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Improving fallow productivity in the forest and forest-savanna transition of Ghana : a socio-economic analysis of livelihoods and technologies

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IMPROVING FALLOW PRODUCTIVITY IN THE FOREST AND FOREST-SAVANNA TRANSITION OF GHANA: A SOCIO-ECONOMIC ANALYSIS OF LIVELIHOODS AND TECHNOLOGIES

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To God be the Glory, Great Things He Hath Done

(MHB 313)

TO DAVE, NANA DARKOA, ADOWA, MY PARENTS, BROTHERS AND SISTERS.

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ABSTRACT

Rotational bush fallowing, the dominant agricultural land-use practice in Ghana is no longer sustainable as fallow periods have declined from over 10 to five or less years mainly due to increased population pressure on land, along with inter alia drought and rampant wild fires. Managed fallows have in recent times been useful in improving short fallow productivity in many parts of the tropics including Sub-Saharan Africa (SSA). However, adoption of agricultural innovation by smallholders has often been poor. This is attributed to the inappropriateness of sound scientific breakthroughs to the complex socio-cultural and economic conditions that characterize rural livelihoods in the SSA. This study forms part of a bigger project that tested and developed managed fallow technologies in a participatory manner in three villages, Gogoikrom, Subriso III and Yabraso in the Atwima, Tano and Wenchi Districts of Ghana respectively. It involves a socio-economic analysis of livelihoods of farmers and their involvement in the development of the technologies to complement bio-physical aspects to ensure that technologies developed suit the socio-cultural, tenurial and economic circumstances of farmers and are adoptable by the farmers.

PRA tools, mainly key informant, group and semi-structured interviews as well as structured questionnaire interviews of 242 households, were employed in collecting data to characterize the livelihoods of the people in the study villages. This guided the identification of suitable fallow improvement interventions and possible domains for their uptake. The data were analyzed descriptively and complemented with a regression analysis and analysis of variance to describe the intra and inter-village similarities and differences. Input-output data on crop, livestock and off farm enterprises were collected and analyzed to estimate farmers' financial resource capacity. Primary and secondary economic data on the technologies were gathered and analyzed through *ex-ante* cost benefit analysis to assess the profitability of the technologies. A chi-squared analysis was carried out to identify the determinants of adoption of the technologies. Community perceptions of the performance of the technologies and adoption potential were assessed and verified with a survey of 99 non-participating farmers. Farmer indicators were developed for evaluating the performance and the design of the experiments by participating farmers. Technology expansion and diffusion of knowledge gained by the experimenters were also assessed.

The study area is characterized by two main classes of farmers, natives (indigenous landowners) and settlers (mainly tenants) whose livelihoods rely largely on the management of natural fallow rotations for the cultivation of a range of crops, i.e. maize, plantain, rice and cocoa for Gogoikrom; maize, plantain, cassava, groundnuts, tomato and pepper for Subriso; and maize, yam, groundnuts and pepper for Yabraso. However, fallow periods have declined and numerous associated problems of which poor soils, high weed pressure, poor yields and low farm incomes are paramount. Four interventions, namely: maize-legume relay suitable for all three districts; plantain-legume for Atwima and Tano; and cocoa-shade tree for Atwima and planted tree fallow for Wenchi were identified for on-farm experimentation after a series of ranking and discussion of interventions proposed at a stakeholder workshop to address the short fallow constraints. The interventions were experimented with farmers over two seasons.

Farmers' assessment of the technologies over the two seasons revealed that the weed suppression and moisture conservation or retention potential of the maize-legume relay had been realized,

while they anticipated improved maize yields and a reduction in labour for land preparation in subsequent years. The major limitation to the use of this technology identified during a monitoring process was labour for weeding before and after relaying the legume to facilitate growth and spread. The labour constraint for relaying the legume can be addressed by targeting this activity to coincide with the first or second weeding as appropriate to the farmer. The weeding after the legume relay is a necessity where weed pressure is high as this may retard legume biomass productivity. The potential effects of the plantain-legume, cocoa-shade tree and planted tree fallow are likely to be realized in the long-term. However, farmers were hopeful that these technologies would address their respective targeted problems based on their judgments of the performance of the technologies at the time.

The *ex-ante* economic assessment of the farmer experiments yielded higher gross margins, returns to labour, B/C ratios, NPV, LEV and IRR than the alternative options in the absence of the technologies but were sensitive to reductions in prices and yields. However, tenure, age and gender differences may be important in technology adoption. Although all the main community groupings participated in technology development it was observed that male tenants and landowners are potential adopters of the most preferred cocoa-shade tree technology in Gogoikrom-Atwima while in Subriso-Tano, middle-old aged, landowner men are potential adopters of the maize-legume relay and plantain-legume technologies. Native landowners including women are the potential adopters of the maize-legume and planted tree fallow technologies in Yabraso-Wenchi.

The participatory technology development process was documented. It was observed that while the process was interactive, enlightening both farmers and scientists, farmers need to be encouraged to take greater control to enhance innovativeness and reduce research cost. Improving fallow productivity should be a national concern, as it has a wider implication on the livelihoods of rural people and that of the economy of the country. The majority of the producers that are directly involved in crop production may be tenants who are unlikely to improve soil productivity due to tenure restrictions. Government policies that encourage landowners to adopt fallow improvement technologies are required. Policies encouraging education, training or extension of improved fallow techniques are useful. Likewise, participatory policy research for improving traditional tenure systems to encourage sustainable land improvement need consideration. Policies that ensure stability in prices of agricultural commodities will improve farm income gained from improved fallow productivity and encourage the adoption of fallow techniques.

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LIST OF ACRONYMS

CARE	Cooperative for Assistance and Relief Everywhere
CRI	Crops Research Institute
CRIG	Cocoa Research Institute of Ghana
DDA	District Directorates of Agriculture
DFID	Department for International Development, UK
EPHTA	Forest Margins Benchmark of the Ecoregional Program for the Humid and Sub-Humid Tropics of Africa
FEWS NET	Famine Early Warning Systems Network.
FORIG	Forestry Research Institute of Ghana
GDP	Gross Domestic Product
GIPC	Ghana Investment Promotion Centre
GOAN	Ghana Organic Agricultural Network
GTZ	Deutsche Gesellschaft für Technische Zusammenarbeit
HFZ	Humid Forest Zone
IBRD	International Bank for Reconstruction and Development
IITA	International Institute of Tropical Agriculture
MOFA	Ministry of Food and Agriculture
NRSP	Natural Resources Systems Programme
NTFPs	Non-timber Forest Products
PAN	Pesticide Action Network
PRA	Participatory Rural Appraisal
PTD	Participatory Technology Development
R & E	Research and Extension
R&D	Research and Development
SCD	Scored Causal Diagramming
SEI	Stockholm Environment Institute
SFSP	Sedentary Farming Systems Project
SRL	Sustainable Rural Livelihoods
SSA	Sub-Saharan Africa
UNDP	United Nations Development Program
UST	University of Science and Technology
UWB	University of Wales, Bangor
[1]£	Great Britain Pound
¢	Ghanaian Cedis

[1] £ = ¢10,000 in 2000, ¢11,000 in 2001, ¢13,000 in 2002 and ¢15,000 in 2003

CHAPTER ONE
INTRODUCTION AND BACKGROUND

This study involves a socio-economic analysis of livelihoods in three farming villages in the forest and forest savannah transition zones of Ghana that served as a basis for developing suitable technologies for improving fallow productivity to enhance crop productivity and ultimately livelihoods in these villages. The study also documents the technology development process, assesses farmers' perceptions and economic viability of the technologies, examines their adoption potential and suggests issues that require consideration to enhance the uptake of the technologies.

1.1 Rationale

Per capita food production in Sub-Saharan Africa (SSA) has consistently declined over the past two decades characterized by an average annual increase in food production of less than 1.5% since 1970 not matching the rise in population. Although this weak agricultural growth has often been partially attributed to unfavourable farm policies, specifically, inappropriate fiscal and pricing policies, inadequate extension and marketing services, the capability of the natural resource base, especially soils, to sustain continued production under current farming practices is questionable (Ehui and Spencer, 1990).

The predominant farming systems in SSA are based on shifting cultivation and related bush fallow systems with minimal reliance on improved farming inputs, (Ehui and Spencer, 1990). Traditionally, the practice entails clearing and burning small plots of land for a few years (1-5 years) cultivation and then abandoning the site for much longer periods (5-20 years) to grow natural vegetation to restore soil fertility. This system is a necessity in the tropics where the productivity of soil under cultivation declines rapidly. The efficiency of this practice is, however, dependent on the duration of the fallow phase and the structure, composition, biomass and functioning (mineral nutrient recycling) of the fallow vegetation (Nye and Greenland, 1960). A significant proportion of crop nutrients are found in the fallow biomass, which is recycled and made available to crops when the fallow vegetation is cleared. It is generally accepted that the capability of the soil to sustain crop production is higher with longer fallow periods as the fallow vegetation becomes richer with, particularly, trees.

Bush fallow rotation is ecologically sound as it relies on natural processes to restore soil fertility decline. However, it requires the availability of abundant land resources to facilitate the rotation of plots to produce adequate food without destroying the soil resource base, as natural soil fertility restoration takes several years (over 10 years) to be adequately achieved. The practice has come under intense criticism as being the main cause of deforestation in the tropics. Contrary, some authors have judged the practice as a "rational farming system that reflects indigenous knowledge accumulated through centuries of trial and error, an intricate balance between products harvested and ecological resilience and an impressive degree of agrodiversity" (Cairns and Garrity, 1999 citing Conklin 1954 and 1957; De Foresta & Michon, 1997).

Until recently, sufficient arable land was available to enable the use of land in this fashion. Population growth and socio-economic changes in recent times have led to a relative shortage of cultivable land, imposing excessive demand on the natural resource base. Coupled with these demographic and socio-economic factors are ecological factors, particularly, weather failures including floods and drought as well as natural and man-made disasters such as wild fires that have persistently degraded vegetation and soils. A combination of these factors has culminated in increasing cropping intensities, thus reducing fallow periods.

The management of short fallow rotations is increasingly characterizing crop production in many farming communities in rural Africa. In Ghana, short fallow rotations of 1-5 years duration are common. *Chromolaena odurata* and several grass species, which in most cases are unable to adequately rejuvenate the fertility of the soil, dominate the fallow vegetation. Short fallow regimes thus cannot sufficiently restore soil fertility to maintain sustainable crop production in most farming communities in Ghana. Where these systems have prevailed for a period of time problems of declining crop yields arising from declining soil fertility and higher weed incidence are common and loss of access to other fallow products such as fuel wood, bush meat, stakes, props for rural construction and so on have been reported.

Improved or managed fallows are short-term fallow improvement technologies being widely promoted for soil fertility replenishment in the tropics, (Niang *et al.*, 2002). According to Kaya and Nair (2001) these fallows are increasingly being experimented with as a measure for sustaining crop production in impoverished farming systems of Sub-Saharan Africa.

Managed fallows involve the deliberate planting of fast-growing, nitrogen-fixing leguminous shrub and tree species for improving soil fertility and nutrient conservation. They are essentially intensive systems with the potential to reduce extensive cultivation of land and reduce fallow length while improving productivity in short fallow systems, where the pressure on agricultural land is high. This implies that they are capable of contributing to the enrichment of the vegetative cover of the current degraded and treeless off-reserve areas or farmlands in some farming communities in Ghana and improving the productivity of soil, the most important assets on which rural people depend for survival. Managed fallows also have the potential to contribute to the development of longer and tree fallows, thereby increasing the range of fallow products such as fodder, fuelwood, poles, stakes, game animals, and so on, hence, diversifying the rural economy.

Agriculture contributes an average of 41% to the gross domestic product (GDP) of Ghana and employs 54% of the workforce (GIPC, 2002), most of who are smallholders, relying entirely on the management of bush fallow rotations for crop production. Consequently, the livelihoods of farmers and ultimately, the economy of the nation are under threat. The need to increase the productivity of rotational bush fallow systems is thus imperative. However, this calls for the development of adoptable technologies that are sustainable and economically viable. The majority of the farmers in Ghana, as in most parts of SSA, are classified as resource-poor farmers. They cannot afford recommended quantities of mineral fertilizers; hence low-cost or low-input technologies that provide alternative sources of nutrients to support crop production are desirable to facilitate adoption and to improve their livelihoods (Kwesiga *et al.*, 1999).

To contribute to improving the productivity of shortening fallow rotations, a project entitled "Shortened bush fallow rotations for sustainable livelihoods in Ghana" sponsored by the Natural Resources Systems Programme (NRSP) of the Department for International Development (DFID) of the United Kingdom was implemented in three districts namely, Wenchi & Tano Districts in the Brong-Ahafo Region & Atwima District in the Ashanti Region of Ghana. The main objective of the project was to improve the productivity of shortened bush fallow systems by testing and developing three interventions (improved management of natural fallow, improved planted fallow and conversion of short fallows into multi-strata agroforestry systems) with farmers in a participatory manner based on their indigenous ecological knowledge, land-use, cultural, tenure and socio-economic circumstances. The project was undertaken over three years, comprising two phases. The first phase of six months was spent on participatory appraisal and knowledge acquisition of farming systems in the three study districts during which their livelihoods were characterized. The second phase of two and half years was spent on developing and testing technologies via on-farm experimentation using a participatory technology development (PTD) approach to improve the productivity of fallows with farmers. The PTD approach was adopted to ensure that the technologies are more applicable to farmer circumstances to ensure a higher uptake.

1.2 Scope of the study

The Bush Fallow Rotations Project comprised biophysical and socio-economic aspects. The author handled the socio-economic aspects and was also involved in project coordination. This study was tailored alongside the main project socio-economic activities in order to satisfy both project and academic requirements within three years of project duration. Both qualitative and quantitative socio-economic data gathered for the project were used for an in depth analysis for this study.

It is often argued that the low rate of adoption of technologies by poor farmers is due to discrepancies between scientifically sound biophysical findings and political or socio-economic realities (Kaya *et al.*, 2000). It is also being increasingly recognized that agricultural innovations in addition to increasing food production, should also maintain ecological stability, preserve the natural resource base (Ehui and Spencer, 1990) and fit into the socio-cultural and economic settings of the target communities. It is for this reason that this study is aimed at conducting a comprehensive socio-economic analysis of the livelihoods of farmers and their involvement in the development of technologies for improving fallow productivity in the forest and forest savannah transition zones of Ghana. This is to ensure that these technologies address constraints related to fallow productivity more appropriately and suit farmers' socio-economic and cultural circumstances. The major research questions that require addressing in order to attain this aim include the following:

1. Who are these farmers, what constitutes their livelihoods (assets, activities and strategies) and to what extent do these livelihoods depend on fallow rotations?

2. What are farmers' resource potentials (natural, human, social, financial and physical and what factors influence their access to and use of these resources for livelihood?

3. What factors constrain farmers' livelihood opportunities, particularly in relation to short fallow rotation and what technologies can adequately address these constraints?

4. How valuable are the technologies developed with farmers to improve fallow productivity from their perspectives? How feasible are the technologies with respect to economic viability, farmers' socio-cultural and tenure set-up and how would these influence the uptake of the technologies?

Addressing these research questions will essentially provide a basic understanding of the dynamics and functioning of the livelihood systems of farmers in the study area, determine the feasibility with respect to the profitability and adoptability of technologies for improving fallow productivity developed with the farmers and identify issues that need to be considered to ensure their uptake.

1.3 Hypothesis and Objectives of the study

1.3.1 Hypothesis

The general hypothesis for this study is that technologies developed for improved fallow productivity in this study are appropriate to the farmers' socio-economic conditions.

1.3.2 Specific Objectives

The specific objectives of the study are as follows:

1 To characterize livelihoods including constraints in relation to fallow rotations to aid in the identification of specific interventions for improving fallow productivity and to determine factors that regulate resource use patterns for the development of suitable recommendation domains for adoption of the interventions

2 To describe and evaluate the PTD process for designing and characterizing the interventions for improving fallow productivity with farmers

3 To evaluate the interventions being experimented with farmers to assess their profitability and feasibility in improving farm productivity and their adoption potential

4 To analyze the interventions in relation to livelihoods and identify implications for the process of technology development with farmers and policy, highlighting issues that need to be considered to enhance technology adoption by farmers.

The relevant information on issues investigated to satisfy all the above objectives was collected at the village, household and plot levels. In each village the population was stratified into four farmer categories based on land ownership status and gender for detailed socio-economic study at the household and plot levels. Table 1.1 summarizes the main issues considered and corresponding data collection and analysis methods for each of the objectives outlined above. The methods are described in their appropriate chapters below.

Table 1.1: Issues investigated and methods used

Objective 1	**Issues investigated**	**Data collection method**	**Data analysis method**
To characterize livelihoods in relation to fallow rotations	Livelihoods capitals/assets and their interrelationships. •Socio-economic/demographic profile of farmers -age, gender, education, ethnicity, household, occupation, etc. •Land resources and use pattern •Land tenure/acquisition •Agricultural production systems -Cropping systems -Soils, weeds & soil fertility management -Livestock production -Labour demand & use -Financial resources, availability & use, -Crop, livestock and off-farm income analyses -Agricultural produce marketing, -etc. •Other services, infrastructure and facilities.	•PRA: group & individual interviews & discussion, farm visits •Questionnaire survey of households & individuals	•Descriptive •Descriptive -Mean -Percentage -Tables -Graph -Charts, etc. •Regression
Characterization of livelihood/production constraints	•Biophysical & socio-economic constraints •Causes & opportunities for addressing constraints	•PRA: Group constraint -Identification - Causal analysis -Diagramming	•Descriptive

Objective 2	Process activities	Method	Presentation
Describe the process of designing and characterizing interventions with farmers	-Identification and selection of study area -Farming system/livelihoods & problems characterization -Development of technology options -Experimentation of technologies -Exposure visits & demonstration areas -Monitoring on-farm experiments -Evaluation of experiments	-PRA (key informant interviews & community meetings, farm visits, etc.) -Individual/household interviews -Stakeholder workshop -Prioritizing technologies -On-farm experiments -Field days -Periodic monitoring - Bio-physical & economic plot level data -Farmer perceptions	Descriptive

Objective 3	Issues investigated	Data collection method	Data analysis method
Evaluation of interventions	•Economic assessment -Profitability of interventions compared with farmer practice -Determinants of participation/adoption *Land status/ tenure, gender, age, profitability of technology, labour, etc.* •Farmer assessment/perceptions -Labour requirements -Soil fertility, crop yield & income improvements -Desirable aspects, limitations & modification of technology design -Prospects of technology adoption & diffusion	•Plot level farm data records -Farmer characteristics -Plot characteristics -Input-output estimation •Matrix of indicators for farmer assessment •Questionnaire interviews of participants & non participants •Group interviews and discussion with participants and non-participants	•Cost/Benefit analysis •Descriptive •Chi-square test Descriptive

Objective 4	Issues investigated	Data collection method	Data analysis method
Analyze interventions in relation to livelihoods and implication for process and policy	•Which intervention is best for which farmer type •Circumstances under which they are suitable (land tenure, labour, cash, gender, farmer characteristics, etc) •Issues in PTD process to be considered for interventions to be appropriate and enhance uptake •Policy issues to be considered to enhance adoption of technologies and improve livelihoods	-	Descriptive

1.4 Study area selection and description

1.4.1 Study area selection

The study was undertaken in three districts, selected according to their ecology, which more or less determines the type of farming system and follows an ecological gradient from the moist forest in Atwima to Savannah transition in Wenchi. Figure 1.1 is a map of Ghana showing the three districts.

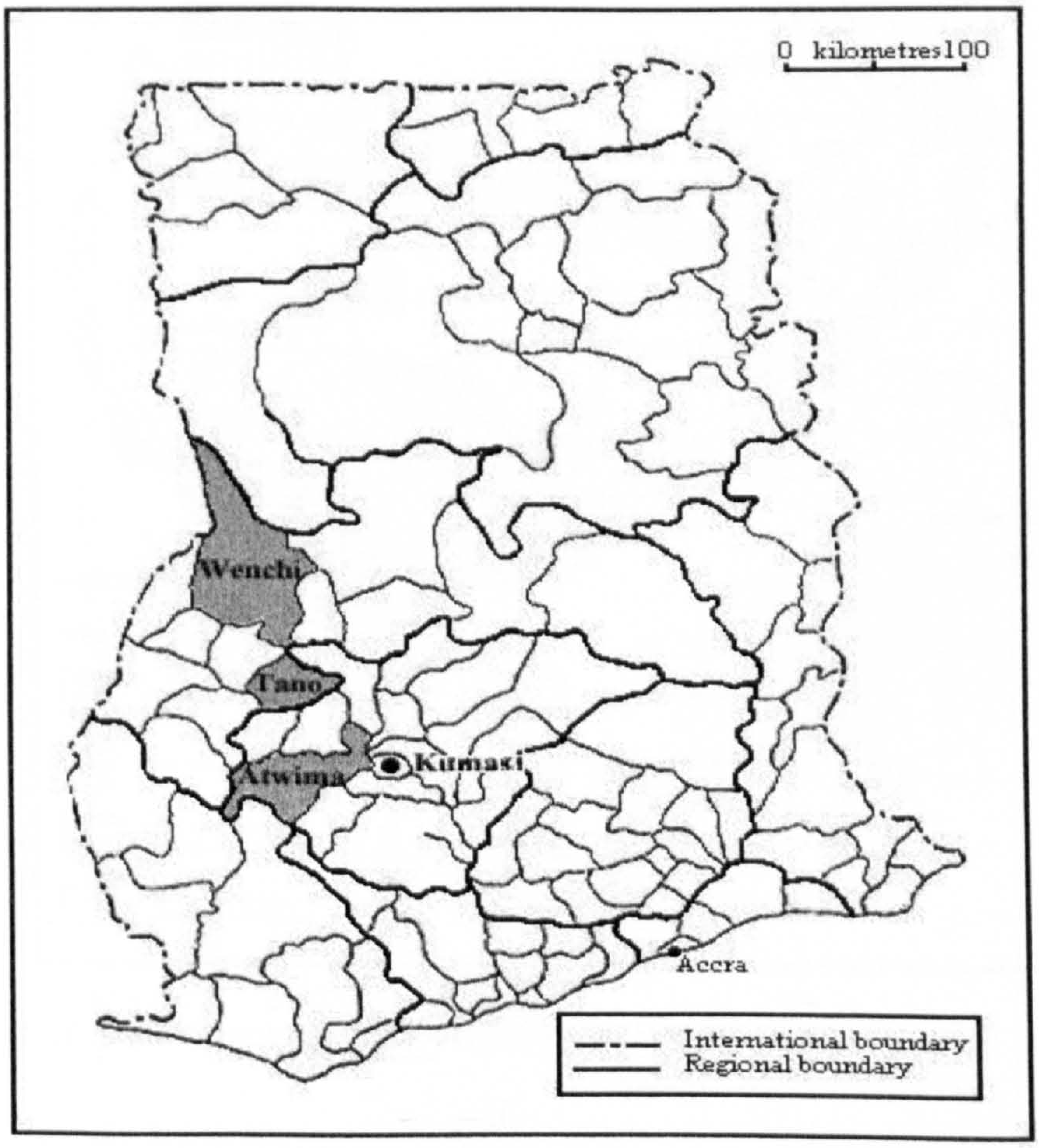


Figure 1.1: Map of Ghana showing study districts

A number of issues were considered in selecting the study districts. Atwima District lies in the moist semi-deciduous forest zone (Southeast Sub-type, Figure 1.2), favourable for cocoa production. The District was selected because it falls within the Kumasi Block of the EPHTA (Forest Margins Benchmark of the Ecoregional Program for the Humid and Sub-Humid Tropics of Africa) Bench Mark for the IITA Ecoregional Humid Forest Centre in Cameroon (a collaborating institution), where some initial characterization of the farming system was underway. This was to enable the Bush Fallow Project to benefit and build on the information being collected. The district is also the major Cocoa District of the Ashanti Region, where most old cocoa lands are being replanted after several years of abandonment and conversion into food crop production. This made it a suitable place for testing and developing the multistrata cocoa-shade tree agroforestry intervention aimed at converting short fallow cropping systems into perennial agroforests.

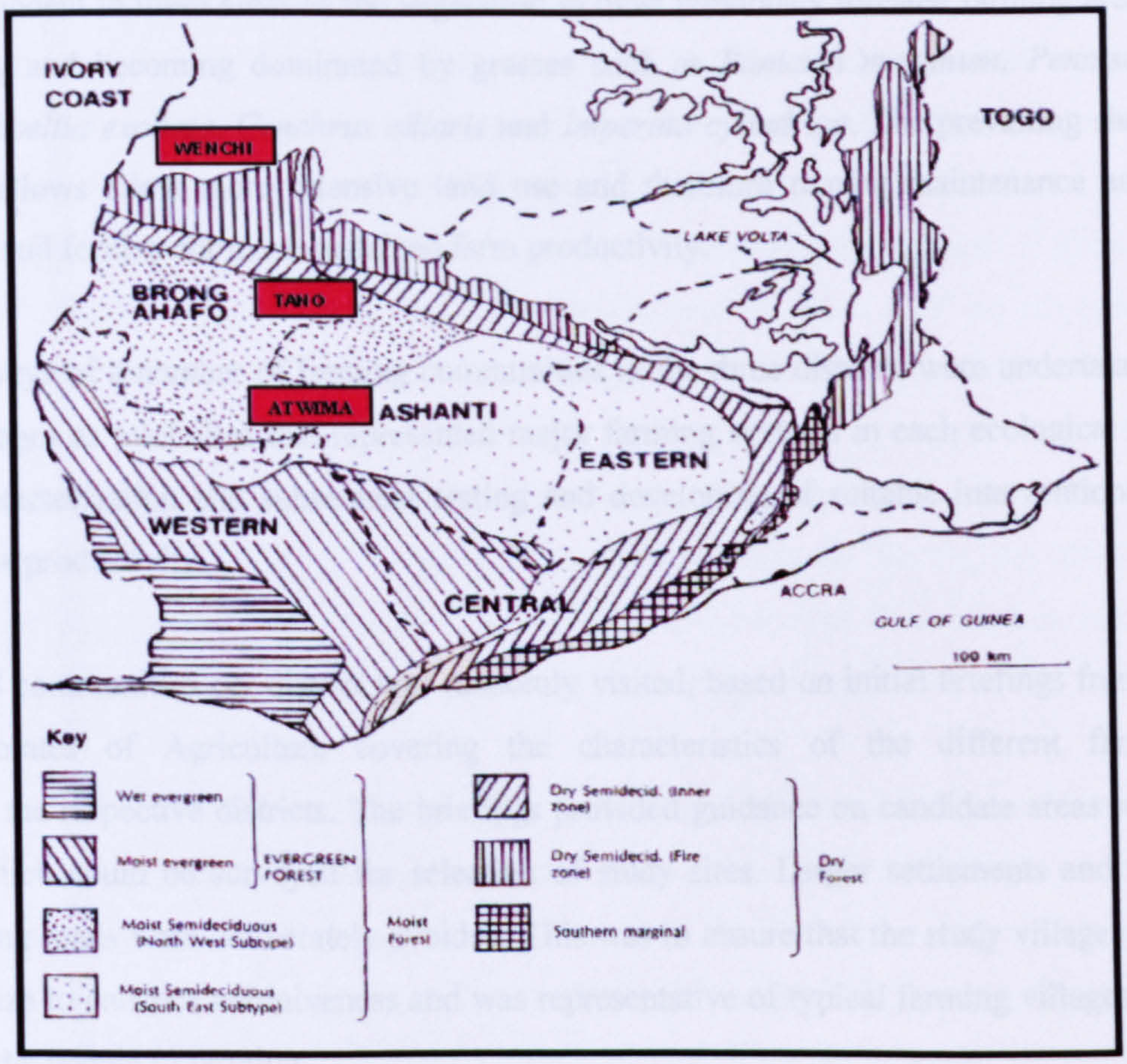


Figure 1.2: Map of Ghana showing the ecological zones of the study districts

Initial contacts with the Brong Ahafo Regional Directorate of the Ministry of Food and Agriculture revealed that other soil improvement projects funded by GTZ and DFID were being implemented in some districts of the region. Tano and Wenchi were selected to avoid duplication because none of such projects was being undertaken at the time. However, it was later realized that the DFID project had introduced organic soil improvement techniques to vegetable producers in some parts of the Tano District.

Tano and Wenchi Districts are located in the moist semi-deciduous forest (Northwest Sub-type) and the dry semi-deciduous (forest-savannah transition) zones respectively (Figure 1.2). They were selected mainly for testing and developing the natural and planted fallow interventions. These districts are typically characterized by seemingly rapidly shortening fallow periods that have been caused by changes in the farming system (resulting from drought, wild fires, population pressure, and so on) from cocoa tree-based into mainly maize, yam and vegetable systems. The process of savanisation is evident in these areas as the vegetation in most previously forested farming areas is rapidly changing and becoming dominated by grasses such as *Panicum maximum*, *Pennisetum purpereum Rottboellia exaltata*, *Cenchrus ciliaris* and *Imperata cylindrica*. The prevailing shorter bush or grass fallows allow more intensive land use and therefore require maintenance and/or improvement of soil fertility for more sustained farm productivity.

Exploratory surveys of a number of farming communities in the three districts were undertaken to select study villages as pilot sites that represented major farming systems in each ecological zone for detailed characterization and subsequent testing and developing of suitable interventions for improving fallow productivity.

An average of 8 communities per district was randomly visited, based on initial briefings from the District Directorates of Agriculture covering the characteristics of the different farming communities in the respective districts. The briefings provided guidance on candidate areas within the districts, which could be surveyed for selection of study sites. Larger settlements and those along major trunk roads were deliberately avoided. This was to ensure that the study villages were not too big in size to enhance cohesiveness and was representative of typical farming villages with the majority of the people in farming.

In each community, an overview of the farming system and the livelihoods of the people was obtained, particularly, social structure, ethnic groupings, occupations, land availability and tenure (acquisition), trends in agricultural production, major crops, soil and fallow management and production constraints. An analysis of the exploratory information led to selection of the study villages. In the Atwima District, Gogoikrom was selected as the study village, whereas in the Tano and Wenchi Districts Subriso III and Yabraso respectively were chosen.

1.4.2 Profiles of study sites

1.4.2.1 Background to study districts

1.4.2.1.1 Location, Size, Topography & Demography

Wenchi is the largest of the three study districts, extending over a total land area of 7619 sq km. It is located in the western part of the Brong Ahafo Region, within latitudes 07^0 30' N and 08^0 45' N and longitudes 02 10' W and 02 45' W. Atwima, the second largest of the three districts, is in the south-western part of the Ashanti Region, covering a total land area of 3564.7 km^2 (9.6% of land area of the country) and located between latitudes 5° 60' North and 5° 62' North and longitudes 1^0 52' and 1^0 9' West. Tano, the smallest of the three districts, spans an area of about 1500 sq km and lies approximately between latitudes 7° 0' and 7° 25' N and longitudes 1° 45' W and 2° 20'.

All three districts have gentle undulating topographies, although these are steep at a few points in Atwima and mainly flat with slopes of less than 1% at Wenchi. Tano has the highest altitude of about 290 metres above sea level, followed by Atwima, where it is between 77 and 94 metres above sea level with Wenchi lowest at between 30 metres and 61 metres above sea level.

Currently, the population of the three study districts follows a gradient, being highest at Atwima and lowest at Wenchi. In 1996 the population at Atwima was estimated to be 427,770 people with a density of 120 persons per sq km, The population of Tano and Wenchi were estimated during the same period to be 142,700 (average growth rate of 3.1%) with a density of 95 persons per sq km and 220,396 (average growth rate of 3.2%) with a density of 29 persons per sq km respectively. The observed population gradient may be explained by the fact that Atwima is closer to Kumasi, the second city of the country and the main economic centre of the northern sector of the country and has larger settlements (peri-urban areas) as compared to Tano and Wenchi which are further away.

1.4.2.1.2 Climate, Ecology, Vegetation & Soils

All three districts are characterized by a semi-equatorial climate marked by a bi-modal rainfall pattern (peaking in June and October), being more wet in Atwima and dryer at Wenchi. The mean annual rainfall in Atwima ranges between 1400mm and 1850mm. It is about 1500mm in Tano and ranges from 1140-1270 mm in Wenchi. Temperatures are fairly uniform across the three districts, with mean monthly minimum and maximum temperatures of 26°C and 31°C occurring in August and March respectively. Relative humidity is generally high between 70 and 82%.

Atwima District falls within the moist semi-deciduous ecological zone with such vegetation characterized predominantly by Celtis-Triplochiton Floristic Association. Although Tano District is also located within the same ecological zone, its vegetation is largely of the dry semi-deciduous forest type, characterized by Antiaris-Chlorophora floristic association, (IBRD, 1986 & 1987). Wenchi is characterized by the moist-semi-deciduous and Guinea Savannah woodland ecological zones. The vegetation is characterized by an Antiaris-Chlorophora association and guinea savannah woodland (IBRD, 1986). The original forest vegetation has largely been disturbed in all three districts mainly through indiscriminate bush burning, slash-and-burn agriculture, logging and felling of trees for fuel over the last few decades. Thus, in certain parts of the districts, the vegetation is rapidly changing into *Chromolaena odurata* (Acheampong) and grasses notably, *Panicum maiximum* (guinea grass) with scattered trees and thickets. Grass-dominated vegetation progresses from relatively low in Atwima to high in Wenchi.

The predominant soils found in the Atwima and Tano districts are the forest ochrosols, although forest ochrosols-oxysol intergrades are also found in Atwima. In Wenchi, the soils are predominantly the savannah ochrosols, with some lithosols and brunosols. Forest ochrosols also occur within the deciduous forest part. The ochrosols are typically well drained and fertile, and hence important for agricultural production as they support a wide range of food crops (maize, cassava, plantain, yam, cocoyam, etc). This makes the forest ochrosols very important for agricultural production. The oxysols on the other hand, are prone to leaching and support mainly tree crops (cocoa, oil palm and citrus) (Atta-Quayson, 1999).

1.4.2.1.3 Local economy

Agriculture is the main economic activity of the people in all three districts, employing 67, 64 and 76% of the working population in the Atwima, Tano and Wenchi Districts respectively. Farming is generally at subsistence level with few exceptions engaged in commercial farming. The hoe and the cutlass (machete) are the main farm implements used and farm holdings or plot sizes cultivated are typically small. For instance, in the Atwima District, the average farm size is 2.5 acres (1 hectare) with as many as 64 percent of farmers owning less than six acres (2.9 hectares) of farmland (Atwima District Assembly, 1996). Both staples and vegetables produced are largely for sale with some household consumption in Atwima, Tano and Wenchi. Intercropping and crop rotations are commonly practiced; however, vegetables produced on a commercial basis are cultivated in monocultures.

The major food crops or staples cultivated in Atwima and Tano are maize (*Zea mays*), cocoyam (*Xanthosoma spp*), cassava (*Manihot esculantum*) yam (*Rotunda spp.*) and plantain (*Musa spp.*) with rice (*Oryza sativa*) cultivated on a minor scale but more in Atwima than Tano. In Wenchi maize, rice, groundnut (*Arachis hypogaea*), millet (*Pennisetum typhoides*), sorghum (*Sorghum bicolor*), soya bean, cowpea (*vigna unguiculata*), yam and cassava are the food crops grown. Vegetables such as tomato (*Lycopersicum esculanta*), garden egg, okra and pepper (*Capsicum spp.*) are also cultivated in all three districts. In Atwima, vegetable production for the urban market in Kumasi is gaining prominence.

Cocoa (*Theobroma cacao*) is a major tree cash crop in Atwima and Tano. The main tree cash crops in Wenchi are cashew (*Anarcadia occidentale*) and mango (*Mangifera indica*). Oil palm (*Elais guinensis*) and citrus are produced on a minor scale in all three districts. In Tano, coffee is cultivated, but also on a minor scale.

Livestock production in all three districts is at the subsistence level with small numbers of poultry, sheep, goats and pigs commonly kept for sale and consumption; nevertheless, a few large-scale poultry establishments may be found, notably in Atwima. Cattle rearing can also be found in Wenchi.

Agricultural extension services are woefully inadequate in all study districts. For instance, in Atwima, only 37% of farmers have access to extension services with an extension officer-farmer ratio of 1:1174 (Atwima District Assembly, 1996).

1.4.2.2 Background to study villages

Gogoikrom in the Atwima District is situated about 48km from Kumasi. The map of Atwima District is shown in Appendix 1. Subriso Number III is located at the northern border of the Tano District with the Ashanti Region as shown in Appendix 2. Yabraso is found 19 mm north-west of Wenchi, the district capital and 10 km from Nsawkaw as shown in Appendix 3. Nsawkaw is important because the indigenes/natives of the village migrated from there and still have strong economic, social and cultural links with the town.

Gogoikrom is at the end of a dirt road that links it with Nkawie, the district capital and Kumasi, the capital of the Ashanti Region and a nodal business or economic centre for the northern sector of the country. Subriso and Yabraso, on the other hand, have the dirt roads, which are also passable throughout the year, running through them and linking them to respective centres of administration and markets.

The three study villages differ considerably in terms of size. Gogoikrom-Atwima is the smallest of the three villages. It has 58-60 houses in a nucleated type of settlement and a population of about five hundred (500) people out of whom about 125 were adults and about 110 were between the ages of 0-5 years in the year 2000. Yabraso-Wenchi is medium and had 175 houses with a population of 960 people, comprising 600 males and 360 females in 2000. Subriso III, the biggest of the three, has 351 houses and had a population of about 2,560 people in 1998 with the males dominating.

The population of each of the villages is multicultural, comprising of a number of ethnic groups, broadly classified as natives and settlers based on residential status. The natives are the indigenes and originate from the various traditional areas in which the villages are situated, namely Atwima, Tano and Nsawkwaw traditional areas for Gogoikrom, Subriso III and Yabraso respectively. In Gogoikrom, the natives are Ashantis and are in the minority. They originate from bigger towns such as Twedie, Apre and Mapasatea in the Atwima area. At Subriso III, the natives, who are also in the minority, are Brongs (or *Bonos*) and originate from Techimantia, a town about 13 km away, south of the village. On the other hand most of the inhabitants of Yabraso are natives with their ancestors migrating from Nsawkaw and other parts of the Brong Ahafo Region. They are also Brongs (or Bonos) people.

The settlers, the majority of whom live permanently in the villages, obviously originate from other areas of the country outside these traditional areas. Across the three villages, the majority of the settlers commonly originate from northern Ghana (Northern, Upper West and East Regions). The others are from other districts in the Ashanti and Brong Ahafo Regions in which the study villages are found as well as Eastern, Central and Volta Regions of Ghana. Some settlers also trace their origins to neighbouring countries such as Burkina Faso, Mali, Ivory Coast and Niger.

The inhabitants of the three study villages are predominantly farmers. Historically, all three villages have links with cocoa production. The drought and fires of 1983 dramatically changed the local economies of Subriso and Yabraso into food-crop based (maize, yam and cassava), as the agro-ecologies are devoid of important shade trees and have become drier and prone to persistent annual fires that have eroded the supporting forest vegetation required for cocoa production (Obiri *et al.*, 2000). By virtue of being located in the moist forest zone, the wild fires affected Gogoikrom least, thus cocoa production still characterizes the local economy.

The three villages are similarly structured socially. Each has a chief, who together with his elders rules the village traditionally. There is also a Unit Committee (with its chairman) and an Assemblyman who represent the community at their respective District Assemblies. The other community members have a say in all community issues. Taboo days (Tuesday for Gogoikrom and Subriso; Friday for Yabraso) are essentially rest days on which no farm activity is undertaken, however, they are also important for community work, marketing, funerals & other social functions. During the study taboo days were useful for holding community meetings and farmer field days. A number of community societies including churches are found in the villages; however, these are geared towards welfare activities (funerals, etc.) with little or no links with farming activities except in Yabraso, where maize and yam associations are more functional.

1.5 Limitations of the study

The major limitation encountered in the study concerns the insufficiency of economic data for assessing the profitability of the technologies developed with farmers, since the real effects of the technologies are realized in the long term. Nevertheless, the limited economic data gathered over the two years of experimentation is supplemented with primary data from other aspects of the study and secondary data from relevant sources for an *ex-ante* profitability assessment of the technologies.

1.6 Organization of the thesis

The thesis is organized into six chapters besides this one. Chapters Two to Six report the main findings of the study and are structured in a similar manner, each consisting of a brief introduction objective of the chapter, methods of data collection and analysis, findings and discussion and a summary to conclude the chapter.

In Chapter Two, the livelihoods of the three-study villages are qualitatively characterized in relation to fallow rotations. The qualitative analyses of the livelihoods led to the identification of suitable interventions for improving fallow productivity, which were experimented with farmers in the villages. Chapter Three describes the process for developing the interventions otherwise referred to in this thesis as technologies experimented with.

In Chapter Four, the livelihoods of the three study villages are quantitatively characterized, in order to assess the livelihood strategies and major distinguishing features that regulate access to and use of assets and also to assess the resource potentials of farmers. The output from Chapter Four is intended to assist in determining suitable recommendation domains for the technologies for improving fallow productivity. An economic analysis of the technologies, assessing their profitability and adoption potential is presented in Chapter Five. In Chapter Six farmers' assessment and perceptions of the technologies are also presented particularly to assess management feasibility and potential adoption and diffusion. Chapter Seven concludes the study with an analysis of the major findings in relation to livelihoods and adoption of the technologies and spells out implications for policy.

CHAPTER TWO
QUALITATIVE CHARACTERIZATION OF LIVELIHOODS

2.1 Introduction

The literature is replete with definitions of the term livelihood. It is defined as 'the capabilities, assets (including both material and social resources) and activities required for a means of living' (Carney, 1998; Scoones, 1998). Alternatively, it can be described as 'the activities, the assets and the access that jointly determine the living gained by an individual or household' (Ellis, 1999).

Most rural livelihoods in Sub-Saharan Africa depend on natural resources. Consequently, sustainable management of these resources is critical to the survival of rural people. Sustainability may be defined as "the ability of a system to maintain a certain well-defined level of performance (output) over time, and if required to enhance the same, including through linkages with other systems, without damaging the long-term potential of the system" (Dittoh *et al.*, 1997). With respect to the natural resource base it may be defined as the use of natural resources in a manner that does not eliminate or degrade them, or diminish their usefulness for future generations. At the rural and farm levels the essential concern is that the production system should not collapse in the foreseeable future (Upton, 1996).

According to Upton (1996) there are two ways in which the collapse of the system may occur. One way may be as a result of chance fluctuation or shock such as drought or flood from which the system may be unable to recover. If the system is sufficiently resilient to recover then it may be sustainable. The other alternative is collapse due to a gradual decline in the stocks of resources and household incomes. Sustainability requires that this decline be prevented by adequate conservation measures. Essentially, the rate of off-take (e.g. mining of soil nutrients) should be less than the rate of new growth. Stocks can only be conserved by careful control of the rate of off-take. Consequently, a livelihood may be described as sustainable when it can "cope with and recover from stresses and shocks and maintain or enhance its capabilities and assets both now and in the future, while not undermining the natural resource base" (Carney, 1998; Scoones, 1998).

The livelihood concept has been applied in research and development agenda, particularly for developing countries, in understanding how the poor draw upon a range of different assets and activities to achieve their well being. Specifically, the concept has found usefulness in policy matters and others relating to health, trade, agriculture and natural resource management, research for technology targeting, etc. A proliferation of frameworks has been developed for livelihood conceptualisation and analysis by several authors including DFID, OXFAM, UNDP and CARE International (Pardey, *et al.*, 2001). The frameworks differ in the elements that are recognised, the emphasis placed on those elements, and the extent to which the relationships between the elements are described (Witcombe, 2003). Nevertheless, they are modelled around five capital assets namely, natural, human, social, financial and physical capitals that are commonly relied on for livelihood by rural people and thus can be regarded as livelihood building blocks. They commonly demonstrate how rural people make a living out of available assets and cope and survive in the face of shocks and disasters (Soussan, 2002). Table 2.1 summarizes the DFID concept of livelihoods.

Table 2.1: Capital assets related to the sustainable rural livelihood concept

Capital Asset	Definition	Examples
Natural capital	The natural resource stocks from which resource flows useful for livelihoods are derived.	Land (including soil type and quality, altitude), water, forests/vegetation, wildlife (animals, etc.) biodiversity, climate and other environmental resources
Social capital	The social resources upon which people draw in pursuit of livelihoods or the institutions, relationships, networks and norms that shape the quality and quantity of a society's social interactions or social cohesion	Networks, membership of groups, relationships of trust, access to wider institutions or Kinship ties, power, relationships, rights and responsibilities, formalised institutional relationships (government, law and judicial system, civil and political liberties
Human capital	The skills, knowledge, ability to labour and good health important to the ability to pursue different livelihood strategies Or The level of skills and knowledge and the ability to use them	Muscle, brain and health (natural ability) plus expertise/training/education amounting to labour and enterprise
Physical capital	The basic infrastructure and the production equipment and means which enable people to pursue their livelihoods	Infrastructure - transport, shelter, water, energy and communications Production equipment-machinery, animal/draught power, seeds, fertilizer, irrigation and drainage
Financial capital	The financial resources which are available to people and which provide them with different livelihood options	Cash-savings, supplies of credit, regular remittances or pensions Gold, jewellery, household assets, etc.

Source: Adapted from Carney (1998)

The DFID version of the Sustainable Rural Livelihoods (SRL) concept is embedded in a SL framework that serves as an analytical structure portraying the complexity of livelihoods and also helps in understanding influences of poverty and identifying where interventions can best be made.

SRL is systems-based and people-centred while not compromising for sustainable use and management of the environment. More generally, it puts the poor at the centre of analysis and aims to identify interventions to meet their needs and opportunities through a comprehensive analysis of their assets. The basic assumption underlying the SRL framework is that people pursue a range of livelihood outcomes (health, income, reduced vulnerability, etc.) by drawing on a range of assets to pursue a variety of activities. Rural people often pursue multiple activities and outcomes. For example, one may depend on income from his/her own farming, sell labour locally for money or migrate elsewhere to work for money, all within the same year. Livelihood outcomes will not only be monetary or even tangible in all cases. They may include intangible ones like a sense of being empowered to make wider or clearer choices. Examples of general livelihood outcomes include more income, increased well-being, reduced vulnerability, improved food security and more sustainable use of the natural resource base (Farrington *et al.,* 1999).

Activities people undertake and ways they reinvest in asset building are partly driven by their own preferences and priorities. However, they are also influenced by types of vulnerability including shocks such as drought, trends in for instance resource stocks and seasonal variations. Options people make for livelihood are also determined by structures such as government or private sector roles and processes like institutional, policy and cultural factors. All these in total dictate their access to assets and livelihood opportunities and the way in which, these can be converted into outcomes (Farrington *et al.*, 1999), such as their wellbeing.

On the whole, the various frameworks as well as the burgeoning literature on livelihoods point to the fact that rural people in developing countries pursue complex or diverse livelihoods by drawing upon a number of assets. These assets play specific, though interconnected roles and the wider natural, social, political and economic environment play important roles in mediating access to assets. They also acknowledge that the interconnections between the various livelihood assets exploited for survival are complex and that an understanding of this complexity is critical if the livelihoods of rural people are to be improved (Ashley *et al.,* 2003). Of utmost importance is the understanding of the variability within the assets and the interactions between them such that the potential effects of interventions on livelihoods can be predicted (Carney, 1998). However, it is only the UNDP framework that incorporates the role of technological innovation as a driver for improving livelihoods (Figure 2.1).

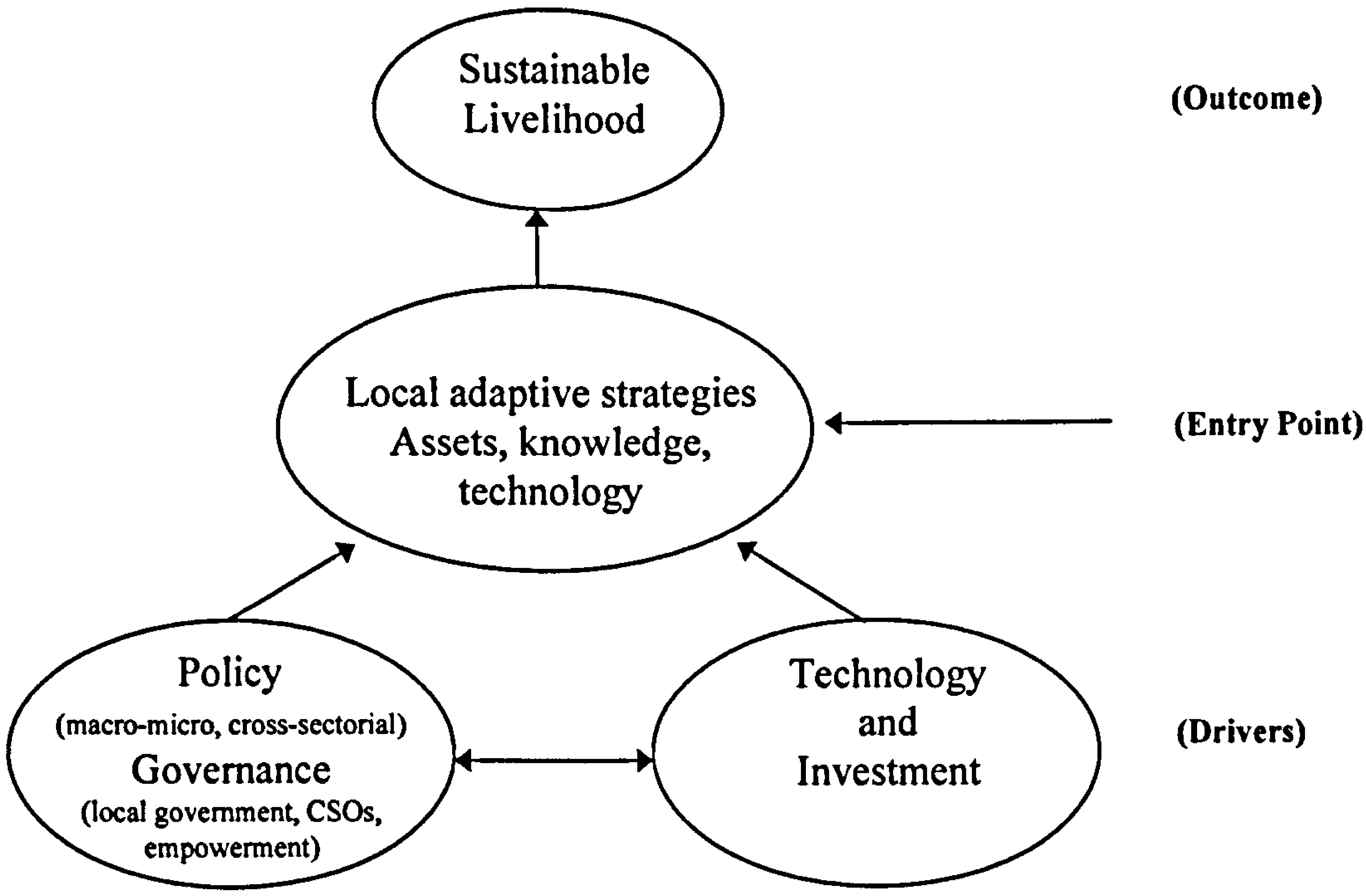


Figure 2.1: UNDP's approach to sustainable livelihoods (Adapted from Witcombe, 2003)

According to Witcombe (2003) human development has been heavily dependent on technology. The Industrial and Green Revolutions are typical examples of the potential of technology in enhancing economic and physical well being of people. Witcombe (2003) argues that lack of adoption of improved technologies is the main cause of poverty among rural people and that appropriate technology can transform the lives of the rural poor.

2.2 Objective & methods

The main objective of Chapter Two is to qualitatively characterize livelihood systems in the Forest and Forest-Savannah Transition Zones of Ghana. This is to aid in understanding the dynamics of the livelihood strategies of the people and their links with fallow rotations to aid in the identification of appropriate interventions for improving the productivity of fallow regimes. More specifically, the qualitative characterization identified general livelihood sources and assets, categories of farmers, uses of livelihood assets in pursuing livelihood activities especially crop production, conditions under which the assets are being utilised including availability and the level of access by the various farmer categories. Factors that militate against the use of assets, interconnections between assets and links with fallow rotation are also described.

Participatory rural appraisal (PRA) methodologies namely, key informant, group and individual interviews and discussions; resource mapping, transect walk and farm visits were employed in gathering both primary and secondary information from the study communities for the analysis. The key informant interviews were conducted during an exploratory survey to select study sites, establish a rapport with district and village authorities as well as village people in general for a quick overview of the farming system. Village level meetings during which community resources were mapped helped in determining community resources, their importance and establish farmers' understanding of their resource potentials.

Group and individual interviews and discussions were then used for gathering more detailed information on the farming system (including farmer ecological knowledge) and livelihoods, as well as for the analysis of production constraints after classification of the village population on a residential and land status basis. The transect walk and farm visits were then done to validate issues discussed during the various key informant and group discussions. Issues of interest during this exercise included farm types, cultural practices, cropping patterns, characteristics of soils, trees on croplands and fallows types, and so on. Detailed descriptions of the various PRA methods are presented in Chapter Three. The checklist of issues covered is presented in Appendix 4.

The livelihood analysis largely uses diagrams to portray the general livelihood pattern of the study communities. Visualization techniques were employed in drawing livelihood diagrams which show the differences in farmer categories and the interconnections between assets they rely on for their livelihoods, namely land, labour, capital, tenure, livestock and so on. The analysis centres mainly on characteristics of the people, their access to land (the main natural asset on which their livelihood as farmers is hinged) and uses of the land for various farm enterprises. Labour, finance and marketing issues associated with farm production have also been mentioned briefly as well as the contribution of other complementary sources of livelihoods including livestock rearing and off-farm employment. An elaborate quantitative description of the various livelihood aspects of the study villages is presented in Chapter 4.

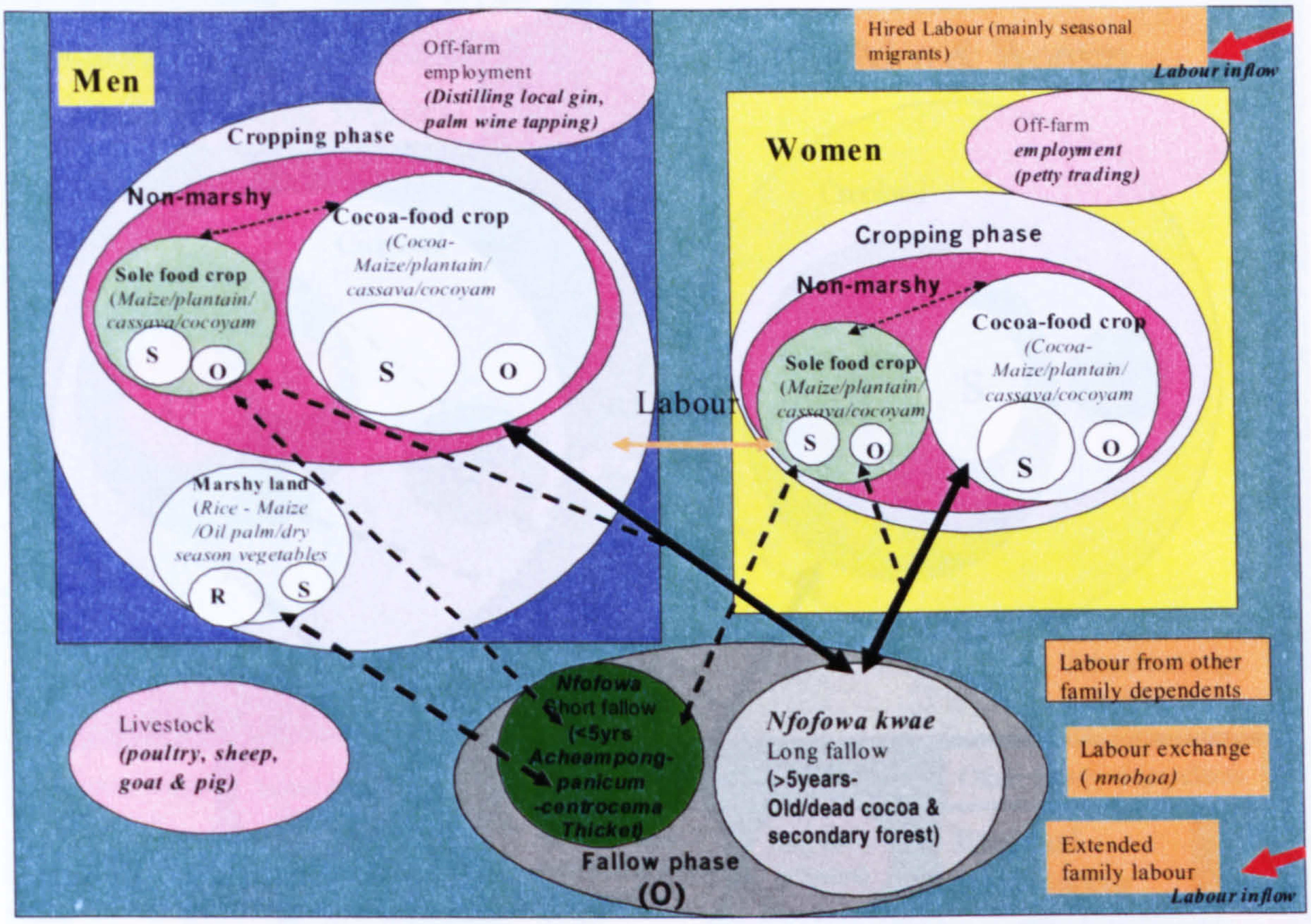
2.3 Livelihoods of Gogoikrom, Subriso III and Yabraso

The livelihoods of the people in the three villages are mainly agriculture-based which in turn is based on landownership status of individuals and households, which governs their ability to access and use land either for cultivation and/or fallow. Two main livelihood systems, native and settler livelihood systems, have been distinguished in all three villages primarily based on the origin or residential status of the people. The farmers identified this criterion as the main distinguishing feature of the village population which dictates the land tenure and to some extent the agricultural land use options between the two sets of households in most cases.

The natives are, by status, the original land owning group, possessing a greater proportion of the farm land supplied to the settlers under various tenure arrangements depending on crop type, either by rental with cash or sharecropping or even as gifts particularly, in the olden times such that some settlers also own land inherited from ancestors who settled in the villages several years ago. Natives may rent or sharecrop in some cases to supplement land owned. Each livelihood system has been further distinguished on a gender basis since gender forms an integral part of rural livelihoods and men and women may have different assets, access to resources and opportunities (Ellis, 1999). Consequently, the livelihoods of four categories of farmers namely, native men, native women, settler men and settler women are described.

2.3.1 Human resources

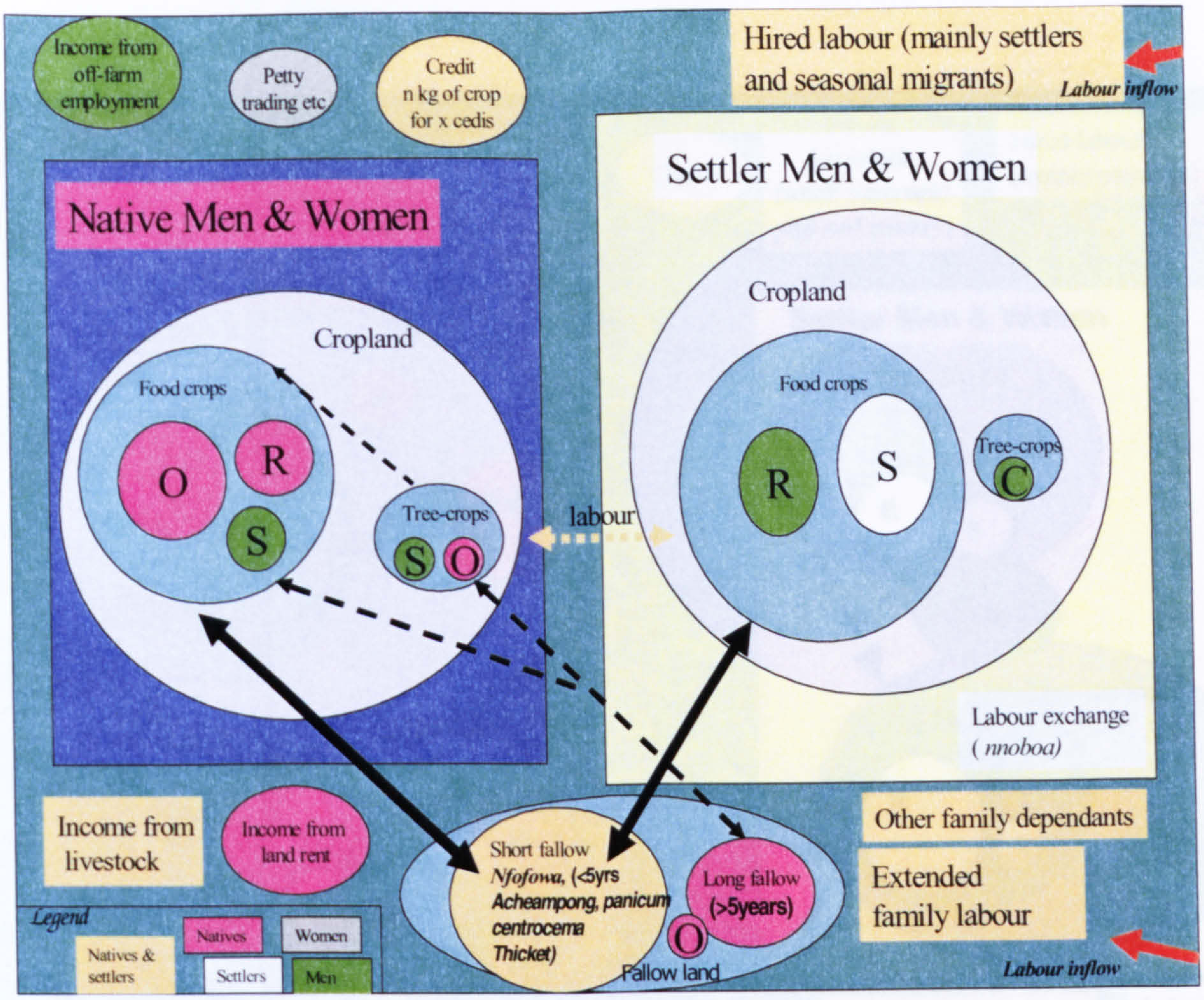
Figures 2.2-2.4 describe the main livelihoods systems in Gogoikrom, Subriso III and Yabraso. The full and broken arrows represent the major and minor land rotations respectively. The population of the three villages is commonly characterized by two main classes of farmers, natives/indigenes and settlers/migrants in variable proportions and is dominated by males. In Gogoikrom, the majority of the inhabitants are settlers (depicted by the bigger white circles S and R relative to O in Figure 2.2 with respect to access to land for cultivation). The majority of the natives are absentee farmers contracting the settlers, mainly from northern Ghana, as caretakers or tenants to establish and/or manage cocoa plantations based on a variety of tenure arrangements.



[1]**Figure 2.2: Livelihood system of Gogoikrom-Atwima District**

The inhabitants of Gogoikrom believe there is essentially not much difference in the way in which the different categories of farmers, i.e. natives and settlers or landowners and non-landowners as well as men and women access and use land for cocoa production, the main enterprise they pursue for their livelihoods. The livelihood diagram presented in Figure 2.2 is largely based on this premise, although some differentiation in gender-related niches is shown.

[1] *O-own land, R-rent, S-sharecrop*



[2]**Figure 2.3: Livelihood System of Subriso III-Tano District**

In Subriso III and Yabraso native and settler livelihood systems are distinguished as their access to land and its use pattern differ in some regards (Figures 2.3 and 2.4). The relative proportion of natives and settlers in Subriso was not very certain. However, the sizes of their respective living quarters in the village suggested that the population was dominated by settlers as they occupied a larger land area as compared with that of the natives (Figure 2.3).

In contrast to Subriso, most of the inhabitants of Yabraso are natives with the settler/migrant population being itinerant, the majority coming in seasonally from northern Ghana to work as hired labourers during the major season and others to cultivate maize or yam on rented fields or to burn charcoal, although a number of them remain permanently.

[2] ***O-own land, R-rent, S-sharecrop, C-caretaking***

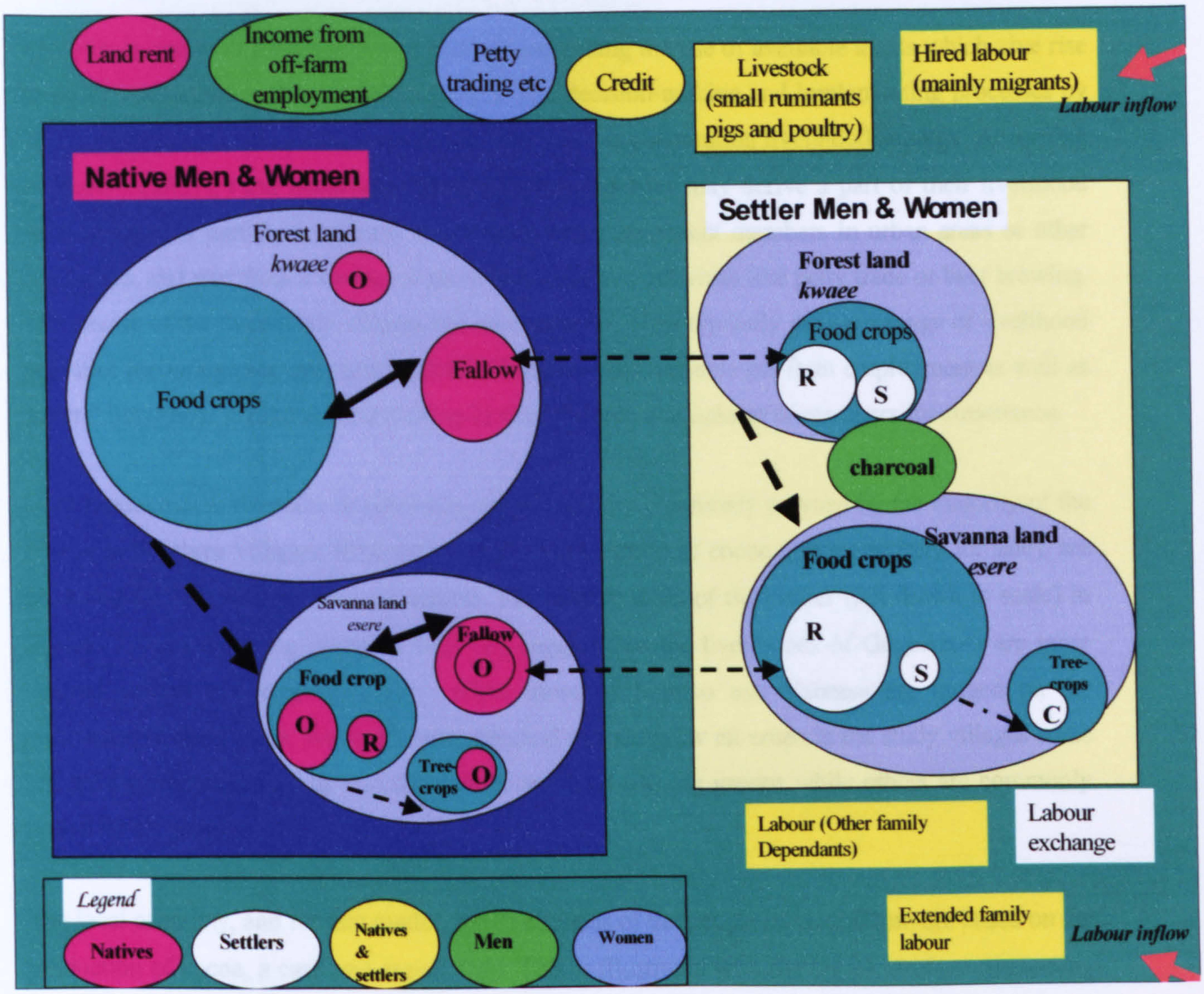


Figure 2.4: Livelihood System of Yabraso-Wenchi District

There are a number of social institutions in all three villages. Apart from the chief and his elders forming the traditional symbol of authority, there are the Christian and Islamic religions to see to the spiritual and moral upbringing of the people as well as serving other welfare purposes. Unlike Gogoikrom and Subriso, there are a number of more functional associations in Yabraso including the Christian Mothers' Association, (a ladies club of the Roman Catholic Church); *Anidaso Kuo* (assisting members during funerals); *Bayere Mmoa Kuo* (Yam help association), Maize Sellers (around 30 people) and Cashew associations for general welfare and facilitating production of these crops.

2.3.2 Livelihood activities

Livelihoods are built from a series of choices concerning the use of available assets which give rise to livelihood activities (Soussan *et al.* 2001). The decision-making and implementing processes by which choices are made for survival can be described as constituting livelihood strategy. According to Murray (2001), rural households in developing countries may derive a part of their livelihood from farming, a part from migrant labour undertaken by absent members in urban areas or other rural areas, and part from a variety of more or less formal activities like petty trade or beer brewing. The people of the three study villages are no exception. They typically pursue a range of livelihood activities including crop production, livestock rearing and variable off-farm employment as well as general household maintenance including having children and upkeep of members for sustenance.

Crop production is the main livelihood/economic activity commonly pursued by the majority of the people in the three villages. Most crops, with the exception of cocoa (grown entirely for sale), are produced for sale with some consumption. The relative sizes of the circles (not drawn to scale) in Figures 2.2-2.4 depicting cropping activities suggest that the livelihoods of Gogoikrom are more centred around tree crop cultivation while those of Subriso and Yabraso are hinged on the cultivation of food crops. Although both men and women grow all crops in the study villages some are grown predominantly by specific gender and land owning groups while others are commonly grown by all people.

The local economy, and for that matter, the livelihoods of the people of Gogoikrom are based on the production of cocoa, a cash and export crop. This is illustrated with the bigger circles representing the relative size of cocoa farms in Figure 2.5. Both men and women pursue cocoa farming for their livelihood in Gogoikrom. According to the farmers, every household in the village has some parcel of land under cocoa, which is the prime reason for their presence in the village. Some of these plots have been inherited from relatives. The farmers also reported that women tend to have smaller plot sizes than men, although generally, the size of plot cultivated most often depended on availability of adequate land at the disposal of the farmer. It also depends on individuals having adequate money to rent or engage hired labour to clear a sizeable piece of land.

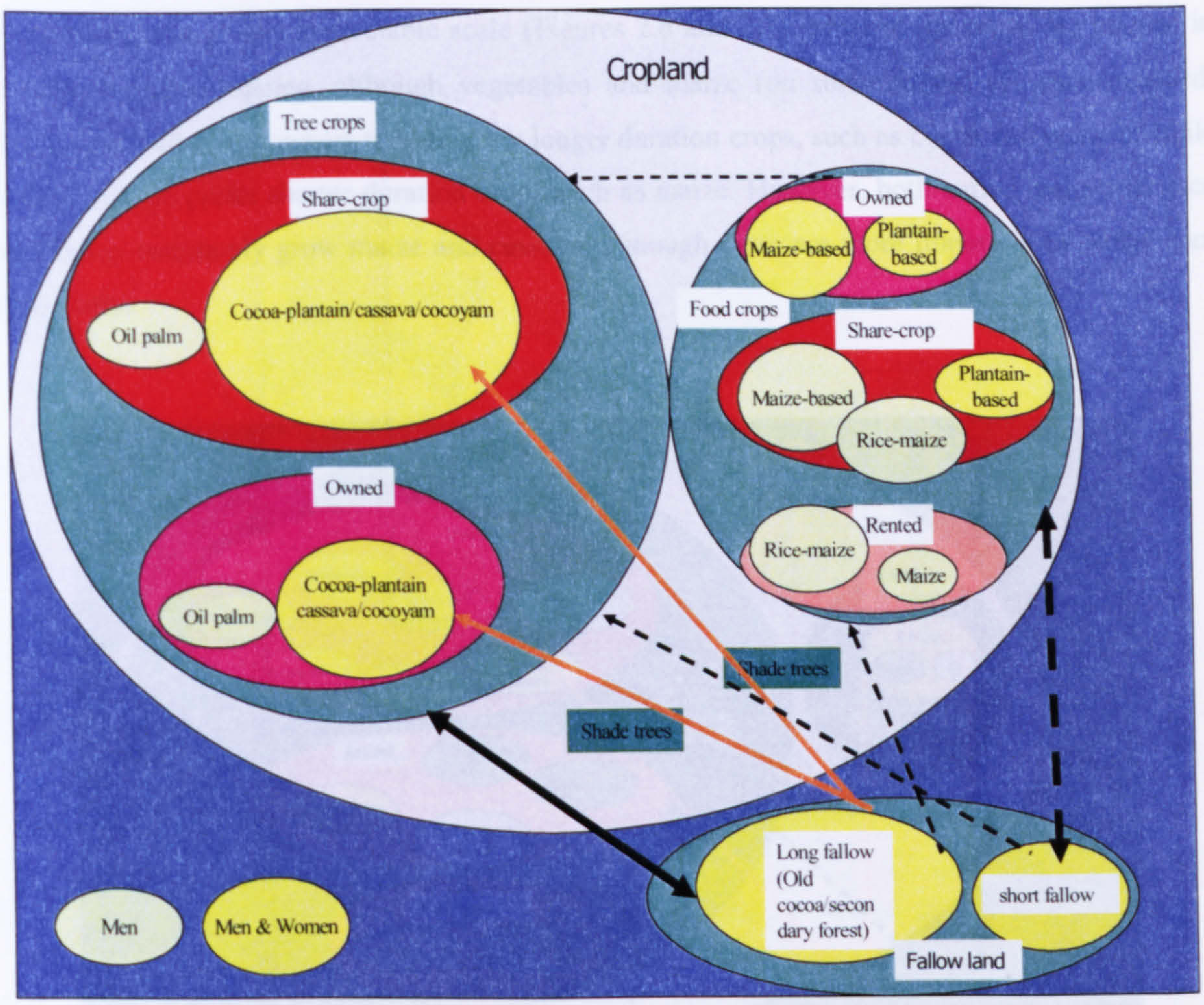


Figure 2.5: Major crops grown by men and women in Gogoikrom

Cocoa is a long gestation crop starting to bear fruit from 3 to 4 years or more depending on the variety. Cocoa is planted in mixtures with maize, plantain, cassava, and cocoyam during this initial period to provide early shade to the young cocoa plants, earn income while tending the crop as well as provide food for the household. The majority of people in addition cultivate separate fields in mixes of maize, plantain, cassava and cocoyam and in some cases rice as sole food plots, again for money and food to support cocoa production. Of course, the food farms are necessary to provide household food needs when the cocoa closes canopy in addition to serving as diversified sources of income. Farmers say oil palm cultivation is a recent practice in the village with few farmers involved. Dry season vegetable production on wetland is also done by the youth, some of whom are migrants who come to the village from other areas mainly for this purpose.

The people of Subriso predominantly cultivate maize, plantain, cassava, cocoyam and vegetables such as tomatoes, garden eggs and pepper for livelihood. Some cocoa and oil palm are also produced but not on any appreciable scale (Figures 2.6 and 2.7). Most of the crops are planted in mixtures by intercropping, although vegetables and maize (on some fields) are monocropped. Natives and settler landowners tend to grow longer duration crops, such as cocoa and plantain while landless settlers prefer shorter duration crops such as maize. However, both native and settler men and women commonly grow maize and cassava, although these are more important to settler non-landowners.

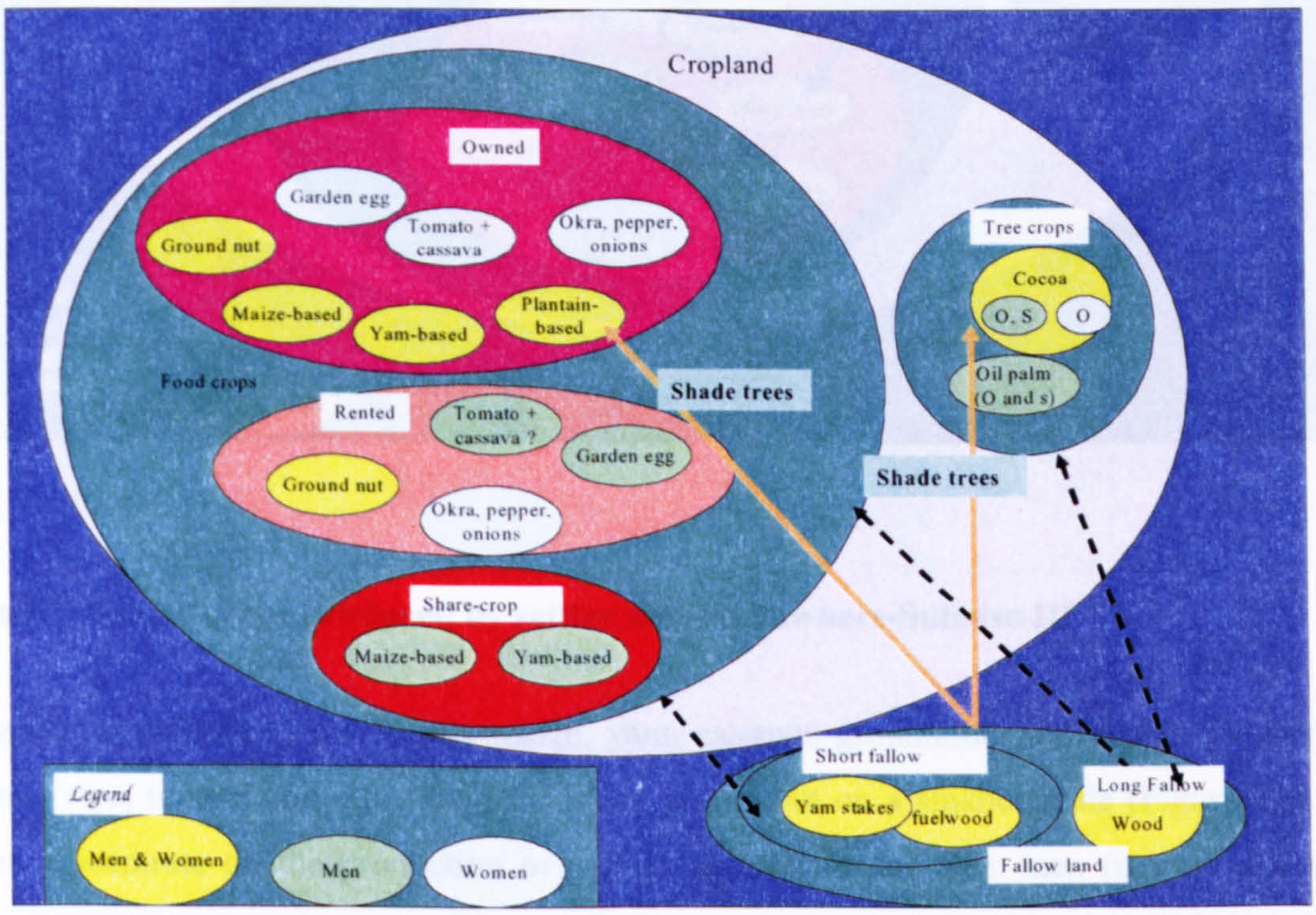


Figure 2.6: Major crops grown by natives and settler landowners-Subriso III

Maize and vegetables (tomato and garden egg) are predominantly grown by men as handling is difficult (post harvest and marketing for maize; ridging, fertilizer and herbicide application and harvesting for tomato) and probably because they are cash oriented. Tomato in particular is expensive to cultivate because it is labour demanding, requires a considerable amount external inputs in the form of fertilizers, pesticides and fungicides but is a highly perishable crop, making its production very risky in times of glut and price fluctuations. While males of all productive age classes grow maize, tomato is intensively cultivated by young men, the majority of whom are natives. Women are more involved in the production of groundnut, pepper, onion and okra.

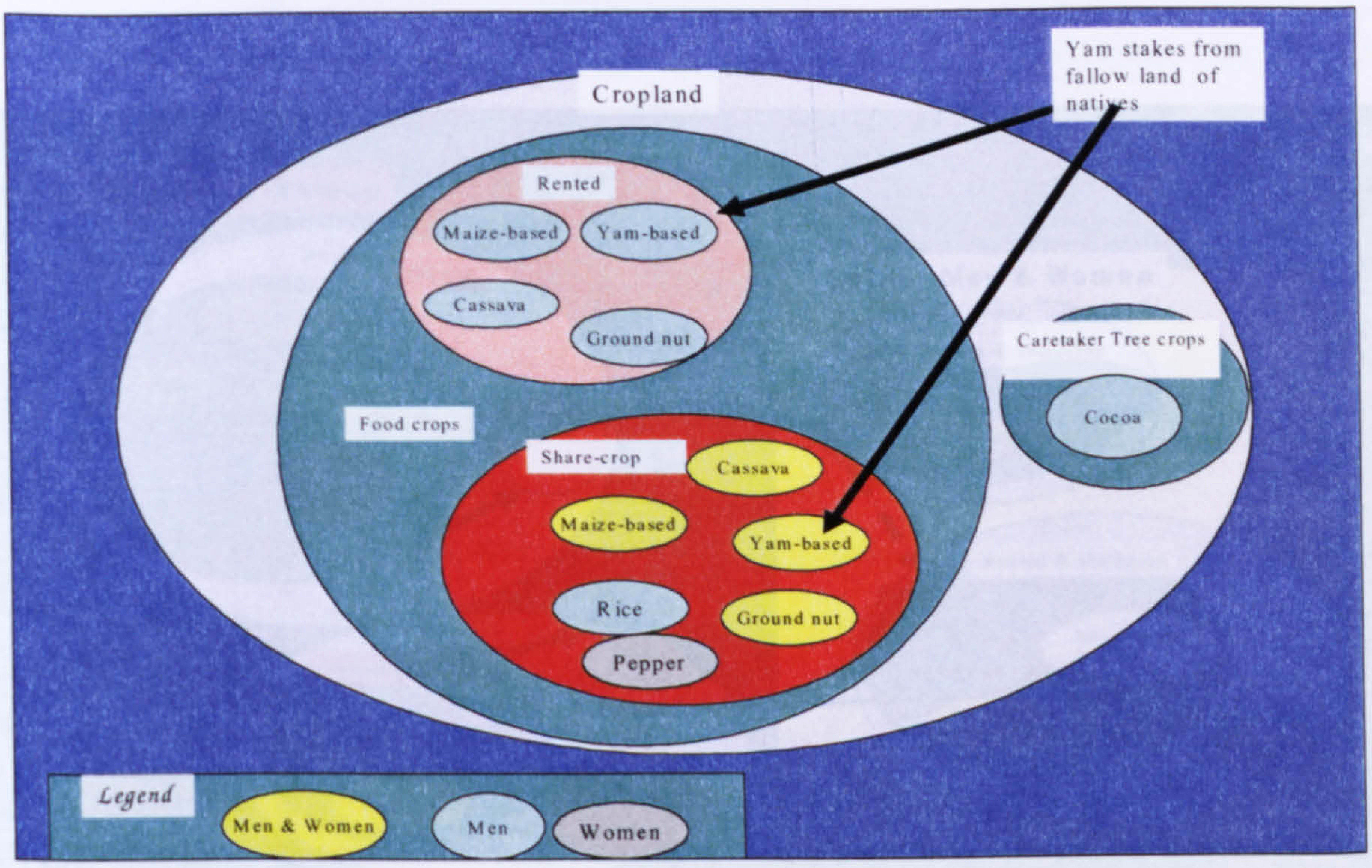


Figure 2.7: Major crops produced by settler non-landowners-Subriso III

The people of Yabraso grow mainly maize, yam, cassava, groundnuts and pepper for livelihood. Sorghum, rice, tomato and other food crops are grown but on a smaller scale (Figure 2.8). While women concentrate on the production of pepper, groundnut and rice, men (natives and settlers) concentrate on yam and maize. Either of these crops could be monocropped but is often intercropped with cassava and others. All crops except cashew can be cultivated on both the forest (*kwaeé*) and savannah (*eseré)* lands. Yam is often intercropped with groundnut, cassava and cashew on the *eseré*. Cashew and oil palm are the main tree crops cultivated but these are yet to be of any cash significance to the local economy as the majority of such plots are in the process of being established and are often destroyed by wild fire during the dry season.

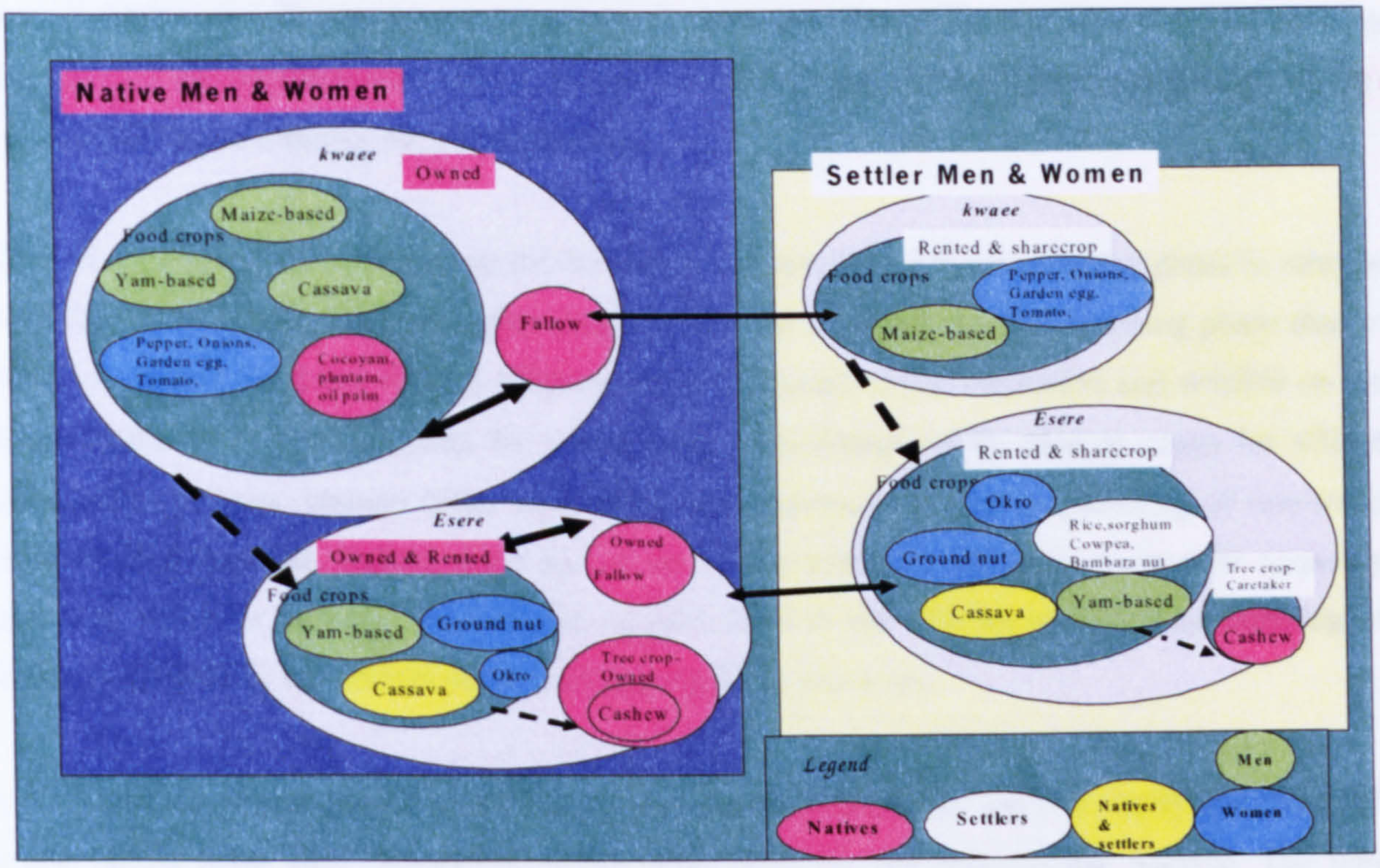


Figure 2.8: Major Crops grown by natives and settlers Yabraso-Wenchi District

Crop production is commonly supplemented by a wide array of off-farm work and the rearing of livestock, mainly sheep, goats and poultry by some people in all three villages. The off-farm employments undertaken include petty trading, hairdressing, sewing and so on, which largely involve women. Men tend to engage in activities such as tailoring, carpentry, painting, driving, corn milling, brewing of local gin *(akpeteshie)* and so on. In Yabraso, charcoal production is an important economic activity undertaken by the *Sisala* settler men from northern Ghana.

2.3.3 Natural resources, access & use

Land resources

Crop production, being a key livelihood activity, implies that the types of land resources and especially the quantity and quality of such resources are crucial to the sustenance of livelihoods.

The land resource base cultivated as farm plots and on which livelihoods depend is located in the off-reserve forest areas with the traditional landholding groups in this case, mainly native households/families, having the right of access and control over its use. However, the landless segments of the population are able to access portions of this land for cultivation through various tenure (rent, sharecropping, etc.) arrangements.

The off-reserve areas that constitute the farmlands consist of land in the cropping phase in rotation with that in the fallow phase. A higher proportion of the farmland is in the cropping phase than in the fallow phase in all the villages (Figures 2.2-2.4). Access to the vegetation and wildlife on the fallow lands by village members for wood, (e.g. poles/timber) to be used as props for village construction (houses, storage cribs, etc.), stakes and firewood, as well as gathering of non-wood products like medicine, fodder, fruits and so on, is not restricted. However, timber for carpentry purposes, wood for burning charcoal and oil palm trees in the wild for tapping wine/distilling of local gin are sold by the owners of the land bearing these resources.

Land under the fallow phase in Gogoikrom and Subriso comprises long (>5 years) and short (<5 years) fallow fields with Gogoikrom having more of the longer fallows than Subriso. The long fallows, locally called *nfofowa kwae,* are important in supporting tree crop production in these two villages, although they are also cultivated for food crops. In Yabraso, forest (*kwaeé)* and savannah (*eseré)* land types are distinguished (Figure 2.4) on each of which the cropping and fallow phases are rotated, with the natives operating more on the forestland and settlers more on the savannah land. The observed trend in Yabraso for the settlers may be explained by their socio-cultural association with savannah. The majority of the settlers in the village are from northern Ghana where the vegetation is the savannah type predominantly characterized with yam cultivation and charcoal burning. Short fallow fields also known as *nfofowa* are commonly used more for food production in all the three villages. However, short fallow fields in Yabraso cultivated to food crops are often converted to cashew plantations when intercropped with the cashew.

Land under the cropping phase in Gogoikrom comprises marshy and non-marshy lands that are important for specific crops. While most crops are cultivated on the non-marshy lands, the marshy areas are important for the cultivation of rice and oil palm sometimes in mixtures with maize. Marshy fields may be found in Subriso and Yabraso as well but were not represented in their respective livelihood diagrams (Figures 2.2 and 2.3) because they are not cultivated by many people.

The level of the quality of the agricultural land resources found in the villages could not be readily established at this stage, although this could give an indication of the potential of the resource base in sustaining livelihoods. However, the sizes of the long and short fallow circles give an indication that Gogoikrom probably has the best of the land for agricultural production compared to that found in Subriso and Yabraso. An analysis of farmers' ecological knowledge on the fertility of soils indicates that longer fallow fields are more fertile than the shorter fallow ones, as longer fallows tend to be dominated by trees while short fallow vegetation is often characterized by grasses. According to farmers the litter from the vegetative cover on longer fallows conserves moisture and decomposes over a longer period to improve the soil whereas shorter fallows dominated by certain grass species like the *Panicum maixmum* mine the soil of nutrients for rapid growth, developing root stools that often impede rainwater seepage, thus hampering biomass decomposition important for improving soil fertility.

Fallow lands often belong to landowners, represented by "O", the majority of who are natives, although in Gogoikrom and Subriso, a couple of settlers also own such lands through ancestral families. In Ggoikrom, the *nfofowa kwae* has the most fertile soil, which is critical for establishing cocoa in addition to providing timber, poles, fuelwood, etc. The farmers claim not all landowners have *nfofowa kwae* in their possession. However, landowners who do not have such land as well as non-landowners in general, provided they have money, can access *nfofowa kwae* for cocoa production either by purchasing outright or through the *abunu* (1:1 shares between tenant and landlord) tenure arrangement. Thus, all farmer categories have equal access to both long and short fallows for crop production in Gogoikrom under appropriate tenure arrangements. Non-landowners, the majority of whom are settlers sharecrop ("S") and rent by cash ("R") both long and short fallow fields depending on the crop type to be cultivated. Sharecropping is more common on the non-marshy land for both tree and food production. On the marshy land short fallow fields are often rented by cash payment for rice and maize cropping and for dry season vegetables but are sharecropped for oil palm on *abunu* basis.

Distinct native and settler niches prevail with respect to the type of access to fallow fields in Subriso and Yabraso. Native and settler landowners have access to both fallow types in these villages. However, male and female settlers who do not own land have access to largely the short fallow fields which they cultivate to shorter duration food crops such as maize and others. While in Subriso, settler male tenants serve as caretakers on some cocoa plantations; both male and female settler tenants in Yabraso merely intercrop their sharecropped or rented fields with cashew belonging to their landowners on the savannah land, not having anything to do with the cashew after their tenancies expire.

Other natural resources

Water bodies in the form of rivers and streams are open access resources for general community use. In Gogoikrom, the Offin River is the main permanent water source for household use although there are some streams equally used but which dry during the dry season. The adjacent flood plain to the Offin is important for rice cultivation in the wet season when the river overflows its banks and for dry season vegetable production. The Subri River flowing through Subriso III is less used for household purposes because of boreholes constructed in the village but it may be used for watering vegetables. Streams in Yabraso are also less used by households as they draw a greater proportion of their water from a borehole constructed in the village. For instance, the Muramura stream, which used to be the main water source before the construction of the borehole, is only utilised for consumption as drinking water and for cooking on the farm.

2.3.4 Labour resources

2.3.4.1 Labour availability & use

Family, hired and communal labour are commonly employed in crop production in all three villages (Figures 2.2-2.4). Family labour is largely provided by immediate family dependents (spouses, children, nieces & nephews) and may be sometimes supplemented with unpaid labour from other extended family members (sisters, brothers, and so on), although this may be difficult to access during peak periods. All farmer categories engage hired labour, mainly the daily waged type termed 'by-day' (i.e. 5-6 hours) largely provided by seasonal male migrants from northern Ghana. Hired labour is used mainly for farm activities like land clearing, stumping, tree felling, weeding, brushing of cocoa, etc. Settler men from northern Ghana living in the village provide the bulk of the local hired labour, although their women may also be hired to sow/plant or weed. It is also possible for a few native men and women to sell off labour to earn money for household use in times of financial stress. Women are usually paid less than men, as they take longer to complete the work.

2.3.4.2 Gender and age labour distribution

Table 2.2 and 2.3 summarize the key roles men, women and children play on the farm and at home. Within the household men and women share labour on the farm. Men often undertake the more arduous jobs – clearing, mounding/ridging and so on, while women and children do planting, harvesting and others, which are less tedious activities, although both adults and children are also involved in weeding. In situations where especially, single women (widowed, unmarried or divorced) have inadequate money to hire labour, they also undertake the more tedious activities related to land preparation.

Table 2.2: Gender and age labour differentiation for agricultural activities

Agricultural Activity	Men	Women	Males <18 years	Females <18 years
Land clearing	√	√	-	-
Burning trash	√	√	-	-
Weeding	√	√	√	√
Ridging and mounding	√	-	-	-
Planting and sowing	√	√	-	√
Transplanting (mainly vegetables)	√	-	-	-
Harvesting	√	√	√	√
Earthing up tomatoes	√	-	-	-
Spraying agro-chemicals	√	-	-	-
Staking yam	√	-	-	-
Fertilizer application	√	-	-	-
Carrying tomato crates	√	-	-	-
Cooking food on the farm	√	√	-	√
Hunting	√	-	-	-
Fetching water for the farm	-	√	√	√
Carrying stakes	-	√	√	-
Watering crops	-	√	-	-
Running errands on the farm	-	-	√	-
Putting maize in heaps at harvest time	-	-	√	-
Babysitting	-	-	√	√

While at home, men tend to be involved in off-farm work but enjoy more leisure and are more involved in social activities while women are mostly occupied with household chores including child care (Table 2.3). This implies that women are occupied for the greatest part of the day and are less likely to participate in some social and other activities after farm work. The situation may be worse for the single woman with children and for those who cultivate separate fields as they have to do most of the farm work as well as the household chores.

Table 2.3: Domestic and other activities under taken by men and women

Activity	Men	Women
Resting	√	-
Listening to the radio	√	-
Playing indoor games such as drafts	√	-
Going to church	√	√
Cooking	-	√
Pounding fufu	√	√
Visiting friends	√	-
Fetching water	-	√
Bathing children	-	√
Playing football	√	-
Going to funerals	√	√
Basketry	√	-
Hunting	√	-
Barbering	√	-
Washing utensils	-	√
Petty trade (cooked food sale, table top provisions, etc.)	-	√
Cleaning, sweeping and tidying	-	√
Washing clothes	-	√
Fetching firewood	-	√

2.3.5 Capital resources: cash availability and use

Income earned from crop production is the main source of finance for farm production and for satisfying household needs. This may be supplemented by income from off-farm work and sale of small numbers of livestock. Landowners earn additional income from land rents including proceeds from sale of produce from sharecropping arrangements.

Income earned from the series of livelihood activities are used to purchase inputs like planting materials, agro-chemicals, labour, materials/items for off-farm job, livestock and repair of buildings and so on. Part of the income may be used for making payments like District Assembly levies/taxes, resettlement of loans and interest payments as well as for funeral, marriage, church, welfare and general community/local contributions. Part of the income may be invested in maintaining or enhancing livelihood assets, such as acquiring more *abunu* sharecropped land for cocoa at Gogoikrom, improving children's education or trade skills, purchasing capital goods like more implements (machetes, hoes, etc.) and for savings either at the bank or with friends. Lastly, part of the income is used for purchasing food, clothes, radios, bicycles, acquiring a house, etc. that contribute to the material quality of life of the household.

In times of financial difficulty, money may be borrowed from friends, family, moneylenders and traders for both farm and household needs. With informal arrangements with relatives and friends no interest is charged, and the money may not always be paid back. Some friends or community members may require some form of collateral, e.g. a productive plantain farm, bicycle or television set which can be seized in case of non-repayment. Interest may be charged at 50-100%, particularly by moneylenders. Traders usually pre-finance agricultural activities, especially maize production; however, the set price for repayment by produce is often very low.

2.3.6 Physical resources: roads & produce marketing

Accessibility and availability of markets for disposing of produce contributes to a large extent to the economic well being of rural people. Produce may be sold on markets or at the farm gate. Traders come to the villages from other parts of the country and nearby countries in the West African Sub-Region such as Togo to purchase various farm goods. The traders come virtually all year round but their numbers decline during the lean season and when the rains are poor and production is low as there is little supply in the village. Traders may also not come to the village when there is a glut as they can easily get their supplies from other villages closer to them to reduce transport cost. In times of glut, prices are low with high post-production loss. During such times the produce is sold on nearby periodic markets or markets in bigger cities such as Sunyani and Kumasi. All the villages are linked to the national road network by all year round passable dirt roads, thus accessibility and transport of produce to the market is often not a problem throughout the year as there are vehicles plying between the villages and the respective market centres daily and throughout the year.

2.3.7 Constraints to livelihoods-problem causal diagramming

A number of factors constrain farmers' livelihoods and more specifically, their farm production activities. These were explored using the scored causal diagramming (SCD) methodology (Galpin *et al.*, 2000). SCD is one of the participatory farm management methods that have been developed by Galpin *et al.* (2000) to help farmers identify problems and their root causes in the farming system. Problems identified are scored to analyze their relative importance in order to prioritize them. With facilitation from the researchers and extension staff, different strata of farmers first identified problems/constraints in agricultural production and then their respective causes.

The "end problem" i.e. the ultimate effect of all the problems listed, for example, low farm incomes, poverty, etc. was then identified. Then, following some discussion, starting with the major identified reasons for the end problem farmers built up the causes that led to the other problems into causes and effects diagrams. When the farmers were satisfied that the diagrams were complete, they scored the causes using counters. The scoring involved grouping a number of the counters at the end problem and then distributing them up the causal chain in proportion to the relative importance or magnitude of each problem. Bigger weights were assigned to priority causes. Stone pebbles, neem seeds and maize grains were used respectively as counters in Gogoikrom, Subriso III and Yabraso. The Figures that follow below summarize the problem causal analyses for the three study villages. Figures 2.9 - 2.11 do not have the scores or weights assigned by farmers indicated because each is an amalgamated diagram of three diagrams drawn and scored separately by different strata of farmers but have been conveniently combined because the contents are virtually the same.

2.3.7.1 Problem-causal analysis in Gogoikrom-Atwima

Figure 2.9 is the combined problem causal diagram drawn by men and women in Gogoikrom. There were similarities in the key problems and causes identified by men and women. The reddish-brown, green and yellow colours indicate where men, women or both gender placed more emphasis respectively. The diagram indicates that causation is linked in relation to either cocoa production, or food crops.

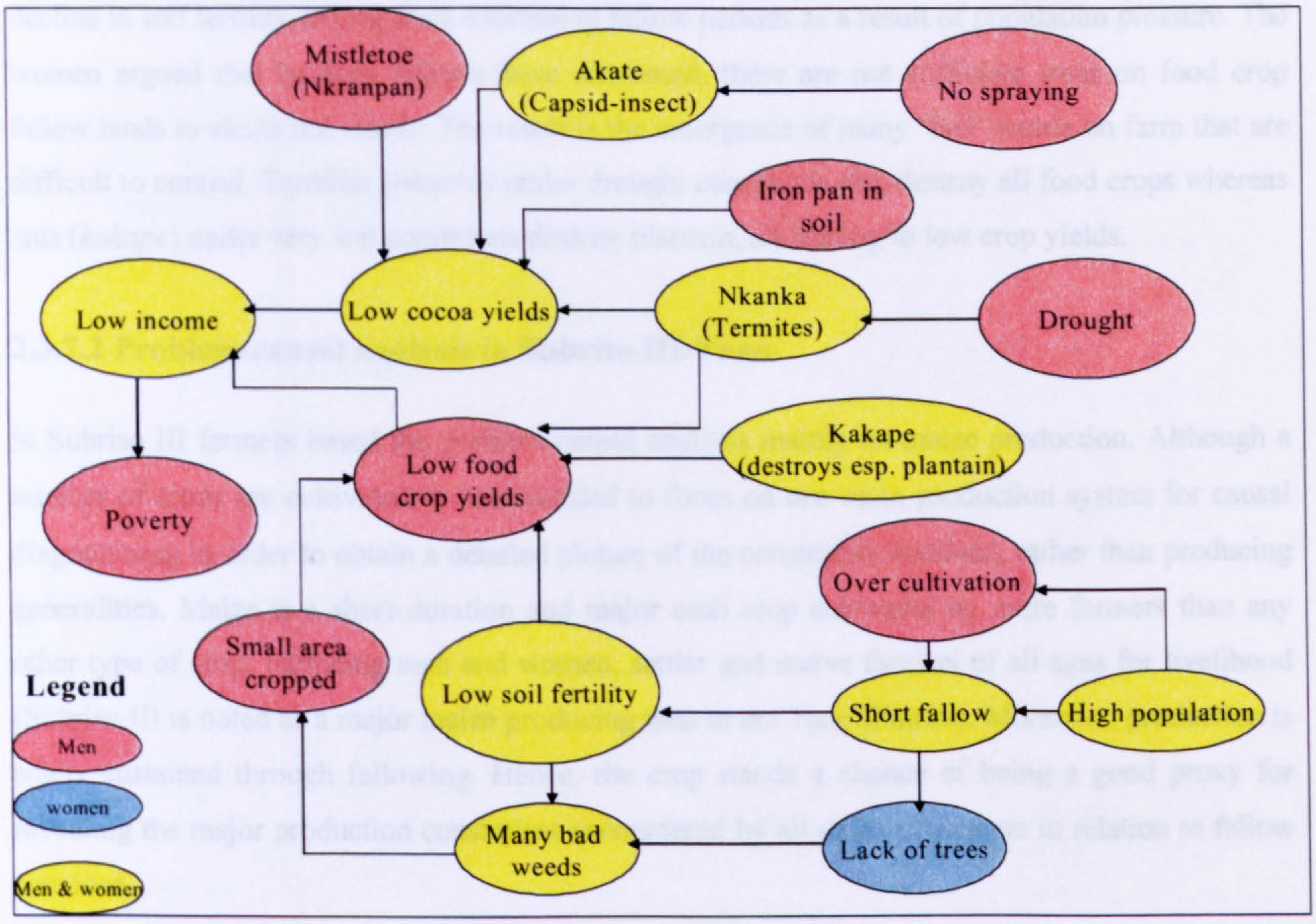


Figure 2.9: Problem causal diagram for farm production-Gogoikrom (Atwima)

In Gogoikrom farmers believe poverty resulting from low farm income is the ultimate problem in farming. This has been caused by low crop yield to which low yield in cocoa was considered significant by both genders. Pests and parasites were the main factors recognized to contribute to low yields in cocoa. The main ones are the parasitic epiphyte, mistletoe (*nkranpan*) and others like *senkohoma* which men reckoned were the most dangerous. Other pests are the capsid (*akate),* an insect that attacks the cocoa when not sprayed and termites or ants (*nkanka*) that emerge when there is drought or insufficient rainfall. The termites are usually transferred from the old farm to the new farm on plantain suckers that are transferred for planting. Also important in reducing cocoa yield is iron pan *(etwre)* in the soil. Root growth and penetration is disrupted when the roots hit iron pan causing eventual death of the crop.

