
Man labor	md/ha	33	1511.2	49670.8	27	1468.9	40314.7
Animal labor	ad/ha	6	3996.3	22412.4	5	4591.8	24700
FYM	ton/ha	4.7	4996.6	23311.9	4.8	4286.7	20460.9
Sub-total (b) Opportunity Cost	**Ks/ha**			95395.1			85475.6
(c) Labor-input (Hired)							
Man labor	md/ha	33	1123.1	37207.3	38	1086.3	41737.6
Animal labor	ad/ha	5	3986.5	19529	0	0	0
Sub-total (c) Cash Cost	**Ks/ha**			56736.3			41737.6
(d) Interest on Cash Cost							
Interest on subtotal (a)		0.2	64531.5	12906.3	0.2	77951.2	15590.2
Interest on subtotal (c)		0.2	56736.3	11347.3	0.2	41737.6	8347.5
Total Interest on Cash Cost				24253.6			23937.8

Appendix 7 Inputs used in sesame+ pigeon pea- chillies- tomato cropping pattern

Item	Sesame+ Pigeon pea				Chillies		
	Unit	Level	Effective cost/unit	Total cost	Level	Effective cost/unit	Total cost
Variable Cost							
(a) Non Labor Input Cost							
1st Crop seed	Kg/ha	171.3	81.5	13961.1	4.3	1838.7	7845.9
2nd Crop seed	Kg/ha	160.3	72.4	11599.6			
Compound Fertilizer	Kg/ha	97	264.8	25692.8	89.5	212.8	19049.9
Pesticide	li/ha	2.9	4524.9	13277.9	2.2	6862.1	15360.3
Sub-total (a) Cash Cost	**Ks/ha**			64531.5			42256.1
(b) Labor-input (Family)							
Man labor	md/ha	33	1511.2	49670.8	36	1560.8	56329.7
Animal labor	ad/ha	6	3996.3	22412.4	5	4121.2	19760
FYM	ton/ha	4.7	4996.6	23311.9	3.61	5973.7	21565
Sub-total (b) Opportunity Cost	**Ks/ha**			95395.1			97654.7
(c) Labor-input (Hired)							
Man labor	md/ha	33	1123.1	37207.3	21	1280.8	27170
Animal labor	ad/ha	5	3986.5	19529	4	2900	11938.3
Sub-total (c) Cash Cost	**Ks/ha**			56736.3			39108.3
(d) Interest on Cash Cost							
Interest on subtotal (a)		0.2	64531.5	12906.3	0.2	42256.1	8451.2
Interest on subtotal (c)		0.2	56736.3	11347.3	0.2	39108.3	7821.7
Total Interest on Cash Cost				24253.6			16272.9

Appendix 7 Continue: Inputs used in sesame+ pigeon pea- chillies- tomato cropping pattern

Item	Tomato			
	Unit	Level	Effective cost/unit	Total cost
Variable Cost				
(a) Non Labor Input Cost				
Seed	Kg/ha	16.1	919.4	14820
Compound Fertilizer	Kg/ha	46.3	253.3	11732.5
Pesticide	li/ha	1.9	6000	11115
Sub-total (a) Cash Cost	**Ks/ha**			37667.5
(b) Labor-input (Family)				
Man labor	md/ha	37	1758.3	65146.3
Animal labor	ad/ha	4	5000	18525
FYM	ton/ha	1.9	7000	12967.5
Sub-total (b) Opportunity Cost	**Ks/ha**			
(c) Labor-input (Hired)				
Man labor	md/ha	11	2076.9	22230
Animal labor	ad/ha	0	0	0
Sub-total (c) Cash Cost	**Ks/ha**			22230
(d) Interest on Cash Cost				
Interest on subtotal (a)		0.2	37667.5	7533.5
Interest on subtotal (c)		0.2	22230	4446
Total Interest on Cash Cost				11979.5

Appendix 8 Inputs used in sesame+ pigeon pea- groundnut- sunflower cropping pattern

Item	Sesame+ Pigeon pea				Groundnut		
	Unit	Level	Effective cost/unit	Total cost	Level	Effective cost/unit	Total cost
Variable Cost							
(a) Non Labor Input Cost							
1st Crop seed	Kg/ha	171.3	81.5	13961.1	50.1	604.4	30271.2
2nd Crop seed	Kg/ha	160.3	72.4	11599.6			
Compound Fertilizer	Kg/ha	97	264.8	25692.8	122.3	231.1	28256.8
Pesticide	li/ha	2.9	4524.9	13277.9	4.3	4493.5	19423.2
Sub-total (a) Cash Cost	**Ks/ha**			64531.5			77951.2
(b) Labor-input (Family)							
Man labor	md/ha	33	1511.2	49670.8	27	1468.9	40314.7
Animal labor	ad/ha	6	3996.3	22412.4	5	4591.9	24700
FYM	ton/ha	4.7	4996.6	23311.9	4.8	4286.7	20460.9
Sub-total (b) Opportunity Cost	**Ks/ha**			95395.1			85475.6
(c) Labor-input (Hired)							
Man labor	md/ha	33	1123.1	37207.3	38	1086.3	41737.6
Animal labor	ad/ha	5	3986.5	19529	0	0	0
Sub-total (c) Cash Cost	**Ks/ha**			56736.3			41737.6
(d) Interest on Cash Cost							
Interest on subtotal (a)		0.2	64531.5	12906.3	0.2	77951.2	15590.2
Interest on subtotal (c)		0.2	56736.3	11347.3	0.2	41737.6	8347.5
Total Interest on Cash Cost				24253.6			23937.8

Appendix 8 Continue: Inputs used in sesame+ pigeon pea –groundnut- sunflower cropping pattern

Item	Sunflower			
	Unit	**Level**	**Effective cost/unit**	**Total cost**
Variable Cost				
(a) Non Labor Input Cost				
Seed	Kg/ha	113.4	68.9	7821.7
Compound Fertilizer	Kg/ha	61.8	264	16302
Pesticide	li/ha	1.5	6800	10497.5
Sub-total (a) Cash Cost	**Ks/ha**			34621.2
(b) Labor-input (Family)				
Man labor	md/ha	26	1476.2	38285
Animal labor	ad/ha	7	3400	25194
FYM	ton/ha	3.3	5000	16466.7
Sub-total (b) Opportunity Cost	**Ks/ha**			79945.7
(c) Labor-input (Hired)				
Man labor	md/ha	39	1196.8	46312.5
Animal labor	ad/ha	4	4333.3	16055
Sub-total (c) Cash Cost	**Ks/ha**			62367.5
(d) Interest on Cash Cost				
Interest on subtotal (a)		0.2	34621.2	6924.2
Interest on subtotal (c)		0.2	62367.5	12473.5
Total Interest on Cash Cost				19397.7

Appendix 9 Inputs used in sesame+ pigeon pea –cotton- chillies or onion cropping pattern

Item	Sesame+ Pigeon pea				Cotton		
	Unit	Level	Effective cost/unit	Total cost	Level	Effective cost/unit	Total cost
Variable Cost							
(a) Non Labor Input Cost							
1st Crop seed	Kg/ha	171.3	81.5	13961.1	12.6	630.7	7971.4
2nd Crop seed	Kg/ha	160.3	72.4	11599.6			
Compound Fertilizer	Kg/ha	97	264.8	25692.8	177.2	106.1	18796.7
Pesticide	li/ha	2.9	4524.9	13277.9	2.5	8750	21612.5
Sub-total (a) Cash Cost	**Ks/ha**			64531.5			48380.6
(b) Labor-input (Family)							
Man labor	md/ha	33	1511.2	49670.8	30	1430.9	43056.6
Animal labor	ad/ha	6	3996.3	22412.4	5	3518.6	18172.1
FYM	ton/ha	4.7	4996.6	23311.9	5.02	4707.7	23619.4
Sub-total (b) Opportunity Cost	**Ks/ha**			95395.1			84848.1
(c) Labor-input (Hired)							
Man labor	md/ha	33	1123.1	37207.3	29	855.5	24587.7
Animal labor	ad/ha	5	3986.5	19529	5	3000	14820
Sub-total (c) Cash Cost	**Ks/ha**			56736.3			39407.7
(d) Interest on Cash Cost							
Interest on subtotal (a)		0.2	64531.5	12906.3	0.2	48380.6	9676.1
Interest on subtotal (c)		0.2	56736.3	11347.3	0.2	39407.7	7881.6
Total Interest on Cash Cost				24253.6			17557.6

Appendix 9 Continue: Inputs used in sesame+ pigeon pea –cotton- chillies or onion cropping pattern

Item	Chillies				Onion		
	Unit	Level	Effective cost/unit	Total cost	Level	Effective cost/unit	Total cost
Variable Cost							
(a) Non Labor Input Cost							
Crop seed	Kg/ha	4.3	1838.7	7845.9	5.9	7891.1	46256.4
Compound Fertilizer	Kg/ha	89.5	212.8	19049.9	121.4	334.9	40672.7
Pesticide	li/ha	2.2	6862.1	15360.3	2.5	2500.5	6176.2
Sub-total (a) Cash Cost	**Ks/ha**			42256.1			93105.3
(b) Labor-input (Family)							
Man labor	md/ha	36	1560.8	56329.7	1588.2	61132.5	1588.2
Animal labor	ad/ha	5	4121.2	19760	3726.7	17642.9	3726.7
FYM	ton/ha	3.6	5973.7	21565	4880	25111.7	4880
Sub-total (b) Opportunity Cost	**Ks/ha**			97654.7			103887
(c) Labor-input (Hired)							
Man labor	md/ha	21	1280.8	27170	43	1321.8	56810
Animal labor	ad/ha	4	2900	11938.3	7	500	3705
Sub-total (c) Cash Cost	**Ks/ha**			39108.3			60515
(d) Interest on Cash Cost							
Interest on subtotal (a)		0.2	42256.1	8451.2	0.2	93105.3	18621.1
Interest on subtotal (c)		0.2	39108.3	7821.7	0.2	60515	12103
Total Interest on Cash Cost				16272.9			30724.1