Men placed more emphasis on low yield in food crops probably because they are more involved in the cultivation of sole food crops mainly maize, rice and plantain. This is particularly caused by a decline in soil fertility arising from shortening fallow periods as a result of population pressure. The women argued that because fallows have shortened, there are not sufficient trees on food crop fallow lands to shade out weeds. The result is the emergence of many 'bad' weeds on farm that are difficult to control. Termites *(nkanka)* under drought conditions also destroy all food crops whereas ants (*kakape*) under very wet conditions destroy plantain, all leading to low crop yields.

2.3.7.2 Problem-causal analysis in Subriso III-Tano

In Subriso III farmers based the problem-causal analysis mainly on maize production. Although a number of crops are cultivated, it was decided to focus on one main production system for causal diagramming in order to obtain a detailed picture of the constraints involved, rather than producing generalities. Maize is a short duration and major cash crop cultivated by more farmers than any other type of crop, including men and women, settler and native farmers of all ages for livelihood (Subriso III is noted as a major maize producing area in the Tano District). Moreover, production is solely sustained through fallowing. Hence, the crop stands a chance of being a good proxy for revealing the major production constraints encountered by all strata of farmers in relation to fallow rotations.

Figure 2.10 is an overview of the combined perception of male and female native and settler farmers to the problems in maize production in Subriso III. Similar problems were identified to be hampering maize production by the different strata of farmers. The circles filled with the gold colour indicate problems and causes commonly emphasised by men and women as important in constraining maize production, whereas the red and green are those men and women separately mentioned as important. Problems and their respective causes marked in bold print were scored comparatively higher than the others, as farmers believed these were the major issues of concern.

Ultimately, farmers acknowledged low income from maize production to be the end problem resulting mainly from low maize yields. Several factors were identified to contribute to low yields in maize cultivation. The first issue to be mentioned, and that most frequently returned to, was that of the worsening quality of the land, i.e. decline is soil fertility. This they literally described as '*Asase na seç*' i.e. the land has become bad (literally – rotten or decayed). This is strongly associated with the transition of previously forested land into grassland. Farmers also see the declining quality of the land as responsible for the increasing number of weeds, and the arrival of new noxious weeds (*nwora bone*).

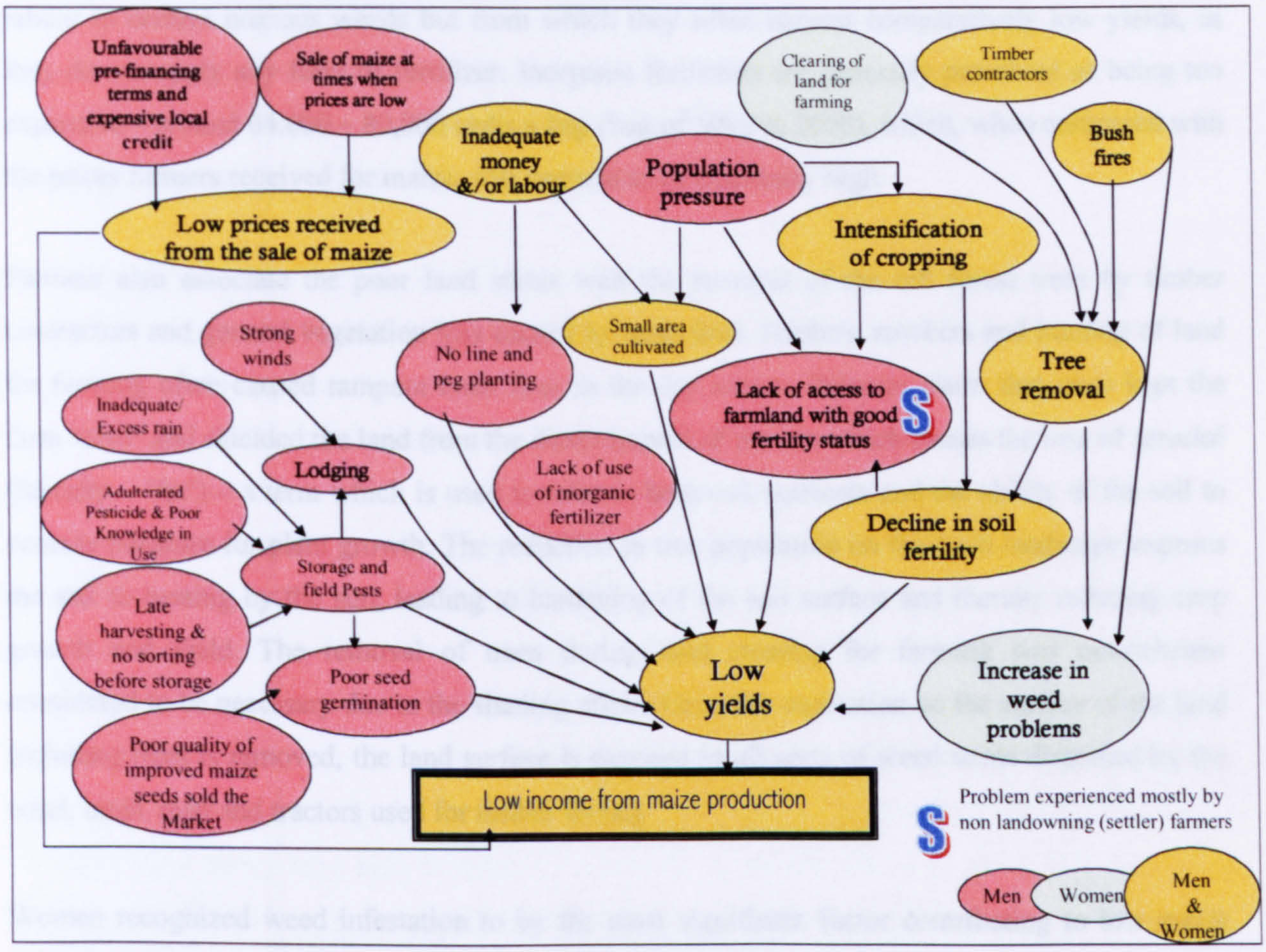


Figure 2.10: Problem-causal diagram for farm production-Subriso III (Tano)

The decline in the land quality is seen as mainly due to an increase in the intensity and frequency with which the land is cropped, as a result of population pressure and land scarcity. This has caused a decline in the fallow period sometimes to as little as one year. Land is also hardly left to fallow sufficiently as cash needs of aging landowners for their upkeep and that of the younger ones at the beginning of the cropping season for cultivating their fields compel them to rent out land irrespective of the fertility status. To worsen this case is the fact that when land has been abandoned by one tenant to fallow because the fertility has drastically reduced it is given to another who needs it for cultivation almost immediately. This is because landowners, particularly old/aged people (>50 years) might be in urgent need of money to cater for their needs, as they cannot do much work and are quite inactive in farming.

By virtue of not owing land the majority of male settlers lack access to good or fertile farmland for maize cultivation. They often sharecrop poor or infertile lands in which they invest heavily in labour to control noxious weeds but from which they often harvest comparatively low yields, as they do not apply any form of fertilizer. Inorganic fertilizers are generally perceived as being too expensive – around 64,000 – 80,000 cedis a bag (bag of 50kg in 2000), which, when compared with the prices farmers received for maize, was deemed to be extremely high.

Farmers also associate the poor land status with the removal of the tall forest trees by timber contractors and general vegetation loss caused by bush fires. Hunters, smokers and burning of land for farming often caused rampant bush fires in the dry season. Farmers claim that trees kept the farm 'cool' and shielded the land from the direct impact of the sun which causes the loss of *seradeē* (literally – 'fat') – a term which is used to refer to both soil nutrients and the ability of the soil to provide moisture for plant growth. The reduction in tree population on the farm landscape exposes the soil to heating by the sun, leading to hardening of the soil surface and thereby reducing crop growth and yield. The removal of trees during land clearing for farming was nevertheless considered to be necessary due to the shading effect. Once the vegetation on the surface of the land including trees is removed, the land surface is exposed to all sorts of weed seeds dispersed by the wind, birds, man and tractors used for timber felling.

Women recognized weed infestation to be the most significant factor contributing to low maize yields probably because in the absence of male seasonal labourers they do much of the weeding either as hired by-day workers or on their own or family farms. Quite a number of noxious weeds found on farms are difficult to weed or control as they easily sprout after cutting. Ideally, one should weed at least three times or more if there is enough money to do so as failure to weed frequently reduces crop yields or may result in crop failure. Most farmers have more than one plot which may all require weeding around the same time. However, they neither have adequate family labour (as children are in school) to work on all these farms nor have money to engage enough hired labour to weed frequently and on time.

Another common factor emphasized as contributing to low income from maize production was low prices received from the sale of maize. Because most farmers have inadequate money at the start of the growing season, some are compelled to secure informal local credit from other, better-off farmers in the community at rather high interest rates, sometimes 50% or more. Some farmers go into pre-financing agreements with traders or other community members. Any of these loans often require repayment immediately after harvest when prices may be low, 30,000 cedis per 100-125kg of maize. Sometimes for pre-financed maize production, every 15,000 cedis that is lent (in 2000) is repaid with one bag (bush weight of 100-125kg) of maize at harvest. This is often far lower than the prevailing price at the time of harvest, making pre-financing very expensive. Male settler farmers considered this to be the most crucial of all the constraints after scoring as it is also the major cause of insufficient cash income earned from growing maize.

Constraints imposed by the need to satisfy numerous household financial needs, particularly school fees, medical expenses, household food and other social responsibilities including travelling to the north (settlers), funerals and so on forces the majority of farmers to dispose their produce soon after harvest in October-November when prices will be low rather than waiting until April the following year when prices rise.

To the farmers of Subriso III, possession of adequate cash resources appears to be the ultimate solution to all production constraints. They explained that with adequate money, it is possible to rent a 'good', i.e. fertile, piece of land and pay for labour for weeding and would not have to rely on traders for expensive credit, or have to sell early when prices are low. Formal credit from the rural banks is difficult to come by as such small farmers are noted to be incapable of resettling loans. Although rural banks have been mandated nationwide to provide micro-credit facilities to small-scale farmers in rural areas, the procedure for acquiring the loan is complex, requiring several trips to the bank located in a bigger town. Moreover, the interest rate is as high as 40% and loans are not granted on time to coincide with the peak period, when the money is required for farm operations. The lack of adequate money prevents most farmers from cultivating larger areas.

Pests on maize fields, such as grass cutters (when rains are excessive), termites and stem borers (when rains are inadequate), squirrels, grasshoppers among others as well as weevil in grain storage contribute to low yields. Weevil infestation in storage is caused by poor knowledge of the application of the relevant pesticides that are often adulterated and hence, have low efficacy as well as inadequate finance to buy pesticides. It is also caused by late harvesting of maize from the field when maize cobs get soaked with the minor season rains before haulage for storage. Most farmers also do not sort cobs to cull infested ones before storage. Moreover, the increase in moisture content not only assist weevil multiplication but also causes fungal infection and discolouring of the grains, leading to low price for the produce.

Low yield is also caused by poor seed emergence or germination due to poor quality of seeds purchased on the market and pests, particularly ants that eat the embryo of the seed maize in the soil when sown. Lodging of maize stems, usually caused by strong winds, especially when previously attacked by stem borers and termites, also reduce maize yields.

On the whole, most people involved in maize cultivation in Subriso III earn low incomes as a result of low maize yields to which a plethora of causes, mainly soil fertility decline, weeds and poor maize prices have been attributed. The majority of non-landowning settlers are particularly confronted with the necessity of cultivating poor lands, which often render the enterprise unprofitable.

2.3.7.3 Problem-causal analysis in Yabraso-Wenchi

At Yabraso, the problem-causal analysis was done for maize and yam production systems since these are the two key crops cultivated by all strata of farmers. Also lands on which both crops are cultivated are commonly fallowed when fertility declines and, more particularly for yam the same piece of land is hardly ever cultivated for the crop more than once. It was assumed that these two production systems may be appropriate candidates for improvement by fallow interventions. Figures 2.11 and 2.12 are the problem causal diagrams drawn by farmers for maize and yam systems respectively.

Constraints to maize cultivation

Figure 2.11 is a combined diagram developed by a group of men and women farmers (dominated by men) and that done separately by the women. The yellow filled circles represent issues men and women commonly identified to be hampering maize production whereas the green filled ones were those women perceived were very important contributors to a decline in maize yields, which did not appear that important in the group analysis. Again circles in bold print are the key problems and causes culminating in low income realized from maize production.

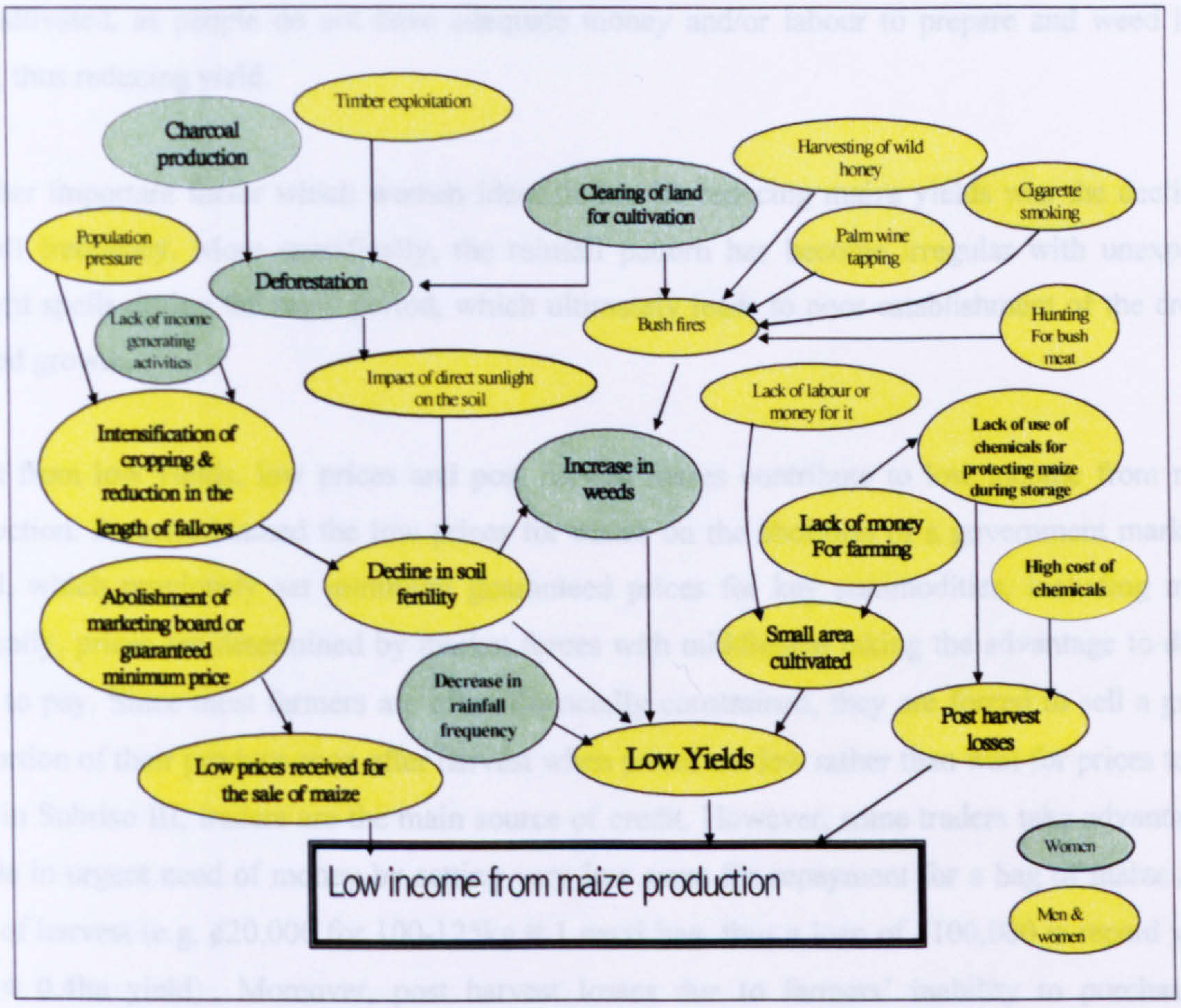


Figure 2.11: Problem-causal diagram for maize production-Yabraso (Wenchi)

Essentially, farmers in Yabraso identified similar problems and causes as those of Subriso III and Gogoikrom. Farmers claim increasing population pressure has resulted in frequent cropping of the land (i.e. intensification), which has led to a decline in fallow length. The women particularly believe that lack of alternative income generating activities for most people has led to this intensification or over reliance on the land for livelihood. As a result soil fertility has declined causing an increase in weeds and a reduction in maize yields. Also important to the decline in soil fertility is the direct impact of the sun on the soil due to the removal of trees caused by charcoal production, timber exploitation and clearing of land for farming. The soil is baked, reducing water infiltration capacity, which is critical to crop growth.

Farmers in Yabraso, like those in Subriso III, were also of the view that frequent bush fire has resulted in an upsurge in weeds and, more particularly new ones that are difficult to control. Some of the troublesome weeds include Rawlings *(Cenchrus ciliaris)*, nkyenkyen (*Rottboellia exaltata*), krawoni *(Agerantum cornyzoides)* and adanko milk (*Euphorbia heterophyllum*). Smaller field sizes are cultivated, as people do not have adequate money and/or labour to prepare and weed larger areas, thus reducing yield.

Another important factor which women identified to be reducing maize yields was the decline in rainfall frequency. More specifically, the rainfall pattern has become irregular with unexpected drought spells during the rainy period, which ultimately leads to poor establishment of the crop or stunted growth.

Apart from low yields, low prices and post harvest losses contribute to low income from maize production. Farmers blamed the low prices for maize on the abolition of a government marketing board, which previously set minimum guaranteed prices for key commodities, including maize. Currently, prices are determined by market forces with middlemen taking the advantage to dictate what to pay. Since most farmers are often financially constrained, they are forced to sell a greater proportion of their produce soon after harvest when prices are low rather than wait for prices to rise. Like in Subriso III, traders are the main source of credit. However, some traders take advantage of people in urgent need of money by setting very low sums for repayment for a bag of maize at the time of harvest (e.g. ¢20,000 for 100-125kg ≡ 1 maxi bag, thus a loan of ¢100,000 is repaid with 5 bags ≡ 0.4ha yield). Moreover, post harvest losses due to farmers' inability to purchase the appropriate storage chemicals further reduces income earned from maize cultivation.

Constraints to yam cultivation

Figure 2.12 is the problem-causal diagram drawn by a group of male farmers in Yabraso for yam production. The content is not different from that drawn for the maize, indicating that constraints may be similar for a number of production systems. The group scored the problems with 100 counters. The ultimate problems constraining yam production were low incomes earned from the sale of yam and inadequate yam for household consumption. The pink filled circles are priority issues attracting scores of more than ten counts. Of particular interest in this diagram is the fact that low yam yields and post harvest losses caused by rodents and improper aeration during storage severely affect the availability of yam for household food security. Although yam is sold for cash it is the main staple crop consumed by both native and settler households.

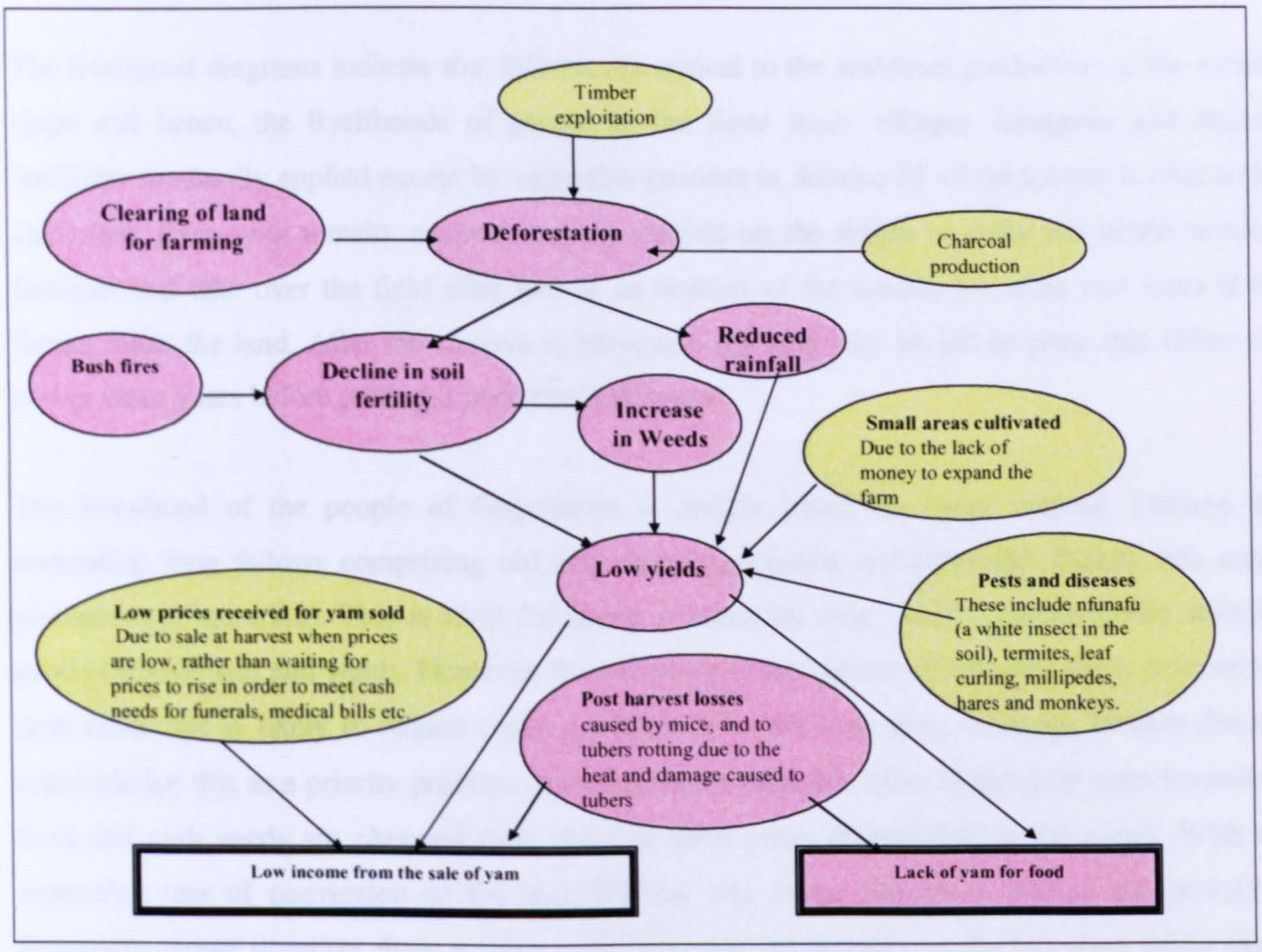


Figure 2.12: Problem-causal diagram for yam production-Yabraso (Wenchi)

In summary, all the three villages have been commonly affected by increased population pressure with the associated intensification of cropping and shortened fallows coupled with tree depletion brought about by bush fires (except Gogoikrom), timber extraction, clearing of land for farming and so on. These have led to a decline in soil fertility and an increase in weed problems for which most farmers have inadequate labour or money to control properly, resulting is low crop yields. Irregular rainfall pattern, pests and disease problems on the field and during storage in addition to the fact that farmers are generally constrained by money to cultivate larger acreages have also been attributed to low yields in crops cultivated. Low yields together with poor prices (with the exception of cocoa) and expensive local/informal credit overall reduces income realized from farming.

2.4 Conclusion

The livelihood diagrams indicate that fallows are critical to the sustained production of the various crops and hence, the livelihoods of people in the three study villages. Inorganic and organic fertilizers are hardly applied except by vegetable growers in Subriso III where tomato is intensively cultivated. Even with tomato, cassava may be relayed on the ridges to make use of the residual fertilizer and take over the field after two or so seasons of the tomato for some two years if the farmer owns the land. After the cassava is harvested, the land may be left to grow into fallow for two or more years before putting it back into cultivation.

The livelihood of the people of Gogoikrom is mainly based on cocoa income. Farmers are converting long fallows comprising old and abandoned cocoa and secondary forests into cocoa plantations (Figure 2.2). This is ideal for cocoa, a perennial crop, which requires fertile soils for good establishment and yields. However, the reduction in the volume of valuable shade trees on the farm landscape is likely to reduce cocoa productivity in the long term, although farmers did not acknowledge this as a priority problem in the constraint analysis. Most of the short-term household food and cash needs are obtained from the first three years of establishing the cocoa. With the increasing rate of conversion of the long fallows into cocoa plantation, due to the prevailing favourable tenure situation, there is likely to be increased dependency on the few short fallow lands for cultivation of food in the long term when the greater part of the long fallow land will be under sole cocoa.

Short fallow lands are in frequent rotation with sole food cropland. The fallow phase is not managed to enhance productivity over the short period of about 1-3 years. In addition farmers may not purchase any form of fertilizer even if they earn good income from cocoa. The productivity of short fallow lands is likely to dwindle more than it is now in the future, posing threats to household food security and causing a possible decline in income earned from food crops to supplement that from cocoa.

Subriso III appears to be the most fragile and worst of the three villages in terms of soil productivity in the long term. The people rely more on the conversion of short fallows into arable crops for livelihood. Again the fallow is left to naturally recover soil fertility, in most cases from 1-3 years. The presence of the large settler population aiming at maximizing gains from the short fallow lands makes the situation more alarming, not to mentioned the rampant seasonal fires that often hardly allow the fallow vegetation to grow to perform its soil fertility recovery functions.

The farmers are of the view that the increasing build-up of short fallow land for cultivation impacts negatively on their livelihoods, as the soils are becoming poorer, requiring more of their meagre farm incomes to be spent on labour to control noxious weeds, notwithstanding the poor yields. In addition they have virtually lost sources of some non-timber forest products like snails, game and mushrooms that commonly characterized tree dominated fallows.

The scenario in Yabraso is not very different from that of Subriso III. Short fallow lands are being largely converted into yam and maize production. These two crops are heavy feeders, depriving the soil of its nutrient at a faster rate. Meanwhile, the need for stakes to ensure adequate light reception by yam vines for bigger tuber development results in the firing of tree saplings on savannah fallow land cleared for cultivating yam. This kills the root stock of trees, thereby discouraging coppicing. In addition, yam is not normally grown on the same piece of land for more than two seasons. This means more short fallows devoid of coppice shoots that could grow faster into tree saplings to enhance restoration of the soil. With virtually no external fertilization of the soil and rampant bush fires, the long term sustainability and hence livelihood of the people of Yabraso is also questionable.

From the above, it can be seen that short fallows are increasingly becoming important for the provision of immediate household food and cash needs. With the exception of Gogoikrom, where there seem to be a more secured source of long-term income not threatened by seasonal fire outbreaks, livelihoods of Subriso III and Yabraso seem to be hinged on short term incomes at the risk of fire and weather. It can be concluded that the need for improving the short fallow lands is imperative to improve yield and curtail the need for the cultivation of several fields of poor fertility status to safeguard, crop failure and poor yields. This is also likely to leave more land under longer fallows to ensure better yields for improved livelihoods, although the issue of wild fire, land tenure and produce prices will require some consideration if the desired impact is to be realized.

CHAPTER THREE
DESIGNING AND CHARACTERIZING TECHNOLOGIES WITH FARMERS

3.1 Introduction

There has been a shift in the manner in which agricultural development is researched and implemented towards participatory approaches over the past two decades (Okali *et al.,* 1994). Farmer participatory research has received a lot of attention in recent times as a better option for integrating farmers who are end users of a technology into its development. The Bush Fallow Rotations Project adopted a Participatory Technology Development (PTD) approach for testing and developing with farmers the technologies for improving the productivity of shortening fallows. Douthwaite *et al.* (2002, citing van Veldhuizen *et al.,* 1997) described this process of involving farmers in research as one by which outside facilitators and rural people interact to enable the target groups to have a greater capacity to adapt a new technology to their conditions and the facilitators to have a better understanding of traits and characteristics of local farming systems. Farrington (1998) also described it as the approach whereby intended clients of agricultural research and extension (R & E) have some influence over decisions about the focus and content of R & E. Thus, in participatory research, local people are able to conduct their own analyses and establish their own research and extension priorities.

The increasing advocacy for greater farmer participation in research is because technologies developed under on-station research conditions as well as those developed during the farming systems research era in the recent past and transferred to end users, especially farmers in developing countries were not particularly suited, to their existing socio-economic and cultural conditions. This, in most cases, culminated in poor uptake of these technologies and also did not have the desired impact on beneficiary communities. Nevertheless, there is evidence of widespread use of improved agronomic practices, tools and crop varieties that are indications of poor resource farmers benefiting from formal agricultural research (Sumberg and Okali, 1997).

The socio-economic and agro-ecological conditions of low-income farmers are complex, diverse and risk prone. Thus, conventional approaches to research based on research station trials followed by unidirectional technology transfer are unlikely to be fruitful (Farrington, 1998). Indeed, there is increasing realization that unless farmers are involved in the various stages of technology development, adoption of any improved technology will often meet difficulties after it has been developed (Ofori, 1993). According to Sumberg and Okali (1997), the fact that farmers do and/or are capable of doing their own experiments also justifies their inclusion in technology development as their current traditional farming systems have evolved from several years of experimentation.

The benefits of PTD are manifold. Farrington (1998) argues that close engagement with farmers through the cycle of diagnosis, experimentation and dissemination increases understanding of these conditions, and of opportunities and constraints farmers face and of their own technical knowledge. Thus, this approach, apart from enhancing the prospects of the adoption of externally promoted technologies, might also ensure that the technology is locally owned, environmentally and institutionally sustainable and could also enhance the efficiency of the technology development process. While PTD encourages and enables resource poor farm families themselves to identify priority research issues (Lightfoot *et al.*, 1988), it also enhances the relevance, appropriateness and acceptance of the technology, even if adoption is limited by other extraneous factors (Aroyoko 1996). Furthermore, the adoptability of a technology is enhanced if the generation of the technology is geared to meet farmers' perceived problems and farmers are encouraged to think of the experiments as their own (Lightfoot *et al.*, 1988).

3.2 Objective and methods

The objective of this chapter is to describe the process employed in designing and characterizing technologies experimented with farmers in the study villages. The Bush Fallow Rotations Project adopted a Participatory Technology Development (PTD) approach for testing and developing with farmers, three main interventions namely, improved natural fallows, planted improved fallows and conversion of short fallow cropping systems to perennial multi-strata cocoa agroforests in Ghana. The ultimate goal of the project was to ensure that these interventions evolved into technologies that are appropriate for improving fallow productivity and thereby sustain and improve livelihoods of poor farmers in Ghana.

The methods employed in documenting the process are described in detail in the PTD process below. PRA methods including mainly key informant, group and individual interviews and discussion, farm visits, resource mapping, transect walks and seasonal calendars (Nabasa *et al.*, 1995; Theis and Grady 1991; Bellon, 2001) and problem-causal diagramming (Galpin *et al.*, 2000) as well as structured questionnaires were employed in gathering information for the first stage of the PTD process which, entailed knowledge acquisition and characterization of livelihoods in the study areas.

Table 3.1: Stages and methods employed for designing & characterizing technologies

Objective	Process stage	Method/activities	Presentation
Describe the process of designing and characterizing interventions/technologies with farmers	-Identification and selection of study area -Farming system/livelihoods & problems characterization	-PRA (key informant interviews & community meetings, farm visits, etc.) -Individual/household interviews	Descriptive
	-Development of technology options	-Stakeholder workshop -Prioritizing technologies	
	-Experimentation of technologies -Exposure visits & demonstration areas	-On-farm experiments -Field days	
	-Monitoring on-farm experiments -Evaluation of experiments	-Periodic monitoring - Bio-physical & economic plot level data -Farmer perceptions	

Analysis of this information led to the identification of suitable interventions for improving the productivity of shortening fallows. The study communities rated these interventions and feasible, preferred choices were tried by way of farmer managed on-farm experiments. The farmer experiments were monitored periodically, during which both biophysical and socio-economic data were collected.

Farmer perceptions of their experiments were also ascertained at the end of the two seasons of trial, based on criteria developed with farmers. The PTD process described below is largely descriptive using diagrams, graphs and tables to summarize and present the process.

3.3 Participatory Technology Development Process/Methodology

Several variants of farmer participatory methodologies have been developed and/or are being increasingly used by research and development practitioners. About 30 different terms currently relating to participatory approaches has been reported (Pretty, 1995). With respect to agricultural research, the approach often entails various levels of involvement of farmers in experiments or research processes aimed at developing improved technologies intended to improve their livelihoods. While some of such research procedures may be designed and managed by researchers, others may be designed by researchers but managed by the farmer or may be designed and managed solely by the farmer. Farmers and scientists in any of these cases may monitor the experiments.

Table 3.2 summarizes the various ways in which farmers are involved in the research process. The objectives of research vary in each of these cases. It may range from measurement of biological performance under farmers' soil condition by researchers in the researcher designed-researcher managed type to assessing the level of experimental capabilities and farmers' ability to integrate the technology into their existing farming practices in the farmer designed and managed types. Farmers' perception or evaluation may be assessed in each of these cases (Kwesiga *et al.*, 1999 and Bellon, 2001).

Table 3.2: Level of farmer involvement in research

Degree of interaction/involvement			
Research category	**Scientist**	**Farmer**	**Possible research objective**
1. Researcher-designed and managed	Designs, manages & analyzes	Provides the experimental field	An understanding of processes, components of new technology under farmers biophysical conditions
2. Researcher designed-farmer managed	Designs & analyzes	Manages, provides input into the analysis	An understanding of processes, components of new technology under farmers biophysical conditions and their management
3. Joint researcher-farmer design and managed	Designs, manages & analyzes	Designs, manages & analyzes	Joint evaluation and modification
4. Farmer designed and managed	Provides training, guidelines, technical support	Designs, manages & analyzes	Capacity building & empowerment

Source: Adapted from Bellon (2001).

Three key decisions are encountered in a participatory research process, namely where to work (site selection), who to work with (participants) and how to work with them (mode of interaction). These decisions often depend on the research objectives. The Bush Fallow Rotations Project employed the researcher designed and farmer managed type of process for involving farmers in designing and characterizing appropriate technologies for improving fallow productivity in the study villages. Figure 3.1 outlines the various steps followed in the PTD process. The sequence of activities pursued during the process can be grouped into four main stages namely, diagnosis and analysis, planning, implementation and evaluation stages.

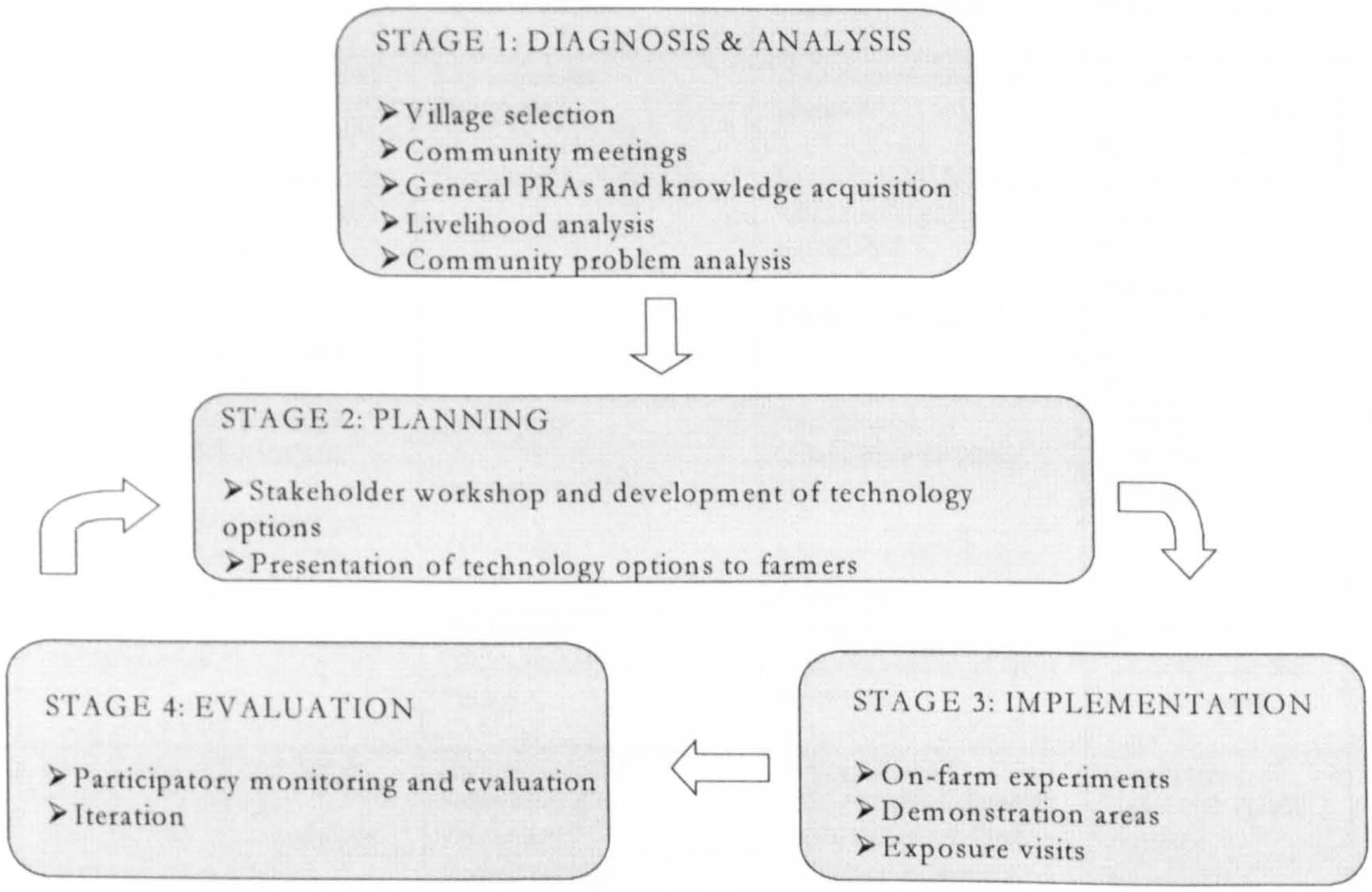


Figure 3.1: The Participatory Technology Development (PTD) Process (adapted from Defoer, 2002)

3.3.1 Diagnosis and Analysis

The first stage (i.e. diagnosis and analysis) involved identifying suitable places to work, the people to work with and characterizing the farming and livelihood systems in the study areas to understand the dynamics and functioning of these systems. The characterization, which is reported in detail in Chapters 2 and 4, was to set a pace for the identification of appropriate interventions/technologies for improving the productivity of fallow regimes and for developing suitable recommendation domains for adoption of these technologies. Activities undertaken in the diagnosis and analysis process are presented in Table 3.3.

Table 3.3: Activities in the diagnosis and analysis stage

Activity	Objective	Tools/Methods	Expected Output	Who Involved	Time Spent
Exploratory survey	Familiarization & selection of study sites Introduce project to district & village heads, extension staff and establish rapport Collect secondary information form District Assemblies & Agricultural offices	Key informant discussions Secondary information	Overview of study area obtained Rapport with district & village authorities established Study sites selected	Researchers Extension agents Key informants (District Chief Executives, District Agricultural Directors village heads, Farmers, etc.)	Flexible (2 days or more)
General village meeting	Introduce project to whole village & establish rapport Background information on livelihood, farming system, natural resources, etc.	Discussion Resource mapping	Background information on study sites Rapport with villagers established	Researchers Extension agents Farmers	2 days
Transect walk	Ground touting/ Perambulation	Discussion Diagramming Photos	Cross section diagram/profile of farm landscape	Researchers Extension agents Village heads Farmers	1 day
Focused group meetings	Detail livelihood and farmer ecological knowledge characterization of study site	Semi-structured interviewing & discussions	Information on -Main livelihood types Agricultural land use -Changes in farming system -Cropping systems -Indigenous ecological knowledge on crops, soils, weeds, trees, fallow rotation -Land rotation -Land tenure -Labour -Finance -Marketing -Gender issues -Agricultural production constraints	Researchers Extension agents Farmers	Flexible
Problem causal diagramming	To identify and analyze agricultural production constraints	Scored problem diagramming		Researchers Extension agents Farmers	1 day
Individual/household interviews	To confirm issues discussed at village & group meetings To establish the magnitude of issues	Structured interviews		Researchers Extension agents Farmers	Flexible
Farm visits (During growing season)	To assess cross section of cultural practices, cropping patterns, characteristics of soils, trees on croplands & fallows, etc.	Discussion Diagrams		Researchers Extension agents Farmers	Flexible

3.3.1.1 Exploratory/reconnaissance survey

The first step in deciding which farmers to work with is to decide where to work. This was achieved through an exploratory survey of the study districts. During the survey background information on the study districts was collected and rapport developed with district and village authorities. District profiles and general agricultural information were collected from the offices of the various district administrative centres (also known as District Assemblies) and the District Directorates of Agriculture (DDA) of the Ministry of Food and Agriculture (MOFA) located in the respective district capitals i.e. Nkawie - Atwima, Bechem - Tano and Wenchi.

In consultation with the DDAs candidate areas were selected for two-day familiarization visits to a number of farming villages (8 on average per district) as there were innumerable number of villages in a district. At each village visited, an overview of the livelihoods of the people (population, infrastructure, sources of income, tenure, fallows, crops, animals, and so on) was obtained from key informants, notably village heads such as the chiefs, assemblymen, unit committee chairman or any farmer available at the time of visit. An analysis of the secondary and primary information gathered in the exploratory survey led to the selection of suitable sites for detailed characterization and on-farm experimentation.

Details on the considerations made in selecting the study sites are presented in Section 1.5.1 of Chapter 1. Normally, sites selected should enable meaningful comparison to be made based on certain factors hypothesised to influence farmer conditions and/or decisions, for instance, differences in agro ecology, access to markets, population sizes and so on (Bellon, 2001).

For this study, consideration was essentially given to representative sites where fallow management was critical to livelihoods, where none of such research had ever been conducted and with other characteristics (e.g. mix of crops grown, fairly accessible all year and tenure issues important in land management) that would enable the project goal of generating technologies for improving the productivity of short fallows to be achieved.

3.3.1.2 General village meetings

Having identified suitable sites for research, village meetings involving semi-structured interviewing and discussions with the inhabitants were necessary to establish a rapport with the entire village or community. This interaction generated more general information on the livelihoods situation of the study communities, throwing more light on the socio-cultural set up, demographic and socio-economic characteristics, production systems, natural resources, physical assets and so on.

The people sketched village and resource maps of their villages with facilitation from extension staff of MOFA and researchers. The resource map showed the position of the villages relative to their surrounding natural resources, i.e. rivers, streams, farmlands, fallow lands, sacred groves, etc. and their uses. From the resource map transect routes were selected for transect walks to observe some of the issues discussed during the semi-structured interviewing, particularly, to assess land use patterns, nature of fallow series and so on. The checklist of issues covered in the village discussions is found in Appendix 4. Copies of the resource map and transect diagrams for Subriso III are attached in Appendices 5and 6

3.3.1.3 Focus group meetings

Communities are characteristically heterogeneous in nature, often comprising different groups of people who differ in various ways (ethnicity/culture, age, gender, wealth status, literacy status and so on). Even people within the same groups, families and households differ (Bellon, 2001). These differences greatly influence their perceptions, needs and preferences, which must be recognized in the development of appropriate interventions for improving their livelihoods. The information gathered during the exploratory surveys and village meetings showed that the population of each village broadly comprised natives or indigenes of the area and settlers from other regions of the country.

Further interaction with some community leaders revealed that the basic unit of distinction between natives and settlers is the land ownership status of households and individuals. According to farmers, residential status is perhaps the appropriate criterion for classifying the village population as this determines the extent to which one secures access, right and control over land, the main resource upon which their livelihoods depend. Those from the indigenous land-owning families are natives, whereas those who are not from such families are generally settlers. Land for cultivation is hired or share-cropped for a period of time, after which it reverts back to the owner, hence, this is the only way the majority of settlers have easy access to land for cultivation for their livelihoods. It was hypothesized that this was likely to determine what crops to grow and land/soil management pattern among the different categories of farmers and thereby was likely to influence the adoption of the technologies that were to be developed for improving fallow productivity.

Based on this information, the population in the villages was stratified into natives and settlers. Each sub-group was further divided into male and female where appropriate to capture differences or variation that may be caused by origin/residential status and gender in the analysis of their livelihoods for the development of technologies suitable for uptake by the different strata of farmers. The four strata were considered as focus groups, as they shared some common socio-economic characteristics (Kienzle and Murray, 1998).

Focus group meetings (often comprising 10 or more people) were held with the four classes of farmers on a number of occasions, each time on a taboo day of a particular village (Tuesday for Gogoikrom and Subriso; Friday for Yabraso). The taboo days were convenient for such meetings, as farmers did not work on their plots on such days; hence quite a number of them were able to attend the meetings and contributed actively to the discussions. The major issues discussed included changes in farming system, cropping systems (crops, cropping pattern, cultural practices, etc.); indigenous ecological knowledge on crops, soils, weeds, trees, land and fallow rotations; land tenure, labour use, seasonality and availability; credit and marketing systems; gender issues and agricultural production constraints.

3.3.1.4 Semi-structured interviews, field observations & questionnaire survey

The group meetings were followed by random individual interviews and farm visits. These were usually undertaken on other days of the week when farm work was in progress. Farms were visited and farmers interviewed randomly along the different farm routes. Information gathered spanned cropping patterns, soils and their management, fallow successions, rotations/management and uses; trees on fallow and crop lands, their importance, management and uses; weeds, their importance and management. All of the informal data gathered from this and the preceding sections have been employed in a qualitative livelihoods description of the three villages presented in Chapter 2.

A detailed questionnaire survey of 242 individuals and households was administered after the general PRA exercises. This was necessary to verify and complement data collected from the PRA and to support on-farm experimentation. The data has been employed in a quantitative characterization of the livelihoods of the people (Chapter 4) to aid in determining recommendation domains for probable adoption of the technologies that might emerge from the experimentation with farmers.

3.3.2 Planning

3.3.2.1 Stakeholder workshop and development of technology options

Activities undertaken during the stakeholder workshop are presented in Table 3.4. Initial protocols of interventions were developed for the various study areas. These were derived after an analysis of PRA/baseline information presented in Chapter 2, taking into consideration production constraints in relation to land status of farmers and cropping systems with respect to fallow rotations at a stakeholder/planning workshop. The emerging issues of concern for redress were mainly poor yield and its links with soil fertility decline, noxious weeds, short-term access to farmland and financial problems encountered by the farmers.

Table 3.4: Activities in the Workshop

Activity	Objective	Tools/ Methods	Expected Output	Who Involved	Time Spent
Presentation and discussion of PRA findings	To understand the dynamics/functioning of the farming & livelihood system	Presentations Discussions	Background knowledge for critical analyses of farming & livelihood systems to aid proposing of on-farm interventions obtained by participants.	UWB, FORIG, IITA, MOFA, GOAN, CRIG, CRI, UST, GTZ-SFSP	1 day
Field trip to study sites	Other participants from IITA, MOFA, GOAN, CRIG, CRI, UST, GTZ to familiarize or have overview of study sites to aid understanding of farming system	Brief meeting/interaction with farmers Farm visits	IITA, MOFA, GOAN, CRIG, CRI, UST, GTZ participants obtain overview of study site	UWB, FORIG, IITA, MOFA, GOAN, CRIG, CRI, UST, GTZ-SFSP	1 day
Analytical sessions	To analyze farming/livelihood systems and propose/ develop protocols on appropriate interventions for farmer prioritization and subsequent on-farm experimentation	Expert/technical group discussions Pictorial representations of proposed interventions	Protocol of proposed interventions developed	UWB, FORIG, IITA, MOFA, GOAN, CRIG, CRI, UST, GTZ-SFSP	2 days

Table 3.5 summarizes the inventions proposed at the stakeholder workshop. Planted tree fallow (woodlot), tree-food crop, enrichment planting with high value trees, maize-legume relay, permanent plantain and intensified livestock/compost interventions were proposed as alternatives for both Tano and Wenchi to ease declining soil fertility, weeds and cash problems. The tree related interventions were thought more appropriate particularly to landowners who might be in the position to plant trees or fallow for longer

periods and would probably be interested in protecting and improving the productivity of the land in the long term. It was thought that people would be proactive in protecting their farms and surrounding vegetation from bush fires if they were to invest in planting trees of high value.

Table 3.5 Interventions proposed at stakeholder workshop

District	Intervention Name	Intervention Proposed	Description	Problem Addressed
Tano & Wenchi	Planted tree fallow followed by woodlot	Establish planted tree fallows during cropping phase that suppress weeds and are productive (tree fallow serve as a woodlot that can be harvested for wood and sold for cash	Fast growing species – e.g. *Gliricidia, Cassia,* plus high value timber species e. g. *Tectona grandis*) established in food crop. Harvest poles and then timber and return to cropping	Declining soil fertility Increase in weeds Need for cash (wood production for cash)
	Tree – crop establishment in food crop	Establish trees during food crop phase that suppress weeds and are productive	High value trees established in food crop phase, possibly plus cover crops for conversion to tree-crop system e.g. cashew, cocoa, oil palm	Declining soil fertility Increase in weeds Need for cash Declining availability of forest and long fallows
	Enrichment planting	Plant or retain high value trees on food croplands.	High value trees established at low density in food crop phase and protected during fallow phase to result in permanent agroforestry system (trees in fields).	Declining soil fertility Declining tree cover Need for cash
	Relay cropping legumes and maize	Relay crop/main season maize with a legume (either a cover crop or grain legume)	Long season *Mucuna*, Canavalia or *Vigna* planted at tassling stage of main season maize (60 days after planting/possibly during the last maize weeding). The legume will add nitrogen and smother weeds increasing soil fertility, reducing weeds and increasing yield of subsequent crop (which may be any crop)	Declining soil fertility Short land tenure No opportunity to fallow Increase in weeds
	Permanent plantain system	Plant trees and cover crops, for shade and mulch, with plantain	Trees (hedge species – e.g. *Flemingia, Gliricidia, and Inga edulis*) established in food crop. Fallow for two years, cut back trees to hedges and establish plantain (cocoyam) and perennial cover crops (e.g. *Peuraria* but preferably something that doesn't climb). Harvest plantain for one or two ratoons. Fallow for two years *ad infinitum*	Declining availability of forest and long fallows Need for long fallow for good yields of plantain and cash
	Intensified livestock and compost	Intensify livestock production and promote compost production	Control livestock movement, increase livestock numbers, improve feed for livestock (fodder banks); collect more dung and mix with other residues to make compost, apply compost to crops and increase yield at the same time as increasing livestock productivity and cash income	Declining soil fertility Need for fertilizer Need for cash

Atwima	Cocoa established with a cover crop	Initiate land clearance for cocoa by establishment of a food legume inter-crop to increase soil fertility and reduce weed infestation by the time of cocoa planting	In March clear land and establish a cover crop/maize relay intercrop. Short duration cover crop could be *Mucuna* (8 months) and longer duration, *Pueraria* (2 years). Shade trees are established at the same time. In April, food crop and cocoa establishment	Declining soil fertility; Increase in weeds lead to problems in establishment of cocoa
	Organic/inorganic fertiliser usage	Increasing resource levels to overcome declining soil fertility	Use of organic and inorganic fertilizers, as prescribed by the Cocoa Research Institute of Ghana (CRIG)	Declining soil fertility reducing cocoa yields
	Manipulation of cocoa shade	Increase productivity of shade species, or identify species with soil-improving properties	Early shade is intended to comprise of the farmers' food crops and the treatments will be the farmers' normal practice of inter-planting with plantain, cassava, maize and cocoyam. Identification of potential late shade species will be by farmer survey of desirable criteria and species' characteristics, and by ecological survey and use of existing data sets	Requirement for shade reduces cocoa yields directly and indirectly by utilization of crop land Declining soil fertility
	Improved cocoa germplasm	Planting of new, improved hybrid varieties	Replacement of traditional Amelonado stock with improved hybrids developed by the Cocoa Research Institute of Ghana	Declining cocoa yields because of varietal drift and pest/disease problems

The maize-legume relay was purposely proposed to cater to the needs of the non-landowners with short tenancy of at least two years and for those landowners who might not be in a position to fallow because they probably do not have adequate land to permit fallow rotations. The livestock intervention was for all classes of farmers interested in improving the production of livestock as a supplementary income source for supporting the household and farm as well as a source of organic manure for improving soil fertility. Interventions for Atwima were cocoa-based because of the project's aim to improve and sustain cocoa yields using multi-strata cocoa agroforests in that area.

3.3.2.2 Prioritizing interventions

The workshop proposed interventions were represented pictorially (Appendices 8 and 9) and presented to farmers in the study villages for rating. Figures 3.2-3.4 show the pattern in farmers' rating of the workshop-proposed interventions in the three villages.

In Gogoikrom both male and female farmers were substantially in favour of the cocoa-cover crop intervention particularly due to its potential to control weeds once the cover crop is in place (Figure 3.2). Farmers indicated weed incidence as one of their biggest problems on the farm. This was followed in popularity by the cocoa hybrid, mainly due to its early and higher yielding attributes. The next choice was the cocoa-fertilizer intervention, which scored higher than the cocoa-shade tree due to its potential to increase yields in the short term. The cocoa-shade tree was the least preferred because it involved the planting of shade trees with cocoa, which farmers thought could possibly lead to destruction of their cocoa farms by timber concessionaires.

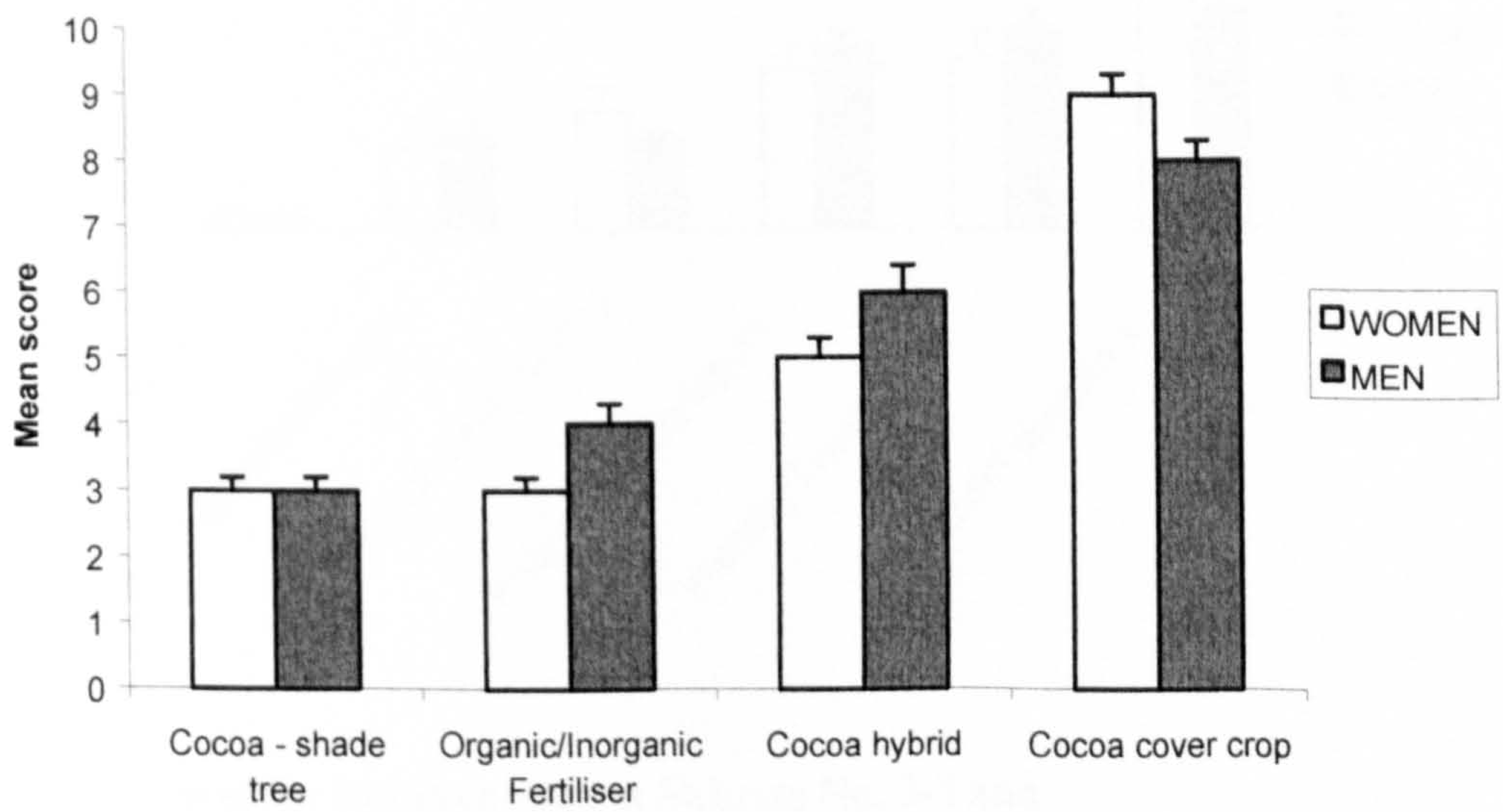


Figure 3.2: Mean scores for interventions at Gogoikrom-Atwima

The permanent plantain system, followed by livestock and maize interventions were the most popular intervention preferred at Subriso III, Figure 3.3. Reasons farmers gave for rating the permanent plantain system as their most preferred choice included the fact that plantain can be cultivated as a long duration crop and can fruit for 10 to 15 years if properly maintained. Plantain also requires less weeding than other crops (once every 3 - 4 months is sufficient) for it to establish. The livestock-compost intervention was the next preferred for economic, food security and socio-cultural reasons. Livestock could be sold to generate cash for farming and household needs and could also be used as collateral to access credit from others in times of financial difficulties.

Relay cropping maize with legumes was rated next to livestock-compost because maize is an important food source and has a number of uses e.g. *kenkey* (ground, fermented, boiled maize), roasted maize that stores well and used by hunters, pito brewing. Maize can be stored for a long time and is important for bridging the hungry season (March/April). It is a short duration crop that can easily be grown by all people including seasonal migrants in need of quick money. Maize is also exported to other nearby countries in the Sahel area, e.g. Burkina Faso.

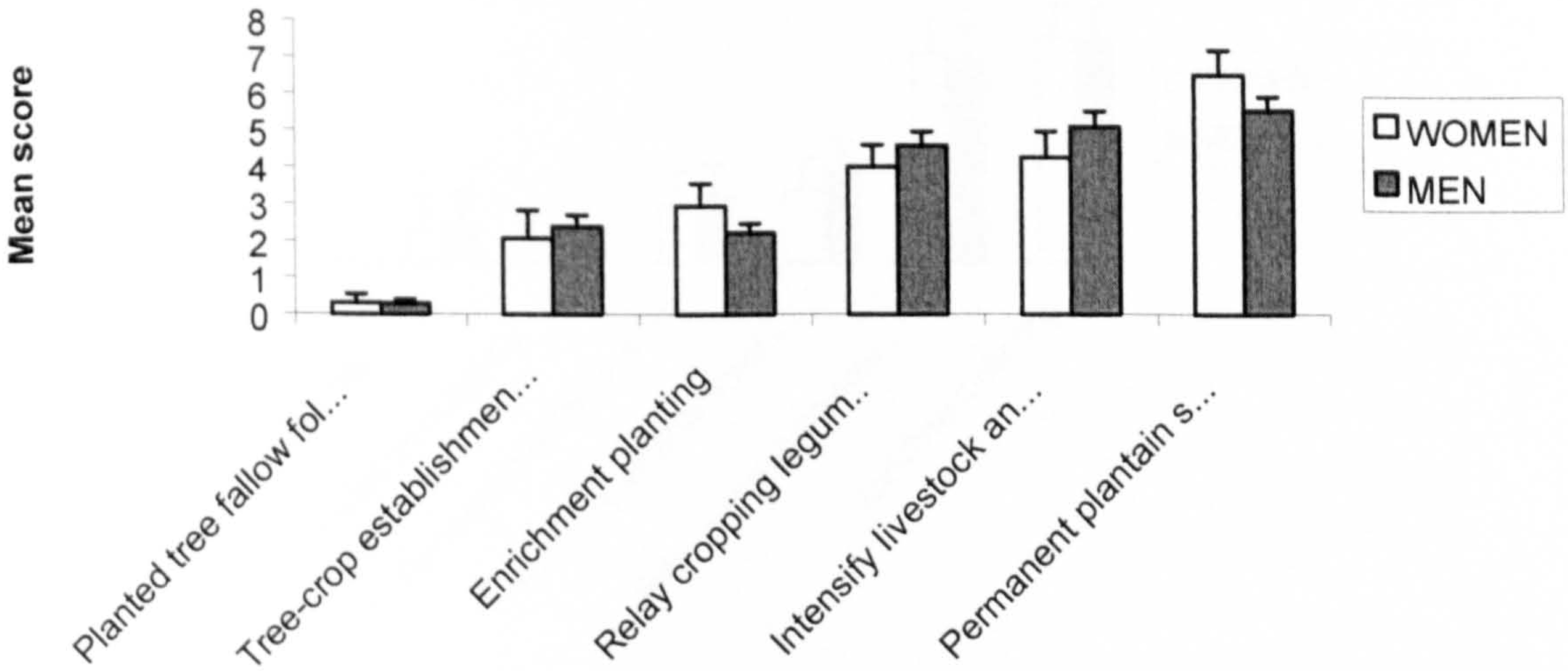


Figure 3.3: Mean scores for interventions at Subriso No. 3-Tano

Conversion to tree-crop systems was the next choice after maize because, although cocoa is regarded as an important crop, the prevailing ecology and soils are not suitable for its cultivation by most people. However, oil palm cultivation is rising and so some people might desire the tree-crop system. The enrichment planting and planted tree fallow/woodlots were the least popular options probably because annual bush fires make this kind of investment unattractive, besides not being a common practice. It was generally observed from further disaggregating of the data that non-landowning settlers were not in favour of the tree-crop system, enrichment planting and the planted woodlot interventions probably because the prevailing tenure is not favourable for adopting such systems.

The pattern of rating in Yabraso is shown in Figure 3.4. Enrichment planting had the highest score followed by maize-legume relay, tree-crop, permanent plantain, livestock-compost and planted tree fallow in that order. Enrichment planting was the most popular for both men and women because the majority of the inhabitants of Yabraso are natives cultivating their own lands, who thus regard this intervention as more or less a long term undertaking to be rated first. Also, the fruit tree aspect was most desirable as species like cashew (*Anacardia occidentale*) and mango (*Mangifera indica*) are becoming increasingly integrated into the farming system as alternatives to cocoa.

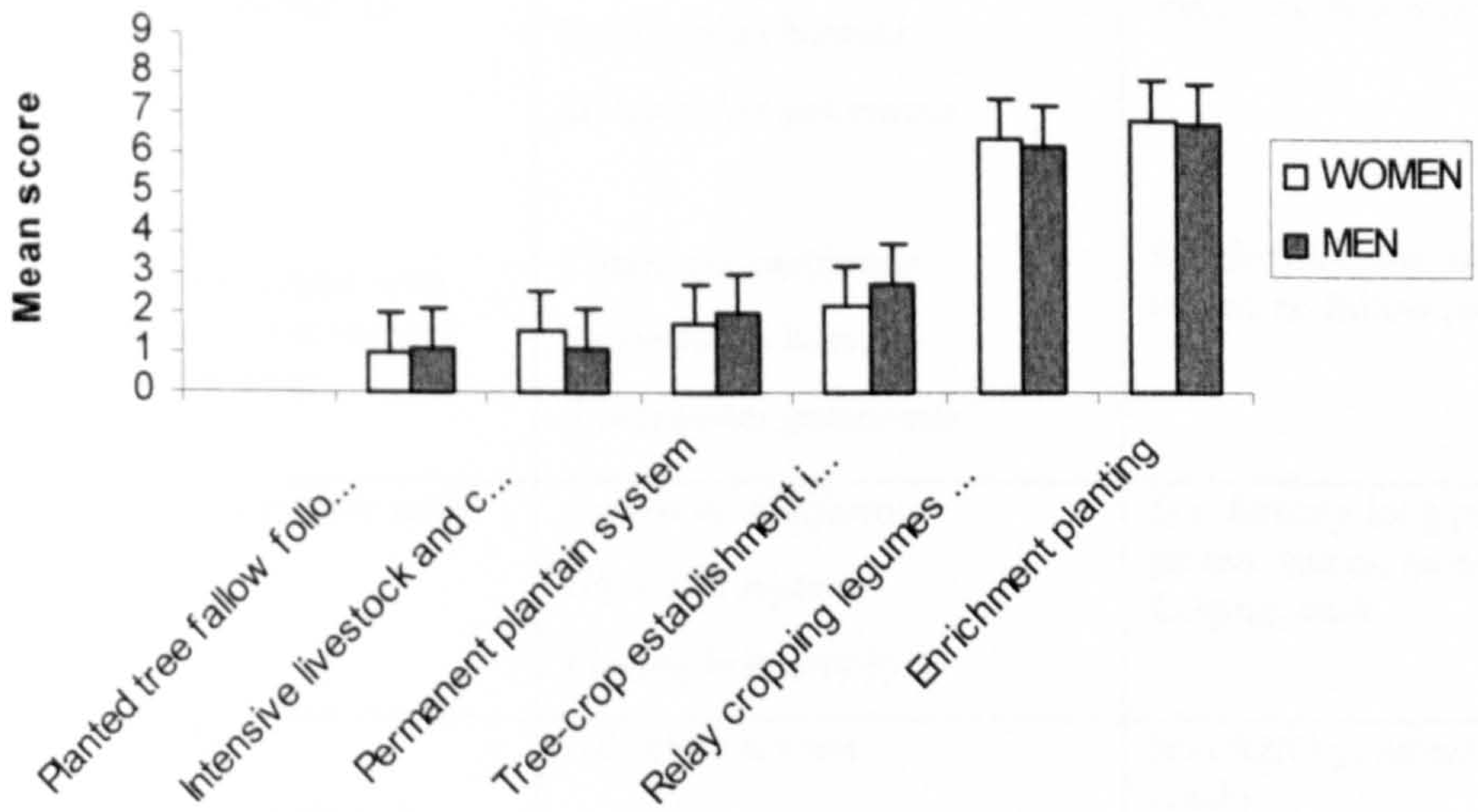


Figure 3.4: Mean scores for interventions at Yabraso-Wenchi

Relay cropping legume with maize was rated next because, although a short term crop, maize is important for food and cash and is grown by all farmer categories in the village. Tree-crop appears to be the next after the maize system probably because such systems particularly with fruit trees such as cashew and mango, and timber species like teak (*Tectona grandis*) is gaining prominence in the Yabraso area. Although some farmers desire to plant plantain on the forest land, the prevailing dry ecology does not favour its production. Livestock-compost and planted tree fallow were the least because livestock such as goat was regarded notorious in destroying farms and the planted tree fallow was highly prone to persistent wild fires in the dry season. The results of the rankings and the discussions that followed lead to the development of on-farm trial protocols for the three study sites (Table 3.6).

Table 3.6: Profile of on-farm experiments in Gogikrom, Subriso III and Yabraso

Farm type	Trial/cropping system	Legume/tree species	Problem to address	Village
Mono crop	Sole maize-cover crop relay	*Mucuna spp* *Lablab purpureus* *Pueraria spp* *Canavalia ensiformis* *Clitoria ternatea* *Stylosanthes hamata* *Stylosanthes guianensis*	Soil fertility, weeds, short tenure, no fallow (settlers)	Gogoikrom Subriso III Yabraso
Mixed crop	Maize intercropped with cassava, plantain, etc. – cover crop	*Canavalia ensiformis* *Stylosanthes hamata* *Stylosanthes guianensis*	Soil fertility, weeds, short tenure, no fallow (settlers)	Gogoikrom Subriso III Yabraso
	Yam intercropped with maize, cassava, cashew, etc –cover crop	*Canavalia ensiformis* *Stylosanthes hamata* *Stylosanthes guianensis*	Soil fertility, weeds, short tenure, no fallow (settlers)	Yabraso
Mixed	Plantain-tree-cover crop	*Canavalia ensiformis* *Gliricidia sepium* *Flemingia microphylla*	Soil fertility-long productive period, stakes, poles, fuelwood, lodging, cash	Gogoikrom Subriso III
Planted fallow	Tree fallow -Whole field planted	*Gliricidia sepium*	Soil fertility, weeds, wood (cash)	Subriso III Yabraso
Mixed	Cocoa-shade tree	*Albizia zygia (Okoro)* *Newbouldia laevis (Sesemase)* *Tetrapleura tetreptera (Prekese) Terminalia ivorensis (Emire) Entandrophragm angolense (Edinam)* *Pericopsis elata (Kokrodua)* *Entandrophragma utile (Utile)*	Soil fertility – long productive period, weeds Trees of important ecological & socio-economic values integrated on cocoa farms Tree cover- long fallows Wood sales-extra cash	Gogoikrom

The cocoa-shade tree, maize-legume relay, permanent plantain and improved fallow protocols were developed for Gogoikrom-Atwima. This was because cocoa, maize and plantain are commonly grown in the area. The improved fallow was added on to observe whether some landowners could adopt it for improving the productivity of the short fallow systems practiced for rice and maize production systems which are normally fallowed from 1 to 3 years or more. It was realized from the discussions with the farmers that although cocoa-legume cover crop and cocoa-fertilizer were most preferred, farmers complained of the possibility of the creeping legume they referred to as carpet to climb or strangle the cocoa. Also fertilizers both organic and inorganic are difficult to come by and are not usually applied on tree crops.

The Maize-legume relay, permanent plantain and improved fallow interventions were suggested for Subriso III-Tano because these were the interventions the majority of the farmers desired during the prioritization. Moreover, maize and plantain are predominantly grown in the area and these production systems are commonly fallowed over short periods (1 to 3 years or more), hence, their improvement could enhance the livelihoods of the majority of households. The livestock system could not be pursued although farmers expressed much interest because there was a MoFA project in the district working on that aspect.

Maize-legume relay, yam-legume relay (suggested by farmers), improved fallow and tree-crop interventions were suggested for Yabraso-Wenchi because maize and yam are commonly grown in the area and desired by most farmers. Like Subriso, these production systems are usually fallowed over short periods from 1 to 3 years. Tree-food crop systems with cashew, mango and teak tree are increasingly being planted in the area. Also, farmers showed much interest in enrichment planting which involved planting or retaining high value trees on food croplands, which they perceived as fruit trees with food crops during the ranking.

3.3.3 Implementation

3.3.3.1 On-farm experimentation

3.3.3.1.1 Farmer choice of on-farm experiments

The on-farm trial protocols were presented and discussed with farmers in the respective study villages. Farmers exercised their choice of experiments at the beginning of the 2001 and 2002 farming seasons (Figures 3.5-3.7). In Gogoikrom-Atwima cocoa-shade tree was the most desired technology for both men and women for 2001 and 2002, since cocoa is the mainstay of the people. This was followed by maize and plantain which are supplementary crops cultivated for food and cash while establishing cocoa farms. A total of sixty-nine and seventy-six farmers enrolled for the on-farm experimentation during the first (2001) and second (2002) years respectively with some trying more than one and/or repeating some experiments in the second year, although not all who enrolled took part each year.

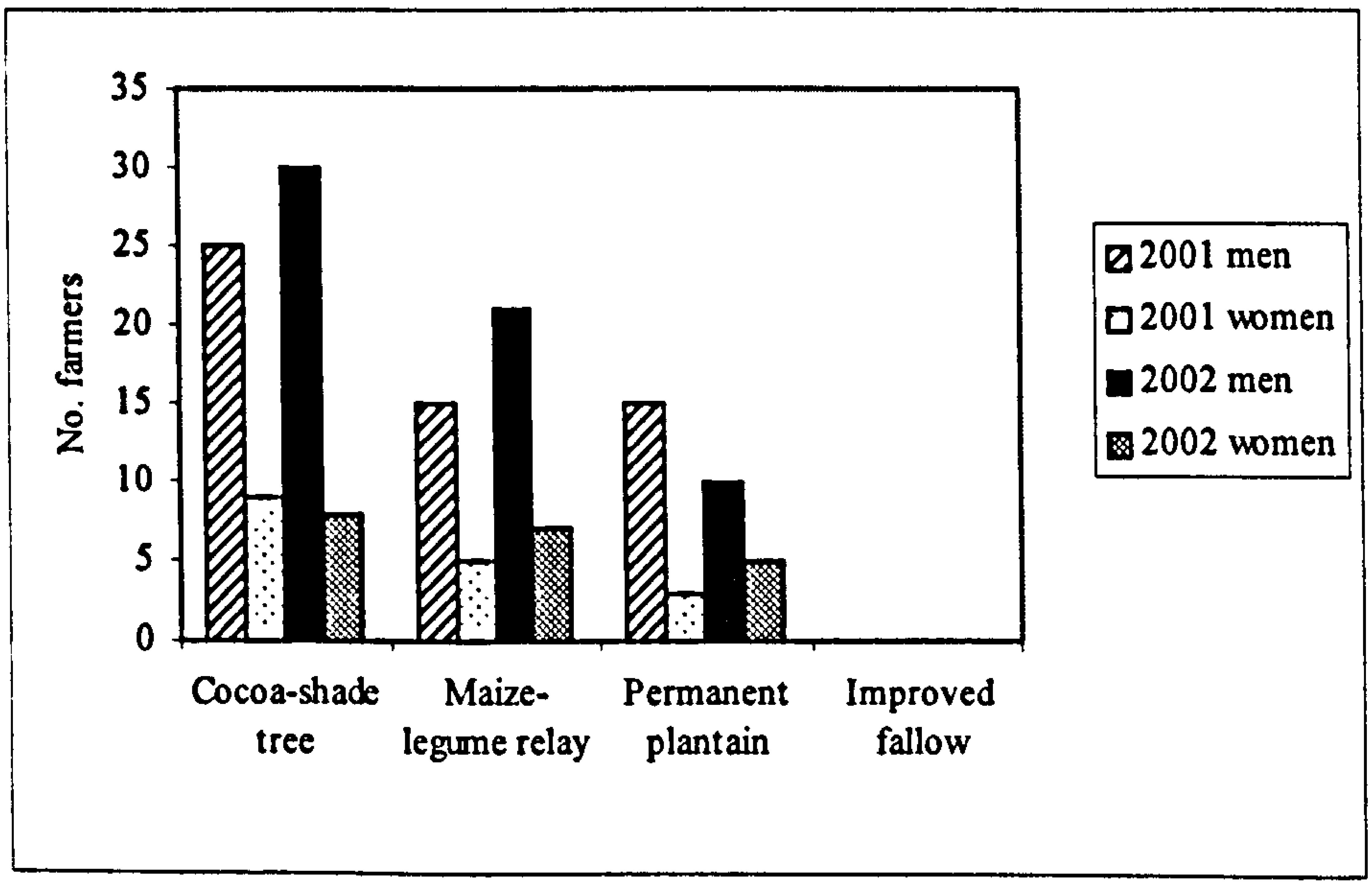


Figure 3.5: Farmer choices of on-farm experiments-Gogoikrom-Atwima

At Subriso III –Tano maize-legume relay was the overall preferred experiment followed by permanent plantain and improved fallow for both years (Figure 3.6). In the second year, forty-four people showed interest in the maize-legume relay, about twice the number doing so in the first year. This could be attributed to the reduction in the level of the usual uncertainties farmers encounter in trying new things. In particular, doubts over ownership of proceeds from the experiment were cleared as farmers realized the project demanded nothing by way of produce or money from the 2001 participants after the harvest, which some of them feared was going to be the case.

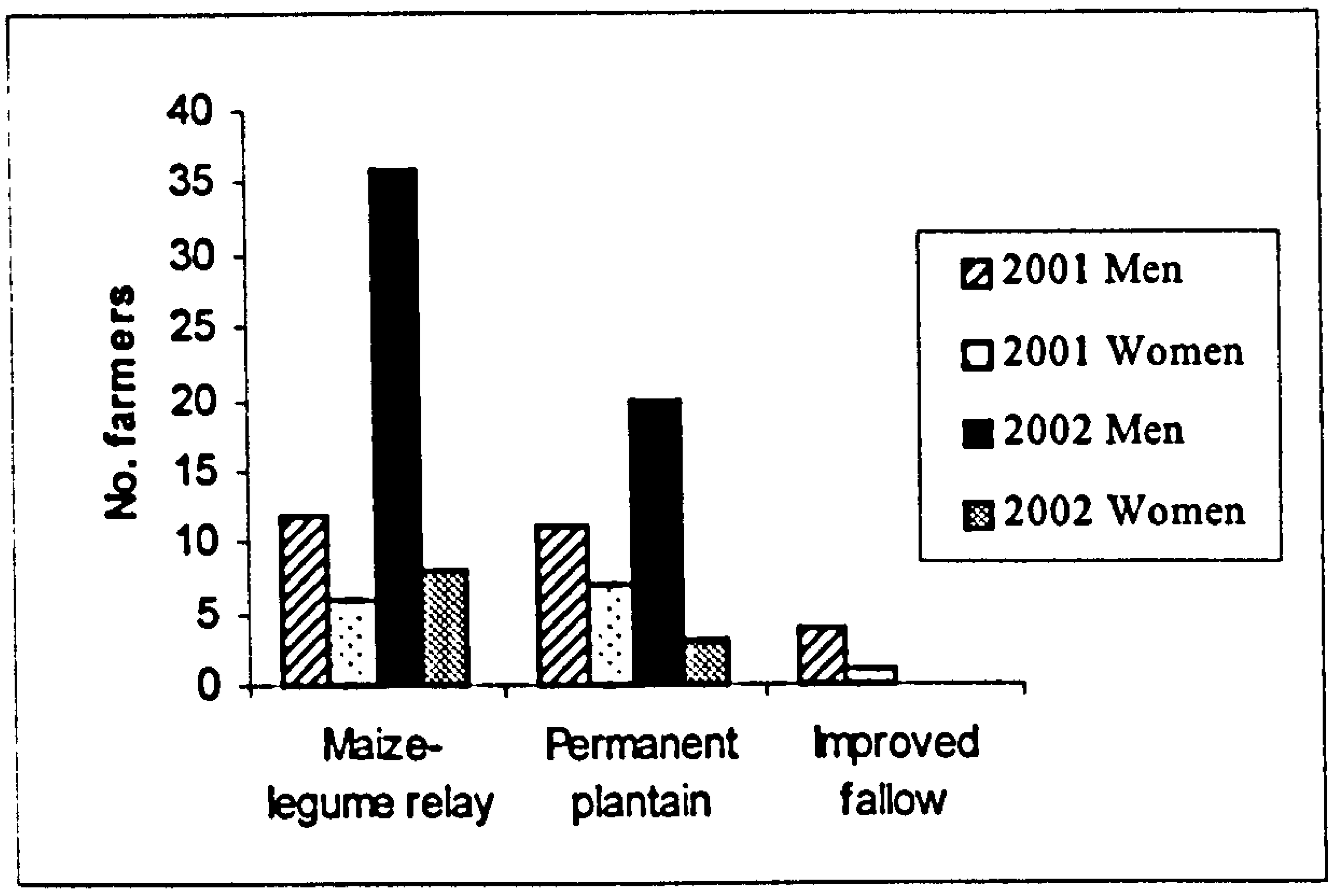


Figure 3.6: Farmer choices of on-farm experiments Subriso III-Tano

There were more men than women at the meeting. This reflected in the big difference in numbers between men and women for the three experiments, particularly, in the second year. Unlike Gogoikrom, a few landowners including one woman expressed the desire to try the improved fallow in the first year, which could actually not be implemented due to shortage of stocks of the fallow species (*Gliricidia*) at the project's nursery. During the second year, however, no one showed interest in the improved fallow, possibly because no one tried it in the first year.

Figure 3.7 indicates the pattern in choice of technologies for on-farm experimentation at Yabraso-Wenchi. A total of seventy-three and fifty-two farmers enrolled for on-farm experimentation for 2001 and 2002 respectively. There were more women than men at the meetings for enrolling farmers in both years, the converse of Gogoikrom and Subriso where there were more men than women. Most people chose yam and maize over improved or planted tree fallow for experimentation.

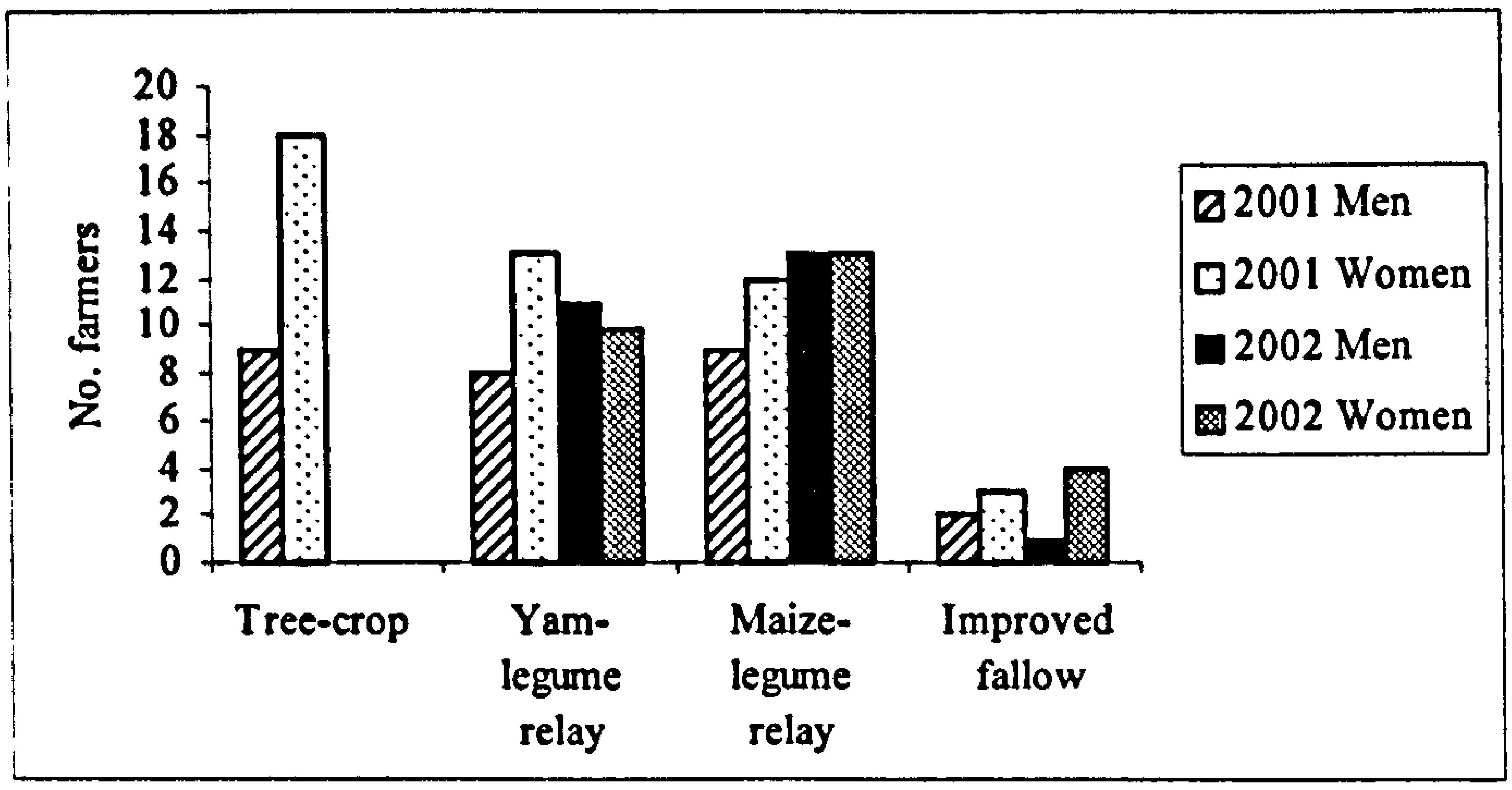


Figure 3.7: Farmer choices of on-farm experiments at Yabraso-Wenchi

Although, the majority of farmers preferred to plant cashew and oil palm for the tree-food crop technology in 2001 as the people tend to regard cashew as the new cocoa of the area it was realised that the seeds were expensive and not easy to come by, thus could not be implemented.

3.3.3.1.2 On-farm experiments

Two types of trial were established. The first was researcher-managed trials established on-station for the collection of more accurate biophysical data for complementing on-farm data and also to serve as a demonstration. The biophysical data collected comprised biomass assessment of fallow species particularly, screening of these species, studying the effect of planting date and density, phosphorus, etc. on herbaceous and tree fallow species. The second type of trial was on-farmer fields as researcher-designed and farmer-managed on-farm experiments. Table 3.7 indicates the respective roles farmers and researchers played during the experimentation process.

Researchers provided seeds for the experiments and advised on planting and management. Farmers provided their land and labour for planting and weeding. Researchers also marked plots. Each participating farmer's intended trial plot was first visited to ensure that it was ready for planting before the experiments into the prevailing cropping systems. The protocols for the various experiments are described under the respective sections below.

Table 3.7: Researchers & farmers' contribution in experimentation

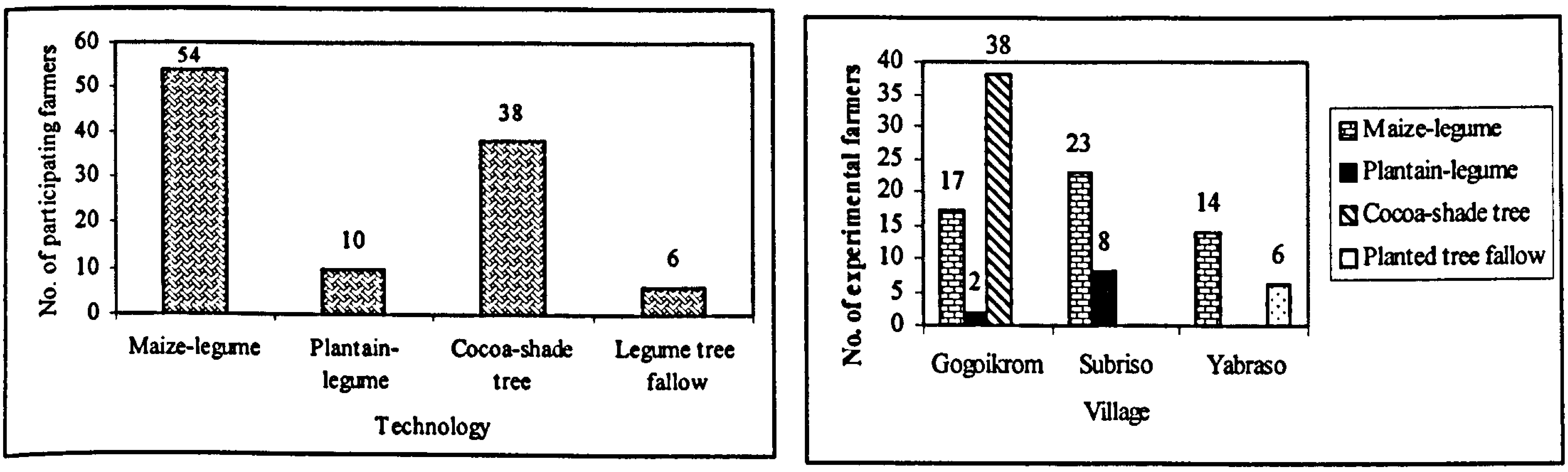
Activity	Researchers & Farmers Roles
Field preparation	Farmer
Design of experiment	Researcher
Selection of fallow and test species	Researcher with input from farmer discussion
Supply of planting materials	Researcher
Nursery activities	Farmer (indigenous trees and cocoa) & researcher (all other species)
Planting experiment	Farmer & researcher
Weeding	Farmer
Data collection	Researcher
General observations	Farmer & researcher
Monitoring &evaluation	Farmer & researcher
Crop harvest	Farmer
Ownership of proceeds	Farmer

Farmers planted maize and yam the way they would normally do in any pattern they wished. The researchers assisted with the planting of legume covers in a regular pattern. For the plantain and improved fallows researchers assisted farmers with marking out the positions of trees, plantain, and legume covers as well as planting these species in a regular pattern.

For the cocoa experiment farmers planted the cocoa seedlings and plantain (early shade for cocoa) the way the would normally plant or in any manner they preferred, after the tree positions had been regularly marked or pegged at 12 x 12m triangular spacing by researchers and farmers together. The farmers then planted seven different indigenous trees species wherever they deemed fit at the pegged positions. The indigenous tree species were identified by farmers as suitable shade trees for cocoa farms during the qualitative characterization period.

3.3.3.1.2.1 Profile of participating farmers

A total of 108 farmers participated in all of the trials over the two years (2001 & 2002) in all three-study villages (Figures 3.8 and 3.9). Maize had the highest number of farmers experimenting, followed by cocoa, permanent plantain and improved/tree fallow in that order.



Figures: 3.8 & 3.9: Total number of farmers experimenting in 2001 and 2002

The trend in participation is shown in Figure 3.10 and Table 3.8. The drop in the number for the maize in the second year was mainly because some farmers were discouraged as a result of the poor performance of the experiments in the first year and particularly for Yabraso it was also because a Ghana Government-African Development Bank food security project was offering credit for maize cultivation. Thus, although a number of farmers enrolled for participation and were supplied with seeds, they declined to relay the legume. In Gogoikrom interest shifted towards the cocoa-shade tree technology, as cocoa was more of a priority than maize.

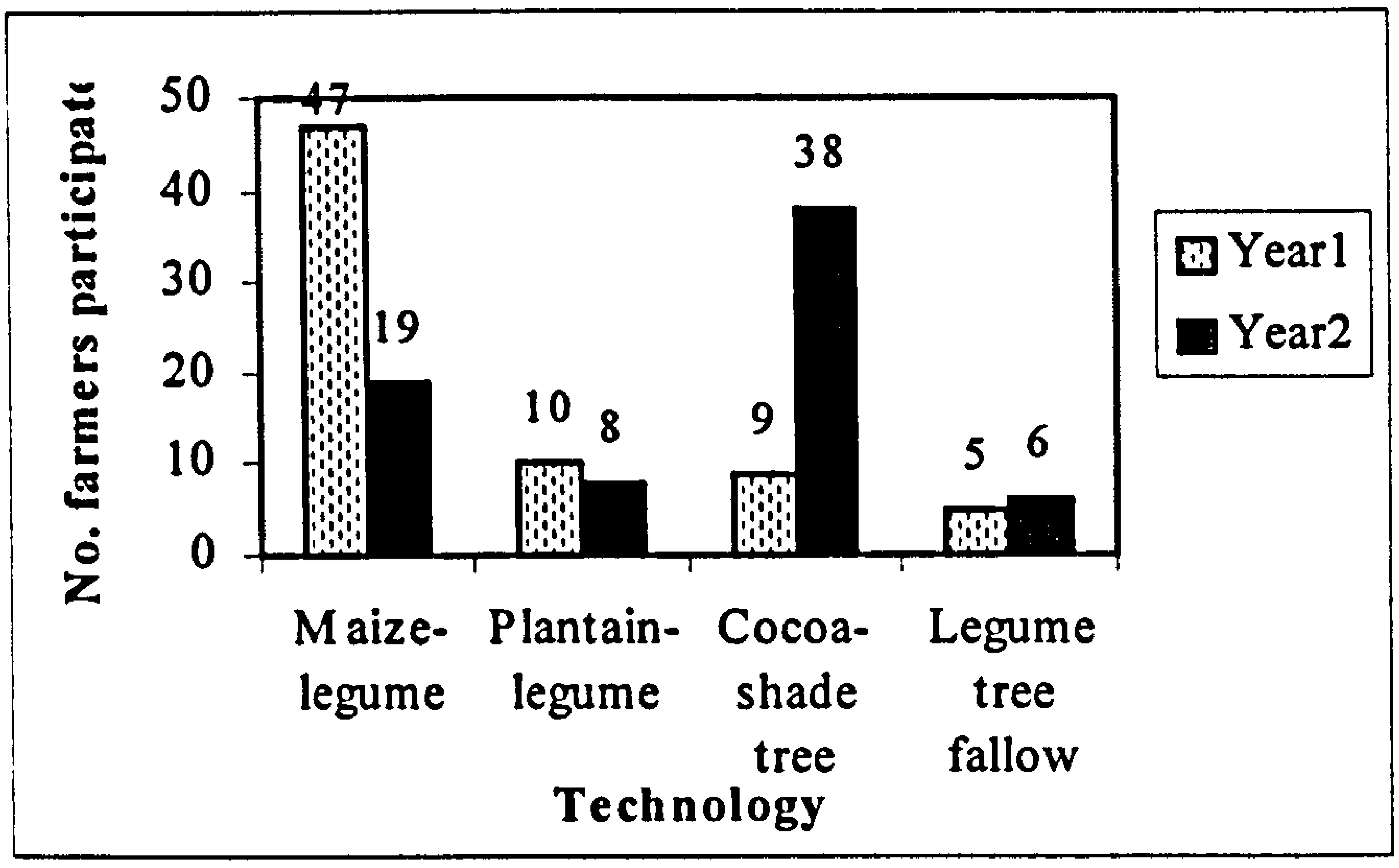


Figure 3.10: Participation trend over two seasons/years

Table 3.8: Participation trend over two seasons/years

Technology/intervention	Number of farmers					
	Yearl	Year2	Repeated	New	Did not repeat	Total (2001 & 2002)
Maize-legume	47	19	12	7	35	54
Plantain-legume	10	8	8	0	2	10
Cocoa-shade tree	9	38	9	29	0	38
Legume tree fallow	5	6	5	1	0	6
Total farmers = 108						

Table 3.9 summarizes the characteristics of the trial farmers. Generally, the proportion of male farmer experimenters was higher for maize, plantain and cocoa trials than the female experimenters probably because there were usually more males than females at the village meetings at the time of enrolling farmers except at Yabraso. For the planted tree fallow in Yabraso the proportion of female experimenters was higher than that of the males.

Table 3.9a: Profile of trial farmers

Characteristic	Maize legume-relay	Permanent-plantain	Cocoa-shade tree	Improved/tree fallow
Site				
Gogoikrom-Atwima	28%	30%	100%	-
Subriso III-Tano	43%	70%	-	-
Yabraso-Wenchi	28%	-	-	100%
Farmer category				
Native female	16%	20%	5%	67%
Native male	22%	30%	8%	33%
Settler female	15%	20%	16%	-
Settler male	47%	30%	71%	-
Gender				
Male	69%	60%	79%	33%
Female	31%	40%	21%	67%
Age (years)				
Mean	45	46	45	51
Range	20-86	29-53	23-82	40-78
Educational status				
Literate (%)	57	82	38	86
None (%)	43	18	62	14
Cropping type				
Mono crop	67%	100% Plantain-legume mix	100%	100% tree legume fallow
Mixed crop	33%			
Plot size				
Mean farmer plot size (ha)	0.3 (0.1-0.6)	-	-	-
Intervention plot size (ha)	0.12	0.13	0.26	0.08
Land status of trial plot				
Land owner	54%	70%	21%	100%
Tenant	46%	30%	79%	-
Tenant tenure to trial plot				
Sharecrop	57%	100%	100%	-
Rent by cash	24%	-	-	-
Free	19%	-	-	-
Previous use of land				
Long fallow land	9%	10%	72%	-
Short fallow land	38%	10%	22%	-
Food cropped land	53%	-	6%	100%
Not recorded	0%	80%	0%	0%

Characteristic	Maize legume-relay	Permanent-plantain	Cocoa-shade tree	Improved/tree fallow
Tenant tenure to trial plot				
Sharecrop	57%	100%	100%	-
Rent by cash	24%	-	-	-
Free	19%	-	-	-
Previous use of land				
Long fallow land	9%	10%	72%	-
Short fallow land	38%	10%	22%	-
Food cropped land	53%	-	6%	100%
Not recorded	0%	80%	0%	0%

All the four farmer categories, i.e. native males, native females, settler males and settler females comprising both landowners and non-landowners participated in the maize, plantain and cocoa trials whereas only natives (landowners) experimented with the improved/tree fallow in Yabraso. A chi-square analysis showed no significant differences between the proportions of the participants from the four farmer groupings in the communities with their distribution in the total village population across the three sites (Table 3.9b). Over 50% of the experimenting farmers for all the technologies were literate except those for cocoa of which the majority had had no formal education.

Table 3.9b: Overall community groupings in experimentation

Farmer samples	Native men	Native women	Settler men	Settler women	χ^2
Village population	21%	17%	47%	15%	
Experimenting farmers	21%	17%	48%	14%	6.3^{NS}

Chi square test: NS: Not significant at $p = \leq 0.05$ and $p = \leq 0.01$

The maize-legume relay was experimented with in all three villages with Subriso III having the highest number of farmers participating (Table 3.9). Two-thirds of the experiments were planted to monocrop maize fields and a third in mixtures of maize with cassava, plantain, cocoyam, etc. Nearly half of the farmers planted the experiment on land they owned and the remaining fields were planted largely on sharecropped land. The majority (53%) of the experimental fields had been previously cropped to maize or yam, although a couple of them had been planted to short and long fallow lands respectively. Both the young and old participated in planting the maize-legume technology with a mean age of 45 years and the majority (69%) of these were men. The higher proportion of native and settler males experimenting with the maize-legume is because males predominantly grow the crop across the three villages.

An important issue that must be noted from Table 3.9 is the fact that the maize experiment was being established on mainly short fallow and previously cropped lands almost equally by landowners with secured tenancy and non-landowners with insecure short tenancies with a mean tenancy period of 2 years (1-3 range, median 2 and mode 1). This will put more pressure on the soil nutrient resource base, which is in agreement with the underlying reasons for suggesting this intervention at the stakeholder workshop. The fact that maize is a short duration crop and is currently an important food and cash crop across the three villages for all categories of farmers makes the maize-legume relay technology very appropriate for adoption as maize cultivation is being increasingly intensified, which can lead to further degradation of the farm environment.

The permanent plantain system was tried in Gogoikrom and Subriso III with 70% of the farmers in Subriso III. The experimenters comprised both native and settler male and females and the majority (60%) of them were men. 70% of the experiments were planted on land owned and 30% planted on land acquired through sharecrop arrangements. 10% each of the experimental plots had been cleared from land previously under short and long fallow respectively but for 80% of experimental plots the previous use was not recorded. It appears that whereas both landowners and non-landowners may easily experiment with the maize legume relay, the permanent plantain may be more appropriate for landowners, since plantain is more of a perennial food crop and the planting of trees to improve the soil requires a secured tenure.

The cocoa-shade tree experiment was planted only in Gogoikrom-Atwima where cocoa production is the mainstay of the people. All farmer categories comprising male and female natives and settlers participated in the experiment. 79% of these farmers were men with the majority being settlers. The majority (79%) of the experimenters were tenants all of whom planted the experiment on land acquired through the *abunu* sharecrop arrangement. Most (72%) of the fields planted to the experiment had been cleared from long fallow lands with 22% from short fallow land and 6% from long fallow land previously cropped to maize-cassava-plantain for at least two years.

The improved/tree fallow experiment was planted at Yabraso-Wenchi. The experimenters comprised solely natives, 67% of whom were women. All the experiments were planted on land owned and which had previously been cropped for an unspecified number of years.

3.3.3.1.2.2 Establishing on-farm experiments

Maize - legume relay experiment

Figure 3.11 shows the ground layout of the maize-legume relay experiment. Farmers at their own convenience between March and June sowed 2kg of maize on variable plot sizes of their choice. The mean farmer maize plot size was 0.3 (0.1-0.6) ha. The intervention plot measuring 40 x $30m^2$ (0.12ha) was marked by researchers and laid within the farmer's maize field. It was demarcated into 3 treatment plots for legume species 1 and 2 and a control. The control plot was twice the size of each of the legume ones to make comparison of the outcome of the experiment at the end of the season more meaningful to the farmer.

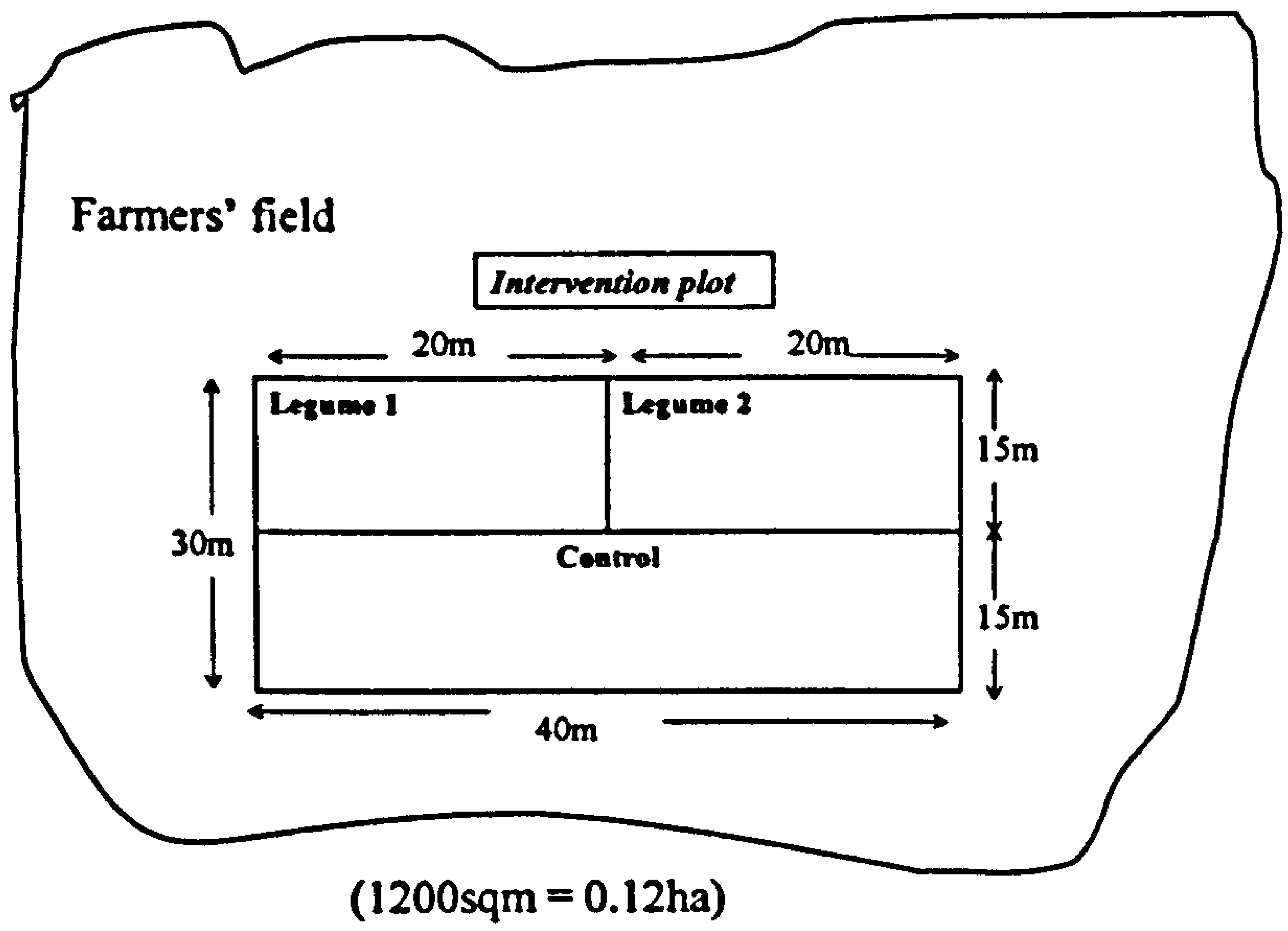


Figure 3.11: Plot layout of maize-legume relay on-farm experiment

The legumes were relayed after 8 weeks of sowing maize during the first year. Each farmer was supplied with 750 grains of the large seeds of legume covers like *Mucuna*, *Canavalia*, and *Lablab* and 60 grams of small seeded legumes such as *Stylo*santhes and *Pueraria* in the first year. Creeping legumes like *Mucuna* *spp., Lablab purpureus, Pueraria spp., Clitoria tenatea* were sown on sole maize farms while non-creeping ones like *Canavalia ensiformis, Stylosanthes hamata* and *Stylosanthes guianensis* sown on mixed farms (maize-plantain-cassava-cocoyam, etc).

The quantity of legume seeds planted, time of planting and the planting distances adopted in the first year did not favour establishment with respect to production of enough biomass and spread of legume to suppress weeds. There was inadequate rain after sowing of the legume. Also there was competition from weeds because farmers did not weed after sowing the legume, and there were problems of shading by the maize and other food crops. Consequently, the quantities of legume seeds were doubled and the within-row spacing halved in the second year to quicken ground coverage and ensure sufficient biomass production before the end of the rains.

The legumes were relayed quite early, 5-6 six weeks after sowing maize (when the first weeding is usually done and the maize would be at knee height) depending on the species and cropping pattern. *Canavalia*, a non-creeper, was sown at 4 weeks on both mono and mixed fields, whereas *Mucuna*, a creeper, was sown at 5-6 weeks after sowing the maize on monocrop fields. The legumes were planted from late May to July depending on when the farmer planted his maize. The number of legume varieties was reduced to *Mucuna spp., Pueraria spp* and *Canavalia ensiformis* during the second year due to unavailability of seed for all the other species like the *Stylosanthes* and *Clitoria* used in the first year.

Rainfall was fairly evenly distributed throughout the growing period in the second year. Consequently, legume establishment on most farmer fields was impressive. Plates 1-2 (Appendix 13) show some of the farmer fields with *Mucuna/Canavalia* and the control (without legume) respectively. *Mucuna* is much faster at growing and spreads faster than *Canavalia* and *Pueraria*. On some of the farmer fields, *Mucuna* coverage and/or biomass was so heavy that its vines strangled and covered some maize plants together with well-formed cobs.

Some biophysical data on growth and biomass production of legumes, weeds and maize yield was gathered over the two years. Maize yield data was estimated from 5m x 5m plots laid within each treatment plot to ensure uniformity/accuracy. Details on the biophysical aspect of the study are reported in Ayisi Jantango (2003). More data on the effect of legumes on soil, maize yield and weeds has been collected during the 2003 growing season for further analysis. Data on labour for clearing legume fallow as against the control was gathered at the onset of the 2003 growing-season for cost-benefit analysis of labour-yield relationships in Chapter Five.

Yam-cover crop/legume experiment

The yam – legume experiment was tried at Yabraso. The design of the experiment was the same as that for maize (Figure 3.11). The farmers planted their own yam seeds. They planted their yam fields by December (dry season), the previous year. Non-creeping legume covers such as *Canavalia ensiformis, Sylosanthes hamata* and *Stylosanthes guianensis* were sown during the rainy period since yam fields were mixed (yam-cassava). Also, the yam crop matures in about 8 months and so creeping legumes are likely to strangle the yam stakes and shade the vines to reduce tuber development.

Interest in the yam-legume relay, however, waned as the *Stylo* species relayed in the first year performed poorly due to insufficient rain after sowing. It was also observed that there were cassava and sometimes cashew on the plots after the yam had been harvested since this system was a mixed one. For this reason it was not possible for some of the farmers to repeat the experiment on the same field. Only one field, which was previously under a monocrop yam, could be planted. The new entrants listed could not experiment because *Stylo* seed was in short supply. No meaningful data was gathered over the two years of trials for this experiment.

Permanent plantain experiment

The design of the experiment comprised two rows of plantain spaced at 3m x 3m between two rows of leguminous tree species (*Gliricidia sepium, Flemingia microphylla*) spaced at 6m x 1m and two rows of leguminous shrub *(Canavalia ensiformis)* at 1m x 0.5m spacing between two rows of plantain. Each permanent plantain trial plot measures 42m x 30m and was divided into four portions of dimensions 21m x 15m. The four areas were each planted to plantain and *Canavalia*, plantain and *Flemingia*, plantain and *Gliricidia* or sole plantain (Figure 3.12). The *Gliricidia* and *Flemingia*, were pruned when necessary and the biomass applied on the plot as mulch to decompose, to improve the soil and control weeds to sustain plantain production over a longer period. The *Flemingia*, may have to be replanted at least after two years, while the *Canavalia* may have to be replanted annually or after two years.

In the first year, 450 seeds of *Canavalia ensiformis* and 80 seedlings from poly-potted seedlings of

Flemingia macrophylla and *Gliricidia sepium* were planted. In the second year, the quantity of seeds of *Canavalia* was increased to 1260 and seedlings of *Flemingia* and *Gliricidia* increased to 160. This was to enhance ground coverage in a shorter time. During the first year, farmers preferred to plant the experiment during the minor season i.e. September and October because when planted earlier with the major season rains in May-June, the pseudostems were likely to grow very tall and become highly prone to wind throw by strong winds at the onset of the next major season between February and April. When planted later with the minor season rains in September/October, the stems are shorter and can withstand the strong winds.

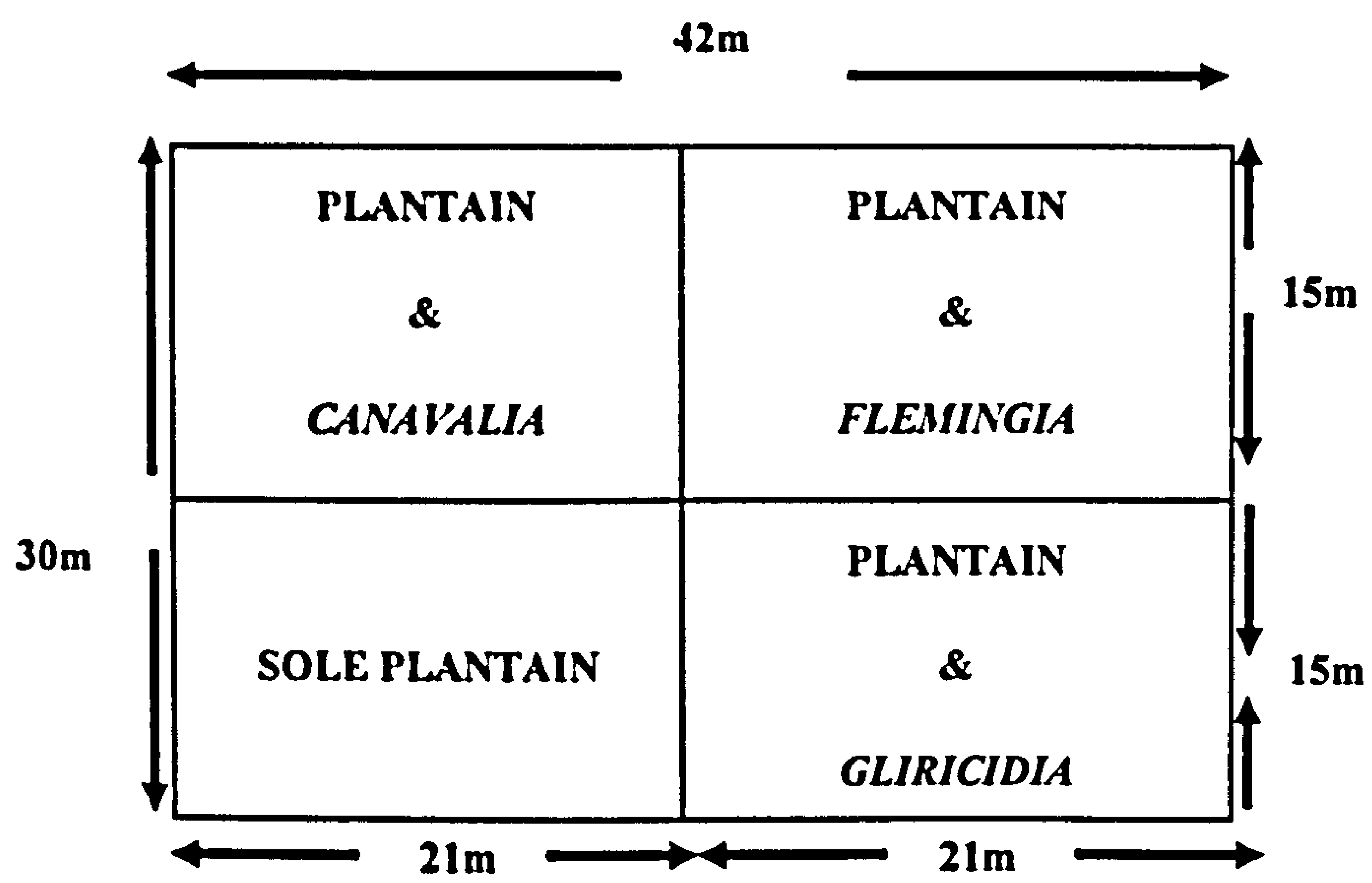


Figure 3.12: Plot layout of permanent plantain experiment

However, it was realized during experimentation that early drought during the minor season affected the uptake and establishment of the plantain suckers and legumes. Thus, the outcome of the experiment at the end of the first year was quite poor. Consequently, during the second season the experiment was planted earlier (May-June) when there was enough rain to ensure that the plant species obtained adequate moisture for proper establishment. Nearly all the first year fields were re-established in the second year. The result of the experiment at the end of the second year was impressive. Plate 3 (Appendix 13) shows the permanent plantain experiment with the *Gliricidia* portion on a farmer's field at Gogoikrom-Atwima in October 2002.

Initial data on growth and biomass production for *Gliricidia* and *Flemingia* has been gathered, although not sufficient to warrant any meaningful analysis in the biophysical portion of the study. Since this is more of a perennial system, more data, particularly on the effect of legume mulch on soil, weed development and plantain yield as well as costs and revenues, will be collected in the coming years for a more a comprehensive assessment of the experiment. However, an *ex-ante* analysis of the profitability of the technology has been done to access its potential for adoption.

Improved/tree fallow experiment

Figure 3.13 shows the design for the improved fallow experiment. It is comprised of two blocks/plots of 20 x 20m each under a leguminous tree *Gliricidia sepium* spaced at 3m x 1m and with natural fallow (farmers' practice).

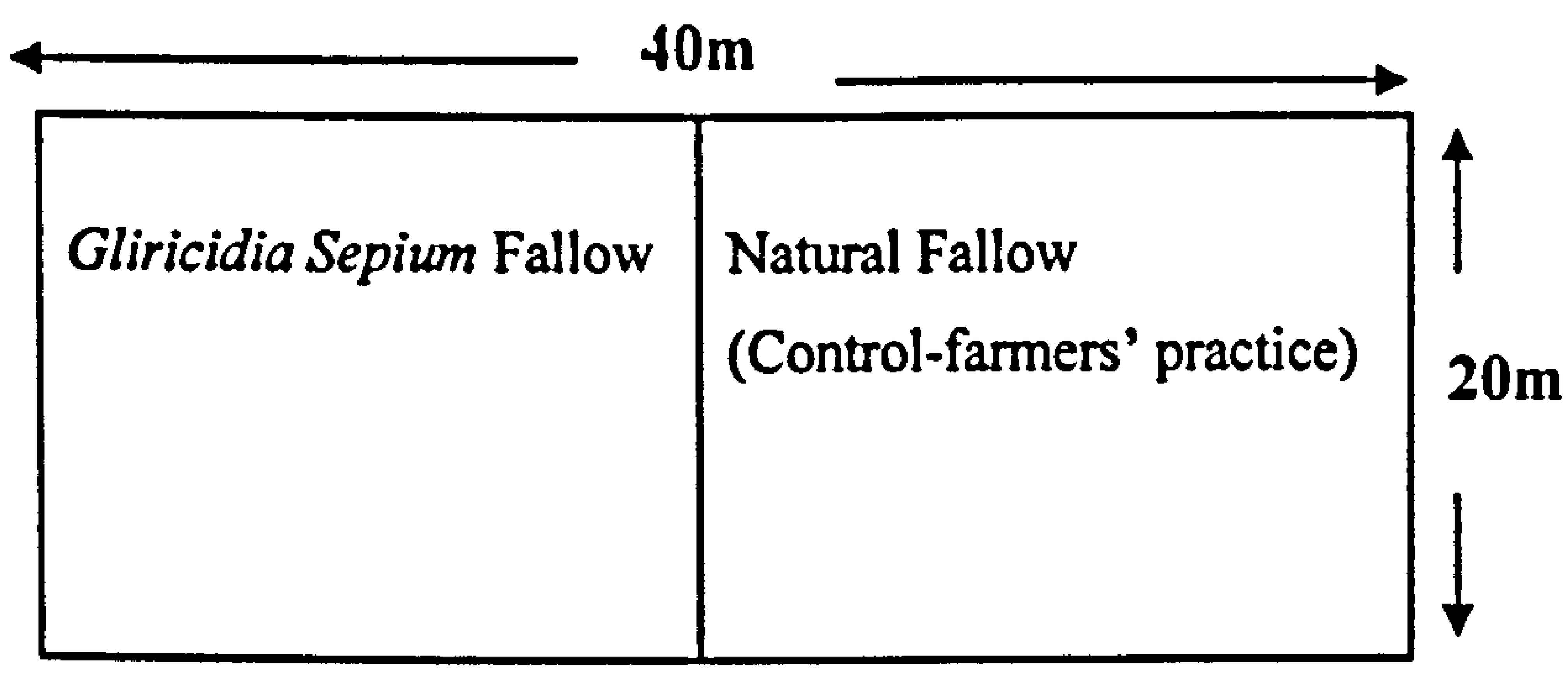


Figure 3.13: Plot layout of improved fallow experiment

A farmer's field going into fallow was planted to the experiment. In the first year, *Gliricidia* seedlings were planted with the minor season rains, in September, as it is from this period onwards that particularly, all maize is harvested and fields left to go into fallow. However, the sudden drought during the minor season resulted in the seedlings establishing poorly.

All the first year fields were re-established in the second year. This was done during the rainy period (May-June) to ensure adequate moisture for good plant establishment. The within-row spacing was also halved to quicken canopy closure since no food crop would be planted in the alleys. If the technology is to be used halved to quicken canopy closure since no food crop would be planted in the alleys. If the technology is to be used in the major season, then it might be worth planting maize in the alleys for the first three months when the *Gliricidia* seedlings would have taken off to prevent wasting the prepared alley space.

The farmer will clear the fallow after 2-3 years, which is the current length of fallow period in most places, and cultivate the two plots to any crop of his/her choice. The productivity of the *Gliricidia* and natural fallows with respect to the yield of a succeeding crop, labour used in clearing and fallow products will be assessed. Again, an *ex-ante* analysis of the profitability of the technology has been done to access its potential for adoption

Multi-strata cocoa agroforest /cocoa-shade tree experiment

Typical traditional cocoa fields in their initial years of establishment are often in mixtures with cocoyam, plantain, cassava and maize with coppice shoots of desirable, naturally occurring tree species. Consequently, the experiment was set up to mimic this pattern. Each farmer plot under the experiment is 24 x 54 m (1296m^2) comprising two blocks of hybrid cocoa and seven indigenous shade tree species per block intercropped with plantain, cassava, etc., Figure 3.14.

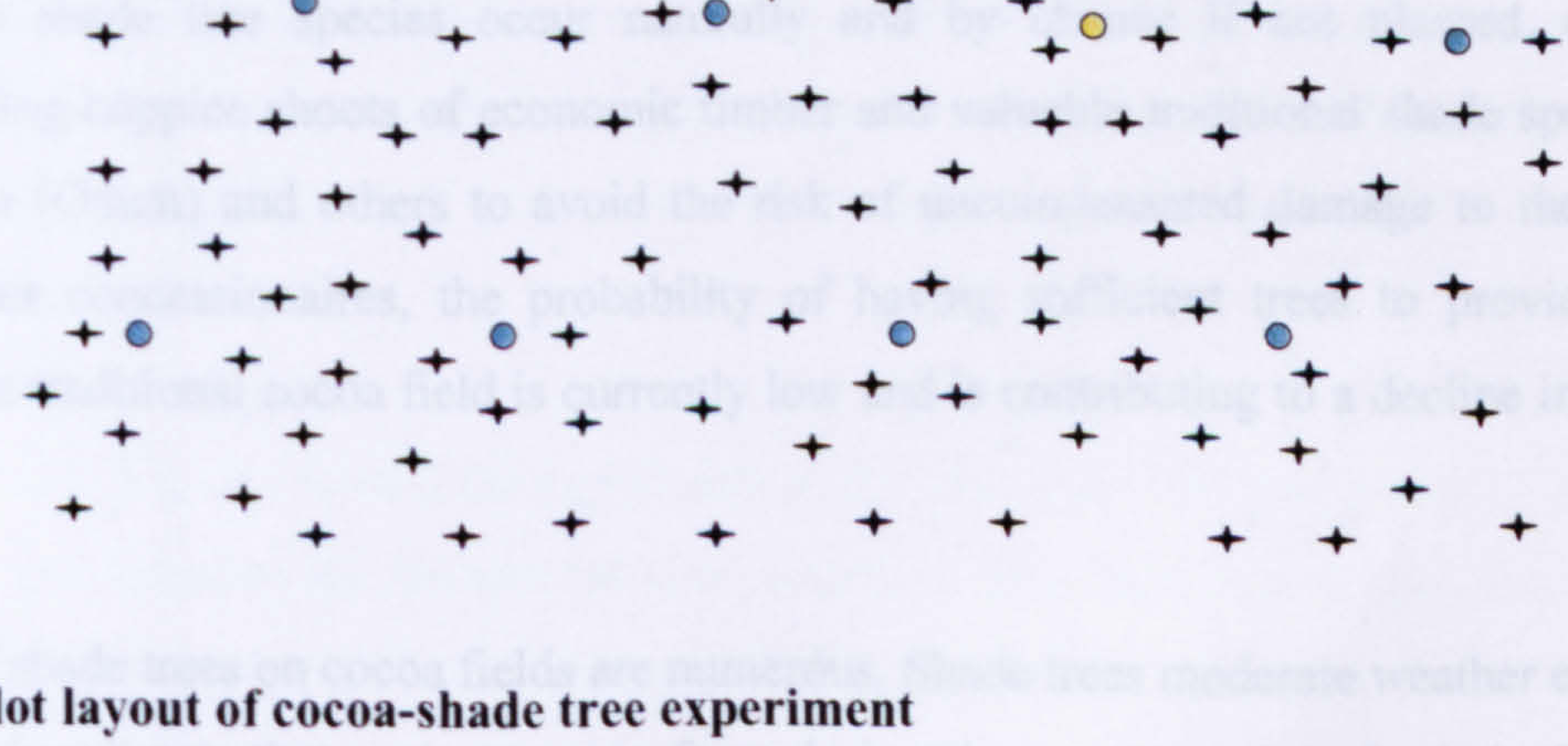


Figure 3.14: Plot layout of cocoa-shade tree experiment

The blocks have no specific experimental design but each has a control where, instead of shade tree species, cocoa is planted (yellow spot). This is because farmers do not normally plant trees on cocoa farms. They traditionally retain indigenous forest tree species after clearing the vegetation to provide permanent shade for cocoa. Thus, most trees found on cocoa farms occur naturally and are those desired, so that if no desirable tree is naturally present, the farm is left devoid of trees with the provision of early shade using plantain, cocoyam, cassava and maize.

Each farmer planted 320 hybrid cocoa seedlings (160 per block) and food crops (early shade) in any pattern desired with no regular spacing (the way they normally plant crops) but planted the tree seedlings at 12m x 12m triangular spacing. The shade tree positions were jointly marked and pegged with the researcher's help.

Farmers are very selective with types of tree species they keep on cocoa fields, as not all trees are suitable companions for cocoa. Some have deleterious or allelopathic effects and others have heavy crowns that reduce aeration on the farm and intercept rainwater, preventing it from reaching the ground. Trees that habour pests or pathogens that damage the crop and deplete the soil of moisture essential to cocoa growth are also undesirable for the provision of shade for cocoa. Farmers listed desirable indigenous shade tree species, some of which they planted in the experiment. Usually, tall trees and/or those with light crowns are preferred, possibly because cocoa trees require more filtered sunlight as they mature (Young, 2003). Trees that contribute to soil moisture availability for the cocoa, particularly during the dry season, as well as those with some economic and/or food values are desirable. In selecting the trial shade trees, researchers also considered in addition to farmers' criteria, the availability of seeds from the natural vegetation, for easy propagation.

Since desirable shade tree species occur naturally and by chance if not planted, and farmers are persistently killing coppice shoots of economic timber and valuable traditional shade species such as the *Milletia excelsa* (Odum) and others to avoid the risk of uncompensated damage to their plantations in future by timber concessionaires, the probability of having sufficient trees to provide the necessary functions on the traditional cocoa field is currently low and is contributing to a decline in the productivity of cocoa.

The benefits of shade trees on cocoa fields are numerous. Shade trees moderate weather elements, creating a favourable microclimate that protects cocoa from desiccation, sun scorch and winds. Beer *et al.* (1998)

report the benefits of shade trees on cocoa fields to include reducing the stress on cocoa by ameliorating adverse climatic conditions; for instance, buffering high and low temperature extremes by as much as 5°C. Shade trees also act as nutrient pumps, moving nutrients from deeper soil layers to the upper layers for use by the cocoa to enhance its productivity. According to Beer *et al.* (1998) shade trees reduce nutritional imbalances, although they may also compete for growth resources. However, careful management of shade trees allows the farmer to earn extra income from timber. As much as 14 mg ha^{-1} yr^{-1} of litter fall and pruning residues containing 340 kg N ha^{-1} yr^{-1} and 4-6 m^3 ha^{-1} yr^{-1} of merchantable timber have been harvested from commercial species such as *Cordia alliodora* in Central America (Beer *et al.*, 1998). It is also reported that maintaining 10 large or 15 medium trees per hectare helps to reduce damage on cocoa caused by insect pests such as capsid. Other benefits of shade trees include reduction of weeds and some parasitic plants on cocoa (PAN UK, 2001). According to farmers of Gogoikrom-Atwima, shade trees serve as alternative hosts to parasitic plants such as the mistletoe, which otherwise uses the cocoa as a host plant, depriving it of growth nutrients, thereby reducing yield.

Farmers reported a productive period of 50-100 years while Young (2003) reported 75-100 years for shade-grown cocoa. Apart from improving cocoa productivity, the planted shade trees will also provide additional socio-economic and environmental services, thereby diversifying income and enriching the environment or the ecology. According to Weise (2003), the advantages of growing cocoa in association with numerous tree species by small farmers involves diversification of production, ensuring better protection of soils, contributing to cutting back of greenhouse gas emissions and serving as a basis for sustainable incomes. Furthermore, the resulting agro-ecosystem diversity ensures ecological and financial stability that reduces uncertainty and risk for farmers (Ramirez *et al.*, 2001).

The cocoa experiments were planted in August in the first year. This was because the seedlings to be transplanted were not ready by June when farmers normally prefer to plant cocoa as the rains peak around this time and there is adequate moisture in the ground to ensure survival of seedlings. This severely affected uptake and establishment of both cocoa and shade trees, as the minor season rains did not extend well into the season.

Furthermore, only 9 farmers planted the experiment in the first year. This was because both cocoa and tree seedlings were inadequate as the farmers failed to raise these seedlings in large numbers for their own use communally. Those who contributed to raising the seedlings planted the experiment in the first year. This situation generated conflict between some members of the village, as they felt left out although enrolled for experimentation.

To overcome the conflict, farmers were supplied with cocoa and shade tree seed to raise and transplant on their farms in the second year at their own convenience. The farmers suggested this arrangement during the evaluation of the first year's activities with them. Farmers raised the seedlings either in their backyards or on their farms. This was also to ensure that enough planting material was produced on time for the second years' planting. Most of the first year cocoa fields were replanted in June during the second year and the number of farmers rose to 38. Some initial growth and socio-economic (farmer characteristics, cost of establishment, etc.) data has been collected, as the cocoa-shade tree experiment is a long-term one. However, an *ex-ante* analysis of the profitability of the technology has been done to assess its potential for adoption

3.3.3.1.2.3 Monitoring of On-farm Experiments

The on-farm experiments were monitored through periodic visits to each plot at least once in every month by researchers, extensionist and farmers. During these visits the performance, particularly the growth of the legume and tree species, were observed. Farmers' behaviour/attitudes and perceptions towards participation as well as other management (labour, cash, etc.), tenure and natural factors that were affecting on-farm experimentation were also noted.

Table 3.10: Monitoring on-farm experiments

Activity	Objective	Tools/Methods	Expected Output	Who Involved	Time Spent
Monitoring of on-farm Experiments	Assess progress of experiments during growing season	Field visits Discussion with individual farmers	Progress of farmer experiments assessed during growing season	Researchers Extensionists	Once every month
	Identify factors that affect experimentation on farmers' fields		Farmers' attitudes, perceptions & other human and natural factors affecting farmer experimentation identified		

It was realized from the monitoring visits that some farmers in the three villages normally weeded their maize fields once. An analysis of the questionnaire survey revealed that most maize fields were weeded twice although some would weed once for the simple reason that maize is a short duration crop, maturing in three months. Discussion with some farmers indicated that the ideal is 2-3 times but in practice, most farmers may prefer to do it once if weed incidence is not high. Also, insufficient money to engage labour for a second and third weeding during the lean period may prevent some people from weeding more than once, if the crop is physiologically matured by 8 weeks after planting.

If maize is planted between April and the end of May, June-July is the time for the second weeding (i.e. 8 weeks after sowing), which scientists designated based on GTZ experience, (Loos, 2000) as the ideal time for relaying the legume to prevent it from strangling the maize. However, the baseline information showed that this period coincides with the time when most farmers have little or no money to engage labour because all money would have been invested in the farm, the previous years' food reserves for sale might have dwindled and crops would not yet be ready for harvesting. Also, even if money were not limiting, labour is scarce during this period as the northern migrants providing the bulk of hired labour would have gone back to work on their farms and the local settlers are also busy on their fields. Family labour is often relied on during this period but this is often inadequate as the majority of the households have only 1-4 people involved in farm production with at least 2 or more plots to be worked in any one particular season. This naturally delays the second weeding on some fields.

It was observed that most fields were quite weedy at the time the farmers were to under-sow the legumes. At 8 weeks the maize stand was dense and towered with thick weed undergrowth. Some of the farmers were not willing to do a second weeding before relaying the legume. Some farmers felt the legumes had the potential to smother weeds, so there was no need to weed before sowing, while others expected the project to assist with money to weed. In some cases even if the weeds were cleared it was difficult to sow legume and there was bound to be shading from the maize, which could delay establishment of the legume.

According to farmers the first weeding is crucial and the strategy some of them employ is to delay weeding from 4 weeks after sowing maize to about 6 weeks after sowing depending on the aggressiveness of the weed type(s) found on the farm, so that weeding is done only once. After the maize reaches physiological maturity (cobs well developed) at 8 weeks, there is no need for the second weeding. A second weeding might be done when weed pressure is high such that failure to do so might result in crop failure. Some farmers may delay sowing maize till about May/June or may do it very early in February with the first rains for the crop to mature in 3 months and to avoid weeding more than once. These are all strategies to reduce labour cost. A second weeding might also be necessary if maize is intercropped with other crops like cassava, plantain, cocoyam, cashew, etc. to enhance their growth.

From the above, it was realized that the time suggested for relaying the legumes, i.e. 8 weeks after sowing maize might be ideal to prevent creeping legumes from strangling the maize but in reality does not tie in well with the normal practice and socio-economic circumstances for some farmers at this designated time. The legume probably has to be sown at the time farmers do the first weeding, 5-6 weeks after sowing maize, to alleviate labour problems and ensure good establishment if the objectives of soil fertility improvement, weed suppression, reduced labour, and so on are to be achieved. There may be the need to cut back vines of species like *Mucuna* to prevent them from strangling the maize crop, which could lead to a reduction in maize yield. This was observed on some fields during the second year when some farmers planted *Mucuna* 5 weeks after sowing maize. Fischler *et al.* (1999) reported that early planting of *Mucuna* 3-4 weeks after sowing of maize at the first weeding reduced maize yield by 24%. However, a further delay in inter-sowing combined with cutting back of vines climbing on maize could reduce competition of the *Mucuna* with maize. Efficiently managing *Mucuna* and other green manures increases their productivity and can reduce labour costs, resulting in increased net benefit.

It was generally realized from the monitoring visits that most farmers put up partial attitudes towards the experiments in the first year, with the exception of those experimenting with the cocoa, which happened to be a valuable asset. For instance, most of them did not bother to weed their plots after planting the legumes. Again, for some it was simply because they were anticipating financial support from the project for doing so while others felt the legumes could smother the weeds. Despite all the initial briefings and discussions on technological components and conditions under which the experiments would be conducted, some farmers were still doubtful of the credibility of researchers. While some of them planted the maize so close that it was impossible to relay the legume, others intercropped the maize with rice and others quickly harvested and sold the maize when it was due for yield assessment. Some tenant farmers in Subriso also discontinued participation because they claimed their tenancies were terminated at the end of that growing season and thus lost access to the experimental plot in the second season.

3.3.4 Exposure visits

Prior to making decisions to experiment with a new technology or practice, it is important for farmers to see the innovation demonstrated (Bellon, 2001). This is often achieved through field days or exposure visits. Farmer field trips were organized during the first and second years of experimentation to expose farmers to researcher experiments and those of farmers participating in a GTZ project in other parts of the Brong Ahafo Region. These trips were to enlighten farmers and enable them to interact to learn from each other and others outside the project. However, they were also useful in enlightening scientists and extensionists about farmer perceptions of the technologies.

The trips were organized on taboo days to ensure that as many farmers as possible could go on the trip. The appropriate date was decided at meetings with farmers participating in the experimentation in the three villages. At each village dates that coincided with taboo days (Tuesday for Gogoikrom and Subriso and Friday for Yabraso) were suggested. Eventually, a consensus was reached for dates in August-September that fell on a Tuesday as the Yabraso farmers often attended funerals on Fridays. A date between August and September during the major season was chosen, as farmers were less busy with farming activities during this period and fields not yet harvested, allowing meaningful observations to be made.

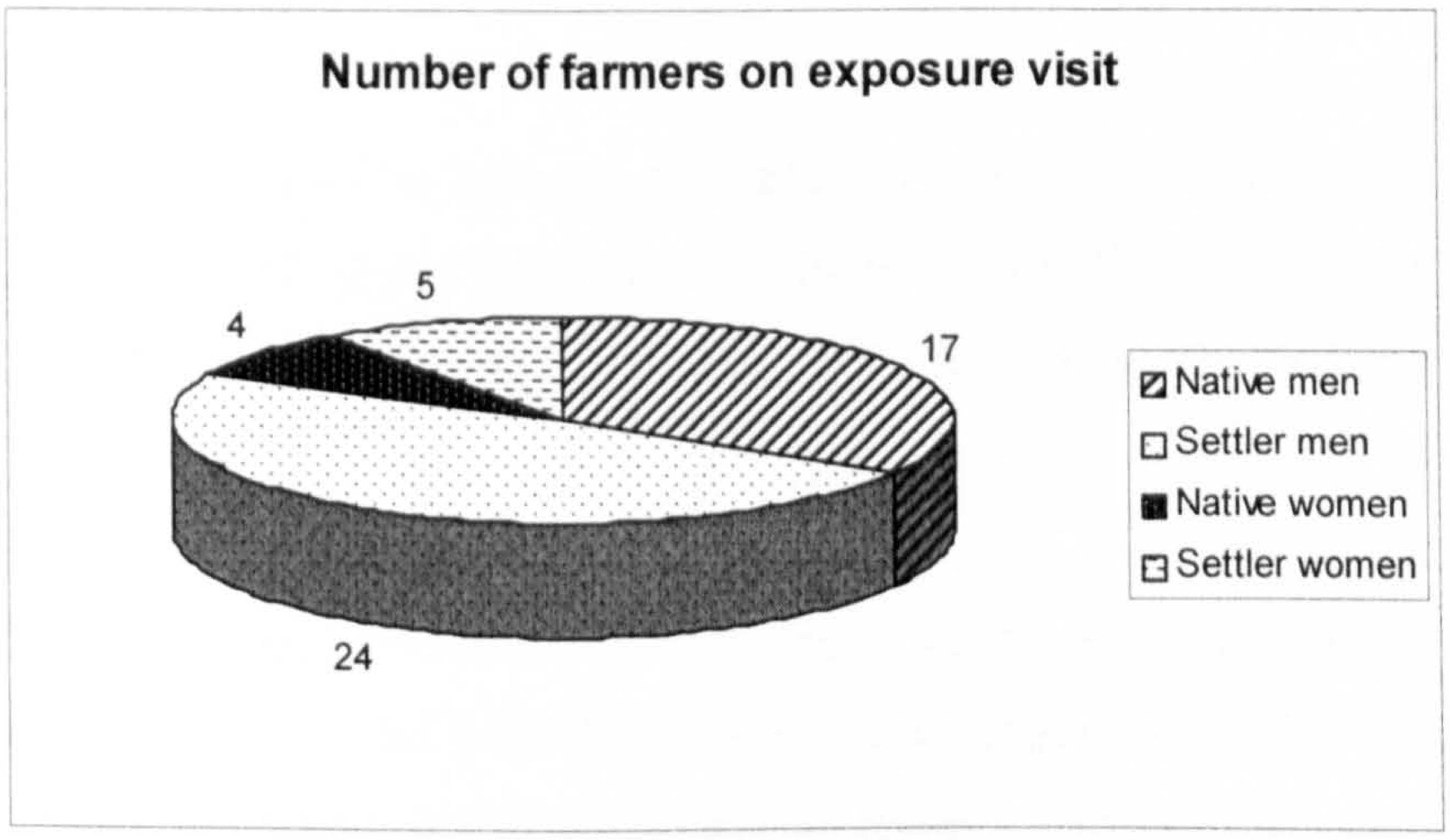


Figure 3.15: Category of farmers on exposure visit per year

An average of 50 farmers belonging to the four farmer categories went on the exposure visit per year (Figure 3.15). The number and category of farmers were not purposively selected, as there were no restrictions as to who to take on the trip. As many of the experimenters and non-experimenters who were willing to go and were able to make it on the appointed dates went on the trip. Usually, few numbers of participants are preferable, as this enables more in-depth discussion about the technologies on demonstration.

3.3.4.1 Exposure visit to the Wenchi Agricultural Station

The main objective of the Wenchi trip was to enable farmers to observe and assess the trial species (both herbaceous and woody) at first hand, especially their characteristics with respect to farm production. It was realized during the monitoring visits that although some of the species had been planted on their fields, they were not yet established, hence making them doubtful of species characteristics, potentials and disadvantages on the farm.

About 50 male and female native and settler participating farmers from the 3 villages together visited the project demonstration plot at the Wenchi Agricultural Research Station during the first year. The trip was organized well into the first season in September because it was by then that the plots were well established and could enable a meaningful assessment. Farmers in Gogoikrom had earlier on in January visited the project demonstration plot established in the village with similar fallow species as those found at Wenchi to observe the physical characteristics of the fallow species and to aid in informing their decision and choice of experiments on-farm.

Tables 3.11 and 3.12 summarize farmers' assessment of the 7 herbaceous and woody trial legume species with respect to weed smothering, biomass production and soil fertility improvement potentials as well as suitability for different cropping patterns and systems (e.g. mono and mixed cropping) and fallow improvement.

Shade cast by *Gliricidia*, *Tephrosia* and *Flemingia* stands was adjudged good at suppressing weeds. Farmers also observed that leaf litter from these woody legumes could decompose to improve the soil, especially its fertility (Table 3.11). The herbaceous legumes (*Stylo*s, *Mucuna*, *Lablab* and *Pueraria*) were assessed to be effective for weed control as a result of their dense vegetative carpets covering the soil surface. Some farmers observed the *Stylo*s to be slow growing on their farms while others observed *Mucuna* to be very fast growing. The creeping vines on *Mucuna* and *Lablab* could strangle crops as they were seen climbing old maize stalks and grasses (*Panicum* and *Pennisetum*) on the plot.

Table 3.11: Farmer's Assessment of Trial Species at Wenchi Agric. Station

Species	Farmer's Assessment
Gliricidia sepium	Dense shade controls weed growth Leaf litter drop improves soil fertility
Tephrosia candida	Shade controls weed growth Leaf litter drop improves soil fertility
Flemingia mycrophylla	Shade controls weed growth Leaf litter drop improves soil fertility
Stylosanthes spp	Effective for weed control Reseeding problem high Slow growth (observed on-farm)
Mucuna spp	Fast growth (observed on-farm) Climbing could strangle crops Effective for weed control
Canavalia spp	Fast growth (observed on-farm)
Lablab spp	Fast growth (observed on-farm) Creeping nature not good for cocoa (could strangle crop) Effective for weed control
Pueraria spp	Effective for weed control

In Table 3.11, farmers observed *Mucuna* and *Gliricidia* to be better than the others with respect to spread as they grow faster than the other species. The *Stylo*s and *Mucuna* were adjudged better at smothering weeds because they grow profusely while *Gliricidia* was the best fallow species as its fast growth coupled with the heavy tree biomass could rejuvenate the soil in a shorter time. It should be remembered from the PRA that farmers regard tree fallows to be best at improving soil fertility.

Gliricidia was also adjudged the best species for both mono and mixed cropping systems. Being a tree that grows fast and does not climb, farmers believe *Gliricidia* could mix well with crops, as it is not likely to suppress them. This is not surprising because farmers are used to leaving some trees on farms whereas most of them have never experienced the legume-relay techniques. Although cowpea, sweet potato, groundnut and melon mixed with other crops may trail on the ground beneath the other crops, they are not relayed purposely to improve the soil. No reason was recorded for *Gliricidia* being the best for monocrop systems.

Table 3.12: Farmer's Assessment of Trial Species at Wenchi Agric. Station

Parameter	Suitable species	Reasons
Ability to spread and cover land faster	*Mucuna, Gliricidia*	Grow very fast
Ability to smother weeds better	*Stylos, Mucuna*	Grow profusely
Best fallow species	*Gliricidia*	Grows very fast. Being a tree that can produce lot of biomass
Suitability for mixed cropping systems	*Gliricidia*	Does not climb Tree with fast growth
Suitability for mono cropping systems	*Gliricidia*	-
Ability to improve crop yield better	*Gliricidia* *Mucuna*	Grow very fast. Biomass and shade (moisture) improve soil.

Overall, *Gliricidia* and *Mucuna* were the most fascinating species; as the dense vegetative growth combined with their potential to conserve moisture could enhance leaf litter decomposition. These species were acknowledged to have the greatest potential for suppressing weeds and improving the soil in a shorter time to enhance yield. In all, it appeared the weed smothering and vegetative growth or biomass production potentials of the species were readily recognized, as these were indicators that could readily be observed physically on the field.

Questions on species management (time to prune trees for mulch, time to clear legumes in order to plant food crop, reseeding of legumes, etc.) and edibility were also raised. It was learnt that the trees could be pruned anytime they appear to shade the food crops. Also species like *Gliricidia* could be planted for 1-3 or more years before clearing depending on its intended use. *Gliricidia* to be used for poles and charcoal could be left longer, for up to five years. *Flemingia* and *Tephrosia* may be similarly treated but were likely to die off with severe drought. The problem of reseeding could best be managed by early weeding of the emerged plants to prevent further seeding at maturity. Concerning edibility of the legumes, it was learnt that *Mucuna* and *Canavalia* grains must be treated by boiling to remove the seed coat and detoxify before consumption.

Farmers also assessed the effects of 2 planting dates of *Mucuna*, 4 and 8 weeks after planting of maize on maize performance and establishment of the legume while on the field. It was observed that 8 weeks after planting maize could be a better time for relaying legumes with the maize. This was because *Mucuna*, being a creeper had begun strangling the maize even before it was ready for harvesting when planted at 4 weeks after sowing maize. This could particularly increase labour for harvesting maize and may reduce maize yield.

3.3.4.2 Exposure visit to GTZ sites

During the second year 52 farmers comprising largely male and female participating and a few non-participating farmers of Gogoikrom and Subriso III went on an exposure visit to the GTZ-MOFA farmers plantain experimental plots in the Asunafo District of the Brong Ahafo Region. Yabraso farmers did not go on this trip because emphasis was on the plantain system, which was not relevant for them. The objective of this trip was mainly to enable the farmers to learn more of plantain-legume systems, which they knew little about as simple alternatives for improving plantain production.

The farmer experiments visited included plantain-legume (*Canavalia*, cowpea), plantain-animal manure and plantain-household residue systems. The farmers owning these experiments explained how they went about establishing their fields and what they expect to gain. The farmers in addition had the opportunity to visit GTZ maize-legume (*Mucuna*, *Canavalia* and pigeon pea) experiments in Sunyani District. The visiting farmers asked several questions, some of which focused on the management of the legumes and manure. The briefings from the GTZ farmers as well as GTZ and MOFA staff on the various experiments visited strengthened the visiting farmers' understanding of strategies for improving productivity of maize and plantain systems. Having seen other farmers establishing and managing experiments might motivate them to collaborate more actively and show more concern for the experiments on their fields.

Visits to the on-farm plots in September 2002 after the exposure visit for farmer assessment of their experiments revealed that some farmers had began putting into practice some of the new ideas learnt on the second exposure trip. It was observed that one of the farmers in Gogoikrom had cleared and cultivated the *Mucuna* and control portions of his maize-legume experiment as a minor season crop, leaving the *Canavalia* portion. The farmer did not give any good reason for his action. However, it was learnt from one GTZ staff member during the second exposure trip that *Mucuna* could improve soil fertility for good yields in a short time. Also, one farmer who had established the plantain-*Canavalia* system reported gaining about 4 million cedis from the sale of *Canavalia* grains. These could be possible reasons for cultivating the *Mucuna* portion of his experiment/fallow to maize and leaving the *Canavalia* uncleared.

While the above might explain the farmer's behaviour, it demonstrated the possibility of relaying *Mucuna* early in the major season to improve the soil for minor season production in September for those who plant their maize early i.e. February to the end of March and might have only a year's tenancy on a comparatively poor land. One other farmer in Gogoikrom had begun practicing a plantain-organic residue (mulch) technique for improving bunch yield learnt from a GTZ farmer while on the exposure visit. Farmers probably learn techniques more quickly from each other than observations they make from scientists' experiments (Bellon, 2001). Thus, exposure visits, particularly to successful trial farmers' fields even within the community, might be useful in enhancing their understanding and encouraging them to innovate with new technologies. Visits to unsuccessful farmer fields during the season may also be useful in discussing the pros and cons of the technology and identifying issues that are important for attaining the desired objectives.

3.3.5 Evaluation

Biophysical and socio-economic evaluations of the farmer experiments were undertaken. Table 3.13 summarizes the activities pursued for the evaluation.

Table 3.13: Activities for the evaluation of on-farm experiments

Activity	Objective	Tools/Methods	Expected Output	Who Involved	Time Spent
Researcher Evaluation of on-farm Experiments	To assess performance of legume cover on-farm with respect to -spread & biomass production -weed suppression -soil fertility, etc.	-Legume cover biomass assessment, -Maize yield assessment -Weed assessment -Soil analysis	Soil improvement potential of fallow technologies assessed	Researchers Extension	-As and when appropriate during the growing season -End of each farming season
	To determine economic viability of experiments	-Input-output data (gross margin/cost-benefit analysis)	Profitability of technologies assessed	Researchers	-As and when appropriate during the growing season
	To determine adoption potential of technologies	Chi-square test	Factors influencing adoption of technologies identified Adoptability of interventions assessed	Researchers Researchers	-End of each farming season
Farmer Evaluation of on-farm Experiments	Farmers assessment of performance of experiments Identify factors that affect experimentation on farmers' fields Identify gaps/issues that require redress	Individual questionnaire interviews Field visits Group discussions	Farmer perceptions of agronomic and socio-economic potentials and limitations of technologies assessed Issues to address to make technologies more appropriate to higher uptake identified.	Farmers Researchers Extension	-Periodic visits -At least one week in each village at the end of each farming season

3.3.5.1 Researcher evaluation of on-farm experiments

Plot level biological and socio-economic data were collected during each growing season over two seasons. Data/farm record sheets were used for the data collection. The biological analysis comprised growth, biomass, weed and yield (maize-legume relay) assessments. Soil was also sampled from all plots for laboratory analysis to serve as base data for future comparison.

For the socio-economic aspects, the data was on characteristics/profile of participating farmers and their respective plots, such as age, tenure/access to land, farm size, labour, timing of activities, inputs and costs and output and their values. This data has been used in Chapter 5 for economic evaluation of the experiments to determine their viability and adoptability under existing farmer conditions.

3.3.5.2 Farmer evaluation of on-farm experiments

An assessment of the on-farm experiments was carried out with participating farmers at the end of each season for the two years. Open-ended questionnaire interviews of individual participating farmers were first conducted before following up with group discussions in village meetings.

Each participating farmer's view of his/her field was first assessed on his/her experimental plot. The objective of the exercise at the end of the first season was to assess farmers' perceptions of the on-farm experiments, particularly the performance of the legume covers with respect to establishment, i.e. their ability to spread and form thick carpet/produce biomass and their ability to smoother weeds. Farmers' perceptions of soil fertility improvement potential of the experiments and their usefulness to the farm household for food, effect on labour requirement and so on were also assessed, including problems encountered in experimentation and any suggestions for improving experimentation in the following season.

A village meeting was then held after all individual field assessments had been completed for a more general perception of the technologies and on-farm work including strengths and weakness observed by both participating and non-participating farmers. Analysis of farmers' perceptions helped in identifying factors that affected experimentation and gaps or issues that required redress. It also helped in planning new strategies to enhance experimentation in the second season.

In all the three villages it was realized that the legume species needed to be planted early enough to ensure good establishment and spread during the major season. On some of the maize fields where biomass production and spread were good, weed suppression and moist soil conditions under the mulch were observed. Farmers believed labour to clear the legume fallow might reduce by at least half when compared to the control and that yield of the next season crop was also likely to be higher than that of the control.

It also became evident that farmers preferred dual-purpose legumes which can produce grain for food and suppress weeds, improve soil, etc. as well. Most of the farmers were in high anticipation of financial support from the project, the absence of which they mentioned as the key issue that discouraged some of them from active participation.

Concerning modification of the experiment, suggestions were made for planting the legumes irregularly i.e. unsystematically, as done traditionally as this eases labour for planting. Wild fire destroyed some of the *Gliricidia* tree fallow plots in the dry season at Yabraso. To this farmers suggested the planting of evergreen trees to protect their fields from bush fire.

At the end of the second season, farmers' perceptions of crop performance, especially growth and yield, resulting from the legume covers as well as labour requirements in the maize system were assessed using a set of indicators developed with them. The plantain, cocoa and improved fallows are more perennial, hence, only perceptions of growth were solicited. Strengths and weaknesses observed with the interventions/experiments and experimentation in general and the way forward were also assessed. Details on farmer evaluation of the on-farm experiments are provided in Chapter 6.

3.4 Conclusions

Farmer participatory research is an interactive learning process between scientists and farmers with iterations that enables farmers to affect the outcome of research directly (Hoang Fagerström *et al.*, 2003). It is a systematic dialogue between farmers and scientists aimed at jointly solving problems related to agriculture in a manner that ultimately increases the impact of agricultural research as the process enables the development of technologies that are more widely adopted (Bellon, 2001).

The researcher designed-farmer managed mode of farmer involvement was employed in developing the technologies for improving fallow productivity in the study area. The process was quite extensive and fairly interactive enabling farmers, extensionists and scientists to learn in a systematic and structured manner.

Although the participatory idea may be simple and has been shown to have many advantages over earlier approaches, its application has proved to be rather complex. This is because one is often faced with diverse, complex subjects, as people generally tend to participate in research and development activities for various reasons. Some people might participate simply because they want to help or are interested in or like the external agents whereas for others it might be to disrupt the process. Yet for some others participation might be to gain from the process (Bellon, 2001). This may include material gains such as money, entertainment/food, favourable policy (probably the research could influence policy decisions) and social favours or even using the process as a platform for campaigning for a political favour or publicity. For some others it might be to establish a relationship with the external agents while for other people it might be just out of curiosity or not wanting to be left behind, in case the research becomes useful in the future. Such issues, among others, might complicate the farmer participatory research process, as they are likely to defeat the purpose of the participatory ideology.

Pretty (1996) has developed a typology on how people participate in development programmes and projects. He identified modes of participation to include passive participation in which people participate by being told what has been decided or has already happened, participation by being consulted or by answering questions and participation for material incentives whereby people participate by contributing resources, for example labour, in return for food, cash or other material incentives. Participation in a project/programme could also be functional (in which case participation is viewed by external agencies as a means to achieve project goals), interactive (where people participate in joint analysis, development of action plans and formation or strengthening of local institutions) and self-mobilized (where people participate by taking initiatives independently of external institutions to change systems). Pretty argues that passive participation, participation by consultation, participation for material incentives and functional participation are superficial and have no lasting impact on the people's lives.

Participatory research approach is probably more expensive than was thought. For instance, a lot of staff and villagers' time and resources are spent in the process. The challenge, however, to research and development practitioners, is to search for the most efficient ways of farmer involvement in research and development activities for the intended impact to be realized. Irrespective of the approach adopted, a PTD process should ultimately enhance the welfare of farmers, improve scientists' work efficiency and, for the society in general, improve agricultural productivity and encourage natural resource conservation.

CHAPTER FOUR
QUANTITATIVE CHARACTERIZATION OF LIVELIHOODS

4.1 Introduction

Livelihood is a means of living or of supporting life and meeting individual and community needs. Essentially, it comprises activities which, when applied to capital assets produce outcomes that constitute the means of living (Alumira, 2002). With respect to rural people, livelihood can be taken to mean the welfare supporting activities undertaken for the upkeep of a household during a yearly cycle (Tuson, 2001).

Sustainable livelihoods entails "the creation of conditions that are (self-) supportive of sustainable development in human, natural and economic systems, which, whilst safeguarding resources and opportunities for future generations, provides individuals with means to provide themselves with food, shelter and an acceptable quality of life" (SEI, 2003). Rural livelihoods are sustainable if the people have the capacities to generate and maintain their means of living, enhance their well-being, and that of future generations. Very often these capabilities are contingent upon the availability and accessibility of ecological, socio-cultural, economic, and political resources.

Within the rural context, a livelihood analysis explores the specific set of strategies that people employ in order to obtain food, cash, shelter, and other basic services (such as health, education, extension information, roads and transport/marketing infrastructure), and takes into account the particular constraints and opportunities inherent in their specific geographic context (FEWS, 2003). It is learnt from Chapter Two that because the conditions under which rural livelihoods are pursued are complex, a thorough understanding of the complex interrelationships that exist between various livelihoods resources are a prerequisite if suitable interventions are to be developed for sustainably improving the well being of the people.

4.2 Objective and Methods

The objective of this chapter is to quantitatively characterize and compare the livelihoods of households in three farming villages: Gogoikrom-Atwima, Subriso III-Tano and Yabraso-Wenchi in forest and savannah -transition zones of Ghana, following on from a qualitative appraisal of farming and livelihood systems in these communities, to aid in the development of technologies for improving fallow productivity.

The quantitative characterization is specifically to confirm the findings documented in the qualitative livelihoods analysis and identify the major distinguishing features of the livelihoods of the different categories of farmers in these villages that may determine or regulate their access to and use of assets. The household is the main unit of analysis as this micro level of analysis has been recommended for use in livelihood research (Murray, 2001 and Tuson, 2001) since it enables the needs of poor farm households to be integrated into macro level decisions. A household may be defined as a social unit living together or a domestic residential group whose members live together in intimate contact, rear children, share the proceeds of labor and other resources held in common, and in general cooperate on a day-to-day basis (WEBNOX, 2003).

For simplicity, a household within the context of this study constitutes those who live together and eat from the same pot (Bellon, 2001), usually comprising a husband, his spouse(s), children and other dependents (including members of the extended family such as nieces, nephews and aging parents and so on). However, it is possible to find some households either without the husband or wife due to death, divorce or out migration. Generally, spouses and children who for some reason (working, schooling, learning a trade, etc.) lived outside the village but were still catered for were considered as part of the household.

The quantitative characterization was also to determine patterns of resource use of households within and between villages in the different ecological zones. This is to ultimately provide a basis for developing suitable recommendation domains for technologies to be developed with farmers for improving the fallow productivity. In other words, it is to aid in determining which farmers among the rural population are likely to adopt what type of technologies and under what circumstances. It has been recognised that different household types have different preferences, objectives and expectations. They may also have different levels of access to assets/resources (Bellon 2001) and thus tend to have different livelihood strategies. According to Alumira (2002) end users of technologies belong to different socio-economic groups, which in turn, make different decisions to invest in specific technologies depending on their capability to overcome barriers to investment.

This consequently calls for the need to target different technologies to distinct groups of end users to ensure that they are suitable to their particular circumstances in order to enhance adoption.

Data collection for the quantitative analysis was done in two stages. Firstly, a detailed, structured questionnaire survey of households was administered to gather the relevant information. The questionnaire was designed following the qualitative analysis of the livelihoods in the study villages, and thus was based on the information from the participatory rural appraisal. Every house in each of the three villages was visited to interview respondents. This was because the villages were not too big in size (Nicholas, 1998). A house in the study villages is usually a compound unit comprising one or more households or individuals living alone. Usually, the house is organized on an extended family or lineage basis. However, it is possible for more than one family to occupy the same compound as was found in Gogoikrom-Atwima where some settler families live in the compounds of the landowners whose field they cultivate.

Respondents interviewed comprised a cross section of men and women farmers from the native and settler groupings who were present in their homes during the visits. Some of these were male and female heads of households and others were individuals living with no dependants in the village who in most cases were either unmarried or had their spouses and children living elsewhere outside the village. Each respondent interviewed cultivated a parcel either individually or jointly with a spouse and is therefore capable of making decisions concerning farm production. Where couples cultivated the same parcel (which was common among settlers from Northern Ghana) either the man (usually the head of household) or the woman available at the time of the visit was interviewed. Where they cultivated separate parcels, each of them was interviewed if available at the time of interview. Using this approach, a total of 242 (approximately, 81 per village on average) respondents were interviewed across the three villages comprising 77, 83 and 82 in Gogoikrom-Atwima, Surbiso III-Tano and Yabraso-Wenchi Districts respectively. Details on the proportions of the different farmer categories and their characteristics are presented below.

Information gathered spanned all aspects of the livelihood of the farmers, paying attention to the five livelihood capitals mentioned in Chapter Two. These comprise the socio-demographic profile/characteristics of the farmers including age, gender, employment, household sizes and composition, residential, educational and marital status that describe the human resource status. Information relating to tenure or access to and control over land resources, livelihood activities, particularly crop production (crops, objective of production, weed and soil fertility management as well as production constraints) were also collected. Other information gathered includes labour and financial sources, use and availability, livestock rearing, crop and livestock marketing and off-farm employment.

The questionnaire survey provided information for collecting detailed economic data on farm and off-farm enterprises in the second stage of the data collection process. From the questionnaire information, farmers involved in the cultivation of particular crops, those rearing livestock and those engaged in the different off-farm enterprises were identified. Specific enterprise data sheets were then designed and used for the collection of input-output data on crop, livestock and off-farm enterprises. The questionnaires and other data sheets used for the collection of the information are found in Appendices 10-12. The Microsoft Excel computer software has been used in analysing the data gathered.

4.3 Quantitative description of livelihoods of Gogoikrom, Subriso III and Yabraso

4.3.1 Socio-economic/demographic characteristics

4.3.1.1 Residential Status and Gender

As mentioned above there are two main categories of farmers, natives and settlers, distinguished by residential status and amongst these there are men and women. Figure 4.1 shows the proportions of the four farmer categories interviewed in the three study villages. The farmer populations of Gogoikrom and Subriso III appear to be dominated by settlers comprising 86% and 72% respectively of respondents in each of the two villages whereas that of Yabraso is dominated by natives, making up 70% of the respondents in that village. The figure also indicates that men dominate the farmer population of the three villages. This is partly because couples of some male-headed households cultivated joint fields. Since men are usually at the helm of affairs, they availed themselves for the interview unless absent at the time of interview. Tuson (2001) experienced a similar situation with farmers in the Wenchi District of Ghana. He observed that among the immigrant/settler farmers from northern Ghana, decision making often rested with the male household head, hence his survey questions were more answered by male household heads. This finding could also explain the observed proportions of male settlers as compared to settler women in Figure 4.1

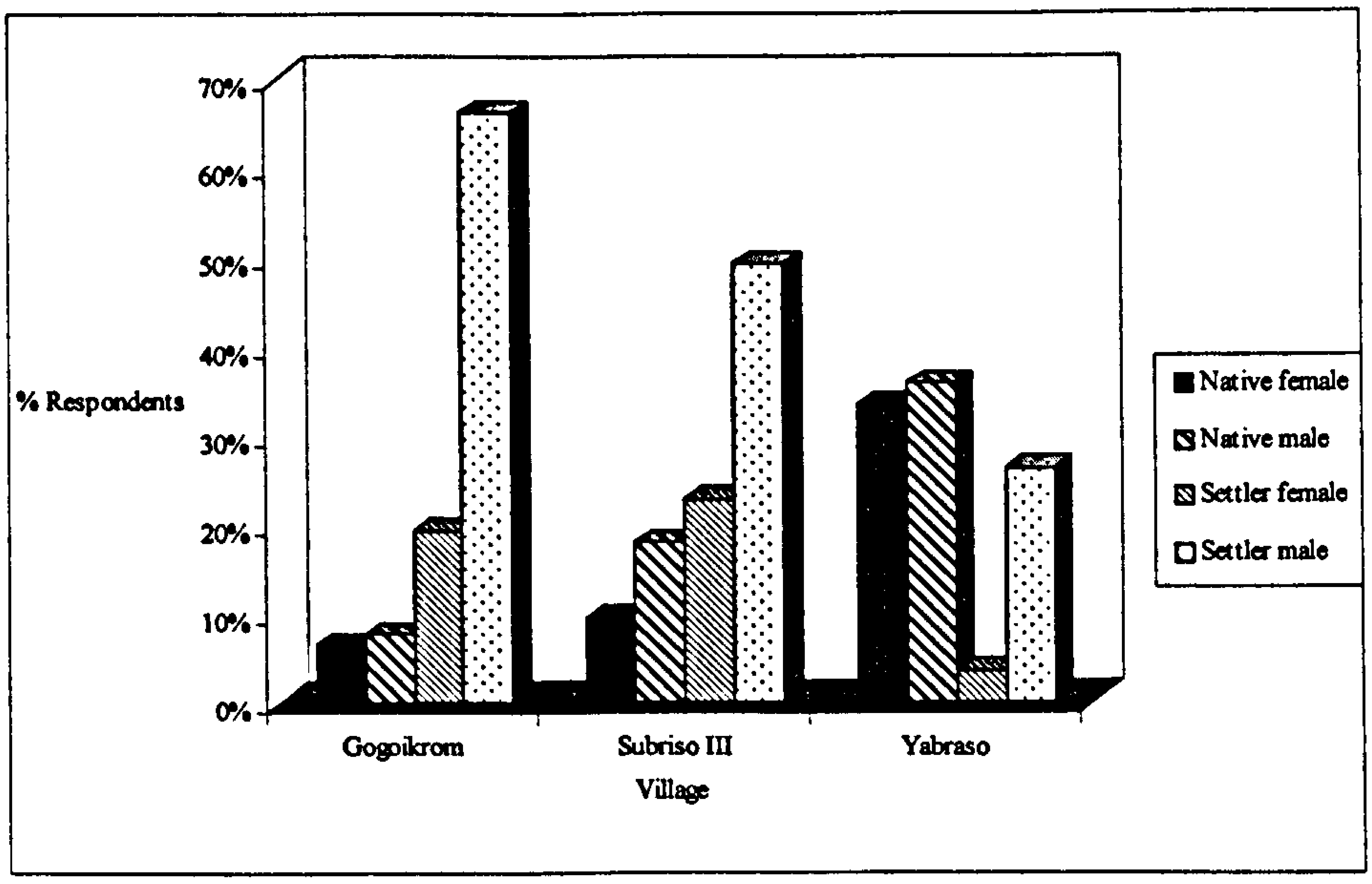


Figure 4.1: Proportion of farmers interviewed in study villages

The higher settler population in Gogoikrom is due to the influx of farmers migrating from the north to farm cocoa, maize and rice. The higher settler population in Subriso III can also be explained by the fact that the village was, until the drought and wild fires of 1983, a predominantly cocoa growing village where settlers, the majority of whom originated from northern Ghana, were engaged as caretakers on cocoa plantations. The loss of cocoa income and the forest ecology required for cocoa production opened up the area for maize cultivation to provide quick cash to replace that lost from cocoa. This caused an inflow of more settlers of northern origin to cultivate maize, a crop whose production the natives/landowners were not very familiar with (Obiri *et al.*, 2000).

Generally, a significant proportion of settlers interviewed comprising 58% from Gogoikrom, 50% from Subriso III and 52% from Yabraso originated from northern Ghana, i.e. Northern, Upper East and West Regions. Nsiah-Gyabah (1994) referred to these migrants as refugees from degraded environments who move down to settle in a less degraded environment. Rampant tribal conflicts, particularly in the Northern Region, are also contributing to massive emigration of farmers from affected areas to the more stable southern part of the country to settle. These northern settlers are, however, of crucial importance to the local economies as they provide a greater proportion of labour for agricultural production as well as extra income/food from land rent and shared crop proceeds to the natives and/or landowners of the communities in which they settle. The landless settlers on the other hand, get easy access to land to cultivate for food and cash, some of which is exported as cash or personal effects like bicycles to their various homes of origin. Saved income from this sojourn is also important for social activities like marriage and funerals as well as investment in buildings and livestock back at the homes of origin.

Another striking feature of the general settler population in the study villages is that a number of them originate from the Ashanti and Brong Ahafo Regions. While about 35% of settlers in Gogoikrom originate from other parts of the Ashanti Region, 18 and 22% of those in Subriso originate from the surrounding towns in the Ashanti and Brong Ahafo Regions respectively whereas 32% of those in Yabraso are from other traditional areas in the Brong Ahafo Region. The majority of these settlers cultivate their own land secured by ancestral relatives who migrated to the villages to settle several years back. These landowner settlers sometimes regard themselves as indigenes because they farm their own land.

Farmers generally regard the native-settler divide or dichotomy as a key feature determining the land status of households. Natives take pride in being the original owners of the land, part of which their forefathers gave as gifts to their settler landowning friends' ages ago. They also take pride in cultivating their own land and often regard their land ownership status as a symbol of wealth. Generally, the more land a group of native households belonging to a particular family lineage has, the wealthier they are, since they have enough to crop themselves and to rent to others to earn more income. Being a settler is likely to mean not farming one's own land and this could be interpreted to mean poverty with respect to land, the vital asset for survival.

4.3.1.2 Age

Although both the young and old are involved with farming in all the villages, there appear to be very few or virtually no young people below 20 years of age doing so. The bulk of the farmers interviewed are aged between 30 and 49 years (Figure 4.2). Male settlers aged between 20 and 49 years in Gogoikrom and those aged between 30 and 59 in Subriso III form the core of agricultural production in these villages whereas it is rather the native males and females within the age group of 30 and 59 years who form the core in Yabraso.

Generally there are very few young people below 30 years of age from native households involved in agricultural production. This is probably because the majority of young native people do not cultivate fields of their own as the majority of them might be in school or learning a trade. However, there are more settler males of this age group farming in Gogoikrom and Yabraso.

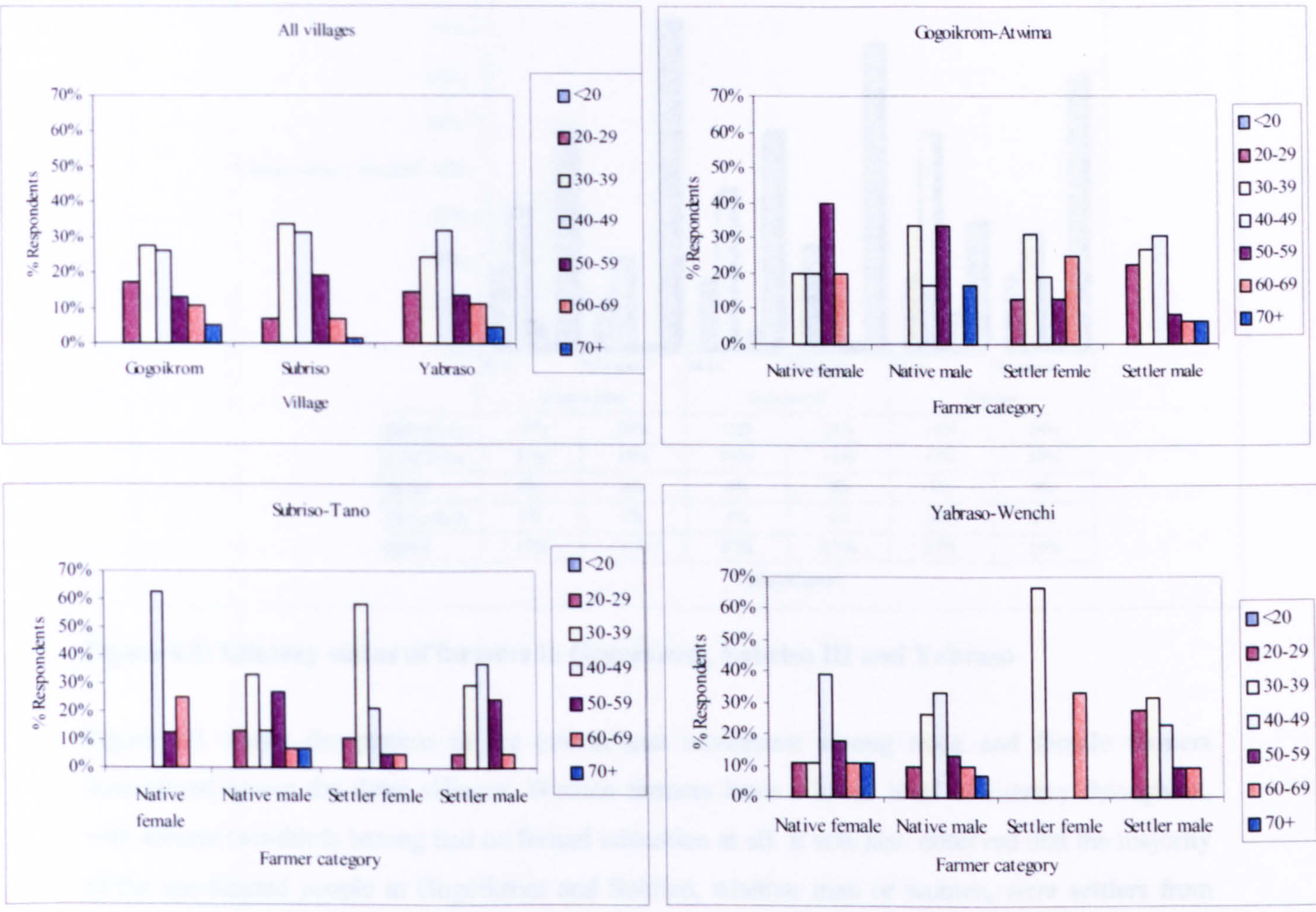
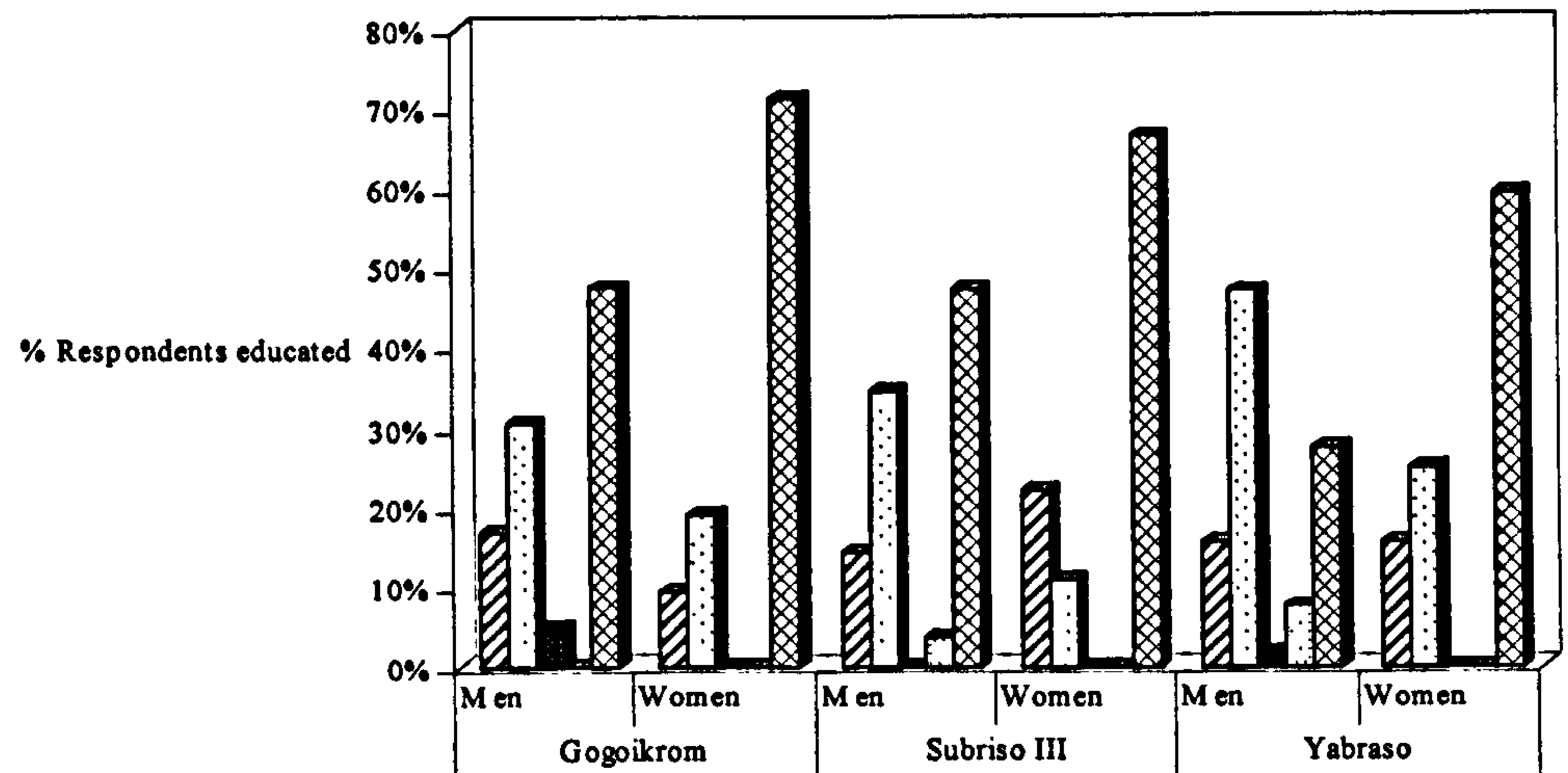


Figure 4.2: Age distribution among sample of farmers interviewed in study villages

4.3.1.3 Education/Literacy

The literacy rate for rural Ghana is about 50% (Asare, 1995). A number of farmers in the study villages appear to have had some basic formal education. The total figures of educated people in the sample of farmers interviewed showed that Yabraso has the highest population of literate farmers with Gogoikrom having the least. 45%, 46% and 60% of the farmers interviewed in Gogoikrom, Subriso and Yabraso respectively have had some formal education with the majority going up to the middle/junior secondary school level. The Yabraso Roman Catholic School was established in the 1961 while that of Subriso is quite recent. This has had some influence on the literacy level of the farming population in these two villages, particularly, Yabraso as compared to Gogoikrom where there is no school.



	Gogoikrom		Subriso III		Yabraso	
	Men	Women	Men	Women	Men	Women
Primary	17%	10%	15%	22%	16%	16%
Mid/Jss	31%	19%	35%	11%	47%	25%
Sec	5%	0%	0%	0%	2%	0%
Tertially	0%	0%	4%	0%	8%	0%
Nil	47%	71%	47%	67%	27%	59%

Village/Gender

Figure 4.3: Literacy status of farmers in Gogoikrom, Subriso III and Yabraso

Figure 4.3 shows the pattern in the educational attainment among male and female farmers interviewed across the three villages. Women farmers have a lower level of literacy throughout, with around two-thirds having had no formal education at all. It was also observed that the majority of the uneducated people in Gogoikrom and Subriso, whether men or women, were settlers from northern Ghana, as they constituted 65% and 61% of the uneducated in these villages. In Yabraso the northern settlers comprised only 27% of the uneducated people, probably because natives dominate the village population whereas settlers dominate that of Gogoikrom and Subriso.

Education is valuable to a dynamic rural economy. It is often believed that a literate farming community stands the chance of gaining from technical progress in agriculture. Some authors suggest that primary school education with a minimum of four years schooling is sufficient to achieve functional literacy among rural people, (Gockowski and Ndoumbé, 1999). Primary to middle/junior secondary education in Ghana involves 6-10 years of basic education. This implies that at least 50% of men and about 30% of women in the study villages are functionally literate. Although these figures are not very high they are likely to improve over time with more children currently being educated.

In many parts of Sub-Saharan Africa, women's illiteracy rates are twice as high as are of men, which limit their ability to access information (CTA, 2000) and undertake community leadership roles. It was observed in the study villages that, apart from the inherent benefits of being enlightened, being educated even up to the primary level was also particularly important at the local level for being elected as a community representative to the District Assembly as an Assembly man/woman or even a unit committee member or chairman irrespective of residential or land status. In all three villages these community representatives were men.

4.3.1.4 Household structure/characteristics

Marital status

One key activity or responsibility of the household is to ensure the sustenance of its reproductive role and the general well being of its members which is often attained through marital relationships. Most of the farmers interviewed were married. Gogoikrom and Yabraso had comparatively lower proportions of married farmers (75%and 74% respectively) than Subriso III (83%). Gogoikrom and Yabraso had a greater percentage of young unmarried farmers or young people between 20 and 29 years of age interviewed. In general, male-headed households dominated in all three villages. The majority of married couples had men as household heads. 100% of the married households in Gogoikrom had men as heads while Subriso and Yabraso had 94% and 87% respectively. The female-headed, married households had male partners living outside the villages. The unmarried female household heads were either divorced or widowed.

Male dominance in household leadership may play a key role in general household decision making including those relating to the farm. However, the farm household's production decisions (what to grow, who to grow what, where to grow, when to grow, inputs to be used and sources, how to dispose of the proceeds, etc.) may be jointly determined by both the man and his spouse(s) (Ellis, 1998). It was observed that 57%, 44% and 80% of the married women interviewed in Gogoikrom, Subriso and Yabraso respectively having husbands as household heads cultivated their individual or separate fields. The higher proportion observed in Yabraso can be explained by the fact that the majority of the women in that village are natives cultivating land owned through family ties, whereas the majority of women in Gogoikrom and Subriso are settlers, most of whom are likely to be cultivating joint sharecrop fields acquired by their husbands.

Married women cultivating separate fields explained that they often cultivated any crop of their choice as well as making all relevant decisions concerning its marketing so long as they had the means to do so. Although women appear to be gaining independence in making production decisions, men often have greater influence on these decisions (CTA, 2000) and specific roles to play in the women's production activities. For instance, it was noticed that the male head of household in both native and settler households often had the obligation to ensure that the women's field had at least been cleared for subsequent cultivation; thereafter, the woman was solely responsible for her plot (Obiri *et al.*, 2000).

Household size & Composition

The mean household sizes of farmers interviewed in Gogoikrom, Subriso and Yabraso were 6.4, 6.5, and 5.7 people respectively, (Table 4.1). Overall, households appear to be of nearly the same sizes across the three villages as Anova showed no significant differences between them (F=1.89, p=0.153).

Table 4.1: Household sizes in study villages

Village	Mean Household Size	Range	Standard Deviation
Gogoikrom	6.4	1-15	3.49
Subriso III	6.5	1-15	2.44
Yabraso	5.7	1-18	2.84

F-value = 1.89

P-value = 0.153

The distribution of household sizes among the three villages is shown in Figure 2.2.4. The majority of households in Gogoikrom (67%) and Subriso III (87%) have sizes between 4-10 people while 86% of those in Yabraso range between 1 and 6 people.

Within the villages, native households in Gogoikrom and Yabraso are bigger (i.e. 7.9 and 6.0) than those in Subriso (5.4) whereas for the settlers, it is Subriso which has the largest of 6.9 people (Figure 4.4). Although native households are bigger than those of settlers in Gogoikrom and Yabraso these differences are not significant, (F=2.73 and p=0.102 for Gogoikrom and F= 3.34 and p=0.071 for Yabraso).

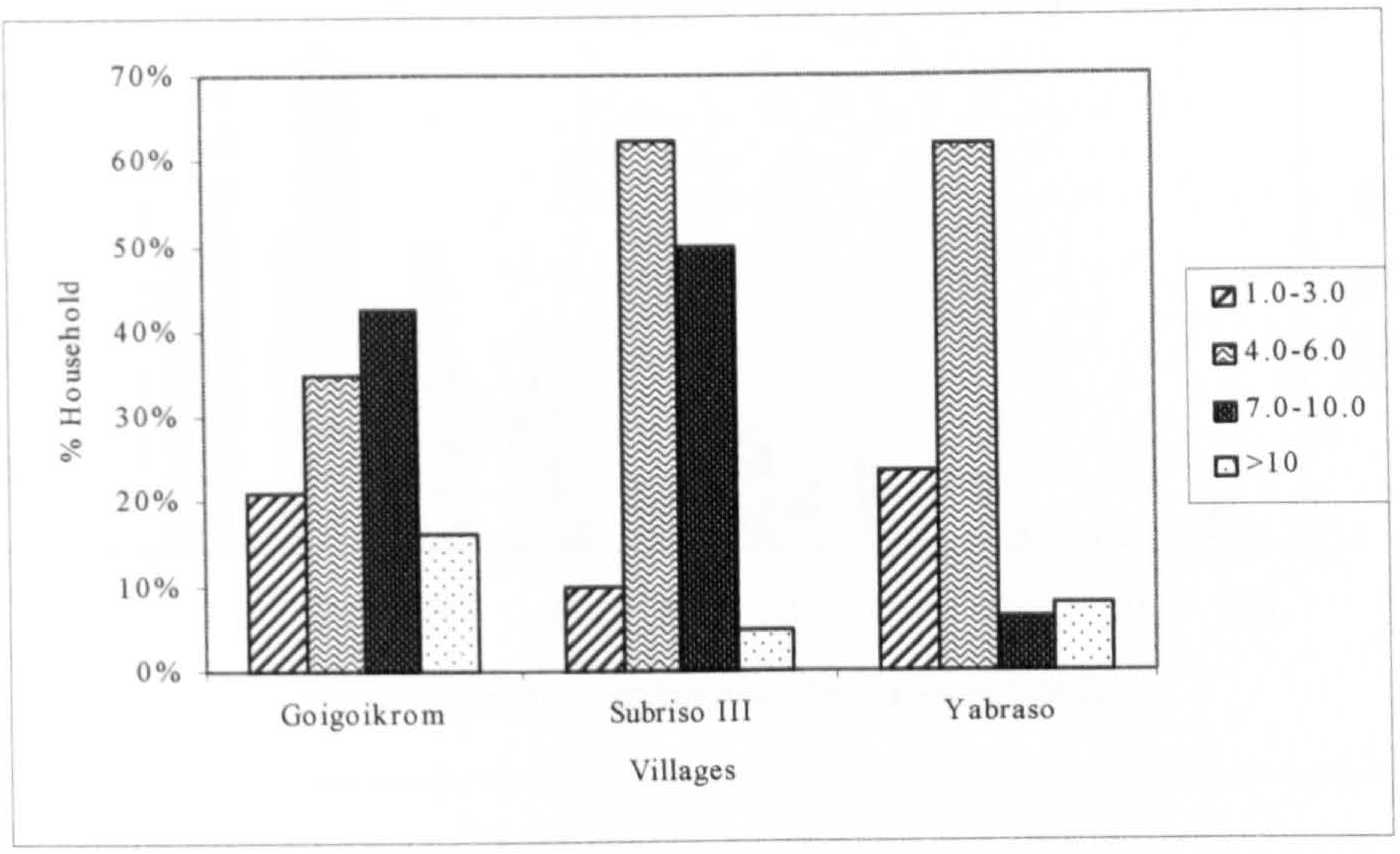


Figure 4.4: Household size distribution -Gogoikrom, Subriso III & Yabraso.

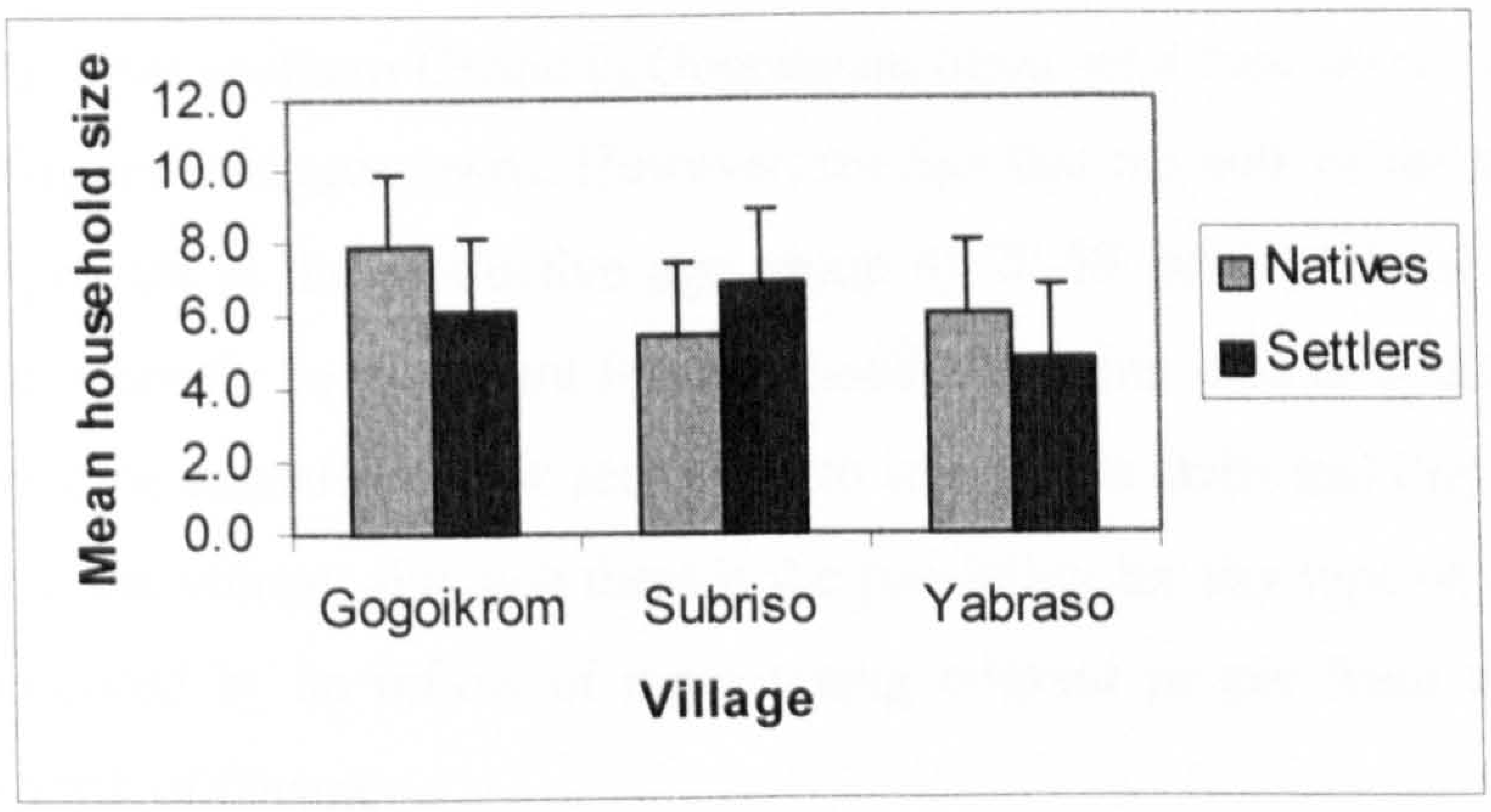


Figure 4.5: Mean household sizes of farmer categories -Gogoikrom, Subriso III & Yabraso.

Household involvement in agricultural production

The overall proportions of household members involved in farm production are 57%, 45% and 47% for Gogoikrom, Subriso and Yabraso. Figure 4.6 shows the distribution. Most households in Gogoikrom and Subriso have from 1-4 household members involved in farm production while it is 1-3 people in Yabraso.

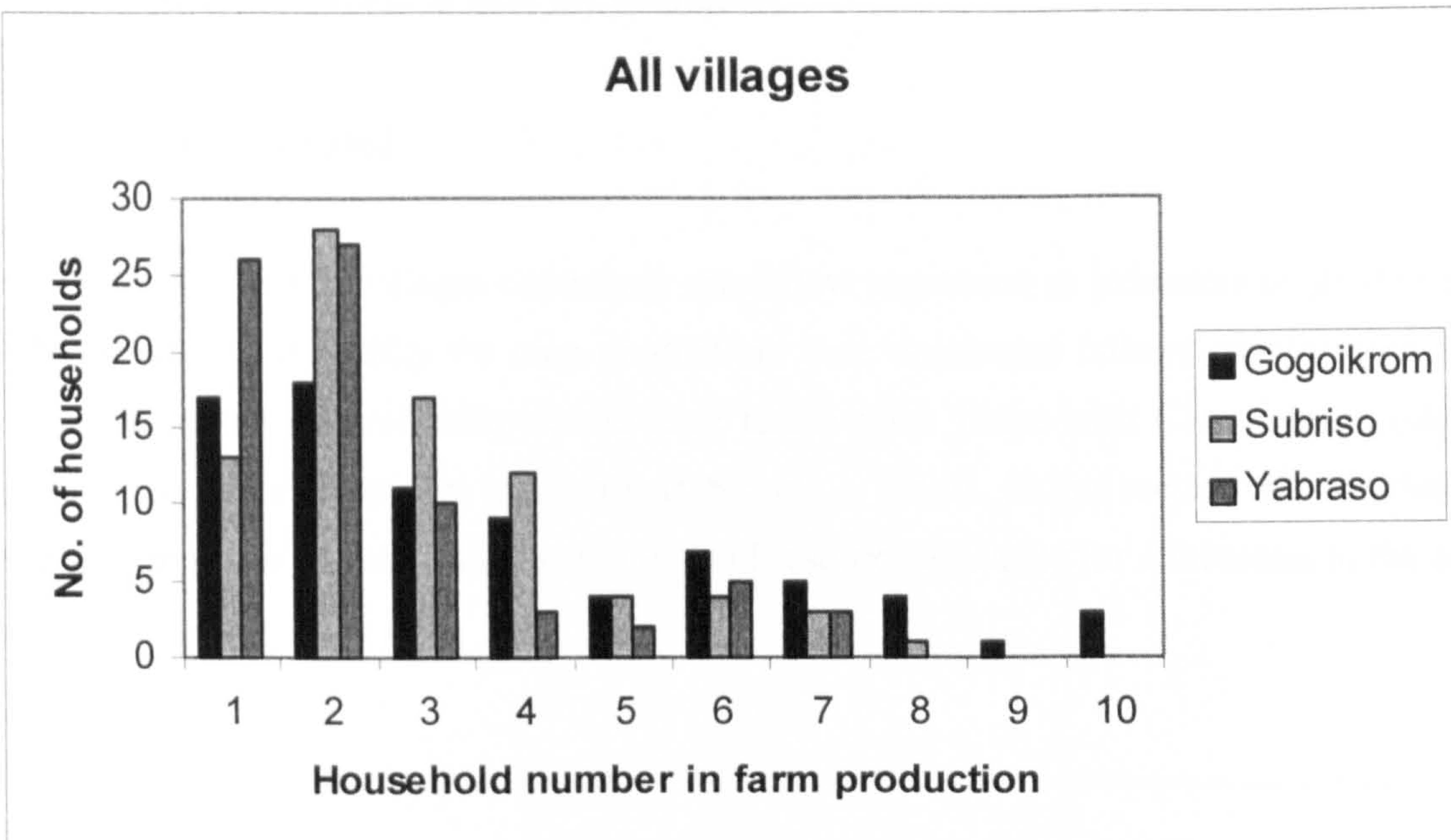


Figure 4.6: Household involvement in farm production

On the whole, Gogoikrom has the highest proportion of young people involved in farm production due to the presence of young settler men from northern Ghana. It was observed that natives and settlers originating from southern Ghana in Gogoikrom often send their wards out of the village to live with other relatives in bigger towns. However, the fact that the bulk of the people in agriculture in the three villages are in the productive age group of 20-59 years probably suggests that land resources will continuously be important for livelihoods for some time to come. There is tendency for more children to be educated and/or sent away to learn trade skills and they might not return to live permanently in the village, although there is the possibility for this type of emigration of young people to be succeeded by an inflow of more young migrant people from degraded land areas, especially in the north of Ghana.

Occupation/employment

The magnitude of dependency of farmers in the study area on land for livelihoods is enormous. This is demonstrated by the fact that 98%, 93%, and 87% of the respondents in Gogoikrom, Subriso and Yabraso respectively are engaged in farming as their main occupation. However, some farmers undertake variable off-farm employment in addition to farming. Yabraso had the highest proportion of 43% of the people interviewed involved in off-farm employment whereas it was 27% and 29% for Gogoikrom and Subriso respectively.

4.3.2 Land resources, access & uses for livelihood.

4.3.2.1 Land types cultivated

Farmers in these three study villages commonly use fallow vegetation as indicators of good or poor land with respect to soil fertility for crop production. Tree dominated fallows usually aged more than 5 years constitute matured fallows, and have fertile soils. Those with *Chromolaena odorata* and grasses of 1-3 years growth are less fertile (Obiri *et al.*, 2000). In this section this criterion has been used as a proxy to represent the quality of land resource available for cultivation in the study villages.

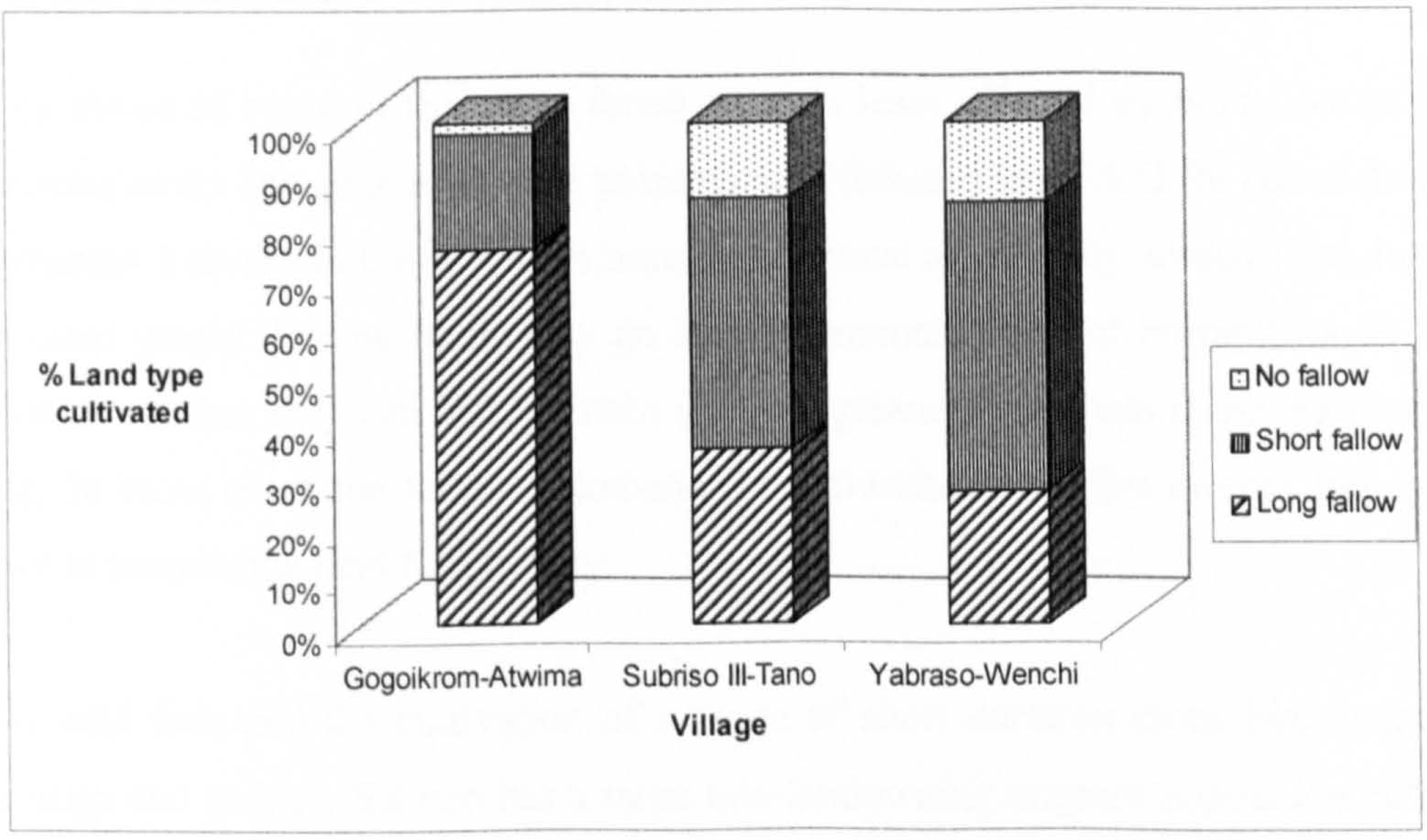


Figure 4.7: Land types cultivated in Gogoikrom, Subriso III and Yabraso

Figure 4.7 shows the general trend in land types being cultivated in the three villages. It can be observed that most farmers generally cultivate previously fallowed land as compared with a few cultivating previously cropped land (i.e. food crop following food crop).

Gogoikrom-Atwima has the best land quality by having about 75% of the farms being cultivated from long fallow lands (59% secondary forest, 41% old/dead cocoa fallows & mature fallows of over 5years) whereas Yabraso-Wenchi has the poorest with about 57% of the farms being cultivated from short fallow lands (mostly grass vegetation aged 1-3 years). Tuson, (2001) described environmental quality as the natural resource households draw upon and inter-react with to sustain their livelihoods. He argued that the pattern of land use and hence the local environmental quality is a proxy for past and present forces leading to changes in land use. Rampant bush fires, cropping systems and inflow of migrant population from the north over the years could be some important factors explaining the observed trends in land types on which farmers in the study villages depend for their livelihoods.

Table 4.2: Land types cultivated Gogoikrom, Subriso & Yabraso

Village	% Land type cultivated		
	Long fallow	Short fallow	Food crop following food crop
Gogoikrom - Atwima	75	23	2
Subriso III - Tano	35	50	15
Yabraso - Wenchi	26	58	16

Gogoikrom, by virtue of being in the moist forest zone, is least affected by wild fires in the dry season, and consequently has quite a sizeable proportion of forested land ideal for cocoa (tree crop) production, whereas Yabraso in the savannah transition is most affected by annual fires, hence the vegetation is more grassy. Fallow fields may go through annual cycles of burning for as long as they remain fallow so that they can hardly attain a rich vegetation mix even if the duration of the fallow is long. In most cases the fallow automatically terminates once fire sweeps through as it becomes easier to prepare the land for planting.

In addition to wild fires and the cultivation of a range of short duration crops like maize, yam, groundnut, tomato and pepper, Subriso has a large non-landowning migrant population cultivating large areas of maize as their main crop for cash and food. This has lead to the development of more of the short fallow land than the long fallow land as the land needs of the growing population of maize cultivators who are not in the position to fallow land must be met and land owners need cash from land rent and share cropping to supplement their farm incomes (Obiri *et al.*, 2000). Moreover, the ecology of the Subriso area is drier, making it more susceptible to wild fires and not very conducive to the production of perennial crops, like cocoa, which require tree, or long fallows.
The type of land a farmer cultivates in Gogoikrom is related more to the crop type. Non-land owning settler males from Northern Ghana, largely involved in the cultivation of maize and rice-based farms, commonly cultivate short fallow lands (mainly *Chromolaena odurata)* as the valley bottom areas often cultivated to these short duration crops are limited, and are hence cultivated more often. Cocoa, the dominant crop of the village, is usually cultivated on long fallow land. Thus all farmers cultivating cocoa, comprising natives and settlers, male and female and landowners and non-landowners, have access to long fallow land (Table 4.3).

Table 4.3: Tenure to land types cultivated - Gogoikrom, Subriso & Yabraso

Land type	Gogoikrom - Atwima		Subriso III - Tano		Yabraso - Wenchi	
	% Landowner	% Tenant	% Landowner	% Tenant	% Landowner	% Tenant
Long fallow	34	66	84	16	92	8
Short fallow	26	74	40	60	74	26
Food crop following food crop	0	100	74	26	74	26

In Subriso III the type of land cultivated by individuals appears to be related to security of tenure, which in most cases dictates the type of crop cultivated. 35% of the farms cultivated in Subriso III are from long fallow land (25% sec. Forest, 75% old/dead cocoa) out of which, native and settler landowner men and women cultivated 84% (Table 4.3).

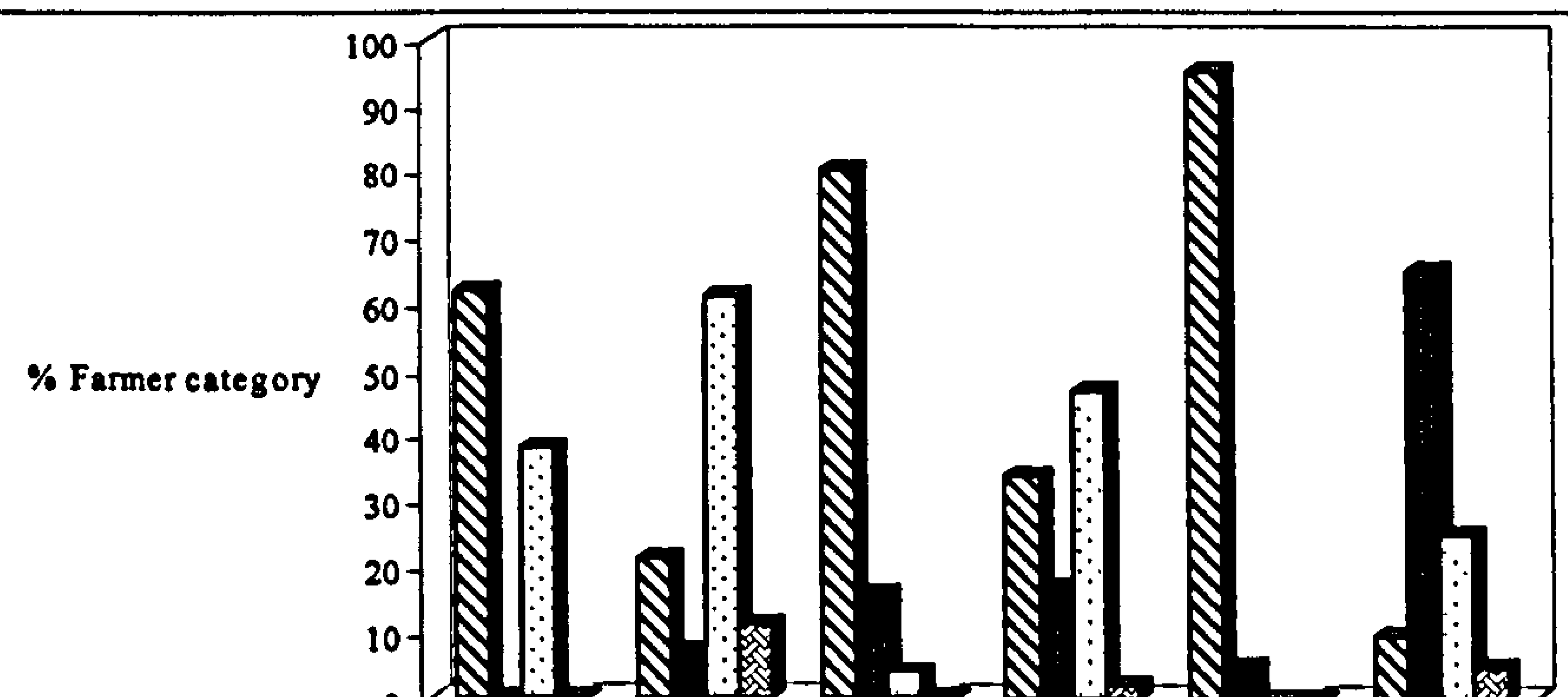
Tenants, comprising mostly (60%) non-landowning settler men and women cultivate short fallow lands. The fact that few of these tenants cultivate previously cultivated food crop land indicates that they probably have short tenancies for use of farm lands and would usually move out in search of another piece of land after the land is cultivated once. It could also be due to the fact that the short fallow lands they easily access for cultivation are poor in fertility and so it might not be profitable to crop them for more than one season. It was also observed that landowners cultivating, for instance, maize and tomatoes, might sometimes allow settler non-landowners to relay these crops with cassava for *abusa* (2:1) shares. After the cassava is harvested and proceeds shared, the land reverts back to the landowner who cultivates the land to another crop of his/her choice. The cassava might remain on the field for about two years during which it is believed its leaf litter conserves moisture and decomposes to improve the fertility of the soil enough for the cultivation of another crop (Obiri *et. al.*, 2000).

26% of the plots cultivated in Yabraso are from long fallows. 92% of these fields are cultivated by mostly native men and women and a few settler landowners with the remaining 8% cultivated by non-landowning settler men and women mainly under sharecrop tenancies (Table 4.7). The majority (74%) of the farmers cultivating short fallow fields are native landowner men and women. This is because much (58%) of the cultivated fields are from short fallow land and the inhabitants of the village are predominantly natives.

Tenants in Yabraso often rent short fallow lands for a period of one year. Moreover, it is common to find these rented fields, especially those for yam production, being relayed with cashew by tenants for landlords. This means that the tenant will hardly have the chance of cultivating the same field twice to a food crop. Landowners and tenants with free access to land where the land has no specific tenancy duration were observed to cultivate food crops consecutively for at least two years or more depending on the productivity of the soil.

4.3.2.2 Land acquisition/tenure

Figure 4.8 indicates how the various categories of farmers interviewed in the study villages access land for cultivation. It can be observed across the three villages that native men and women commonly cultivate their own lands as these comprise 62%, 80% and 90% of native plots in Gogoikrom, Subriso III and Yabraso respectively, although they sharecrop and rent land in some cases. It must be recognised that the native owned lands are largely family owned or individually inherited.



	Native	Settler	Native	Settler	Native	Settler
	Gogikrom		Subriso III		Yabraso	
Own	62	21	80	34	95	10
Rent	0	7	16	17	5	65
Share crop	38	61	4	47	0	25
Free	0	11	0	2	0	5

Figure 4.8: Tenure to farms under cultivation in Gogoikrom, Subriso III and Yabraso

Quite an appreciable proportion (38%) of native plots in Gogoikrom are under sharecrop tenure because some natives are embarking on the *abunu* (1:1) tenure arrangements for cocoa and oil palm prevailing in the area to utilise more from either absentee landlords or other resident landowners who have sufficient land at their disposal but lack adequate money to establish more or expand cocoa (tree cash crop) farms in the short term. Land fragmentation among members of some native households often limits the size of land available for cultivation. Thus it is worthwhile investing in *abunu* shares (where upon sharing 50% of the cocoa plantation belongs entirely to the tenant) to supplement own land and to accumulate more cocoa plantations often viewed as capital assets and as security against old age.

Oil palm, an emerging crop, is cultivated on wetlands and so landowners who do not have such lands but are interested in diversifying their asset base might enter into *abunu* shares with others who have it in order to own oil palm plantations in the same manner as for cocoa. The few native rented fields in Subriso (16%) and Yabraso (5%) had been cultivated to short-term cash food crops. In Subriso these fields were mainly cultivated to tomato by men and groundnut by women whereas in Yabraso they were cultivated to maize and yam by both men and women.

It can be observed from Figure 4.8 that settlers have a broader range of tenure forms (own, rent, sharecrop and free) by which they access land to farm for livelihood. As already mentioned, two main categories of settlers, i.e. settler landowners (men and women) and settler non-landowners (men and women) can be distinguished across the three villages. Generally, settler landowner plots were fewer as compared to those of the settler non-landowners although there were more in Gogoikrom (21%) and Subriso III (34%) as compared to only 10% in Yabraso. This probably reflects their actual population in the villages and could also be due to the fact that as descendents of ancestral migrants who merely got access to portions of farmland as gifts from family friends, they do not have appreciable land holdings at their disposal. Consequently, they may supplement their land needs with renting or sharecropping.