Appendix 10 Inputs used in pigeon pea- green gram cropping pattern

Item	Pigeon pea				Green gram		
	Unit	Level	Effective cost/unit	Total cost	Level	Effective cost/unit	Total cost
Variable Cost							
(a) Non Labor Input Cost							
Seed	Kg/ha	132.6	55.9	7410	254.6	89.9	22895
Compound Fertilizer	Kg/ha	27.8	322.2	8953.8	101.3	144.9	14677.9
Pesticide	li/ha	0	0	0	2.3	4947.1	11346.6
Sub-total (a) Cash Cost	**Ks/ha**			16363.8			48919.5
(b) Labor-input (Family)							
Man labor	md/ha	40	1062.5	41990	35	1491.9	52820.2
Animal labor	ad/ha	5	4000	19760	5	3749	19677.7
FYM	ton/ha	4.9	5125	25317.5	2.9	4928.6	14202.5
Sub-total (b) Opportunity Cost	**Ks/ha**			87067.5			86700.3
(c) Labor-input (Hired)							
Man labor	md/ha	23	1210.5	28405	31	1318.2	41326.7
Animal labor	ad/ha	0	0	0	3	4125	13585
Sub-total (c) Cash Cost	**Ks/ha**			28405			54911.7
(d) Interest on Cash Cost							
Interest on subtotal (a)		0.2	16363.8	3272.8	0.2	48919.5	9783.9
Interest on subtotal (c)		0.2	28405	5681	0.2	53122.6	10624.5
Total Interest on Cash Cost				8953.8			20408.4

Appendix 11 Inputs used in sesame+ pigeon pea- onion cropping pattern

Item	Sesame+ Pigeon pea				Onion		
	Unit	Level	Effective cost/unit	Total cost	Level	Effective cost/unit	Total cost
Variable Cost							
(a) Non Labor Input Cost							
1st Crop seed	Kg/ha	171.3	81.5	13961.1	5.9	7891.1	46256.4
2nd Crop seed	Kg/ha	160.3	72.4	11599.6			
Compound Fertilizer	Kg/ha	97	264.8	25692.8	121.4	334.9	40672.7
Pesticide	li/ha	2.9	4524.9	13277.9	2.5	2500.5	6176.24
Sub-total (a) Cash Cost	**Ks/ha**			64531.5			93105.3
(b) Labor-input (Family)							
Man labor	md/ha	33	1511.2	49670.8	38	1588.2	61132.5
Animal labor	ad/ha	6	3996.3	22412.4	5	3726.7	17642.9
FYM	ton/ha	4.7	4996.6	23311.9	5.15	4880	25111.7
Sub-total (b) Opportunity Cost	**Ks/ha**			95395.1			103887
(c) Labor-input (Hired)							
Man labor	md/ha	33	1123.1	37207.3	43	1321.8	56810
Animal labor	ad/ha	5	3986.5	19529	7	500	3705
Sub-total (c) Cash Cost	**Ks/ha**			56736.3			60515
(d) Interest on Cash Cost							
Interest on subtotal (a)		0.2	64531.5	12906.3	0.2	0.2	93105.3
Interest on subtotal (c)		0.2	56736.3	11347.3	0.2	0.2	60515
Total Interest on Cash Cost				24253.6			153620.3

Appendix 12 Gross margin analysis of monsoon paddy- fallow land in low land

No.	Description	Unit	Different farm size groups		
			Small farm households (N=7)	Medium farm households(N=15)	Large farm households (N=14)
1	Average yield of monsoon paddy	kg/ha	825.5	1390.37	974.29
2	Average price of monsoon paddy	Ks/kg	190	210	182
3	Value of production (1x2)	Ks/ha	156845	291977.7	177320.7
4	Total variable cost of production	Ks/ha	172340	226370	200670
5	Total variable cash cost of production	Ks/ha	74206	125270	106880
6	Gross margin per unit of land (3-4)	Ks/ha	-15495	65607.70	-23349.2
7	Gross margin per unit of capital (3/4)	Ks/TVC	0.91	1.29	0.88
7	Break-even yield (4/2)	kg/ha	907.0	1077.9	1102.5
9	Break-even price (4/1)	Ks/kg	208.7	162.8	205.9

Appendix 13 Gross margin analysis of monsoon paddy-chick pea in lowland

No.	Description	Unit	Different farm size groups		
			Small farm households (N=4)	Medium farm households (N=5)	Large farm households (N=3)
1	Average yield of monsoon paddy	kg/ha	1186.5	1407.9	2244.3
2	Average price of monsoon paddy	Ks/kg	213	180	217
3	Value of production (1x2)	Ks/ha	252731	253422	487028
4	Total variable cost of production	Ks/ha	211185	219731.2	271535.33
5	Total variable cash cost of production	Ks/ha	113928.7	126118.2	163267
6	Gross margin per unit of land (3-4)	Ks/ha	41546	33691	215493
7	Gross margin per unit of capital (3/4)	Ks/TVC	1.20	1.15	1.79
7	Break-even yield (4/2)	kg/ha	991.4	1220.7	1251.3
9	Break-even price (4/1)	Ks/kg	177.9	156.0	120.9
10	Average yield of chick pea	kg/ha	376.8	357.0	470.2
11	Average price of chick pea	Ks/kg	518	540	400
12	Value of production (10x11)	Ks/ha	195203.1	192807	188096
13	Total variable cost of production	Ks/ha	164810.7	160812	152300.3
14	Total variable cash cost of production	Ks/ha	81139.5	86712	67085.33
15	Gross margin per unit of land (12-13)	Ks/ha	30392.3	31995.0	35795.6
16	Gross margin per unit of capital (12/13)	Ks/TVC	1.18	1.20	1.24
17	Break-even yield (13/11)	kg/ha	318.1	297.8	380.7
18	Break-even price (13/10)	Ks/kg	437.3	450.3	323.8
19	Total gross margin per unit of land (6+15)	Ks/ha	71938.2	65685.8	251288.6
20	Total gross margin per unit of capital (3+12)/(4+13)	Ks/TVC	1.19	1.17	1.59