The majority of the settler plots were under sharecropping arrangements in Gogoikrom (61%) and Subriso (47%) while those at Yabraso were rented (65%). Settler men and women landowners also sharecrop and rent land, but to a lesser extent and more like the natives. Thus, settler non-landowners cultivate a higher proportion of the settler plots. In Gogoikrom the sharecropped fields were mainly under *abunu* cocoa shares, while the rented ones were for maize and rice.

Free land is one, which tenants cultivate without having to pay for its use either by produce or cash. The tenant is not obliged to pay anything but may offer some proceeds to the landowner at his/her own will. The proportion of plots under free access is highest in Gogoikrom because of the absentee landlords. By virtue of being a tenant to an absentee landlord, non-landowner settlers have the privilege cultivating portions of their landlord's land to short term crops for which they pay nothing to the landlord. The same prevails in Subriso III. However, in Yabraso free land is most often land granted by the village chief and his elders to government workers like schoolteachers, community health workers, extension agents and social workers including pastors/catechists of churches posted to the village. These workers cultivate such fields to supplement their paid income. This in many ways serves as an incentive to encourage them to render their services to the community.

4.3.2.3 Quantities of land cultivated for livelihood

Table 4.4 shows that on average each farmer in any of the three study villages cultivates two or more pieces of plots at any point in time irrespective of residential and land status.

Table 4.4: Number of plots cultivated in study villages

Characteristic	Gogoikrom		Subriso III		Yabraso	
	Native	Settler	Native	Settler	Native	Settler
Mean number of plots per household	3.1	2.6	3.2	2.9	2.7	2.0
Range	1-4	1-5	1-6	1-6	1-6	1-4

Farmers cultivate plots of variable sizes ranging from 0.1-6.0, 0.1-3.0 and 0.1- 4.4 hectares respectively in Gogoikrom, Subriso and Yabraso. These cultivated fields tend to be bigger in Gogoikrom (1.2ha average) than those found in Subriso III and Yabraso (average 0.7 and 0.8 ha respectively) (Table 4.5). Gogoikrom thus has a higher proportion of larger farm plots with approximately 50% of the plots bigger than 1.0 ha compared with about 20% in Subriso and Yabraso (Figure 4.9).

Table 4.5: Mean plot sizes (ha) cultivated in study villages

Village	Mean plot size (ha)	Range (ha)	Variance
Gogoikrom-Atwima (n=165)	1.24	0.1-6.0	0.947
Subriso-Tano (n=212)	0.67	0.1-2.8	0.223
Yabraso-Wenchi (n=191)	0.81	0.1-4.4	0.623
F-value = 26.11			
P-value = 0.00			

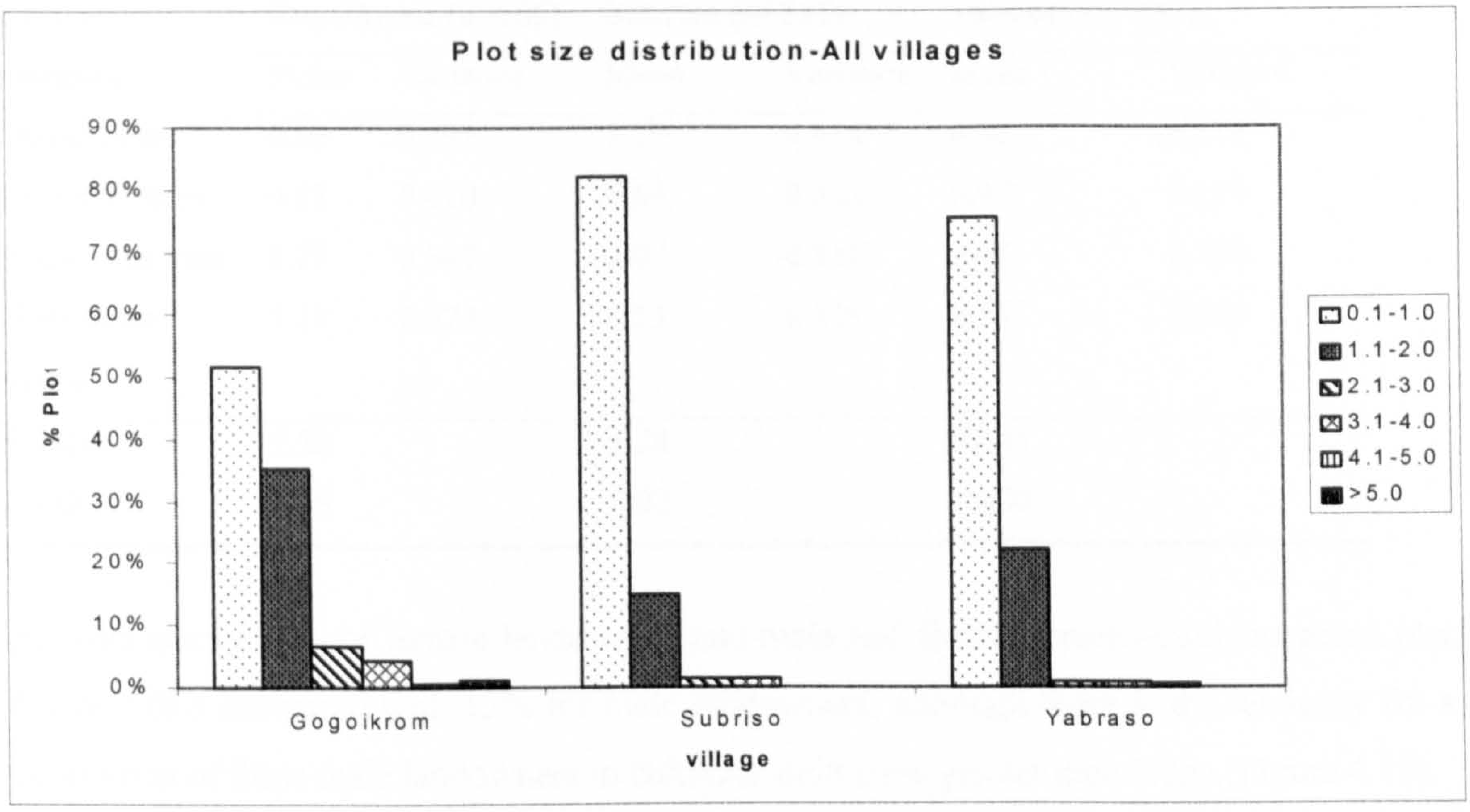


Figure 4.9: General distribution in plot sizes in study villages

On the whole the mean plot sizes cultivated when compared across the three villages are significantly different, i.e. F=26.11, p=0.00. However, plot sizes cultivated in Subriso III and Yabraso are about the same, F=0.24, p=0.627 as Table 4.6 indicates.

Table 4.6: Comparison of plot sizes cultivated in study villages

Comparison	F	p-value
Gogoikrom vs. Subriso vs. Yabraso	26.11	0.00
Gogoikrom vs. Subriso	42.23	0.00
Gogoikrom vs. Yabraso	36.33	0.00
Subriso vs. Yabraso	0.24	0.63

From discussions with farmers there appear to be an increasing land scarcity as a result of inflow of settler/migrant population mainly from the North of Ghana. However, the observed cross site differences in cultivated plot sizes seem to suggest that the problem could be more intense in Subriso, and Yabraso and less so in Gogoikrom. The bigger acreages found in Gogoikrom may be due to the dominance of cocoa plantations that are characteristically expanded annually. Comparing differences in plot sizes between landowners and non-landowners within villages, it is observed that women generally cultivate smaller plots across the three villages (Table 4.7).

Table 4.7: Mean plot sizes (ha) cultivated by landowners & tenants in study villages

Farmer category	Gogoikrom (n=165)		Subriso (n=212)		Yabraso (n=191)	
	Mean	Variance	Mean	Variance	Mean	Variance
Owner men	0.89	0.892	1.29	4.454	0.90	0.318
Owner women	0.88	0.410	0.64	0.522	0.49	0.114
Non-owner men	1.27	0.547	1.02	0.816	0.69	0.158
Non-owner women	1.11	0.474	0.53	0.129	0.54	0.089
F-value	2.56		3.28		11.43	
P-value	0.06		0.02		0.000	

In Gogoikrom nearly 50% of female landowners and male and female tenants cultivate mean plot sizes of over 1.0ha compared with 15% for male landowners, although there is the tendency for a higher proportion of these male landowners to cultivate field sizes greater than 5.0ha (Figure 4.10).

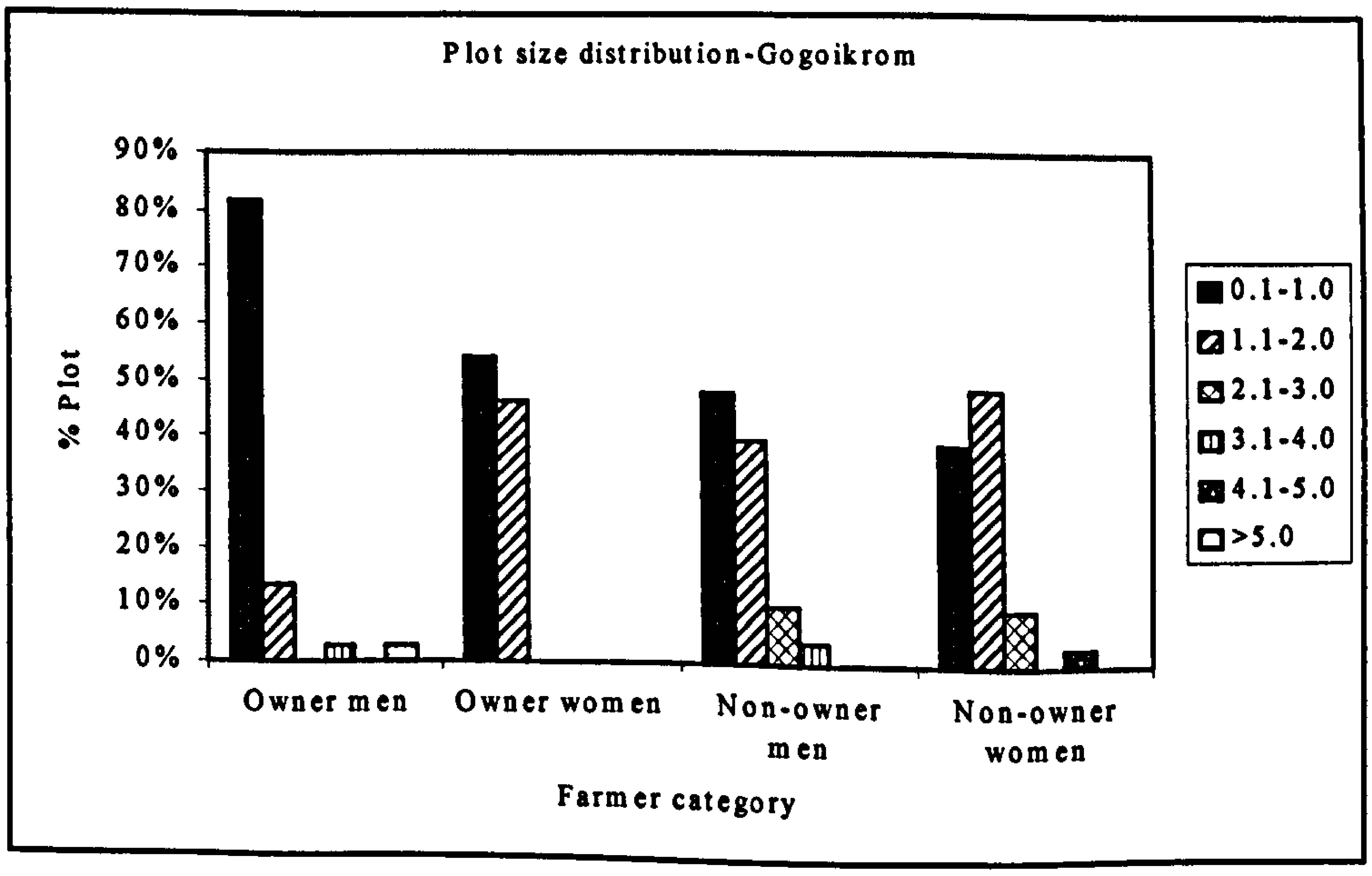


Figure 4.10: Distribution in plot size between landowners & tenant-Gogoikrom

Some female tenants cultivated joint fields with their spouses, who were often responsible for these fields. Where the man was absent at the time of interview, the woman was interviewed, resulting in the observed trends for tenant women of Gogoikrom. Tenants appear to be cultivating bigger plots than landowners in Gogoikrom because some of them have access to large areas belonging to absentee landlords they convert to cocoa. Generally, the majority of both landowners and tenants cultivate fields of not more than 1.0 ha in Subriso with over 80% of the women in both categories cultivating such fields.

Unlike Gogoikrom, where both landowners and tenants cultivate up to 2.0 ha and more, the majority of farmers cultivating plots of such sizes in Subriso are male tenants, although a few of the male landowners may cultivate plots bigger than 2.0ha (Figure 4.11).

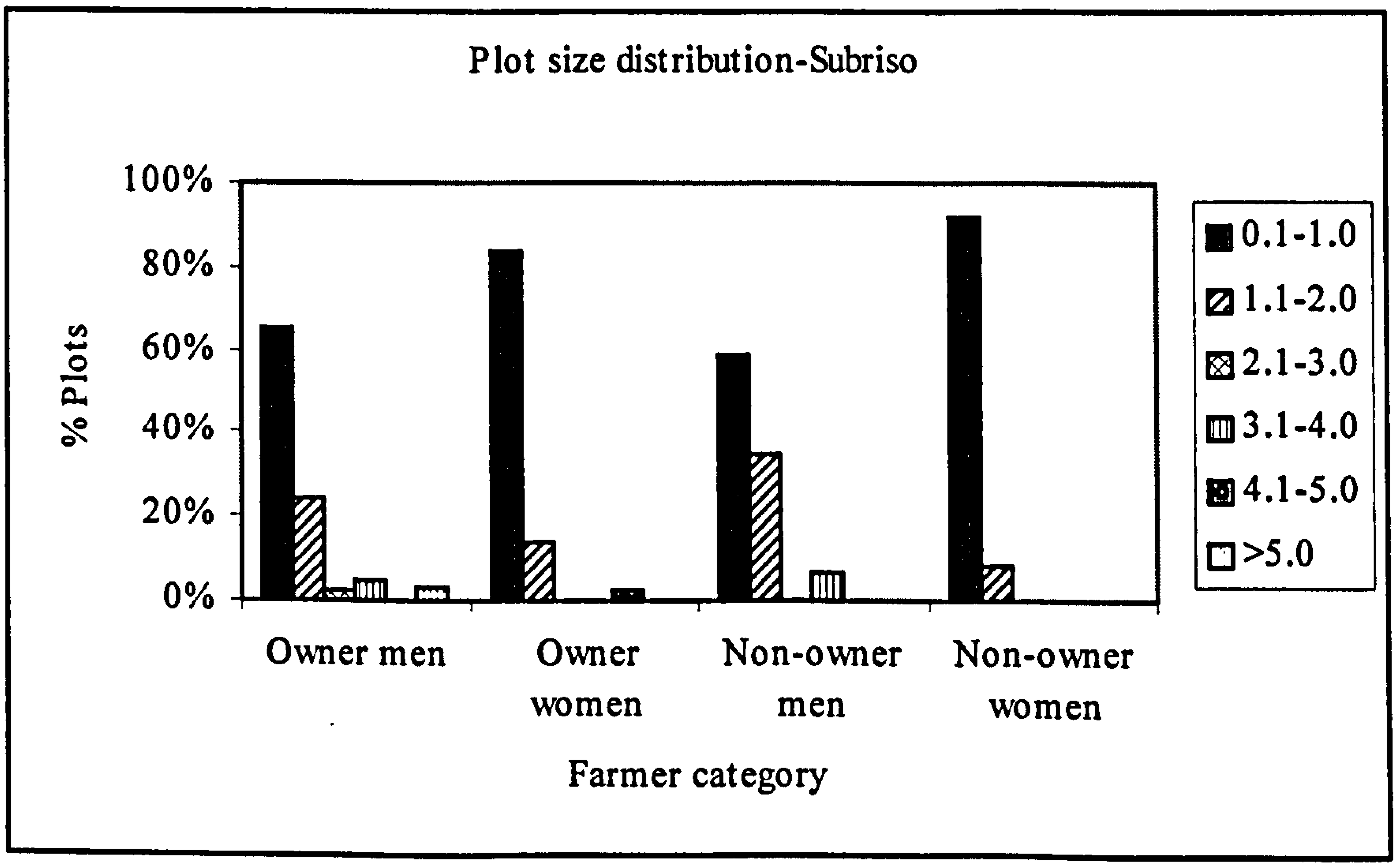
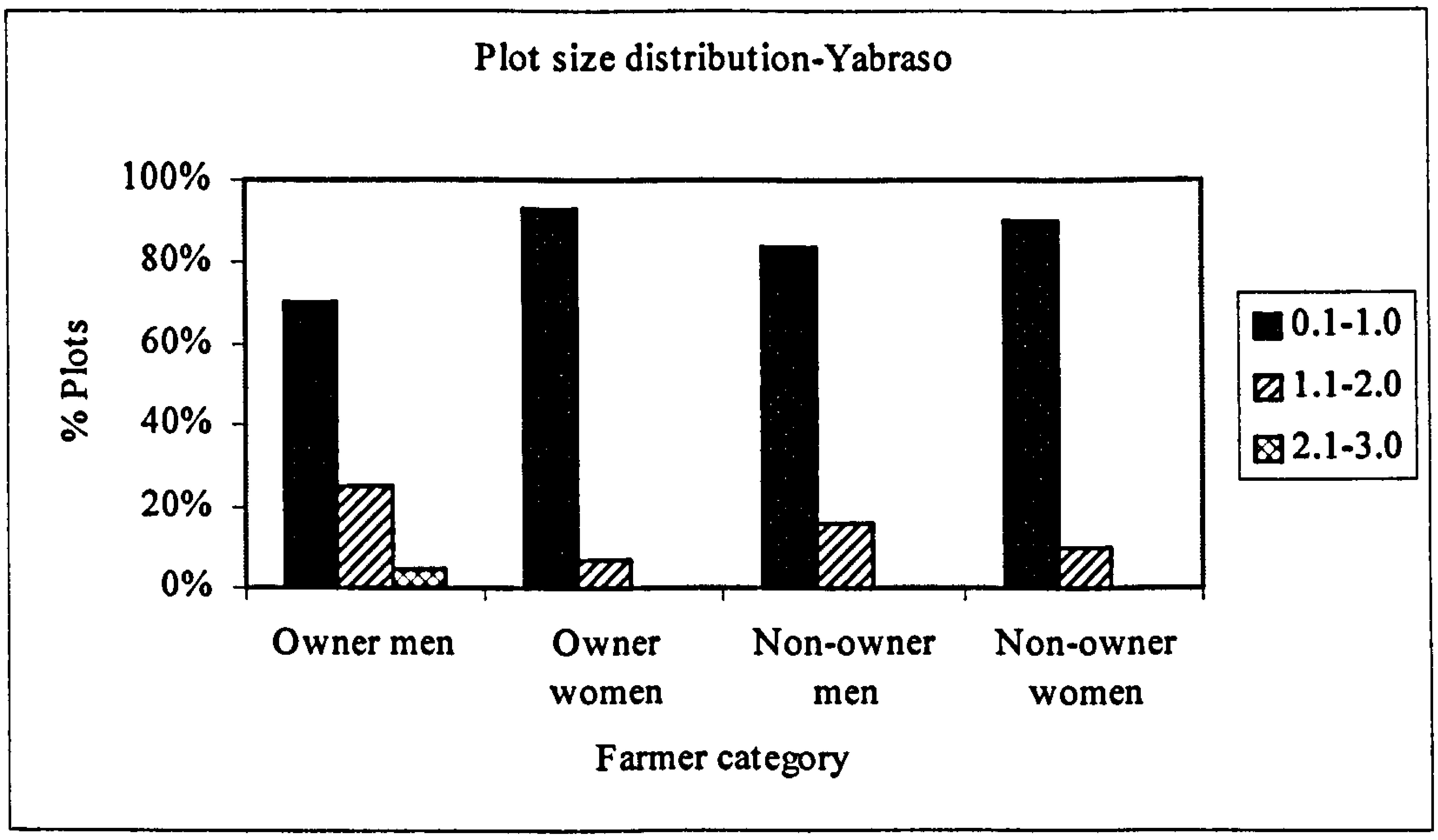


Figure 4.11: Distribution in plot size between land owners & tenants-Subriso III

The majority of both landowners and tenants of both genders cultivate plot sizes of not more than 1.0 ha in Yabraso. Nevertheless, 25% of the male landowners cultivate larger plots of up to 3.0ha compared to a lesser proportion of the fields of the other categories that do not exceed 2.0ha (Figure 4.12).



Figures 4.12: Distribution in plot size between landowners & tenants-Yabraso

In summary, native and settler men and women may not be constrained in terms of access to land to cultivate as each farmer category cultivates at least two fields in any one season. Men in general cultivate bigger areas than women across the three villages. However, male tenants, the majority of whom are northerners tend to cultivate bigger plot sizes than the landowners in Gogoikrom and Subriso, which further confirm the fact that access to land for cultivation may not be a critical issue for landless people. This is probably because these villages are dominated by this category of farmers, to whom most landowners would usually rent out land, although they are exploiting nutrients from of the land without replenishing them. The fact that plot sizes are smallest in Subriso may mean that it is the most constrained with respect to land, as it has the largest population.

4.3.4 Land cultivation and management

4.3.4.1 Crop production

Figure 4.13 shows that cocoa, maize and rice are the main crops cultivated in Gogoikrom comprising 56%, 17% and 13% of plots under cultivation in the village. Other important crops in Gogoikrom are plantain and oil palm, which constitute 6% and 5% of fields cultivated. The key crops grown in Subriso III are maize (26%), plantain (20%), yam (11%) and cassava (10%). However, pepper, groundnut, tomato and oil palm are also important but cultivated by a relatively small number of farmers.

Maize and yam are the major crops grown in Yabraso comprising 33% and 34% of plots cultivated. Other important crops in Yabraso are pepper, groundnut and cashew, making up 7%, 7%, and 2% of plots respectively. On the whole, there is a wider range of crops grown in Subriso III (15 crop types) than Yabraso (12 crop types) and Gogoikrom (9 types). The higher crop diversity in Subriso probably suggests that the agro-ecology has changed from its moist semi-deciduous type and is gradually approaching the forest-transition as this enables a wider range or mix of crops of forest and transition origin to be cultivated (Gyasi *et al.*, 1995).

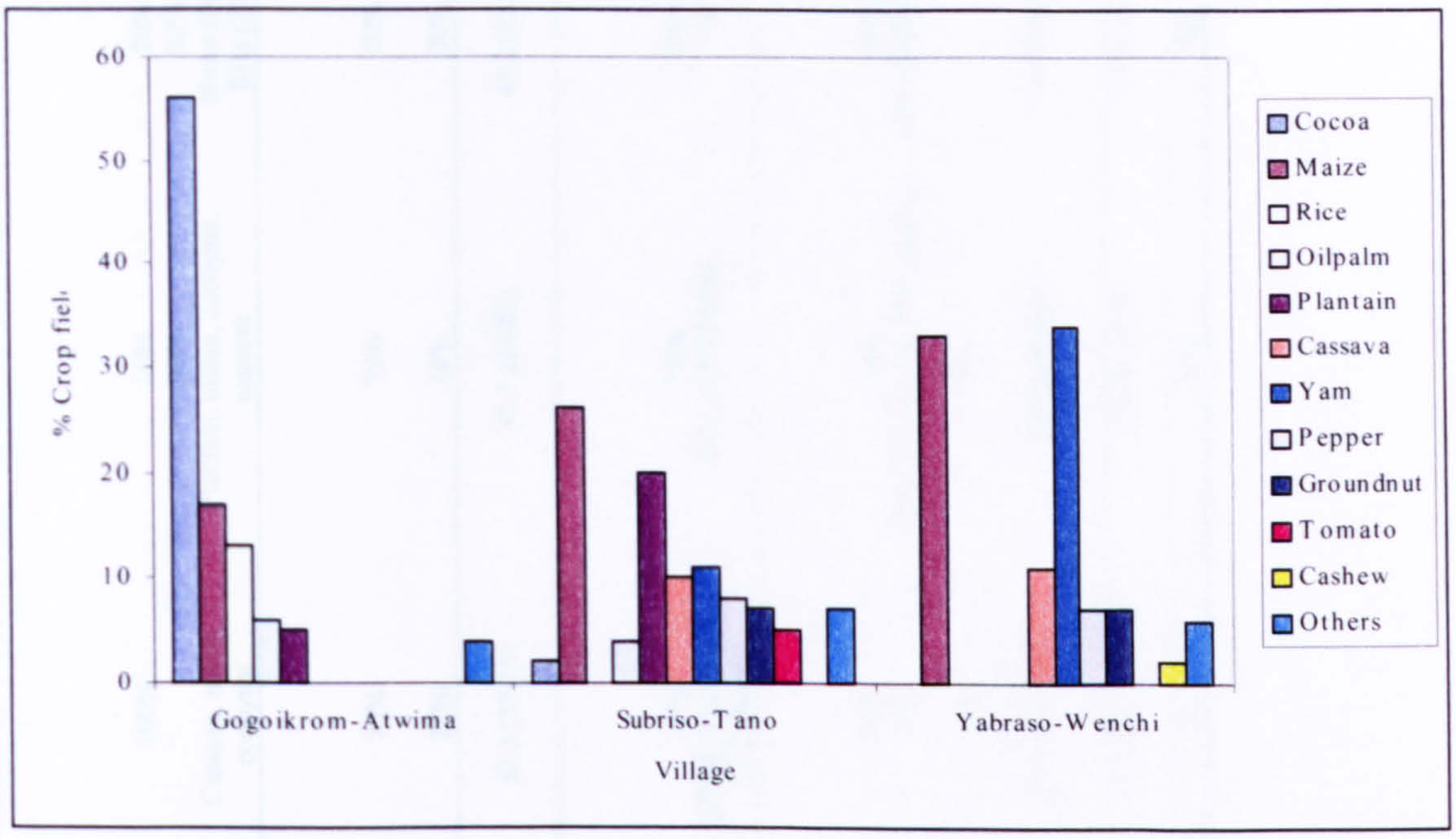


Figure 4.13 Crops cultivated in Gogoikrom, Subriso III and Yabraso

Tables 4.8-4.10 summarize details on some characteristics of food and tree crops cultivated in the study villages. It must be noted that most of these crops are cultivated mainly for sale with a proportion for consumption. Less than 50% of the main food crops, including some vegetables i.e. maize, rice, groundnut, yam, plantain, tomato, garden egg and pepper, are for consumption depending on their food value to the people of the area. For instance, in Subriso and Yabraso yam and cassava are two of the key staples, with only 22% and 45% respectively sold in Subriso and 40% and 44% in Yabraso. Farmers explained that, where crops are grown in mixtures, the main crop constitutes about 80% of the plot.

Table 4.8: Typology of crop production in Gogoikrom-Atwima

Characteristic	Crop type				
	Maize	**Rice**	**Plantain**	**Cocoa**	**Oil palm**
% Plots	17	13	5	56	6
Cropping pattern					
Mono	34%	55%	-	10%	20%
Mixed	66%	45%	100%	90%	80%
Other crops	Plantain, cassava, cocoyam, rice	Maize, oil palm	Cassava, maize, cocoyam	Plantain, maize, cocoyam, cassava	Maize (60%), Rice (20%)
Gender					
Male	83%	82%	75%	70%	70%
Female	17%	18%	25%	30%	30%
Mean age (years)	38.9 (20-75)	36.9 (22-75)	52.3 (25-75)	45.1 (23-82)	47.2 (25-82)
Resident status					
Natives	14%	-	13%	15%	30%
Settlers	86% (66% north, 34% south)	100% (91% from north)	87% (63% Ashanti, 37% North)	85% 954% North)	70%
Tenure					
Own	28%	18%	50%	27%	50%
Sharecrop	55%	55% (57% abunu, 43% abusa)	25%	68% (81% abunu, 19% abusa)	50% (100% abunu)
Rent	3%		-	-	
Free	14%	27%	25%	5%	
Mean tenancy period	2 years (78 % for one year)	1-3 years (72% 1 year)	Not specified	Not specified	Not specified
Mean plot size (ha)	0.8 (0.2-2.4)	1.3 (0.2-2.4)	0.7 (0.2-1.2)	1.4 (0.1-6.0)	1.4 (0.2-3.2)
% Sold	56	74	58	100	96

Table 4.9: Typology of crop production in Subriso III-Tano

Characteristic	Crop Types								
	Maize	Plantain	Yam	Cassava	Pepper	Groundnut	Tomato	Cocoa	Oil palm
% Plots	26	20	11	10	8	7	5	2	4
Cropping pattern									
Mono	49%	14%	26%	32%	38%	-	55%	50%	63%
Mixed	51%	86%	74%	68%	62%	100%	45%	50%	37%
Other crops	cassava, plantain, groundnut, beans, plantain, etc.	maize, cassava, etc.	cassava, maize, groundnut	cocoyam, plantain, yam, etc.	maize, cocoyam, cassava, okra	cassava, maize, pepper	pepper, cassava, cocoyam	cola, orange	maize, plantain
Gender									
Male	69%	55%	50%	50%	62%	43%	91%	86%	
Female	31%	45%	50%	50%	38%	57%	9%	14%	
Mean age (yrs)	43.0	46	41.5	45.1	40.6 (20-60)	43.1	38.8	50.4	
Range	(20-86)	(30-86)	(20-60)	(30-65)		(30-65)	(20-52)	(30-60+)	
Resident status									
Natives	18%	52%	75%	36%	38%	29%	36%	29%	
Settlers	82% (75% north)	48% (72% south landowners)	25%	64%	62%	71%	64% (86% south (Ash & BA)	71% (100% south i.e. Ash & BA)	
Tenure									
Own	31%	84%	63%	55%	69%	43%	64%	100%	
Sharecrop	53%	14%	25%	40%	25%	21%%	18%	-	
Rent	16%	2%	13%	5%	6%	36%	18%	-	
Free	-	-	-	-	-	-	-	-	
Mean tenancy period	10% 1-3 years (rent) 90% not specified (sharecrop)	-	0-2 years	-	-	-	1 year	-	
Mean plot size (ha)	1.1	0.8	0.4	0.6	0.3	1.1	1.1	1.2	
Range	(0.2-4.0)	(0.2-1.6)	(0.1-1.2)	(0.2-1.6)	(0.1-0.6)	(0.5-2.0)	(0.25-2.5)	(0.1-2.0)	
% Sold	70	59	22	45	82	76	87	100	80

Table 4.10: Typology of crop production in Yabraso-Wenchi

Characteristic	Crop Types					
	Yam	Maize	Cassava	Pepper	Groundnut	Cashew
% Plots	34	33	11	7	7	2
Cropping pattern						
Mono	20%	73%	83%	50%	25	5%
Mixed	80%	27%	17%	50%	75%	95%
Other crops	Cassava, maize, beans, pepper, groundnut	Cassava, pepper, tomato, plantain	Maize, groundnut, cashew	Cassava, tomato, okra, garden egg	Cassava, cashew, maize	Yam, cassava, maize
Gender						
Male	55%	65%	61%	14%	-	65%
Female	45%	35%	39%	86%	100%	35%
Mean age (years)	47.3 (23-101)	42.6 (21-101)	41.4 (21-70)	45.8 (33-66)	47.2 (24-80)	51.5 (30-80)
Resident status						
Natives	75	73%	67%	93%	100%	100%
Settlers	25	27%	33%	7%	-	
Tenure						
Own	82%	69%	78%	86%	100%	100%
Sharecrop	5%	8%	-	-	-	-
Rent	9%	19%	22%	14%	-	-
Free	4%	3% (from friends, landlord, chief)	-			
Mean tenancy period (years)	1.0	1.4 (1-2) on rented land), Not specified on sharecrop land	2.0	1.0	-	-
Mean plot size (ha)	0.5 (0.2-2.8)	1.0 (0.4-2.4), mode=2	0.5 (0.2-1.0)	0.4 (0.1-0.8)	0.4 (0.2 – 0.8)	0.8 (0.2-1.6)
% Sold	40	66	44	80	70	100

Food crop production

Maize & Rice

Across the three sites, maize is commonly cultivated by all classes of farmers (irrespective of age, gender, residential and land status) in monocrop (Yabraso 80%) and mixtures (Gogoikrom -66% and Subriso-49%). Maize fields were largest in Subriso III having a mean size of 1.1(0.2-4.0) ha compared to 0.8 (0.2-2.4) and 0.5 (0.2-2.8) in Gogoikrom and Yabraso respectively.

Maize appears to be cultivated mainly by men. In Gogoikrom, 83% of the maize fields are cultivated by men. 86% of these fields are for settler men, 66% of whom originate from Northern Ghana, most of whom do not own land. Consequently, the majority of maize-based farms are on sharecropped land under the *abusa* (2:1) arrangement, usually for tenancies of one year in 78% of the cases, although it could also range from 2 years to an unspecified period of time in some cases (Table 4.8).

The scenario is not very different in Subriso where 69% of the maize fields belong to men. 82% of these fields belong to settlers, the majority (75%) of whom are from the north of Ghana (Table 4.9). Consequently, most (69%) maize fields are cultivated by tenants under shared arrangements (53%) as this is the easiest means for the landless to acquire land to cultivate for cash and food without having to pay cash. In Yabraso, because maize is a major crop and natives who own land they cultivate dominate the population of the village, 73% of maize fields belong to natives, often (69%) found on land owned. Non-landowning maize farmers often grow the crop on rented land (19%) for periods ranging from 1 to 2 years (Table 4.10).

Rice is grown mainly in Gogoikrom under similar tenure conditions to maize, usually by settlers, 91% of whom originate from northern Ghana. 55% of rice fields found in the village are on sharecrop land for a tenancy of 1-3 years but for about 1 year in 72% of the cases if fields are rented with cash. Rice fields are bigger, with a mean of 1.3 ha, compared to other food crops like maize and plantain (Table 4.8). Rice is regarded by the men who grow it as an important cash earner with higher returns compared to maize.

Plantain

Plantain-based fields are common in Gogoikrom and Subriso often in mixtures with cassava, cocoyam, maize, etc. In both villages, plantain is cultivated by natives and settlers of ages ranging from 25-86 years but more by landowners comprising native and settler landowners from southern Ghana. This is not surprising as the crop is more perennial as compared to maize and rice, which are cultivated and harvested within a year under less secure tenancies by the landless.

Yam and Cassava

Yam and cassava based plots are popular in Subriso and Yabraso where they are cultivated by natives and settlers. In Subriso the age of yam and cassava growers ranges from 20-65 while it is 21-101 years for those in Yabraso (Tables 4.9 and 4.10).

In Subriso, it is mainly landowners who cultivate yam, as their fields comprise 63% of yam plots in the village. However, tenants often sharecrop yam, usually under *abusa* tenure (60%). Similarly, in Yabraso most (82%) yam fields are owned by the natives but tenants often grow yam on rented land under one year tenancies.

More non-landowning settlers appear to be involved in cassava cultivation in Subriso under *abunu* sharecrop-tenure as compared to Yabraso where most cassava fields are owned, probably because most of the inhabitants of the village are native landowners. The earlier PRA studies indicated that cassava is a key crop for non-landowning settlers in Subriso, (Obiri *et al.*, 2000). As has been explained earlier, it is usual for landowners to engage non-landowners to relay either maize or tomato with cassava on sharecrop basis. Tuson (2001) described cassava as a low risk crop in that it can be retained in the soil and harvested when required, especially in times of hardship.

Groundnut

Groundnut-based fields constitute 7% each of farms in Subriso and Yabraso (Tables 4.9 and 4.10). The crop is often found in mixtures in both villages with maize and cassava. It is also in mixtures with pepper in Subriso and cashew in Yabraso. Females in both villages mainly cultivate groundnut although quite a number of males (43%) are also involved in Subriso.

In Yabraso groundnut is cultivated solely by the native women on their own land. However, in Subriso the growers comprise both natives and settlers (but more [71%] settlers) and may be cultivated on land owned, rented or sharecropped. As has been explained, groundnut is an important crop for women in that it provides early cash for household needs, being one of the first crops to be harvested.

Pepper and Tomato

Pepper farms are more common in Subriso (8% of farms) and Yabraso (7% of farms) both in pure stands or mixtures with maize, cassava, tomato, etc. These farms are comparatively small with means of 0.3 (0.1-0.6) and 0.4 (0.1-0.8) ha respectively in the two villages.

More males (62%) than women are involved in pepper cultivation in Subriso compared to Yabraso where women constitute 86% of pepper farmers. In Subriso pepper cultivation is popular with settlers, comprising 62% of pepper cultivators, who grow the crop on their own land while in Yabraso the crop is popular with native women (93%), hence commonly found on land owned by the farmers.

The PRA analysis identified pepper as a female crop in Subriso. The fact that there are more men in its cultivation could be due to the fact that men are increasingly diversifying into its cultivation since it can be easily processed and better stored for a longer period for sale at higher prices during the dry season than can be done for maize. Moreover, the household consumes only small quantities of pepper, as it can be stored and sold for cash. Pepper is a biennial crop, which can yield for at least two seasons, and so once established more cash can be earned as compared to maize which brings returns once in a season.

Tomato-based fields are more common in Subriso where it is predominantly cultivated by males who comprise 91% of the growers and more by settler landowners on their own land (64%). It may also be cultivated under rental and sharecrop arrangements but often for only one year.

Tree crop production

Cocoa

Cocoa-based plots are found in Gogoikrom and Subriso. However, while cocoa plots are the commonest found in Gogoikrom, comprising 56% of cultivated fields in the village, they are not common in Subriso, making up only 2% of the fields. As has been explained above, the moist forest ecology ideal for cocoa production is virtually absent in Subriso. Cocoa fields are either in pure stands when matured/after canopy closure or mixed with plantain, maize, cocoyam, cassava which provide shade to the crop during its early stages of establishment. Most (90%) cocoa fields in

Gogoikrom are in their early stages of development. This is because old cocoa fields and others that were abandoned during the drought in 1983 are currently being replanted.

In both villages both males and females cultivate cocoa but there are more males involved. There appear to more young people involved in the cultivation of the crop in Gogoikrom mainly on an *abunu* sharecrop (68%) basis while in Subriso it involves more older people cultivating it on their own land (100%). This is expected since the ideal cocoa ecology in Gogoikrom coupled with the *abunu* system practiced in the area provides a somewhat secure tenure environment that encourages non-landowners to grow the crop as they are entitled to 50% of the crop after investing their resources in its establishment. However, this poses some threat to food crop production for household survival in the future as the congenial tenure security is encouraging more long fallows being converted into cocoa plantation by non-landowners with the hope of owning land or a plantation in the future.

Oil palm

Oil palm-based fields are found mainly in Gogoikrom and Subriso in pure stands and also in mixtures. In Gogoikrom, it is an emerging cash crop being cultivated in addition to cocoa; hence the majority of the farms are in their early stages of establishment and are often found mixed with maize and rice in about 80% of the cases on wetlands.

In contrast, 63% of the oil palm fields are in pure stands in Subriso. This implies that most of these fields are established or matured. This is not surprising as cash income from cocoa production declined in the area after the 1983 drought and fires, hence the need for a suitable substitute in a degrading environment not suitable for cocoa production.

In both villages, the majority of oil palm growers are settlers. In Subriso, it is established mainly on own land whereas in Gogoikrom both landowners and tenants cultivate the crop. Because of the peculiar nature of the land type for oil palm cultivation in Gogoikrom (wetland) both landowners and non-landowners cultivate it on an *abunu* shared basis similar to that for cocoa as landowners who desire to grow the crop may not have such a land type in their possession.

Cashew

Cashew is an emerging cash crop suitable for the drier climate in Yabraso. Farmers believe it could conveniently replace cocoa production, which was lost through drought and wild fires that swept through most farming communities in the country in 1983. Most of the cashew fields are in their early establishment stages where they are commonly in mixtures (95%) with yam, cassava and maize on grass-dominated land often referred to in the area as Savannah. Cashew is cultivated solely by natives who own their land, with 65% of the fields belonging to men.

On the whole, maize, rice and tomato are predominantly cultivated by men. Farmers explained that post-harvest handling and marketing of these crops are strenuous. For rice and tomato it is also because their field input requirements are capital (agro-chemicals, hired labour) and labour intensive (tomato ridging and harvesting, application of agrochemicals for both, bird scaring for rice and so on.). Men also dominate cocoa, oil palm and cashew production. These tree crops require cash to purchase inputs such as labour and seeds/seedling for establishment. It is evident that more men than women are involved with the production of labour and capital intensive crops because they are better resourced in terms their physique and money.

Plantain appears to be equally important for both male and female farmers in Subriso but in Gogoikrom, although it is a common crop grown by all categories of farmers on cocoa fields, it is grown especially by men for cash. In Gogoikrom the food crops play a key role in the establishment of cocoa farms, providing both cash and food for the household before the cocoa matures and also cash to purchase the needed inputs for establishing the cocoa.

Groundnut and pepper are cash earners for women in Subriso and Yabraso. They explained that groundnut provides early cash for household use soon after the lean season. Pepper, on the other hand, can be processed and stored providing cash for use in the dry season when it is not possible to cultivate the crop under the usual rain-fed conditions. Women in Gogoikrom did not report that they had any special crop.

Returns and labour costs in crop production

Labour often constitutes a greater proportion of production cost in smallholder agriculture (Upton, 1996). Variable sums of money are spent on labour in food crop production in the study area depending on the crop type in a season. A brief analysis of labour costs incurred and income earned from food crop production in the study villages indicates that both men and women in Subriso and Yabraso spend more money on labour and earn higher incomes from food crops than men and women in Gogoikrom (Figure, 4.14).

Figure 4.14: Gender differences - mean income and labour cost for main food crops

The higher labour costs of over one million cedis per hectare in Subriso and Yabraso may be related to the differences in land preparation activities, explained in detail in Section 4.4 on labour below. It is also probably an indication of the fact more labour is expended in controlling weeds as a result of the shorter fallows found in these two villages.

Although the estimated costs and incomes may not be accurate because over 80% of the farmers do not keep records of production activities, the trend observed in figure 4.14 suggests that men in general irrespective of residential status may be more resourceful with respect to fiscal cash than women. For women in Yabraso, poor income earned from groundnut and onion account for the overall lower income they earned from food crops.

Tables 4.11-4.13 indicate household incomes earned from the cultivation of main food crops. Not all households cultivate all crops. In Gogoikrom, rice which is cultivated mainly by settler men from northern Ghana is the most lucrative crop enterprise (Table 4.11). About ¢3.8million is earned in a season from its cultivation. Households (mostly men within the household) cultivating plantain also earn an appreciable amount of income.

Table 4.11: Returns on main food crops-Gogoikrom-Atwima

Crop	Mean crop margin (¢)/ha	Range (¢)	Standard deviation
Yam	288,375	192,250-384,500	135,941
Cassava	323,088	276,933-415,400	79,943
Maize	575,319	125,700-1,257,000	322,289
Plantain	1,155,640	462,256-1,849,024	596,770
Rice	3,784,611	774,125-9,289,500	2,572,816

In Subriso the highest income of ¢3.4 million is earned from plantain (Table 4.12) which is cultivated mainly by native and settler landowner men and women. The very low income from tomato, a male crop, confirms the fact that its cultivation is risky and is associated with wide fluctuations in prices. However, its cultivation is capital and labour intensive and often regarded as a lucrative enterprise, especially in times of high prices. An appreciable amount of income is also earned by households (mainly settler landless men and elderly male landowners) cultivating cassava and maize.

Table 4.12: Returns on cultivating main food crops-Subriso III-Tano

Crop	Mean crop margin (¢)	Range (¢)	Standard deviation
Tomato	15,7230	41,094-410,935	98,374
Pepper	267,688	97,341-584,046	121,804
Yam	330,440	88,572-1,062,857	249,963
Maize	812,008	158,758-3,175,158	592,671
Cassava	1,175,762	424,046-3,392,364	773,443
Plantain	3,354,895	857,786-6,862,286	1,790,196

The highest income from food production is earned from yam (¢1.6million average per season) in Yabraso (Table 4.13). Both men and women cultivate yam as a main crop. However, most men tend to cultivate larger total food crop acreages of about 2 ha than women, who cultivate less about 1ha, accounting for the differences in income and labour costs observed in this village. Women in Yabraso earn the highest income compared to their counterparts in Subriso and Gogoikrom. This may be due to income obtained from pepper cultivated by most native women in Yabraso.

Table 4.13: Returns on cultivating main food crops-Yabraso-Wenchi

Crop	Mean crop margin (¢)	Range (¢)	Standard deviation (¢)
Onion	27,500	18,333-36,667	12,964
Groundnut	53,955	27,908-111,630	24,662
Maize	471,463	92,107-1,289,498	259,440
Cassava	567,569	185,750 - 928,749	258,580
Pepper	760,019	443,344 -1,773, 378	365,945
Yam	1,579,503	527,920-7,390,880	1,180,941

Generally, within households, men in Gogoikrom and landowner men and women and settler men in Subriso may be more financially resourceful while in Yabraso, it is men and women cultivating yam and women cultivating pepper.

Table 4.14: Returns/ha on cultivating main food crops across villages

Village	Total income (food crops) /ha (¢)
Gogoikrom-Atwima	6,127,000
Subriso-Tano	6,189,850
Yabraso-Wenchi	3,460,000
Poverty line 2001 (data collected) = 8,634,000 per household of 6 people	

The poverty line set by a living standard survey conducted in 1998/1999 for food crop cultivation, which is the main economic activity in most rural areas is about ¢900,000 (Ghana Statistical Service, 2000). This figure is estimated per head in the population. It is multiplied by the average number of people per household across the villages (6) and inflation indices from December 1999 to December 2000 (Xedia, 2001) to arrive at a poverty line of about 8.6 million cedis (per household) at the beginning of 2001. It is assumed that this figure would not change appreciably in the early part of 2001, when the data for the analysis was collected. Comparing this with the total household income from food cultivation shows that most households across the villages earned incomes below the poverty line in 2001.

4.3.4.2 Weed management

Weed management generally constrains smallholder agriculture (Amanor, 1995). Weed control on crop fields is largely by hand or manual weeding in all study villages, although a handful of farmers in Gogoikrom may supplement with herbicides/weedicides. A combination of chemical weed control by the use of herbicides and manual weeding was reported on 17% of plots cultivated mainly to rice and a few on maize and cocoa. Several different weed species were reported to grow on farms in the study villages (Figure 4.15).

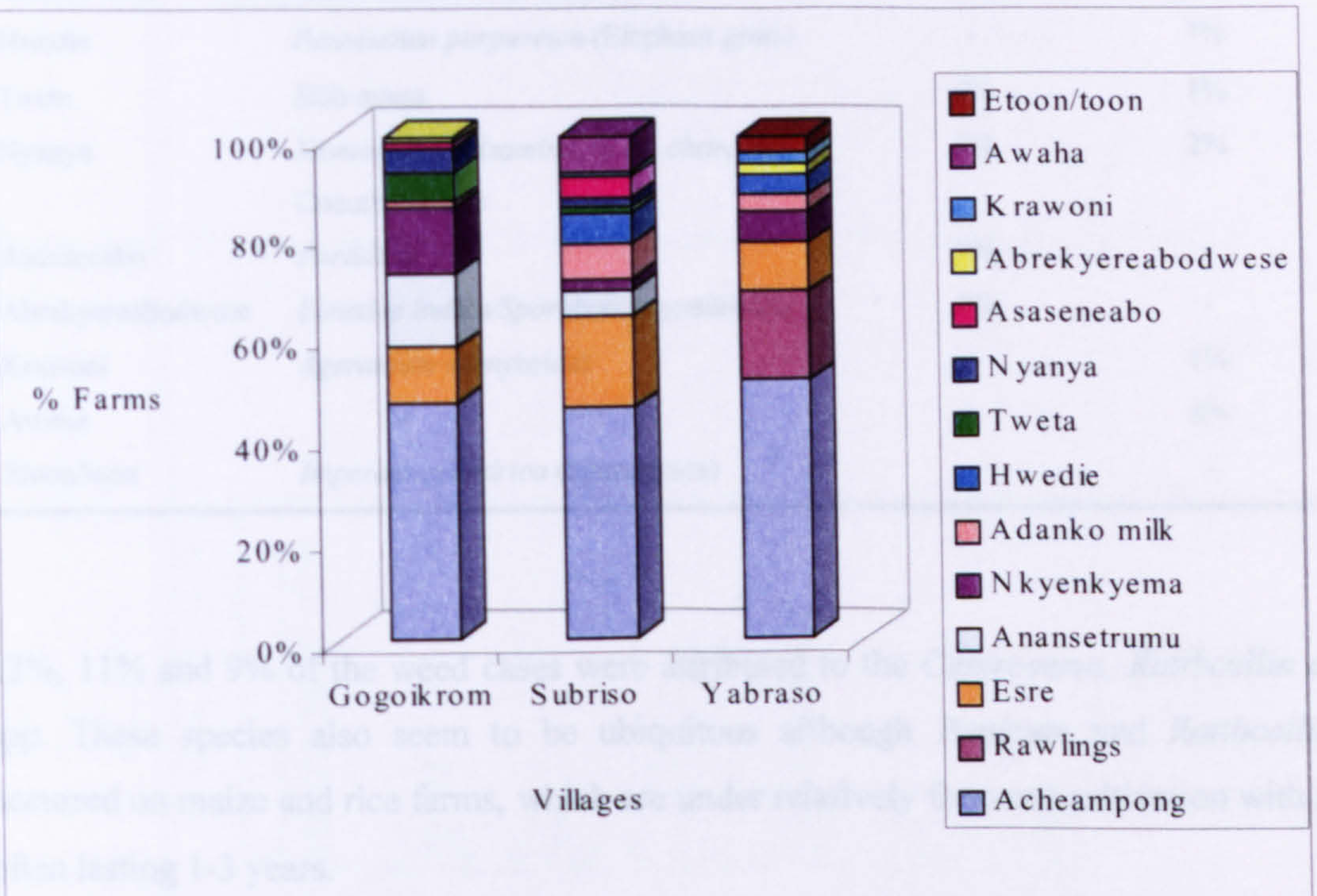


Figure 4.15: Weed species occurring on farms in study villages

The most frequently occurring species in Gogoikrom are *Chromolaena odorata (Acheampong), Centrosema pubescens (Anansetrumu homa), and Rottboellia exaltata (Nkyenkyema)* and *Panicum maximum (Esre)*. 39% of weed cases reported to occur on various crop fields including, cocoa, maize, plantain, rice, cassava, oil palm, cocoyam, etc and their mixes, involved *Chromolaena odorata*. This weed occurred everywhere irrespective of location of the farm along the toposequence and soil type. Farmers explained that the *acheampong* plant has winged seeds that easily disperse over long distances.

Table 4.15: Weed species found on farms in the study villages

Local Name	Scientific Name	% Occurrence on farm reported		
		Gogoikrom-Atwima	Subriso III-Tano	Yabraso-Wenchi
Acheampong	*Chromolaena odorata*	47%	48%	51%
Rawlings	*Cenchrus ciliaris*	-	-	17%
Esre	*Panicum maximum* (Guinea grass)	11%	18%	10%
Anansetrumu	*Centrocema pubescens*	14%	5%	-
Nkyenkyema	*Rottboellia exaltata*	13%	2%	7%
Adanko milk	*Euphorbia heterophyllum*	1%	8%	3%
Hwedie	*Pennisetum purpureum* (Elephant grass)	-	7%	4%
Tweta	*Sida acuta*	6%	1%	-
Nyanya	*Momordica balsamina*, or *M. charantia*, Cucurbitaceace	5%	2%	-
Asaseneabo	*Portulaca*	1%	-	-
Abrekyereabodwese	*Eleusine indica/Sporobolus pyramidalis*	1%	-	2%
Krawoni	*Agerantum cornyzoides*	-	1%	2%
Awaha	-	-	8%	-
Etoon/toon	*Imperata cylindrica* (Spear grass)	-	-	3%

12%, 11% and 9% of the weed cases were attributed to the *Centrosema, Rottboellia and Panicum* spp. These species also seem to be ubiquitous although *Panicum* and *Rottboellia* frequently occurred on maize and rice farms, which are under relatively frequent cultivation with short fallows often lasting 1-3 years.

Most farmers weed cocoa fields two to three times in a year (Figure 4.16). This could be because most of the fields are in the establishment phase, hence prone to higher weed incidence. Farmers explained that *Chromolaena* is very fast growing and so, if not weeded frequently, could easily smother cocoa.

Most maize farmers weed their plots one to three times during the maize growing period. It is not surprising as the *Panicum* as well as the other weed species (including *Chromolaena*) often found, on maize land are also aggressive. However, on relatively fertile soils, farmers reported maize could be weeded once. They explained that when the soil is fertile, particularly on freshly cleared, long fallow land, maize grows very fast to shade out weeds and so one weeding is often enough for the cobs to fully develop after which most farmers do not bother to do any more weeding.

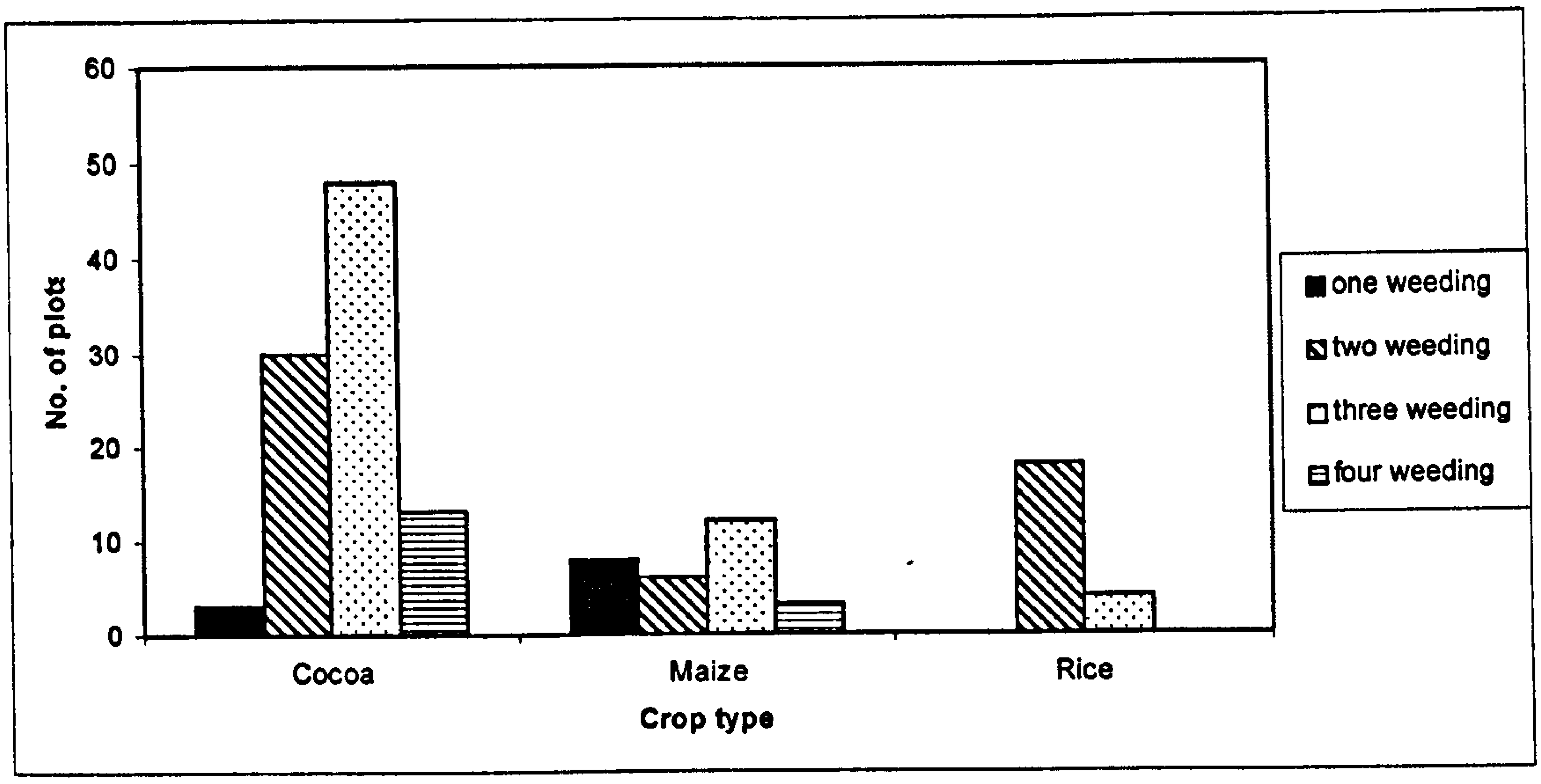


Figure 4.16: Weeding frequency on crop fields per season-Gogoikrom-Atwima

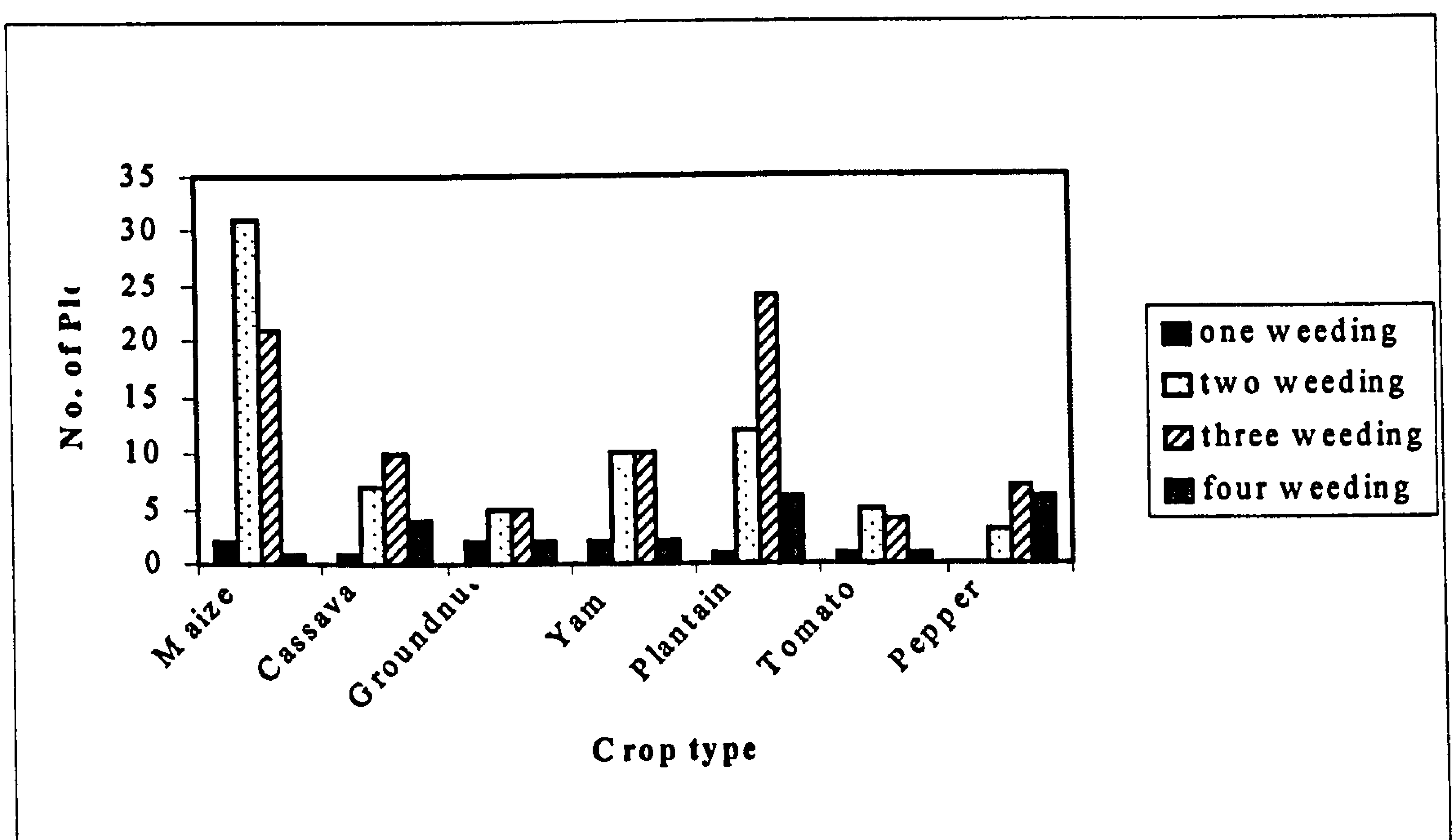


Figure 4.17: Weeding frequency on crop fields per season-Subriso III-Tano

Rice farms are often weeded twice during the growing period. Some farmers apply weedicides once after sowing at the early stages of growth and top up with one manual weeding for the crop to cover the ground.

As in Gogoikrom *Chromolaena odorata* and *Panicum maximum* are the dominant weed species found to occur almost everywhere on the farm landscape in Subriso. These comprise 44% and 17% respectively of the cases reported (Table 4.15). Nearly all crop fields in Subriso are weeded two to three times during their period of cultivation in a year (Figure 4.17).

Maize fields are commonly weeded twice by most farmers but a third weeding might be necessary where weed incidence is high. This is expected of the short fallow lands often used for maize cultivation as these are heavily infested with *acheampong* and *Panicum*. Cassava, plantain and pepper may require a fourth weeding in the first year of growth as these, when mixed with maize, have to be protected from competition from weeds after the maize has been harvested.

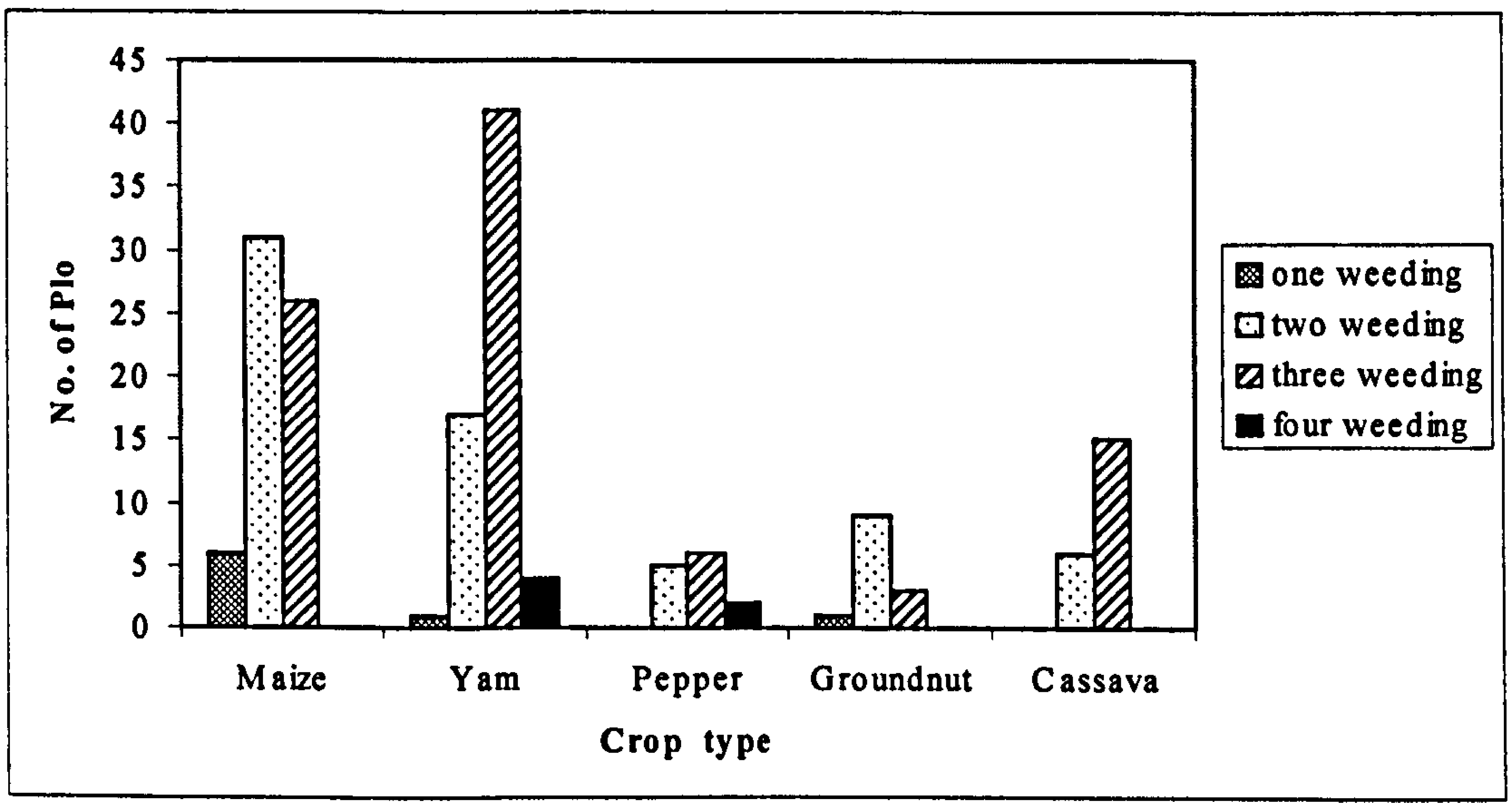


Figure 4.18 Weeding frequencies on crop fields per season - Yabraso-Wenchi

In Yabraso, *Chromolaena odorata* also topped the list. The frequency of *Panicum* is also high but *Cenchrus ciliaris*, otherwise known as *rawlings*, is second to *Chromolaena* on the weed list. It was observed that *Chromolaena* occurred on farms on both forest and savannah lands, the two major vegetation types in the area, hence is found on all crop fields. Figure 4.18 shows that as in Gogoikrom and Subriso, a large number of crop fields are weeded two to three times during the growing season. For maize and groundnut the mode of weeding is twice, whereas for yam, cassava and pepper it might be done thrice.

The main reason farmers in the three study villages gave for the observed weeding frequencies is because weed species are fast-growing, recurring within short periods after weeding. They commonly described them literally as 'bad' weeds (*Nowora bone*) reflecting their noxiousness. It is reported that the number of weed seeds in arable soil is very large, running into 30,000 to 350,000 seeds per square metre and that about 2-10% of weeds in the soil seed bank emerge each year (Nkongo, 2002). The implication here is that labour and consequently, cost for weed control may be high in these smallholder systems. It is estimated that weed control alone constitutes over 40% of the total cost of production of most arable crops in the tropics (Yamaoh *et al.*, 1986 citing Akobundu, 1980).

A regression analysis in which the dependent variable was the number of times a crop field was weeded in a season, showed a low relationship ($R^2 = 0.1$-0.2) between this variable and household and plot parameters across the three villages, although significant at 95% (Table 4.16).

Table 4.16: Factors influencing weeding frequencies

Factor	Gogoikrom-Atwima		Subriso-Tano		Yabraso-Wenchi	
	Coefficients	t Stat	Coefficients	t Stat	Coefficients	t Stat
Intercept	1.83	3.91**	2.64	7.14**	2.64	6.84**
Gender	0.22	1.40	0.20	1.52	0.00	0.01
Household size	0.03	1.52	-0.03	-1.03	-0.02	-1.34
No. of plots	0.02	0.39	-0.04	-0.81	0.09	1.87*
Plot size	0.02	0.62	0.01	0.79	-0.05	-0.94
Maize	0.23	0.53	-0.08	-0.29	-0.29	-0.89
Rice	0.53	1.20	-	-	-	-
Plantain	0.64	1.31	0.41	1.44	-	-
Cassava	1.00	1.77*	0.32	1.03	-0.04	-0.11
Yam	-	-	0.07	0.22	0.12	0.39
Groundnut	-	-	0.03	0.08	-0.63	-1.74
Tomato	-	-	0.10	0.29	-	-
Pepper	-	-	1.00	2.99**	0.23	0.66
Garden egg	-	-	1.68	2.52**	-0.15	-0.31
Okro	-	-	0.47	0.52	-	-
Onion	-	-	-	-	-1.24	-2.24**
Cocoa	0.21	0.51	-0.11	-0.23	-	-
Oil palm	0.71	1.50	0.07	0.19	-	-
Orange	-	-	0.48	0.73	-	-
Cashew	-	-	-	-	-0.29	-0.66
Teak	-		-	-	-0.86	-1.77*
n	161		215		192	
F	1.56		2.26		3.28	
R^2	0.09		0.15		0.19	

* Significant at $p = 0.01$; ** Significant at $p = 0.05$

Resource poor farmers often face liquidity problems (Lutz *et al.*, 1994). They are also constrained by labour. It may be hypothesized that larger farm families with sufficient family labour may be able to weed more frequently than those with smaller family sizes. Also, the more plots and the bigger the total area cultivated is, the less frequently would fields be weeded. Fields cultivated to longer duration crops such as cocoa, oil palm, plantain, cassava and so on may require more weeding during the initial years than those cultivated to shorter duration crops like maize, tomato, groundnuts and so on.

It can be observed from Figures 4.16-4.18 above that, generally, most fields are weeded at least twice during the growing season in the three villages. The fact that this is the case irrespective of the factors that are likely to influence weeding frequencies on plots, implies that other factors, probably availability of money to engage labour and/or labour availability during the peak weeding period between May and August, i.e. the lean period when migrant and settler male labour as well as money are scarce) may be more important. Farmers indicated in the initial PRA that the ideal practice is to weed each crop field at least three times. However, the majority of the people are unable to do so due to the scarcity of money and hired labour during the peak weeding period, which coincides with the lean period. A more detailed discussion on this is presented in Section 4.3.5 below.

4.3.4.3 Sustaining soil productivity: Soil fertility management

Farmers in the three study areas express soil fertility literally as soil "strength" with soil moisture, leaves of standing crop and its yield as the main indicators. A fertile soil is consequently regarded as one that is moist (not water logged), on which the standing crop has dark green leaves and is likely to give a good yield (Obiri *et al.*, 2000). Frost (2000) citing Talawar & Rhoades (1997) described soil fertility as the soil's capacity to sustain productivity, its permeability, and water holding capacity, drainage, tillage and manure requirements and how easy it is to work.

Exhausted fields are commonly fallowed to improve fertility. Except for vegetable cultivation, where some inorganic fertilizers may be applied, virtually no soil fertility replenishment is carried out on most fields during the cropping phase (Figure 4.19). A few fields may be mulched with weeded debris in all three villages and crop rotation undertaken on a few. In Yabraso, some farmers do convert to a tree crop (cashew) when the fertility on the food plot has declined.

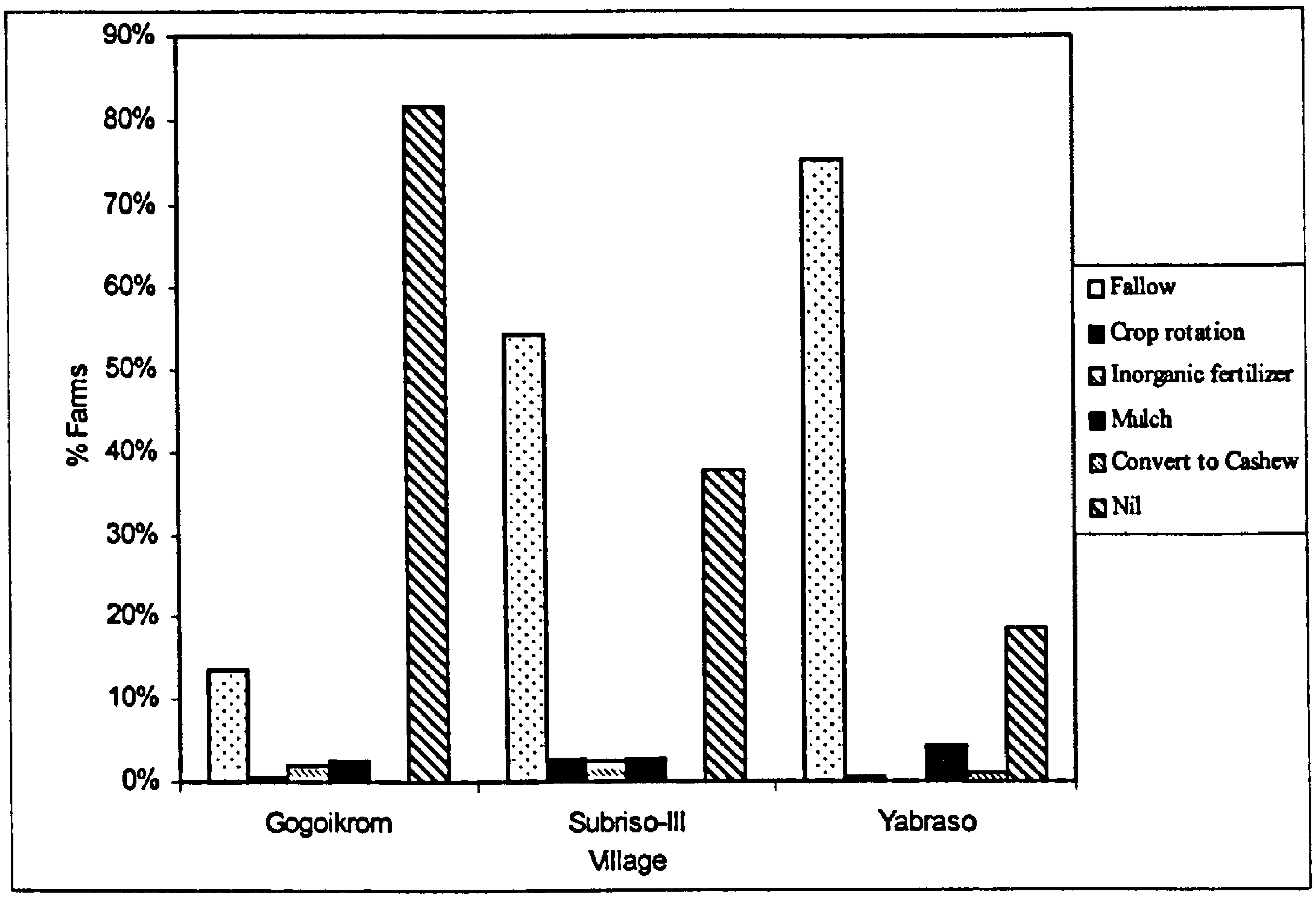


Figure 4.19: Soil fertility replenishment methods in study villages

It is observed that whether or not soil fertility is replenished on a particular field is closely linked with the tenure status of the cultivator/farmer (Figure 4.20). Generally, the prevailing cropping system also dictated the need for replenishing soil fertility. These accounted for the reason why some farmers do not carry out any soil fertility replenishment at all on their fields

Soil fertility is usually replenished on food crop fields where replenishment is critical to sustain annual or biennial mining of soil nutrients while none is carried out on tree crop fields. Gogoikrom has the highest number of fields receiving no fertility replenishment mainly because most farms are under cocoa, a tree crop, although for some of the food crop fields it is because tenants who often vacate the land after their tenancies are cultivating them.

The same is true for Subriso and Yabraso, although, there are higher numbers of food plots in these villages than in Gogoikrom, and thus more fields require fertility replenishment. However, it can be seen that in Subriso and Yabraso, it is landowners who usually do improve the fertility of soil mainly by fallowing while tenants may not do so. There are more fields without any soil fertility replenishment in Subriso than in Yabraso because there are more tenants cultivating food plots in Subriso compared to Yabraso where the majority of the food cultivators are landowners who do at least fallow to restore fertility of soils on their plots.

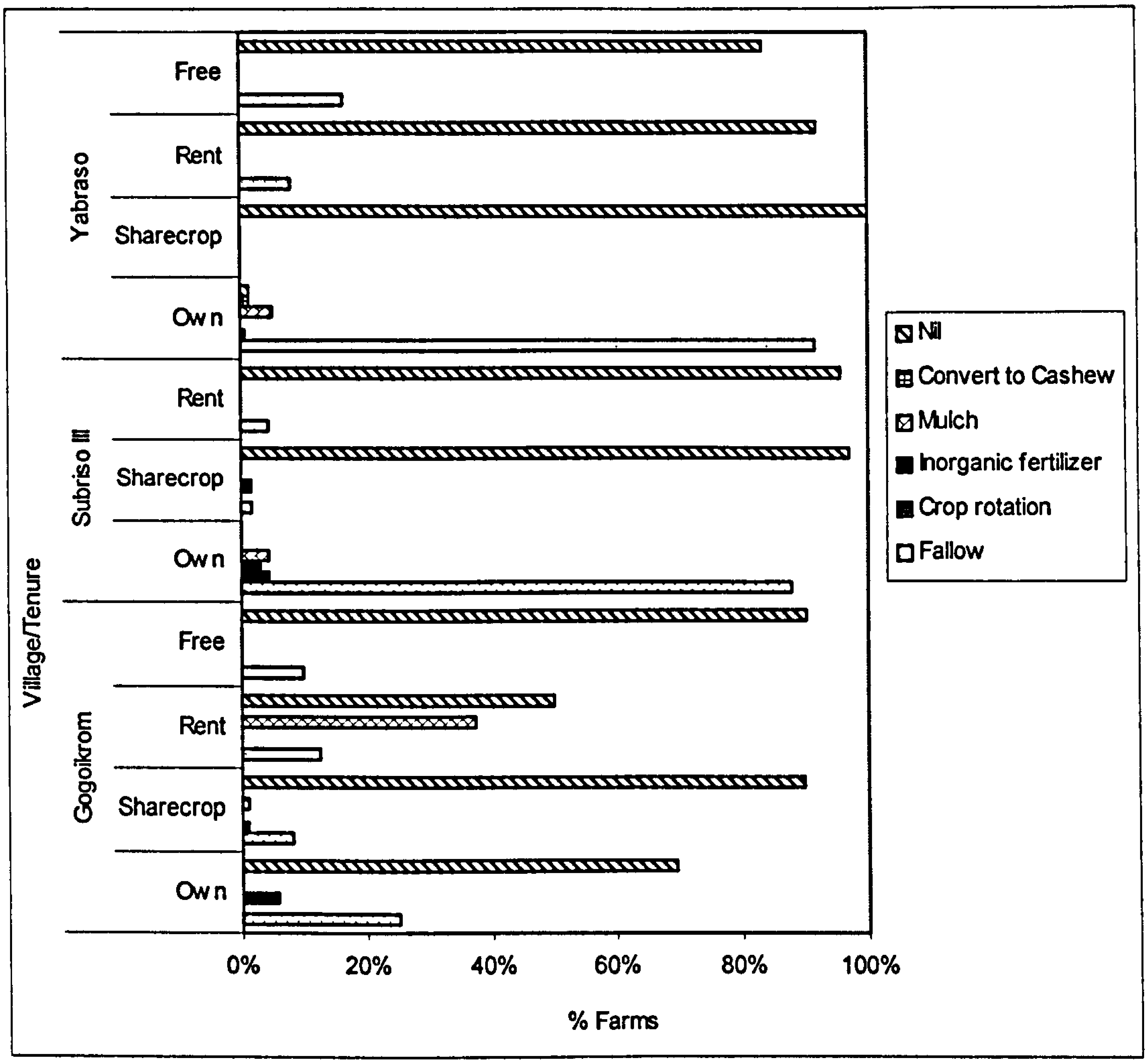


Figure 4.20: Soil fertility replenishment methods applied & tenure in study villages

Replenishing soil fertility in cropping systems in Gogoikrom-Atwima

Cropping systems where soil fertility replenishment is of importance in Gogoikrom are maize, rice and plantain-cassava based systems. As already mentioned, soil productivity is usually improved through fallowing. While 24 and 28% maize and rice farmers respectively would usually fallow their fields when fertility declined, the remaining 76% and 72% did not embark on any soil fertility replenishment method. The smaller proportion of farmers who are able to fallow to improve fertility either own the land or are tenants with free usufruct rights to the use of land belonging to absentee landlords whose cocoa land they cultivate and thus are able to fallow when necessary.

It was observed that 58% and 83% of maize and rice farms were under sharecrop and rental tenancies, with the majority having only one year tenancy. Some of the one-year tenancies, although often renewable over a number of unspecified years so long as there is no conflict between landlord and tenant, do not make it obligatory for the tenant to sustain productivity. This makes it possible for some tenants to leave the land for the landlord to fallow when necessary with the tenant returning to cultivate the land after the fallow. However, it is common for tenants to abandon the field when the fertility declines drastically, measured in terms of rapid incidence of noxious grass weeds like *Panicum* and *Rottboellia* and poor crop growth and/or yield, in search of other fields. Few of the tenants renting land for one year reported leaving weeded debris on the soil during the period of cultivation to enhance soil fertility (Figure 4.20).

Plantain-cassava based systems are also fallowed to improve soil fertility when the productivity of the plantain declines. Farmers reported that yield is low after 3-4 years of cultivation. However, no soil fertility replenishment is undertaken during the cropping phase. At least 50% of the plantain farms are owned, in addition to about 25% for which tenants have free access with no specified tenancy periods. Thus, with some level of secured tenure, 75% of those cultivating the crop are able to fallow their fields. The remaining 25% of the plantain-cassava based cultivators are sharecropping tenants who are under no obligation to fallow after tenancies of 3-4 years of cultivating the land.

No soil fertility replenishment is carried out on cocoa and oil palm-based plots, as these are obviously tree systems with longer productive periods, although they do require fertile soils to sustain yields. Almost all cocoa farmers interviewed claimed soils on their cocoa plots were relatively fertile, as these plots were previously under secondary forest or matured fallows. Such plots do not require any soil fertility replenishment until they reach the end of their productive life (probably after 50 years) when yields become very low. At this stage the plantation is either replanted or abandoned to fallow.

Maize, rice and plantain-based systems constitute 42, 34 and 22% of the total croplands fallowed in Gogoikrom (Table 4.17). These cropping systems are typically characterized by short fallow rotations. Farmers may cultivate maize fields for 2.3 years on average, although this could range from 1-5 years, and fallow for 2.6 years on average, ranging from 1-4 years. Farmers indicated that yield usually declines and weeds are a problem when the maize-cropping phase is two or more years. The mean length of the maize cropping phase and the fallow phase are not significantly different from each other ($F=0.5$, $p=0.5$). This means maize fields may be cultivated and fallowed for about the same duration of time. Similarly, the cropping and fallow phases of the plantain/cassava based systems are about the same (F=0.06, p=0.8).

Table 4.17: Fallowing crop fields –Gogoikrom (Atwima)

Cropland	% of total cropland fallowed	Mean length cultivated (years)	Mean length fallowed (years)	F	p-value
Maize	42	2.3 (1-5)	2.6 (1-4)	0.50	0.50
Rice	34	1.3 (1-3)	2.3 (1-4)	8.82	0.01
Plantain/cassava	22	3.4 (2-5)	3.4 (2-5)	0.06	0.80
Cocoa	2	-	-	-	-

On the other hand, rice fields in Gogoikrom are cultivated for a shorter period of 1.3 years on average, although this may vary from 1-3 years, and fallowed for a longer duration, averaging 2.3 years with a range of 1-4 years. This suggests that rice fields may be very poor in fertility with probably a higher weed pressure as compared with the other crops.

The plantain/cassava system has the longest cropping and fallow phases because the crops are perennial and plantain particularly requires a relatively more fertile soil base. However, farmers reported that in recent times, yield, particularly of plantain, has usually declined after two years, although when the farm is well maintained and if the land has been cleared from a long fallow it is possible to crop beyond the two years.

The differences in cropping and fallow phases observed between maize and plantain on one hand and rice on the other, may be explained by the fact that maize and plantain may be cultivated on a wider range of land types and locations whereas rice is limited to wet areas in valleys or flood plains, which are often found in limited locations in the village. Consequently, there is more pressure on rice land and thus, the land may have a poorer fertility status, necessitating shorter cultivation length when compared with either maize or plantain/cassava systems. Rice is a major cash earner for the young men who cultivate the crop, the majority of whom are tenants. The crop has a higher cash value than maize and plantain and is also a source of food and cash for the landowners who rent out their wetlands for its cultivation. This places a higher demand on rice land. For this reason and coupled with the fact that wetlands are in limited locations, rice fields are fallowed for shorter duration compared with that of plantain.

Rice farmers interviewed reported that yields decline and weed infestation is high when their fields are cultivated for more than one season, unless the land has been under a long fallow. Because rice fields are frequently cultivated with virtually no inorganic fertilizer inputs, problems of soil fertility decline and weeds are likely to be higher, thus most rice farmers would crop their fields once in a season and shift, leaving the land to be fallowed by the owner for at least two years before being cultivated again. This could explain why most of the tenancies to rice fields are for only one year.

Replenishing soil fertility in cropping systems in Subriso III-Tano

Subriso III is predominantly a food growing area where fields are frequently cultivated to maize, plantain, cassava, yam, groundnuts, tomato and pepper with short fallow rotations to replenish soil fertility. As observed in Figure 4.20, landowners (comprising native and settler landowners of both genders) fallow to improve the fertility of the soil. A handful of non-landowning settlers who have free access to lands belonging to absentee landlords, also fallow.

Non-landowning settlers, who make up the bulk of the population of the village, cultivating at least 65% of the fields, do not fallow. However, they are sometimes forced to fallow for a year during their tenancies (if up to 4 years for instance) when the condition of the soil being cultivated becomes too poor such that it would be unprofitable to continue cultivation as this could raise weeding costs or might result in a drastic decline in yield (Amanor, 1995). Some with unspecified tenancies may seek permission from the landowners to fallow when the soil becomes very poor. This holds particularly for maize that is cultivated by a large number of landless tenants. It was observed that while maize fields may be only left to fallow, a few plantain plots might be mulched with weeded debris during the cropping phase to improve soil fertility.

Small amounts of inorganic fertilizer are frequently applied to vegetables, especially tomato and garden eggs to enhance growth and yield. However, while tenant tomato or garden egg farmers rent the land and abandon it after a year, it is common to find such fields, if cultivated by owners, being relayed with cassava, which often takes over the field for at least 2 years. It was reported during the initial PRA that farmers generally regard this period as a fallow or rest period for the soil as they have observed that leaf litter falling from the crop decomposes and, together with shade from the crown conserves moisture to improve the soil (Obiri *et al.*, 2000). 75% of the farmers reported that such fields may be repeated with tomato or cultivated to maize/maize-cassava-plantain before leaving to fallow for at least 3 years.

As in Gogoikrom, plantain fields are cultivated and fallowed for the longest period. Groundnut and tomato fields have the shortest cropping and fallow phases when compared with the other food crops (Table 4.18). Plantain is cultivated for about 4 years although this varies from 2-10 years, and the plot fallowed for a mean duration of 3.7 years, ranging from 2-6 years. Such fields are cultivated mostly by landowners and more often established on land cleared from a long fallow of (old/dead cocoa/cola fields) since plantain is a longer duration crop, and thus require a higher soil fertility-supporting base. Farmers claim that trees with light crown densities from these long fallows are important in providing partial shade for prolonging the productivity of a plantain plot as well as the quality of the fruit (Obiri *et al.*, 2000). Long fallows of about 10 years duration are becoming rare in the Subriso area, as most people are unable to leave fields to fallow for longer than 6 years once a long fallow is cleared. A possible decline in productivity of plantain fields after two years of cultivation was reported by some farmers when established on short fallow lands.

Table 4.18: Fallowing crop fields – Subriso III (Tano)

Cropland	% of total cropland fallowed	Mean length cultivated (years)	Mean length fallowed (years)	F	p-value
Maize	57	2.6 (1-5)	2.9 (1-5)	1.10	0.299
Plantain	20	4.2 (2-10)	3.7 (2-6)	0.21	0.656
Cassava	13	2.7 (1-4)	3.0 (2-4)	0.36	0.563
Groundnut/tomato	10	1.6 (1-2)	2.6 (1-4)	3.13	0.115

The cropping and fallow phases for maize and cassava fields are about equal as indicated in Table 4.18. Maize and cassava fields are usually cultivated and fallowed for at least 3 years, while groundnut and tomato fields are cropped 1.6 years and fallowed for 2.6 years on average. Most groundnut and tomato fields are rented for one season and sometimes for only three months. Groundnut may be intercropped with major season maize and tomato relayed with major season maize or cassava, which remains on the land for at least two years.

Replenishing soil fertility in cropping systems in Yabraso-Wenchi

The scenario for soil fertility management on farms in Yabraso is not very different to that found in Gogoikrom and Subriso. The main cropping systems that require soil fertility replenishment are those of maize, yam, groundnuts, cassava and pepper. Almost all farmers interviewed who cultivate these crops apply hardly any soil amendment measure during cultivation except for a few landowners mulching with weeded debris (Figure 4.20). Food plots are commonly fallowed by the landowners or may be planted to cashew when fertility declines while tenants abandon rented and sharecropped infertile land at the end of their tenancies.

The majority of fields that are fallowed had been cultivated to maize. A lesser proportion of yam, cassava and groundnut fields were being fallowed because there is increasing intercropping of these crops with cashew, particularly on the grassy savannah land that may remain permanent if not destroyed by wild fire in the dry season.

Table 4.19: Fallowing crop fields –Yabraso-Wenchi

Cropland	% of total cropland fallowed	Mean length cultivated (years)	Mean length fallowed (years)	F	p-value
Maize	58	2.5 (1-5)	4.1 (2-6)	47.14	0.00
Yam	27	1.5 (1-3)	4.6 (3-10)	56.98	0.00
Cassava	8	2.5 (2-3)	3.8 (2-5)	6.40	0.03
Groundnut	6	2.0 (1-3)	2.8 (2-3)	2.45	0.17

The cropping and fallow phases for maize and yam, the two main crops are significantly different (Table 4.19). Maize is cultivated for the longest period while yam is cultivated for the shortest period but fallowed for the longest period when compared with the other crops. While it is possible to cultivate maize continuously for about 3 years, or even up to 5 years if the land was cleared from a long fallow, yam is usually cultivated, at most, for two years although it could go up to 3 years on longer fallowed (up to 10 years) land. However, the analysis showed the modal value to be one year, which shows that most people cultivate yam for one year and shift. Yam is a nutrient demanding crop thus, requires longer fallows for higher yields. Secondly, the need for stakes necessitates shifting to new fields with tree saplings that are retained after the fallow has been slashed and burnt. Thirdly, the yam field could be planted to other crops after the short cultivation period. If intercropped with cassava and/or cashew, the cassava remains on the land for the next 2 years while the cashew takes over the land permanently. Cultivation of the yam field after the first or second season could also continue with maize as long as yield does not decline drastically and noxious weeds become do not become a problem. Groundnut is often intercropped with maize or yam.

4.3.4.4 Fallow characteristics, uses and importance

Fallows are known to have important functions in local agricultural systems. They have been reported to improve vegetation and soil nutrients as well as being a major source of non-timber forest products (NTFPs) with social, economic and environmental benefits. More importantly, the type of fallow management practice adopted influences these functions (Nkongo, 2002).

Yabraso has the highest number of people fallowing as well as the highest number of fields under fallow with the fewest in Gogoikrom (Figure 4.21 and Table 4.20). As mentioned earlier most fields in Yabraso and Subriso are under food or short duration crops where the frequency of land cultivation is likely to be higher, necessitating frequent fallowing as compared to Gogoikrom where the majority of fields are under cocoa, a long duration crop, which does not need fallowing in the short term.

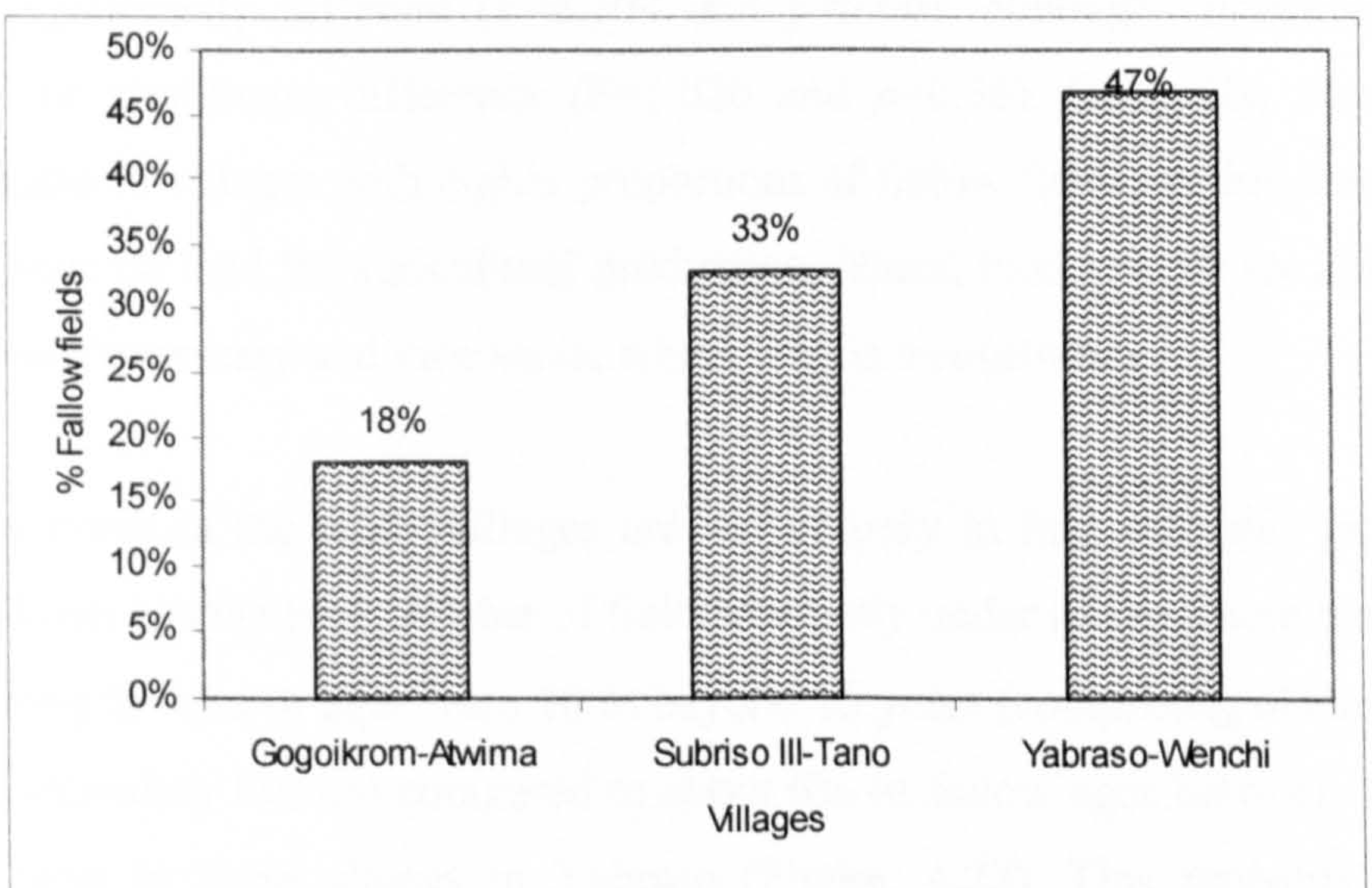


Figure 4.21: Proportion of fields under fallow in study villages

Secondly, the majority of the farmers in Yabraso are natives owning land and so are able to decide to fallow when necessary. This also implies that land is probably not scarce in Yabraso. Conversely, the majority of farmers in Subriso and Gogoikrom, particularly, involved in food crop production, where fallowing is essential are non-landowning settlers who, in most cases, leave the land to owners to fallow at the end of their tenancies. However, in situations like those found in Gogoikrom some tenants cropping cocoa have access to free land belonging to absentee landlords and so are able to rotate the cropping phase with the fallow phase for food production.

Table 4.20: Fallow status of study villages

Parameter	Gogoikrom-Atwima	Subriso-Tano	Yabraso-Wenchi
% Respondents fallowing	35	56	75
Tenure			
Landowner	39	82	90
Tenant	61	18	10
% Farms under fallow	18	33	47
Mean fallow land size (acres)	3.4 (0.5-8.0)	2.8 (1.0-7.0)	7.4 (2.0-30.0)
Standard deviation	1.5	1.4	6.2
Mean fallow length	6.3 (1.0-20.0)	3.8 (1.0-15.0)	4.2 (1.0-7.0)
Standard deviation	5.3	2.6	1.3
Mean length cultivated before fallow	5.5 (1.0-20.0)	5.2 (1.0-20.0)	3.1 (1-10)
Standard deviation	6.4	5.0	1.8

A single factor Anova comparing mean lengths of fallow period between the three villages showed that they were significantly different (F=6.104 and p=0.00), although comparing Subriso and Yabraso showed no significant difference (F=1.020 and p=0.36). Generally, one would expect longer fallow lengths in villages with higher proportions of fallow fields, as this may be interpreted to mean less pressure on land for agricultural production, hence, more people are able to leave crop lands to fallow when necessary and vice versa, where land is a constraint.

The observations made in the study villages are not entirely in line with this general ideology. Although, Gogoikrom has the least number of fields currently under fallow, more than 20% of these fields are under long fallows of ages from 10 to beyond 15 years (comprising old/abandoned cocoa tree fallows and secondary forests) compared to about 6% of fallow ages between 10 and 15 years in Subriso and none in these classes in Yabraso (Figure, 4.22). This probably influenced the magnitude of the mean fallow lengths, such that although Subriso and Yabraso have higher proportions of fallow fields, the mean lengths of these fallows are lower than that of Gogoikrom.

Also, the ability of a farmer to fallow his/her crop land and the need to fallow a particular crop field are more related to tenure status of the farmer and plot or crop types cultivated, i.e. food or tree crop, as has been explained above. Generally, the differences between cultivation before fallowing for the three villages are significant (F=3.866 and P=0.02), with the Yabraso average substantially below the others. The grassy nature of the vegetation found in the Yabraso area is probably an indication that the fertility status of soils on most fields is relatively not high.

Fallow phases

The dominant fallow classes that are likely to be seen across the three villages are fallows of 1-3 and 4-6 years (Figure 4.22). These classes are more related to food crop systems. In Gogoikrom, the presence of longer duration fallows of 10 years and above is because some landowning households possess old/dead/abandoned cocoa forests as well as secondary forests. The prevalence of a higher proportion of the 1-3 years fallow class in Subriso can also be explained by the heavy cultivation of maize, predominantly by virtually all landless settler people who form the majority of the population and most of whose livelihoods depend to a greater extent on this crop.

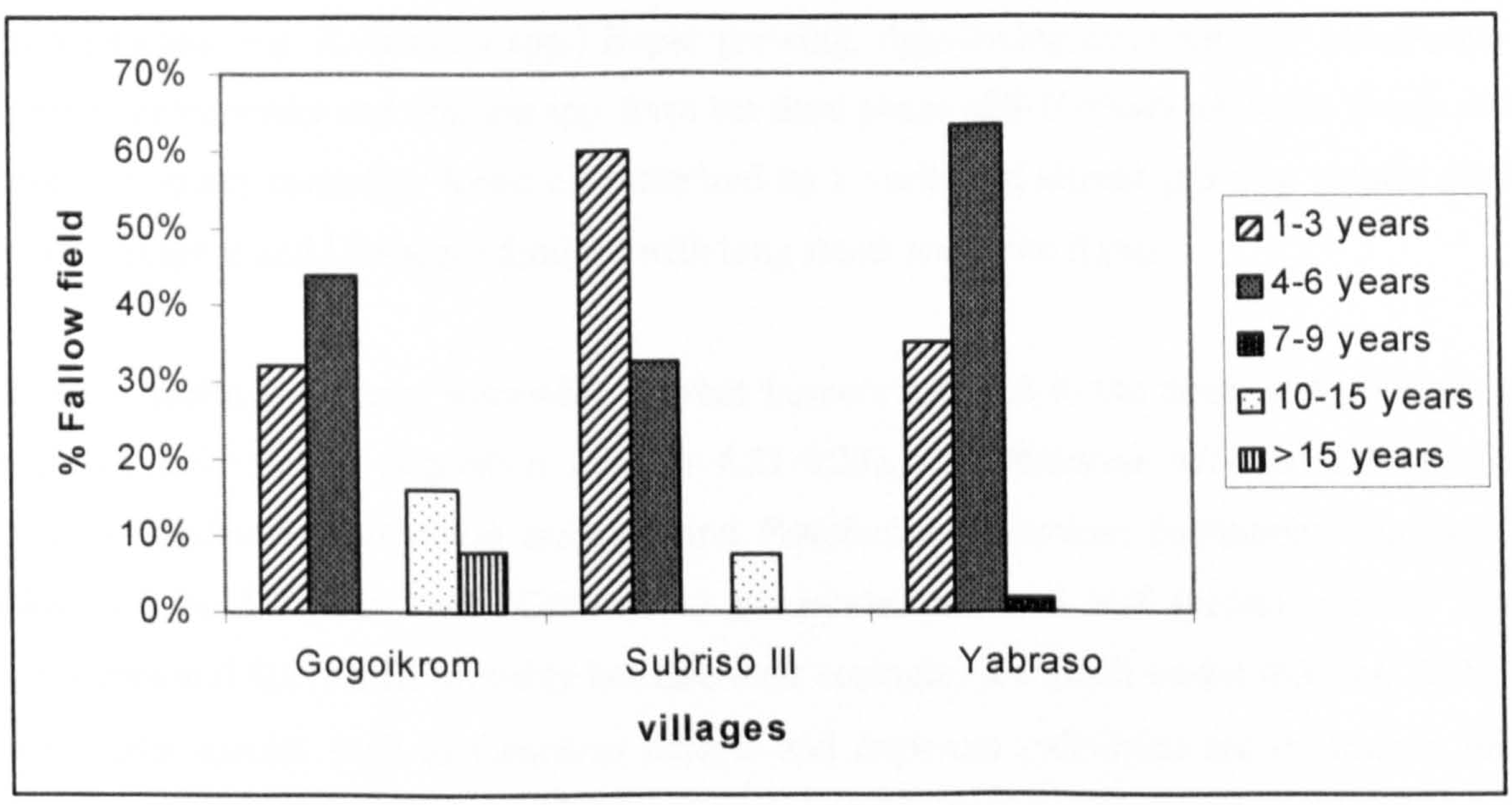


Figure 4.22: Distribution in fallow length in study villages

The dominance of the 4-6 year class of fallow in Yabraso can be attributed to the fact that this length of fallowing is important for the growth of tree saplings used for staking yam, a major crop in the area. Also already explained above, yam removes an appreciable amount of nutrients from the soil and so a tree fallow is important to restore the fertility of the soil to support its cultivation. Marfo and Wiggins (1999) observed that in the Wenchi area yam-based systems are possible where fields can be left in fallow for a longer duration. In systems where trees are not required, as in maize, vegetable and groundnuts systems, fallows could be shorter. This also explains the reason for the higher proportion of the 1-3 year class in Subriso. In other words, if land is to be fallowed for the sake of improving its fertility level for food crop systems, which do not require trees, then 1-

3 years of fallowing is enough, particularly where land is a constraint to the majority of farmers, as in Subriso. A few native landowners in Yabraso also reported being able to fallow for 4-6 years because land is not scarce.

Nkongo (2002) identified four fallow successions or phases. The first 1-4 years forms the first phase of succession, which she described as being less diversified and dominated by ephemeral (i.e. short-lived) weeds including grasses. She found that in the Humid Forest Zone (HFZ) of Southern Cameroon, the vegetation at this stage was commonly dominated by the Asteraceae species, *Chromolaena odorata.* The second phase usually occurring after period of 4-5 years is more 'woody,' comprising herbs, climbers, shrubs and trees with most of the species belonging to four families: Euphorbiaceae (e.g. *Alchornea* spp.); Fabeaceae (e.g. *Albizia* spp.); Poaceae (e.g. grasses) and Rubiaceae (e.g. *Rothmania* spp.) Rapid growing, light-loving trees such as *Mucaranga* spp., *Musanga cecropoides* and *Milletia* spp. form the third phase of 8-10 years while the fourth and final phase is a young secondary forest characterized by a variety of slower growing woody species of the Sterculiaceae and Ulmaceae families with long stems and more lianas.

Nkongo's findings conform somewhat to what farmers reported in the three study villages on the nature of their fallow vegetation (Tables 4.21-4.23). *Chromolaena odorata* and grasses like *Panicum maximum*, *Rottboellia exaltata*, and *Pennisetum pupureum* commonly characterize the fallows of the 1-3 year class. *Centrosema pubescens* (a broad leaf species) can be found in Gogoikrom and Subriso III probably because their ecologies are much wetter than that of Yabraso, where grass species such as *Cenchrus ciliaris* and *Imperata cylindrica* are commonly found in addition to *Chromoleana odorata.* The local names of the plant species found on fallow lands are in brackets.