Appendix 14 Gross margin analysis of monsoon paddy-green gram in low land

No.	Description	Unit	Large farm households (N=2)
1	Average yield of monsoon paddy	kg/ha	1642.5
2	Average price of monsoon paddy	Ks/kg	200
3	Value of production (1x2)	Ks/ha	328510
4	Total variable cost of production	Ks/ha	272490.00
5	Total variable cash cost of production	Ks/ha	25000.00
6	Gross margin per unit of land (3-4)	Ks/ha	56020.00
7	Gross margin per unit of capital (3/4)	Ks/TVC	1.21
7	Break-even yield (4/2)	kg/ha	1362.4
9	Break-even price (4/1)	Ks/kg	165.8
10	Average yield of green gram	kg/ha	605
11	Average price of green gram	Ks/kg	465
12	Value of production (10x11)	Ks/ha	281325
13	Total variable cost of production	Ks/ha	173394
14	Total variable cash cost of production	Ks/ha	142272
15	Gross margin per unit of land (12-13)	Ks/ha	107931
16	Gross margin per unit of capital (12/13)	Ks/TVC	1.62
17	Break-even yield (13/11)	kg/ha	372.8
18	Break-even price (13/10)	Ks/kg	286.6
19	Total gross margin per unit of land (6+15)	Ks/ha	163951
20	Total gross margin per unit of capital (3+12)/(4+13)	Ks/TVC	1.37

Appendix 15 Gross margin analysis of sesame-fallow land in upland

No.	Description	Unit	Medium farm households (N=2)
1	Average yield of sesame	kg/ha	241.5
2	Average price of sesame	Ks/kg	800
3	Value of production (1x2)	Ks/ha	193200.00
4	Total variable cost of production	Ks/ha	181400.00
5	Total variable cash cost of production	Ks/ha	90995.00
6	Gross margin per unit of land (3-4)	Ks/ha	11800.00
7	Gross margin per unit of capital (3/4)	Ks/TVC	1.07
7	Break-even yield (4/2)	kg/ha	226.75
9	Break-even price (4/1)	Ks/kg	751.14

Appendix 16 Gross margin analysis of sesame+ pigeon pea - green gram or groundnut in upland

No.	Description	Unit	Different farm size groups		
			Small farm households (N=17)	Medium farm households (N=16)	Large farm households (N=14)
1	Average yield of sesame	kg/ha	313	306	376.2
2	Average price of sesame	Ks/kg	835	833	877
3	Value of production (1x2)	Ks/ha	261355	254898	330006.3
4	Total variable cost of production	Ks/ha	172565.8	178300	203722
5	Total variable cash cost of production	Ks/ha	90009.7	92143.3	123217.6
6	Gross margin per unit of land (3-4)	Ks/ha	88789.1	76598	126284.3
7	Gross margin per unit of capital (3/4)	Ks/TVC	1.51	1.43	1.62
7	Break-even yield (4/2)	kg/ha	206.6	214	232.2
9	Break-even price (4/1)	Ks/kg	551.3	582.6	541.4
10	Average yield of pigeon pea	kg/ha	533.9	350.8	627.3
11	Average price of pigeon pea	Ks/kg	477	486	463
12	Value of production (10x11)	Ks/ha	254689.3	170513.1	290453.7
13	Total variable cost of production	Ks/ha	166493.7	164163.7	187407.2
14	Total variable cash cost of production	Ks/ha	83964.5	84952.7	109766.8
15	Gross margin per unit of land (12-13)	Ks/ha	88195.6	6349.3	103046.6
16	Gross margin per unit of capital (12/13)	Ks/TVC	1.53	1.04	1.55
17	Break-even yield (13/11)	kg/ha	349	337.7	404.8
18	Break-even price (13/10)	Ks/kg	311.8	467.9	298.7
19	Average yield of green gram	kg/ha	387.4	366.1	672.7
20	Average price of green gram	Ks/kg	480	497	470

Appendix 16 Continue: Gross margin analysis of sesame+ pigeon pea - green gram or groundnut in upland

No.	Description	Unit	Different farm size groups		
			Small farm households (N=17)	Medium farm households (N=16)	Large farm households (N=14)
21	Value of production (19x20)	Ks/ha	185980.8	181966.6	316154.9
22	Total variable cost of production	Ks/ha	133710	161090	181990
23	Total variable cash cost of production	Ks/ha	64452	81976	10369
24	Gross margin per unit of land (21-22)	Ks/ha	52270.8	20876.6	134164.9
25	Gross margin per unit of capital (21/22)	Ks/TVC	1.39	1.13	1.74
26	Break-even yield (22/20)	kg/ha	278.6	324.1	387.2
27	Break-even price (22/19)	Ks/kg	345.1	439.9	270.6
28	Average yield of groundnut	kg/ha	604.6	498.2	631.2
29	Average price of groundnut	Ks/kg	613	540	604
30	Value of production (28x29)	Ks/ha	370638.2	269017.2	381226.7
31	Total variable cost of production	Ks/ha	193220	193270	182550
32	Total variable cash cost of production	Ks/ha	114020	114450	106520
33	Gross margin per unit of land (30-31)	Ks/ha	177418.2	75747.2	198676.7
34	Gross margin per unit of capital (30/31)	Ks/TVC	1.92	1.39	2.09
35	Break-even yield (31/29)	kg/ha	315.2	357.9	302.2
36	Break-even price (31/28)	Ks/kg	319.6	387.9	289.2
37	Total gross margin per unit of land (6+15+24+33)	Ks/ha	406673.8	179571.1	562172.5
38	Total gross margin per unit of capital (3+12+21+30)/ (4+13+22+31)	Ks/TVC	1.61	1.26	1.74