Chromolaena and the other species dominating the first class still grow during the second phase; however, tree saplings of species like *Ficus, Albizia, Ceiba*, spp. etc were reported. Of course, more of the tree species were reported in Gogoikrom, which is in the Moist/Humid Forest Zone that can probably represent what Nkongo described as the "chaotic wilderness"

Table 4.21.Characteristics of fallow phases in Gogoikrom-Atwima

Fallow Phase (Years)	% Fallow	Fallow vegetation	Fallow products
1-3	32	*Chromolaena odorata (Acheampong), Centrosema pubescence (Amantem wire), Panicum maximum (Esre), Rottboellia exaltata (Nkyenkyema)*	None
4-6	44	*Chromolaena odorata, Centrosema pubescens Panicum maximum, Rottoboellia exaltata* *Trees e.g. Albizia* spp, *Ficus* spp, *Alchornea cordifolia (Gyama), Ceiba bonupozense (Akata), Mallotus oppositifolius (Nyanyafrowa)*	Firewood, Fodder
7-9	0	Na	Na
10-15	16	*Chromolaena odorata* *Trees e.g. Triplochiton scleroxylon (Wawa), Terminalia superba (Ofram), Terminalia ivorensis (Emire), Celtis malbraedii (Esa)*	Firewood, Fodder, Wood
>15	8	*Chromolaena odorata (Acheampong)* *Trees e.g. Triplochiton sclerexylon (Wawa), Terminalia superba, (Ofram), Terminalia ivorensis (Emire), Celtis malbraedii (Esa)*	Firewood, Fodder, Construction Wood

Table 4.22: Characteristics of fallow phases in Subriso III-Tano

Fallow Phase (Years)	% Fallow	Fallow vegetation	Fallow products
1-3	60	*Chromolaena odorata, Pennesitum purperuem (Hwidee), Panicum maximum (Ageaboso), Imperata cylindrica (Etoon), Ficus* spp.	Fuelwood, game
4-6	33	*Chromolaena odorata, Panicum maximum, Awaha, Tetrapleura tetreptera (Prekese), Ficus* spp.*(Nyankyeren), Albizia* spp *(Okoro)*	Fuelwood, fodder, fruits e.g. *prekese*
7-9	0	*Na*	Na
10-15	8	*Trees e.g. Griffonia simplicifolia (Kagya)*	Fuelwood construction wood
>15	0	Na	Na

No tree species was reported to occur in the second fallow class in Yabraso probably because grasses especially *Cenchrus ciliaris* and *Chromolaena* still dominate the vegetation. However, the fact that firewood can be gathered from this vegetation indicates the presence of species of some tree saplings. Also it should be remembered that this second class is an important source of stakes for yam production in the area.

Table 4.23: Characteristics of fallow phases in Yabraso-Wenchi

Fallow Phase (Years)	% Fallow	Fallow vegetation	Fallow products
1-3	35	*Chromolaena odorata, Cenchrus ciliaris* (Rawlings), *Euphorbia heterophyllum* (Adanko millk), *Rottboellia exaltata, Pennesitum purperuem* (Hwidee), *Panicum maximum*	Firewood
4-6	63	*Chromolaena odorata, Cenchrus ciliaris, Euphorbia heterophyllum* (Adanko millk), *Rottboellia exaltata, Pennesitum purperuem* (Hwidee), *Panicum maximum*	Firewood
7-9	2	*Chromolaena odorata, Cenchrus ciliaris*	Firewood
10-15	0	Na	Na
>15	0	Na	Na

The 7-9 years fallow class was only reported in Yabraso. This may probably be the longest period a plot may be fallowed, as no mention was made of the 10-15 and >15 year fallows. In Gogoikrom and Subriso no mention was made of the 7-9 year class probably because of the way the class intervals have been made. If Nkongo's classes were used, some fields would fall into that class. It is also possible no farmer interviewed had a fallow within this age class since only a sample was interviewed. In reality, the 7-9 year class exists in the two villages as farmers identified fallows within this interval during ground touting on land use types and resources in the PRA (Young *et al.*, 2000). The vegetation at this stage, although it had upper canopy trees, had *Chromolaena odorata* thicket dominating the lower canopy species. In Yabraso, the grass species, *Cenchrus ciliaris* is also found in addition to *Chromolaena* (Table 4.23).

Fallow classes beyond 10 years were reported in both Gogoikrom and Subriso III, although in Subriso, there was none for the greater than 15 year class. Obviously, the fallow vegetation becomes dominated by more tree species after 10 years and approaches the secondary forest stage beyond 15 years (Tables 4.21-4.23).

A systematic progression of a reduction in fallow length can be observed as one moves, from the moist forest area in Gogoikrom through the dry forest in Subriso to the savannah-transition in Yabraso. The fact that there is a progressive absence of longer fallows beyond 15 years in Subriso and then beyond 10 years in Yabraso probably illustrates the extent of degradation of vegetation and associated soil along the vegetation gradient from Gogoikrom to Yabraso.

As has been stated above, farmers in the three villages traditionally relate the length of a fallow and its associated vegetation to the fertility status of the soil. A longer fallow duration causes the development a higher tree population for a higher soil fertility status. In this vein it can be said that there is generally a high probability of the soils in Gogoikrom being better than those in Subriso, which, could also be better than those of Yabraso. In fire-prone areas such as Yabraso, however, longer fallows may not always have older or tree-dominated vegetation, as the fallow vegetation is constantly at the mercy of annual wild fires in the dry season.

Factors influencing fallow duration

A number of factors may influence the length of time farmers leave their farmlands to fallow. It is generally reported that population pressure, which determines land availability influences fallow length. Thus, where population pressure is low and/or land is not scarce, farmers are able to leave land under longer duration fallows. Other important factors may be cropping systems, tenure and wild fires.

Gockowski and Ndoumbé (1999) observed that fallow management practices adopted by smallholders in Southern Cameroon were influenced by the household's endowment of land and labour. Households with abundant land and labour fallowed for longer periods exceeding 10 years. Conversely, households with scarce land resources fallowed as short as two years. However, in some cases where land was abundant farmers managed their production systems with shorter fallow periods than the optimal because of increasing labour requirements for clearing fallows of longer durations.

During the PRA farmers in the study area listed factors influencing fallow length to include population pressure, land availability, need for money by a landowner, extent of decline in yield and weed pressure. In Subriso III and Yabraso fallow length was also influenced by wild fire (Obiri *et al.*, 2000). From the discussion above, fallow length is also determined by the cropping systems in the study area. Cropping systems requiring the use of trees and/or a higher soil fertility supporting base or have longer duration crops such as cocoa, yam and plantain may be adapted to longer duration fallows and *vice versa* for others such as maize, rice, vegetables and groundnut that are cultivated over shorter duration and do not require trees or very high soil fertility base. This observation somehow confirms that reported by Nkongo (2002). She found farmers in the HFZ of Southern Cameroon adapting specific cropping systems to fallow lands of specific age classes. Generally, she observed that food crop fields were targeted to short term fallow systems of 2-6 years old. Medium term fallows of 6-10 years were also adapted to food crop fields although to a lesser extent compared to the short fallows. The medium term fallows were more adapted to perennial crop production where there was scarcity of long fallow lands. Generally, farmers do prefer to establish perennial tree crop plantations in long fallows in order to capture fertility rent (citing Kotto-Samè *et al.*, 2000).

Effects of fallow duration on crop production and rural economy

Fallows are important mainly in soil fertility restoration and weed control (Ikuenobe and Anoliefo, 2003) as well as for diversifying the rural economy and for biodiversity conservation. Beneficial changes occur during the course of the fallow. There is an increase in soil organic matter with the rate of increase depending on vegetation type and number of fallow cultivation cycles following clearing of the primary forestland. Furthermore, an improvement in soil physical structure occurs as trees in particular increase soil porosity and permeability and thereby reduce erosion (Nkongo, 2002).

Farmers fallow for a number of reasons. The main reason all farmers possessing fallow fields interviewed in the study villages gave for fallowing their crop fields was to enable soil fertility restoration to improve yield. It was also to reduce the level of weeds. It has generally been observed that weed infestation is often the reason for smallholders to abandon cropland to fallow (Gockowski and Ndoumbé, 1999). For some farmers in Yabraso, fallowing was to ensure the availability of stakes for yam production.

Gockowski and Ndoumbé (1999) argued that the obvious impact of the length of fallow is the effect on soil fertility. However, there are other interrelationships existing with levels of pest, diseases and weed pressures. Tuson (2001) observed, in the Wenchi area of Ghana, that fallow length might not only be related to recovering soil fertility but also with elimination of noxious weeds like *Imperata cylindrica* (spear grass).

It is known that a decline in fallow length leads to a decrease in crop yield. However, Nkongo (2002) argues that this finding needs to be debated as various studies show conflicting results. According to Nkongo (2002), while some studies showed no correlation between fallow length and yield, others report of a positive relationship between fallow length and yield and a few reported a negative relationship. That increasing fallow length results in decreasing weed seed density in the soil is widely known. It has been reported that in long fallow systems (up to 20 years or more) the number of weed seeds in the soil seed bank is often low while short fallow systems are characterized by a higher number of weed seeds in the soil seed bank.

Fallows serve as the primary sources of a wide range of products to rural people. The collection, processing and marketing of these products also provide employment in addition to improving income. Firewood, fodder, stakes and construction wood were the main products farmers collected from all the fallow classes. These were used mainly for household purposes. Fruits from tree species like *Tetrapleura tetreptera* (*Prekese*) were collected and oil palm trees in the fallow vegetation were tapped for wine used for brewing *akpeteshie*, the local gin particularly in Gogoikrom. *Prekese*, a traditional condiment may be sold on the market.

4.3.4.5 Crop storage and marketing

Generally, as subsistence producers, farmers in the three study villages usually produce various crops for sale and consumption. All tree crops are produced purposely for sale while variable proportions of food crops are sold and consumed. The marketing infrastructure is moderately developed. There are major markets in which produce is sold and the villages are linked to these markets by roads that are reasonably passable throughout the year. However, a greater proportion of the sales occur at the farm gate to traders/middlemen from other parts of the country and sometimes from some neighbouring countries including Togo, Niger and Burkina Faso.

Gogoikrom-Atwima

Cocoa, maize, rice, cassava, plantain and cocoyam are the main crops marketed by farmers of Gogoikrom. Although oil palm is intended for sale most of the fields are not ready for doing so. About 89% of the sales are done at the farm gate, while 11% might be done in the market and sometimes at the farm gate. The main market where farmers might sell produce is Kumasi; however, they sometimes do so at other nearby smaller markets in the Atwima area such as Nkawie, Anyinamso and Mpasetia. Traders from Kumasi comprise 67% of produce buyers at the farm gate. The others include resident middlemen and others from nearby towns like Mpasetia, Nkawie and Kotokuom (Table 4.24).

Table 4.24: Origin/destination of traders purchasing produce at Gogoikrom-Atwima

Trader origin/destination	Region	% Cases
Kumasi	Ashanti	67
Gogoikrom	Ashanti	10
Nkawie	Ashanti	10
Mpasetia	Ashanti	4
Sefwi	Western	2
Anyinamso	Ashanti	2
Accra	Greater Accra	1
Kotokuom	Ashanti	1
Abuakwa	Ashanti	1
Sepase	Ashanti	1

The government Cocoa Produce Buying Company (otherwise known as CMB or PBC) purchases all cocoa at government fixed prices for export and local processing. It has a warehouse located in the village, which is often opened for purchases within the locality from September to December annually.

Cassava, plantain and cocoyam are kept in the field and harvested anytime for sale and consumption once matured. Thus they could be sold at low or high prices depending on the market price at the time of harvest.

Rice and maize are commonly stored by all farmers cultivating these crops, mainly to sell later for better prices. They also serve as reserves for cash and food security throughout the year. This is important during the lean season from April-July when all monies would have been invested in farm production and the crops are not ready for harvest or sale. Stored maize and rice also provide seed stock for planting in the following season.

85% of the rice farmers interviewed sold a greater proportion of their produce when prices were average to high whereas the remaining 15% sold at variable times. Similarly, 88% of maize farmers interviewed sold their produce from average to high price periods with 70% selling during the period February-July when prices tend to be high.

Subriso III-Tano

Generally, farmers at Subriso III store maize, groundnut, yam, pepper, rice, onion, and cowpea. 94% of the farmers stored at least one crop, usually maize, for sale for better prices and also to provide food for household consumption. Similarly, yam is stored for a better price and household food security. Groundnut, pepper, rice and cowpea are stored, mainly to earn better income. Cassava, plantain and cocoyam are kept in the field and harvested for sale and consumption when matured. Some farmers indicated that storage for a better price was essential for supporting farm production, although inadequate storage facilities and the ever-growing household financial needs hardly permit this to be achieved. It is probably for such reasons that very few farmers, about 6%, comprising male and female native and settlers, hardly stored any crop, although they produced at least one of the storable crops like maize and had at least two plots with total cultivated field sizes ranging from 0.4-1.6ha. Moreover, 60% of them have off-farm jobs (e.g. cooked food sales, blacksmithing, and painting) which ordinarily should supplement farm production and enable storage for the benefit of better prices and income.

Earlier discussions with farmers in Subriso III during the initial PRA phase of the study indicated that apart from crops like tomatoes being perishable, small field sizes, poor yields, pressing household financial needs and repayment of informal pre-financed credit obtained from traders and money lenders may necessitate selling a greater proportion of storable produce soon after harvest when prices are not attractive.

Like in Gogoikrom, all crops produced at Subriso III are marketed at both the farm gate and in nearby markets in Techimantia (13 km), Akumadan (14.4 km) and Techiman (28.9km), with farm gate sales constituting 74% of the cases. Traders from a wide range of places in the country and other nearby places in the sub- region purchase produce at the farm gate in Subriso III (Table 4.25). Traders from Togo and Accra purchase mostly tomato and plantain. Those from Northern Ghana, Burkina Faso, Mali, Takoradi and Cape Coast, purchase maize whereas those from Techiman, Techimantia, Akumadan, Kumasi and Obuasi purchase all crops.

Subriso III appears to be more active with crop marketing than Gogoikrom. Techimantia, Techiman and Akumadan markets are periodic ones. The road linking Subriso III and these nearby markets, as well as other buyer destinations, is accessible throughout the year with cargo trucks, mini buses and taxis conveying goods and people to and fro.

Table 4.25: Origin/destination of traders purchasing produce at Subriso III – Tano

Trader origin/destination	Region	% Cases
Techiman	Brong Ahafo	35
Kumasi	Ashanti	31
Tamale, Wa, Bolga & Bawku	Northern, Upper East & Upper West	13
Accra	Greater Accra	8
Cape coast	Central	4
Techimantia	Brong Ahafo	2
Obuasi	Ashanti	2
Akumadan	Ashanti	2
Togo	West Africa	1
Mali & Burkina Faso	West Africa	1
Subriso III (Village it self)	Brong Ahafo	1

Yabraso-Wenchi

At Yabraso, maize, yam, groundnut and pepper are the key crops produced for marketing. Most farmers reported storing these crops for gradual release for sale either at the farm gate or market, with 71% of the sales occurring at the farm gate. The main market in which these crops are sold is Techiman located about 48 km away. Yabraso is linked to major marketing centres like Wenchi, (19km) Techiman (48km) and Nsawkwaw (3.75km) away by a reasonably good road, accessible throughout the year, with fairly frequent vehicular movement conveying people and goods.

All classes of farmers at Yabraso cultivate maize. It is often sold any time cash is needed, with sales beginning soon after harvest in August/September until July (lean period) at the farm gate and also in the market. The majority (88%) of farmers sold some of their maize when prices were higher (January-July). Most people (64%) sold the produce only at the farm gate while others (36%) sold at both the farm gate and markets at Techiman and sometimes nearby Nsawkwaw. At the farm gate, buyers include middlemen from mainly Techiman and Accra. Other buyers are from Kumasi, Sunyani, Wenchi as well as the village (Table 4.26).

The majority of farmers sell yam at the farm gate so long as stocks last. Sales begin soon after harvest in September when prices are low, but 94% sold a greater proportion of it from December to

July when prices would be higher. The majority of the yam buyers are from Techiman but a few others come from Accra, Kumasi, Wenchi and Tamale.

Table 4.26: Origin/destination of traders purchasing produce at Yabraso-Wenchi

Trader origin/destination	Region	% Cases
Techiman	Brong Ahafo	40
Accra	Greater Accra	21
Kumasi	Ashanti	13
Wenchi	Brong Ahafo	9
North (Tamale, Wa)	Northern & Upper West	4
Sunyani	Brong Ahafo	3
Yabraso (Village)	Brong Ahafo	3
Seikwa	Brong Ahafo	2
Takoradi	Western	2
Cape Coast	Central	1
Mankesim	Central	1
Nsawkwaw	Brong Ahafo	1
Sampa	Brong Ahafo	1

Native females predominate in the cultivation of groundnut in Yabraso. About 73% of them sell their produce at the farm gate with a few occasionally taking it to the market at Techiman or Nsawkwaw for sale. Like all other crops, groundnut is sold when money is needed but at least 87% of the groundnut growers interviewed often sold it from January to April, when prices would be higher. Buyers at both the farm gate and market include traders/middlemen from a wide range places including Accra, Kumasi, Sunyani, Wenchi, Sampa, Tamale and Wa.

Pepper cultivated mainly by women is one of the key crops stored and marketed by 88% of the growers from December to June when prices were higher. It might be equally sold either at the farm gate or taken to the market at Techiman. Pepper buyers are from the variety of towns/cities listed for the other crops.

On the whole, farmers in the three study villages are able to market their produce quite adequately in terms of accessibility (moderate roads and buyers from a wide range of places). Also, most people sell some produce when the prices were higher. However, the problem of poor and fluctuating prices either at the farm gate or on the market was mentioned by nearly all farmers interviewed as the main marketing constraint. According to the farmers, this is because prices are dictated by traders/middlemen based on periods of abundance and scarcity. It is believed that large fluctuations in food prices can have severe negative effects in immediate nutritional and livelihood terms (DFID, 2000). Generally, poor people may fail to effectively invest in productive resources if they are worried about price instability.

Farmers also explained storage is largely by traditional methods that are not adequate for ensuring good quality of the produce stored for later sale. High transport costs for taking produce for sale at the market also reduces profit margins. There is hardly any association geared towards marketing in any of the villages although there are some for general welfare activities.

4.3.5 Labour resources

Family, hired and communal are the main labour sources for farm production in the study areas (Figure 4.23). Most people use most labour provided by the family with more people using it in Gogoikrom compared to Subriso III and Yabraso. There are two main sources of hired labour in all the villages, namely: seasonal male migrants and locally resident settlers from the north.

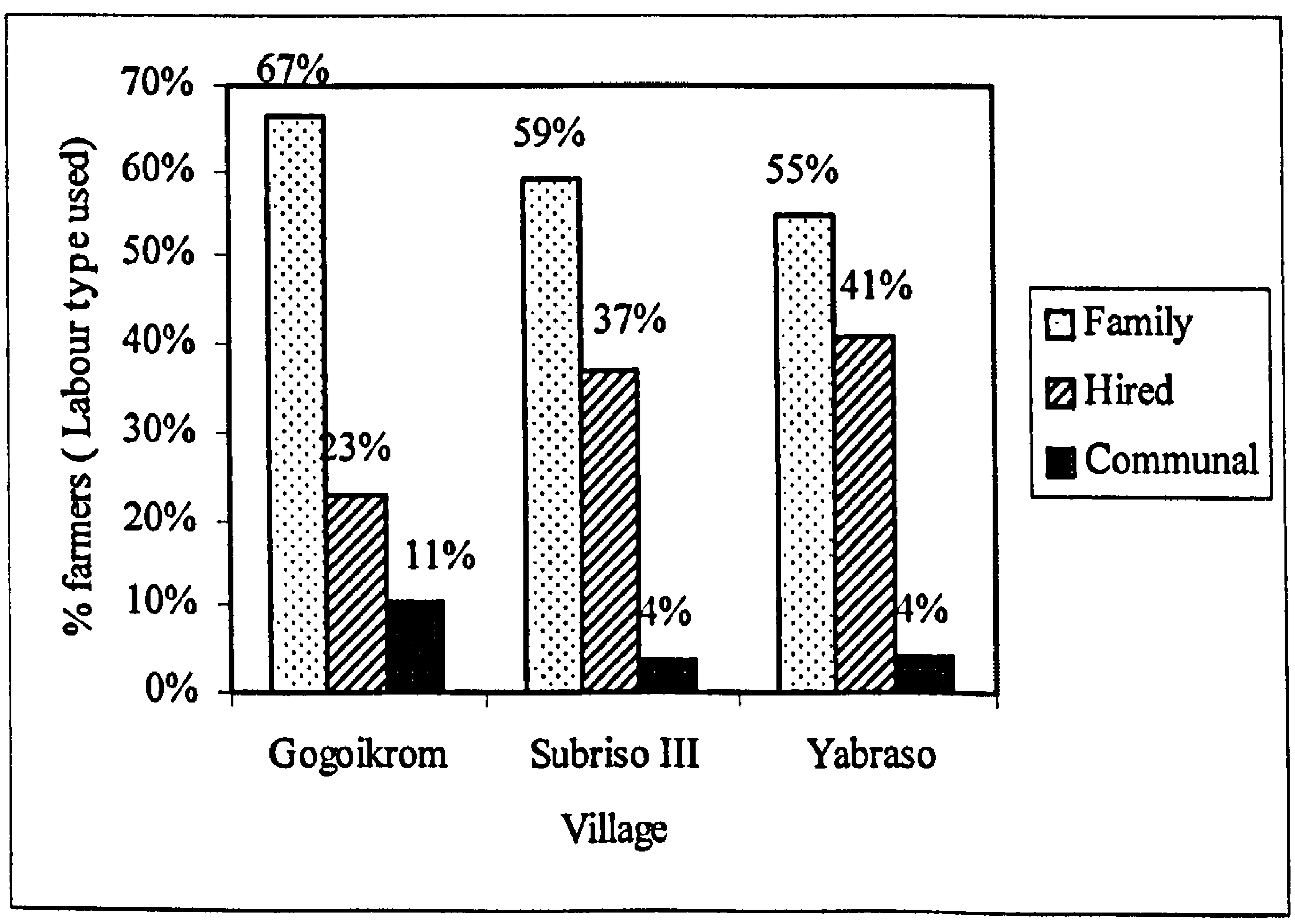


Figure 4.23: Main labour sources in study areas

According to Upton (1996) hired labour is of increasing importance as smallholder production becomes more oriented towards the market and individualisation becomes more widespread among rural people (less dependent on each other to draw on communal labour resources). Upton observed that, although hired labour provides less than 20% of the total farm work input, it makes up the largest single item of expenditure on most farms. In the study villages, labour is often hired for land preparation operations, as these are difficult tasks. More people use hired labour in Subriso and Yabraso than Gogoikrom because of the differences in land preparation operations, which are closely linked with crop types cultivated. Most people employ hired labour for ridging for vegetables (especially tomato) in Subriso. In both Subriso and Yabraso hired labour is also important for making mounds for yam and groundnut cultivation. These crops are not major crops in Gogoikrom, where the cocoa, maize, rice and plantain systems only require slashing and burning and planting on the flat.

Family labour is used for nearly all farm operations, from land preparation (i.e. land clearing, burning, tree felling, stumping, cleaning, ridging and mounding) to loading of produce for sale by most people in the study villages. In Gogoikrom, between 1 and 4 people provide family labour in most homes although it could be up to 10 people or more in some cases. Between 50-100% of the family labour available to households is used for all farm operations except land clearing, for which over 50% of the labour is hired (Figures 4.24 & 4.25).

Hired labour is important for tree felling, stumping, cleaning and weeding although only a little over 30% is engaged for these activities, which undertaken by men. They are laborious and needing to be done on time during the peak labour period. Women headed households (natives and settlers) rely more on hired labour for land clearing as this constitutes about 60% of the their labour needs for this activity. Meanwhile, labour is often in abundance from hired sources provided by the northern male seasonal migrants and local settlers during the land clearing period at the onset of the cropping year, between January and March. Most people reserve some money for engaging hired labour for clearing the new plot.

Communal labour provided by friends and relatives is important for burning, planting, harvesting and haulage. The importance of communal labour in burning is to prevent the fire getting out of control. It is also used for hastening planting which farmers describe as time consuming. Most farmers do not have money to engage hired labour during the period that harvesting and haulage of produce are done and so rely on relatives and friends, rotating on each other's field.

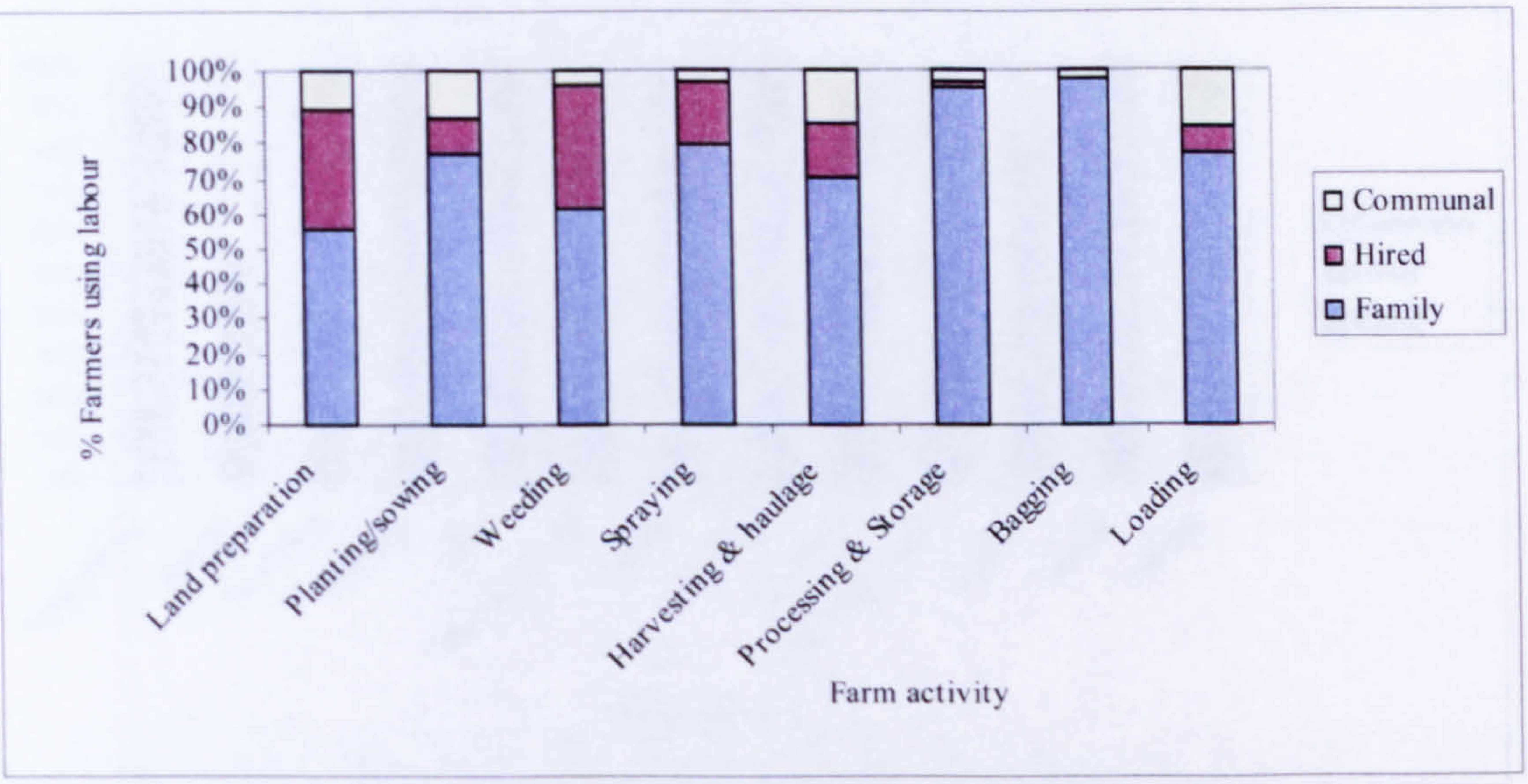


Figure 4.24a: Labour types used for farm main activities in Gogoikrom-Atwima

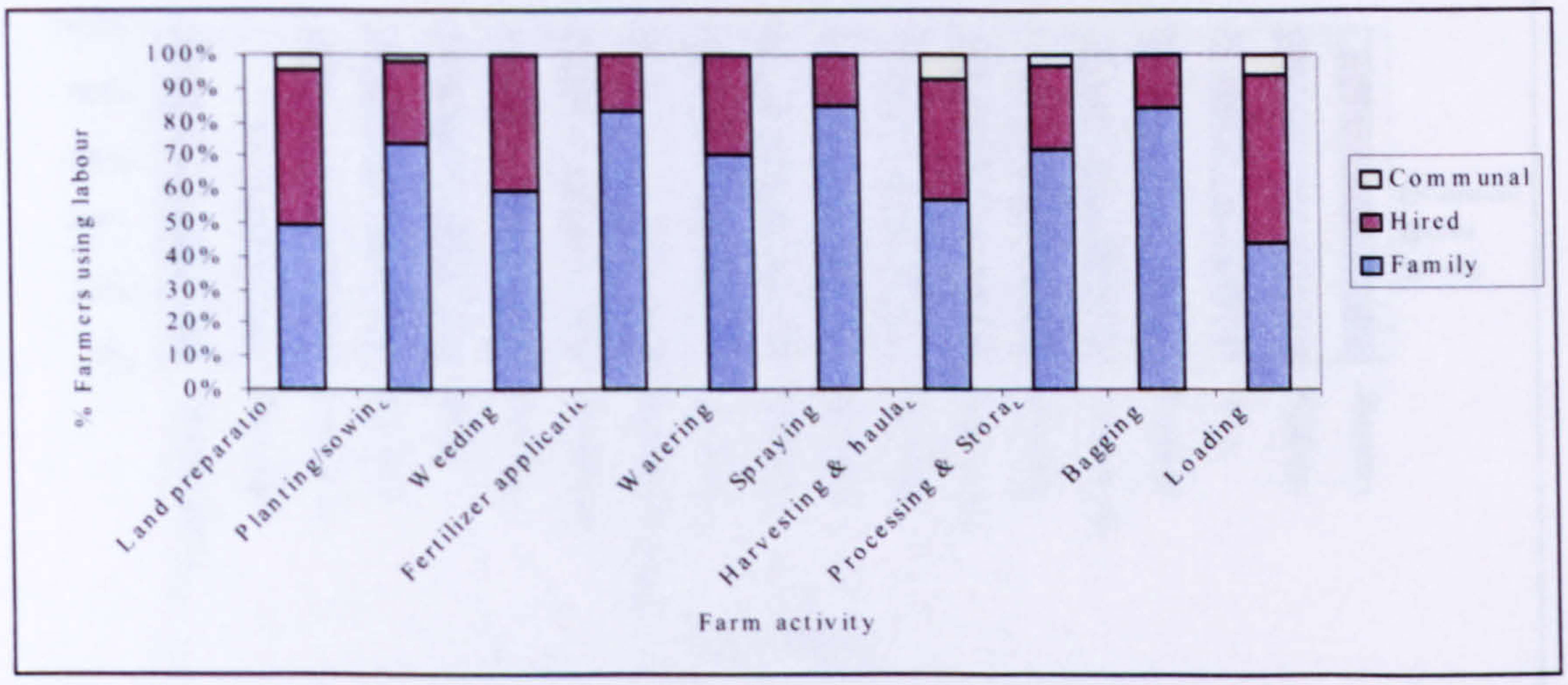


Figure 4.24b: Labour types used for farm main activities in Subriso-Tano

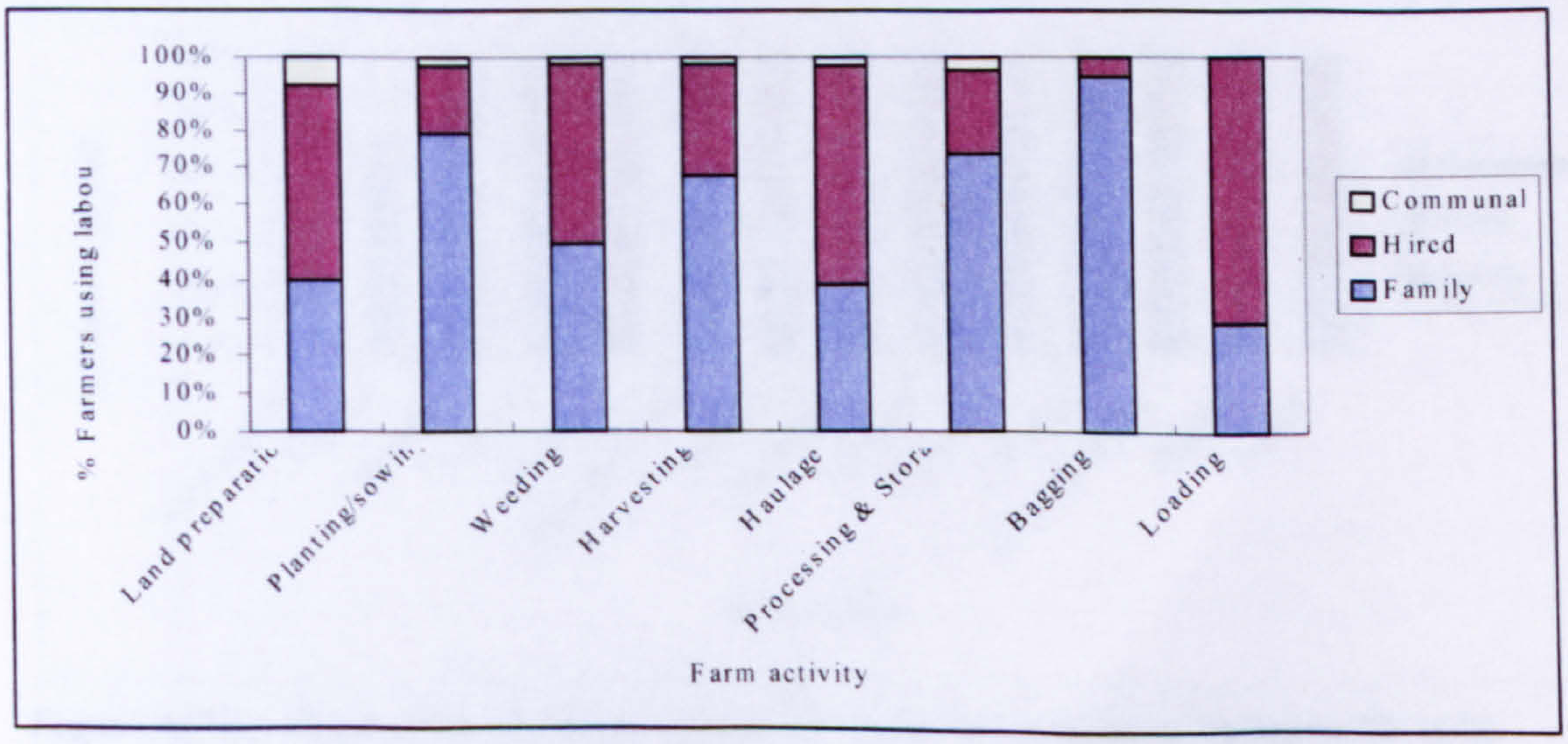


Figure 4.24c Labour types used for farm main activities in Yabraso-Wenchi

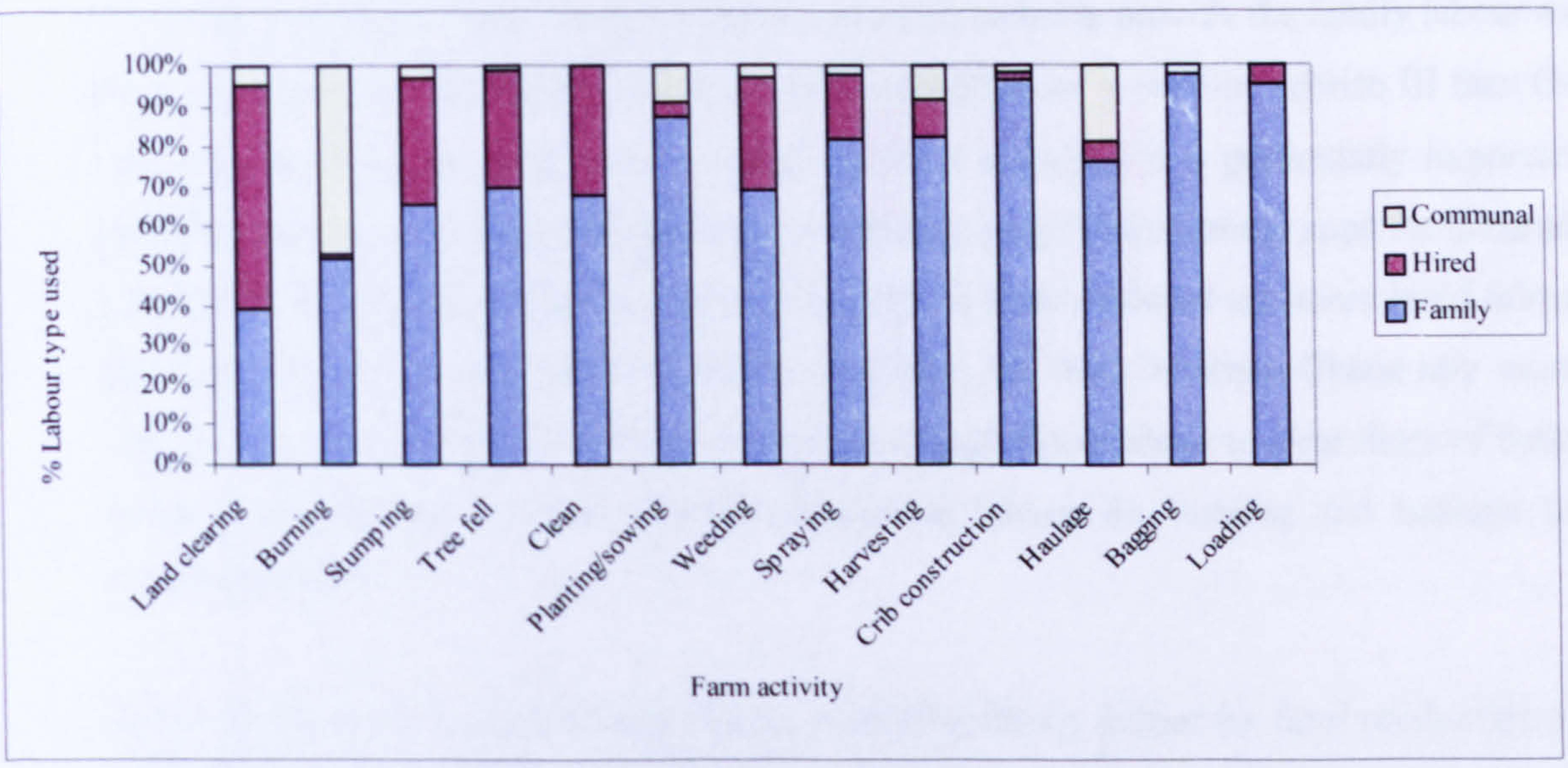


Figure 4.25a: Proportion of Labour types for farm operations in Gogoikrom-Atwima

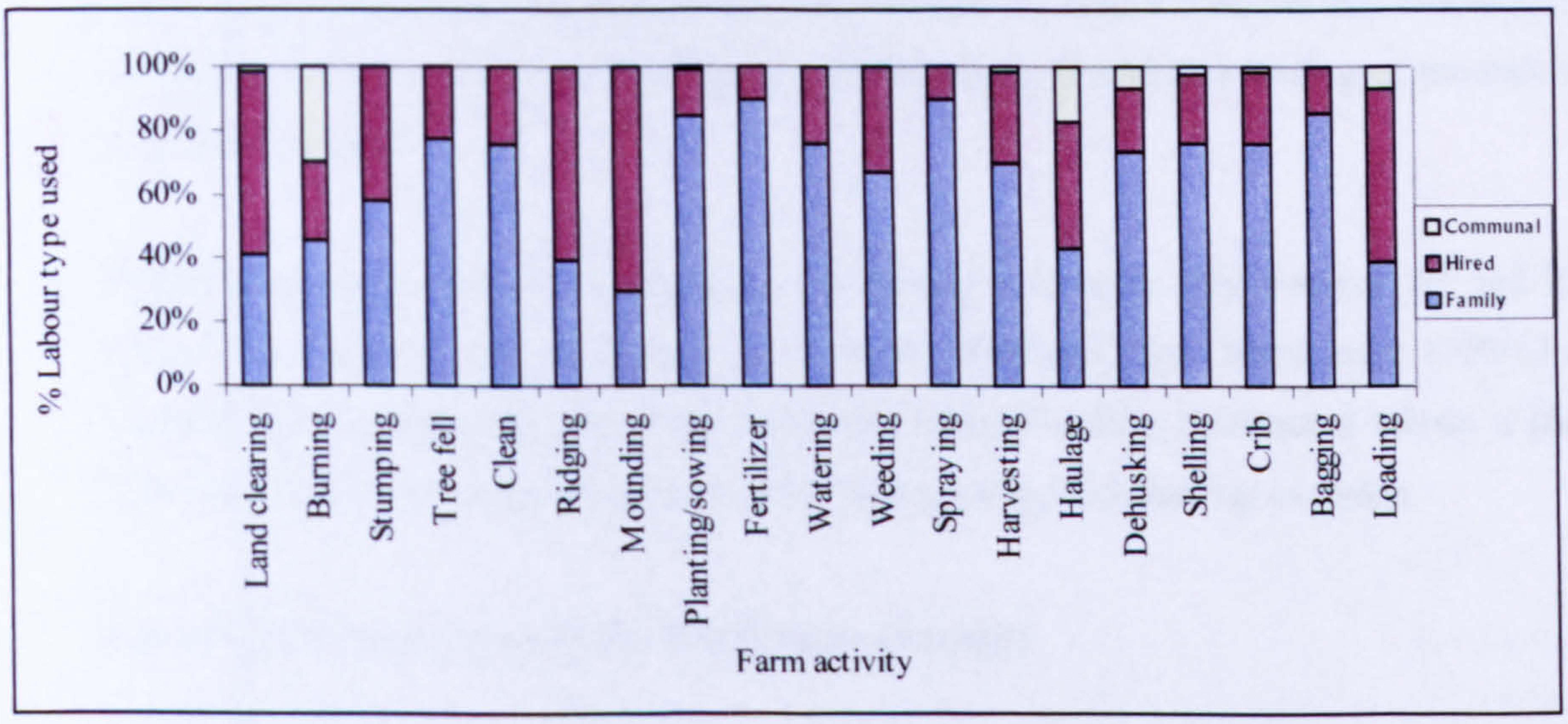


Figure 4.25b: Proportion of Labour types for farm operations in Subriso-Tano

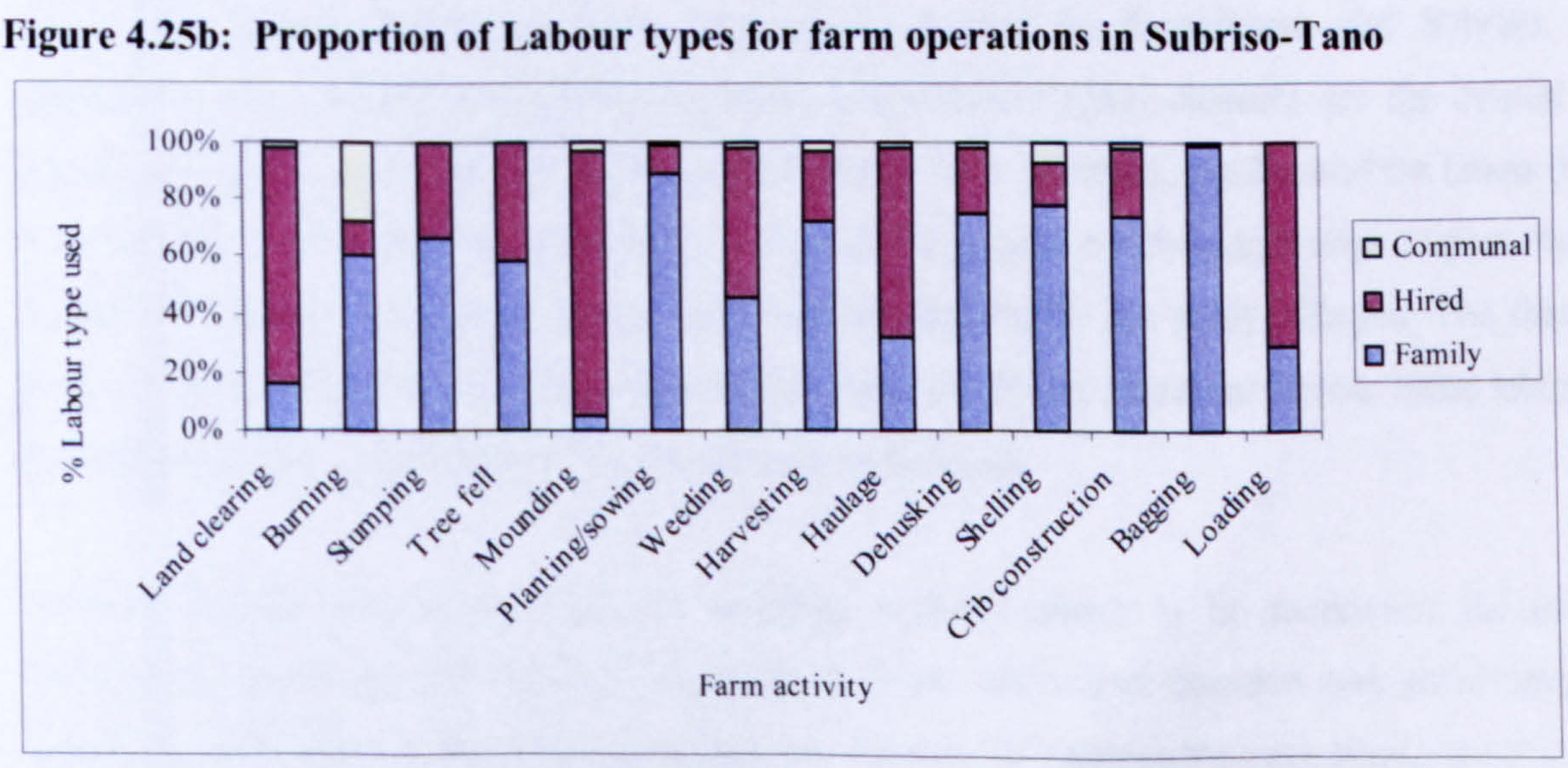


Figure 4.25c: Proportion of Labour types for farm operations in Yabraso-Wenchi

As in Gogoikrom, between 1and 4 people in most households provide the family labour required for farm production in Subriso III. However, more hired labour is used in Subriso III than Gogoikrom. Although hired labour is used for a wider range of activities it is particularly important for land clearing, ridging, mounding and loading, constituting over 50% of labour used for these activities. It was observed that native men and women as well as settler women use more hired labour for land clearing than settler men. Most of settler men who are from northern Ghana rely more on male family labour for clearing their fields but might engage hired labour to clear those of their wives. In Subriso, friends and relatives provide communal labour for burning and haulage for reasons explained above.

There are about 1-3 people in most homes providing family labour for farm production in Yabraso, although there could be over 10 people in some cases. More hired labour is used in Yabraso as compared to Gogoikrom and Subriso III. Over 80% of the labour used for land clearing, ridging and mounding and about 60% used for haulage (from farm to home) and loading of produce for sale on the market is hired.

Within the household men and women, irrespective of origin, hire between 67 and 92% of the labour required for land preparation in Yabraso. However, men hired more (>50%) labour for weeding than women who rely more on family labour (>50%). Communal labour is least used in Yabraso where a few people might use it for land clearing and shelling of maize.

Critical labour periods and household labour dynamics

The critical labour periods are from February to August for Gogoikrom and Subriso. Land preparation and planting (February-April/May) and weeding (May-August) are the crucial farm activities that most people do during this period. However in Yabraso, the demand for labour begins to rise earlier from the ending of September of the previous year for the preparation of yam mounds. Figure 4.26 shows the general labour dynamics for farming in the study villages. The thick full arrows represent major hired labour sources, the thin full arrows represent female hired labour and the broken arrows, unpaid labour (i.e. family and communal).

Between January and May (onset of cropping season) labour is in abundance for all land preparation operations and the first weeding on fields with short duration and early crops like maize, groundnuts and tomato in Gogoikrom and Subriso. In Yabraso the peak labour supply period is from October to March. Male seasonal migrants and settlers from northern Ghana provide the bulk of the labour during the peak labour supply period in all the villages. Such labour is hired either on contract or daily wage basis.

In Gogoikrom, 78% of the people engage hired labour during the peak supply period (January-May) with 51% and 36% of it from the male seasonal migrants and settlers from the north respectively. 83% of the few who do not use this labour mentioned lack of money as the main reason for this; 80% of them were found to be male settlers from the north who rely on family and communal labour for clearing or preparing their fields. It must be noted that these males also sell their labour during this period to earn money for general household use and investment in their cocoa farms.

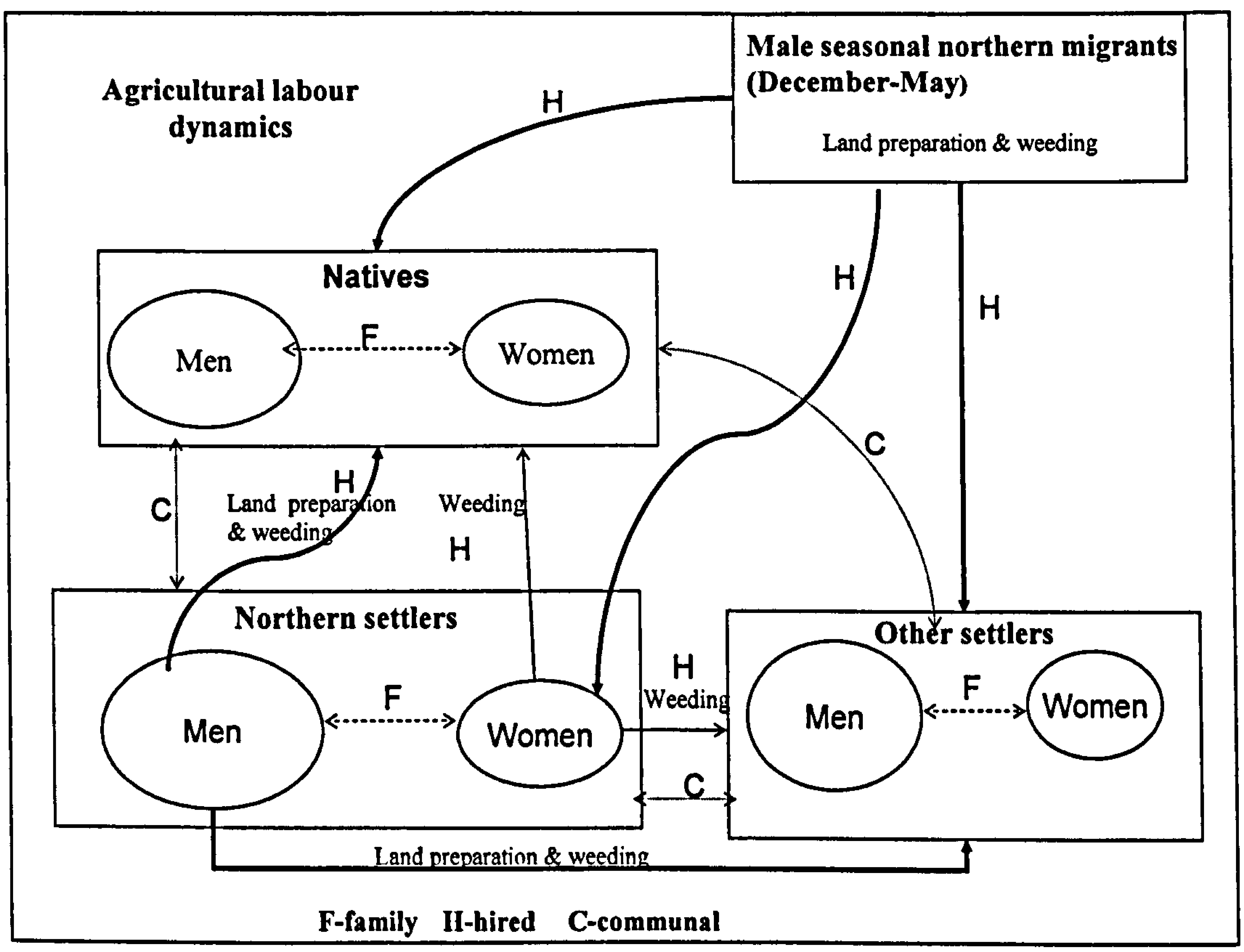


Figure 4.26: Agricultural labour dynamics-Gogoikrom, Subriso & Yabraso

The trend in hired labour use in Subriso III and Yabraso during the land preparation period is similar to that of Gogoikrom. In Subriso III, 90% of the people use hired labour during this period with 53% and 33% provided by the seasonal migrants and settler males from northern Ghana. The few who did not use this labour were northern settler males relying solely on family labour, since they lack money during this period.

Similarly in Yabraso, 95% of the people use hired labour during this period with 53% and 43% from seasonal migrants and settlers from the north. Again a few did not use this labour because they lacked money and were men relying solely on family labour during this period.

The period between May and August is the critical period for weeding. Farmers describe weeding as one of the most difficult farm operations because of the need for frequent weeding to effectively reduce competition between crops and weeds to avoid crop failure. Labour is scarce during this period because the seasonal migrants have returned home and northern settlers are busy on their own farms, although some make themselves available for by-day labour. Thus after the northern seasonal migrants depart, the demand for hired labour is moderate mainly for weeding but the supply from the local settler residents often is low.

Unfortunately, between May and September is the 'lean' or money scarcity period; hence most people might not be in a position to hire the limited labour available. Shortage of money and labour simultaneously leave most people to rely on family labour, supplementing with occasional by-day labour when money is available, but farmers claim this sometimes delays weeding as it takes the family a longer time to weed all the various fields planted within the year. It should be remembered that most people cultivate two or more plots in any one farming season and for most homes a maximum of four people provide family labour for working on the farm which might not be adequate for weeding all fields around the same time and on time.

The important farm operations after September are harvesting, haulage and processing. Farmers describe this period as a low labour demand period as there is not much to do on the farm. Family labour is often sufficient, but could be supplemented with communal labour if need be.

On the whole, men and women use similar types of labour but in variable proportions for the range of farm activities. However, within the household, men provide about 70% of the labour required for strenuous activities like land clearing, stumping, tree felling, mounding and ridging. In female-headed households, this labour is hired by the woman from her own resources but in some male-headed households, the man may engage hired labour where he is not in a position to undertake these activities himself on the woman's separate plot. The woman afterwards is responsible for all labour required on her plot, which is provided by herself, children, by-day hired labour, and occasionally by the husband. In male-headed households women provide at least 50% or more of the labour for sowing/planting, weeding, harvesting and haulage. In smallholder systems, women are reported to provide 60-80% of the labour required for farming activities including weeding (Shimba, 2000).

While women household heads may be saddled with monetary requirements for hiring labour for strenuous farm operations, those from male headed households have the advantage of husbands aiding them in this, but have additional responsibility to provide labour for planting, weeding, harvesting and haulage on their husband's field as well as theirs if they cultivate separate fields.

Most settlers from northern Ghana usually visit their home of origin at the end of the cropping season, usually around Christmas/end of the year. Money made from sale of various produce harvested between September and December is invested in capital items like bicycles, buildings and so on back in the north. Thus, they return in January with little or no money for undertaking farm activities in the new season, hence the need for selling labour at the beginning of the season to earn money to undertake their own farm activities.

Shortage of money during the lean period between June and August forces all other farmer categories in the productive age group, including women in addition to northern settler men to sell labour for weeding to earn some money for household use. The amount earned is probably not substantial as money is scarce and only a few people may be capable of hiring labour.

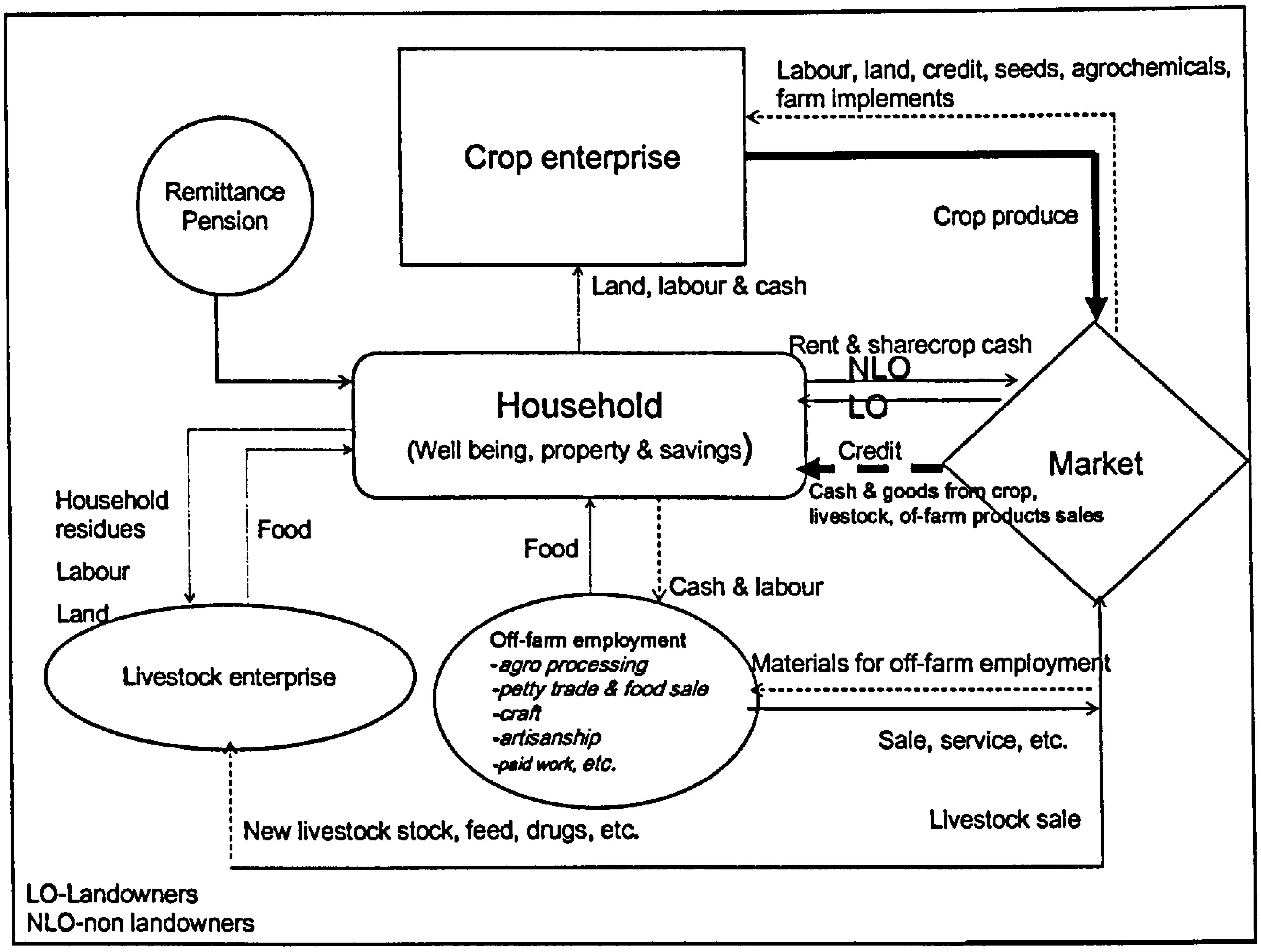
For the seasonal male migrants, the sojourn mainly to sell labour to earn money is because the slack period in northern Ghana i.e. December-May coincides with the period during which the tedious major season activities are done in the south. Northern Ghana, characterized by a unimodal rainfall pattern and a shorter growing season, leaves most people with less farm work to do during the six months slack period. This enables the diversion of the slack family labour into the labour market in the south where demand is high to earn extra money to supplement farm income. It must be noted that the northern part of the country is quite fragile (Savannah) and more degraded than the south; hence, crop productivity and farm income may be low, as annual food deficits are common among farm households.

4.3.6 Financial resources

Agriculture, despite its central importance to the rural economy and livelihoods of Sub-Saharan Africa, is unable to solely provide adequate means of survival in terms of incomes for rural/farm households. Consequently, rural households tend to diversify their income sources as a livelihood survival strategy. Two income streams, natural resource-based and non-natural resource-based sources are characteristic of rural livelihoods. People may supplement the natural resource-based, which is the main income source in most cases with the non-natural resource-based and vice versa (Ellis, 1999).

The natural resource-based sources include collection/gathering of fuelwood, wild plants etc., food cultivation, cultivation of export crops, livestock keeping, etc. and non-farm activities such as brick making, weaving and carpentry as well as charcoal burning, house building, rent from leasing land and so on that depend on natural resources. The non-natural resource-based ones include self-employment, (e.g. trade, vehicle repair), rural wage or salary employment, remittances (international and local) and pension. Reasons for diversification include risk reduction, overcoming income instability caused by seasonality, taking advantage of nearby or distant labour markets, improving food security, generating cash in order to meet family objectives (e.g. children's education) or sometimes, the sheer necessity of survival following personal misfortune such as accident, ill health or natural and human disasters such as drought, flood and civil war (Ellis, 1999).

Figure 4.27 summarizes the general income sources and uses in the study villages. The full and broken arrows respectively, show the sources and uses of income acquired by households. The thick black full and broken arrows show the main source and use of income respectively. The faint dotted arrows show potential sources of money, which is either used by the household for its well being or invested in another enterprise. Household residue or waste has no cash value in the study area and so if it is not fed to livestock, it would have been deposited at the backyard to benefit a garden if any.



Cash sources **Cash uses** **Potential cash sources**

Figure 4.27: General household money sources and uses in study villages

Income earned from crop enterprises constitutes the main source of money for household use and farm investment for all farmer categories. Settler and native landowner men and women may in addition rent out and sharecrop their land to earn additional income, whereas settlers from northern Ghana, the majority of whom do not own land, sell their labour to earn additional income. While a few farmers may lend money to their fellow farmers, others may borrow money from the banks or secure credits from traders. Other minor sources of income are from livestock, off-farm employment (agro processing, tailoring, petty trade, artisanship, etc.) remittances and pension.

Own money

Farmers generally refer to money obtained from all sources other than that from remittances and borrowed as their own money. The majority of farmers in the study villages rely only on money from own sources while a few may, in addition, access some form of credit for use mainly on the farm. For a few people, in addition to their own funds, money may be remitted by adult children and husbands working outside the village (Figure 4.28).

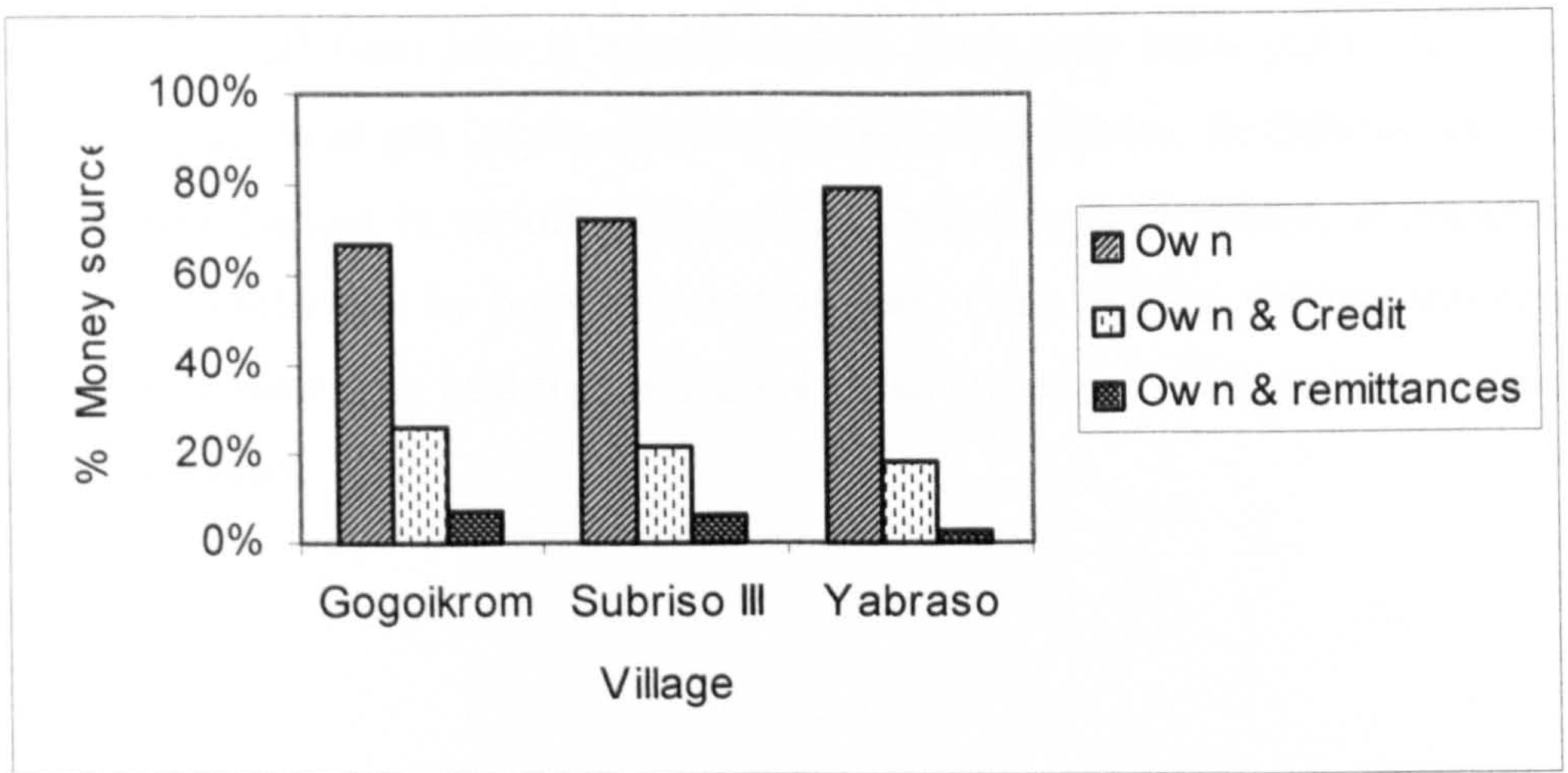


Figure 4.28: Main sources of finance for farm and household

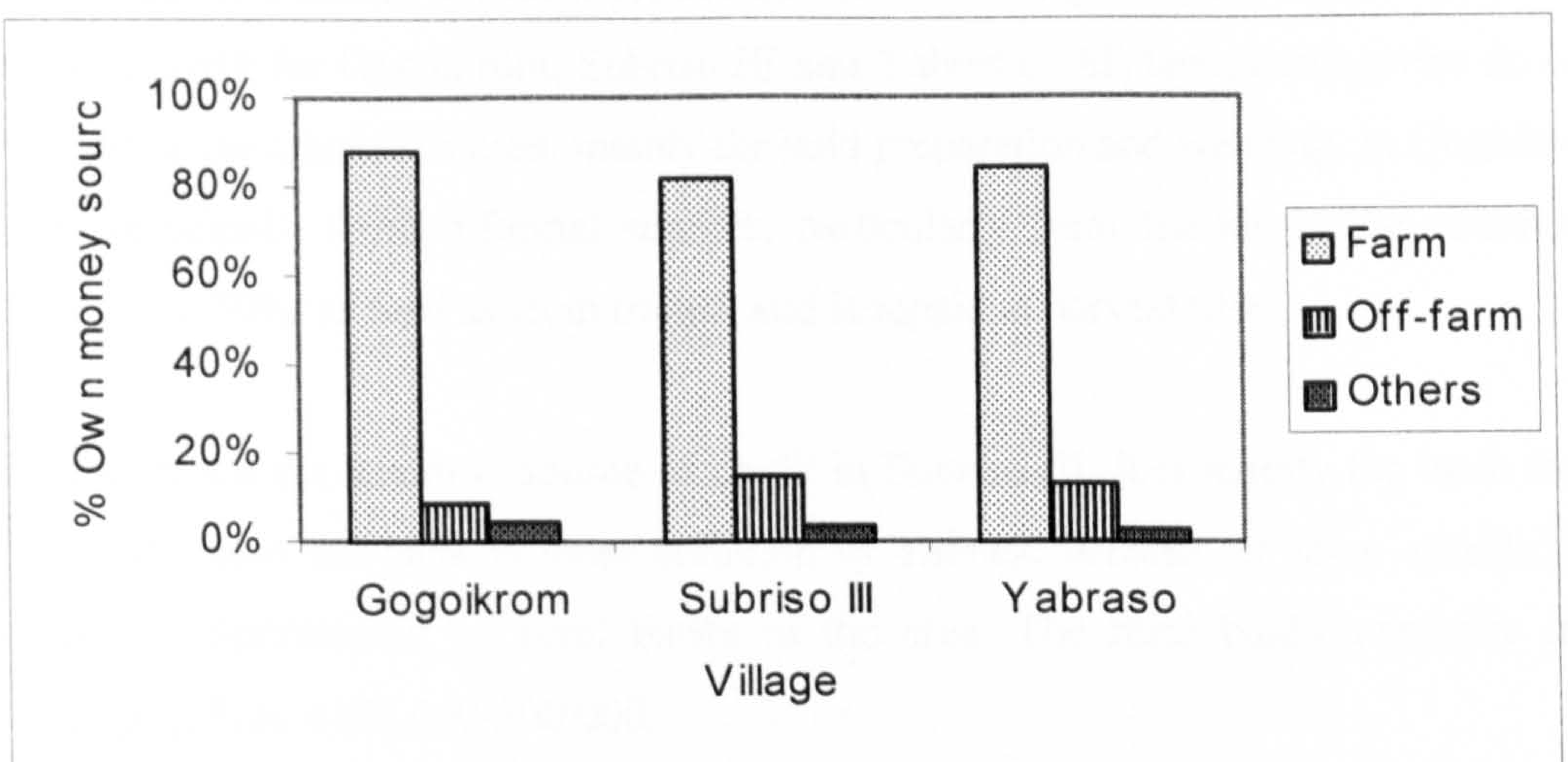


Figure 4.29: Own finance sources

The farm is the main source of own money for all farmer categories in the three villages. In Gogoikrom this money is mainly earned from cocoa, maize, plantain, cassava and cocoyam for everyone and from rice for settler men and women from the north. Own money from the farm for all farmer categories in Subriso III is mainly from the sale of maize and cassava with some also earning it from pepper. Landowning natives and settlers may, in addition, earn income from plantain, groundnuts (women) and tomato (men).

In Yabraso own money from the farm is earned from the sale of maize and yam by all farmers and from cassava by some in addition. Women also gain income from pepper and groundnuts. Money earned from off-farm work is the next important source of own money, yet very few farmers earn money in this way (Figure 4.29). The various off-farm jobs have been enumerated in Section 4.3.8 below. Money from off-farm jobs is earned mainly from petty trade including cooked food by women and distilling local gin (*akpeteshie*) by men in Gogoikrom. At Subriso and Yabraso, it is earned mainly from trading in various commodities including food, drinks, provisions, medicines, maize and yam (middlemen) by both men and women. Corn milling, driving and employment in government service (teaching, health care, etc.) are also important off-farm income earning sources in Subriso and Yabraso.

Credit

Informal credit remains an important source of rural finance for farm production in smallholder systems in developing countries. Less than 30% of the farmers interviewed borrow money to supplement their own money for farm production in each village (Figure 4.28). Figure 4.30 shows the sources of credit for Gogoikrom, Subriso III and Yabraso. All farmer categories do access one form of credit or the other if desired, mainly for land preparation and weeding. In Gogoikrom credit is obtained principally from informal sources, particularly from friends in the community with interest from 0 to 50%, as well as from traders and is repaid at harvest time.

Whereas traders are the common source of credit in Subriso III, it is mainly the bank for those in Yabraso. Credit from the bank is more common in Yabraso because of some smallholder credit schemes being administered by rural banks in the area. The rural banks normally lend small amounts ranging from ¢100,000-500,000.

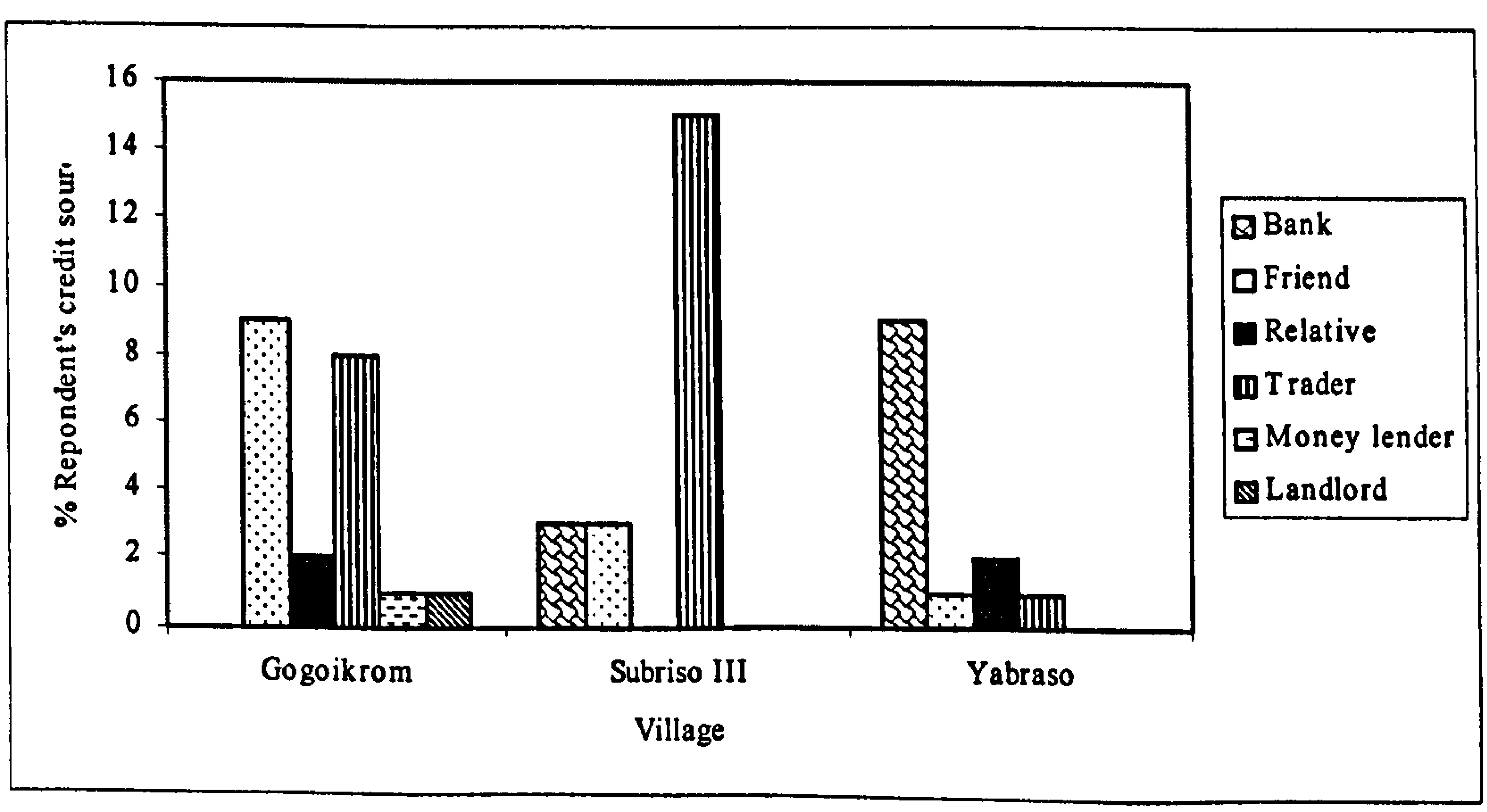


Figure 4.30: Credit sources for study villages

Table 4.27: Rural bank lending rates

Amount lent (¢)	Interest rate (%)	Duration (months)
100,000	50	12
150,000	36	3
200,000	36	3
360,000	33	8
400,000	25	10
540,000	30	12

Credit from traders is repaid in quantities of produce (agreed upon at the time of advancing the loan) soon after harvest, while that from the bank is repaid after 3-12 months in cash with variable interest, depending on the amount and duration (Table 4.27). It is important to note that informal loans from traders and local money lenders, although being comparatively easier to access by farmers than those from the bank, may turn out to be more expensive, as the price for produce used for repayment is often fixed lower than the prevailing market price of the same quantity of produce. Jones *et al.*, (2000) report that community money lenders may advance loans at interest rates, often higher than the banks, although without collateral and disbursed quickly if the client is known.

Savings

Less than 50% of all farmer categories interviewed in the study villages saved variable proportions of the income obtained mainly from crop production (Table 4.28). Although the proportion of income saved by most people is small, it is important as financial security against contingencies or uncertainties like ill health, funerals, etc.

Table 4.28: Savings in the study villages

Savings	Gogoikrom	Subriso III	Yabraso
% People	40	44	48
% Mean income saved	30.8 (10-60)	36.4 (10-70)	33.5 (10-80)
Place of savings			
Bank	48%	61%	68%
Others			
Friends	28%	30%	16%
Susu,	24%	9%	16%

Money saved is also important for next season's farming, especially land preparation and weeding, as well as paying school fees. The reason why the majority of the farmers do not save is because income earned is inadequate, as there are often numerous household and other social expenses to attend to.

Those farmers who do save are able to save about 30% or more of their income on average (Table 4.28). There are more people saving at the bank in Subriso and Yabraso probably because one of the criteria for being eligible for credit from the rural bank is to demonstrate or provide evidence of already saving with a bank. While it is also common for some farmers to save money at home, others might keep savings with friends or relatives or join a *susu* scheme.

Susu is an informal, small local savings facility run by a group of individuals who accumulate money over a period of time to be given to each other in turns. An entrepreneur or a firm who goes round homes, offices and market places could also run a *susu* scheme. These entrepreneurs, otherwise known as *susu* collectors, often run their businesses from kiosks located in the market place and act as mobile bankers. Some rural banks have recently also been involved in *susu* collection. Deposits, often of low but regular value, are usually taken on a daily basis over the course of a month. At the end of the month, the *susu* collector returns the accumulated savings to the client but keeps one day's savings as a commission. *Susu* collectors may also advance loans to their clients to be repaid with daily contributions (Jones *et al.*, 2000).

It can be deduced from above that, high proportions of rural credit and savings are still managed informally. This may be because informal financial services are often characterized by easy access, flexibility in loan use, rapid processing, flexibility in interest rates and collateral requirements. For instance, loans made by informal financial agents like the *susu* collectors to their regular depositors are usually of low value, very short term, provided on an interest-free basis (since debtor pays money back with daily savings collected with a commission of one day's savings), without collateral and disbursed immediately if the money is at hand. On the other hand formal financial institutions are characterized by relatively high value and longer duration loans that require formal application and collateral, which rural people find cumbersome and/or are not in a position to provide. However, it is known that formal rural financial services, especially in Africa, are problematic to administer due to the seasonal nature of production, the risks associated and the wide spatial dispersion of potential borrowers (DFID, 1997).

Critical money periods

Most farmers have sufficient money towards the end of the year from October to December when a greater proportion of most crops are harvested and sold. Cocoa, maize, plantain, cassava, vegetables, groundnuts, yam and cocoyam are sold during this period. Money made during this period is invested in capital goods like buildings, bicycles, clothes, electronics, etc. and used for celebrating Christmas. Settlers from other regions travel home for a break, to visit families, marry or to make capital investments.

The farming season begins soon after this period with land preparation from January to March/April. Most farmers in the three villages described this period up to July/August as the peak money demand period. Although nearly all the money made before Christmas might have been spent, there is some money made from the sale of stored maize (Gogoikrom, Subriso and Yabraso), rice (Gogoikrom), groundnuts (Subriso and Yabraso) and dried pepper (Subriso and Yabraso), as well as reserves of cassava and cocoyam (Gogoikrom and Subriso). This money is spent on the fields for land preparation and, at least, a first weeding from January-May.

Prices of farm produce pick up during this period (dry/off-season) and most farmers might sell over 50% of reserved produce to get their fields prepared, planted and at least weeded once. Those whose reserves might have dwindled by this period sell their labour, livestock or secure credit for doing some of these activities. It must be noted that prices for most farm produce except cocoa, are low between October and December when people make a lot of sales but may have to sell larger quantities to be able to make necessary purchases.

The period between May and August was described as the money scarce/lean period by most of the farmers in Gogoikrom, Subriso III and Yabraso. Nearly all money made would have been invested in establishing the crop, which is not yet matured for harvesting. Food reserves might have dwindled for most people. Although prices of produce would be high during this period, there is very little to sell and eat. Weeding is the critical activity for which money is required during this period. Most farmers cultivate two or more plots in any one season, hence with little money available and each of these fields requiring at least two weedings, due to rapid weed growth, family labour is relied on for doing much of the weeding with some by-day labour in a few instances when it can be afforded. This might delay weeding and some fields are likely to be weeded less often. The crop matures, but yield is likely to be adversely affected.

The majority of farmers in Gogoikrom, Subriso III and Yabraso reported relying on small food reserves for occasional by-day labour and household expenses during the lean season. A few others borrow money from others who have funds or go for credit from traders and others occasionally sell labour or livestock. Farmers with off-farm employment rely on this during the money scarce period. Some women sell cooked food or do general petty trading while men tap palm wine/distil local gin, and so on to generate small amounts of money to cope with the lean season. A few men in Subriso and Yabraso burn charcoal and a few women in Yabraso gather fuelwood for sale.

4.3.7 Livestock production

Farmers generally described livestock as assets, a store of wealth important as cash security for contingent expenses, farm production and for household food, particularly during festive occasions like Christmas, Easter and Eid ul Adha and so on.

60%, 57% and 58% of farmers interviewed in Gogoikrom, Subriso III and Yabraso respectively kept livestock. Chicken, goats and sheep are the main stock kept by most people (Figure 4.31 and Table. 4.29). Chickens are the most commonly kept livestock in Gogoikrom and Yabraso while it is goat in Subriso III. A mean of 9-14 chickens may be kept across the three villages (Table 4.30). The highest number is kept in Yabraso (14 with a range of 1-50). The mean numbers of goats kept in the three villages range from 5-7; with the highest of 7 (range 2-20) being kept at Yabraso.

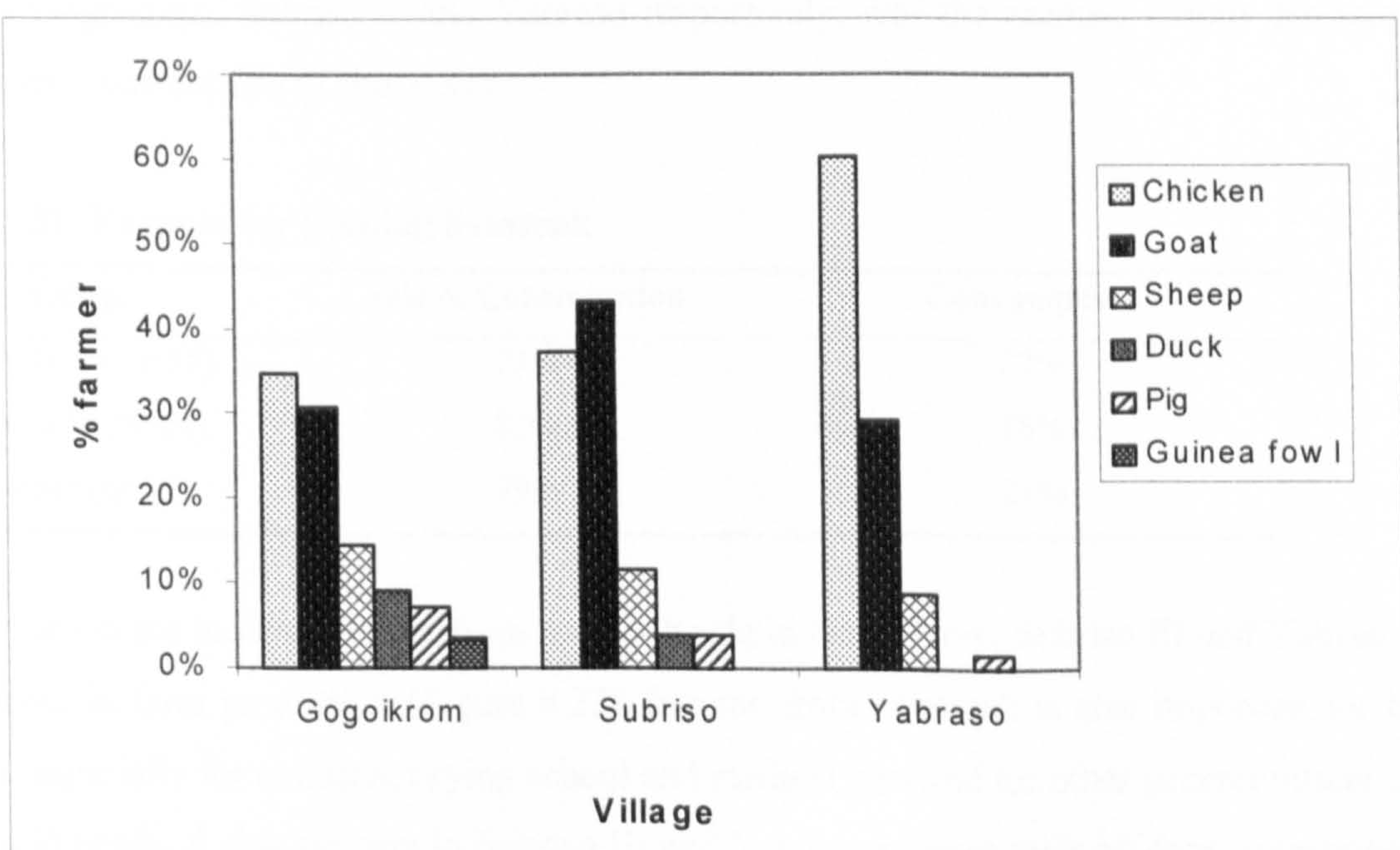


Figure 4.31: Livestock kept in Gogoikrom, Subriso III and Yabraso

Table 4.29: Proportions of respondents keeping various livestock in study villages

Village	% Livestock keepers					
	Chicken	Goat	Sheep	Duck	Pig	Guinea fowl
Gogoikrom	35	31	15	9	7	4
Subriso III	37	43	12	4	4	-
Yabraso	60	29	9	-	2	-

Table 4.30: Mean numbers of main livestock kept in study villages

Village	Mean numbers of main livestock kept		
	Chicken	Goat	Sheep
Gogoikrom	9 (1-20)	5 (1-13)	7 (1-20)
Subriso III	8 (3-20)	5 (2-11)	10 (1-30)
Yabraso	14 (1-50)	7 (2-20)	6 (2-10)

Fewer people (15, 12 & 9% in Gogoikrom, Subriso III and Yabraso respectively) keep sheep as compared to chicken and goats in the three villages although it is the most expensive of the three (Table 4.30). The highest mean number of 10 ranging from 1-30 sheep is kept in Subriso III.

Although not kept in large numbers most (73%, 82% and 79%) of the livestock keepers in the 3 villages Gogoikrom, Subriso II and Yabraso respectively, rear the animals mainly for sale with some home consumption (Table 4.31).

Table 4.31: Purpose for keeping livestock

Village	Sale & Consumption	Consumption
Gogoikrom (n=55)	73%	27%
Subriso III (n=51)	82%	18%
Yabaso (n=56)	79%	21%

The major use for income derived from livestock sale in Gogoikrom, Subriso III and Yabraso is for investment in farm production (Figure 4.32). Income from livestock is also important for buying clothes, especially for children, paying school and medical fees and for other general/miscellaneous household needs. A few farmers in Subriso III and Yabraso support their off-farm enterprises with income earned from livestock.

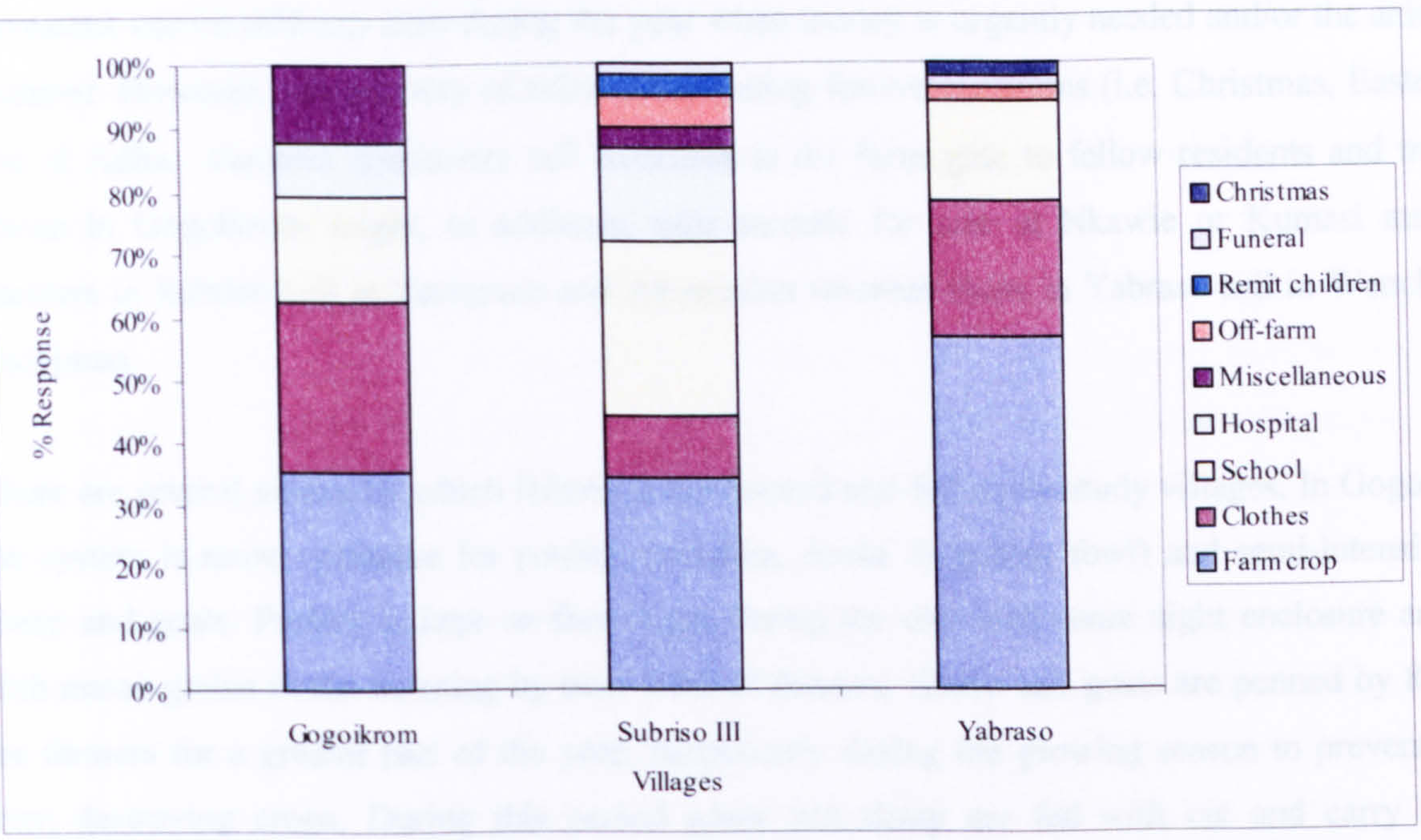


Figure 4.32: Use made of income from livestock in the study villages

Income from livestock might be used to remit children learning a trade, for funeral expenses and for use during festivities like Christmas celebrations, although these constitute 2-3% of the uses of livestock income in Subriso and Yabraso.

Table 4.32: Net income earned by livestock keepers in study villages

Village	Mean annual net income (¢) for livestock keepers			
	Chicken	Goat	Sheep	Pig
Gogoikrom	63,308 (-170,000-365,000)	122,125 (-40,000-450,000)	210,000 (80,000-340,000)	973,000 (796,000-1,150,000)
Subriso III	122,425 (-25,000-915,000)	157,038 (-40,000-750,000)	-	1,270,500 (563,000-1,978,000)
Yabraso	241,358 (-63,000-1,189,500)	248,778 (-22,000-682,000)	141,333 (37,000-291,000)	-

Estimated mean incomes from chicken, goat, sheep and pigs in the study villages are shown in (Table 4.32). Pig rearing appears to earn the highest return with chicken earning the lowest. It must be noted that while it is evident that farmers' estimation of production expenses and incomes might be inaccurate, there is certainly some income earned from this very small scale livestock rearing which is important for the reasons listed above.

Livestock can be sold any time during the year when money is urgently needed and/or the animal is matured. However, the majority of sales occur during festive occasions (i.e. Christmas, Easter and Eid ul Adha. Farmers commonly sell livestock at the farm gate to fellow residents and traders. Those in Gogoikrom might, in addition, take animals for sale at Nkawie or Kumasi markets. Farmers in Subriso sell in Techiman and Akumadan whereas those in Yabraso sell in Wenchi and Techiman.

There are several means by which livestock are housed and fed in the study villages. In Gogoikrom the system is more extensive for poultry (chicken, ducks & guinea fowl) and semi-intensive for sheep and goats. Poultry is kept on free range during the day with some night enclosure and fed with maize grains in the morning by over 90% of farmers. Sheep and goats are penned by 80% of the farmers for a greater part of the year, particularly during the growing season to prevent them from destroying crops. During this period goats and sheep are fed with cut and carry fodder including *Ficus* spp. (Table 4.33) and household residues. Stewart (2002) reported that small ruminant livestock owners in Gogoikrom usually confine their animals during the day but leave them to roam by night with very few of them practicing zero grazing. Pigs are penned throughout the year and fed with maize, wheat and rice bran as well as household residues.

Table 4.33: Small ruminant fodder in study villages

Local name	Scientific name
Kagya	*Griffonia simplicifolia*
Esa	*Celtis malbraedii*
Hwidee	*Pennisetum purpereum*
Krahyere	*Ptericarpus erinaceus*
Nyankyere	*Ficus exasperata*
Pepeewa	*Margaritaria disoidea*
Mango	*Mangifera indica*
Yorke	*Brousnetia papavifera*

Source: Adapted from Stewart, 2002.

In Subriso III the livestock system is more extensive. Most people keep poultry on free range but a few keep then in coops and provide grains as feed. Unlike Gogoikrom, where most people pen sheep, goats and pigs, 73% of the people rearing these animals in Subriso kept them on free range or grazing providing some enclosure at night, whereas 23% penned them, providing cut and carry fodder for goats and sheep. Maize, rice and wheat bran, as well as household residues, are fed to pigs.

The system in Yabraso is also more extensive. Poultry is usually kept on free range by most people with a few keeping them in coops and providing grains. Most (73%) farmers rearing goats and sheep also keep them on free range to graze, while a few pen them most of the time and provide fodder.

There is very little formal veterinary care from extension services for livestock kept in Gogoikrom and Subriso III. Farmers apply traditional methods of treating livestock diseases. Poultry might be given paracetamol against cold and ampicillin in water, juice from mango, avocado and pawpaw leaves for common diseases like Newcastle disease and Coccidiosis which farmers generally refer to as *nkokoyarie* (chicken disease). Sheep and goats are treated for ticks and spots by rubbing dirty engine oil on their fur; diarrhoea is treated with juice from *Chromolaena odurata* leaves and bloats with salt solution. Worm infestation in pigs is treated with powder from dried pawpaw roots mixed with pig feed. Similar livestock diseases occur in Yabraso as those found in Gogoikrom and Subriso III. However, there appears to be relatively better veterinary care in Yabraso. Most farmers reported of regular/periodic vaccination or treatment from veterinary officers for their livestock. Nevertheless, some farmers may apply traditional treatments such as paracetamol against cold; boiled mango leaves or mango bark soaked in water, ampicillin and other antibiotics for *nkokoyarie* and ampicillin, i.e. antibiotic mixed with palm kernel oil for treating facial spots in poultry.

4.3.8 Off-farm Employment

Off-farm/non-farm employment in rural communities plays supplements farm income for both household use and farm investment. It is reported that in 1992, non-farm self-employment accounted for 33% of rural households' incomes in Ghana, (Jones *et al.*, 2000). Tables 4.34-4.36 summarize the various off-farm jobs and respective incomes per week undertaken by men and women in the study villages. Women tend to be more involved with cooked food sales and petty trade while men are more involved with agro-processing and services although in Subriso they are also found to be active in petty trading, particularly in kiosks and purchasing maize as middlemen to sell in the markets in Akumadan and Techiman.

Table 4.34: Off-farm jobs - Gogoikrom (Atwima)

Off-farm work	% Farmers	Gender	Mean net income/week (¢)
Cooked food	20	Women	-18,150 (-65,000-6,900)
Petty trading (*apketeshie*, provisions, etc.)	20	75% Women 25% Men	40,000 (20,000-60,000)
Service (renting distilling equipment, driving, photography, tailoring)	20	75% Men	652,000
Agro processing/ handicraft (soap manufacture, distil/brew *akpeteshie*, basketry, palm wine tapping)	40	88% Men	124,556 (-19,000-460,000)
Village mean gross income per week (for respondents with off-farm employment)		**¢111,275 (-¢65,000-¢652,000)**	

Table 4.35: Off-farm jobs - Subriso III (Tano)

Off-farm employment	% Farmers	Gender	Mean net income/week (¢)
Cooked food	21	Women	59,575 (-49,000-183,000)
Petty trade (middlemen (maize), bar/drink sales, kiosk provisions, other consumables	29	25% Women 75% Men	1,031,000 (-300,000-4,800,000)
Service (corn milling, driving, barbering, tailoring, painting, homeopathy)	25	Men	63,200 (3,600-252,000)
Agro processing/manufacture (distil *akpeteshie*, basketry, blacksmithing, palm wine tapping, charcoal burning)	17	Men	354,000 (308,000-400,000)
Formal employment/paid work (teaching, forest guard, catechist, etc.)	8	Men	-
Village mean gross income per week (for respondents with off-farm employment)		**¢381,206 (-¢300,000-¢4,800,000)**	

Table 4.36: Off-jobs – Yabraso (Wenchi)

Off-farm employment	% Farmers	Gender	Mean net income/week (¢)
Cooked food	14	Women	53,520 (14,000-133,000)
Petty trade (middlemen-maize, drinking bar, provisions, fishmonger, charcoal sales, drug shop)	43	80% Women 20% Men	157,393.00 (1,000-900,000)
Service (corn milling, driving, barbering, tailoring, painting, shoe shining)	17	Men	119,867 (11,200-300,000)
Agro processing/manufacture (charcoal burning)	9	Men	148,000
Formal employment/paid work (teaching)	17	17% Women 83% Men	111,000 (52,500-150,000)
Village mean gross income per week (for respondents with off-farm employment)		**¢125,590 (¢1,000-¢900,000)**	

On the whole, Yabraso appears to be the most vibrant with respect to off-farm jobs, with the highest proportion of farmers in off-farm employment. Off-farm ventures in Yabraso include cooked food sales at table tops and chop bars, table top petty trading in a variety of consumables, kiosks, drinking bars, charcoal producers, government workers and middlemen purchasing maize from the village and its surrounding communities to sell on bigger markets in Wenchi, Techiman, Sunyani and Kumasi. Gogoikrom has the smallest number of off-farm jobs.

Yabraso and Subriso are bigger than Gogoikrom with second-class roads running through them. Yabraso, in addition, has the worst vegetation, which is further deteriorating due to persistent annual fires and charcoal burning. Thus, the people tend to focus more on trading to supplement income.

Gogoikrom, on the other hand, is small and is on a dead-end road, and hence has less trading activities. Moreover, the people are more focused on cocoa production, which is a key foreign exchange earner with a fixed government guaranteed price. There is a higher proportion of agro-processing, especially distilling of the local gin (*akpeteshie*), in Gogoikrom probably because the vegetation is richer in oil palm trees occurring in the wild.

Incomes from off-farm employment are highest in Subriso III (about ¢380,000 per week) while those at Yabraso and Gogoikrom earned ¢126,000 and ¢111,000 per week respectively. The most profitable in Subriso and Yabraso is maize trade. This yields about ¢1,000,000 and ¢157,000 on average for those involved in the two villages respectively. In Gogoikrom the most profitable off-farm job was driving, bringing an income of about 652,000 per week. The least profitable off-farm employment across the three villages is cooked food sold by women. This is probably because the household might consume some proportion of the food cooked for sale.

4.3.9 Constraints to farm production/The vulnerability context

A number of issues constrain agricultural production in the study villages (Figures 4.33-4.35). These can be regarded as providing the vulnerability context within which farmers operate while pursuing their livelihood strategies or activities. Each farmer interviewed listed a number of issues constraining his/her production activities. These issues have been categorised and each category computed as a percentage of the number of farmers mentioning it as an important constraining factor. Similar issues were raised as hampering agricultural production across the study villages.

Inadequate finance for both household and farm investment was the paramount issue mentioned by the farmers. In Gogoikrom it was mentioned by 52% of the farmers and by 82 and 85% respectively of those in Subriso III and Yabraso.