Appendix 17 Gross margin analysis of sesame+ pigeon pea –chillies- tomato in upland

No.	Description	Unit	Different farm size groups		
			Small farm households (N=2)	Medium farm households (N=4)	Large farm households (N=2)
1	Average yield of sesame	kg/ha	300	342.3	423
2	Average price of sesame	Ks/kg	800	910	900
3	Value of production (1x2)	Ks/ha	240000	311447.5	380700
4	Total variable cost of production	Ks/ha	132632	172036	205511
5	Total variable cash cost of production	Ks/ha	31122	62429.3	104481
6	Gross margin per unit of land (3-4)	Ks/ha	107368	139411.5	175189
7	Gross margin per unit of capital (3/4)	Ks/TVC	1.81	1.81	1.85
7	Break-even yield (4/2)	kg/ha	165.8	189.1	228.4
9	Break-even price (4/1)	Ks/kg	442.1	502.7	485.9
10	Average yield of pigeon pea	kg/ha	347	578.5	570.3
11	Average price of pigeon pea	Ks/kg	450	450	503
12	Value of production (10x11)	Ks/ha	156150	260325	286835.8
13	Total variable cost of production	Ks/ha	127692	200478	216990
14	Total variable cash cost of production	Ks/ha	31122	84696.3	88549.5
15	Gross margin per unit of land (12-13)	Ks/ha	28458	59847	69845.8
16	Gross margin per unit of capital (12/13)	Ks/TVC	1.22	1.30	1.32
17	Break-even yield (13/11)	kg/ha	283.8	445.5	431.4
18	Break-even price (13/10)	Ks/kg	367.9	346.6	380.5
19	Average yield of chillies	kg/ha	262	346.3	383
20	Average price of chillies	Ks/kg	793	869	1068

Appendix 17 Continue: Gross margin analysis of sesame+ pigeon pea - chillies - tomato in upland

No.	Description	Unit	Different farm size groups		
			Small farm households (N=2)	Medium farm households (N=4)	Large farm households (N=2)
21	Value of production (19x20)	Ks/ha	207766	300891.3	409044
22	Total variable cost of production	Ks/ha	116830	185810	170800
23	Total variable cash cost of production	Ks/ha	30381	85771	55946
24	Gross margin per unit of land (21-22)	Ks/ha	90936	115081.3	238244
25	Gross margin per unit of capital (21/22)	Ks/TVC	1.78	1.62	2.39
26	Break-even yield (22/20)	kg/ha	147.3	213.8	159.9
27	Break-even price (22/19)	Ks/kg	445.9	536.6	445.9
28	Average yield of tomato	kg/ha	423	806	635
29	Average price of tomato	Ks/kg	275	305	366
30	Value of production (28x29)	Ks/ha	116325	245830	232410
31	Total variable cost of production	Ks/ha	113370	177590	155610
32	Total variable cash cost of production	Ks/ha	39273	50388	59280
33	Gross margin per unit of land (30-31)	Ks/ha	2955	68240	76800
34	Gross margin per unit of capital (30/31)	Ks/TVC	1.03	1.38	1.49
35	Break-even yield (31/29)	kg/ha	412.3	582.3	425.2
36	Break-even price (31/28)	Ks/kg	268	220.3	245.1
37	Total gross margin per unit of land (6+15+24+33)	Ks/ha	229717	382579.8	560078.8
38	Total gross margin per unit of capital (3+12+21+30)/ (4+13+22+31)	Ks/TVC	1.47	1.52	1.75

Appendix 18 Gross margin analysis of sesame+ pigeon pea - groundnut - sunflower in upland

No.	Description	Unit	Different farm size groups		
			Small farm households (N=1)	Medium farm households (N=4)	Large farm households (N=1)
1	Average yield of sesame	kg/ha	200	260.3	465.6
2	Average price of sesame	Ks/kg	800	785	850
3	Value of production (1x2)	Ks/ha	160000	204296.3	395717.5
4	Total variable cost of production	Ks/ha	151658	160674	227734
5	Total variable cash cost of production	Ks/ha	110000	102628.5	114114
6	Gross margin per unit of land (3-4)	Ks/ha	8342	43622.3	167983.5
7	Gross margin per unit of capital (3/4)	Ks/TVC	1.06	1.27	1.74
7	Break-even yield (4/2)	kg/ha	189.6	204.7	267.9
9	Break-even price (4/1)	Ks/kg	758.3	617.4	489.2
10	Average yield of pigeon pea	kg/ha	404	449.8	484
11	Average price of pigeon pea	Ks/kg	480	465	450
12	Value of production (10x11)	Ks/ha	193920	209133.75	217800
13	Total variable cost of production	Ks/ha	169689	175988	207727
14	Total variable cash cost of production	Ks/ha	80000	112076.3	90402
15	Gross margin per unit of land (12-13)	Ks/ha	24231	33145.8	10073
16	Gross margin per unit of capital (12/13)	Ks/TVC	1.14	1.19	1.05
17	Break-even yield (13/11)	kg/ha	353.5	378.5	461.6
18	Break-even price (13/10)	Ks/kg	420	391.3	429.2
19	Average yield of groundnut	kg/ha	420	493	
20	Average price of groundnut	Ks/kg	720	675	