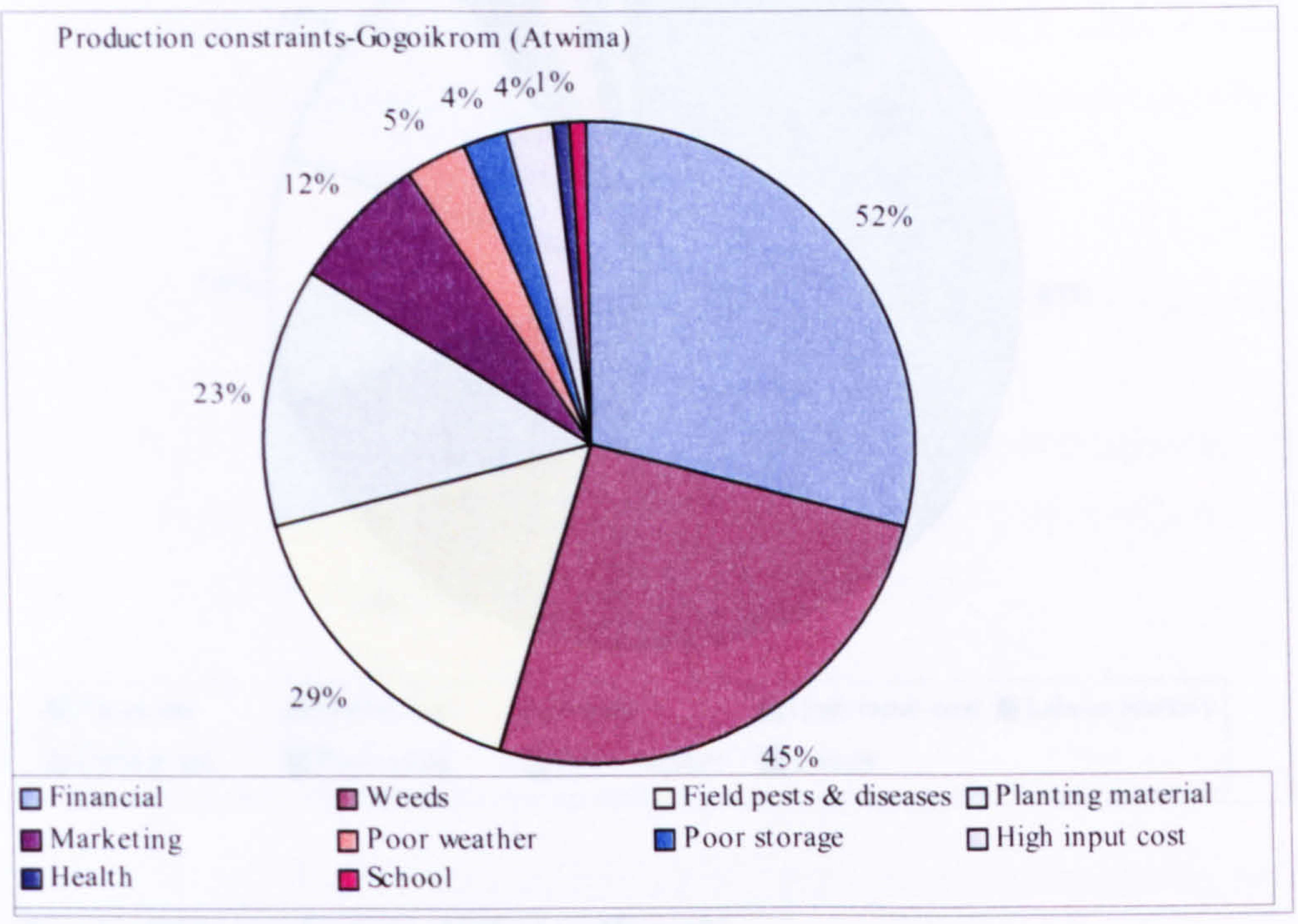


Figure 4.33: Production constraints-Gogoikrom-Atwima

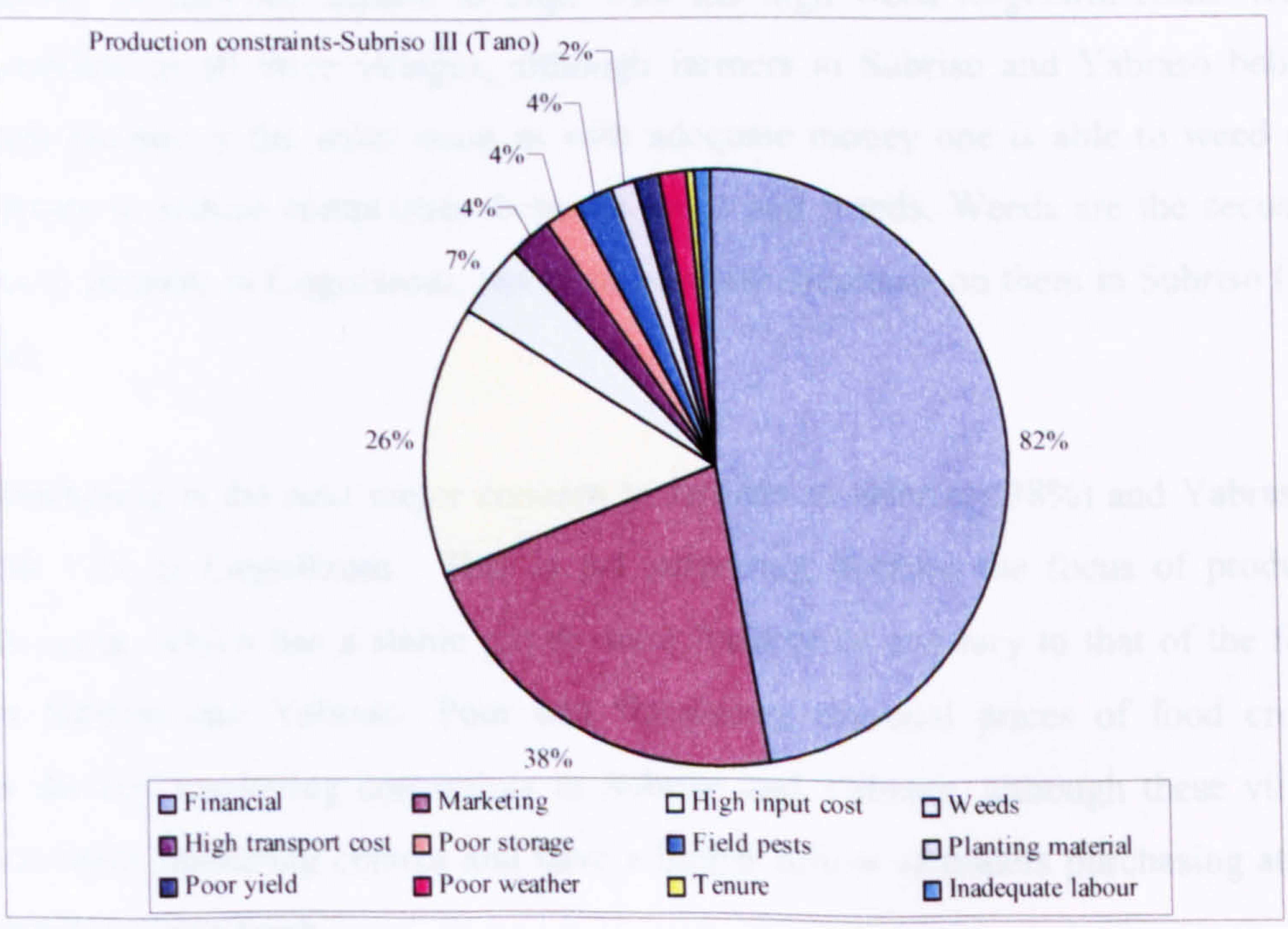


Figure 4.34: Production constraints Subriso III-Tano

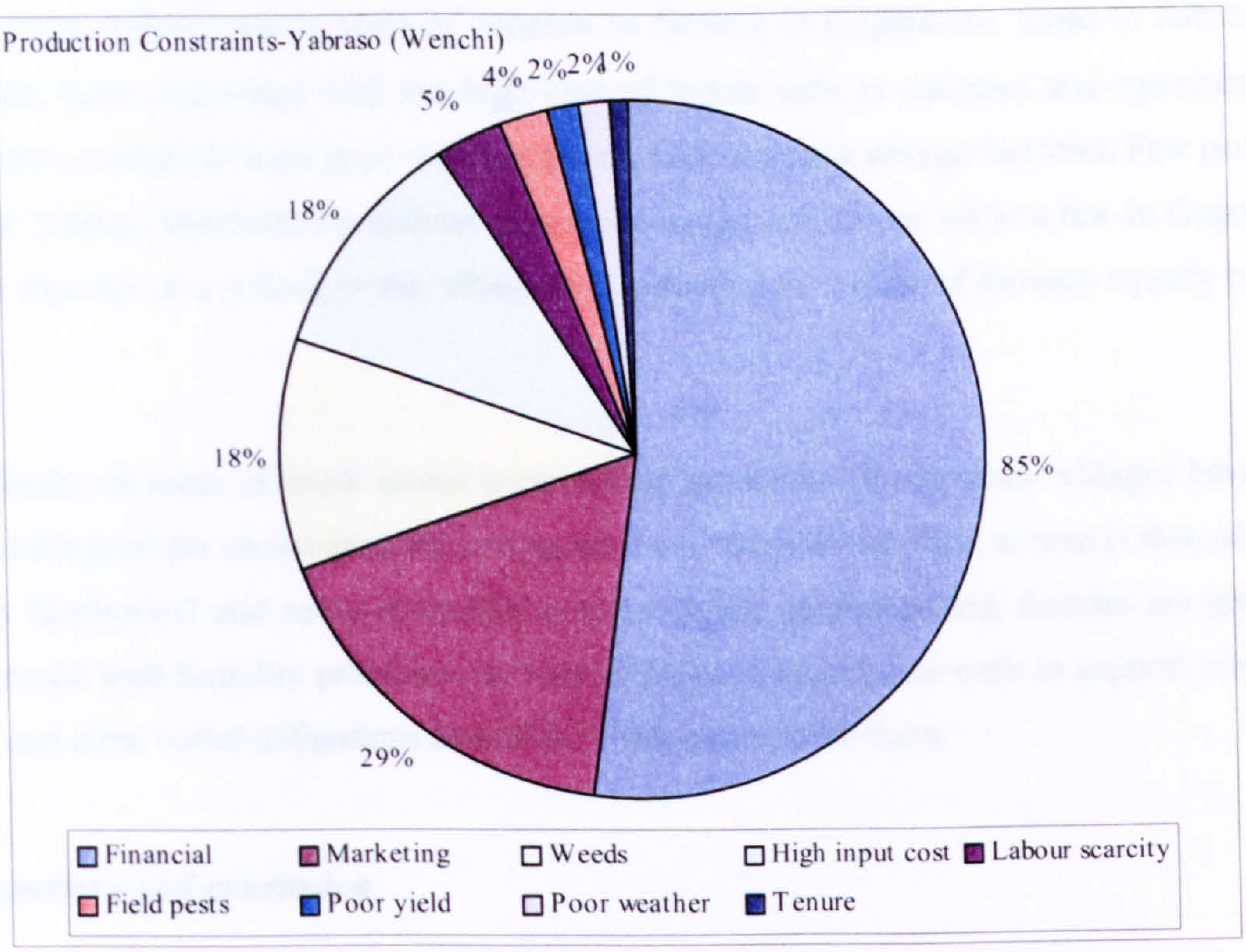


Figure 4.35: Production constraints -Yabraso-Wenchi

The upsurge in the number of noxious weed species that are difficult to control constrain farmers' production efforts, as they are unable to cope with the high weed re-growth rates. Weeds are obviously a problem in all three villages, although farmers in Subriso and Yabraso believe that inadequate farm income is the main issue as with adequate money one is able to weed as many times as necessary to reduce competition between crops and weeds. Weeds are the second major (45%) concern to farmers in Gogoikrom, but there was less emphasis on them in Subriso (7%) and Yabraso (18%).

Conversely, marketing is the next major concern to farmers in Subriso (38%) and Yabraso (29%) compared with 12% in Gogoikrom. This is not surprising because the focus of production in Gogoikrom is cocoa, which has a stable government fixed price contrary to that of the food crop economies in Subriso and Yabraso. Poor and fluctuating seasonal prices of food crops were mentioned as the key marketing constraints in Subriso and Yabraso, although these villages are better linked to main marketing centres and have a higher inflow of traders purchasing at the farm gate as compared to Gogoikrom.

While pests and diseases, particularly termites and ants destroying plantain and cocoa, as well as inadequate cocoa hybrid plants, were of concern to farmers in Gogoikrom, those in Subriso and Yabraso were more concerned with the high cost of inputs such as cutlasses and agrochemicals. Other common constraints were poor weather, poor yields and poor storage facilities. Few people in Subriso and Yabraso mentioned problems relating to tenure and labour while a few in Gogoikrom believe the absence of a school in the village and general poor health of farmers equally hamper production.

The root causes of some of these issues constraining production in the study villages have been discussed in the problem causal analysis in Chapter Two. What is important to note is that, although the various biophysical and socio-economic constraints are interconnected, farmers are generally more concerned with liquidity problems, as they often have insufficient cash to support numerous household and other social obligations as well as investments in the farm.

4.4 Summary and conclusion

The population of the study villages is characterized by two main groups of inhabitants, natives and settlers, distinguished by land and residential status. At least 80% of the people are farmers relying on land as a major occupation for their livelihood. The high proportion of people in agriculture reflects their heavy dependence on soil resources for livelihood.

There is a wide range of household sizes, from 1-18 people. Most of the young members of these households may not be very actively involved in agricultural production, leaving about 1-4 people providing regular family labour in most households. The majority of these youngsters, especially in native and settler landowner households, may be in school, learning a trade or employed in some kind of job, usually in bigger towns or cities.

Family labour is important for all farm operations. However, it is often supplemented by hired labour for the most tedious farm operations, particularly land preparation and weeding. Hired labour is provided mainly by seasonal male migrants and settlers from northern Ghana. Typical field sizes cultivated irrespective of land status and gender by the majority range from 0.1-2.0 ha, with the majority of the non-landowning women cultivating up to 0.5ha.

Income and expenditure patterns of households in the study area, typical of low-resource households are highly seasonal in relation to the farming cycle characterized with various financial commitments such as acquisition of farm inputs (seeds, tools, land, labour, etc.), household essentials, payment of school fees and contingencies, notably ill health. Most farmers suffer money shortage between May/June-August, when all money has been invested in the farm, crops not yet harvested and stores from previous season have almost been depleted (Bright, 1999). Money is however, required during this period for the second weeding and general upkeep of the household. Some people may rely on credit from traders, sale of livestock or money from off-farm employment; however the majority of households are constrained. Households have more money towards the end of the year principally from the sale of harvested produce. Much of this income is spent on Christmas celebration and land preparation later in the New Year.

Shortage of money to engage hired labour to supplement that of the family during the lean period from May to August coupled with scarcity of hired labour (northern migrants returned home and local northern settlers busy on their farms) during this same period means most people rely on family labour, thus delaying weeding on most fields. The implication is that any innovation that requires investment in cash and labour during this period would be constrained.

Across the three villages, landowners usually fallow cultivated farmland when its fertility declines, while tenants often abandon such fields in search for new ones to cultivate. The population of Yabraso-Wenchi is dominated by natives who cultivate family owned and individual inherited lands, thus more people fallow their fields when the fertility of the soil declines. Settler tenants, on the other hand, dominate the population of Subriso and Gogoikrom. In Subriso these tenants, either under sharecrop or rental agreements, often abandon the land after their tenancies have expired for landowners to fallow. While the majority of such tenants do not attempt to apply any soil improvement measure during the period of cultivation (except tomato growers), they try to keep weeds down to get the maximum possible yield out of the land. In Gogoikrom some tenants do cultivate lands belonging to absentee landlords with no specific tenancies, except turning assigned portions of the land into cocoa plantations. This gives such farmers the freedom to cultivate some portions of land assigned to them to food crops and fallow when the need arises. Such lands will eventually be cultivated to cocoa.

It was observed that tenants also tend to cultivate the land more often than the owners do. For instance, while most landowners may cultivate their fields to maize only in the major season, tenants are likely to cultivate the same piece of land for both major and minor seasons in one year to maximize returns. This puts a lot of pressure on the land, as soil nutrients rapidly decline. According to Gyasi *et al.* (1995) strangers tend to exploit the land without respect for the local traditional management systems. The implication is that where there are many tenants cultivating food crops, which is the case in all the three study areas the productivity of the soils are under threat if landowners do not actively adopt suitable soil improvement technologies to sustain production.

It is believed that with inadequate assets and/or the lack of the prerequisite or appropriate abilities to put the available assets into more productive use (Ravindra and Thomas, 1998). Under such circumstances, priority tends to be given to short-term subsistence needs or use of the natural resource base rather than long-term/future needs and sustainability. With poor farm incomes, farmers' capability to invest in improving fallow productivity may be limited necessitating the development of simple, inexpensive yet highly profitable technologies that can be accommodated within especially limited financial resource capacity.

CHAPTER FIVE
ECONOMIC EVALUATION OF TECHNOLOGIES AND ADOPTION

5.1 Introduction

The analysis of the livelihoods of the three farming villages, Gogoikrom-Atwima, Subriso III-Tano and Yabraso-Wenchi in the forest and forest savannah transition zones of Ghana showed that food crop production in these areas relies to a great extent, on the management of short fallow rotations of 1-6 years (Chapter Four). The key agronomic constraints commonly reported by farmers managing these systems were declining soil fertility and an increase in weed load that often lead to a decline in crop yields although inadequate money topped the list of production constraints in a household survey. It is known that smallholders are often confronted with liquidity problems, which those in the study area attributed to the seasonal nature of production. Inorganic fertilizers are expensive and in fact even if farmers could afford them, their use on soils with declining organic matter may be uneconomical (MacLean *et al.,* 2003). As a measure to address both the agronomic and socio-economic constraints relating to the decline in fallow productivity and to diversify farm incomes, the Bush Fallow Rotations Project tested four technologies, namely the maize-legume relay, permanent plantain/plantain-legume, planted tree fallow and cocoa-shade tree technologies, with farmers in the study area.

The four technologies were identified through different sessions of stakeholder and farmer workshops/discussions and experimented with farmers in the three study villages as described in detail in Chapter Three above. The purpose of the on-farm experiments was to assess farmers' perceptions and management constraints relating to the technologies for improving fallow productivity and to gather biophysical and socio-economic data to assess the appropriateness of the technologies to farmer circumstances. Part of the socio-economic data is used in this chapter to evaluate the financial profitability of the technologies under farmer conditions in order to assess their adoption potential. The following sections cover *ex-ante* assessments of the profitability of the technologies as compared to the farmer practice without the technology. A chi-square analysis for identifying other potential adoption determinants is also covered.

5.2 Objective & Methods

5.2.1 Objective

The objective of this chapter is to undertake an economic evaluation; mainly of the profitability and adoption potential of the technologies for improving fallow productivity. According to Baum *et al.* (1999) an economic evaluation of innovations or land-use changes is fundamental to the assessment of the adoption potential and their desired sustainability as the economic viability of a technology has often been an important consideration in determining its adoption by farmers. Consequently, it is hypothesized that farmers' willingness in adopting the fallow productivity improvement technologies is dependent on their profitability, although other socio-economic parameters including constraints characterizing their livelihoods are also important. The research questions for exploring this objective include the following:

1. What are the extra costs a farmer incurs by adopting the new technology?

2. Can the farmer cope with the extra costs within his/her existing resource capability?

3. What benefits will the farmer gain from adopting the technology, particularly in comparison with his/her traditional practice?

4. What are the other possible factors that are likely to influence the farmer's decision in adopting the new technology, assuming it yields comparatively higher returns than the traditional practice?

The profitability of the technologies is evaluated by estimating certain economic indicators compared with the farmer's practice without the technology. Economic indicators are generally more important the more a farmer is integrated into the market economy. In a subsistence-oriented economy, economic and particularly, monetary indicators may be of little significance where crops are grown exclusively for home consumption (Baum *et al.*, 1999). Nevertheless, in the study areas, most crops are produced mostly for sale (50-100%) with some consumption. More importantly, crops associated with the technologies experimented with are produced for sale. In fact, one can confidently say that the local economy in the study villages is highly integrated into the market economy judging from the marketing and distribution patterns of farm goods produced (Chapter 4). Consequently, economic analyses of the technologies under study are very relevant in assessing their adoption potential.

5.2.2 Methods

The profiles, ground plans and detailed description of the technologies/farmer experiments are presented in Chapter Three. The experiments were essentially researcher designed-farmer managed types. The farmers were non-purposely selected, primarily based on their willingness to collaborate. Biophysical and socio-economic evaluations of farmer experiments were undertaken over two cropping seasons in 2001 and 2002. The socio-economic evaluation, of which this chapter forms a part, involved farmer and economic evaluations. Details on the farmer evaluation are presented in Chapter Six.

5.2.2.1 Data collection methods

Data sheets were designed for recording farmer and plot characteristics as well as input and output figures for each farmer plot over two cropping seasons in 2001 and 2002. Data collected comprised age, tenure/access to land, previous use of the land, plot size, labour, timing of activities, inputs and costs and output and prices.

The data on characteristics of participating farmers and their respective plots was recorded at the start of the experiment between March-April for all technologies. Labour and material costs for establishing all technologies were collected during the course of the season by way of periodic monitoring visits. The maize – legume relay technology is an annual system, hence, it was possible to gather some data for one rotation or production cycle over the two seasons to estimate the effect of the legume fallow on maize yield. The remaining three technologies have longer gestation periods; hence, it was only possible to gather some initial data on farmer and plot characteristics in the first year and labour and material costs for some plots over the two years. The economic data collected on all four technologies has been supplemented with other primary data from other aspects of the study and secondary data from work done under similar conditions on smallholder fields elsewhere in Africa for an *ex-ante* profitability analysis of the technologies. Details on data collected for each of the technologies are described under their respective sections below.

5.2.2.2 Analytical methods

The data was analyzed using the Microsoft Excel computer software. The analytical methods include gross margins, returns to labour and Cost Benefit Analysis, estimating the Benefit-Cost ratios (B/C ratio), Net Present Values (NPV), Internal Rates of Return (IRR), Land Expectation Values (LEV) and Equivalent Annual Value (EAV) as well as sensitivity analyses. A 10% discount rate used by the World Bank for agricultural projects is applied in assessing the profitability of all four technologies (Gittinger, 1982). Table 5.1 summarizes the profitability indicators and respective decision criteria.

Table 5.1: Economic indicators used for profitability assessment

Profitability indicator	Formula	Decision criteria	Technology
Gross margin	(Extra gross returns) – (Extra variable costs)	GM > 0	Maize-legume relay
Returns to labour	$\frac{Extra\ Profit}{Labour / ha}$	RL >1.0	Maize-legume relay
Discounted returns to labour	$\frac{(NPV + Discounted\ labour\ cost)}{(Discounted\ labour\ cost)}$	DRL >1.0	Plantain-legume
B/C Ratio	$\frac{\sum B_t}{(1+r)^t} \Big/ \frac{\sum C_t}{(1+r)^t}$	BCR ≥ 1.0	Plantain-legume Cocoa-shade tree *Gliricidia* fallow
NPV	$\sum_{t=0}^{t=n} \frac{(B_t - C_t)}{(1+r)^t}$	NPV ≥ 0	Maize-legume relay
LEV	$NPV\ x \frac{(1+r)^n}{(1+r)^n - 1}$	LEV ≥ 0	Cocoa-shade tree Plantain-legume
EAV	$NPV\ x \frac{(1+r)^n\ x\ r)}{(1+r)^n - 1}$	EAV ≥ 0	*Gliricidia* fallow
IRR	$\sum \frac{(B_t - C_t)}{(1+r)^t} = 0$	IRR ≥ r	Maize-legume relay Plantain-legume Cocoa-shade tree *Gliricidia* fallow

B=benefit, C=cost, t=time in years or rotation/production period, r =discount rate, n= nth month during the rotation.

A chi-square analysis is also used in identifying the determinants of adoption. This, together with the output from the profitability analysis, is used in discussing and drawing conclusions on the adoption potential of the technologies. The analytical methods employed are briefly reviewed below.

5.2.2.2.1 Gross margin

The gross margin on a crop is the monetary value of the total output per unit area after deduction of the variable input costs incurred in the production of the crop (Baum *et al.*, 1999; and Sprey and Murphy, 1986; Bright, 2003). If variable costs are those that change when the technology is introduced, then it can be used to estimate what that crop enterprise is adding to farm profits. With respect to the maize-legume technology, the gross margin per hectare of investing in the legume fallow is the difference between extra gross returns from maize and extra variable cost associated with planting and managing the legume fallow and is computed as follows:

Gross margin/ha = extra gross returns/ha – extra variable costs/ha.

5.2.2.2.2 Returns to labour

This is the extra income per unit of labour used. It measures the magnitude of extra profit obtained in relation to one unit of labour invested. It is computed as follows:

$$\text{Returns to labour} = \frac{extra\ profit\ /\ ha}{Labour\ /\ ha}$$

Returns to labour is usually estimated when an innovation affects labour allocation. With respective to the maize-legume relay, returns to labour measures the extra income the farmer gains or earns from each unit of man-day of labour invested in planting and managing the legume fallow. Since labour is a dominant constraint in smallholder systems characterized by fallow rotations, increasing returns to labour is usually much more important than merely increasing yields per unit land area. Hence, estimating labour requirements for an improved fallow innovation and calculating the returns to labour for the innovation are helpful in the evaluation of the practice (Cairns and Garrity, 1999).

5.2.2.2.3 Cost Benefit Analysis (CBA)

Cost-benefit analysis (also known as benefit-cost analysis) is defined "as an economic appraisal of costs and benefits of alternative courses of action, whether those costs and benefits are marketed or not to whomsoever they accrue, both in present and future time; the costs and benefits being measured as far as possible in a common unit of value" (Price, 1989).

The CBA is essentially a technique for comparing streams of net benefits over time for competing investment opportunities. There are three main types of CBA; Economic, Financial and Social Cost Benefit Analyses. While the Financial CBA (FCBA) is concerned with the assessment of profitability from the private point of view, the Economic CBA (ECBA) determines whether investment would provide an economically efficient use of the resources available to society, (Akter, 2001 citing ODA 1988).

With respect to improved agricultural technologies or innovations, the FCBA is appropriate. The reason being that farmers are private individuals who operate under market influences; thus, they are interested in private profitability rather than public welfare or the welfare of society. The FCBA attempts to assess the desirability of the technologies by determining whether their costs of establishment are offset by higher returns from sustained crop yields compared to traditional practices.

The common profitability indicators estimated in a CBA are the Benefit Cost Ratio (BCR), Net Present Value (NPV) and the Internal Rate of Return (IRR) (Gittinger, 1982). These are suitable for assessing the performance of long term investments, such as tree related technologies in the case of a farmer. For agricultural technologies lasting over a short period (annually or one or two seasons), partial budgeting, may be the most appropriate measure of profitability (Baum *et al.*, 1999) although monthly cash flows can be discounted to estimate the profitability or the rate of return on the capital to be invested by the farmer in adoption of the technology. The Equivalent Annual Value (EAV) and Land Expectation Value (LEV) are other measures of profitability linked to the NPV and may be useful in certain circumstances (Bright, 2001).

5.2.2.2.4 Discounting criteria

Discounting accounts for the time value of money, since the value of a given sum of money at two different points in time is not the same. In other words the value of a cedi received today is not the same as the value of a cedi to be received a year later. Consequently, discounting can compare the cash flows accruing at different times. Discounting is used to estimate the present equivalent of an amount by dividing the future amount by a discount factor, i.e. $(1+r)^t$. Investments made in the adoption of a technology yield returns in the future. With respect to agricultural technologies, the streams of incremental costs and benefits of a technology to be adopted by farmers are discounted by applying the discount rate over the productive life or rotation period of the technology to assess its profitability or attractiveness for adoption.

The discount rate, r in the formula is the opportunity cost of capital, which is the return, which would be earned, in the next best alternative use of the money tied up in the investment in the particular technology. In the case of a farmer or a private entity the rate at which the enterprise is able to borrow money is often chosen as the discount rate. In most developing countries, the real discount rate is assumed to be between 8 and 15% (Gittinger, 1982). The World Bank has adopted a 10% discount rate for agricultural projects in developing countries. This is employed in estimating the profitability indicators in this study.

5.2.2.2.5 Benefit-Cost Ratio (BCR)

The Benefit-Cost Ratio (BCR) is computed by dividing the present value of revenues by the present value of costs as follows:

$$BCR = \frac{\sum B_t}{(1+r)^t} \Big/ \frac{\sum C_t}{(1+r)^t}$$

Where B_t and C_t are the benefits and costs in year t, r is the discount rate and n is the project life time (i.e. length of a complete production cycle or rotation). Projects having a ratio of more than one are generally acceptable (Gittinger, 1982). Consequently, a technology is attractive for adoption if the B/C ratio is greater than 1.0

5.2.2.2.6 Net Present Value (NPV), Land Expectation Value (LEV) and Equivalent Annual Value (EAV)

The NPV is the present worth of the income (incremental benefit or cash flow) stream generated by an investment. It indicates the increase or decrease in profits and is obtained by computing the sum of all discounted revenues minus the sum of all discounted costs (Gittinger, 1982). The NPV of an investment, e.g. farming under an improved fallow system over n, years can be calculated from the following equation:

$$NPV = \sum_{t=0}^{t=n} \frac{(B_t - C_t)}{(1+r)^t}$$

If there are a series of rotations, then the NPV of one rotation would omit the effect of future rotations. To take account of this, the Land Expectation Value (LEV) is calculated from the NPV of one rotation. The LEV is the present value of an infinite series of rotations and is commonly used in forestry (Bright, 2001). If all future rotations on the site are expected to be the same, the LEV is computed from the formula:

$$LEV = NPV\, x \frac{(1+r)^n}{(1+r)^n - 1}$$

To express profitability in annual terms, the annuity value often referred to as the Equivalent Annual Value (EAV) may be derived directly from the NPV to compare the benefit streams. The EAV is the NPV, which is expressed as a sum at the start of the investment, converted into an equal amount for every year of the lifetime of the investment (Bright, 2001). The EAV is computed from the formula:

$$EAV = NPV\, x \frac{(1+r)^n\, x r)}{(1+r)^n - 1}$$

Where n is the lifetime of the investment. A technology is profitable if the NPV, LEV and EAV are positive, i.e. greater than zero.

5.2.2.2.7 Discounted return to labour (DRL)

For technologies involving long term investments in substantial amounts of labour, such as labour for planting and managing a hedgerow in an agroforestry system or for planting and managing a tree plantation, the discounted return to labour (DRL) is computed to determine how worthwhile it is investing labour in the new system compared to the old system. The difference between the DRL of the new and old system is the incremental return to labour which a farmer gains from adopting the new technology. A technology is profitable if its DRL is greater than one. The discounted return to labour is computed from the formula:

$$DRL = \frac{(NPV + Discounted\ labour\ \cos t)}{(Discounted\ labour\ \cos t)}$$

5.2.2.2.8 Internal Rate of Return (IRR)

The discount rate, which makes the present worth of the incremental net benefit stream or incremental net cash flow equal to zero, (i.e. NPV = 0) is known as the internal rate of return (IRR) (Gittinger, 1982). The IRR is the maximum interest rate a project could pay for the resources used if it is to recover its investment and operating costs and still break even. With respect to agricultural technologies, the IRR refers exclusively to the technologies' internal ability to generate a rate of return. In other words, it represents the upper limit for the cost of capital or interest rate or the resources invested by the farmer in adopting the technology. The computation of IRR is by iteration. The decision rule for accepting the technology is IRR > r, i.e. IRR greater than the interest or discount rate. IRR is computed from the following formula for interpolation between two discount rates:

$$IRR = \sum \frac{(B_t - C_t)}{(1+r)^t} = 0$$

5.2.2.2.9 Sensitivity analysis

Sensitivity analysis deals with the issue of risk and uncertainty, since it is difficult to predict future happenings concerning investment decisions made in the present. Agriculture in smallholder systems in SSA is typically subjected to irregularities in weather, markets, crop pests, and so on. Newly introduced systems may alter farmers' ability to cope with such risk factors (Avila, 1992). Thus, risk analysis is an essential component of any economic analysis and is often done by testing how sensitive a new system is to variations in certain predetermined factors or parameters. In most cases it involves assessing the effects of changes in the parameters on the profitability of an investment.

According to Baum *et al.* (1999), sensitivity analysis aids in identifying the most critical areas of an investment project and indicates the relative stability of an intervention or technology as well as the risks associated with its adoption. With respect to agricultural and agroforestry innovations, parameters commonly tested or varied in a sensitivity analysis include discount rates, crop yields, costs and prices (Asare, 1995). More specifically, the sensitivity of the returns to changes in tree or crop yields, prices of tree or crop products and prices of key inputs such as labour are of particular importance (Baum *et al.*, 1999).

5.2.2.2.10 Chi-square (χ^2) test

Chi-square tests measure the relationships between nominal or qualitative variables, such as state of health of an animal or plant in which case the object under investigation is either healthy or diseased; sex: male or female; marital status: single or married; response: yes or no and so on. There are four chi-square tests namely, tests for the equality of several proportions; tests of independence; tests of goodness-of-fit and tests of homogeneity (Fowler *et al.*, 1998; Hoshmand, 1998).

The chi-square test of differences among proportions which, tests the hypotheses about the significance of the differences that may exist between three or more sample percentages is used in this study to identify adoption determinants. A test statistic is computed and compared with a chi-square distribution. This is achieved by comparing observed frequencies with that expected on the basis of some null hypothesis such as there being no differences between the groups. If the discrepancy between the observed and expected frequencies is great, then the value of the calculated test statistic will exceed the critical value at the appropriate number of degrees of freedom. The null hypothesis is rejected in favour of some alternative. χ^2 is computed from the formula:

$$\chi^2 = \sum \ [(O\text{-E})^2 / \text{E}]$$

Where *O* is the observed frequency, and E the expected frequency (Fowler *et al.*, 1998).

5.3 Financial profitability of technologies

5.3.1 Maize-Legume Relay Technology

The maize-legume relay technology is described in Chapter three. The legume is relayed between 5 and 8 weeks after sowing maize. The maize is harvested at about 12 weeks after planting and both fields with and without legumes are left under fallow for about eight months to go through the dry season. In the second season the legume and natural fallow (on control plot) are cleared between February and March and planted to maize, which is harvested between August and September. The cropping calendar is presented in Figure 5.1.

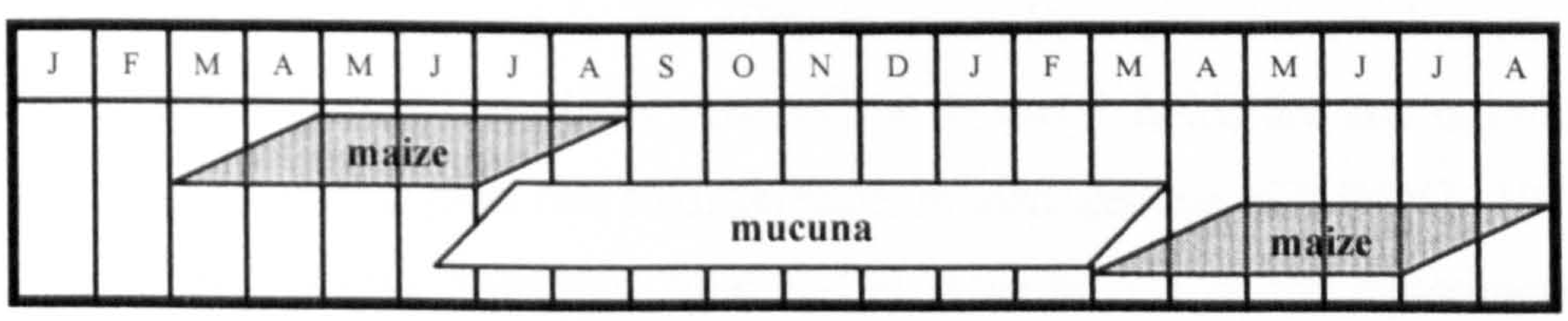


Figure 5.1: Maize-legume relay cropping calendar

In the traditional maize system, the farmer is likely to rotate a two to three year cropping phase with a three to four year natural fallow phase on average. The profitability indicators estimated for the maize-legume technology relay are the gross margins, returns to labour, NPV and IRR. A sensitivity analysis, determining the effect of a 20% increase in labour cost and 20% increase and decrease in the price of maize on the NPV and IRR is also presented.

For the analysis, monocrop maize field with and without the legume fallow cultivated over two seasons (20 months) is considered. Input and output data used in the analysis were collected over the two seasons and covers value of production and costs ranging from (land to maize marketing costs). This is mainly because maize production has become cash oriented, although maize is also important for household food security. Production costs and prices for maize output were estimated from average farm gate figures prevailing in the three study villages in 2001 and 2002.

Maize yield was recorded by researchers and then by farmers at harvest between August and September. This was followed by researcher and farmer estimations of labour for clearing the legume fallow at the beginning of the following season (March-April). The accuracy of the farmers' labour estimates on clearing the eight months' fallow was verified with timing of the labour required by engaging hired labour to clear a few farmer fields.

The output data on maize yield collected from farmers' fields was not used in the analysis due to inconsistencies in farmer behaviour. Some farmers did not repeat the experiment on the same plots in the second year as was done in the first year. Also, some who repeated on the same plot as the first year did not plant the same legumes as species like the *Stylo, Pueraria and Clitoria* were in short supply in the second year, thus it was difficult to estimate maize responses for specific legume species although it was possible to estimate general legume effects irrespective of species. To correct for this shortfall, data on maize yield from 8 month legume fallows of the species experimented with on-farm that were established and cropped during the same period from on-station plots in the Wenchi District are used in the analysis. The on-station data on maize yield were adjusted downwards by 10% to take into account production under farmers' conditions. It is reported that yields obtained on farmers' fields are approximately, 10% lower than that from on-station plots due to differences in management (CIMMYT, 1998). The research station is in the savanna transition zone and is close to one of the experimental village sites, Yabraso in the Wenchi District. Moreover, the *Panicum maximum-Chromolaena odorata* vegetation mix characterizing this site is a replica of that currently characterizing most maize fields in the three study areas.

The input and output values estimated for the analysis are presented in Table 5.2. The labour cost is a product of the man-days per hectare employed in undertaking an activity and the local daily wage rate. The establishment cost covers cost of seeds and labour for sowing/relaying the legume and weeding it once afterwards to enhance growth and spread.

Table 5.2: Input and output values for the maize-legume technology

Treatment	Legume fallow establishment cost (¢)	Total variable cost over 2 seasons (¢)	Adjusted Yield kg/ha 2001	Adjusted Yield kg/ha 2002	Gross revenue/ha 2001 (¢)	Gross revenue/ha 2002 (¢)
Lablab purpureus	145,996	301,329	711	1780	639,900	1,780,200
Mucuna spp.	228,865	395,680	720	2204	648,000	2,203,920
Stylosanthes spp.	143,996	317,329	990	1652	891,000	1,652,400
Pueraria phaseoloides	145,996	328,218	918	1657	826,200	1,656,900
Canavalia spp.	317,734	531,512	703	1980	632,610	1,980,000
Legume mean	196,577	374,814	808	1855	727,542	1,854,684
Natural fallow	0	314,222	1002	990	901,530	990,000

For maize output, 100kg=1maxi bag =¢90,000 in 2001and ¢100,000 in 2002 on average[1]

The gross revenue per hectare is a product of the average farm gate price per 100kg (1 maxi bag) of maize and maize yield per hectare for each treatment. The legume is planted in the first season and its benefit is reaped in the next. The entire production period over the two seasons is about 20 months. The costs that vary over this period considered for the analysis are costs of establishing the legume fallow, clearing the fallow and weeding the succeeding maize crop. One of the advantages of adopting the legume fallow is the fact that the maize crop following the legume fallow will be weeded once compared with twice for that on the natural fallow plot. This accounted for the comparatively higher total variable labour cost for the natural fallow.

The extra cost a farmer incurs in adopting the technology by planting any of the legume species is that for its establishment, comprising seed and labour costs for planting and weeding before and after planting/relaying the legume. It is assumed that the farmer relays the legume between 5 and 8 weeks after sowing maize, i.e. the time the first or second weeding may be done depending on the species (earlier for non-creeping and later for creeping species). Consequently, the cost of weeding before planting the legume may be assumed to be zero, as it would be the same whether the legume is adopted or not. Thus, legume relayed at first or second weeding takes advantage of the weeding labour in May-July and no extra cost is incurred by the farmer by using the technology at this time when money and labour are scarce, as it is the lean period.

[1] £1=¢11,000 in 2001 and £1=¢13,000 in 2002.

The cost of seed for the five legume species used in the analysis is estimated from that of *Mucuna* and *Canavalia* based on their level of use i.e. demand and supply in the country, although the project supplied the initial seed stock obtained at no cost from IITA-Nigeria, supplemented by some purchased from the Crop Research Institute-Ghana and GTZ-Sunyani, Ghana. This approach was adopted as seeds of *Mucuna* and *Canavalia spp.* are available on local markets while that of *Stylosanthes, Pueraria* and *Lablab* are not, making it difficult to price a kilogram of seeds from these species. It is currently anticipated that seed multiplication from farmer and on-station fields would provide subsequent supplies. However, it might be necessary to incorporate seed cost in the analysis as the acquisition of legume seed for establishing the fallow is a key extra cost to the farmer.

Table 5.3: Estimating legume seed cost

Legume spp	Supply	Demand	Cost/kg (¢)	Quantity/ha (kg)	Cost /ha (¢)
Canavalia	High	High	3,000	59.30	177,740
Mucuna	High	Medium	1,500	59.50	89,250
Pueraria	Medium	Medium	1,500	4.00	6,000
Stylo	Medium	Low	1,000	4.00	4,000
Lablab	Low	Low	1,000	4.00	4,000

Since *Mucuna* and *Canavalia* are readily available, they can be assumed to have a higher supply. The cost of a kilo of *Mucuna* is 1500 cedis and that of *Canavalia* is 3,000 cedis. The price per kilo of *Canavalia* is higher than that of *Mucuna* because *Canavalia* has a food value, in addition to being used as short fallow species, thus has a higher demand. The price of *Mucuna* is half that of *Canavalia* indicating a medium demand. Although *Mucuna* has a food value as some local varieties are consumed (Osei-Bonsu *et al.*, 1996) it is reported to contain toxins which limits its consumption as the beans have to be treated before consumption. Thus it can be said to have a medium demand.

Pueraria is under-sown on oil palm plantations in some areas to control weeds and so can be assumed to have medium supply and demand and priced the same as *Mucuna*. *Stylosanthes* has been promoted in some livestock rearing areas as a fodder species and may be easily obtained from livestock research stations and some Non-Governmental Organizations (NGOs); hence its supply can be ranked medium. However, its demand is low because the practice has not been widely adopted and is not common among livestock farmers, so the price is rated lower. *Lablab* is priced lowest alongside *Stylo*. It is not readily available and may be obtained with some difficulty even from research stations in Ghana, thus its supply is low. Likewise with its demand as it is not common or used for any other purpose.

5.3.1.1 Gross margins for maize-legume relay

In computing the gross margins, it was assumed that all other costs except those that vary between legume and natural fallow are constant over the two seasons. For simplicity, it is assumed that the effect of the legume on the first season maize yield (i.e. maize response to legume) would be zero or negligible so the actual effect of the legume on maize yield is obtained during the second season cropping. This explains the use of only the gross field benefits from season two in estimating the gross margins and returns on labour (below).

Table 5.4: Gross margin for establishment of legume fallow

Treatment	Legume establishment cost/ha (¢)	Gross field returns/ha (¢)	Gross margin/ha (¢)
Mucuna spp.	228,865	2,203,920	1,975,055
Canavalia spp.	317,734	1,980,000	1,662,266
Pueraria phaseoloides	145,996	1,656,900	1,510,904
Lablab pupureum	145,996	1,780,200	1,634,204
Stylosanthes spp	143,996	1,652,400	1,508,404
legume mean	**196,517**	**1,854,684**	**1,658,176**
Natural fallow	0.00	990,000	990,000

Table 5.4 shows that the cost of establishing the legume or planting any one of the legume fallows is quite small when compared to the value of the returns gained. Maize production, if any one of the legume fallows is planted, is profitable compared to the natural fallow. Gross margins ranging from approximately ¢ 1.5 to ¢2.0 million may be earned from only one fallow rotation of about 8 months of the legume species compared with about ¢ 990,000 with the natural fallow when the farmer does not adopt the technology.

Table 5.5: Gross margin for total production over two seasons of 20 months

Treatment	Total cost /ha (¢)	Returns/ha (¢)	Gross margin/ha (¢)
Mucuna spp.	395,680	2,203,920	1,808,240
Canavalia spp.	531,512	1,980,000	1,448,488
Pueraria phaseoloides	328,218	1,656,900	1,328,682
Lablab pupureum	301,329	1,780,200	1,478,871
Stylosanthes spp.	317,329	1,652,400	1,335,071
Legume mean	**374,814**	**1,854,684**	**1,479,870**
Natural fallow	314,222	990,000	675,778

Maize with legume fallows is still more profitable than without them, although the total labour cost was higher for some of the legume systems compared with the natural fallow when all costs that vary over the two seasons are considered (Table 5.5).

Two main factors account for the natural fallow being the least profitable option. Firstly, maize yield is certainly bound to decline when a short fallow field is cultivated consecutively over two seasons without any added nutrients, except those from a short fallow of 8 months growth. The vegetation at this stage comprises mainly herbaceous plants mixed with some grasses depending on the dominant plant species in the soil seed bank. A mixture of *Chromolaena odorata* and *Panicum maximum* was common. Secondly, the absence of the legume mulch, which could otherwise boost maize growth and reduce weeds means weed incidence will be higher in maize under the natural fallow system, necessitating two weedings compared to once with the legume fallow. This makes the natural fallow system more expensive, reducing the gross margin further, as observed in Table 5.5.

Both Tables 5.4 and 5.5 show that *Mucuna* fallow is the most profitable, attracting a gross margin of about ¢2 million (about twice that of the natural fallow) when only establishment is considered and ¢ 1.9 million (2.5-3 times that of the natural fallow) when all variable costs over two seasons are considered. Differences in labour costs are explained by the different labour requirements for clearing each fallow type. Details are presented in the section on returns to labour below.

5.3.1.2 Returns to labour - maize-legume relay

The labour requirements for adopting a legume or natural fallow, measured in man-days per hectare are shown in Table 5.6. One man-day is equivalent to five hours of hired labour, popularly known as by-day labour in Ghana. Obviously, more labour is required per hectare for adopting the legume fallow than if the farmer decides to continue with his traditional fallow system.

A farmer adopting any one of the legume species has an opportunity to earn about ¢80,000 for each extra man day of labour invested in establishing any one of the legume fallows (Table 5.7). Comparing the individual legume fallows, *Mucuna* yields the highest return to labour of ¢95,000. It must be noted that the cost of one man day of labour (5 hours) in the study villages at the time of data collection was ¢7,000. Thus a farmer is likely to gain 11 times the labour cost on average and up to 14 times if *Mucuna* is planted in the fallow. Similarly, the legume fallows give higher returns to labour (e.g. almost twice in the use of *Mucuna*) than the natural fallow, when all the variable costs over the two seasons are considered (Table 5.8).

Table 5.6: Labour requirement of the maize-legume relay technology

Treatment	Labour (man days/ha)
Labour planting legume	6.7
Labour weeding legume	16.7
Clearing legume	7.0
Weeding legume maize plot (once)	15.0
Legume mean	**45.7**
Clearing natural fallow	9.3
Weeding natural fallow maize plot (twice)	30.0
Natural fallow total	**39.3**

The main factor causing the differences among the legume species is their cost of clearing for the second season maize. This is more related to individual species' biological characteristics. *Canavalia* has the highest labour cost because the shrub has strong vines/stalks and the plant may thrive over two seasons if not cleared (i.e. biennial) and so requires more effort to clear as compared to the others. *Pueraria*, which comes next after *Canavalia* in terms labour requirements is a perennial plant and so more labour is required to clear the carpet of live biomass. On the other hand *Mucuna* and the others are short lived. Thus they naturally dry out or die off over the dry season leaving a carpet of mulch at the onset of the next season to clear, making it easier to prepare such fallow fields for planting.

Table 5.7: Returns to labour for establishment of legume fallow

Treatment	Extra labour (man days)/ha	Gross Revenue (¢)/ha	Returns to labour (¢/man-day) /ha
Mucuna spp	23.33	2,203,920	94,456
Canavalia spp	23.33	1,980,000	84,860
Pueraria phaseoloides	23.33	1,656,900	71,012
Lablab pupureum	23.33	1,780,200	76,297
Stylosanthes spp	23.33	1,652,400	70,819
Legume mean	23.33	1,854,684	79,489
Natural fallow	0.00	990,000	

Table 5.8: Returns to labour for total production over two seasons

Treatment	Labour (man days)/ha	Gross Revenue (¢)/ha	Returns to labour (¢/man day) /ha
Mucuna spp	44.2	2,203,920	49,882
Canavalia spp	50.1	1,980,000	39,558
Pueraria phaseoloides	46.1	1,656,900	35,932
Lablab pupureum	43.0	1,780,200	41,397
Stylosanthes spp	45.0	1,652,400	36,718
Legume mean	**45.7**	**1,854,684**	**40,610**
Natural fallow	39.3	990,000	25,204

On the whole, it is evident that the additional labour invested in establishing or adopting any of the legume fallows is compensated for by the higher maize yield of the succeeding maize crop. However, there might be a problem, as the time the extra labour is required for planting and weeding the legume planted coincides with the period of both money and labour scarcity. One can, however, argue that the cost of labour invested in undertaking the extra labour activities is negligible when compared to the potential benefit derived from the legume as indicated by the increase in yield of the succeeding maize crop. In any case some amount of extra investment needs to be made in order to reap the extra benefits associated with any improved technology.

Table 5.9: Labour requirements for clearing fallows

Treatment	Labour clear (man days/ha)	Gross revenue (¢/ha)	Returns to clearing labour (¢/man days)
Mucuna spp.	5.9	2,203,920	376,739
Canavalia ensiformis (strong vines & biennal)	11.7	1,980,000	168,942
Pueraria phaseoloides (perennial)	7.8	1,656,900	212,969
Lablab pupureum	4.7	1,780,200	381,199
Stylosanthes spp.	6.7	1,652,400	247,736
Legume fallow	**8.4**	**1,854,684**	**252,751**
Natural fallow	9.3	990,000	106,681
All treatments	$F = 1.827$, P-value =0. 153		
Legume mean vs. natural fallow	F=0.271, P-value = 0.612		

Farmers often seek to reduce production costs, especially labour cost. Gockowski and Ndoumbé (1999) report that, even where land is not a constraint, farmers may be reluctant to clear long fallow fields due to difficulty in doing so and may end up managing short fallows that are easier or require less labour to clear. Table 5.9 shows that all the legume fallows are less expensive to clear than the natural fallow except that of *Canavalia* for reasons explained above, although the differences in labour man days are not significantly different. Thus an added advantage for adopting the legume is the higher returns to labour for clearing the legume fallows compared with that of the natural fallow. *Canavalia* is a biennial plant, dying off after two seasons and so if both the *Canavalia* and natural fallows are left over a longer period, say two seasons, without clearing, the natural allow may turn out to be more expensive to clear as its vegetation at that stage would be denser and may comprise tree coppices, while that of the *Canavalia* will be withering and easier to clear.

5.3.1.3 Cash flow analysis for maize-legume relay

The total stream of costs and benefits over two seasons of twenty months is presented in Appendix 16. A monthly cash flow analysis over the 20 months production further confirms that, it is profitable to plant the legume fallows as these have positive net present values, ranging from ¢305,000 for a *Lablab* fallow to ¢653,000 for a *Mucuna* one at 10% discount rate (i.e. monthly discount rate of $(1+0.10)^{1/12} - 1$) (Table 5.10). The monthly discount rate is computed from the formula: $(1 + r)^{1/12} - 1$. Where r is the annual discount rate. The net cash flow for each month was then multiplied by the monthly discount rate and the summation computed to arrive at the NPV. Similarly, the internal rates of return for the legume fallows were much higher, ranging from 37% for *Lablab* to 65% for *Mucuna* fallow when compared with that of the natural fallow, (-1%). The IRR (annual) was obtained from the formula: $(1+irr)^{12} - 1$), where *irr* is the monthly rate of return, i.e. the monthly discount rate at which the net present value would be equal to zero.

Table 5.10: Profitability of maize-relay and maize-natural fallow technologies

Profitability Indicators	All legumes	*Mucuna* spp.	*Stylosanthes* spp.	*Canavalia* spp.	*Pueraria phaseoloides*	*Lablab pupureum*	Natural fallow
Monthly IRR (%)	3.3	4.3	3.6	3.0	3.0	2.7	-0.1
Annual IRR (%)	48.0	65.2	52.2	44.8	44.6	37.3	-1.0
NPV (¢)	418,440	653,097	410,259	404 ,221	347,013	304,585	-80,905

5.3.1.4 Sensitivity analysis for maize-legume relay

The performance of the legume fallows relative to the natural fallow is fairly stable under a range of possible changes in two key parameters, namely, labour costs and produce price. Labour costs and price of agricultural produce are two main determinants of profitability in smallholder low external input systems, assuming all other factors that contribute to production, including the weather, are fairly favourable. Labour costs are likely to appreciate with inflationary pressures. For instance, the daily labour wage (by-day) increased by ¢1,000.00 each year during the three years (2000-2002) of the study in the villages. A 20% increase in labour cost was assumed. Maize produced on the legume fallow plots is profitable with the rise in labour cost while that on the natural fallow plot is not, with production under a *Mucuna* fallow being the most stable

Maize prices often fluctuate depending on the supply of maize at any particular point in time during the season and transport costs. A 20% increase or decrease in maize prices was assumed. The legume fallow systems are much more profitable than the natural fallow with the rise in maize price, with the production in the *Mucuna* system being superior (Table 5.12).

Table 5.11: Sensitivity analysis on 20% increase in labour cost

Profitability indicators	All legumes	*Mucuna*	*Lablab*	*Canavalia*	*Pueraria*	*Stylo*	Natural fallow
Monthly IRR (%)	2.8	3.9	2.2	2.6	2.4	2.9	-2.0
IRR (%)	39.2	58.8	29.5	36.6	33.4	40.5	-21.6
NPV (¢)	361,035	657,907	246,772	352,654	266,372	335,053	-260,690

Table 5.12: Sensitivity analysis on 20% increase in maize price

Profitability indicator	All legumes	*Mucuna*	*Stylosanthes*	*Pueraria*	*Canavalia*	*Lablab*	Natural fallow
Monthly IRR (%)	6.2	7.0	6.6	6.1	5.9	5.4	3.5
IRR (%)	105	125	116	104	98	88	52
NPV (¢)	1,042,769	1,392,114	1,006,934	927,579	1,041,988	877,138	290,857

Table 5.13: Sensitivity analysis on 20% decrease in maize price

Profitability indicator	All legumes	*Mucuna*	*Canavalia*	*Stylosanthes*	*Pueraria*	*Lablab*	Natural fallow
Monthly IRR (%)	1.4	2.7	1.3	1.3	0.9	0.7	-4.5
IRR (%)	18	37	17	17	11.4	8.9	-42.7
NPV (¢)	89,994	328,119	82,446	69,631	14,408	-12,724	-406,855

On the other hand a decline in maize price adversely affects the profitability of both the legume and natural fallow systems, although production under all legumes, except that of *Lablab* is still profitable (Table 5.13).

To summarize, maize production in a legume shrub fallow system is quite lucrative, as indicated by the higher gross margins, returns to labour, NPV and IRR compared with that of the traditional natural fallow. Relative profitability of maize production in the legume system is also fairly stable under increases in labour costs but very sensitive to fluctuations in maize prices. A 20% increase in maize prices makes maize production highly profitable, even under natural fallow. Conversely, a 20% decline in maize prices reduces profitability sharply, with production under a *Mucuna* fallow yielding the most income and that under natural fallow the poorest income. *Mucuna* fallow is the most profitable under all tested conditions. Fallows with *Stylosanthes, Pueraria, Canavalia* and *Lablab* are also profitable in that order but are severely affected when maize price is low. The natural fallow is consistently the least profitable.

5.3.2 Permanent plantain system

The permanent plantain system involves rows of tree and shrub legumes with plantain planted in the alleys (Figure 3.11). It is essentially an alley cropping system involving *in situ* mulch production that can support the productivity of plantain on a sustained basis. Four treatments were considered for the on-farm experiment, namely, plantain-*Gliricidia sepium*, plantain-*Flemingia macrophylla*, plantain-*Canavalia ensiformis* and plantain-no legume (control). All the four treatments are planted on each farmer's plot as replicates. The benefits of the plantain-legume technology include increasing plantain yield by way of improving soil fertility and conserving soil moisture, which are critical in sustaining productivity in plantain. In addition to biomass from pruning the hedgerow applied as mulch, hedgerows continually add organic material to the soil through litter fall, tree roots and exudates and by way of biological nitrogen fixation if the hedgerow species is leguminous (Dvorak, 1996).

Mulch also reduces weed growth despite the additional increase in labour requirements for managing hedgerows with respect to pruning and application of the mulch. Other possible benefits of the system include the provision of wind breaks by the hedgerow, firewood, stakes and fodder. The use of the leguminous cover crop *Canavalia ensformis*, to effectively control weeds and improve soil productivity in plantain-based systems on farmer fields in the Asunafo District of the Brong Ahafo Region of Ghana has been reported by Osei-Adade *et al.*, (2001). Ruhigwa *et al.*, (1995) also reported reduced labour for weeding a plantain-alley cropping system with mulch from *Senna siamea, Dactyladenia barteri* and other species

Although some work has already been done on the effect of *Flemingia macrophylla* and *Canavalia ensiformis* mulch on plantain in Ghana, these studies did not consider economic assessment of the effect of the legume mulch on particularly plantain yield and labour (two principal economic parameters that are of importance to farmers). In this *ex-ante* economic analysis, only the plantain-*Gliricidia* and the control (i.e. plantain-no legume) treatments are considered. The comparative advantage of the *Gliricidia* mulch on plantain yield is taken to be its potential to sustain production over a 10-year productive period after which the hedgerows may have to be replaced. The extra costs a farmer incurs in adopting the technology relate to legume seeds/seedlings and labour to plant and establish the hedgerow in the first year. It also includes labour to prune the hedgerow and apply the biomass as mulch over the productive life of the hedgerow. Costs saved may be reduction in labour for weeding upon application of the mulch and labour for land preparation every three to four years following natural fallow as this is done only once in a hedgerow system.

For this analysis, the control with sole plantain is assumed to be the traditional system if a farmer does not adopt the technology and is managed under a 3-year cropping and 4-year natural fallow rotation system. It was observed from the initial characterization of the farming system that, the average cropping and fallow phases for plantain fields are 3 or 4 years, ranging from 2-6 years in Gogoikrom and Subriso III. Due to the declining soil fertility and increasing land scarcity, most plantain fields are cropped for 3 years and fallowed for 4 years where the farmer has sufficient land. On the other hand, where land is limiting the farmer may choose to grow the plantain for two years and fallow the land for three years.

By not adopting the technology, the farmer saves on money and labour for establishing the legume hedgerow, pruning and mulch application. However, his opportunity cost for doing so is the extra weeding labour cost that he has to incur if he is to weed thrice in a year. Assuming his fallow management regime is sufficient to enable appreciable production, he loses the benefits of windbreak, which is particularly important nowadays to save plantain from lodging during windstorms at the onset of the rainy/cropping season of every year.

Data on farmers and their plot characteristics as well as some initial input-output data on establishment of the technology were collected in 2001 and 2002. Other primary data were drawn from participatory budget information for plantain production in Subriso III collected during the initial livelihoods characterization (Moss *et al.*, 2000). The participatory data relates to the traditional plantain system covering resources, costs and returns on a monthly basis for plantain production over 3 years after which the land is fallowed.

Since the plantain-legume technology was only properly established in 2002, it has been possible to estimate only labour used for establishing the technology in the first year (2002) from farmer experimental plots. Labour estimates for pruning and mulching used in this *ex-ante* analysis have been drawn mainly from work reported by Avila (1992) and Dvorak (1996), for pruning and mulching in *Leucaena Leucocephala* alley cropping systems on farmer fields in Western Nigeria (due to limited information on labour for managing *Gliricidia* hedgerows in the literature) and from other work on *Gliricidia* hedgerows reported by Sumberg *et al.* (1985). Other sources of information for the analysis include Ruhigwa *et al.* (1995) and Banful *et al.* (2000). The experiments are continuing on farmer fields; consequently, details on seasonal plantain yields and labour requirements for pruning, mulching and weeding from the 2003 cropping season onwards will be estimated for more accurate economic analysis in the future.

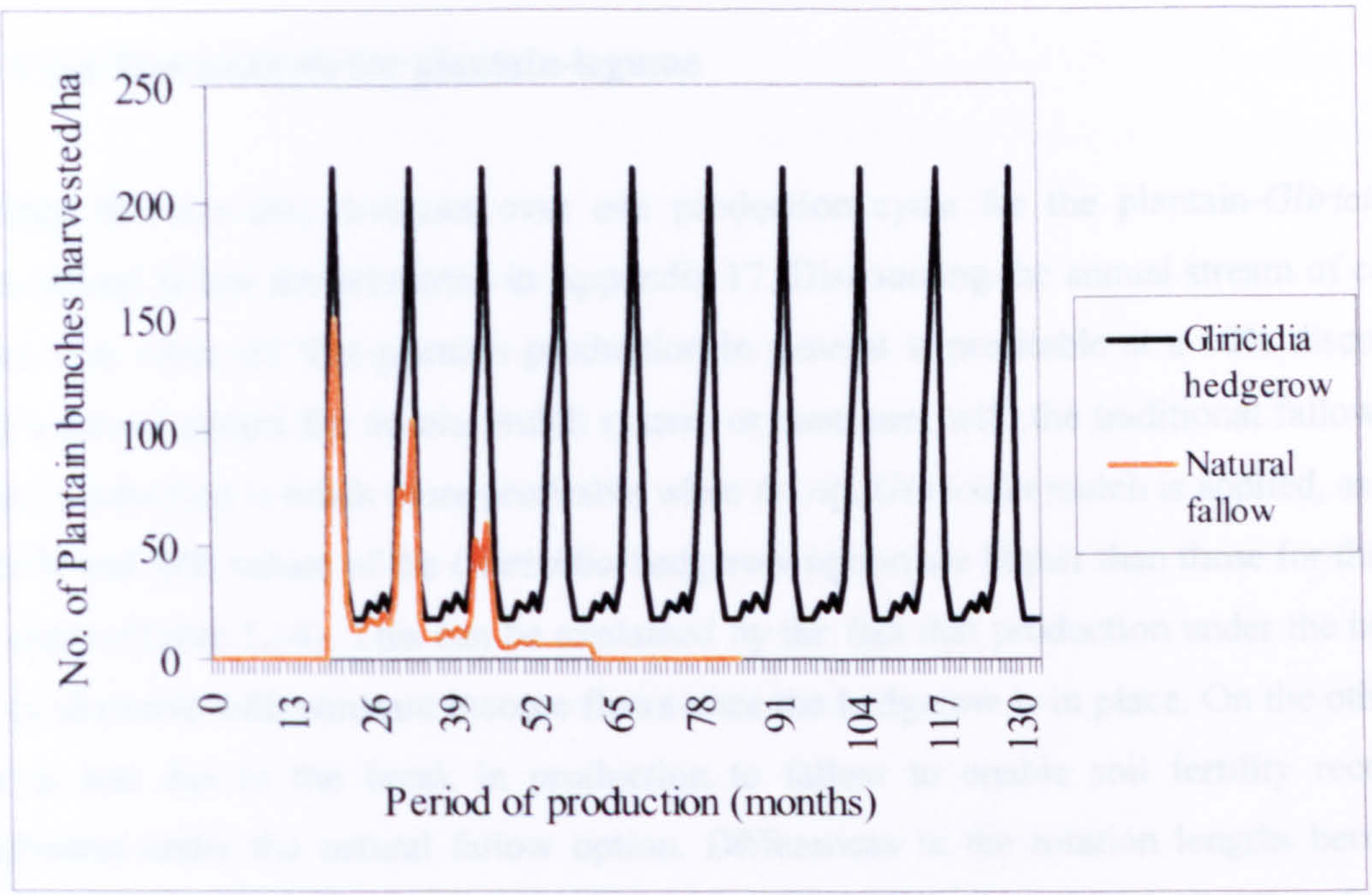
Major costs included in the analysis are those for land, tools, planting materials (plantain suckers and *Gliricidia sepium* seedlings) and labour for establishing and managing the plot over one production cycle. The bulk of the produce would be sold at the farm gate; hence, no marketing costs are included. About 70% of the experimental farmers are landowners (who do not pay for the use of land) as plantain is a longer duration crop requiring a more secured tenure. However, tenants are becoming involved due to its cash value. Some may rent the land (pay by cash) and others sharecrop on an *abunu* basis. The opportunity cost of land is estimated as that of the average cost for rented land.

Refilling of the plantain plot is done annually after the first year in order to increase the density of the plantain stand following harvesting of bunches in subsequent years. This activity is done with about 10% of the quantity of suckers planted in the first year (Moss *et al.*, 2000). Annual suckers used for this operation are obtained from the existing stock on the plot at no cost. This is income foregone, which has been estimated as an annual cost of production in addition to annual weeding, pruning, and mulch application, that constitute the annual maintenance schedule for the technology. If the farmer has more than what is required for refilling, he may sell the remaining suckers to others for an income. On other hand, if for some reason (e.g. the mother plants are not very productive, nematode and termite attack, drought and wind/rainstorms leading to severe lodging, etc.) his stock of suckers is inadequate for refilling, he may have to purchase them from others or from the market.

Pruning labour is hypothesized to be a function of tree species, tree number and time elapsed between prunings. Environmental conditions between prunings affect tree growth and pruning labour. Sumberg *et al.* (1985) reported that about 18 man-days per hectare are required for pruning a *Gliricidia* hedgerow system. The total pruning labour required over a season will depend on the pruning frequency (Dvorak, 1996). An optimal cutting interval of 12 weeks is recommended for *Gliricidia sepium* hedgerows (Simon and Stewart, 1992). For this analysis it is assumed that two prunings of the *Gliricidia* hedgerows per year are appropriate, the first in March/April at the on-set of the rains and the second 3-4 months (between June and July) afterwards since farmers are already burdened with labour problems during the periods when the pruning is needed. The first pruning requires more labour than the second, as there would be about 8 months of growth from August of the previous year. The second pruning with only 3-4 months growth would obviously require less labour. It is anticipated that successive pruning will increase the overall labour requirement for the season but at a deceasing rate (Dvorak, 1996). This is because the total pruning and mulching labour is likely to decline as the hedgerow ages, but due to the unavailability of such information it will be assumed to be the same over the 10 years. The first year is for establishing the *Gliricidia* hedgerow and so no pruning and mulching are undertaken.

For the purpose of estimating the effect of the mulch on weed control, it was assumed that number of weedings will reduce from 3 to 2 from the first to the second year of mulching and remain constant until the end of a productive period of 10 years for the plantain or hedgerow. The first weeding is done in April and the second in October before the dry season.

Only one production cycle or rotation is considered in comparing the profitability of the plantain-legume and plantain-natural fallow options. Plantain bunches (fruits) are the only tangible product earning returns from the system. Plantain begins fruiting about 18 months after planting. The seasonal yield pattern for plantain under the traditional three-year cropping and four-year natural fallow system as reported by farmers in the participatory crop budget in Subriso III is as shown in Figure 5.2. Production peaks in November in the first harvest year after a natural fallow is cleared, where about 150 or more plantain bunches per hectare may be harvested. This declines by 30% in the subsequent years since production relies on inherent fertility of the soil, until the plot is fallowed after the third harvest year.



Source: Field notes (Moss *et al.,* 2001).

Figure 5.2: Seasonal plantain yield pattern over one production cycle

As stated above the *Gliricidia* hedgerow technology is expected to improve and sustain plantain yield over a longer period of time. It is assumed that the *Gliricidia* mulch increases plantain yield in the hedgerow system by 43% over the sole plantain (Smith, 1992). The yield pattern is assumed to be constant over the productive life of the plantain (Figure, 5.2), although it may decline with decline in biomass production as the hedgerow ages. For the sole plantain treatment, no tilling or maintenance activity is undertaken during the fallow as land is left to rest, although a few bunches may be harvested from remnants of plantain stands in the fallow vegetation in the first few months. It is assumed that the quantity of plantain harvested gradually declines to zero as the fallow ages.

All input costs and prices were assumed to be constant in real terms over the 10-year production period. Although the wage rate for daily labour increased each year by ¢1000 over the period of research, a daily labour wage of ¢7000 paid in 2002 was used throughout in the analysis. The average price per bunch of plantain in 2002 estimated at ¢5,000 remained constant during the productive period of the plantain. In real terms there are seasonal variations in price of plantain, usually determined by both supply (dictated by weather conditions) and demand (urban and foreign markets).

5.3.2.1 Cash flow analysis for plantain-legume

The stream of costs and revenues over one production cycle for the plantain-*Gliricidia* and plantain-natural fallow are presented in Appendix 17. Discounting the annual stream of costs and revenues, it is observed that plantain production in general is profitable at a 10% discount rate whether a farmer adopts the *in-situ* mulch system or continues with the traditional fallow option. However, production is much more profitable when *in-situ Gliricidia* mulch is applied, as the B/C ratio, EAV and IRR values of the *Gliricidia*-hedgerow option are higher than those for the natural fallow option (Table 5.14). This can be explained by the fact that production under the hedgerow system is intensive with constant income flows once the hedgerow is in place. On the other hand, income is lost due to the break in production to fallow to enable soil fertility recovery or replenishment under the natural fallow option. Differences in the rotation lengths between the plantain-mulch and the natural fallow systems resulted in different cash flow patterns which made the NPV's of the two systems incomparable, although their BCR's and the IRR's could be compared. To resolve this anomaly, the NPV's were converted to EAV's using the formula, $NPV\,x\frac{(1+r)^n\,xr)}{(1+r)^n-1}$, where n is the nth month during the rotation. The EAV's are comparable as they are expressed on annual basis (Bright, 2001).

The superiority of the plantain-*Gliricidia* hedgerow over the plantain-natural fallow production system is further confirmed by its higher discounted return to labour value of 2.9 as compared with 1.3 for the natural fallow, although it requires about three times the amount of labour resource, primarily for planting and managing the hedgerow.

Table 5.14: Profitability of plantain-*Gliricidia sepium* and plantain-natural fallow

Profitability indicator	Plantain - *Gliricidia sepium* hedgerow	Plantain - natural fallow
B/C Ratio	2.4	1.2
EAV	¢1,680,654	¢122,000
IRR	49%	20%
Discounted Return to Labour (DRL)	2.9	1.3
Discount rate = 10%		

Although the plantain-legume technology has the potential to reduce weeds, thus reducing weeding labour and cost, it increases total labour requirements due to the extra labour required for hedgerow pruning and application of mulch. MacLean *et al.* (2003) argue that, although establishing and maintaining hedgerows is labour intensive, family labour, if available, can readily perform the necessary operations even on 1-3 ha farms. They add that, the more labour available, the greater the benefit from alley cropping. For labour-scarce families, mulching without incorporation of the mulch biomass is the best option since this biomass incorporation is labour intensive. Labour demands may however, decline over the years as the system stabilizes.

5.3.2.2 Sensitivity analysis for plantain-*Gliricidia* hedgerow/natural fallow

The profitability of the plantain system would depend to a large extent on the yield or quantity of the number of bunches harvested, the price and the cost of labour. However assessing sensitivity by varying yields also provides a measure of the effect of varying the relative prices of plantain. Thus Table 5.15 shows the sensitivity to yield variation only.

Table 5.15: Sensitivity analysis for plantain-*Gliricidia sepium* hedgerow and plantain-natural fallow

Factor	Profitability indicators	Plantain -*Gliricidia* hedgerow	Plantain-natural fallow
Base case	B/C Ratio	2.4	1.2
	EAV (¢)	1,680,654	122,000
	IRR (%)	49	20
	DRL	2.9	1.3
20% Increase in yield	B/C Ratio	2.8	1.4
	EAV (¢)	2,263,442	138,475
	IRR (%)	59	32
	DRL	3.5	1.6
20% Decrease in yield	B/C Ratio	1.9	0.94
	EAV (¢)	1,097,865	-197,96
	IRR (%)	37	6
	DRL	2.2	0.92

As indicated above, plantain production in Ghana is currently prone to two main production influences, namely soil productivity (fertility and nematodes) and the weather. These make yield highly unstable. Table 5.15 confirms the fact that stability in plantain system profitability is highly dependent on yield enhancement factors. A 20% increase in plantain yield favours both the *Gliricidia* hedgerow and the natural fallow systems. Conversely, the *Gliricidia* hedgerow option with relatively better soil conditions is still profitable when yield declines by the same proportion while the natural fallow is not. Thus, the plantain-*Gliricidia* technology is comparatively stable and worth adopting. Even if the new technology were to exhibit a 20% lower yield than expected, it would still be more profitable than the natural fallow with no yield decline (e.g. IRR = 37% and 20% for plantain-*Gliricidia* and natural fallow respectively).

5.3.3 Cocoa-shade tree technology

A detailed description of the cocoa-shade tree technology planted is presented in Chapter 3. The technology comprises two blocks measuring 24 x 54 m (1296m^2) of hybrid cocoa and seven indigenous shade tree species per block, intercropped with plantain, cassava and other crops. It is designed to mimic the traditional system but improved with planted shade trees. Each farmer planted 320 hybrid cocoa seedlings (160 per block) and food crops (early shade) in any pattern desired with no regular spacing (the way they normally plant crops), but planted the tree seedlings at 12m x 12m triangular spacing. The control is the traditional practice, where selected natural coppice shoots of indigenous trees are retained after clearing of the vegetation to provide shade for the cocoa. However, the volume of such shade tree species is declining on cocoa fields, reducing cocoa productivity.

It is hypothesized that the indigenous shade trees planted will sustain cocoa yield and prolong its productive life, while the productive period of cocoa on the control plot with no planted shade trees will be lower. In other words, the optimum plantation age is assumed to be higher if farmers adopt the practice of planting desirable shade trees than when they continue with the traditional practice. Thus cocoa in planted shade tree systems are expected to yield higher returns than those grown in the traditional systems. A productive period of eighty years for the cocoa is considered for this analysis, although this length of time may be uneconomic.

Data employed for the analysis is largely from primary sources gathered from 2001 to 2002, supplemented with secondary data. A seasonal cropping calendar on cocoa production developed during the initial farming system characterization provided basic information on the series of activities undertaken over the productive life of the cocoa. Data on farmer and plot characteristics and on inputs and outputs were gathered in the first year of establishment of the technology.

The cocoa yield pattern over the eighty year production period was estimated from data on cocoa collected from a sample of 25 farmers comprising both participating and non-participating farmers on their traditional cocoa fields under different stages of growth. This strategy was used as a proxy for the estimation of cocoa yields and costs of operation beyond the first year of establishment, as the farmer experiments only began in 2001. Data on quantities of cocoa sold and price per kilo in various years were also gathered on these proxy cocoa fields from farmer cocoa sales record books. Adapting work done by Ryan *et al.* (2003) which showed a positive relationship between the age of a cocoa plantation and its yield, a cocoa yield curve was fitted from a regression of the age of the plantation on cocoa yield. Table 5.16 shows the result from the regression in which natural log of cocoa was the dependent variable.

Table 5.16: Output from a regression of age of cocoa plantation on cocoa yield

	Coefficients	Standard Error	*t*- Statistic	*p-value*
Intercept	-1.822	1.688	-1.079	0.300
Age of cocoa plantation (YRS)	-0.166	0.047	-3.563	0.004
Natural log of age	3.931	1.014	3.877	0.002
$R^2 = 0.54$; F = 7.56				

The results of the regression showed a significant relationship between the natural log of cocoa yield and plantation age and its natural log, i.e. $R^2 = 0.54$ and F = 7.56. Figure 5.3 shows the derived cocoa yield pattern, with a maximum yield of about 800kg/ha occurring in year 25. The equation for estimating the yield of cocoa in any year during the eighty-year production cycle is, therefore, as follows:

Y= exp (-1.822 - 0.166 x age + 3.931 x ln (age)-----(1)

Where Y is cocoa yield/ha and age is age of the cocoa plantation in years.

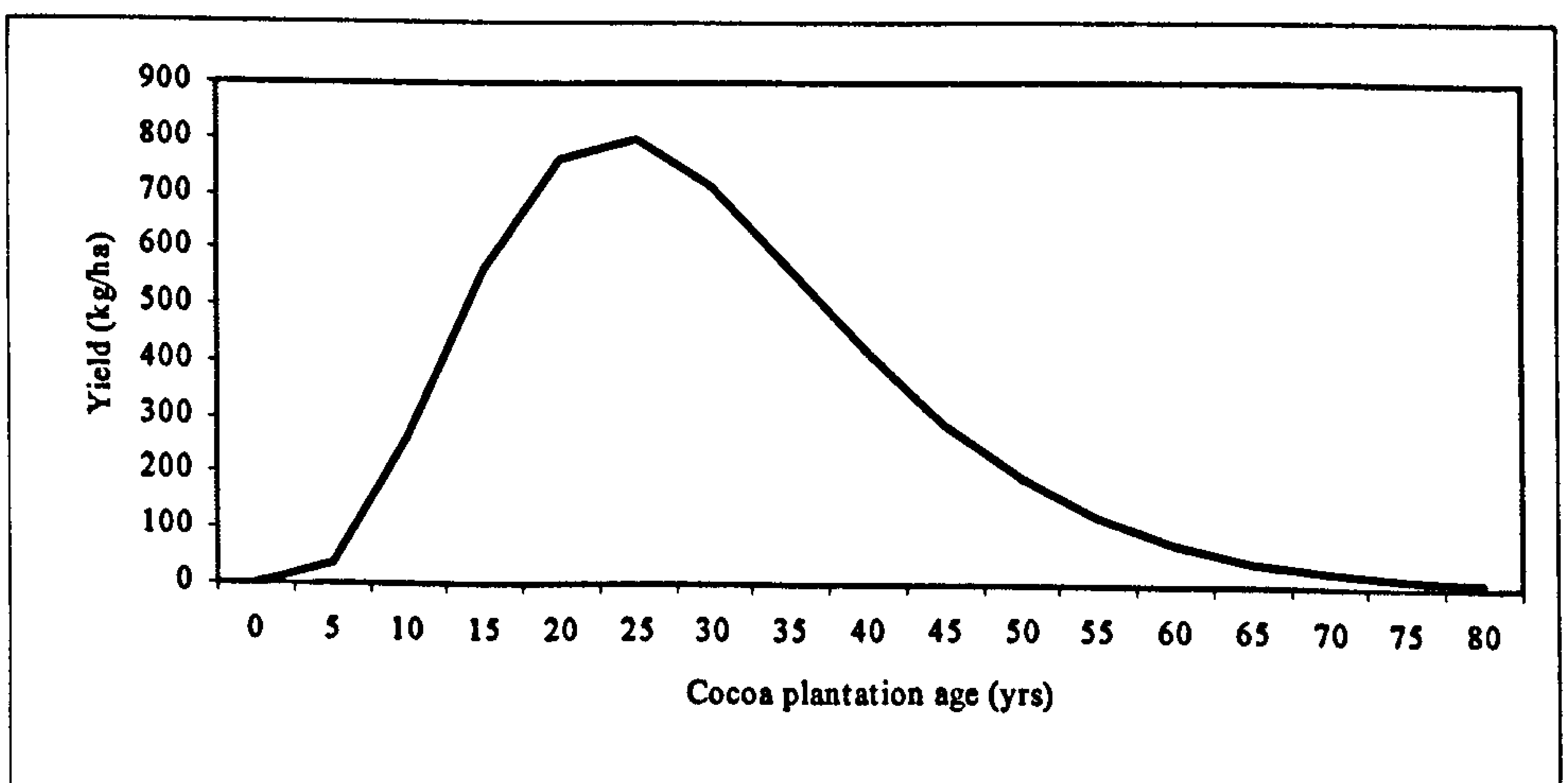


Figure 5.3: Derived cocoa yield pattern in the traditional system

A mixture of cocoa varieties, amelonado and amazonia and the hybrid are planted in the traditional system. The hybrid cocoa used in the technology is early maturing and high yielding, beginning to fruit in the fourth year with a productive life of over 50 years depending on the level of shading and how the plantation is maintained, i.e. regular weeding/brushing, removing epiphytes such as the mistletoe, spraying against insect pests such as capsids and mealy bugs and fungal diseases such as the black pod and destroying trees attacked by the swollen shoot virus.

Costs of production and prices considered in the analysis were estimated at 2002 figures at the farm gate. Extra costs incurred by the farmer in adopting the technology are that for tree seedlings and labour cost for establishing the trees, i.e. pegging, digging holes and planting. The first four years of production are considered as the establishment phase of the crop. Cocoa closes canopy in about the eighth year. After this period, the costs of all operations undertaken are assumed to be the same until the end of the productive life.

Costs related to protecting the cocoa (removing epiphytes, spraying against pests and diseases, etc.) are important but could not be estimated because farmers interviewed hardly undertook these activities and so were unable to assign costs. No marketing costs are considered as the bulk of the produce, including cocoa, is sold at the farm gate. As mentioned above, there are numerous tenants involved in cocoa cultivation. In order to simplify the analysis, the cost of land for cocoa production is assumed to be the value of the initial sum of goodwill money paid by tenants involved in sharecropping under the *abunu* arrangement as this is the common mode of access to land for cocoa cultivation by most people, including some landowning families with insufficient land resources.

Returns estimated from the treatments include that of food intercrops, i.e. maize, plantain, cocoyam and cassava in the establishment phase. These are planted as nurse crops providing early shade and are also important in providing early cash and food for the farm household and cash for the maintenance of the cocoa, while awaiting cocoa proceeds. Cocoa output, i.e. bags of processed beans per hectare, is the only long-term tree product estimated in the analysis.

Since the experiment is long-term, the real effect of the shade tree on cocoa yield, i.e. the ability of the shade tree to improve and sustain cocoa production is assumed to be its ability to prolong cocoa yields up to 80 years. The income lost if the farmer does not adopt the technology, i.e. continues with the traditional practice of not planting trees on his cocoa farm (but is likely to have fewer stands of naturally occurring trees) is the lower total cocoa output harvested, since maximum production will lower. He also loses possible income from tree products, including timber, fruits, medicine and so on.

It is known that a cocoa plantation is less productive with insufficient shade trees (PAN, 2001). This means a reduction in the maximum point of production and/or a reduction in the age at which the maximum yield occurs, but the question is by how much? There seems to be limited quantitative information on the effect of indigenous tree shade on cocoa, particularly the marginal yield differences between optimum shade and that below the optimum. Consequently, hypothetical cases were considered in order to estimate the yield pattern for the improved and traditional cocoa systems with and without planted shade trees.

The Ryan *et al.* (2003) equation takes into account optimum shade for cocoa, which gives a maximum yield of 1200 kg/ha. Adapting the equation for the traditional Ghanaian system with insufficient shade (i.e. equation 1) gave 800kg/ha. Assuming the cocoa shade tree technology ensures optimum shade, then there is the possibility of improving yield by about 50% (i.e. (1200–800)/800) kg/ha). Moreover, shade tree population is continuously depleting on cropland, which means yields are likely to decline in the future. Consequently, 50% minimum and maximum changes in yield about the traditional system were assumed for determining the curves for the planted and without planted shade trees scenarios (Figure 5.4).

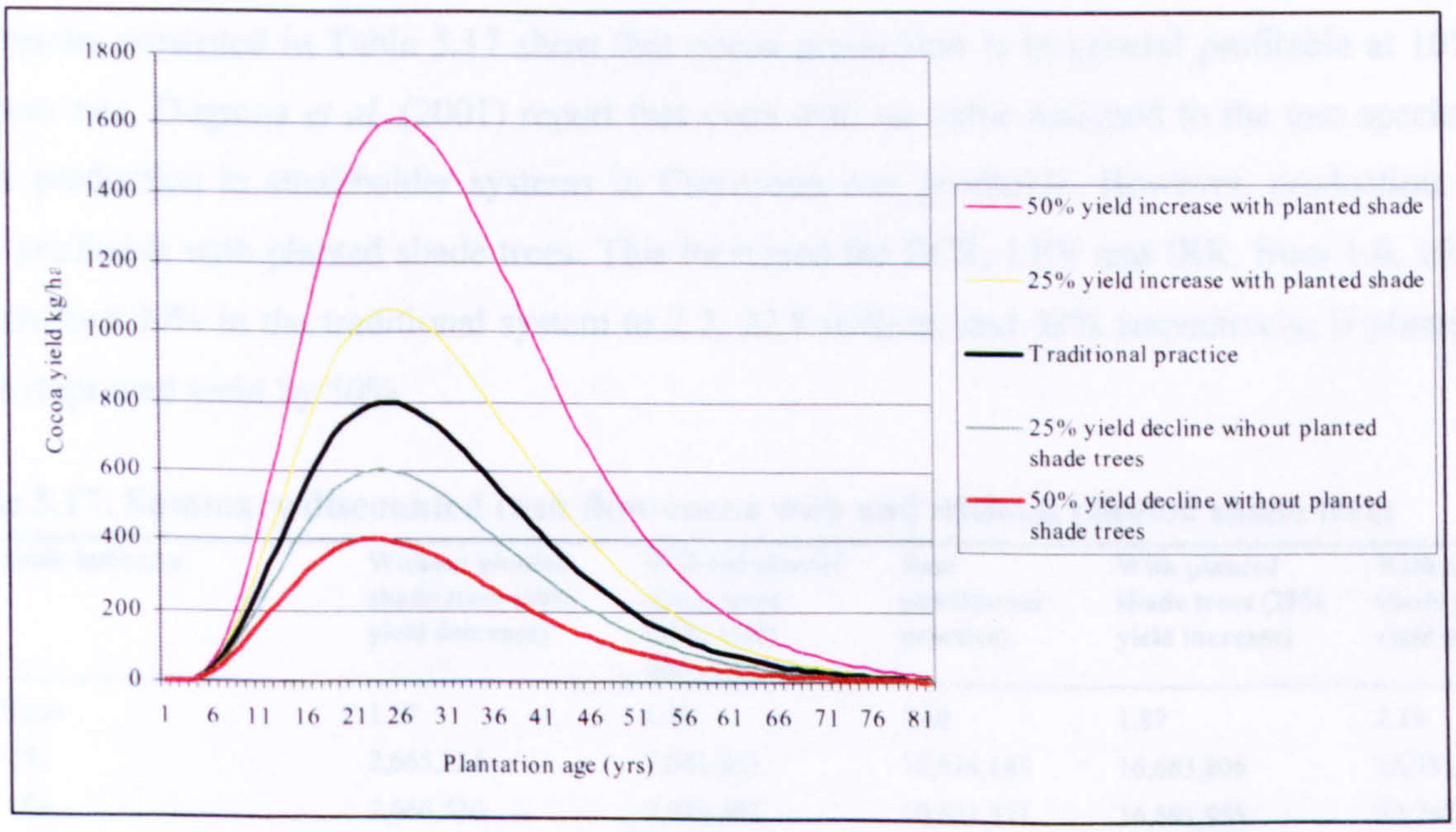


Figure 5.4: Derived cocoa yield patterns in planted and without planted shade tree systems

The equations for these are as follows:

= exp (-1.822-0.166 x age + 3.84 x ln (age) ------(2)

= exp (-1.822-0.166 x age + 3.71 x ln (age) -----(3)

= exp (-1.822-0.166 x age + 4.02 x ln (age) ------(4)

= exp (-1.822-0.166 x age + 4.15 x ln (age) -----(5)

The age at which the maximum yield occurred increased slightly from 24 years in the traditional system to 25 years with 50% yield increase whereas it declined to 22 years, if yield decreased by the same proportion (Figure 5.4). This suggests that improvement in yield as a result of the planted tree shade may be more important.

5.3.3.1 Cash flow analysis for cocoa-shade tree

The discounted cash flows are presented in Appendix 18. Economic indicators estimated are the B/C Ratio, NPV, LEV and IRR. The summarized discounted cash flow analysis for the cocoa with planted shade trees and that for traditional technologies (Table 5.17). The important extra variable costs between the planted shade and traditional options are those for purchasing and transporting indigenous tree seedlings and labour for planting. These are the extra costs resulting from adopting the technology.

The results presented in Table 5.17 show that cocoa production is in general profitable at 10% discount rate. Duguma *et al.* (2001) report that even with no value assigned to the tree species, cocoa production in smallholder systems in Cameroon was profitable. However, production is more profitable with planted shade trees. This increased the BCR, LEV and IRR, from 1.6, 10.6 million, and 30% in the traditional system to 2.2, 22.8 million, and 38% respectively, if planted shade improved yield by 50%.

Table 5.17: Summary discounted cash flow-cocoa with and without planted shade trees

Economic indicator	Without planted shade trees (50% yield decrease)	Without planted shade trees (25% yield decrease)	Base (traditional practice)	With planted shade trees (25% yield increase)	With planted shade trees (50% yield increase)
B/C Ratio	1.17	1.40	1.60	1.87	2.19
NPV (¢)	2,665,224	7,041,963	10,616,185	16,683,806	22,751,427
LEV (¢)	2,666,526	7,045,402	10,621,371	16,691,955	22,762,539
IRR	20%	30%	30%	35%	38%
Max NPV (¢)	2,670,990	7,044,317	10,617,418	16,684,496	22,751,842
Max LEV (¢)	2,706,679	7,117,530	10,707,101	16,820,541	22,933,981
Age of maximum NPV (yrs)	52	60	64	68	71
Age of maximum LEV (yrs)	41	42	44	44	44

The optimum rotation age from the standpoint of the LEV is a little over 40 years for the planted and without planted shade tree scenarios over the 80-year rotation, although planting shade trees will improve income and enhance the ecosystem and provide other benefits to the farmer.

5.3.3.2 Sensitivity analysis for cocoa shade tree

Cocoa production is still profitable with a fall in cocoa price, although quite sensitive to this change. A 20% reduction in cocoa price reduced profitability generally across all scenarios. Profitability is marginal under this condition if yield declines by 50%.

Table 5.18: Sensitivity of profitability of the cocoa-shade tree technology

Economic indicator	Without planted shade trees (50% yield decrease)	Without planted shade trees (25% yield decrease)	Base (traditional practice)	With planted shade trees (25% yield increase)	With planted shade trees (50% yield increase)
B/C Ratio	1.00	1.19	1.3	1.56	1.81
NPV (¢)	56223	3281227	5762089	10616185	15470282
LEV(¢)	56250	3282829	5764903	10621371	15477838
IRR	10%	24%	24%	30%	34%
Max NPV (¢)	70815	3285764	5764385	10617418	15471047
Max LEV (¢)	72133	3325224	5816349	10707101	15597853
Age of maximum NPV (yrs)	42	54	60	64	68
Age of maximum LEV (yrs)	42	42	44	44	44

According to Osei-Bonsu *et al.* (2002) shade for cocoa is becoming a critical issue in Ghana as a result of extensive deforestation. The implication is that if farmers are not encouraged to plant shade trees, cocoa productivity will be severely affected in the future. Unless prices appreciate, downward changes in prices will render production marginally profitable, becoming unprofitable if yield reduces below 50%.

The optimum rotation age however, remains the same whether trees are planted or not or prices appreciate or fall. The present shade level is just sufficient to ensure economic production up to about 44 years. However, it would be more profitable if improved, and returns are likely to double by this time. This suggests that the economic rotation age (probably irrespective of cocoa variety) is about 40 years. It may be more economic to replant the plantation after 40 years, rather than waiting until the 80 years practiced in the traditional system.

5.3.4 Planted Tree Fallow

The planted tree fallow experiment was carried out in Yabraso-Wenchi and involves two 20m x 20m blocks, one planted to a *Gliricidia* fallow and the other left under natural fallow. This analysis involves the comparison of maize production following one *Gliricidia* fallow rotation with that following natural fallow.

The entire period under consideration is about 30 months, i.e. 2.5 years. The *Gliricidia* was planted in May-June in the first season (2002) and the fallow cleared in February in the third season (2004) and cultivated to maize which is harvested in September for sale and/or storage. The stream of costs and revenues for the *Gliricidia* and natural fallows are presented in Appendix 22. The extra costs the farmer incurs in adopting the technology cover *Gliricidia* seedlings (3,300 plants per hectare) and transportation of the seedlings to the farm; labour for clearing, lining, pegging, digging holes, planting and ring weeding the *Gliricidia* once in the first year to aid establishment. Land cost is assumed to be zero since the technology is likely to be adopted only by landowners who due to their land status may be interested in tree fallows. It is also assumed that only one weeding of the succeeding maize is required after the *Gliricidia* fallow, but two in the natural fallow as *Gliricidia* shades out weed completely and the mulch suppresses/delays weed growth. Returns from maize and stakes are the potential income earned from the system.

Data for the analysis was drawn from primary data collected for input-output analysis for maize crop production during the initial characterization, supplemented by other data from the maize-legume and plantain-legume sections 5.2.1 and 5.2.2 as well from work done by Kaya and Nair (2001) on *Gliricidia sepium* fallow in southern Mali. All inputs and output values were estimated in 2002 figures at Yabraso, except that for *Gliricidia* seedlings and stakes which are not tradable items in the area.

According to Kaya and Nair (2001) soil parameters did not change after the *Gliricidia* fallow, but maize yield improved over that of a grass fallow at the end of two seasons of the fallow. Differences in ecological factors, particularly soils and rainfall between Mali and Wenchi (Table 5.19) are likely to influence the growth of fallow vegetation or development, hence fallow productivity. This ultimately will affect maize yields with those of Wenchi, which has better growth conditions, likely to be better than obtained in Mali.

Table 5.19: Ecological differences between Wenchi-Ghana and Southern Mali

Site characteristic	Wenchi	Southern Mali
Ecology	Forest-savanna transition	Sahel
Soils	Sandy clay loam-savanna orchosols (with some lithosols and brunosols)	Sandy loam
Rainfall pattern	Bi-modal	Uni-modal
Rainfall amount	1140-1270 mm	850mm

Sources: Atta-Quayson (1999) and Kaya & Nair (2001)

Although *Gliricidia* is one of the most researched multipurpose agroforestry species, many of the studies relating to smallholder production have been concerned with its use for mulching in alley cropping systems. Due to the lack of data or information on the performance of *Gliricidia* fallows in the savannah transition areas of the tropics or SSA, the Mali figures are adopted to portray the possible effect of such a fallow on the livelihoods of farmers in the study area. In the Mali study, maize yield following the *Gliricidia* fallow increased about 3 times over that of the natural grass fallow (Table 5.20). Average maize yield following 2-3 years natural fallows in Yabraso (from input-output data collected for the livelihood characterization) was estimated as the base yield i.e. the yield without the technology or if the farmer does not adopt the *Gliricidia* fallow which is considered as the control treatment in the experiment.

Table 5.20: Maize yield after *Gliricidia sepium* and natural grass fallow in Southern Mali

Technology	Maize yield kg/ha	% Increase	No. of times
Grass fallow	714		
G. *sepium* fallow	2170	203.9	3.04

Source: Kaya & Nair (2001)

Table 5.21: Maize yield after *Gliricidia sepium* and natural fallow (adapting the Mali case)

Technology	Index of yield	Maize yield kg/ha	No. of bags (100kg = 1 maxi bag)	Price/bag (¢)	Output value (¢)	Variable costs/ha (¢)	Total cost/ha (¢)	Net gain / ha (¢)
Natural fallow	100%	1410.0	14.1	100,000	1,410,000	125,829	995,846	414,154
Gliricidia fallow	304%	4285.4	42.9	100,000	4,290,000	1,104,888	2,336,870	1,953,130

Stakes are not normally purchased for yam production, labour costs of gathering are paid by a few; otherwise standing dead trees are used as support for trailing yam vines. The cost of stakes was estimated from Subriso where they are sold at variable prices ranging from ¢40-¢180 per stake. In pricing stakes, it is assumed that the stake may cost at least ¢100 using the average figure from Subriso since it has no market value or the demand for it is low but may gain value in the future as deforestation is intensifying in the area. The quantity of stakes produced was assumed to be equivalent to the number of *Gliricidia* seedlings planted per hectare, if each seedling develops into a single tree.

5.3.4.1 Cash flow analysis for planted tree fallow

The discounted cash flows for the planted tree fallow are presented in Appendix 19. More cash resources are invested but higher return is earned from the *Gliricidia* fallow as compared with the natural fallow. To adopt the *Gliricidia* fallow, the farmer requires about nine times cash resources as that required for the natural fallow while the return from the *Gliricidia* is about 3.5 times that for the natural fallow (Table 5.21). Both fallow alternatives are profitable but that planted to *Gliricidia* is more profitable yielding higher NPV and EAV of ¢1.5 million and ¢750,000, that are about 5 times that of the natural fallow (Table 5.22).

Table 5.22: Summary discounted cash flow analysis for maize following *Gliricidia sepium* and natural fallows

Profitability indicator	*Gliricidia* fallow	Natural fallow
B/C Ratio	1.8	1.4
NPV	¢1,585,279	¢303,072
EAV	¢747,722	¢142,949
Monthly IRR	4%	9%
IRR	62%	184%

The IRR values indicate otherwise because of the initial costs incurred in planting the *Gliricidia* fallow which does not occur for the natural fallow, making their cash flow patterns differ. This shows that the IRR may not a very good indicator of profitability in this case.

5.3.4.2 Sensitivity analysis for planted tree fallow

Table 5.23: Sensitivity analysis of *Gliricidia sepium* and natural fallows

Factor	Profitability indicator	*Gliricidia* fallow	Natural fallow
Base case	B/C Ratio	1.8	1.4
	NPV (¢)	1,585,279	303,072
	EAV (¢)	747,722	142,949
	Monthly IRR	4%	9%
	IRR	62%	184%
20% labour cost increase	B/C Ratio	1.6	1.2
	NPV (¢)	1,326,434	183,054
	EAV (¢)	625,634	86,341
	Monthly IRR	3%	6%
	IRR	51%	91%
20% maize price decrease	B/C Ratio	1.4	1.1
	NPV(¢)	909,917	80,856
	EAV (¢)	429,177	38,137
	Monthly IRR	3%	3%
	IRR	43%	49%

Both fallows are still profitable should labour cost increase and the price of maize fall by 20%, although the *Gliricidia* is superior and more stable. However, these fallow options may be very sensitive to downward price trends as the 20% decline in maize price sharply reduced the NPV and EAV values to nearly half of the base scenario for the *Gliricidia* and a third of that for the natural fallow (Table 5.23).

5.4 Determinants of farmer participation/Adoption

This section briefly examines the adoption potential of the technologies. It was hypothesized at the onset of the study that working with farmers in a participatory manner to design and develop the technologies for improving fallow productivity would enhance their adoption, as this would enable constraints that are likely to impede adoption to be addressed during the experimentation process.

The literature is replete with factors that either positively or negatively influence small farmers' adoption decisions of improved agricultural technologies in the developing world. According to Lutz *et al.* (1994) the biophysical properties of a technology may not be the only factors constraining the decision to adopt the technology. Also, the profitability of the technology may not be or guarantee its adoption. Normally, other factors such as tenure insecurity, labour unavailability, and so on might prevent a household from adopting a new system. Commonly reported adoption determinants include those relating to land availability, land and tree tenure, labour availability and cost as well as the profitability of the technology relative to the old practice. Other factors influencing adoption of agricultural innovations include the duration it takes for benefits to be realized, the need for the technology (i.e. whether technology solves a perceived problem), availability of technological inputs including seeds, cash to purchase the necessary inputs, the know-how and/or access to information or contact with extension. Other classical adoption determinants that are reported relate to education level of farmers, age, and gender among others (Feder *et al.*, 1985; Hoekstra, 1987; David, 1997; Adesina *et al.*, 1999; Pattanayak, *et al.*, 2002; Thangata and Alavalapati, 2003)

Some key factors that may be of relevance to the technologies in relation to the management of fallows and crop production in the study villages are discussed below. Table 5.24 summarizes farmers' participation in experimentation of the technologies and variation in three main characteristics, namely gender, land wealth/status and age of the farmers in the villages.

A farmer's inherent innovativeness may naturally determine his or her desire to either try new things or decline from doing so. However, any production decision made in smallholder systems is a combination of several factors including resource capacity, culture, values and so on. The interaction between gender, age and land wealth influenced farmers' decision to participate in experimentation (Table 5.25). To be able to participate in experimentation of any of the technologies implied having an appropriate tenure associated with particular test crop to enable the farmer benefit from the innovation. Moreover, gender roles within the household as well as gender and age niches associated with particular test crops also influenced the desire to experiment.

Table 5.24: Participation and non-participation and farmer characteristics across study villages

Farmer categories	Gogoikrom-Atwima (%)			Subriso III-Tano (%)			Yabraso-Wenchi (%)			Total Across Villages (%)		
	VP[1]	PF[2]	NPF[3]	VP[1]	PF[2]	NPF[3]	VP[1]	PF[2]	NPF[3]	VP[1]	PF[2]	NPF[3]
Gender												
Male	74	76	68	62	72	56	67	48	75	68	69	66
Female	26	24	32	38	28	44	33	52	25	32	31	34
Land wealth												
Native landowner men	8	5	14	18	41	4	36	35	36	21	21	20
Native landowner women	6	5	9	10	16	6	35	48	30	17	17	17
Settler landowner men	16	9	36	18	13	22	1	0	2	12	8	15
Settler landowner women	4	3	5	8	9	8	1	0	2	4	4	4
Settler landless men	50	62	18	31	19	39	25	13	30	35	40	31
Settler landless women	16	16	18	14	3	22	2	4	2	11	10	12
Age groups (years)												
<35	35	29	50	26	3	40	18	0	25	26	16	35
35-45	28	31	18	37	31	40	46	61	40	37	37	37
46-55	24	26	18	18	34	8	23	17	25	21	27	17
>55	14	14	14	19	31	12	13	22	10	15	20	11

[1]Village Population, [2]Participating Farmer and [3]Non-Participating Farmer

Table 5.25: Comparing participating & non-participating farmer in study villages

Chi-square test	Gogoikrom	Subriso III	Yabraso	Total/All villages	Degrees of freedom	Significance 0.05	Significance 0.01
Gender	0.49	2.18	5.59*	0.19	1	3.84	6.63
Land status	15.74**	24.80**	4.71	4.09	5	11.07	15.09
Age	3.31	22.89**	9.48*	14.40	3	7.81	11.34

Chi square test: * significant at $p = \leq 0.05$; ** significant at $p = \leq 0.01$

5.4.1 Gender, age and land wealth/status

Generally, all the main community groupings participated in trying nearly all the experiments in the first and/or second year, except the planted tree fallow in Yabraso, for which only native landowners showed interest. The population in the study villages is dominated by male household heads or decision makers in crop production, thus naturally men are more likely than women to be involved in implementing activities aimed at attaining improvements in some aspects of the farming system. Consequently, more men than women participated in the experimentation and are likely to be the prime adopters of the technologies, although in Yabraso there were more women experimenters. The Yabraso exception for the women is probably because the majority of the population are native men and women landowners hence, and the latter have greater autonomy over their production decisions as, although may be married, they usually cultivate lands belonging to their own individual families or inherited from parents. The equally higher proportion of male non-experimenters could be due to restrictions imposed by land status, age and gender niches in crop production, particularly among younger and landless men in Subriso and Yabraso.

The probability of adoption can generally be expected to be higher for land-rich/landowners than for land-constrained/tenant farmers (Buckles & Triomphe, 1999). There is a higher chance for more of the landowners, particularly native middle aged and older landowners, taking up the technologies in Subriso and Yabraso than the landless and younger people in these villages. The native middle aged and older people, especially the men, appear to be more stable in terms of land and/or cash resources; hence may be in a better position to cope with the uncertainties and risks associated with adopting new technologies and are more likely to take interest in long term conservation issues. Conversely the landless and the general younger population appear to be fluid and more oriented to short-term cash opportunities. For the landless majority who could not participate in these villages, insecure tenure to sharecropped (Subriso) or rented land (Yabraso) discouraged participation as tenancy to their maize fields may only be for one year, although accessing land may not be too much of a problem. Some tenants who planted the maize-legume relay technology discontinued participation as they lost access to the use of their plots in the second season. The favourable *abunu* tenure for cocoa in Gogoikrom contributed to the greater participation of settler landless men.

Adoption of fallow management innovations may be very sensitive to realities of uncertainties surrounding land tenure (Cairns & Garrity, 1999). Secure land tenure encourages farmers to consider long-term planning horizons for adoption of agroforestry technologies. A low incidence of shared tenancy (i.e. most people own land) may enable farmers capture the full benefits of investments in long term land or soil improvements. According to Nelson *et al.* (1998) this also affects farmers' confidence with respect to benefits expected from such investments. Shared tenancy is quite high among the landless in the study areas, although rental by cash is more common in Yabraso-Wenchi as it provides a relatively easy means for accessing land for cultivation as the cost of using the land is delayed till the time of harvest. Consequently, tenants are generally less likely to participate.

Settler landowner men showed less interest in participation, particularly in Gogoikrom and Subriso where a couple of settler landowners are found. The observed trend in Gogoikrom is unclear as some men of this age group participated in planting the maize technology but dropped out in the second year. However, in Subriso they are more involved in vegetable production, thus are unlikely to take up technologies related to maize, which is usually cultivated by the landless and elderly landowner men, or plantain, for the elderly landowners. The high proportion of young people who did not show interest in Gogoikrom was because maize is predominantly cultivated by younger landless men from the north having limited tenancy to maize plots.

Generally, fewer women showed interest in participation. Women tend to be more occupied than men due to the extra responsibility for household chores. Thus, they are less likely to participate fully in such activities. For the majority of the landless settler women in all the villages, the chance to participate in planting any of the technologies may rest on their spouse's willingness to participate as the men are usually responsible for the joint fields they cultivate. In Subriso and Yabraso these people were less likely to participate in trying any of the technologies as their husbands were less interested. However, those in Gogoikrom may have the chance to share in the experience of trying the cocoa-shade tree technology.

Generally, women in some parts of Africa are unable to adopt agroforestry innovations, including improved fallows. The main limiting factors include lack of knowledge of the new technology, lack of access to seeds or seedlings and cash or credit to acquire them. Structural factors such as lack of land and labour by women often pose more serious problems to adoption prospects than factors more amenable to policy intervention, such as lack of knowledge or seedlings (Galdwin *et al.*, 2003).

5.4.2 Other factors

Other indirect factors that can be inferred from the study to explain the adoption potential of the technologies include literacy level of farmers, profitability of technologies, labour requirements and the availability of planting material.

5.4.2.1 Education

The proportion of literate farmers who tried the experiments was slightly higher (55%), compared to 45% of the illiterates (Chapter 6). This trend seems to suggest that there might be other important factors that propelled farmers to participate and that formal education may have little influence on adoption of the technologies. However, it also gives an indication that the technologies can be adopted by both literate and illiterate farmers because the techniques involved are not complex, although being literate could motivate innovativeness and the urge to try new things (Kernga, 2003).

5.4.2.2 Profitability of technologies

High establishment costs increase the risk of negative returns from agroforestry interventions with trees and shrubs in the short-term, reducing incentives for adoption (Nelson *et al.,* 1998). The economic assessment of the technologies in Chapter 5 indicates that the technologies are profitable both in the short and long-terms which should make them attractive for adoption. They do not require huge capital outlay, as returns gained far exceed seed and labour costs that may be incurred.

5.4.2.3 Labour

Farmers are often constrained with labour. It is often believed that most small-scale farmers are unable to engage additional labour due to their poor financial status. Thus, so long as the labour demands associated with an innovation are not so high and as long as labour is readily available, and unless other factors take precedence, adoption of an innovation should be enhanced. Also, a technology is attractive for adoption if its returns to, especially, labour are higher than a farmer's traditional practice. The return to labour was high for the technologies which farmers experimented with. The extra labour costs are for planting and managing the fallow species. Although, this is not substantial for all the technologies, except for the plantain-legume which involves a higher labour investment in periodic mulching and pruning, labour to relay and weed the legume may pose slight problems. Available cash resources are low during the period of this activity even if labour is to be hired, and demand for labour to weed is high. However, the technology has the potential to reduce weeding in the subsequent cropping season and, moreover; the return on labour is high.

5.4.2.4 Availability of planting materials

Availability of adequate and appropriate planting material, i.e. seeds and seedlings of tree species may favour agroforestry adoption. Of equally importance is the means of procuring the planting material, especially financial resources for purchasing and transporting the material. While the seeds of the herbaceous legumes tend to be less expensive and farmers are likely to plant fields of less than a hectare in size, cost of seeds for these fallow species may not pose much constraint to adoption. Moreover, they do not need to be propagated in the nursery, making them easier to manage. The cost of acquiring the indigenous tree seeds may be low as they can be collected from the wild and the quantity planted may be low, although propagating into seedlings is required. This can be done at the farmer's own leisure in the backyard, but will require labour for watering. However, the purchase and transportation of *Gliricidia* seedlings may discourage its adoption as this requires a comparatively, higher investment.

The seeds of the herbaceous legume fallow species such as *Mucuna* and *Canavalia* and that of the tree legumes (*Gliricidia*) are available locally in the regions where the study was conducted. The sources may not be known to the farmers in their local areas, however, these species seed profusely, thus enabling farmers to collect/harvest sufficient quantities for subsequent use. A potential market may develop in the future for these species in the traditional communities as the technologies gain prominence and farmers harvest more than they need for their own use. The indigenous tree species used in the cocoa experiment are locally available in the wild in the village and its surrounding communities. Since farmers already possess the knowledge for nursing seedlings, techniques for collection and processing the tree seeds in order not to lose viability may be important in ensuring sufficient quantities for planting and to encourage adoption.

5.5 Conclusion

The fallow productivity-improving technologies appear to be more profitable than their traditional alternatives. Although in certain cases the alternative technologies relying on natural soil fertility were profitable, this might not be sustainable as profitability sharply declined with either a 20% decline in yield or produce price.

Increases in labour cost only reduced profitability moderately, probably because labour increases as a result of the new technologies are not very high. This seems to suggest that an improved productive potential of the soil as well as stable and appreciating produce prices are critical in improving the livelihoods of smallholders. While the former can be handled at the local farm level, the latter is policy and weather-oriented, over which farmers have no control. Therefore, with a fairly good marketing potential, improving the productivity of the land resource, particularly for crop production should be of prime concern as this is the main economic activity of most rural communities. However, post harvest management of the produce is another priority area if farm livelihoods are to benefit from improved fallow productivity.

Gender, age and land status influenced farmer participation in experimentation and are likely to be potential adoption determinants for the technologies. A Chi-square analysis showed that whereas land status (owner or tenant) influenced participation positively in Gogoikrom it negatively affected participation in Subriso and Yabraso. The majority of the participants in Gogoikrom were male tenants (dominant village population) who due to the secure *abunu* tenure they have to cocoa cultivation, showed interest in planting the cocoa-shade tree technology. On the other hand the majority of participants in Subriso and Yabraso were middle-old aged land owners as these are more resourceful with respect to land and are also stable (more glued to the land) and may be able to cope with the risk of trying new technologies and wait for the delayed returns associated with land improvement. Consequently, age significantly affected participation in Subriso and Yabraso where younger people are more fluid and particularly in Subriso are more interested in cultivating vegetables that bring quick and better returns (although production is risky).

Tenants in Subriso and Yabraso, due to tenure insecurity, and women (probably burdened with labour and not the decision maker), particularly in Subriso are less likely to benefit directly from the adoption of the technologies. Overall, the findings suggest that land improvement technologies have a higher chance of adoption where especially, tenure is secured. Even with secured tenure there may be a need to broaden technological options to suit the different farmer categories, according to their production niches but particularly for fallow productivity improvement, landowners and the farmer category above 35 years may be the potential adopters, irrespective of how lucrative these technologies are.

Seed/seedling and labour costs are the extra costs associated with the technologies. Relaying legume in maize increased labour costs by 16% per hectare on average. It was not explicitly discussed with farmers if they are capable of meeting this cost. However, it was observed that this posed a constraint to some farmers during experimentation because money and labour are scarce during the period the legume is planted. Nevertheless, the return to labour for this technology is quite high (Section 5.3.1.2).

Total costs increased by 70% and 135% per hectare in the Plantain-legume and *Gliricidia*-fallow respectively. Planting the indigenous trees also increased the initial cost in the first two years of establishment in the cocoa-shade tree technology by 2% per hectare. Again it is unclear if farmers are able to absorb these costs. However, the livelihood analysis shows that labour and cash resources are normally available at the beginning of the cropping season when these technologies would be planted. Also, farmers are likely to plant smaller acreages of less than a hectare, which reduces the extra cost considerably. Labour for pruning the *Gliricidia* hedgerows for mulching in the plantain-legume requires consideration. This activity would be done twice (March/April and June/July) in a season. Labour and cash resources may be available for the first pruning in March/April but may be a constraint in June/July when these resources are scarce.

Generally, men may be more resourceful with respect to fiscal cash as compared to women (Figure 4.14); hence men may be able to absorb these extra costs more readily than women. However, returns earned from adopting the technologies are appreciable when compared to especially the extra costs for the maize legume relay. Women not constrained by tenure and money stand the chance of gaining favourably from this technology.

CHAPTER SIX
FARMER EVALUATION OF TECHNOLOGIES AND ADOPTION

6.1 Introduction

Farmer evaluation is recognized as an essential step in the monitoring and evaluation aspects of any participatory research process. Prior to the diffusion of a new technology among farmers, there is a need, not only to test the technology under farm conditions, but also necessary to allow its potential users to evaluate and give feedback (David, 1995) that may be useful in refining the technology.

It is increasingly being recognized that, although economic analysis may be valuable in supporting agronomic evaluations of the feasibility of an innovation, innovations that may be promising from agronomic, ecological and economic view points may have other shortcomings that may be identified by farmers. For instance, the taste of a certain cassava variety or the odour of poultry manure may deter some farmers from adopting otherwise very sound and simple improved varieties or soil fertility innovations (Baum *et al.*, 1999). It is thus important to undertake farmer assessment of on-farm innovations to complement agronomic and economic evaluations. It is believed that farmers' assessment or perceptions of technologies developed with them will aid in determining the usefulness of the technologies to their circumstances and aid in better understanding of some complex socio-economic factors that may impinge on farmers' decisions on the use of the technology, and thereby identify any constraints that may inhibit adoption.

6.2 Objective and Methods

6.2.1 Objective

The main object of this chapter is to evaluate farmers' perceptions of the technologies experimented with based on the fact that this sort of evaluation is critical or serves as a "quality control" measure that ensures that the new technologies are truly useful to farmers and have a higher chance of uptake. The research questions that were explored in attaining this objective were the following:

1. How valuable are the fallow improvement technologies to farmers' with respect to their ability to satisfy both farm production/biophysical and household/socio-economic needs?

2. How do farmers express these values and by what indicators can these values be measured?

3. What are farmers' experiences and impressions of the workability/practicability of the technologies with respect to the components/design and management requirements including strengths and weaknesses?

4. What factors are likely to influence the uptake of the technologies by the different farmer strata in the villages and what issues do farmers perceive to be critical in enhancing the uptake of the technologies?

These questions were explored to evaluate farmers' perceptions of the value of the technologies to their farms and households, farmer's perception of the workability of the technological components including the design, identification of management constraints, potential modifications or adaptations and potential spread and adoption of the technologies in the study area.

6.2.2 Data collection and analysis methods

There are a number of approaches to farmer evaluation. Methods used vary from informal to formal and so does the level of farmer participation (David, 1995; Degrande 2001; Cramb and Purcell, 2001; Kanmegne and Degrande 2002; McDonald and Obiri, 2003). Participation may be externally initiated and led by outsiders/scientists, internally initiated and led by farmers or jointly by farmers and outsiders/scientists depending on the objective of the research. In the case of this study, farmers participated in every stage of the evaluation process, but the process was initiated and led by scientists, primarily to enable both parties to learn from the dynamics of the process, as the main project was research oriented.

Both informal and formal methods were used in eliciting the performance of farmer experiments and their potential adoption from groups and individual participating and non-participating farmers. The methods and tools employed for the evaluation of the technologies with the farmers in the study area are illustrated in Figure 6.1. The farmer evaluation process was in three stages during which the methods in Figure 6.1 were applied in collecting the relevant data for this analysis over two years 2001 and 2002 (Figure 6.2). The first stage involved a bi-monthly monitoring schedule for individual farmer experiments. Scientists, extensionists and respective farmers conducted the monitoring visits from the start of the experiment throughout each cropping season. This enabled a systematic collection of quantitative and qualitative data over each season (Okali *et al.,* 1994). Scientists recorded observations made during the monitoring visits on matrix data sheets (Appendix 20).

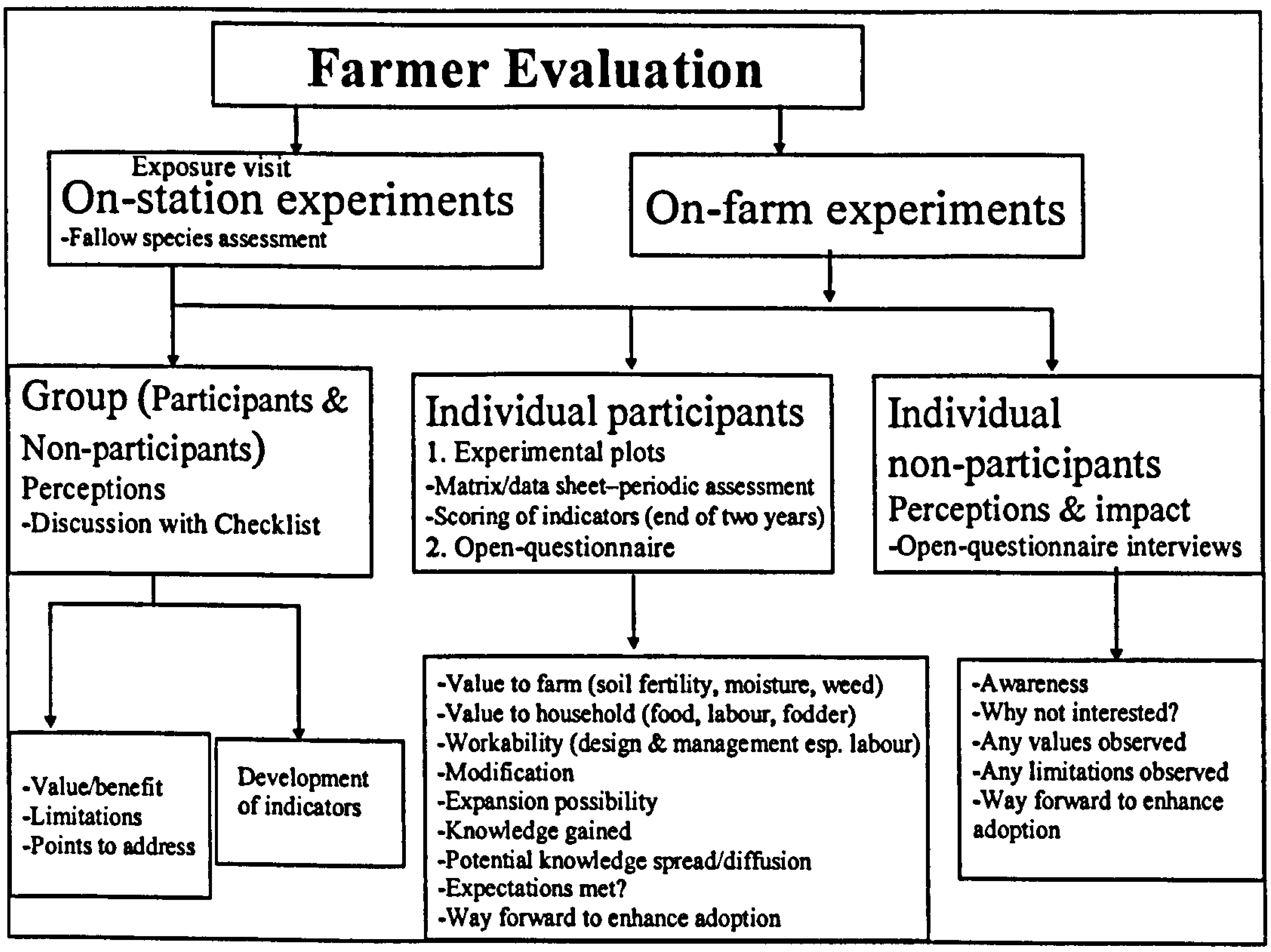


Figure 6.1: Farmer evaluation methods

The first monitoring visit was to ascertain whether farmers had planted their fields. Thereafter, the biophysical performance of the experiments, economic data and socio-economic issues relating to farmer management of their experiments with respect to labour, behaviour or attitudes, perceptions, tenure and environmental factors impacting on the process were documented.

The second stage involved group assessment of the performance of the technologies, potential adoption and appraisal of project impact. This was achieved through group discussions in village meetings with both participating and non-participating farmers. The analysis of farmers' perceptions during the first year helped in identifying factors that affected experimentation on farmers' fields and issues that required redress. It also helped in planning new strategies to enhance experimentation in the second year.

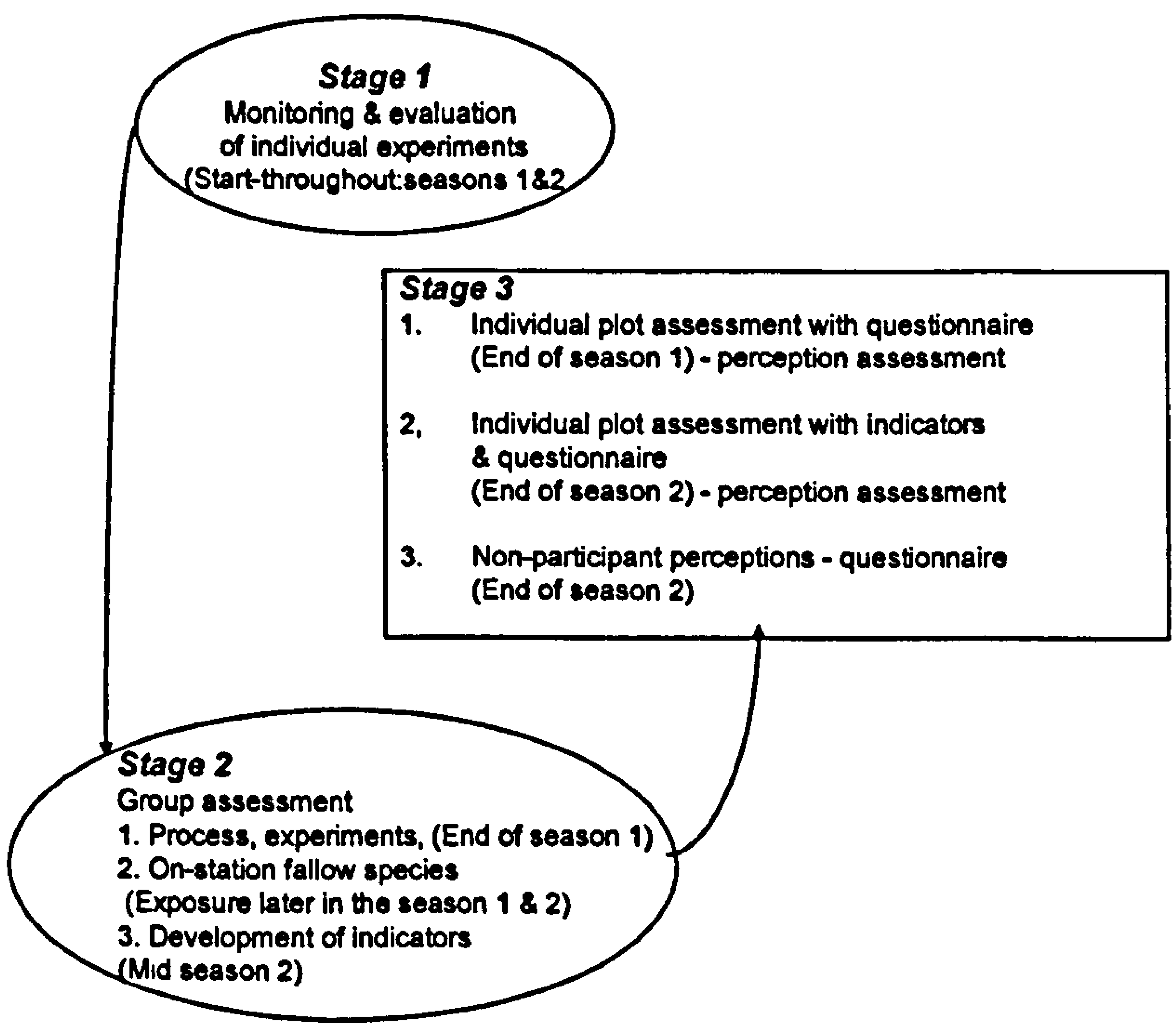


Figure 6.2: Farmer evaluation process

In the second year criteria for evaluation of the experiments were discussed with the community to develop indicators. These indicators were later used to assess their experiments during a participant survey in the third stage. This exercise was done midway through the second year because it was thought that farmers would have had at least two years experience with the technologies at this stage, and would thus be in a better position to identify appropriate indicators. Details on the process for the development of the evaluation criteria and indicators identified are presented in Section 6.2.

The third stage involved an assessment of the on-farm experiments with each participating farmer at the end of each season. In the first year, general perceptions were solicited. In the second year, the indicators developed in the second stage were first employed in assessing perceptions of the agronomic and socio-economic performance of the technologies. This was followed by questionnaire interviews covering factors motivating experimentation (including interests and expectations); appropriateness of the technology design and modifications likely to be extended to other parts of the farm. Other issues included the impact of the technologies on enhancing farmers' knowledge and possible diffusion of this knowledge within and outside the village. Factors contributing to the failure of some experiments to establish as expected as well as general constraints encountered in experimentation and suggestions for improving future work were also solicited. Open-ended questionnaire interviews of individual participating farmers were conducted for this assessment. A total of 83 (52 and 31 in the first and second years respectively) male and female experimenters were interviewed, comprising 65% for maize, 14% plantain, 16% cocoa and 5% for the planted tree fallow.

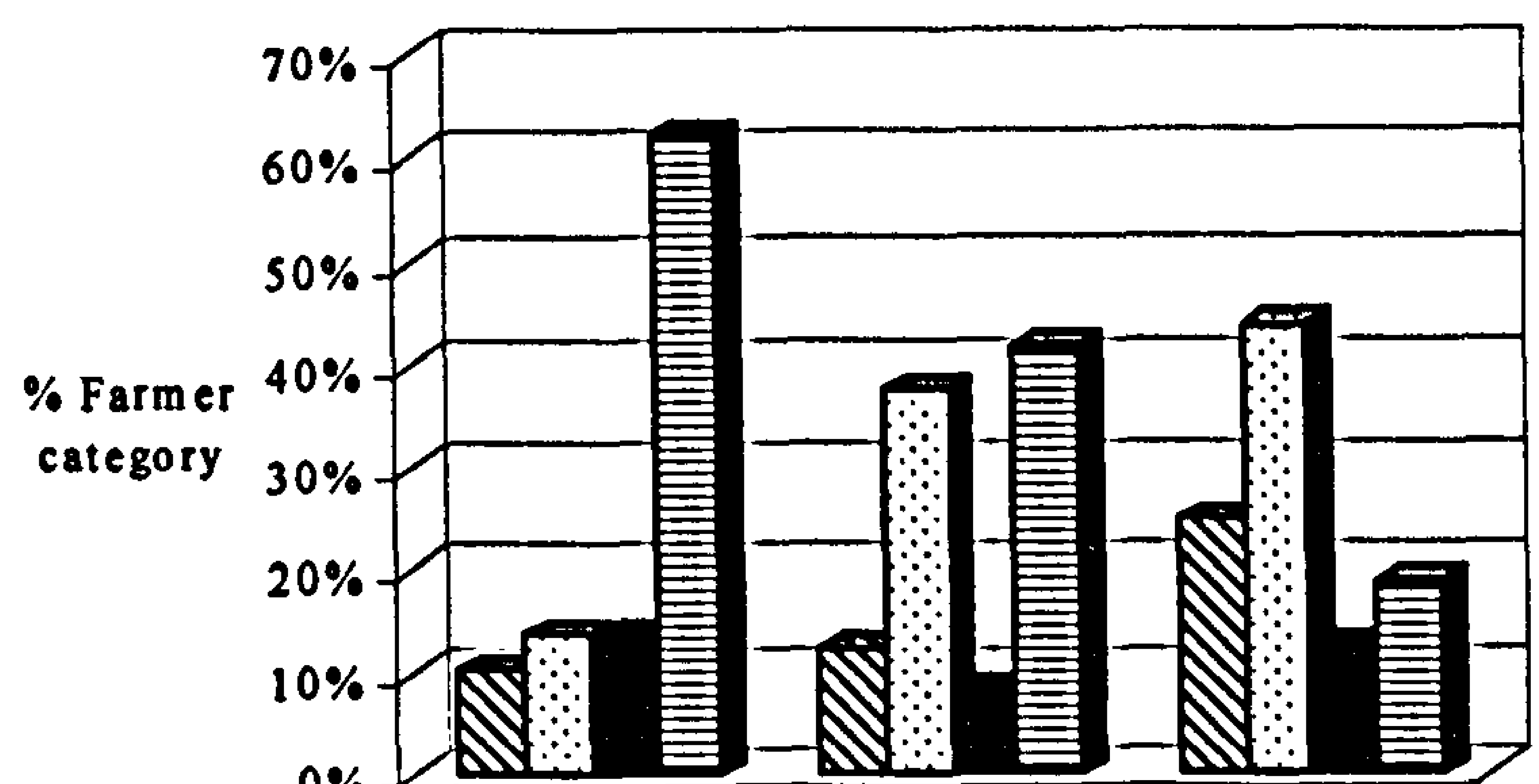
Also in the third stage of the second year an open-ended questionnaire interview of 99 non-participating male and female farmers (33 on average per village) was conducted. Information gathered was similar to that solicited at the second stage. It was intended to validate individual opinions but of particular interest were reasons for not participating as well as benefits and limitations of the technologies from the non-participant's viewpoint. Perceptions of the strengths and weaknesses of project activities were assessed for consideration in future work. The checklist of issues and the questionnaires used for assessing farmer perceptions are presented in Appendices 21 and 22. The Microsoft Excel computer software was used in analyzing the information descriptively and results presented in graphs and tables.

6.3 Development of indicators for evaluating technologies

In participatory research, indicators are useful in enhancing farmers' and researcher's knowledge, thereby reducing uncertainties and improving decision-making concerning production and resource management. Indicators identified by farmers represent the implicit characteristics they value in technologies; hence serve as their criteria for judging the impact of technological options. According to Cramb and Purcell (2001) a good indicator can be judged by its usefulness, ease of collection and the number of stakeholders benefiting from the information it provides. Using the acronym SMART, Estrella and Gaventa (1998) are of the view that indicators should be specific, measurable, action-oriented, realistic and time-framed, although they often need not be extremely precise but should be easy to collect and useful to project decision making.

In the case of farmers, indicators could be measures of farm productivity, sustainability or similar. It must be noted that an indicator that may be useful to researchers, e.g. macro nutrient content of the soil after a legume fallow may be of no interest to farmers, who may prefer increased yield, an observable indicator, for this same measure as it will be difficult for them to appreciate macro nutrients. Consequently, in involving farmers in identification of indicators for measuring technology performance, compromises need to be made to ensure that appropriate ones are chosen. However, the scientists' indicator is equally important in explaining the basis for the increased yield which farmers may easily measure. The important thing is that indicators agreed on are within the scope of the project or technology under consideration.

With respect to this study, indicators which farmers used to evaluate the performance of their experiments were developed with groups of both participating and non-participating farmers. A total of 69 farmers comprising 30 and 39 natives and settlers (men and women) respectively, across the three villages were involved in the criteria development (Figure 6.3).



	Gogoikrom	Subriso	Yabraso
Native female	10%	13%	25%
Native male	14%	38%	44%
Settler female	14%	8%	13%
Settler male	62%	42%	19%

village

Figure 6.3: Farmer categories involved in criteria development in the study villages

Although the participants were not purposively selected, their composition reflected the relative proportions of the four community groupings in the study villages, (Table 6.1).

Table 6.1: Comparing criteria developers with community groupings

Farmer sample	Native female	Native male	Settler female	Settler male	χ^2
Village population	17%	21%	15%	47%	
Criteria participant	14%	29%	12%	45%	2.46^{NS}

Chi square test: NS: Not significant at $p = \leq 0.05$ and $p = \leq 0.01$

This is important in determining differences in their expectations from the technologies or values that would make meaningful impact on their livelihoods.

The following procedure was followed in arriving at the indicators.

- Group discussion with experimenters and non-experimenters in general village meeting
- Situational analysis: recapping on farming system needs necessitating the technologies
- Individual experiences and observations with technologies discussed
- Eliciting and listing of indicators
- Prioritizing indicators
- Scoring of indicators with counters (match sticks)
- Trends in scoring discussed and reasons noted

In each village each of the technologies being experimented with in that particular village was first discussed in relation to its characteristics. This was to assess farmers' understanding of the inter-linkages between the technologies and the farming systems. During the discussion, some participating farmers gave their experiences and perceptions of the performance of their experiments and the impact expected. A list of indicators for each experiment was then generated from the discussion that followed. A maximum of at least the three most important indicators was accordingly listed from the earlier list generated. Usually, in a participatory process, a number of useful indicators may emerge. However, it may be helpful to select a few that are theoretically and logically linked in some causal relationship (Cramb and Purcell, 2001 citing Pacchco *et al.*, 1998).

Each farmer scored each set of indicators for the respective experiments with 10 matchsticks, giving the most important indicator the highest score. The mean scores for each set of criteria were then computed and the results presented to the farmers. The trend in results of the scores was discussed to ensure that they met farmers' expectations and were reasonable within the context of the project. There were primarily no differences in the scoring pattern among the four farmer categories. However, the results of the scores have been differentiated on a gender basis due to the small numbers of native and settler women.

Indicators for evaluating maize-legume relay technology

The maize-legume relay experiment was conducted in all three-study villages. The indicators farmers identified as important for measuring the performance of this technology and associated mean scores are presented in Figure 6.4.

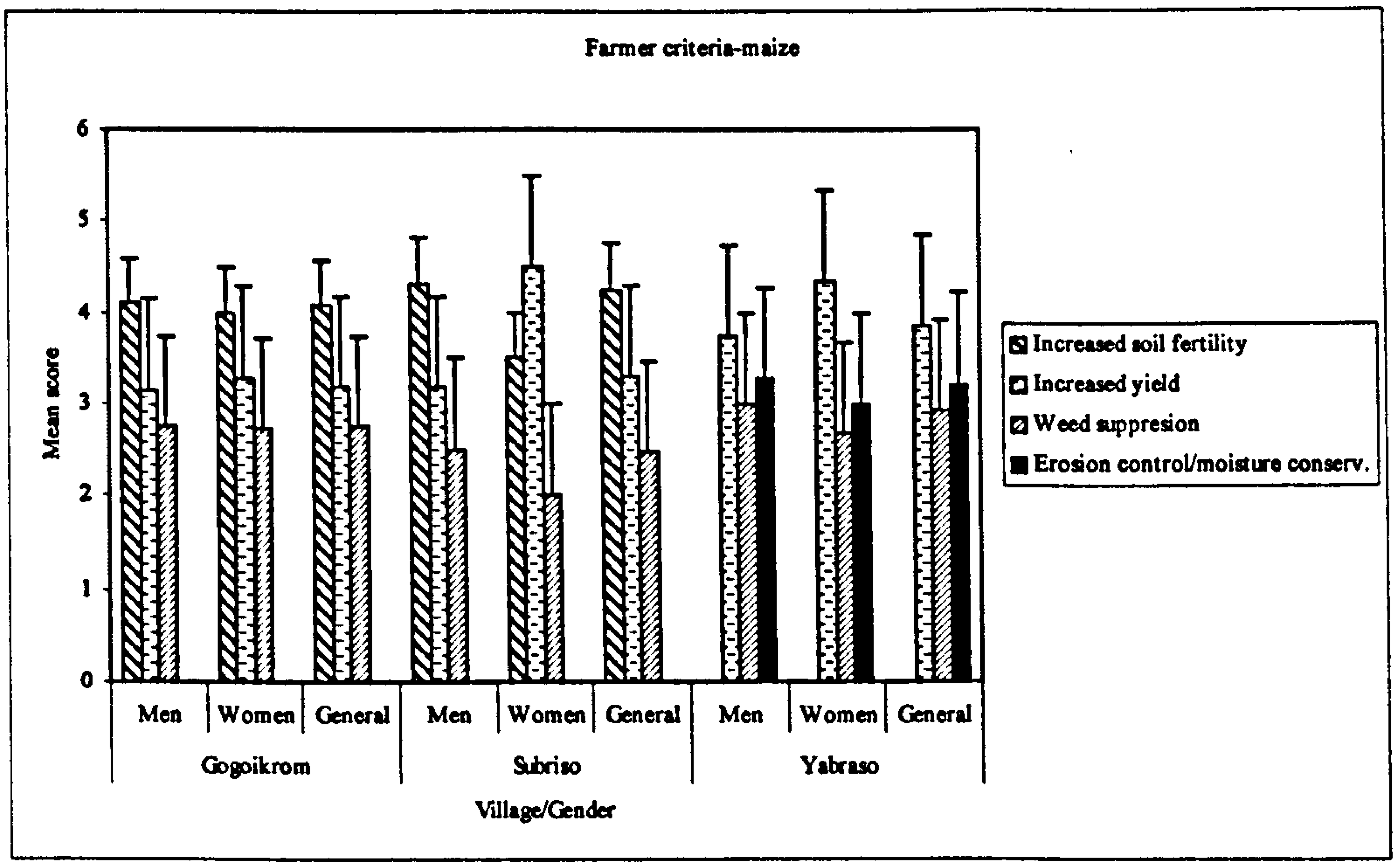


Figure 6.4: Farmers' indicators for evaluating maize-legume relay technology

Three main indicators namely, increased soil fertility; increased yield and weed suppression were identified and scored in that order of importance by farmers at Gogoikrom and Subriso III. In Yabraso erosion control/moisture conservation was identified in addition to increase in soil fertility and weed suppression. The technology's ability to reduce labour was tied to its ability to reduce weeds. Thus weed suppression was chosen over labour reduction during the prioritization.

On scoring the indicators, both men and women farmers placed most emphasis on the ability of the technology to improve soil fertility and the least on weed suppression. Farmers acknowledged that soil fertility was paramount on a maize field as this determines crop yields and level of weed pressure, thus it attracted the highest score in Gogoikrom (4.1) and Yabraso (4.3). Increased maize yield was the second most important indicator with scores of 3.2, 3.3 and 3.8 in Gogoikrom, Subriso and Yabraso respectively.

The reasons farmers gave for the observed trend in ranking or scoring indicate that increased soil fertility and increased maize yield are related. The attainment of an improvement in soil fertility improves crop growth and hence yields. In other words, increased maize yield is the measurable indicator that farmers will use as a proxy for judging the effectiveness of the legumes in improving soil fertility. Weed suppression attracted the least scores of 2.7 and 2.4 in Gogoikrom and Subriso because farmers believe that when soil fertility is improved, crop growth is enhanced. This can possibly shade out weeds. Moreover, improving crop yield may improve income that could be used in controlling weeds, if they are problematic. In Yabraso, soil moisture conservation/erosion control had a mean score of 2.9 following improved soil fertility. The legume's ability to spread or cover the soil surface was acknowledged to be important for soil moisture conservation and for the control of soil erosion, which ultimately improve yields.

Indicators for evaluating permanent plantain/plantain-legume technology

The plantain-legume technology was tested in Gogoikrom and Subriso. There were slight differences in the performance indicators identified in the two villages, although improved plantain yield and weed suppression were similarly identified. In Gogoikrom, improved soil fertility, increased plantain yield and weed suppression were identified and scored in a similar manner as was done for the maize (Figure 6.5).

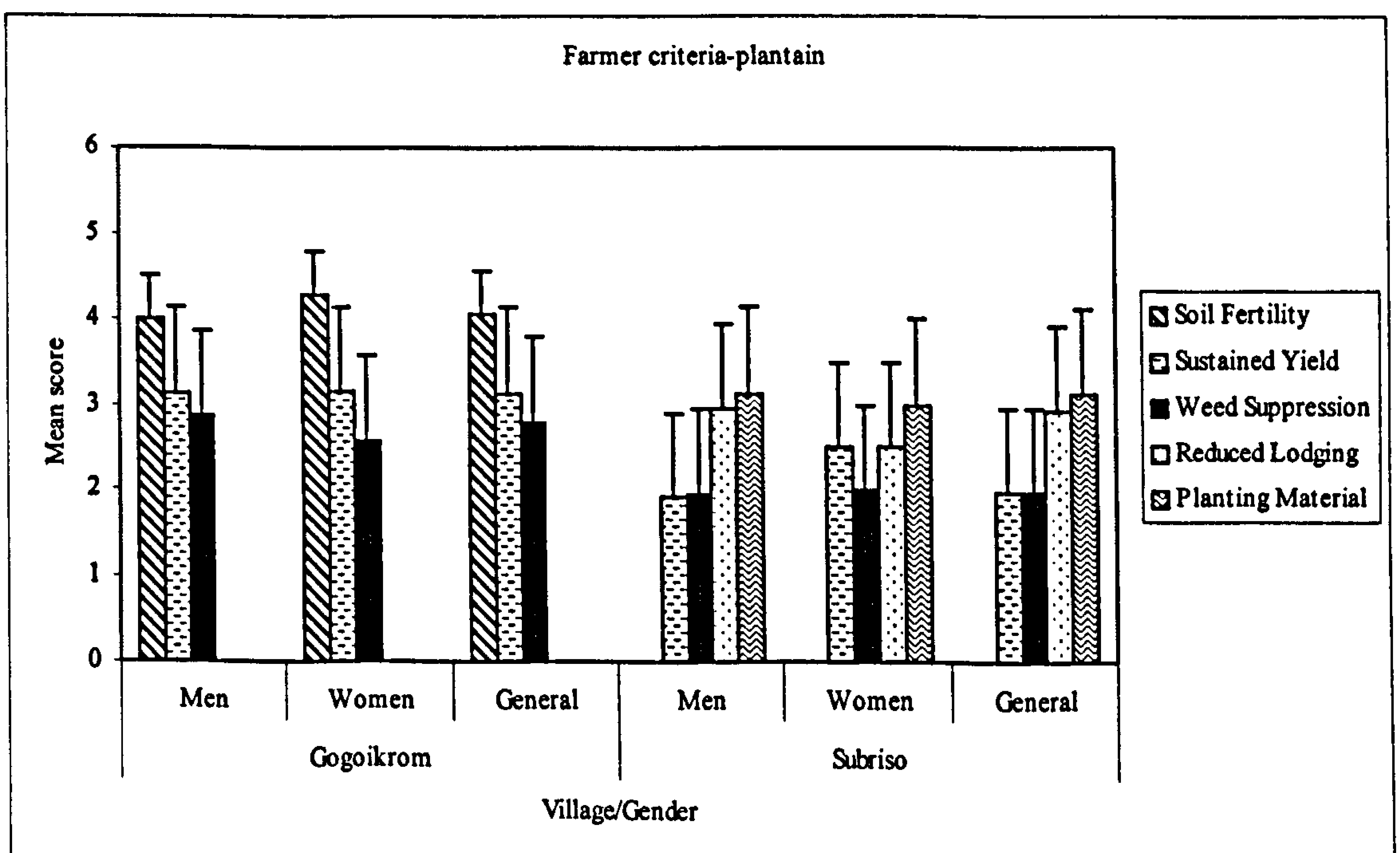


Figure 6.5: Farmers' indicators for evaluating permanent plantain technology

At Subriso farmers identified two additional indicators. Planting material availability and reduced lodging, together with improved crop yields and weed suppression. Available planting material had the highest score of 3.1, followed by reduced lodging, 2.9, before increased crop yield and weed suppression. Both men and women rated the indicators in a similar manner. However, Gogoikrom farmers placed most emphasis on soil fertility in a plantain system, while those in Subriso were more concerned with planting material and lodging. In both villages, weed suppression was not considered a priority as farmers explained (as for the maize system) that weed suppression is automatically achieved if soil fertility is improved and crop growth is enhanced. Emphasis was placed on plantain planting material (i.e. suckers) in Subriso, mainly because of its economic value for earning extra income if sold and its importance in expanding the plantain farm.

The plantain suckers planted in the experiment were pared. Paring is an extension recommendation, which entails slashing or cleaning of the basal portion (roots and buds) of the sucker to rid it of nematodes. Farmers observed that the pared sucker grew faster (will yield earlier), developing numerous other suckers at the base, which can be sold and also facilitate expansion. Sucker development is also important in fortifying the mother plant at the base against lodging, which explains the reason for scoring reduced lodging second. Lodging in plantain is on the increase in recent times due to windstorms at the onset of the rainy season.

Indicators for evaluating cocoa-shade trees

The mean scores for the indicators for the cocoa-shade tree experimented only in Gogoikrom-Atwima are shown in Figure 6.6. The highest score of 5.2 out of 10 was given for high yield followed by shade and then timber. The general argument was that the hybrid cocoa used for the experiment is fast growing, early maturing and high yielding. Moreover, a cocoa plantation is a valuable economic asset yielding regular income for at least five decades. For a cocoa farm the next priority is for shade to protect the young cocoa and later from sun scorch during the dry season. Timber from the intercropped shade trees is also a valuable asset, however, it takes too long a time to realize its income, and thus it attracted the least score of 2.3 out of 10. Although, other tree products such as fruits and medicines may be realized in the short term, these were not considered as economically valuable as timber.

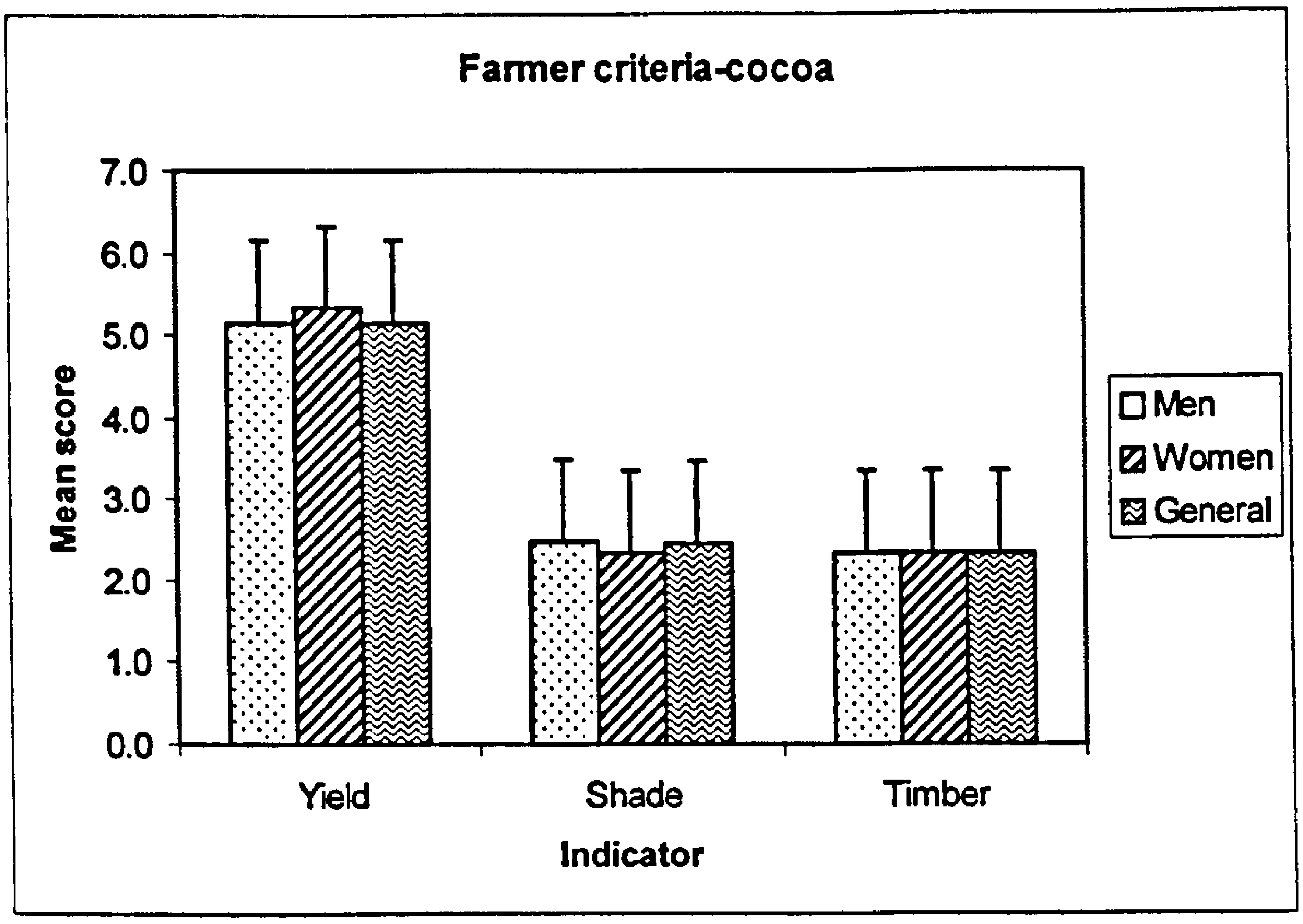


Figure 6.6: Farmer indicators for evaluating cocoa-shade tree technology

Indicators for evaluating improved/Gliricidia sepium fallow

The indicators for the improved fallow technology were identified and scored by farmers of Yabraso-Wenchi, (Figure 6.7). Generally, improved soil fertility was judged the most important indicator for the *Gliricidia sepium* fallow, attracting a mean score of 3.5 with alleviation of deforestation being the least important with a score of 1.6. Improved soil fertility was paramount due to its importance for the production of maize and yam, the two principal crops grown. Scientifically, these are nutrient demanding crops requiring adequate soil nutrients for good yields. Farmers indicated that *Gliricidia sepium* is fast growing, producing substantial vegetative material capable of improving soil fertility.

Wood/poles from *Gliricidia sepium* can be used as yam stakes and fuelwood. Farmers explained that staking of yam enhances tuber development. However, the volume of staking material is dwindling due to persistent annual wild/bush fires. Similarly, fuelwood stocks although not in short supply, are also dwindling. It was also acknowledged that planting a *Gliricidia sepium* tree fallow would, in the long run, contribute to alleviating deforestation.

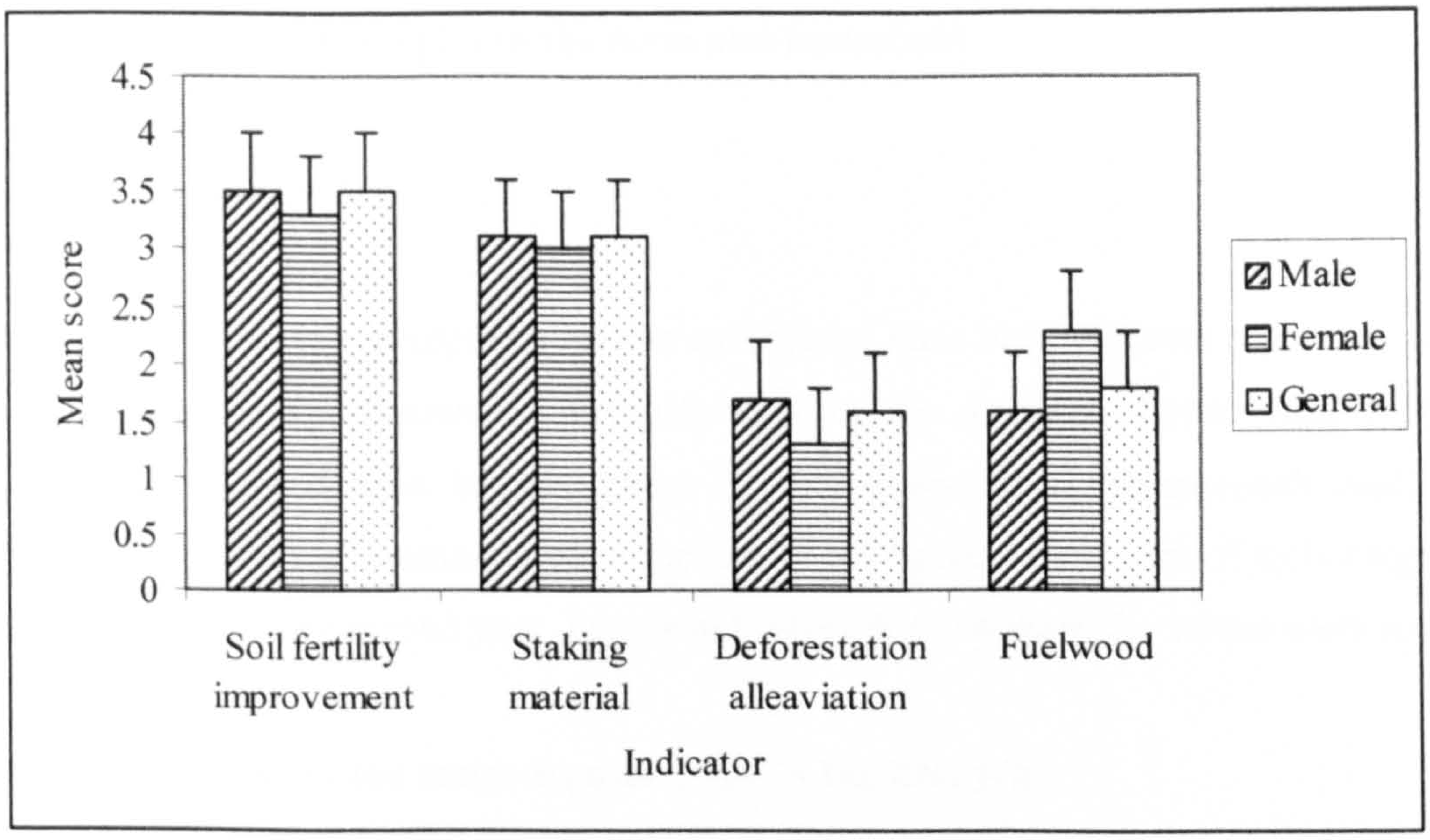


Figure 6.7: Farmer indicators for evaluating *Gliricidia sepium* fallow technology

Men and women rated the indicators in a similar manner, except for fuelwood, for which, women placed more emphasis (mean score of 2.3 against 1.6) than men. This is obvious as women are responsible for fuelwood collection for household use. Problems relating to soil fertility and stakes are key constraints to both genders.

6.4 Farmer perceptions of technologies

By the end of the two seasons of experimentation, farmers could make a fair judgment of the technologies with respect to their performance, value, and limitations in design. The maize–legume relay technology, because it is an annual system, had gone through two production cycles, although the third cycle to substantiate the effect of the legume on production was yet to be undertaken. Nevertheless, farmers were able to assess it better than the other three, which are perennial with effects to be considered over the long-term. Consequently, the farmer perceptions of the technologies presented below are largely related to the maize-legume relay with some limited assessment of the perceptions on the permanent-plantain, cocoa-shade tree and *Gliricidia sepium* fallow technologies.

6.4.1 Value of the technologies to the farm and household

6.4.1.1 Maize-legume relay

The outcomes of farmers' perceptions on this technology have been reported separately for the first and second years of experimentation primarily to show the change in farmer judgements as their knowledge of the technologies increased over the two years. Also, the approach used in the two years differed. Open-ended questions were used in soliciting the perceptions of technology values in the first year while, in the second year, farmer indicators that represent the values were scored.

6.4.1.1.1 Perceptions of the maize-legume relay in the first year

Table 6.2 summarizes farmers' perceptions on the maize-legume technology at the end of the first year of experimentation. Despite the poor establishment of the legume cover on most fields, mainly as a result of insufficient rain after legumes seeds had been sown, farmers made some important observations in relation to the value of the legume associated with the technology. On some of the maize fields where legume biomass production and spread were good, weed suppression was observed by over 50% of the farmers interviewed in each village. *Chromolaena odorata* was commonly smothered across the villages in addition to other weeds such as *Centrosema pubescens, Euphorbia heterophyllum, Sporobulus spp.* and *Cenchrus ciliaris.* However, other noxious weeds such as *Rottboellia exaltata, Panicum maximum, Pennisetum purpureum* and *Eleusine indica* could not be smothered by the shrub legumes, probably due to the poor coverage on some fields.

Two important soil fertility aspects or fertilizer functions of the legumes observed by at least 60% of the farmers were soil moisture conservation and provision of litter/carpet of mulch from the decaying biomass. These are two of the main indicators by which farmers judge the fertility status of a soil. Thus a higher proportion of them anticipated the moist soil conditions under the mulch carpet and the decaying biomass would improve soil fertility, which together with weed suppression will contribute to higher yields that may ultimately, lead to improved income.

Table 6.2: Summary on farmers' perception of the maize/-legume relay technology

Indicator	Farmer Perception of on-farm experiments		
	Gogoikrom (n=12)	**Subriso III (n=15)**	**Yabraso (n=13)**
Weed smothering	Smothering of weeds (*Chromolaena odorata* & *Centrosema pubescens*) observed by 60% of farmers. *Rottboellia exaltata, Cida acuta, Panicum maximum* and tree saplings could not be smothered	Smothering of weeds (*Chromolaena odorata, Sporobolus* spp., *Centrosema pubescens, Euphorbia heterophyllum*) observed by 71% of farmers	Smothering of weeds (*Chromolaena odorata* & *Cenchrus ciliaris*) observed by 56% of farmers. Elephant grass (*Pennisetum purpureum*) & *Eleusine indica* could not be smothered
Fertilizer function	20% observed cool soil under mulch 40% expect litter/mulch to rot to improve soil 40% do not anticipate any effect due to poor establishment of *Stylosanthes* spp., *Clitoria ternatea, Canavalia ensiformis*	7% observed cool soil under mulch/litter 57% expect litter/mulch to rot as organic matter to improve soil 22% expert weed suppression to improve soil 14% do not anticipate any effect due to poor establishment of *Stylosanthes* spp., *Clitoria ternatea and Canavalia ensiformis*	11% expect mulch by legume to enhance soil moisture conservation 89% expect leaf litter drop from legume to rot, add organic matter to the soil to enrich or improve fertility for improved yield.
Labour requirement	60% expect decrease in labour to clear as a result of partial weed suppression by *Lablab purpureus, Mucuna* spp . *Canavalia ensiformis* (Farmers expect labour to decrease by half that of control).	79% expect decrease in labour to clear as a result of suppression of some noxious weeds by *Lablab purpureus, Mucuna* spp. and *Canavalia ensiformis* (Farmers expect labour to decrease by half). 21% anticipate no difference labour due to poor establishment of e.g. *Stylosanthes* spp.	89% expect labour requirement for esp. clearing to decrease as a result of weed suppression by legumes
Food	50% harvested *Canavalia ensiformis* grains for stew and soup	29% harvested *Canavalia ensiformis* grains for stew and soup	56 % harvested *Canavalia ensiformis* grains for stew and soup
Fodder	20% cut *Stylosanthes* spp. as fodder for sheep and goats	7% observed sheep & goat consumed *Stylosanthes* spp. on the farm	11% observed sheep & goat consumed *Stylosanthes* spp. on the farm
Farm Income improvement	70% expect farm income to improve as a result of expected increase in maize yield through weed suppression and improvement in soil condition (fertility, moisture)	86% expect farm income to improve as a result of increase in maize yield through weed suppression and improvement in soil condition (mulch/organic matter/fertility, moisture)	100% expect that if legumes establish well, weed suppression together with moisture conservation and legume litter drop will rot to improve soil fertility and hence, yield and farm income

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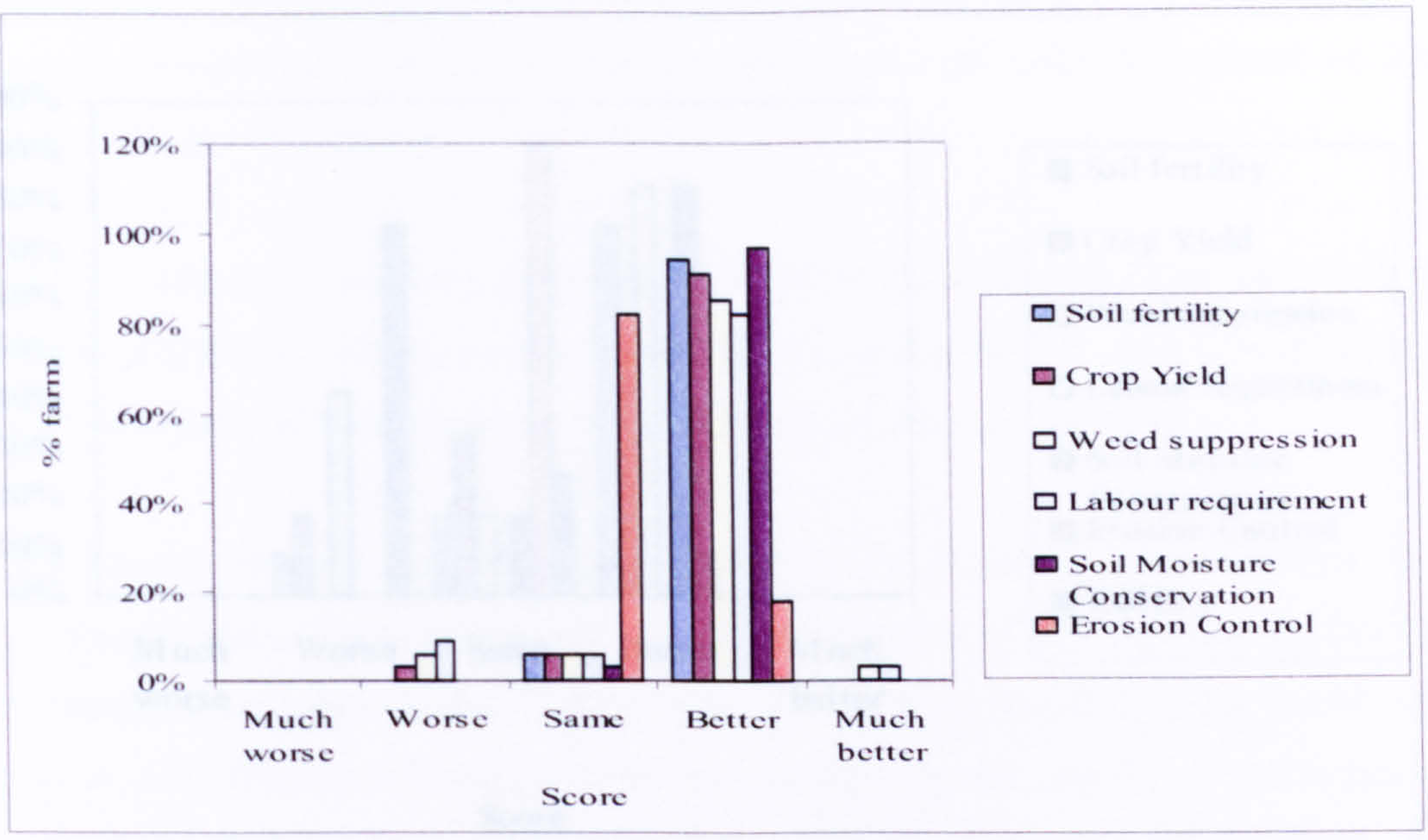

Figure 6.8: Farmers' evaluation of all legumes versus control in the maize-legume relay

Weed suppression and soil moisture conservation were the effects farmers had realized at the time of assessment (September, 2002). That for soil fertility, improved crop yield and reduced labour was deduced from the level of legume biomass coverage and spread. Farmers believed that the heavy biomass would conserve moisture during the dry season to aid the decomposition of leaf litter, thereby improving soil condition and crop yield. The heavy biomass coverage also resulted in the smothering of noxious weeds like *Panicum, Chromolaena,* and *Rottboellia.* This will reduce labour for clearing the fallow in the next cropping season.

A small proportion of farmers rated the legumes the same or much worse than the natural fallow because the legumes established poorly on their fields, either due to waterlogging as a result of excessive rains or failure to weed after the legume seeds were planted.

Mucuna versus Canavalia

The performance of *Mucuna* and *Canavalia* (common fallow legumes) were compared using the indicators. Edibility, observed to be essential with respect to farmer preference of legumes was included for assessment (Figure 6.9).

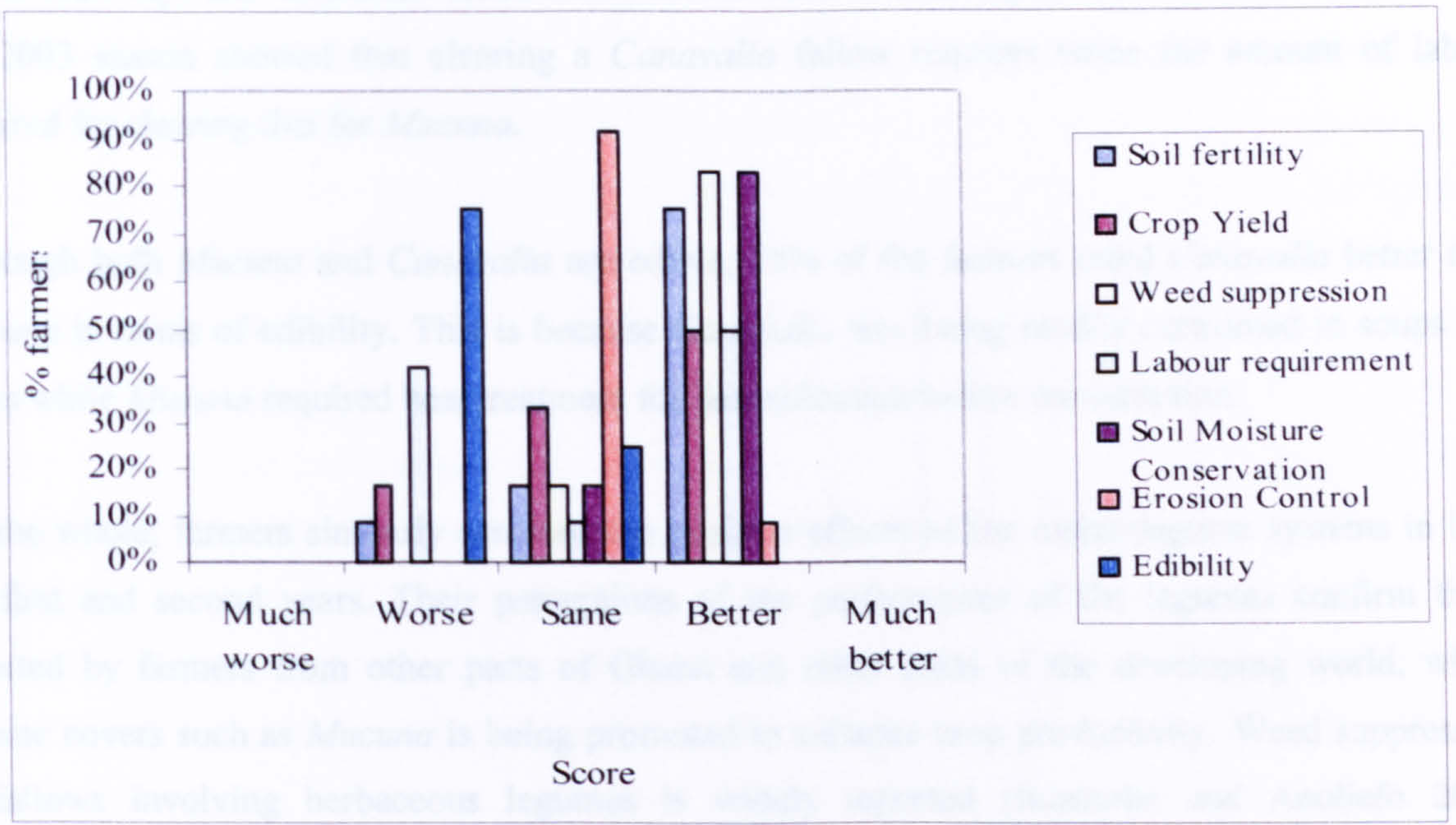

Figure 6.9: Farmers' evaluation of *Mucuna* vs. *Canavalia* in the maize-legume relay

Mucuna was rated better than *Canavalia* with respect to soil fertility improvement, weed suppression and soil moisture conservation by about 75-80% of the farmers. By growing more vigorously, *Mucuna* produced heavier vegetative cover than *Canavalia*. The greater biomass meant more litter rot and soil moisture conserved for improved soil fertility and better tillage in the next season. For these reasons, 50% of the farmers rated *Mucuna* better than *Canavalia* in improving crop yield. However, 33% rated the ability of the two legumes in improving crop yield as the same, arguing that by growing more vigorously; *Mucuna* was likely to use a higher proportion of soil nutrients for its own growth than *Canavalia*. Thus although *Mucuna* produced a higher biomass, the net effect would be the same for the two legumes. The remaining 17% rated *Mucuna* worse than *Canavalia* in improving crop yield. This is because *Mucuna*, being more aggressive, strangled the maize crop on some fields, which could lead to a reduction in maize yield.

Mucuna's ability to reduce labour was rated better than that of *Canavalia* by about 50% of the farmers. *Mucuna* being more aggressive in smothering weeds meant less labour for clearing *Mucuna* plots compared with those of *Canavalia*. Conversely, 42% of the farmers rated *Mucuna* worse than *Canavalia* with respect to labour the vigorous growth and entangling nature of *Mucna* impedes weeding after planting. Also, the greater biomass and leaf litter on *Mucuna* plots would increase labour for clearing the plot, compared with *Canavalia*. The labour analyses in Chapter 5 contrast this argument in favour of the views of the 50% who rated *Mucuna* better. Both farmers' records of labour man days and scientists' clock timed labour used in clearing the *Mucuna* and *Canavalia* in the 2003 season showed that clearing a *Canavalia* fallow requires twice the amount of labour required for clearing that for *Mucuna.*

Although both *Mucuna* and *Canavalia* are edible, 75% of the farmers rated *Canavalia* better than *Mucuna* in terms of edibility. This is because *Canavalia* was being readily consumed in soups and stews while *Mucuna* required heat treatment for detoxification before consumption.

On the whole, farmers similarly assessed the positive effects of the maize-legume systems in both the first and second years. Their perceptions of the performance of the legumes confirm those reported by farmers from other parts of Ghana and other areas of the developing world, where legume covers such as *Mucuna* is being promoted to enhance crop productivity. Weed suppression in fallows involving herbaceous legumes is widely reported (Ikuenobe and Anoliefo 2003; Akobundu and Poku 1984; Osei-Bonsu *et al.*, 1996). Farmers testing *Mucuna* systems in other parts of the Brong Ahafo Region of Ghana appreciated its effects on weed suppression and improvements in soil physical properties and crop yields (Loos *et al.,* 2000). Similarly, Buckles and Triomphe (1999) reported that farmers in Honduras acknowledged the fertilizer effect as a result of *Mucuna* leaf litter improving soil fertility. The aggressiveness of *Mucuna* in smothering weeds, thereby reducing labour for land preparation for the next crop was also reported. The Honduran farmers also reported that thick mulch from slashed *Mucuna* fallow suppressed weeds in the next crop and conserved moisture. Also, both the decaying mulch and green *Mucuna* crop protected soil from eroding.

According to Buckles and Triomphe (1999) for about 36% of farmers in their study, the most important reason for planting maize in a *Mucuna* system was the fertilizer effect of the decaying *Mucuna* litter. Ease of land preparation and moisture conservation were also rated first by a large proportion of the farmers, while weed control rated as the second most important reason by a quarter of the farmers and erosion control by only few of them. Buckles and Triomphe (1999) were of the view that the Honduran farmers' perceptions of the *Mucuna* system could be grouped into criteria related primarily to land productivity (fertilizer effect, moisture conservation and erosion control) and criteria related primarily to labour productivity (ease of land preparation and weed control). This suggests that from the farmers' point of view, the appeal of the *Mucuna* system is its potential to respond simultaneously to both land and labour constraints to productivity.

Mucuna pruriens and *Canavalia ensiformis* are among the most promising legumes currently being studied in the humid tropics. In Ghana, the traditional food uses of *Mucuna* and *Canavalia* could possibly make them an option for farmers with limited land, labour or rainfall. Osei-Bonsu *et al.* (1996) reported that many farmers in the forest and transitional zones grow small quantities of *Mucuna* and *Canavalia* for food. This practice has probably been in existence for about a century or more. Farmers usually plant a few stands of these legumes, 4-8 stands. They observed that about 70% and 55% of respondents interviewed in a survey on traditional use and knowledge on these two legumes in the forest and transition zones respectively knew their food value. 90% and 30% of respondents in the forest and transition zones respectively consumed them regularly in soups and stews. However, none of the respondents interviewed had knowledge of the potential benefits of *Mucuna* or *Canavalia* as green manure or cover crops although a few knew about the use of legumes such as *Pueraria* and *Centrosema* as cover on plantations.

Although farmers have favourably assessed herbaceous legume fallows, potential problems observed with such technologies include risk of damage to maize by rodents that build their nests in the littler layer for protection against predators (Buckles and Triomphe, 1999). Farmers in Benin have also reported snakes under the mulch carpet in *Mucuna* systems (Manyong *et al.*, 1999).

Farmers in the study villages also observed some technical limitations while experimenting with the maize-legume systems. They observed that competition between weeds and the legumes retarded legume establishment if the plot is not weeded after the relay. In such cases aggressive weeds such as *Chromolaena odorata* (*acheampong*) and *Panicum maximum* (*esrè*) suppressed the legume. Moreover, the legumes were sown when maize was either tassling or developing cobs by which time the legume was likely to suffer from shade effects. This situation was worsened if the farm was a mixed one with other crops like cassava, plantain and cocoyam. They anticipated problems with, particularly, snakes although none of them had encountered one.

6.4.1.2 Permanent Plantain/Plantain-legume technology

Limited perceptions of the plantain-legume technology were reported at the end of the first year as the fields were still in the establishment phase. This is because farmers suggested planting of the experiment during the minor season to prevent lodging by strong winds at the onset of the rainy season in early April, the following year. However, on some fields, farmers observed that the legume species planted in the experiment, namely: *Canavalia ensiformis, Gliricidia sepium* and *Flemingia macrophylla,* had the potential to thrive throughout the dry season, a characteristic which they believed would enable soil moisture conservation to enhance plantain growth. Moisture is critical for plantain during the dry season as the stem of the crop usually desiccates due to the low relative humidity during this period, retarding growth and causing warping and/or toppling.

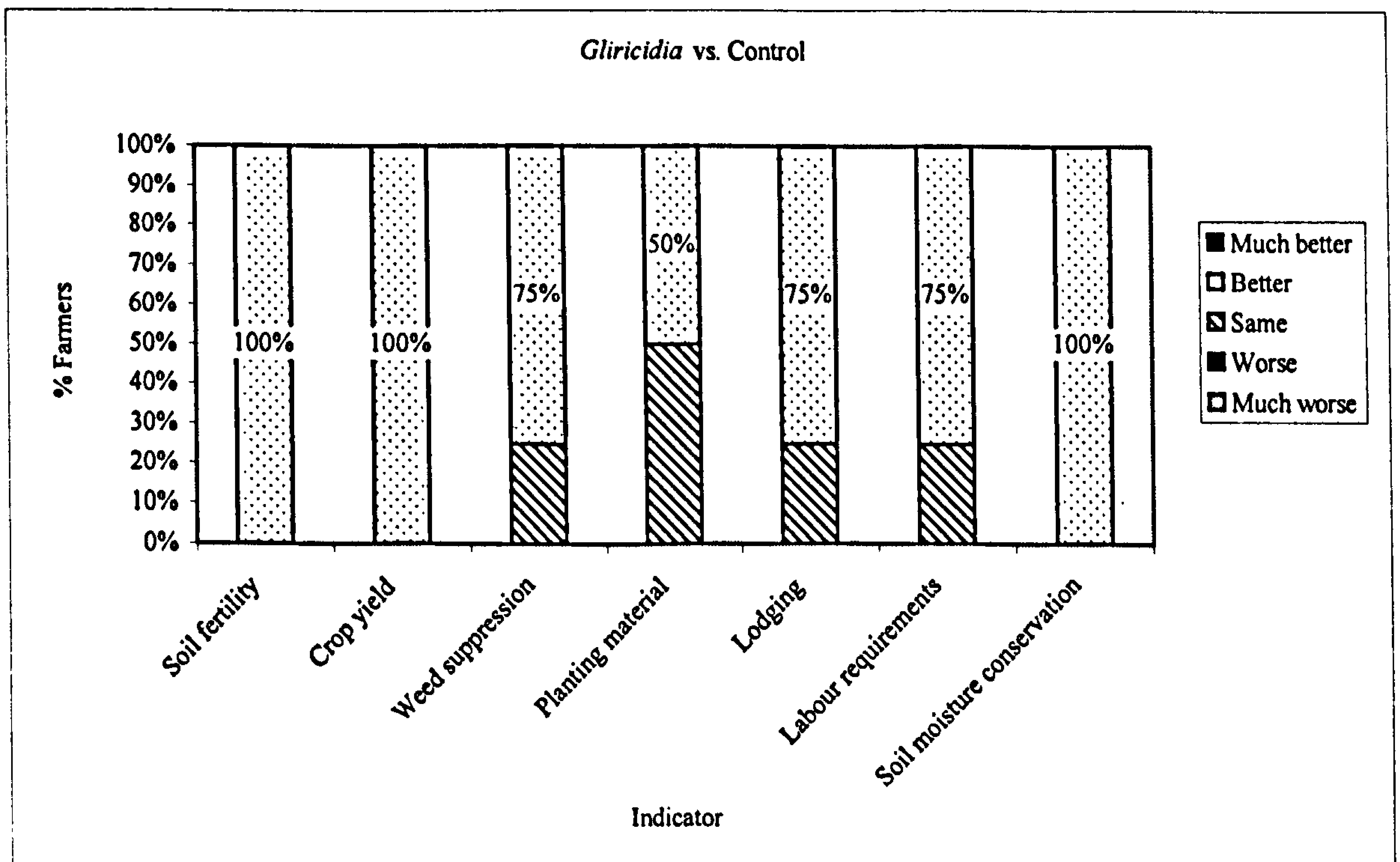

Figure 6.10: Farmer perceptions on plantain-*Gliricidia* against the control

The technology was evaluated with indicators at the end on the second season. Four farmers, comprising one woman and three men were available to individually rate their experiments. Their perceptions are summarized in Figures 6.10-6.12. All three-legume treatments were generally judged better than the control for nearly all the indicators. These perceptions were based on the expectation that biomass produced from the legumes will ultimately decompose and enhance plantain growth while conserving moisture and suppressing weeds.

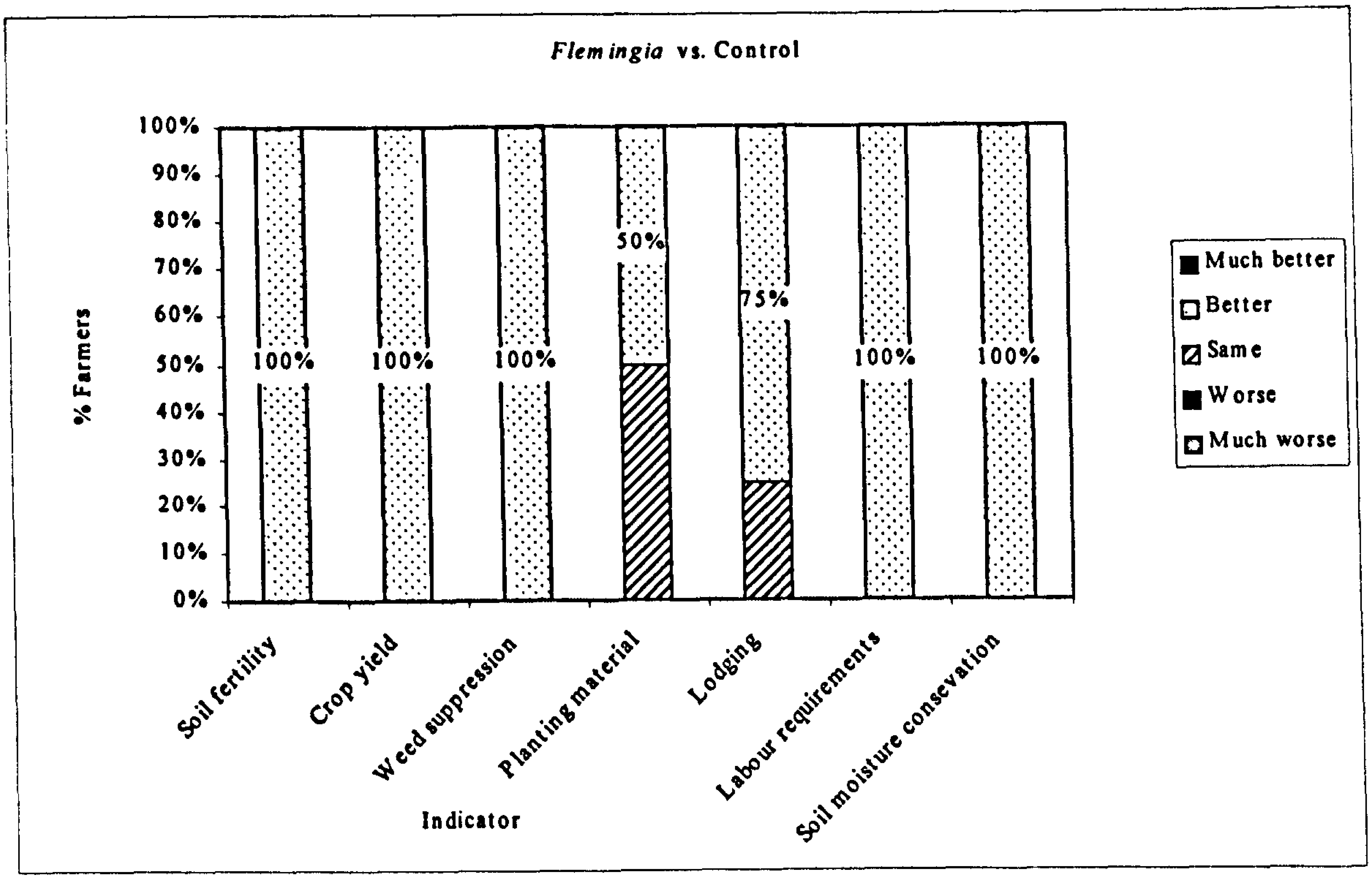

Figure 6.11: Farmer perceptions on plantain- *Flemingia* against the control

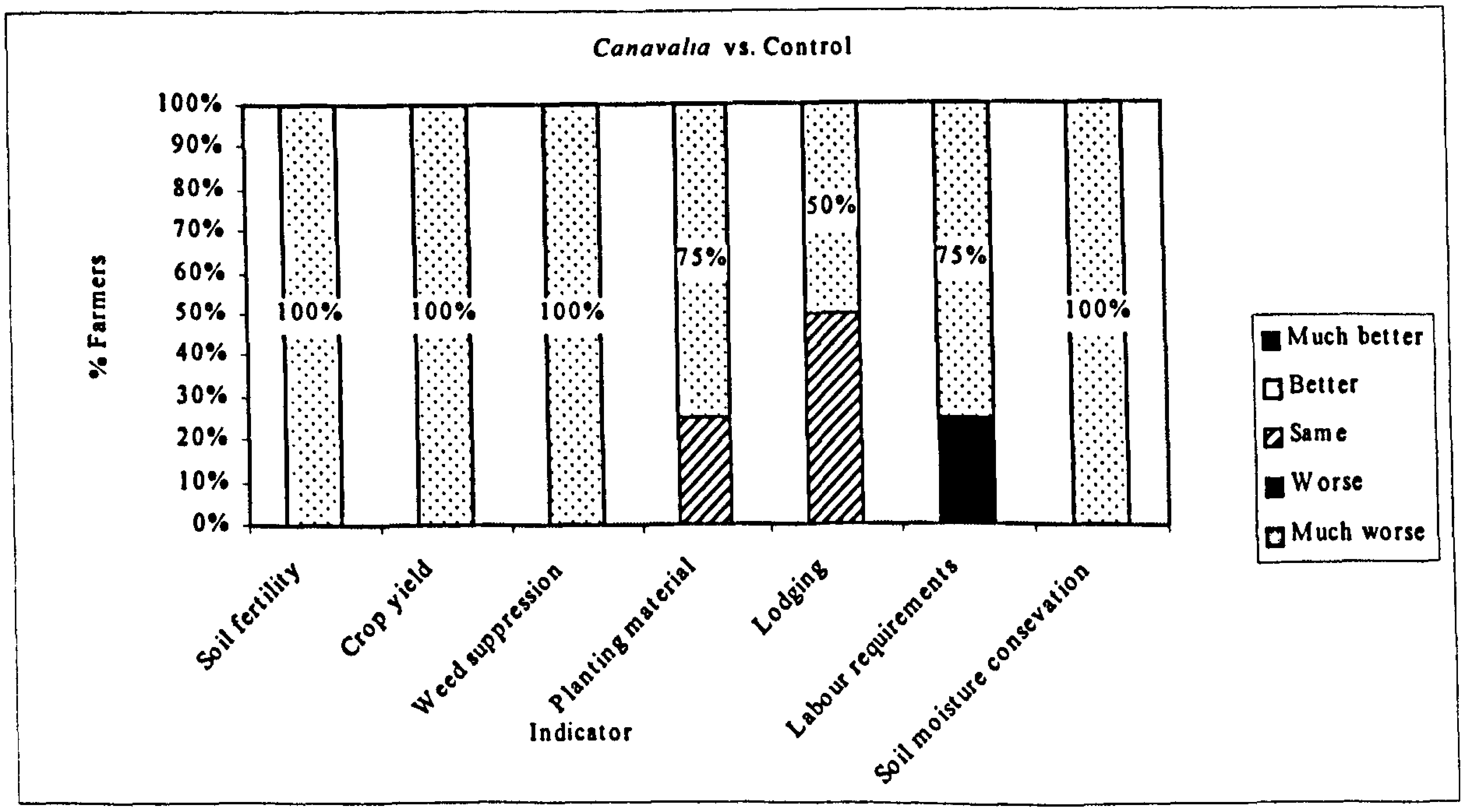

Figure 6.12: Farmer perceptions on plantain-*Canavalia* against the control

In some cases the farmers felt the legume treatments did not differ from the control with respect to planting material development and lodging. This is explained by the fact that suckers planted in both the legume treatments and controls were similarly pared. Farmers observed that this causes proliferation in sucker development as the pared one grows into a mother plant. According to farmers, the level of planting material i.e. plantain sucker development by the mother plant, has an influence on the degree of lodging in plantain. The suckers fortify the mother plant against lodging, hence, the higher the number of suckers, the stronger the fortification.

Labour requirements for the *Gliricidia* and the control were rated to be the same. The reason being that while weed control might be problematic in the control, the *Gliricidia* would require cutting (i.e. pruning), which also involves labour. The shrubby nature of the *Canavalia* planted in the alleys hindered weeding, making the *Canavalia* treatment more labour intensive (rated worse) than the control.

6.4.1.3 Cocoa-shade tree

The cocoa – shade tree technology is the most long-term (up to 80 years rotation possible) system of the four technologies farmers experimented. Thus, even at end of the second year, the majority of farmers could not readily rate the technology against the set indicators, i.e. increased cocoa yields, protection from shade and timber, as the experiments were in the establishment phase.

Nevertheless, about 17% of the farmers, based on their traditional knowledge of the benefits of shade in cocoa system, scored the technology with the planted shade trees better than the control with respect to all three indicators. The main reasons being that trees provide shade to reduce sun scorch and conserve moisture (for both soil and cocoa trees, especially in the dry season). This improves the soil to improve cocoa growth and yield. Furthermore planted trees yield timber. On the other hand, two out of the 18 (11%) farmers interviewed for the cocoa rated the technology with and without the planted shade as the same. This is because there were sufficient naturally occurring shade trees on the control plot; hence, the long term effects between the two systems were likely to be similar.

6.4.1.4 Improved/*Gliricidia sepium* Fallow

The rotation period considered for the *Gliricidia* fallow is three or five years, depending on the availability of land and the end use of the fallow. Farmers could not express their perceptions on this technology during the first year assessment as the *Gliricidia* had not yet taken off due to inadequate moisture. Two female farmers out of the six who planted this technology in Yabraso rated its performance at the end of September 2002. Basically, each perceived the *Gliricidi*a fallow as being better than the natural fallow in all respects. In particular, the luxurious biomass of the *Gliricidia* is expected to improve soil fertility and crop yield. Its branches, if well developed, could be harvested for use as stakes more readily and also for fuelwood.

6.4.2 Workability of technologies

6.4.2.1 Technological components and design

Table 6.3 summarizes farmers' assessment of aspects related to the design of the technologies.

Desirable aspects

The systematic planting of the various components of the experiments was an aspect that farmers commonly desired. While this increased maize plant density, it eased working in the plantain and cocoa. The legumes and shade trees were also desired. The legumes smothered weeds and had the potential of improving the soil, whereas the shade trees of the cocoa experiment would alleviate dry season sun scorch of the cocoa.

Farmers observed that the wider spacing adopted for the cocoa and shade trees would enhance branch and pod development in the cocoa. Farmers usually plant cocoa by direct seeding and densely to ensure faster canopy closure to reduce weeding labour. Ideally, the cocoa plants should be later thinned to enhance branching and pod development. However, most farmers are reluctant to thin due to the extra labour involved and aversion to cutting down fruit bearing trees and wasting the fruits. Farmers claimed the wider and regular spacing (3m x 3m) adopted would save the extra labour spent in thinning out; facilitate working on the farm, especially replacement of dead cocoa seedlings and prevention of wasting of cocoa planting material.

Table 6.3: Summary on farmers' assessments of aspects of technology design

Trial design	Maize legume-relay	Permanent plantain	Cocoa –shade tree	Planted tree fallow
Aspect liked	Legumes (82%): weed suppression, increase soil fertility Line planting (58%): more maize planted	Line/row planting-Eases work Paring of plantain -Increase yield & planting material Legumes-soil improvement likely from biomass rot	Regular planting/spacing of cocoa & shade trees -Eases work esp. weeding & replacement of dead seedlings Planting of shade trees -Protection against dry season sun scorch	Legume species-fast growing
Aspects not liked	*Mucuna* (18%): Weeding after planting *Mucuna* is difficult Time of planting legume, i.e. *Mucuna* (41%): *Mucuna* strangled crop (5-6 weeks)	*Canavalia*: close spacing retards weeding	Wider spacing enhances weed growth	None
Modification	Time of planting legume, esp. *Mucuna*: 6-8weeks to prevent strangling	*Canavalia*: spacing -Plant in rows to ease weeding labour	None	None
Aspect likely to adopt/extend to other farms	Line planting of maize (82%): increase yield Legumes (42%): suppress weeds *Canavalia*: food	Legumes -Improve soil Row planting plantain, *Flemingia* and *Gliricidia sepium* -Ease weeding labour Paring plantain suckers -Increase planting material & ensures fortification of mother plant against lodging	Spacing -No later thinning & pruning of cocoa required -More branch spread of cocoa for more yield Shade trees -Dry season shade protection for cocoa	Legume species

Paring of plantain is a relatively new extension recommendation aimed mainly at enhancing plantain maturity and reducing nematode and termite infestation prevalent on plantain farms. The technology involves cleaning of the basal part of suckers intended for planting by cutting off roots and root nodes and shortening the stem of the sucker. The debris containing possible disease pathogen is left behind and the sucker taken for planting at the intended site. This also reduces the weight of suckers' especially if they are to be transported to other fields for planting. Farmers in Gogoikrom and Subriso III were not familiar with this technique, probably because it has not been introduced in these villages.

Undesirable aspects

Undesirable aspects of the experiments were more related to the growth habits of *Mucuna* for the maize-legume relay; spacing of the *Canavalia* for the permanent plantain and wide spacing of the cocoa and shade trees of the cocoa experiment. *Mucuna* is vigorous at growing and possesses creeping vines, thus spreads very fast, entangling all available plants as well as retarding weeding and harvesting of maize. This occurred in the 2002 growing season when the legume seeds were sown quite early, between 5 and 6 weeks after sowing maize on some fields, to ensure that the legume had adequate rain for good establishment. Similarly, the dense shrubby vegetation of *Canavalia* in 2002 retarded weeding. For the cocoa, although farmers anticipate more branch spread due to the wider spacing, they were of the view that this unfortunately enhances weed growth, increasing weeding labour.

6.4.2.2 Modification in technology design

With regard to modification, farmers suggested sowing *Mucuna* later than 5-6 weeks, probably 8 weeks after sowing maize. This is to prevent strangling as fields relayed with legumes between 7-8 weeks encountered fewer problems with the *Mucuna*. However, experience over the two years of experimentation shows that the time for sowing the legumes to ensure good establishment depended more on the weather. Due to the irregular nature of the weather, it appears that the suitable time has to be optimised between 5 and 8 weeks of sowing maize. 2002 was a normal year with good rains, well distributed throughout the growing season. Thus, apart from sowing early, the legumes received adequate moisture that enhanced establishment. Due to its shrubby nature, some farmers suggested that *Canavalia* be planted at a wider spacing between rows to facilitate weeding.

6.4.2.3 Technology design aspects to adopt/extend

Almost all the participating farmers expressed the desire to adopt or extend the regular planting pattern, legumes and shade trees to other parts of their fields for reasons elaborated above. Planting in rows or regular pattern eases weeding and also increases yield. Planting in rows is an age-old extension recommendation aimed at increasing yield per unit area. Ironically, farmers in most farming communities do not practice this technique simply because more labour is used in systematic planting as compared with the traditional irregular planting commonly practised.

For the permanent plantain, the desire to adopt the paring technique was in order to increase planting material availability and ensure fortification of mother plant against lodging at the onset of the growing season. Legumes in maize and *Gliricidia sepium* in the plantain will be adopted because of the high potential for smothering weeds, whereas for the shade trees in the cocoa it is because of their protection of the crop in the dry season.

6.5 Adoption potential

6.5.1 Knowledge gained and spread

The impact of a project or a new technology at the end of a farmer participatory research process can be realized in many ways over different time-frames. It also forms part of a complex causal sequence, with one aspect of the possible effects leading to the development of the other. Thus, some effects may be immediate (e.g. organized farmer groups resulting from the FPR process), intermediate (adoption of the technology) and long term (e.g. improvement in fallow productivity or crop yields and ultimately, farm income) (Cramb and Purcell 2001).

6.5.1.1 New knowledge acquired

For the farmers who experimented with the maize-legume relay, permanent plantain and the planted tree fallow, the new knowledge gained relates to their experience with the legumes for improving soil fertility and suppressing weeds. Obviously, before the introduction of the technologies, no farmer in any of the three villages had ever planted any plant species to enhance fallow productivity or planted trees in plantain to enhance yield deliberately. Similarly, the cocoa experimenters in Gogoikrom mentioned the deliberate planting of shade trees as the new thing learnt, as shade trees on cocoa fields often developed naturally from coppice shoots of desirable trees retained during clearing of the vegetation to plant cocoa.

As mentioned earlier on, planting in rows or systematically in lines is an age-old extension practice which farmers have not adopted because it is laborious. However, most of the participating farmers mentioned this as a new planting technique learnt. This probably means farmers had not appreciated the trade offs between the extra labour required and the usefulness of the technique in increasing yield and facilitating work on their farms until now.

For the cocoa farmers, planting systematically at a wider spacing was entirely new, as this had never been done in the village. The paring of plantain suckers associated with the permanent plantain experiment was also a new technique farmers had learnt. Farmers are appreciative of pared sucker productivity as an extra income source and improving planting material availability.

6.5.1.2 Potential knowledge spread/diffusion

It is known that the adoption of any new technology is usually a slow process and that in most cases the diffusion of new agricultural practices that become widely adopted usually begin very slowly before becoming popular (Dillman *et al.*, 1989). Thus, although the number of farmers participating at this initial stage may be low, diffusion prospects are high.

At least 53% of the participating farmers interviewed had observed some non-participating farmers planting their maize and plantain in rows. Also, 12% reported of seeing non-participating farmers planting *Canavalia* on their fields, possibly for its food value. 88% of the participants ever discussed or had a conversation concerning the new techniques with friends and relatives in their respective villages as well as some visiting friends from nearby villages such as Techimantia near Subriso III. In Gogoikrom-Atwima, farmers in nearby villages, namely Abasua and Kyenedaso were interested in trying the cocoa-shade tree experiment. The chief of Abasua had already started a tree planting project with his subjects, thus planting cocoa and shade trees was a an opportunity to encourage his people to plant trees.

6.5.2 Farmers interests and expectations

6.5.2.1 Farmer interests for participating

For the majority (90%) of the participants, the supply of planting materials such as cocoa, legume, tree and maize seeds was the principal factor that enticed them to participate. Of course the project supplied those planting materials as incentives for participation and also because some legume and tree seeds were not readily available on the domestic market.

The economic value of the test crops attracted farmers in Gogoikrom-Atwima and Subriso III-Tano. In Gogoikrom, the cash and asset values for cocoa attracted a higher participation for testing the cocoa-shade tree technology than that for plantain and maize. Similarly, in Subriso, maize and plantain, being cash earners, attracted a higher participation in testing their associated technologies.

For some farmers, interest in participation was mainly for financial support for farming. For a few others it was an opportunity to learn techniques for improving the soil to enhance crop yields as well as access planting material for subsequent use.

6.5.2.2 Why farmers did not participate

A survey of 99 non-participating farmers across the three study villages at the end of the second season showed that over 80% of them were aware of the experiments in the respective villages. The main reason given for not participating for the majority was not being present in the village at the time participants were being enrolled.

Some farmers participated in the first year but did not continue in the second year. According to these farmers it was because of the poor outcome of the previous year's experience of the intervention. The legumes established poorly on most fields, hence, could not perform as farmers anticipated, e.g. to suppress weeds. As mentioned above, this was due to inadequate rains after planting, which discouraged some farmers from continuing or even others from joining in the second year. Loss of access to use of their experimental plot in the second year also prevented the continued participation of some tenant farmers.

For some non-participating farmers it was because they realized the project provided no financial support. For instance, in Yabraso-Wenchi, a second project was initiated in 2002 at the village entitled Food Crops Development Project (FCDP). This was an African Development Bank funded Project aimed at improving food production in the short term. The project provided credit in the form of cash, seed maize and fertilizer inputs totalling 1.5 million cedis. Although a number of farmers enrolled for the fallow project and were supplied with planting materials, they shifted to join the FCDP to benefit from the cash and fertilizer credit.

Some farmers never attended any of the village project meetings because of the premonition that the meetings were politically inclined, and thus lost the chance of participating. Others who were present failed to participate due to uncertainty over the ownership of proceeds from the experiment.

6.5.2.3 Farmer expectation

The maize-legume relay experiment was the only one that had produced some immediate results to meet farmers' expectations at the time of the evaluation in September 2002. 88% of the maize farmers observed that noxious weeds such as *Panicum maximum, Rottboellia exaltata, Cenchrus ciliaris* and *Chromolaena odorata* had been smothered on their fields. They also observed moist soil conditions beneath the legumes and anticipated improved maize yield in the following season. The plantain, cocoa and planted tree fallow experimenters were hopeful of their expectations being met as there are positive signs of their experiments achieving good results.

6.5.3 Prospects of continued participation and extending technologies

Prospects of continuation and expansion were quite high among the experimenters. At Gogoikrom, 90% of the farmers expressed the desire to continue the experiment to achieve weed suppression, soil improvement and effect on the farm from continuous cover cropping. 80% wished to expand the technology to other farms for the same reasons. One woman who tried the maize-legume technology expressed the desire to discontinue after the first season due to the poor performance of the *Stylosanthes* spp she relayed.

Similarly, at Subriso III and Yabraso, the participating farmers also showed interest in continuing the experiment and extending the technology to other fields, mainly because of suppression of noxious weeds, which can reduce labour required for clearing. It was also because of the potential of the technology to improve soil fertility to improve crop yield. For two of the farmers (women) it was because of the edible nature of *Canavalia* spp. For others, it was to observe the long-term effect of the technology on crop production.

6.5.4 Suggestions to improve technologies and encourage uptake

Farmers made some suggestions for improving the intervention and encourage participation (Table 6.4). An important issue that was critical to the success of particularly, the maize legume relay experiment concerns labour. There is need to weed before sowing the legume seeds and at least once after sowing due to the aggressiveness of grass weeds and *acheampong* (*Chromolaena odorata*) in areas where maize is predominantly cultivated.

Table 6.4: Suggestions to improve technologies & encourage uptake

Gogoikrom	Subriso III	Yabraso
1. Dual purpose legumes preferred 2. At least one weeding required to improve establishment of legume cover 3. Legumes and trees should be planted early to take advantage of rains for better establishment 4. Increase number of shade trees in cocoa	1. Legume should be planted early to take advantage of rains for better establishment 2. Increase size of experimental plot 3. Assist with other inputs (cutlasses, etc. at subsidized prices)	1. Maize should be sown earlier in the rainy season 2. Legume should be planted early in the rainy season for better establishment (one farmer suggested 6-7 weeks after planting of maize) and to prevent rodents removing seeds 3. Increase quantity of legume seeds and tree seedlings 4. Closer spacing of legume cover for better density and coverage

The time for planting shrub legumes and trees was a common concern in the three villages. The irregular climatic pattern makes it necessary for the planting of shrub legumes and trees to be targeted to meet good rains for better establishment. It also become evident that farmers preferred dual-purpose legumes which produce grain for food and improve labour and land productivities (suppress weeds, improve soil, etc.) as well.

Most of the farmers anticipated material input support from the project, the absence of which they mentioned was the key issue that discouraged some of them from active participation. Although planting materials (seeds and seedlings) were supplied to participants, some suggested the provision of other inputs like cutlasses (machetes) and so on at subsidized prices to encourage participation. Incentives are necessary catalysts for promoting or encouraging adoption of interventions among intended beneficiaries. They may be pertinent at the initial stages of the project when the beneficiaries are unfamiliar with proposed species and do not have adequate resources to bear or accommodate the cost associated with the proposed interventions. It must be admitted that for research projects, subsidized inputs are not congenial to deal with. Nevertheless, it may be dealt with, if an appropriate scheme is developed with farmers for its implementation. Farmers also expressed the need to increase plant density. For the maize-legume relay, this would be to enhance ground coverage over a shorter period, increasing the shade tree population in the cocoa would be to reduce sunlight intensity. A farmer suggested increasing the size of the experimental plot to entice others to participate.

6.6 Conclusion

Farmer evaluation is a participatory concept enabling both farmers and scientists to identify or recognize aspects of technologies that are of priority to farmers. It also allows for modifications in the technology design during its development to ensure better management within the farmers' resource capacity.

Farmers' perceptions of the performance of the technologies in both the first and second years were primarily based on the physical effects they readily observed or deduced and followed a causal-linkage pattern. The reasons they advanced for the effects enumerated were based on their experience or traditional ecological knowledge where the effects were yet to be realized. These arguments are comparable to findings often reported by scientists. For instance, the biomass production potential of legumes could be an indication for its soil improvement potential. Also, level of leaf litter or mulch produced, moisture conserved and weed suppression determine the legumes' potential in increasing crop yield.

In the development of indicators for judging the performance of their experiments, farmers in the study area were very objective, emphasizing effects that were of immediate need to their socio-economic circumstances and were priority problem areas in the farming system. This became apparent during the actual evaluation of the experiments. The results point out those aspects which are valuable to their socio-economic needs with emphasis on yield, food, reduced labour (weed suppression) and cash. Overall, all the indicators are primarily interlinked with a net effect of improved land productivity that ultimately leads to improved crop yields.

The mean scores of the ratings of the indicators by both genders seem to suggest that there are probably no distinct gender differences or preferences for the impact farmers expect to derive from the technologies. Soil fertility improvement is paramount in enhancing yields in maize systems in all villages. Improving soil fertility in plantain production is also desirable in Gogoikrom and Subriso but improving plantain planting material availability for extra income, expansion of farm and for fortification against lodging will further improve plantain productivity and income from this crop in Subriso. Planted leguminous tree fallows may be desirable for their potential in improving soil fertility in Yabraso currently, although by-products such as stakes and fuelwood may curtail scarcity in these products in the future. Once soil fertility is improved in any of the cropping systems, weed suppression may be attained. Erosion control is probably not a problem at the moment in all villages.

In cocoa, improving yield is a priority for which shade trees play a role, but economic products from the trees are not of immediate concern.

CHAPTER SEVEN
SUMMARY, CONCLUSION AND RECOMMENDATIONS

This study has characterized livelihoods of three farming villages in the forest and forest savannah zones in Ghana. The characterization assisted in the development of interventions or technologies for improving fallow productivity in the study area and possible recommendation domains for adoption of such technologies. The technologies were tested in a participatory manner with farmers on their plots over two seasons and were monitored by both farmers and scientists. The technologies have been characterized; their value, modification and potential diffusion from the farmers' viewpoints are assessed. The study also looked at an *ex-ante* economics of the technologies, mainly their profitability and adoption potential. Templates for the different technologies (Appendices 16-19) have been established from the profitability analysis that can be applied by others for now or in the future with improved data.

Potential adopters and non-adopters for the technologies are identified and factors that are likely to influence adoption are discussed. The study documented the participatory scientist-farmer research process. Suggestions for improving this process, the technologies and research are made as well as policy issues that need consideration for enhancing the uptake of the technologies. The PTD process and suggestions can now be adopted and applied and further work done to improve the livelihoods of rural people.

7.1 Summary and Conclusions

Agricultural productivity is maintained largely through bush fallowing or shifting cultivation in most places in Sub-Saharan Africa, including Ghana. The practice is no longer sustainable as fallow periods are no longer long enough to ensure adequate restoration of the soil. Soil regeneration period can no longer go beyond 1-5 years in most places. Crop productivity with respect to yields is declining while labour required to control weeds is on the ascendancy (Amanor, 1985) and the overall household food security and rural livelihoods are being threatened. Upton (1996) is of the view that with increased population pressure and shortening of fallows, production systems may prove unsustainable without increased use of manure and other forms of fertilizers (organic and inorganic).

Developing appropriate technologies for increasing the productivity of short fallows to sustain farm production and livelihoods is thus imperative. However, farmers are often reluctant to adopt research recommendations mainly due to lack of understanding on the part of research and extension of the constraints under which farmers operate, necessitating the PTD approach to ensure that suitable technologies are developed for improving fallow productivity. Developing or testing a new technology with the potential users forms a link between research and development (Kwesiga *et al.*, 1999) making agricultural research more effective (Okali *et al.*, 1994). The process develops of technologies suited to farmers' socio-economic and cultural settings, and thus enhancing the prospects of adoption for a higher impact on poor farmers' fields (World Bank, 1996) and ultimately, their livelihoods.

The initial characterization described the setting in which the study was undertaken as a multicultural or ethnic one whose livelihoods are characterized by small scale crop production economies that employ simple farm implements such as the machete and hoe for cultivating the land. Crop production, which is the main livelihood activity, may be supplemented with the rearing of small numbers of sheep, goats, pigs and poultry and variable off-farm employment by some people. Approximately 50% of the populations in the villages are illiterate, with the majority of these being women. Extension services appear to be limited, being worse in Gogoikrom-Atwima than the other study villages. However, physical accessibility to administrative and market centers by road is fairly adequate enabling regular vehicular movement of goods and people.

The study distinguished two main livelihood systems, native and settler in the three villages. The criterion for this classification was primarily based on origin/residential status of farmers, which determines the land status of households and/or individuals and consequently dictates the right, access to and control over the use of land particularly for farming. While Gogikrom and Subriso III are dominated by settlers, the majority of whom are tenants accessing land for cultivation through mainly sharecrop arrangements and rental by cash, natives cultivating land owned through family ties dominated the population of Yabraso.

A wide range of crops are grown as part of livelihoods strategies, however, there are major ones based on the relative proportions of farms under their cultivation. Cocoa, maize, rice, plantain, and oil palm are the major crops cultivated in Gogoikrom. Maize, plantain, yam, cassava, pepper, groundnut, tomato and oil palm are the main crops in Subriso III while yam, maize cassava, groundnut, pepper and cashew are the main crops cultivated in Yabraso. The majority of the landless are involved in the cultivation of the shorter duration food crops, although in Gogoikrom, the *abunu* tenure (1:1) shares after a tenant establishes plantation allows both landowners and tenants to equally engage in the production of cocoa, a tree crop. Generally, all farmers in specific villages cultivate all crops, however, gender and age niches associated with crop production are found, particularly in Subriso, where young landowner men are more involved in vegetable cultivation, while it is maize for landless men and women of all age groups as well as older landowner men. The latter are also more involved in plantain cultivation because it is a longer duration crop and requires a secure tenure whereas pepper and groundnuts are generally for women of all classes.

Fallowing was the common measure by which soil productivity was restored after limited periods of cultivation, often not more than 6 years, particularly for food crops as farmers hardly use any other soil amendment measure, with the exception of a few cultivating tomato in Subriso III. Even for vegetables like tomatoes and garden eggs, where inorganic fertilizer and other agrochemicals are applied to boost yield, the land may be fallowed for some 1-3 years after the crop has been relayed or rotated with cassava or maize to utilize the residual fertilizer. Consequently, short fallows characterized the food production systems. Such fallows range from 1 to 3 years in most cases with their vegetation characterized by *Chromolaena odorata* and several grass species such as *Panicum maximum*, *Pennisetum purpureum*, *Cenhrus ciliaris*, *Rottboellia exaltata,* and *Imperata cylindrica*, that do not enable sufficient soil fertility recovery. Farmers explained that this has resulted mainly from increasing population pressure resulting from influx of migrants into the study communities which is not only causing land scarcity but also the unavailability of relatively fertile soils for cultivation. Other important factors mentioned for causing shortening fallow were weather adversities and persistent wild fires. Moreover, monetary needs of older landowners make it impossible to leave land under fallow for very long periods to adequately restore its fertility.

Major production constraints, which farmers enumerated in relation to shortening fallows, were poor soils and an upsurge in noxious weeds that reduce crop yield and increase labour costs, reducing farm income. Nearly 20 different weed species were mentioned as growing on farms in the study villages. Most crops fields had to be weeded 2-3 times during the growing season due to high weed incidence. Furthermore, absence of reliable and less expensive farmer credit support systems coupled with poor and seasonal fluctuating prices for farm produce often renders their subsistence production unprofitable subjecting farmers to perpetual financial constraints, although there are adequate marketing outlets.

Various forms of soil fertility restoration technologies are being pursued to address the decline in productivity under shortening fallow rotations over the past two decades. These range from organic (animal and green manure, compost, mulch, short-term intensive fallows, agroforestry, etc.) and inorganic or chemical fertilizers. Short-term intensive fallow systems, commonly called improved fallows involving short-rotation herbaceous and woody species are being increasingly considered as alternative means of sustaining crop production in impoverished farming systems of Sub-Saharan Africa (Kaya *et al.,* 2000). The fallow is enriched with fast-growing trees, shrubs or vines to accelerate soil nutrient recovery with few external inputs, while employing traditional farming skills. Maize-legume relay, permanent plantain (plantain-legume), tree-crop, planted tree fallow, cocoa-shade tree and livestock-compost are among technologies that were proposed at a stakeholder planning workshop to address the plethora of constraints related to shortening fallows, tenure and farm income in the study communities, as presented in Chapter three.

Farmers rated these interventions. The discussions on reasons for their choices led to the identification of priority on-farm experiments appropriate for the three study villages. Farmers, in rating interventions, dwelt on the economic and food importance of the test crop component, i.e. maize and plantain for food and cash, cocoa for cash and asset, etc. It was also observed that they were consistent in their preferred choices, which were often appropriate first for their socio-economic standing with respect to security of tenure and then prevailing cropping and ecological systems.