Appendix 18 Continue: Gross margin analysis of sesame+ pigeon pea - groundnut - sunflower in upland

No.	Description	Unit	Different farm size groups		
			Small farm households (N=1)	Medium farm households (N=4)	Large farm households (N=1)
21	Value of production (19x20)	Ks/ha	302400	332775	
22	Total variable cost of production	Ks/ha	231930	207970	
23	Total variable cash cost of production	Ks/ha	161540	128930	
24	Gross margin per unit of land (21-22)	Ks/ha	70470	124805	
25	Gross margin per unit of capital (21/22)	Ks/TVC	1.30	1.60	
26	Break-even yield (22/20)	kg/ha	322.1	308.1	
27	Break-even price (22/19)	Ks/kg	552.2	421.9	
28	Average yield of sunflower	kg/ha	143	160	145
29	Average price of sunflower	Ks/kg	1150	1155	1120
30	Value of production (28x29)	Ks/ha	164450	184800	162400
31	Total variable cost of production	Ks/ha	122510	133060	133660
32	Total variable cash cost of production	Ks/ha	142270	94292	31863
33	Gross margin per unit of land (30-31)	Ks/ha	41940	51740	28740
34	Gross margin per unit of capital (30/31)	Ks/TVC	1.34	1.39	1.22
35	Break-even yield (31/29)	kg/ha	106.5	115.20	119.34
36	Break-even price (31/28)	Ks/kg	856.7	831.63	921.79
37	Total gross margin per unit of land (6+15+24+33)	Ks/ha	144983	253313.00	206796.50
38	Total gross margin per unit of capital (3+12+21+30)/ (4+13+22+31)	Ks/TVC	1.21	1.37	1.36

Appendix 19 Gross margin analysis of sesame+ pigeon pea - cotton - chillies or onion in upland

No.	Description	Unit	Different farm size groups		
			Small farm households (N=4)	Medium farm households (N=9)	Large farm households (N=9)
1	Average yield of sesame	kg/ha	312	414.2	383.8
2	Average price of sesame	Ks/kg	870	808.9	822.2
3	Value of production (1x2)	Ks/ha	271440	335058.4	315551.6
4	Total variable cost of production	Ks/ha	167688.3	190343.7	182708.7
5	Total variable cash cost of production	Ks/ha	62095.8	90665.4	93020.2
6	Gross margin per unit of land (3-4)	Ks/ha	103751.8	144714.8	132842.9
7	Gross margin per unit of capital (3/4)	Ks/TVC	1.62	1.76	1.73
7	Break-even yield (4/2)	kg/ha	192.8	235.3	222.2
9	Break-even price (4/1)	Ks/kg	537.5	459.5	476.1
10	Average yield of pigeon pea	kg/ha	619	774.1	793.8
11	Average price of pigeon pea	Ks/kg	510	487.5	495
12	Value of production (10x11)	Ks/ha	315690	377388.4	392906.3
13	Total variable cost of production	Ks/ha	160465.3	162921.3	170460.9
14	Total variable cash cost of production	Ks/ha	48757.8	64707.9	80676.4
15	Gross margin per unit of land (12-13)	Ks/ha	155224.7	214467.08	222445.4
16	Gross margin per unit of capital (12/13)	Ks/TVC	1.97	2.32	2.30
17	Break-even yield (13/11)	kg/ha	314.6	334.2	344.4
18	Break-even price (13/10)	Ks/kg	259.2	210.5	214.8
19	Average yield of cotton	kg/ha	161.3	219.1	503.8
20	Average price of cotton	Ks/kg	541.5	541.5	542.2
21	Value of production (19x20)	Ks/ha	87316.9	118658.9	273159.6

Appendix 19 Continue: Gross margin analysis of sesame+ pigeon pea - cotton chillies or Onion in upland

No.	Description	Unit	Different farm size groups		
			Small farm households (N=4)	Medium farm households (N=9)	Large farm households (N=9)
22	Total variable cost of production	Ks/ha	119750	133450	165360
23	Total variable cash cost of production	Ks/ha	45460	54037	83717
24	Gross margin per unit of land (21-22)	Ks/ha	-32433.1	-14791.1	107799.6
25	Gross margin per unit of capital (21/22)	Ks/TVC	0.73	0.89	1.65
26	Break-even yield (23/20)	kg/ha	221.1	246.5	304.9
27	Break-even price (23/19)	Ks/kg	742.6	609	328.2
28	Average yield of chillies	kg/ha	250	481	574.8
29	Average price of chillies	Ks/kg	915	854	915
30	Value of production (28x29)	Ks/ha	228750	410774	525896.3
31	Total variable cost of production	Ks/ha	132630	144250	150020
32	Total variable cash cost of production	Ks/ha	32604	55328	62337
33	Gross margin per unit of land (30-31)	Ks/ha	96120	266524	375876.3
34	Gross margin per unit of capital (30/31)	Ks/TVC	1.72	2.85	3.51
35	Break-even yield (31/29)	kg/ha	144.9	168.9	163.9
36	Break-even price (31/28)	Ks/kg	530.5	299.9	261
37	Average yield of onion	kg/ha	4030	4433	
38	Average price of onion	Ks/kg	153	168	
39	Value of production (37x38)	Ks/ha	616590	744744.00	
40	Total variable cost of production	Ks/ha	190190	195870	

Appendix 19 Continue: Gross margin analysis of sesame+ pigeon pea - cotton - chillies or onion in upland

No.	Description	Unit	Different farm size groups		
			Small farm households (N=4)	Medium farm households (N=9)	Large farm households (N=9)
41	Total variable cash cost of production	Ks/ha	286030	122260	
42	Gross margin per unit of land (39-40)	Ks/ha	426400	548874	
43	Gross margin per unit of capital (39/40)	Ks/TVC	3.24	3.80	
44	Break-even yield (40/38)	kg/ha	1243.1	1165.9	
45	Break-even price (40/37)	Ks/kg	47.2	44.2	
46	Total gross margin per unit of land (6+15+24+33+42)	Ks/ha	749063.3	1159788.7	838964.1
47	Total gross margin per unit of capital (3+12+21+30+39)/(4+13+22+31+40)	Ks/TVC	1.97	2.40	2.25

Appendix 20 Gross margin analysis of pigeon pea - green gram in upland

No.	Description	Unit	Different farm size groups		
			Small farm households (N=2)	Medium farm households (N=1)	Large farm households (N=1)
1	Average yield of pigeon pea	kg/ha	484	605	646
2	Average price of pigeon pea	Ks/kg	502.5	475	500
3	Value of production (1x2)	Ks/ha	243210	287375	323000
4	Total variable cost of production	Ks/ha	124862	139555	156104
5	Total variable cash cost of production	Ks/ha	71877	66690	51129
6	Gross margin per unit of land (3-4)	Ks/ha	118348	147820	166896
7	Gross margin per unit of capital (3/4)	Ks/TVC	1.95	2.06	2.07
7	Break-even yield (4/2)	kg/ha	248.5	293.8	312.2
9	Break-even price (4/1)	Ks/kg	257.9	230.7	241.7
10	Average yield of green gram	kg/ha	645.8		
11	Average price of green gram	Ks/kg	450		
12	Value of production (1x2)	Ks/ha	290610.00		
13	Total variable cost of production	Ks/ha	119548		
14	Total variable cash cost of production	Ks/ha	42978		
15	Gross margin per unit of land (3-4)	Ks/ha	171062		
16	Gross margin per unit of capital (3/4)	Ks/TVC	2.43		
17	Break-even yield (13/11)	kg/ha	265.7		
18	Break-even price (13/10)	Ks/kg	185.1		
19	Total gross margin per unit of land (6+15)	Ks/ha	289410	147820	166896
20	Total gross margin per unit of capital (3+12)/(4+13)	Ks/TVC	2.18	2.06	2.07

Appendix 21 Gross margin analysis of sesame+ pigeon pea -onion in upland

No.	Description	Unit	Small farm households (N=7)
1	Average yield of sesame	kg/ha	362.2
2	Average price of sesame	Ks/kg	760
3	Value of production (1x2)	Ks/ha	275272
4	Total variable cost of production	Ks/ha	151856
5	Total variable cash cost of production	Ks/ha	63133.2
6	Gross margin per unit of land (3-4)	Ks/ha	123416
7	Gross margin per unit of capital (3/4)	Ks/TVC	1.81
7	Break-even yield (4/2)	kg/ha	199.8
9	Break-even price (4/1)	Ks/kg	419.3
10	Average yield of pigeon pea	kg/ha	338.8
11	Average price of pigeon pea	Ks/kg	510
12	Value of production (10x11)	Ks/ha	172788
13	Total variable cost of production	Ks/ha	160748
14	Total variable cash cost of production	Ks/ha	61651.2
15	Gross margin per unit of land (12-13)	Ks/ha	12040
16	Gross margin per unit of capital (12/13)	Ks/TVC	1.07
17	Break-even yield (13/11)	kg/ha	315.2
18	Break-even price (13/10)	Ks/kg	474.5
19	Average yield of onion	kg/ha	4020
20	Average price of onion	Ks/kg	166
21	Value of production (19x20)	Ks/ha	667320
22	Total variable cost of production	Ks/ha	233360
23	Total variable cash cost of production	Ks/ha	140030
24	Gross margin per unit of land (21-22)	Ks/ha	433960.00
25	Gross margin per unit of capital (21/22)	Ks/TVC	2.86
26	Break-even yield (22/20)	kg/ha	1405.8
27	Break-even price (22/19)	Ks/kg	58.1
28	Total gross margin per unit of land (6+15+24)	Ks/ha	569416
29	Total gross margin per unit of capital (3+12+21)/(4+13+22)	Ks/TVC	2.04

Appendix 22 Regression results of sustainability score of low land cropping system

Model	Variables Entered	Variables Removed	Method
1	Legume grow or not, FYM amount, Le land size(ha), HH age, rice insufficient months, crop diversification Le, per capita income of livestock, HH schyrs, cropping intensity Le, livestock qty, per capita income of migration, dependency ratio, HH farm experience[a]	.	Enter

a. All requested variables entered.

b. Dependent Variable: Le sustainability score

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.963[a]	.928	.902	.319	1.730

a. Predictors: (Constant), Legume grow or not, FYM amount, Le land size(ha), HH age, rice insufficient months, crop diversification Le, per capita income of livestock, HH schyrs, cropping intensity Le, livestock qty, per capita income of migration, dependency ratio, farm experience

b. Dependent Variable: Le sustainability score

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	47.159	13	3.628	35.671	.000[a]
	Residual	3.661	36	.102		
	Total	50.820	49			

a. Predictors: (Constant), Legume grow or not, FYM amount, Le land size(ha), HH age, rice insufficient months, crop diversification Le, livestock per capita income, HH schyrs, cropping intensity Le, livestock qty, migration per capita income, dependency ratio, experience

b. Dependent Variable: Le sustainability score

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.183	.669		1.770	.085
	HH age	-.007	.004	-.082	-1.592	.120
	HH schyrs	.122	.043	.288	2.860	.007
	HH farm experience	.012	.015	.145	.802	.428
	dependency ratio	-.013	.005	-.288	-2.774	.009
	Le land size(ha)	.250	.090	.172	2.775	.009
	per capita income of migration	.002	.002	.071	1.033	.308
	per capita income of livestock	.003	.002	.111	1.939	.060
	livestock qty	.004	.007	.052	.504	.617
	FYM amount	.006	.020	.020	.292	.772
	cropping intensity Le	.005	.002	.210	2.837	.007
	crop diversification Le	.001	.001	.056	.895	.377
	rice insufficient months	-.033	.023	-.085	-1.419	.164
	Legume grow or not	.448	.140	.199	3.197	.003

a. Dependent Variable: Le sustainability score

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	.59	4.40	2.06	.981	50
Std. Predicted Value	-1.502	2.387	.000	1.000	50
Standard Error of Predicted Value	.107	.270	.165	.035	50
Adjusted Predicted Value	.60	4.76	2.07	1.011	50
Residual	-.654	.574	.000	.273	50
Std. Residual	-2.052	1.801	.000	.857	50
Stud. Residual	-2.395	2.085	-.006	1.006	50
Deleted Residual	-.891	.769	-.006	.383	50
Stud. Deleted Residual	-2.575	2.192	-.008	1.035	50
Mahal. Distance	4.579	34.192	12.740	6.209	50
Cook's Distance	.000	.190	.030	.044	50
Centered Leverage Value	.093	.698	.260	.127	50

a. Dependent Variable: Le sustainability score

Appendix 23Regression results of sustainability score of upland cropping system

Variables Entered/Removed[b]

Model	Variables Entered	Variables Removed	Method
1	intercropping area(ha), head schooling year, per capita income of livestock, livestock quantity, per capita income of migration, head age, legume growing area(ha), crop diversification Yar, Cropping intensity Yar, yar land area(ha), FYM amount, dependency ratio, head farm experience[a]	.	Enter

a. All requested variables entered.

b. Dependent Variable: yar sustainability score

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.863[a]	.744	.704	.62457	1.924

a. Predictors: (Constant), intercropping area(ha), head schooling year, per capita income of livestock, livestock quantity, per capita income of migration, head age, legume growing area(ha), crop diversification Yar, Cropping intensity Yar, yar land area(ha), FYM amount, dependency ratio, head farm experience

b. Dependent Variable: yar sustainability score

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	93.002	13	7.154	18.340	.000[a]
	Residual	31.987	82	.390		
	Total	124.990	95			

a. Predictors: (Constant), intercropping area(ha), head schooling year, livestock per capita income, livestock quantity, migration per capita income, head age, legume growing area(ha), crop diversification Yar, Cropping intensity Yar, yar land area(ha), FYM amount, dependency ratio, head farm experience

b. Dependent Variable: yar sustainability score

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.907	.569		3.353	.001
	head age	-.004	.006	-.047	-.743	.460
	head schooling year	.016	.030	.035	.546	.587
	head farm experience	.063	.036	.759	1.750	.084
	dependency ratio	-.041	.013	-.831	-3.152	.002
	yar land area(ha)	.072	.072	.119	1.009	.316
	per capita income of migration	.000	.002	.004	.069	.945
	per capita income of livestock	.001	.001	.057	.976	.332
	livestock quantity	.014	.008	.144	1.902	.061
	FYM amount	.046	.036	.348	1.270	.208
	Cropping intensity Yar	.004	.002	.131	1.644	.104
	crop diversification Yar	.003	.001	.237	2.870	.005
	legume growing area(ha)	.098	.054	.117	1.827	.071
	intercropping area(ha)	.133	.088	.144	1.515	.134

a. Dependent Variable: yar sustainability score

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	2.0331	6.6734	3.6771	.98943	96
Std. Predicted Value	-1.662	3.028	.000	1.000	96
Standard Error of Predicted Value	.106	.526	.226	.078	96
Adjusted Predicted Value	2.0372	7.4139	3.6879	1.03257	96
Residual	-2.04619	1.98652	.00000	.58026	96
Std. Residual	-3.276	3.181	.000	.929	96
Stud. Residual	-3.553	3.396	-.007	1.018	96
Deleted Residual	-2.40636	2.38390	-.01080	.70798	96
Stud. Deleted Residual	-3.839	3.641	-.003	1.056	96
Mahal. Distance	1.753	66.337	12.865	11.150	96
Cook's Distance	.000	.263	.018	.046	96
Centered Leverage Value	.018	.698	.135	.117	96

a. Dependent Variable: yar sustainability score