Five main technologies were finally identified as suitable for on-farm experimentation in the study villages. The main objective of experimenting under farmer conditions was to develop, test and demonstrate the new technologies that are to be adopted by farmers. Maize-legume relay, permanent plantain, and cocoa-shade tree technologies were suitable for Gogoikrom-Atwima; maize-legume relay, permanent plantain and planted tree fallow were suitable for Subriso III – Tano, while maize-legume relay, yam-legume relay and planted tree fallow suited Yabraso-Wenchi. The experiments were essentially designed by researchers but managed by farmers. A total of 108 farmers tried these technologies over two seasons in 2001 and 2002, comprising 54 for maize-legume relay, 38 for cocoa-shade tree, 10 for plantain and 6 for the planted tree fallow across the study villages. An average of 50 farmers were also taken on exposure visits to the projects demonstration site and that of a GTZ project undertaking similar experiments with farmers each year for the two years of experimentation.

Farmer experiments were monitored by farmers and researchers at three stages i.e. beginning of the planting season through mid-way to harvest time/end of season, during which socio-economic and biophysical data was gathered by researchers and farmer perceptions were solicited.

The potential of fast growing leguminous species including *Mucuna, Cajunus cajan, Canavalia Gliricidia sepium* and several others to improve soil fertility and effectively control weeds at lower costs on crop lands while providing edible grain and extra income from their sale is known. Systems involving the use of these species in a short fallow system can be described as low cost and low inputs but profitable and environmentally safe or friendly technologies that can be used to reclaim degraded lands while improving the livelihoods of poor people.

The results from farmers' assessment of the experiments in the first year showed that some farmers observed both the biological and socio-economic potentials of the technologies, particularly, the maize-legume relay which is an annual system, although legume biomass production and spread was not encouraging due to insufficient moisture after planting the legume. Timely planting of experiments, reduction of spacing for legumes in the maize and planted tree fallow, timely production of adequate planting materials for plantain, planted tree fallow and cocoa-shade tree and timely supply of planting materials for all experiments were identified as key activities that required tackling in the second year if the experiments were to be successful. Addressing these concerns in the second year, coupled with the fairly evenly rainfall distribution throughout the growing season in 2002 culminated in good establishment for all the experiments. The permanent plantain, cocoa-shade tree and planted tree fallow experiments are more perennial. However, farmers anticipated positive results judging from the luxurious vegetative growth of the plants.

An *ex-ante* economic analysis assessing profitability suggested that the technologies are more profitable than their respective alternative land uses, i.e. traditional practices. Higher gross margins and returns to labour for the maize-legume relay compared with the natural fallow were obtained with a *Mucuna* fallow being the most profitable for adoption, although *Canavalia* also has an added advantage for use as food.

An assessment of the labour required for clearing the legumes in the 2003-planting season by clock timing, showed a slight reduction in the man-days of labour per hectare for clearing any of the legume fallows (7 man-days/ha) when compared with the natural fallow (9 man-days/ha) over 8 months of growth. However, returns to labour for adopting any legume fallow is about 2.5 times that of the natural fallow. According to Avila (1992) a technology developed to improve an agricultural system is likely to be appropriate if it uses labour efficiently since labour is a scarce and expensive resource. For such technologies, ratios of land to labour and capital to labour are high.

Cash flow analysis for all technologies also produced higher B/C ratios, NPV, EAV, LEV and IRR where appropriate, compared with the alternative traditional land uses if the technologies are not adopted. A sensitivity analysis showed that the profitability of the technologies is also stable in the face of increases in labour costs. They are nevertheless quite sensitive to decreases in produce prices or yield, as this caused a sharp decline in the NPV LEV, EAV, and IRR values. Cocoa, at the moment, enjoys a stable price which has recently appreciated annually and so may not be affected, but the maize and plantain systems characterized by seasonal fluctuations in prices may be hampered if yields decline, emphasizing the need to improve the productivity of the traditional systems managed under natural fallow rotations.

Farmers' also evaluated their experiments with indicators they developed in the second year mainly based on their perceptions. Their assessment of the performance of the maize-legume relay revealed that at least weed suppression and moisture conservation by legume cover had been realized. Judging from this, farmers were hopeful of an increase in the yield of a succeeding maize crop in the coming season as they anticipate decomposition of the legume biomass and conserved moisture to improve soil fertility. They also anticipated a reduction in the labour for clearing the legume fallow as compared to the *Panicum maximum*, *Cenchrus ciliaris* and *Rottboellia exaltata* grass and/or *Chromolaena odorata* fallow on the control plot.

In the development of indicators for judging the performance of their experiments, farmers were very objective, emphasizing effects that were of immediate need to their socio-economic circumstances and were priority problem areas in the farming system. This became apparent during the actual evaluation of the experiments. The results point out that the ability of the technologies to increase yields, food and cash were of major interest as these are valuable to their immediate socio-economic needs as they also portrayed while prioritizing the interventions for on-farm experimentation. Overall, all the indicators were primarily interlinked with a net effect of improved land productivity that ultimately leads to improved crop yields.

The mean scores of the ratings of the indicators by both genders seem to suggest that there are probably no distinct gender differences or preferences for the impact farmers expect to derive from the technologies. Soil fertility improvement is paramount in enhancing yields in maize systems in all villages. Improving soil fertility in plantain production is also desirable in Gogoikrom and Subriso but improving plantain planting material availability for extra income, expansion of farm and for fortification against lodging will further improve plantain productivity and income from this crop in Subriso. Planted leguminous tree fallows may be desirable for their potential in improving soil fertility in Yabraso currently, although by-products such as stakes and fuelwood may curtail scarcity in these products in the future. Once soil fertility is improved in any of the cropping systems, weed suppression may be attained. Erosion control is probably not a problem at the moment in all villages.

With cocoa, improving yield is a priority of which shade trees play a role but economic products from the trees are not of immediate concern.

On the whole, the technologies are attractive for adoption by farmers judging from the profitability analysis and farmer perceptions. Farmers often prefer technologies that yield quick returns, thus, particularly; the maize-legume; permanent plantain and the planted tree fallow are suitable for adoption in the short term. For those having long-term goals for assets and future security, the cocoa-shade tree should be attractive as the farmer has a more diversified system, allowing him or her to earn income over a longer period with added benefits from tree products but still providing short term benefits from the intercrop outputs.

7.2 Factors influencing farmers' experimentation and adoption

A number of practical issues arose during the two years of experimentation with farmers. The challenge to develop appropriate technologies that can improve and sustain short fallows for adoption with farmers was predicated by factors like gender, age, land status, labour, wild fires, farmer enthusiasm and willingness to experiment, suspicion of motives of researchers and land tenure. Other issues of importance were farmers' preference for the value of the test crop and the effect or the outcome of the first year of experimentation.

7.2.1 Gender, age and land wealth/ status

Gender, age and land status of farmers were found to be important in dictating farmer decisions to participate in the development of the technologies. Generally, men, older people and native landowners are in a better position to absorb the initial risk of trying the new technologies as they are key decision makers, are better resourced in terms of land and are more likely to be interested in land improvement or conservation measures in the long term.

The favourable tenure conditions for cocoa cultivation enabled both landowners and non-landowners to try the cocoa-shade tree experiment. Although maize can be grown under all tenure conditions, i.e. own, sharecrop, rent or free land by all classes of farmers some tenant farmers did not participate because of short tenancy. It must be remembered from the characterization of production systems above that although tenure on maize land may range from 1-4 years, the majority of maize tenant farmers in the three villages have a one-year tenancy to cultivate sharecrop or rented land. Similarly, for the permanent plantain system only a few tenants who acquired sharecropped land for 3-4 years were able to participate. No tenant farmer or non-landowner showed any interest in trying the planted tree fallow, as they believed it was a technology for landowners.

Some tenant farmers participating in experimentation discontinued or lost interest in repeating the experiment in the second year because they lost access to the use of the experimental plot in the following season. In one case where a farmer established her experiment on family owned land in the first year, another family member having the right to the use of that same parcel cleared the immature legume fallow in the absence of the participating farmer for her own use. This means even for family owned land, security of tenure is required for those who do not have absolute control over their farmland in order to derive the expected benefit from planted fallows.

It is observed that poverty and lack of control over productive resources may make it more difficult for farmers to repeat an experiment over a series of years to enable the confirmation of observations (Sumberg & Okali, 1997 citing Amanor, 1994).

7.2.2 Farmers' objective for participation

Although participatory research may have many advantages over earlier approaches, its application is often driven by diverse farmer interests for participation (Frost, 2000 and Bellon, 2001). It was observed from the study that farmers' willingness to participate might be governed by their aim for participation and their understanding or perception of the objectives of the project. However, farmers often had other expectations outside project objectives. Although farmers may be aware of the poor nature of soils and potential benefits of adopting or participating in soil improvement measures, they are often more concerned with immediate gains. The majority of the farmers in the project villages cooperated in providing the relevant information at the various stages of the project. Some farmers were enthusiastic in following through the project and experiments over the project period of three years. However, the majority (90%) of those who participated in the experimentation did so because they expected some material inputs, such as seeds, and financial gains from the project.

7.2.3 Labour and cash resources

The process of integrating farmers in technology development enlightened the farmer, extension and scientists. However, conflicts of interests arose particularly between the farmer and the scientist in the manner in which the research process is managed. While scientists followed a well-programmed schedule of activities, the farmer's seasonal plan of activities was subject to household socio-economic shocks. Differences in resource capacities may be the leading cause. The scientist was better resourced, having sufficient funds for planned activities. On the contrary, farmers performed cultural operations especially, planting and weeding at their own pace, depending on the availability of labour or money to engage labour for doing so. It is known that poverty, drudgery and risk–averse behaviour hamper the ability of farmers to experiment (Sumberg & Okali, 1997).

Labour, particularly for weeding after the experiments had been established, was a problem to most of the participating farmers for all the technologies. This contributed to most of the plots not establishing well in the first year irrespective of the drought that occurred. Across the three villages most farmers cultivate on the average two or more farms during any particular season. Hired labour (by-day) is commonly used to supplement family labour for weeding. It was realized that by-day labour as well as money was scarce during the weeding period (i.e. June-August). Farmers relied largely on family labour for weeding, which delayed this operation.

For the maize-legume relay experiment, some of the farmers were not willing to do a second weeding before relaying the legumes in the first year (necessary to facilitate growth) because they were expecting financial aid from the project, while others wanted to test the weed smothering potential of the legumes. Moreover, although money and labour are scarce during June-August when this activity is done, the maize is physiologically matured at 8 weeks after planting; hence there is no need to waste scarce resources on weeding maize for the legume to be relayed. However, returns to labour on adoption of the legume are high, a mean of about ¢80,000 per hectare is earned for an extra man-day of labour (worth ¢7,000 in 2002) invested and a gross revenue twice that of the natural fallow could be earned. According to Loos (2000) labour requirements can be rated low since planting of the relay legumes might be combined with the last weeding of the maize crop. Labour for weeding in the succeeding crop will be much reduced due to less weed load as compared with that of the natural fallow re-growth.

7.2.4 Credibility and uncertainty

Some farmers were also suspicious of the motives of scientists for collaborating with them in experimentation. Those who tried the maize-legume relay, especially, were skeptical about ownership of maize proceeds from the experiment even though this had earlier been assured. This discouraged some from relaying the legume in the first year. Others relayed the legumes but quickly harvested for sale before yield assessment was due. Suspicion could possibly be one of the reasons why some farmers refused to weed their experiments after planting the legume. It is known that farmers' ability to try innovations is generally lessened by a reduced capability to follow through with experiments and to bear the risks associated with unproved practices (Sumberg & Okali, 1997 citing Amanor, 1994 & Winarto, 1994) particularly with outsiders.

7.2.5 Outcome of first season experimentation

Although, the potential benefits of herbaceous legumes in improving crop productivity in smallholder systems are widely reported, the technologies were quite new to the farmers. Thus, there is the tendency for the majority who may not be restrained by tenure or particular crop or gender related production niches to sit on the fence, waiting for the outcome on the innovators' fields. This means the outcome of the experiments in the first year is important in inducing uptake.

The outcome of experiments in the first year did not meet the expectation of some farmers. This dampened their enthusiasm to continue the trial in the second year as they opted out explaining that they did not realize any improvement, causing the reduction in participants in the second year, particularly for the maize-legume relay as reported in Chapter 6. As indicated above, some farmers who planted the maize-legume relay did not weed their experiments after the legumes were relayed. This, coupled with the sudden drought that occurred and the fact that some of the maize stands were so thick and so shaded the emerging legumes, lead to poor establishment of the legumes.

It became apparent from discussions with the farmers that due to the irregular weather pattern and erratic nature of rains, time for sowing the legume seeds was important. Some legume species that take longer time to germinate are thus likely to establish poorly if not planted in good time or targeted properly to meet good rains. This accounted for the poor performance of particularly, the *Stylosanthes* spp on most of the fields where it was planted. In all three villages it was realized that the legume species needed to be planted early (5-8 weeks after planting maize) and weeded at least once after the relay to ensure good establishment or spread during the major season.

7.2.6 Multipurpose technologies and value of test crop

According to Kaya *et al.* (2000) improved fallows would not be attractive to farmers, if such technologies did not produce other benefits other than soil fertility improvement and higher crop yield. The technologies introduced for fallow improvement had multipurpose objectives of improving and sustaining soil productivity for higher yields, catering to short tenure problems (maize-legume relay) and diversifying household food and income sources (shrub legumes for food and fodder; tree legumes in plantain and planted fallow for wood, i.e. stakes and poles; planted indigenous shade trees in cocoa for wood, fruits and medicines).

The value of the test crop attracted participation. In Gogoikrom, the cash and asset values of cocoa apart, from the more secure tenure, enticed most farmers to experiment the cocoa-shade tree experiment over the maize and plantain. The immediate cash and food values placed on maize and plantain in Subriso III and for maize and yam in Yabraso lead to the majority of farmers opting to try experiments with these crops over the planted tree fallow. Snapp *et al.* (2002) observed among smallholder farmers in Malawi, that although the majority of them recognized the potential of legume technologies in improving crop productivity, their adoption was not straightforward as higher priority was placed on food and cash values with soil fertility being a secondary concern. They argued that improvements in soil fertility in developing countries were likely to be pursued as a by-product of market development. In other words it is only when markets for technological components are attractive that soil fertility improvement may achieve a higher adoption rate.

7.2.7 Wild fires

The annual wild fires that often sweep through both cultivated and uncultivated fields particularly in the Wenchi area during the dry season, pose a threat to the fallow interventions. For instance, some of the planted tree and herbaceous legume fallows were burnt at the end of the first season on both farmers' fields and on station at the Wenchi Agricultural Station. Protection of the planted fallows from bush fires is critical if their impacts are to be realized. According to Frey *et al.* (2001) leguminous cover cops have the potential to shorten fallow periods from 4-6 to 1-2 years subject to control of bush fires.

In conclusion the study confirms that for land and soil improvement technologies to make desired impacts, their ability to improve crop yields and provide an additional product such as food or extra income opportunity i.e. multipurpose could be important in enticing farmers in the adoption of such technologies. It is observed that farmers often have multiple criteria for assessing new technologies, including economic profitability, risk, and contribution to food security, time taken to see a return on investment and labour requirement. To be widely adopted, new technologies should perform better in meeting these criteria than existing technologies (Carter, 1995).

The study also showed that tenure, age and gender differences might also be important in technology adoption. Men (including male tenants in Gogoikrom) above 35 years and landowners (including native landowner women in Yabraso) are potential adopters. Tenants in Subriso and Yabraso are limited by unsecured tenure while women in general seem to be constrained by gender roles limiting participation in community decision-making and implementation of development processes.

7.3 Recommendations

7.3.1 Recommendation Domains

From the overall analysis of issues above the following technologies can be tentatively recommended as appropriate for improving farm productivity under shortening fallows in the three study areas.

7.3.1.1 Maize-Legume Relay

The maize-legume relay is potentially recommended for all the areas, i.e. Gogoikrom, Subriso III and Yabraso and could be adopted in other areas of the forest and savannah transition zones (Table 7.1). In addition to being suitable for these agro-ecological zones, all farmer segments irrespective of residential status, land status, gender cultivate maize for both food and cash. Although appearing to be gender neutral, the technology may be more suitable for men as they are more men involved in its cultivation in all three-study areas (i.e. 83%, 69% and 55% for Gogoikrom, Subriso III and Yabraso respectively). Farmers explained that handling maize, particularly for marketing is laborious, making its production more suitable for men. Moreover, the crop is commonly cultivated on land previously under a short fallow or cropped and could be grown twice in a season on the same plot. This obviously depletes soil nutrients faster, thus the annual legume-relay is relevant for sustaining soil productivity in maize systems.

The landless are commonly involved in maize cultivation across the study sites. However, duration of tenure and security during the tenancy period may restrain landless people from adopting the technology. To be able to utilize the effects of the herbaceous legumes, access to land for at least two years is required. For farmers constrained by either very short tenure i.e. one year tenancy or landowners with limited land, it is possible to plant species such as *Mucuna* in the major season and clear for second season maize to benefit from the biomass growth over 4-5 months.

Table 7.1: Recommendation domain for maize-legume relay technology

Farmer Category	Districts/Agro-ecology	Features
Natives Settlers Men Women Landowners Tenants	Atwima Tano Wenchi Forest (Moist, semi-deciduous & dry) Savannah-transition	• Short duration • Short tenure but at least 2 years • Legume relay at 5-8 weeks after sowing maize • Labour for weeding at least once for establishment of legume is critical • Protection of fallow against bush fire important for biomass & soil moisture conservation • Possible adaptation for rice, vegetable and yam systems in Atwima, Tano and Wenchi respectively

The legume needs to be relayed between 5 and 8 weeks after sowing maize depending on the legume species and cropping pattern. The legume could be relayed at 5 weeks if erect or non-creeping species like *Canavalia* are desired and in mixed systems. It could also be relayed after 5 weeks (6-8) for monocrop maize and if species such as *Mucuna* (creeping) are desired, to minimize strangling of maize. Also maize should be harvested as soon as matured to avoid the *Mucuna* covering the maize cobs to reduce yield.

The time of relaying legume should coincide with either first weeding for those who might weed once at six weeks after sowing maize or second weeding for those who weed twice (due to high weed pressure) to avoid labour constraints for relaying legume. However, weeding at least once after the legume is relayed is important for enhancing legume establishment, i.e. growth and spread. In fire prone areas in Tano and Wenchi, there is need for creating a fire belt around the legume fallow in the dry season to protect it from being burnt by wild fire.

The use of legume species such as *Mucuna* in rotation with sole cropped rice for weed control and soil improvement is equally feasible in the rice-based cropping systems in Atwima characterized by short fallows of 1-3 years. In Tano and Wenchi, annual rotations of long season *Mucuna* fallow with vegetables and yam have the potential to improve yields and minimize weed evasion.

7.3.1.2 Permanent Plantain (Plantain-legume)

The permanent plantain (i.e. plantain-legume) technology is suitable for Atwima and Tano because the ideal ecology for plantain production is found in these areas and more particularly, for Tano where trees are becoming deficient on farmlands (Table 7.2). Also in Tano, where plantain is the second important crop after maize, the crop is likely to be cultivated on land previously under short fallow, which may not sustain production for more than two years. The legume can enhance the productive life of the crop. Consequently, the technology has wider application in moist forest and semi-deciduous forest ecologies.

Table 7.2: Recommendation domain for permanent plantain technology

Farmer Category	Districts/Agro-ecology	Features
Natives Settlers Men Women	Atwima Tano Forest (Moist & semi-deciduous)	• Land owners • Long tenure • Labour for pruning to mulch • Possibility of planting annuals (e.g. maize, vegetables) in the alley in first year

The analysis of livelihoods and profile of farmers who participated in planting the permanent plantain technology in Atwima and Tano showed that all farmer categories, i.e. natives and settlers as well as landowners, tenants, men and women, grow plantain. However, the technology might be more suitable for landowners as 85% and 50% of plantain-based farms were found on land owned in Subriso III (Tano) and Gogoikrom (Atwima) respectively. Furthermore, 70% of the permanent plantain experiments were established on land owned by the experimenters.

Plantain is a longer duration crop and the tree component of the technology might make it more suitable for landowners. Nonetheless, it is possible for tenants to use annual herbaceous legumes such as *Canavalia* instead of the tree legumes like gliricidia where the tenure system does not permit tenants to plant trees. Tenants desiring to adopt the technology require a longer tenancy, greater than 3 years, to realize the benefits of the legume.

The permanent plantain technology has the potential to enhance and sustain yield. However, investment in labour for pruning the legume hedgerow and application of the biomass is essential if these benefits are to be realized. There is the possibility of planting suitable short duration crops such as maize and vegetables in the alleys for the first year. This will reduce weeding labour and ensure that some benefits are derived from the alley spaces that would otherwise be left unplanted.

7.3.1.3 Cocoa Shade-Tree

The cocoa-shade tree technology is relevant for Atwima and other areas in the moist forest and semi-deciduous forest areas as their ecology and soils (long fallow) are suitable for cocoa production (Table 7.3). Although the crop is cultivated on land cleared from long fallows with fertile soils, the technology is relevant as there is the need to increase the quantity of desirable shade trees, particularly on hybrid cocoa farms to protect the crop from sun scorch during the dry season and to sustain the productive capacity of the soil and the crop over a longer period.

Table 7.3: Recommendation domain for cocoa-shade tree technology

Farmer Category	District/Agro-ecology	Features
Natives Settlers Landowners Tenants Men Women	Atwima Forest (moist & semi-deciduous)	• Increase quantity of shade trees for hybrid cocoa • Secured tenure

The cocoa-shade tree technology is long term but suitable for adoption by all farmer categories in the Atwima area and other areas in both the moist and dry semi-deciduous forest zones. This is because all farmers, irrespective of gender, residential and land statuses do grow cocoa in the area. Analysis of livelihoods and profile of farmers experimenting with the technology indicates that the technology could conveniently be adopted by tenants cultivating cocoa under the *abunu* sharecrop arrangement as this provides a relatively favourable tenure, secure enough for the tenant to benefit from the technology in the long term. Under the *abunu* tenure, the plantation after it is established is shared 50:50 between the tenant and the landlord. Security is ensured through legal documentation, with each party retaining his/her portion for good.

7.3.1.4 Planted Tree fallow

The fact that 65% and 73% of lands cultivated in Subriso III and Yabraso respectively had previously been under short fallow and/or cropped makes the planted tree fallow technology relevant for Tano and Wenchi areas as well as other areas in the semi-deciduous forest and savannah-transition zones. The technology, however, is suitable for adoption by landowner men and women as they are involved in tree crop production in these areas. The tenure systems in the area do not allow tenants to plant trees unless such landless people purchase land outright. Planting of trees is generally tantamount to owning land in most areas in Ghana. Moreover, landowners were found likely to fallow land when its productivity declined while tenants often abandoned land when tenancy expired or productivity declined.

Table 7.4: Recommendation domain for planted tree fallow technology

Farmer Category	District/Agro-ecology	Features
Landowners Men Women	Tano Wenchi Forest (dry semi-deciduous) Savannah-transition	• Landowners • Labour for ring weed at least once to for establishment of Gliricidia critical • Protection against dry season wild fire (fire belt)

Natural fallows in the study areas are not weeded. Nevertheless, the planted tree fallow requires an investment in labour to do ring weeding at least once around the tree seedlings during the first year of planting. This is necessary to reduce competition from weeds and enable a higher seedling uptake for better establishment.

The vegetation of Tano and Wenchi areas predominantly characterized by grasses is highly prone to destruction by wild fires in the dry season. Consequently, some labour is also necessary for creating a fire belt around the fallow during the dry season to protect it from being destroyed by wild fires.

7.3.2 Recommendations for PTD Process

The PTD process adopted was quite elaborate and the iterations were helpful in shaping the experiments. It is undoubtedly an improvement on conventional methods for incorporating agricultural innovations into farming systems. However, certain aspects of the process may require refinement for future work.

7.3.2.1 Frequency of interaction and level of farmer involvement

Experience from this study shows that a participatory technology development process could be an expensive one, requiring sufficient resources or logistics and a well planned programme of activities with farmers that will enable regular contact or interaction with farmers, especially in the case where the technology is entirely new to farmers. Also important is the scale of operation. The project tested four technologies in three villages with several farmers. It also established village demonstration sites in two villages and on-station trials. This means frequency of contact with farmers during experimentation may not be very high, since several activities needed to be undertaken.

There are four main ways by which farmers and scientists can collaborate in developing new technologies depending on the objective of the research (Bellon, 2001; Degrande, 2001). The project adopted the researcher-designed and farmer-managed approach. Unfortunately, farmers failed to recognize their freedom in experimentation as they often waited for researchers' advice before carrying out an activity, which sometimes caused delays.

There is a need to change the strategy on the level of farmer involvement in the process of experimentation and evaluation of outcomes. Farmers should be encouraged to have more control over the experiments, thereby balancing scientific rigour with the flexibility of farmers leading the process in the future to encourage innovativeness. For instance, farmers participating in the cocoa technology in Gogoikrom raised and transplanted seedlings individually in their backyards or plots on their own instead of doing so in a community nursery. This facilitated the production of adequate planting material and timely transplanting of the seedlings for better survival.

To ensure a higher level of participation it is important to shift towards the joint researcher-farmer designed and managed or the farmer designed and managed approaches now that farmers appreciate the usefulness of the technologies and have some experience. Village or cross-site demonstration workshops including field days during which participating farmers can present their experiences and train others in trial establishment and management will go a long way in spreading the knowledge and enable farmers to experiment on their own with little outside influence from researchers and extension. The latter could facilitate by back stopping with technical advice when needed. In this case farmers can plant the experiments with whichever crop and legumes desired, manage on their own and harvest seeds at their own time. This approach will reduce cost and save time and enable more people to explore their innovativeness. It is known that farmers are knowledgeable, well articulated on the bio-physical and socio-economic features of their traditional farming environment and are capable of conducting experiments on their own initiative (Bellon, 2001). These attributes should be harnessed to encourage farmers to be more proactive and enhance adoption.

Technology options were initially conceived at an expert workshop before involving farmers in prioritization for on-farm experimentation. The farmer prioritization process was quite intriguing, revealing a wealth of knowledge and rationale judgments and reasons for choices made that reflected appropriateness to farming systems and socio-economic conditions of particular farmer groups. However, the process was lengthy involving about 5 sub-stages, i.e. Expert/stakeholder workshop for technology identification; farmer rating of proposed interventions; scientists' review of ratings and discussions leading to development of protocols for on-farm trials; farmer rating of on-farm trials and implementation of on-farm experiments. The series of ratings and discussions could have been enhanced with farmer involvement in the first stage of technology identification. Bellon (2001) suggests that researchers and farmers need to jointly discuss possible options for addressing prioritized problems. This early involvement would have made farmers perceive the experiments as their own (Dorward *et al.*, 2000) and clear doubts and fears related to ownership of proceeds and so on encountered during experimentation.

Dorward *et al.* (2003) recommend an ex-ante evaluation process involving participatory farm management methods that in addition to needs assessment could also enable farmers and researchers to jointly develop participatory budgets to analyze current cultivation practices, identify options for incorporation of the technologies into the system and explored direct and wider resource implications of these technologies.

During the discussion with farmers at stage two of the technology prioritization process, labour and monetary limitations associated with the maize-legume relay were identified in Subriso III. This was related more to the feasibility or resource implications of planting large acreages of the legume fallow but not the resource implications related to timing of the relay activity. Farmers explicitly agreed that relaying of the legume at 8 weeks after sowing of maize or second weeding when the maize was at knee height was appropriate without realizing labour and money was scarce during that period. Perhaps a Participatory budget with the farmers would have enabled issues concerning labour and cash constraints, (Dorward *et al.*, 1997 and Dorward *et al.*, 2003) associated with timing of weeding in general and relaying legumes in the maize-legume relay technology be resolved earlier prior to on-farm experimentation. Suitable options for overcoming such constraints could then have been identified over few days for incorporation into experimentation rather than was done over two seasons of on-farm work.

7.3.2.2 Exposure

Exposure visits are essential in enhancing farmers' understanding of experiments much earlier in the technology development process and to minimize doubts, fears or uncertainty in trying the experiments. Consequently, these visits should be embarked on quite early during the experimentation period, particularly to fellow farmers' fields and possibly before or soon after listing for experimentation.

7.3.2.3 Value of technology

Farmers showed preference for cash and food value for fallow species other than soil fertility improvement. This was evident when they were rating the interventions for experimentation and again during the appraisal of the first year's performance of the experiments and the project in general with farmers. There is a need to strike a balance between soil fertility and food values. The choice of *Canavalia* spp. as one of the fallow species was very good in this regard. Farmers, on realizing the food value of this legume, had begun saving seeds and planting it in mixtures on their own.

7.3.3 Policy Recommendations

The study revealed that the practice of fallowing land naturally is the main method for restoring soil fertility in most farming areas in the country and that short fallows of 1-4 years duration, are common. Farmers generally regard these fallows as being relatively low in fertility, although their livelihoods largely depend on the cultivation of such lands. Hence, improving the productivity of these short fallow systems should be of national concern for policy redress. When development policies are favourable, the adoption of farm innovations can be enhanced. A number of policy issues can be raised from this study to serve as incentives for the adoption of techniques for improving fallow productivity. These relate to education, training or extension; land tenure, awards and grants. Price policies also need to be considered to support improved crop productivity to enhance farm incomes and livelihoods.

7.3.3.1 Land tenure

The study showed that landowners did fallow land when its productivity declined while tenants hardly did so. A higher proportion of farmers involved in the cultivation of food-based systems, particularly, maize, rice, and yam in some farming areas may be tenants who, apart from not fallowing, derive the maximum from the land before abandoning. The productivity of soils in such areas and livelihoods are under threat if landowners do not actively adopt suitable soil improvement technologies to sustain production.

Consequently, landowners need to be encouraged to adopt technologies for improving land for renting and sharecropping at higher values. Land tenure is one of the important factors influencing adoption of legume fallow systems. Buckles and Triomphe (1999) observed in northern Honduras that landowners and farmers with larger plots were more likely than other farmers to adopt the *Mucuna* system to grow maize. A third of the landless respondents in their study planted at least some of their maize in an established *Mucuna* field rented from a landowner. Farmers with more land than they can cultivate diverted some to the establishment of *Mucuna* fields for rent or later use themselves. Tenants were willing to pay a premium of 60 to 70% to cultivate maize on land planted to *Mucuna*, a clear indication of the potential of the field. This tenure arrangement can conveniently be adapted to the Ghanaian farming situation. Landowners in the study area and indeed other areas where soil productivity is constraining crop production and livelihoods can be encouraged to improve the productivity of farmland by adopting improved fallow techniques and thereby rent land at higher fees or sharecrop on the 1:1 (*abunu*) basis for food crops as opposed to the 2:1 *(abusa)* for landlord and tenant practiced currently.

7.3.3.2 Education/training/extension

Policies that promote education through training or extension of information on fallow improvement technologies to land owners or communities need to be in place. Research-extension-farmer liaisons are needed to enhance farmers' knowledge in this regard. The government needs to support the appropriate research institutions and the Ministry of Food and Agriculture to develop and extend fallow improvement techniques with farmers. The government must also support District Assemblies to institute land improvement programs that will encourage landowners to adopt improved fallow techniques. Awareness creation in the national and local media is also necessary to enhance the uptake of fallow techniques.

7.3.3.3 Policy research

Traditional land tenure systems in farming communities in Ghana are well developed and complex, although flexible to cater for the needs of the landless. Ownership rights and controls to access and use are vested in traditional landowning families, regulated by local policies developed over time. This makes government intervention in changing traditional tenure unpractical. Participatory policy research that encourage dialoguing with communities to develop tenure innovations that will allow agricultural land users including the landless to adopt technologies for improving land productivity and conservation require consideration.

Policies or legislation on fire management in the dry season is in place at the national level in the country. However, there is need for the development fire prevention policies at the local level. These can be enforced to check bush/wild fires and encourage fallow development.

7.3.3.4 Grants

Farmers' motivation to adopt technology should be supported by the government and its development partners. Government may have to consider putting in place policies for the provision of small grants to serve as incentives for landowners to take land out of intensive or extensive cultivation for fallowing. Some possible sources of such grants may be from ongoing schemes such as the District Assemblies common fund and poverty alleviation fund. Some funds from the ongoing Food Crops Development Project funded by the African Development Bank could also be directed for use in improving the productivity of the short fallow systems, which might be more sustainable in the long term than the current inorganic fertilizer systems being promoted with the fund. Adequate measures would need to be put in place for efficient implementation and monitoring of such schemes to minimize abuse by farmers and officials.

Farmers in the study areas had expectation for credit or material input provision. This was the reason why 90% of the farmers participated in the trials. It might be important for researchers to make provision for some level of incentives in their budgets to donors or funding agents during project preparation to encourage participation in trying experiments.

7.3.3.5 Awards

Institution of awards for best fallow farmers at the district and national levels on annual farmers' day needs to be considered as an incentive for encouraging landowners frequently giving out land for sharecropping or renting to supplement farm income to minimize this behaviour and/or adopt suitable fallow improvement techniques such as the planted tree fallow. This might also force farmers to find suitable means for protecting planted fallows from destruction by wild fires.

7.3.3.6 Price policies

Marketing infrastructure is moderate in the study area, although may be inadequate in other areas. Abolishing of government-controlled prices for agricultural commodities has subjected produce prices to market forces, dictated by middlemen. Prices are poor and fluctuate depending on supply and demand, subject to weather conditions. Consequently, if crop productivity is improved through improved fallow techniques, farmers may not benefit from this change if appropriate price polices that stabilizes prices for agricultural commodities are not put in place.

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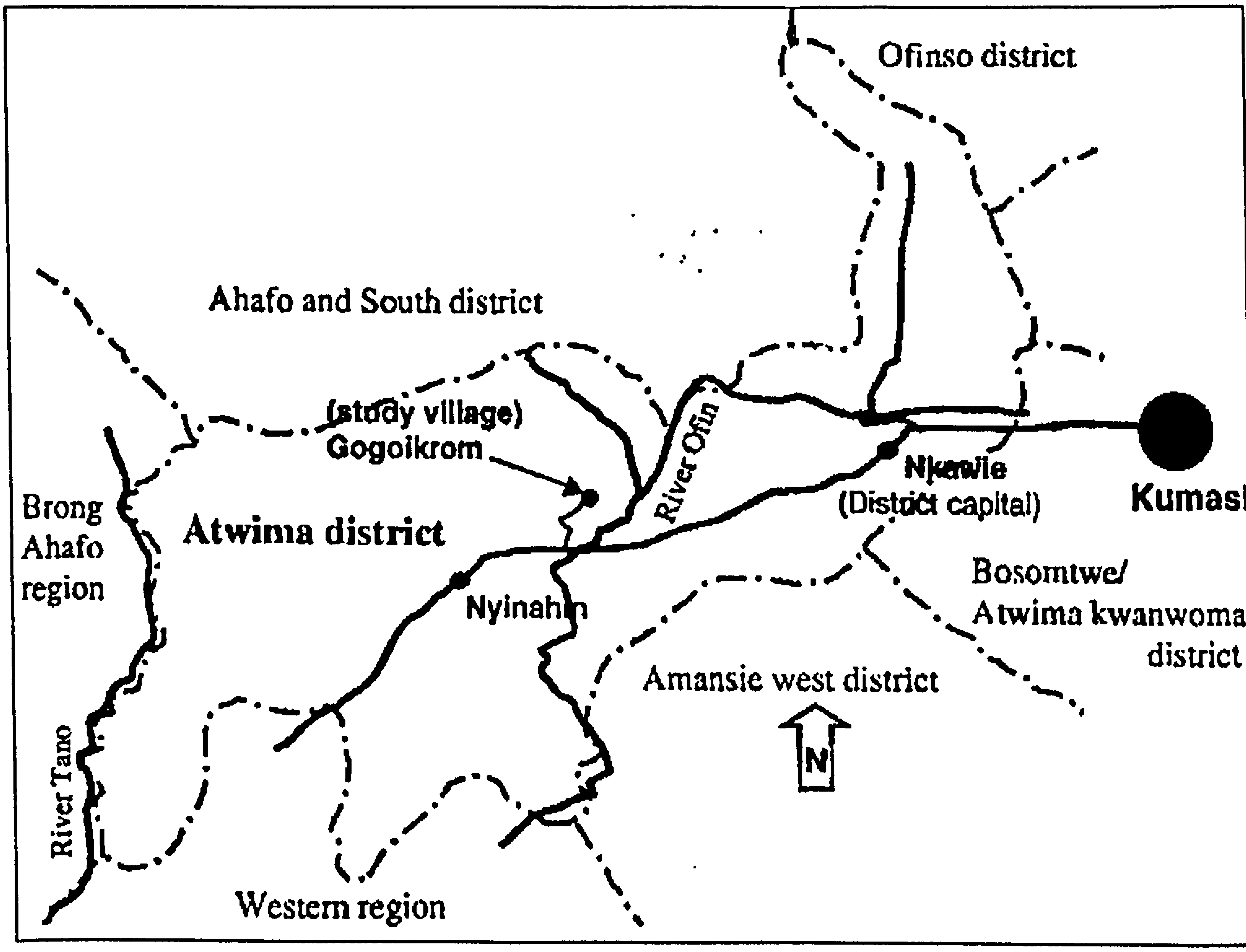
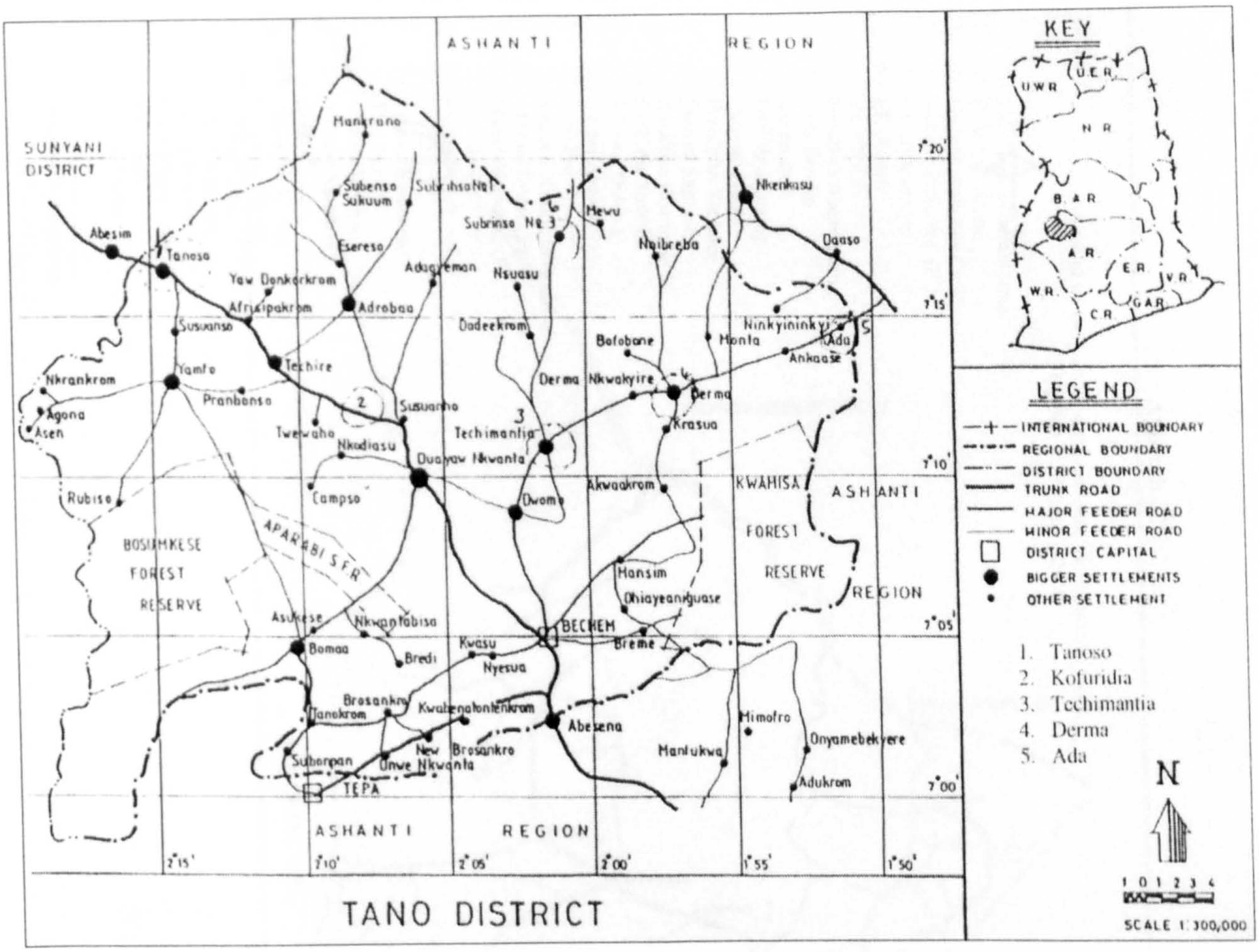
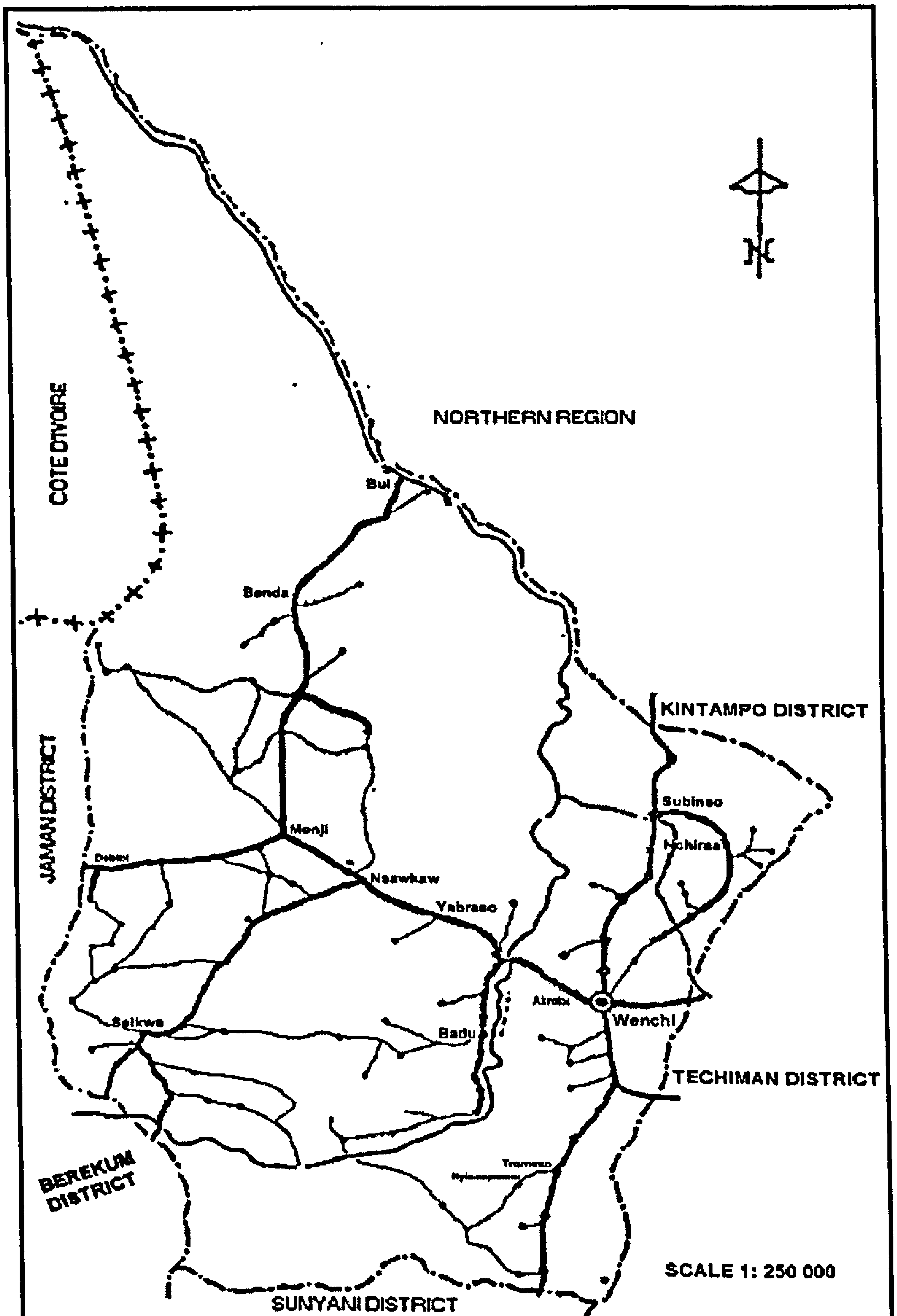
Appendix 1: Map of Atwima District locating Gogoikrom



Appendix 2: Map of Tano District locating Subriso III



Appendix 3: Map of Wenchi District locating Yabraso



Appendix 4: Checklist - Qualitative livelihood characterization

A. Reconnaissance survey & Initial Village PRA

I. Key informants interviews & Village meeting

1. Historical background of village/people
2. Size of village & surrounding area owned
3. Village structure
4. Village population/ number of households or houses
5. Ethnic groups
6. Employment
7. Land use
8. Production systems & gender distinctions
9. Crops and purposes of cultivation
10. Land availability
11. Land tenure/acquisition
12. Land allocation, inheritance & transfer
13. Other means to acquire individual lands
14. Access to land by settlers, women & migrants
15. Labour (availability, seasonality, movement, cost)
16. Division of labour
17. Decision making roles
18. Fallows (availability, length, cropping/production system)
19. Fallow vegetation
20. Trends in fallow (Length, vegetation) – historical diagram
21. Main causes of changes in fallow
22. Effects of changes in fallow & Coping strategies
23. General farming constraints & Coping strategies
24. Trees on croplands
25. Support services (access to capital, markets, extension, educational & health facilities, etc.)
26. Major income sources of villages
27. Farmer's associations, activities and functions
28. Women's participation

II. Resource mapping

1. Village area & boundaries
2. Central point
3. Major bench marks (rivers, forest reserves, sacred groves, roads, church, mosque, markets etc.)
4. Infrastructure (roads, schools, hospital/clinic/health centre, market, banks, post office, church, mosque, etc.)
5. Use of natural resources
6. Major land use (settlement, farms, fallows, forest & other natural vegetation, grazing areas, etc.)
7. Soils, fertility status & uses

III. Transect walk

1. Land use
2. Production system(s)
3. Crop types & cropping pattern
4. Animals
5. Soil types, uses, management and constraints
6. Vegetation
7. Fallow (length, vegetation – grass, shrubs & trees)
8. Weeds and their management
9. Trees & uses
10. Production constraints

Opportunities

B. Group Interviews/Discussions

1. Stratification of village population

Criteria

- Origin (settler/indigenous)
- Land ownership/security of tenure
- Age

2. Historical profile of cropping system and environmental change

- Changes in types of crops grown and varieties & causes of changes
- Cultivation practices (e.g. shift from intercropping to mono-cropping)
- Soil fertility management practices
- Changes in tillage practices
- Changes in types of weed
- Changes in weed management e.g. frequency of weeding
- Changes in length of fallow
- Changes in type of vegetation found on fallow land
- Extent of tree cover
- Degree of commercialization of production

3. **Fallows & soil fertility**

- Fallow types
- Changes in fallow length and effects on crop production (weeding requirements, crop yields, etc.), vegetation, soil productivity and causes
- Coping strategies to effects of changes in fallow

4. **Cropping system**

- Crops grown & seasonality
- Crop land sizes
- Cropping pattern (moncrop/mixtures)
- Cropping sequence
- Crop rotations
- Crop budgets
- Cropping calendars for each crop (crop-monocrop/mixtures, time period- months/major & minor seasons, activities)
- Emphasis on production (cash/consumption) & why
- Gender differences in production and why

5. **Innovation assessment**

- Any previous experience with interventions in the village & types e.g. High yielding varieties, credit or saving schemes
- How interventions got to the village
- Identify any reasons for success or failure

6. **Land tenure**

- Land availability for farming
- Access to land for farming
- Types of tenure
- Cost and arrangements for tenures
- Tenure for different crops
- Differences in fallow for different tenures
- Any problems with renting & sharecrop tenure

7. **Labour**

- Gender and age differences in carrying out activities (men, women, male & female children)
  - ✓ Agricultural
  - ✓ Household
  - ✓ Off-farm & other activities such as trade
- Labour calendar to show seasonal work pattern
- Labour types and sources
- Activities performed by different labour and costs (time used, number of people, cost per acre of land per activity)
- Gender differences in the provision of hired labour
- Labour supply and demand

- ✓ High demand period and for what activities
- ✓ Low demand periods and for what activities
- ✓ Period of labour abundance
- ✓ Period of labour scarcity
- ✓ Mobility/seasonality of migrant labour
- ✓ Constraints to labour acquisition and effect on agricultural activities
- Daily time allocation budget for men, women and children for daily activities

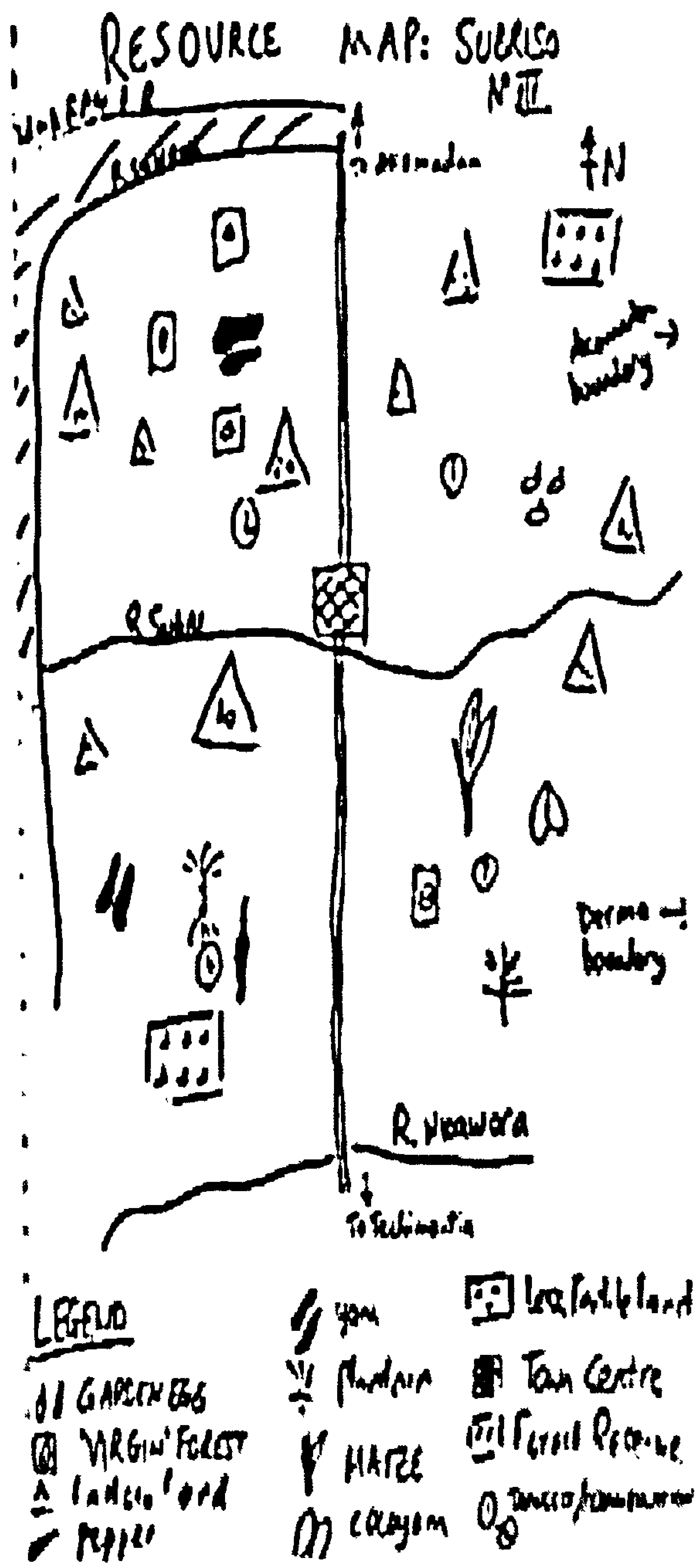
8. Agricultural finance

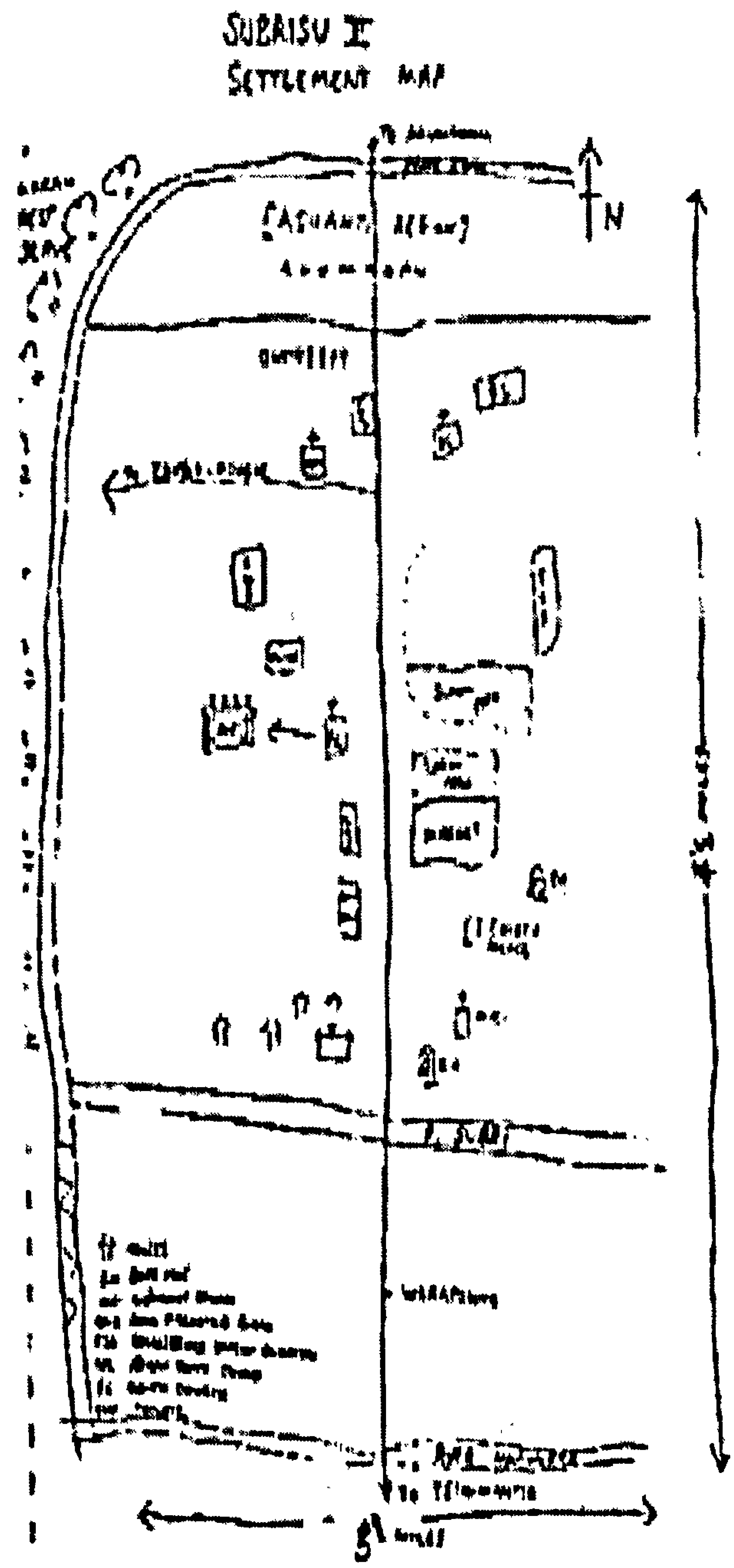
- All expenses for which cash required listed and ranked to determine important ones
- Main income sources for household and farm and times available
- Period of money scarcity in the year and effects
- Period of money abundance in the year & uses
- Peak money demand period and what needed for
- Credit sources, availability, access and cost

9. Agricultural Marketing

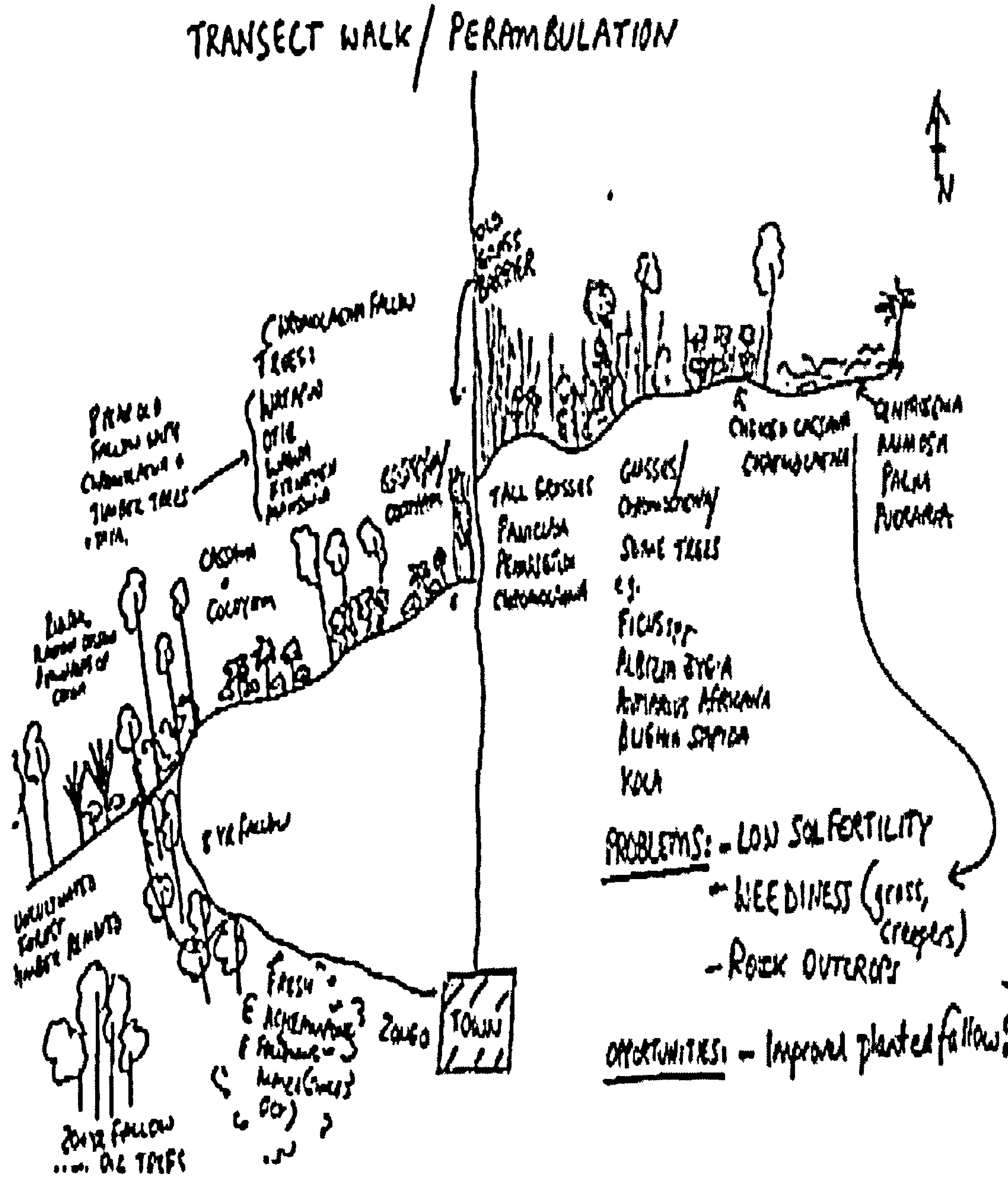
- Gender differences in crop production for sale and at what scale
- Reasons for difference in marketing and importance
- Times of the year crops harvested and marketed
- Crops stored before marketing & reasons
- Storage methods and problems e.g. post harvest loses
- How crops are marketed (individuals, associations, transportation and costs)
- Where marketed (farm gate, market) and who buys in each case
- Where do traders come from, their frequency in the village and during lean period
- Which markets (location, types-daily/periodic)
- Access to these markets and frequency of going to such markets
- How prices are fixed
- Differences in prices at farm gate and markets
- Any marketing constraints (road accessibility all year, prices, no market, etc.)

Appendix 5: Resource and settlement maps-Subriso III-Tano District.

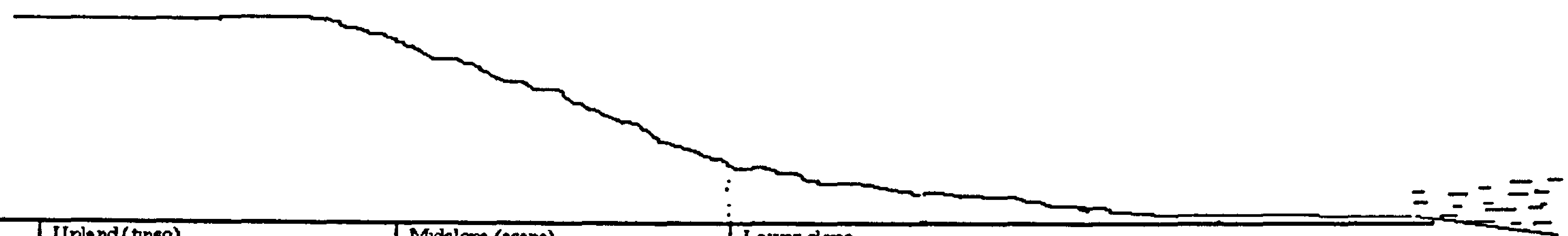




Appendix 6: Transect Map-Subriso III-Tano District

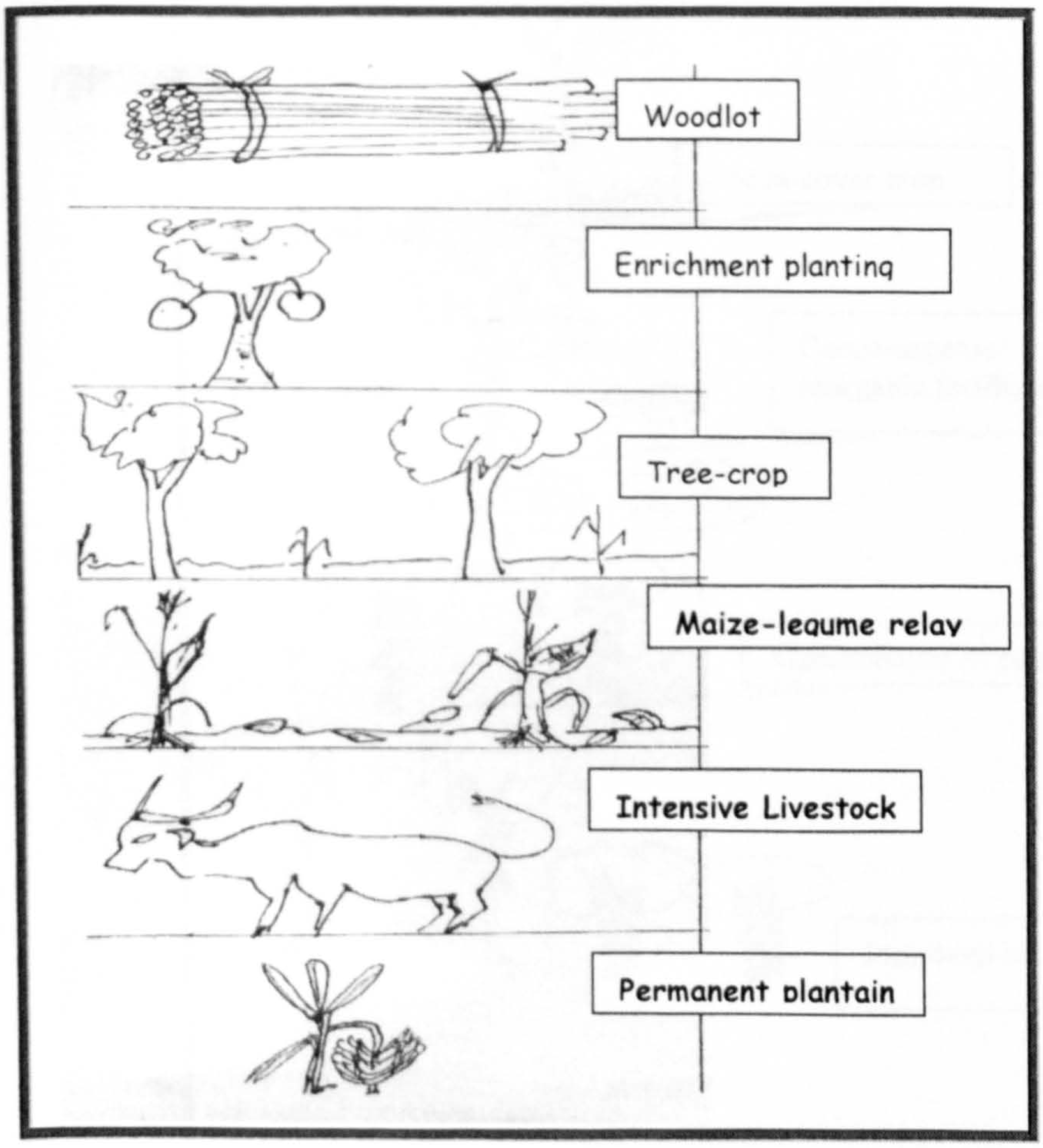


Appendix 7: Farmers soil description & management along the topo-sequence (Subriso III)

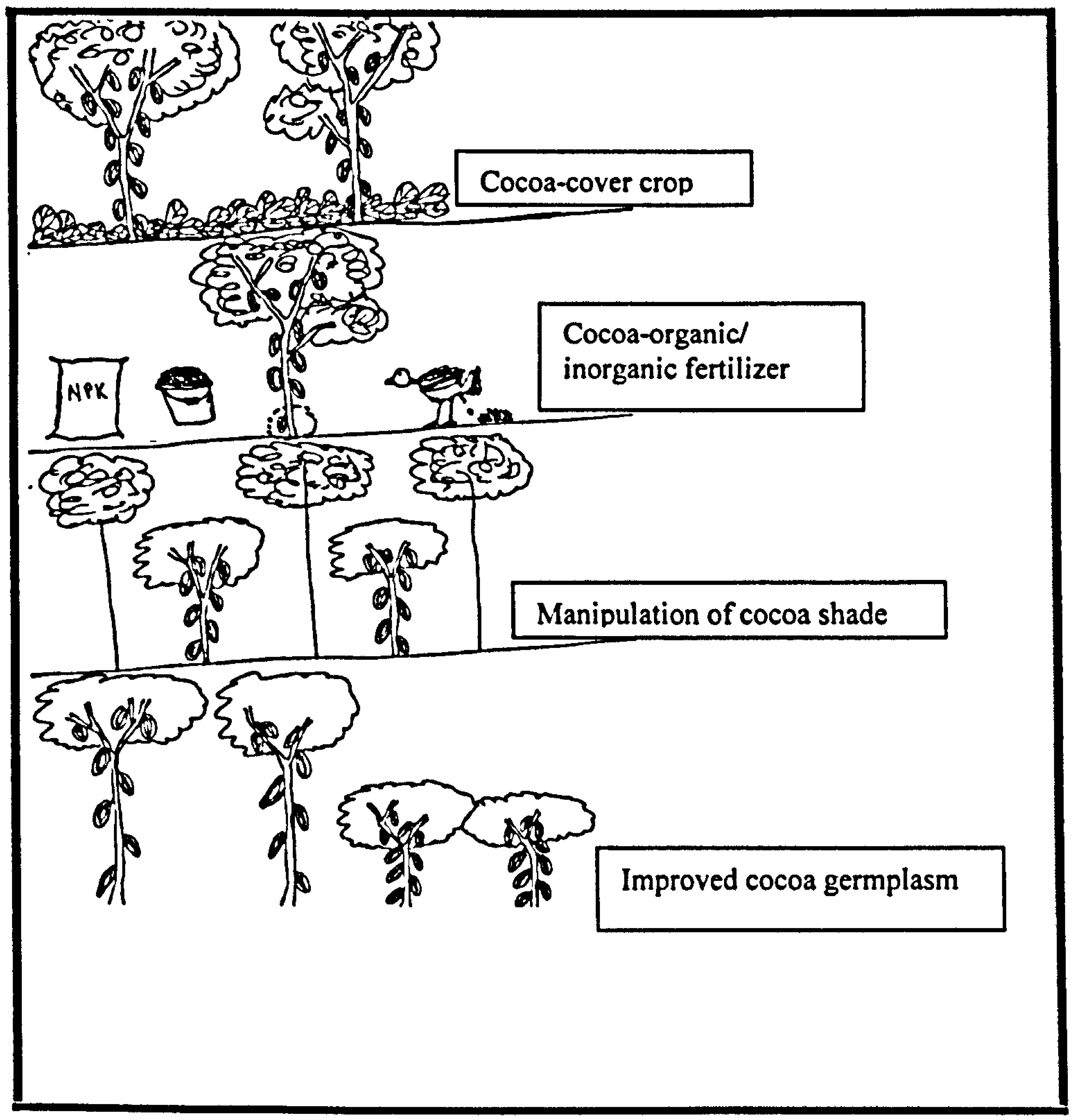


Farmland Location	Upland (tuso)	Midslope (asane)	Lower slope (fom/bepoyase)	Lowland/Valley (Afonweamu)	
Soil type (Local name)	Asase kokoo/Anwea kokoo	Asase kokoo Mixture of asase kokoo & tuntum	Asase Tuntum	Afonwea tuntum	Afonwea fufoo
Description	Red soil Loamy-clay (sticky rainy season, hard and cracks dry season) Could be loamy (friable – futufutu) or gravelly at some places	Red soil Loamy-clay (sticky rainy season, hard and cracks dry season) Could be loamy (friable – futufutu) or gravelly at some places	Black soil Most desired soil	Black sandy soil	White sandy soil
Crops grown	Cocoa, oil palm, maize, groundnuts, plantain, cassava, cocoyam, yam, cowpea, Major season vegetables - tomatoes, pepper, okra, garden eggs, onion/shallots Teak, cashew	Cocoa, oil palm, maize, groundnuts, plantain, cocoyam, cassava, yam, cowpea Major season vegetables - tomatoes, pepper, okra, garden eggs, onion Teak, cashew	Cocoa, oil palm, maize, groundnuts, plantain, cocoyam, cassava, yam, cowpea, Major season vegetables - tomatoes, pepper, okra, garden eggs, onion	Cocoa, oil palm, maize, cassava, plantain, groundnuts, yam, Rice, Dry season vegetables (tomatoes, pepper, okra, garden eggs)	Oil palm, Rice, maize, plantain, yam, cassava, groundnuts, pepper, Dry season vegetables (tomatoes, okra, garden eggs, onion)
Crop rotation	Maize – Cassava Groundnuts – Cassava Yam – Cassava Tomato – Cassava	Maize – Cassava Groundnuts – Cassava Yam – Cassava Tomato – Cassava	Maize – Cassava Groundnuts – Cassava Yam – Cassava Tomato – Cassava	Maize – Cassava/Dry season vegetables Groundnuts – Dry season vegetables	Maize – Cassava/Dry season vegetables Groundnuts–Dry season vegetables
Soil fertility management	Weeding Fallow Crop rotation Fertilizer for tomatoes & garden eggs	Weeding Fallow Crop rotation Fertilizer for tomatoes & garden eggs	Weeding Fallow Crop rotation Fertilizer for tomatoes & garden eggs	Weeding Fallow Crop rotation Fertilizer for tomatoes & garden eggs	Weeding Fallow Crop rotation Fertilizer for tomatoes, okra & garden eggs
Constraints	Weeds Soils exhausted	Weeds Soils exhausted	Weeds Soils exhausted	Weeds, especially grasses Soils exhausted	Weeds, especially grasses Soils exhausted

Appendix 8: Pictorial representation of proposed workshop interventions for the Tano and Wenchi Districts



Appendix 9: Pictorial representation of proposed cocoa interventions for Atwima District.



Appendix 10: Questionnaire for quantitative livelihood survey/characterization

Questionnaire No.: .... Interviewed by..

Region.................................... District..

Village...Date of Interview............................

A. **Personal Information**

1. Name of Respondent..Age ....Gender M ( ) F ( )
2. Educational status: Nil ( ) Primary ( ) Middle/JSS ( ) Secondary/SSS ( )
   Polytechnic/Training college( ) University ( ) Others....................................
3. Origin: Native ( ) Migrant ( ) Settler ( )
4. If settler or migrant home of origin: Town/village................................Region..........................
5. How long have you been in the village?.....................How long have you been in farming?..............
6. What is your social standing in this village? Chief ( ) Linguist ( ) Elder ( ) Assembly man ( ) Unit committee chairman ( ) Unit committee member ( )Youth leader/organizer ( ) Pastor ( ) Teacher ( ) Chief farmer ( ) Others...
7. Major occupation/income source...
8. Other occupation/income sources...
9. Marital status: Single( ):not married/widowed/divorced Married ( ): No. of spouses..............
10. What is/are the name(s) of your spouse(s)..Where does he/her/they live?...
11. Household size...........: Men........... Ages...
    Women......................... Ages...
    Children: Boys............Ages..................; Girls..........Ages...........................
12. Who is the head of your household? Self ( ) wife ( ) Husband ( ) Others..
13. Number & gender of household members involved in farming....................
    Men .... Women............ Children: Boys...........Girls........................

B. **Membership of Farmer Association**

1. Are you a member of any farmer's association? Yes ( ) No ( )
2. If yes, name the association ....
3. If yes what is your position in the association? Chairman/president ( ) Vice chairman/president ( ) Secretary ( ) Treasurer ( ) Organiser ( ) Member ( ) Others..
4. What is the objective of this association?...
   ....
5. How many people belong to the association?...
6. When was it established?...
7. How long have you been a member?...
8. What benefits have you derived or are you expecting from the association?................................

C. **Land Ownership, Acquisition & Use**

1. Farm land status: Land owner ( ) Tenant ( ) Both ( )
2. How did you acquire your farm land?: Family owned ( ) Purchased ( ) Inherited ( ) Rented/Hired ( ) Sharecropped ( ) Free ( ) Other sources ....
3. If family owned who controls access and use to your farm land?...
4. If inherited from who? Mother ( ) Father ( ) Uncle ( ) Husband ( ) Others........................
5. If free please state source e. g. in-law ( ) friend ( ) landlord/landlady( ) Others.................
6. If landowner, how much (acres) of your land have you rented or given out for share cropping?...........
7. If tenant what crop(s) are you not permitted to grow on the land and why?.................................
   ....
8. What are the advantages and disadvantages of renting land and sharecropping in farming?

9. What problems do you encounter in acquiring land for farming?..
10. If tenant what issues on land acquisition and use will prevent you from adopting a new technology for improving your farm land?..

11. How many farms do you have?..

12. If married, does your spouse have his/her own separate farms? Yes ( ) No ( ) If yes do not include your spouse's farm in your responses

13. What main crops do you grow on each of the different farms? Maize ( ) Groundnuts ( ) Plantain ( ) Yam ( ) Cowpea/Beans ( ) Cassava ( ) cocoyam ( ) Rice ( ) Tomato ( ) Garden egg ( ) Pepper ( ) Onion ( ) Okro ( ) Cocoa ( ) Oil palm ( ) Cashew ( ) Others (specify)...................................

14. Please fill in the following tables for the different farms:

Parcel	Main crop	Other crops	Size (Acres)	Means of land acquisition Own/rent/sharecrop/free, etc	Cost/ sharecrop arrangement	Tenancy period	*History	*Future	Who makes decision & who is responsible for the farm
1									
2									
3									
4									
5									
6									
7									
8									

*History: means what land was used for before currently cultivated
* Future: means what will the land be used for after the current crop

Weeds (*nwora*) & Soil Fertility (*asaase ne mu seradee/ahoden*)

15. Where are your different farms located and how do you manage weeds and fertility of soil on these farms?

Parcel	Location Tinso/Asane/Fom/Afo weamu	Soil type Asasekoko/asase tuntum/afonwea tuntum/afonwea fofoo	Weeds found on the farm	How do you control weeds on this farm?	How many times do you weed this farm & why	How do you restore/improve soil fertility on this farm?
1						
2						
3						
4						
5						
6						
7						

Crops grown

16. What is the purpose for growing your crops and how much do you sell and consume?

Crops grown	Variety (local/improved) state actual name	Purpose			% sold	% Consumed
		Sale mainly	Consumption mainly		Both	
Maize						
Cassava						
Plantain						
Yam						
Cocoyam						
Rice						
Groundnuts						
Cowpea						
Tomatoes						
Garden eggs						
Pepper						
Onion						
Okro						
Cocoa						
Oil palm						
Cashew						

D. Fallow (*Nfofowa*)

1. Do you have any fallow land? Yes ( ) No ( ) If no why?..
2. If yes, What is the size of the fallow land?................................Why are you fallowing?...........
3. How long will the fallow be?...
4. How long did you cultivate the land before fallowing?...
5. What crop did you grow before the fallow?...
6. What crop will you grow after the fallow? And why...
7. What vegetation is found on the fallow land?...
8. What benefits or products are you getting from the fallow land?..
9. If a tenant, have you ever fallowed your farm? Yes ( ) No ( )Give reasons ....
10. If tenant what will constrain your ability to fallow?...
11. Which of your farms do you usually fallow? Why?..
....
12. How long will you usually fallow the following croplands?

Crop	No. of years land will be cultivated & why	No of years land will be fallowed & why
Maize		
Cassava		
Plantain		
Yam		
Cocoyam		
Rice		
Groundnuts		
Cowpea		
Tomatoes		
Garden eggs		
Pepper		
Onion		
Okro		
Cocoa		
Oil palm		
Cashew		

E. <u>Labour Types, Availability, Demand & Seasonality</u>

1. How many farms do you have?......Where are farms located: Forestland ( ) Savanna land ( )

2. Please state for each farm, the farm type (monocrop/mixed) and crops cultivated

Farm No.	Farm type *Monocrop/mixed*	Location *Forest/savanna*	Farm size (acres)	Main crop(s)	Intercrop(s)
1.					
2.					
3.					
4.					
5.					
6.					
7.					
8.					
9.					
10.					
11.					

3. What type of labour do you use on your farm (s)? Family ( ) Hired ( ) Friends/communal ( ) Others...

4. Please indicate the type of labour & proportions you use for the different farms listed above

Farm	Crops	Type of labour used				Proportion of each type used (%)			
		Family	Hired	Friends/ communal	Others	Family	Hired	Friends/ communal	Others
1.									
2.									
3.									
4.									
5.									
6.									
7.									
8.									

5. Who provides hired labour on your farm? Migrant farmer ( ) Settler farmer ( ) Native ( ) Others.........
6. Where does the migrant labour come from?..
7. How long is migrant labour available?..............................State period..........................
8. What period is labour in abundance? On set of cropping season ( ) Major season ( ) Minor season Others..Please state specific period.................
9. Why is labour abundant during this period?..
10. What period is labour scarce?.............................Please state specific period...........................
11. Why is labour scarce during this period?...
12. When are peak labour demanding periods? & why...
13. When are low labour demanding periods? & why...
14. What type of labour do you use during peak labour periods? Family ( ) By day ( ) Contract ( ) Communal ( ) Others...Why?...
15. What type of labour do you use during low labour demanding periods? ? Family ( ) By day ( ) Contract ( ) Communal ( ) Others..Why?...

16. Please indicate the type of labour & proportions you use for different farm activities

Farm Activity	Type of labour used					Proportion of each type used (%)				
	Family	Hired		Friends/ communal	Others	Family	Hired		Friends/ communal	Others
		By-day	Contract				By-day	Contract		
Land clearing										
Burning										
Stumping										
Tree felling										
Cleaning										
Ridging										
Mounding										
Sowing/ Planting										
Weeding										
Fertilizer application										
Watering										
Spraying										
Harvesting										
Crib construction										
Haulage										
Dehusking										
Shelling										
Threshing										
Winnowing										
Bagging										
Loading										

How much do you pay if **hired labour** is used for the following activities & which gender does the work?

Farm Activity	**By day No. of people x days x cost**	**Contract**	**Gender of hired labour (male/Female/both**
Land clearing (1acre) **Note vegetation type			
Burning (1acre) **Note who			
Stumping /***apam* (1acre)			
Tree felling (No. of trees)			
Cleaning (1acre)			
Ridging (1acre)			
Mounding (1acre) (Note No. of mounds)			
Sowing/ (1acre) Planting (Note type of crop)			
Weeding (1acre)			
Fertilizer application (1acre)			
Watering (1acre)/ Fetching water into barrel, etc.			
Spraying (1acre)			
Harvesting (1acre)			
Crib construction			
Haulage of produce (note tractor load or by people)			
Dehusking			
Shelling (maize/groundnuts			
Threshing (rice/cowpea)			
Winnowing (rice/cowpea)			
Bagging			
Loading (per bag)			

17. Gender & age of family labour contribution on the farm

Farm Activity	% Contribution by Gender		% Contribution by Age	
	Male	Female	Adults	Children
Land clearing				
Burning				
Stumping				
Tree felling				
Cleaning				
Ridging				
Mounding				
Sowing/ Planting				
Weeding				
Fertilizer application				
Watering				
Spraying				
Harvesting				
Crib construction				
Haulage				
Dehusking				
Shelling (maize/groundnuts				
Threshing (rice/cowpea)				
Winnowing (rice/cowpea)				
Bagging				
Loading				

18. Which of the above farm activities demand lots of labour and why?..

F. **Finance for farm activities**

1. How do you finance your farming activities? Own money ( ) Credit/loan ( ) Husband ( ) Wife ( )Other relatives ( ): State which relative......................................Others ....
2. State proportion (%) of each finance source used: Own money.............. .....Credit ....Others................
3. If own money used where did you get the money? Farm ( ) State farm enterprises...........................

Off-farm ( ) State off-farm enterprises:..

Remittance ( ) state source...

Others..

4. If credit or loan was used, where did you get it?

Credit Source	Amount taken	Interest	Repayment terms (cash/bags of produce, etc.)	Repayment period	Farm enterprise credit used for	Farm activities credit used for
Bank						
Money lender						
Trader						
Friend						
Relativ e						
Others						

5. Which own money or credit sources are important for financing your farm activities? And why?...
....
6. What times of the year do you need money most ?...
7. What do you need the money for?..
8. When do you have lots of money at your disposal?...
9. What times of the year do you have little money?...
10. What causes the scarcity of money?...
11. What do you do to overcome this scarcity? Borrow money ( ) Take credit from trader ( ) Sell livestock ( ) Rent out land ( ) Others ....
12. What are the reasons for low financial standing among farmers? Poor land ( ) Low yields ( )Poor prices ( ) No market for produce ( ) Expensive farm inputs ( ), State input types...

Others.................................... (**Please tick in order of importance giving one to the most important, etc.)

13. Do you save part of your money or farm income? Yes ( ) No ( ) Give reasons ....

....

14. If yes what proportion do you usually save?...
15. Where do you save? Bank ( ) Susu ( ) Others..
16. How beneficial has savings been to you?...

G. Marketing

1. Do you store any of your produce before marketing? Yes ( ) No ( ) If yes, Which crops do you store?....... ....Why do you store?...
2. When do you harvest and market your different crops?

Crop	Period harvested	When stored	How stored Drying, etc.	Period marketed/when sold	Price trend at time of marketing (high/low/average)
Maize					
Plantain					
Cassava					
Tomato					
Pepper					
Etc.					

3. Where do you market your produce and who buys?

Crop	Where sold Farm gate or village/market, etc.	If sold on market, which market (s)	Who buys	Where buyer takes it Kumasi, Accra, Techiman, etc
Maize				
Plantain				
Cassava				
Etc.				

4. If you sell your produce during low price times why do you do so?...
5. What strategy do use to ensure that you sell some of your produce when the price is good?...........................
6. How is the price for the produce you sell fixed?...
7. What factors determine prices of your produce? ....
8. Is there any farmer association for marketing produce? Yes ( ) No ( )
9. If yes, what does the association market?...How does it operate?.................

....

10. Are you a member of this association? Yes ( ) No ( ) If yes has it been of any benefit to you? How?.........

....If not beneficial why?...............................

....

11. If not a member why?...
12. What problems do you encounter in marketing your produce? Poor price ( ) Fluctuating prices ( ) No market ( ) Poor roads ( ) Traders do not come to farm gate ( ) High transport cost ( ) Others ....

....Please explain..

H. Farm Record Keeping

1. Do you keep records on your farming activities? Yes ( ) No ( ) If no why?...................................
2. If yes, Why do you do so?...
3. If yes, which farming activities do you keep records on?..
4. What benefit have you derived so far from keeping records?..
5. Who introduced you to farm record keeping? Extension agent ( ) Own initiative ( ) Friend/relative ( ) Learnt from school ( ) Others......................

I. Livestock

1. Which of the following animals do you keep? Sheep ( ) Goat ( ) Poultry ( ) Pig ( ) Others......
2. How many of each type of animal do you have? Sheep.......Goats...........Poultry........Pig......Others
3. What is your purpose for keeping the animals? Home consumption ( ) Sale ( ) Both ( ) Others.........
4. Who takes care of the animals? Self ( ) Spouse ( ) Children ( ) Herdsman ( ) Others.....................
5. Where do you keep the animals? Pen ( ) Open ( ) Others ....
6. How do you feed the animals? Stall fed/cut and carry ( ) Free graze ( ) Others...............................
7. What type of diseases do the animals suffer? State for each type of animal...................................
....
8. How do you treat the diseases?...
9. If you sell some of the animals, where do you often sell them? Market ( ) Farm gate/village ( )
10. If sold on market which market? Techiman( ) Akumadan ( ) Techimatia ( ) Others.......................
11. Who buys the animals? Traders/Middlemen ( ) Fresh meat sellers ( ) Chop bar keepers ( ) Kebab sellers ( ) Others............
12. How much do you often sell one of the animals? Sheep........................Goats.........................
Poultry..........................Pig...............................Others.......................................
13. At what times do you normally sell the animals? Christmas ( ) Easter ( ) Cropping season ( ) Lean season ( ) Anytime in need of cash ( ) Others...
14. What is the purpose for selling? Pay school fees ( ) Pay medical bill ( ) Support farm expenses( ) funeral expenses ( ) Buy children's clothes ( ) Support off-farm enterprise ( ):state off-farm enterprise......
Others...

15. What problems do you encounter in livestock rearing and how do you solve or think these problems could be solved?

Problem	Solution Suggested

J. General Constraints in Agricultural Production

What problems do you encounter in farming and how do you solve or think these problems could be solved?

Problem	Solution

K. Household Expenses & Other Incomes (per month / year)

1. Household Expenses

Item	Amount (cedis)
Food	
Clothing	
House rent	
School fees	
Medical fee	
Funerals	
Entertainment	
Other social expenses	

2. Other Incomes from off farm (per month/year)

Item	Amount (cedis)/month or year
Petty trade (kiosk/table, etc.)	
Cooked food sales	
Carpentry	
Painting	
Driving	
Charcoal burning	
Firewood sales	
Corn mill	
Dress making	
Tailoring	
Hair dressing	
Livestock sales	
Government work (which type?)	
By-day labourer	
Remittances	
Others	

Appendix 11: Input-output data sheet - crop production

Sheet code:............................ District......................................Village...............................

Crop enterprise:...

Farmer name..Gender..............................Age..................

Residential status.................Home town.......................... Region.......................................

Land status: Landowner/Tenant..........................Farm type: Monocrop/Mixed..............................

Plot size...................Tenure... Tenancy period.......................................

Rented land cost................................... Sharecrop arrangement..

Crop(s) planted: Main crop.............................Intercrop(s)..

Labour

Farm Activity	Labour type used	Labour amount used	Labour cost
Land clearing			
Burning			
Stumping			
Tree felling			
Cleaning of debris			
Mounding			
Staking of yam			
Ridging			
Sowing/Planting			
Maize			
Rice			
Cassava			
Plantain			
Cocoyam			
Yam			
Groundnuts			
Pepper			
Tomatoes			
Onion			
Okro			
Cocoa			
Oil palm			
Cashew			
1st Weeding			
2nd Weeding			
3rd Weeding			
Fertilizer application			
Weedicide application			
Fungicide spraying (vegetables)			
Pesticide spraying (cowpea)			
Harvesting			
Crib construction			

Haulage			
Dehusking of maize			
Shelling of maize/groundnuts			
Bagging of maize			
Loading of maize			
Threshing rice/cowpea			
Winnowing rice/cowpea			
Bagging rice/cowpea			
Loading rice/cowpea			
Others			

Other inputs

Input	Amount Used	Cost
Maize seeds		
Groundnut seeds		
Cowpea/bambara nut seeds		
Yam seeds		
Vegetable seeds		
Plantain suckers		
Cassava sticks		
Tree seeds/seedlings		
Cocoa pods/seedlings		
Cashew seeds		
Yam stakes		
Hoe		
Cutlass		
Weedicide		
Sacks		
Storage chemicals		
Loading fee		
Transportation to market *Farmer*		
Produce		
Assembly tax at loading		
Market toll		
Others		

Output

Crop		Output		Price per unit {bags (maix/mini), tubers, bunches, crates, baskets, etc.)	Value of output
		Quantity consumed	Quantity sold		
Main crop					
Intercrop 1					
Intercrop 2					

Appendix 12: Off-farm income estimation data sheets

A. Off-farm employment

Group 1: Cooked food sales (porridge/ fufu/kenkey/banku/pito/rice/ etc.)

1. Sheet code:................ Interviewed by........................Date of interview......................
2. District...Village...
3. Name of Respondent...Age ....Gender M ( ) F ( )
4. Residential status..................Home town..........................Region...............................
5. Educational status: Nil (   ) Primary (   ) Middle/JSS ( ) Secondary/SSS ( ) Polytechnic/Training college( ) University ( ) Others.................................
6. Marital status: Single(   ):not married/widowed/divorced   Married (   )
7. Household size................................Off-farm work/enterprise.................................
8. How many times do you prepare the food for sale in a week?..
9. Please list capital items (eg. Cooking pots, etc.) used for your work and their respective costs

Item	Cost

10. Please list the ingredients and other recurrent items used during each time of preparation of the food and their respective costs

Ingredient	Quantity used	Cost

11. How much of the food are you able to sell during each time of preparation (in cedis) ?...................
(**Ask for amount for days of highest, average and low sales)

Group 2: Trading: drug store/provision store/drinking bar/fish seller/orange seller/charcoal seller/trader/etc.

1. Sheet code:................ Interviewed by........................Date of interview...................
2. District...Village.......................................
3. Name of Respondent...Age ....Gender M ( ) F ( )
4. Residential status..................Home town..........................Region...........................
5. Educational status: Nil ( ) Primary ( ) Middle/JSS ( ) Secondary/SSS ( ) Polytechnic/Training college( ) University ( ) Others....................................
6. Marital status: Single( ):not married/widowed/divorced Married ( )
7. Household size.................................Off-farm work/enterprise...............................

If a trader what goods do you trade in?...

8. How much purchase of the goods you sell do you make in a day/week/month (in cedis)? (please underline the appropriate period)...
9. How much of the goods are you able to sell on the average in a day/week/month (in cedis)?..........................

(**Ask for amount for days of highest, average and low sales)

Group 3: driver/mechanic/tailor/photographer/painter/corn miller/barber/shoe shine

1. Sheet code:................ Interviewed by........................Date of interview...................
2. District..Village.......................................
3. Name of Respondent..Age ....Gender M ( ) F ( )
4. Residential status..................Home town......................Region..................................
5. Educational status: Nil (   ) Primary (   ) Middle/JSS ( ) Secondary/SSS ( )Polytechnic/Training college( ) University ( ) Others...................................
6. Marital status: Single(   ):not married/widowed/divorced   Married (   )
7. Household size.................................Off-farm work/enterprise...............................
8. How many times do you undertake your off-farm work in a week/month?.........................
9. During each time of operation please list the expenses you make

Item	Quantity used	Cost (cedis)

10. During each time of operation how much income are you able to make?...........................

(**Ask for amount for days of highest, average and low sales)

Group 4: Agro-processing: Apketeshie distiller/palmwine tapper/charcoal producer/soap producer

1. Sheet code:................ Interviewed by........................Date of interview.......................
2. District..Village..
3. Name of Respondent...Age ....Gender M ( ) F ( )
4. Residential status..................Home town..........................Region................................
5. Educational status: Nil ( ) Primary ( ) Middle/JSS ( ) Secondary/SSS ( )Polytechnic/Training college( ) University ( ) Others.......................................
6. Marital status: Single( ):not married/widowed/divorced Married ( )
7. Household size.................................Off-farm work/enterprise.................................
8. How many times do you prepare akpeteshie/charcoal/soap/etc in a week/month ?...................
9. Please list capital items (distilling equipment, etc.) used for your work and their respective costs

Item	Cost

10. Please list the ingredients and other recurrent items used during each time of preparation and their respective costs

Ingredient	Quantity used	Cost

11. How much of the product are you able to produce and how much do you sell during each time of preparation (in cedis) ?...................

Product	Quantity produced	Quantity sold	Price per unit of product (gallon/barrel/bag/tablet of soap, etc) (cedis)	Total value

(**Ask for amount for days of highest, average and low sales)

Group 5: Paid employment: Teacher/labourer/health worker, etc.

1. Sheet code:................ Interviewed by........................Date of interview...................
2. District..Village.......................................
3. Name of Respondent..Age ....Gender M ( ) F ( )
4. Residential status.................Home town..........................Region...............................
5. Educational status: Nil (   ) Primary (   ) Middle/JSS ( ) Secondary/SSS ( )Polytechnic/Training college( ) University ( ) Others...................................
6. Marital status: Single(   ):not married/widowed/divorced Married (   )
7. Household size.................................Off-farm work/enterprise...............................
8. Please state how much you earn in a week/month from your off farm work?......................

B. Livestock production

1. Sheet code:................ Interviewed by..............................Date of interview......................
2. District...Village..
3. Name of Respondent...Age ....Gender M ( ) F ( )
4. Residential status..................Home town.........................Region.................................
5. Educational status: Nil ( ) Primary ( ) Middle/JSS ( ) Secondary/SSS ( ) Polytechnic/Training college ( ) University ( ) Others...................................
6. Marital status: Single( ):not married/widowed/divorce................Married ( )
7. Household size........................
8. Which of the following animals do you keep currently? Chicken ( ) Duck ( ) Guinea fowl ( ) Sheep.(.....)
   Goat ( ) Pig (....) Cattle ( )
   Others...)
9. Please provide the following information on each of the animal you keep
(For enumerator: use 1 sheet per animal and fill in the name & village of the person if he/she has more than 1 type of animal)

a. Please list the inputs used in rearing the animal and respective cost

Input	Quantity purchased	No. Of times purchased per week/month/year	Cost (cedis)
Animal			
Feed			
Drugs			
Disease treatment charges			

b. Please provide the following information on the output

No. of animals produced per year	No. Consumed	No. Sold or to be sold	Price per animal	Total output value	Total sale value

Appendix 13: On-farm experiments

Maize – legume relay

Maize-Canavalia relay

Maize-Mucuna Relay

Plate1. Maize – legume interventions in the on-farm trials

Plate 2: Control in the on-farm trials

Plate 3: Permanent plantain system

Appendix 14: Input-output data sheet for maize-legume, permanent plantain & *Gliricidia* fallow technologies

Sheet code:............................ District......................................Village...............................

Farmer name...Gender...............................Age...................

Residential status.................Home town........................... Region..

Land status: Landowner/Tenant.........................Farm type: Monocrop/Mixed..............................

Total field/farm size....................: Plot size under technology..............Plot size under control........

Tenure.. Tenancy period.......................................

Rented land cost.................................... Sharecrop arrangement...

Farmland history: Previous use (last season/1999-2000)..

If cropped: what crops cultivated...How many years cropped...............

If fallow land: Fallow type.......................................Length of fallow before cleared...................

Crop(s) grown before fallow..Length of cropping before fallow...Future use of land..

Technology type...Field type: with control or without control...........

Food crop(s) planted: Main crop............................Intercop(s).......................................

Cover crop(s) planted..

Tree species planted..Fallow species planted...................................

<u>Field Operations & Labour</u>

Farm Activity	Date	Labour type used	Labour amount used	Labour cost
Land clearing				
Burning				
Stumping				
Tree felling				
Cleaning of debris				
Mounding				
Staking of yam				
Planting of trees				
Sowing/Planting food crop				
Sowing/Planting of cocoa				
Sowing/Planting of cashew				
1st Weeding				
2nd Weeding				
3rd Weeding				
Planting of cover crop				
Fertilizer application				
Weedicide application				
Harvesting				

Crib construction				
Haulage				
Dehusking of maize				
Shelling of maize/groundnuts				
Bagging of maize				
Loading of maize				
Planting of fallow species				
Threshing rice/cowpea				
Winnowing rice/cowpea				
Bagging rice/cowpea				
Loading rice/cowpea				
Others				

Other inputs

Input	Amount Used	Cost
Maize seeds		
Yam seeds		
Plantain suckers		
Cassava sticks		
Tree seeds/seedlings		
Cocoa pods/seedlings		
Cashew seeds		
Yam stakes		
Hoe		
Cutlass		
Weedicide		
Sacks		
Storage chemicals		
Loading fee		
Transportation to market		
Assembly tax at loading		
Market toll		
Others		

Output

Crop		Output	Price per unit	Value of output
Main crop				
Intercrop 1				
Intercrop 2				

** One record sheet for one technology

Appendix 15: Input-output data sheet for cocoa-shade tree technology

A. Farmer & plot characteristics

Sheet code:........................... District.......................................Village...............................

1. Farmer name.......................................Gender...............................Age...................
2. Residential status..................Home town............................ Region.......................
3. Land status: Landowner/Tenant..........................Farm type: Monocrop/Mixed.........................
4. Plot size under technology.................Tenure...............................Tenancy period............
5. Plot size under control.................Tenure...............................Tenancy period............
6. Rented land cost...
7. Sharecrop arrangement: (i) Share type ....(ii) Initial money paid for sharecropping land.............
8. Farmland history: Previous use of land (last season/1999-2000)...
9. If cropped: what crops cultivated...How many years cropped........
10. If fallow land: Fallow type......................................Length of fallow before cleared...........
11. Crop(s) grown before fallow...Length of cropping before fallow...Future use of land...

Technology plot

1. Crop(s) planted: Main crop.......................Intercrop(s)...

....

2. Cocoa variety planted: ....
3. Tree species planted...
4. No. of cocoa seedlings planted: .... No. Surviving..
5. No. of tree seedlings planted:.......................No. Surviving..
6. Pattern of planting cocoa/spacing..
7. Pattern of planting trees/spacing: ....

Control plot

8. Crop(s) planted: Main crop.......................Intercrop(s)...

....

9. Cocoa variety planted: ....
10. Tree species kept...

B. Input-Output data for cocoa production

Year 1			
Activities	**Resources/inputs used**	**Quantity used**	**Cost of input**
Land acquisition Nursery Land clearing Burning Stumping Tree felling Sowing maize Planting plantain, cocoyam, cassava, etc. Transplanting/direct sowing cocoa Weeding 1 Weeding 2 Harvesting maize Harvesting cocoyam Harvesting cassava Harvesting yam	Land		
	Cutlass		
	Hoe		
	Chisel (*soso*)		
	Labour		
	• *Clearing*		
	• *Burning,*		
	• *Stumping*		
	• *Tree felling*		
	• *Sowing maize*		
	• *Planting plantain*		
	• *Planting cassava & cocoyam & yam*		
	• *Transplanting/direct sowing cocoa*		
	• **Weeding 1**		
	• *Weeding 2*		
	• *Harvesting maize*		
	• *Harvesting cocoyam*		
	• *Harvesting cassava*		
	• *Harvesting yam*		
	• *Haulage of maize*		
	• *Dehusking*		
	• *Shelling*		
	• *Crib construction*		
	Cocoa Pods (note source)		
	Plastic bags for nursery		
	Maize seeds		
	Plantain suckers		
	Cocoyam seeds		
	Cassava sticks		
	Yam seeds		
	Maize sacks		
	Storage chemicals		
	Crib materials		
	Loading fee		
	Transportation to market		
	Assembly tax at loading		
	Market toll		
	Others		

Revenue	**Out put ( )**		**Price/ Unit ( )**
	Quantity consumed	**Quantity sold**	
Maize			
Cocoyam			
Cassava			

C. Other information

1. Average productive life of cocoa varieties on technology and control plots..
....

2. How many years the following food crops will be on the farm

Food crop	No. of years on the farm
Maize	
Cassava	
Plantain	
Cocoyam	
Yam	
Banana	
Pepper	
Tomatoes	
Garden eggs	

3. Tree species planted

Local name	Scientific name	Uses (to the farmer)
Okoro	Albizia zygia	
Sesemase	Newbouldia laevis	
Prekese	Tetrapleura tetreptera	
Emire	Terminalia ivorensis	
Edinam	Entandrophragma angolense	
Kokrodua	Pericopsis elata	
Utile	Entandrophragma utile	

4. Tree species kept on control plot

Local name	Scientific name	Uses (to the farmer)

5. How many cocoa farms do you have apart from the one we are establishing with you?...............
6. How old is/are the cocoa farm(s) you are currently harvesting for sale?
7. What is the size of each farm?
8. How many bags or how much cocoa bean did you sell in the last season from each farm and how much did you spend on each farm.

Cocoa Farm	Age of farm	Size of farm	Output last season	Farm activities & materials used	Cost (¢)
1					
2					
3					
4					

9. Kindly let me have a look at your passbook for details over the years. (Check for details on quantity of cocoa sold for each year over 5 years and record).

Year	Quantity sold	Price/Kilo (¢)
1		
2		
3		

Appendix 16: Summary cash flow for maize-legume relay technology

	All legumes	*Lablab pupureum*	*Mucuna spp*	*Canavalia spp*	*Pueraria spp*	*Stylosanthes spp*	Natural fallow
Receipts							
Gross return (¢)	**2,592,342.00**	**2,421,900.00**	**2,898,000.00**	**2,612,610.00**	**2,482,200.00**	**2,547,000.00**	**1,891,530.00**
Expenses							
Land cost	250,000.00	250,000.00	250,000.00	250,000.00	250,000.00	250,000.00	250,000.00
Farm tool (machete)	40,000.00	40,000.00	40,000.00	40,000.00	40,000.00	40,000.00	40,000.00
Legume seeds	56,121.00	4,000.00	89,250.00	177,738.00	6,000.00	4,000.00	0.00
Seeds (maize)	180,000.00	180,000.00	180,000.00	180,000.00	180,000.00	180,000.00	180,000.00
Storage (Crib & chemicals)	108,000.00	108,000.00	108,000.00	108,000.00	108,000.00	108,000.00	108,000.00
Labour	1,125,846.00	1,103,770.00	1,118,317.00	1,153,159.00	1,119,298.00	1,105,270.00	1,105,298.00
Marketing costs							
Sacks	81,000.00	75,000.00	90,000.00	81,000.00	78,000.00	81,000.00	60,000.00
Loading & poterage	27,000.00	25,000.00	30,000.00	27,000.00	26,000.00	27,000.00	25,000.00
Tax	27,000.00	25,000.00	30,000.00	27,000.00	26,000.00	27,000.00	20,000.00
Transportation	145,000.00	135,000.00	160,000.00	145,000.00	140,000.00	145,000.00	110,000.00
Total expenses (¢)	**2,039,967.00**	**1,945,770.00**	**2,095,567.00**	**2,188,897.00**	**1,973,298.00**	**1,967,270.00**	**1,898,298.00**
Net cash flow (¢)	*552,375.00*	*476,130.00*	*802,433.00*	*423,713.00*	*508,902.00*	*579,730.00*	*-6,768.00*

Appendix 17: Cash flow analysis for plantain-legume technology

Appendix 17a: Summary cash flow for Plantain-*Gliricidia sepium* and Plantain-natural fallow

ITEM	Plantain-*Gliricidia sepium*	Plantain-natural fallow
Receipts		
Gross return (¢)	**20,725,000.00**	**9,387,500.00**
Expenses		
Land cost	625,000.00	125,0000.00
Farm tool (machete & chisel)	180,000.00	126,000.00
Planting materials		
Plantain suckers & transport	703,200.00	1,101,680.00
Gliricidia seedlings &transport	1,500,000.00	0.00
Labour	7,110,650.10	3,750,453.10
Marketing costs		
Loading & poterage	0.00	0.00
Tax	0.00	0.00
Transportation	0.00	0.00
Total expenses	**10,118,850.00**	**6,228,133.00**
Net cash flow	10,606,150.00	3,159,367.00

Appendix 17b: Plantain-*Gliricidia sepium* hedgerow

Period (months)	Cost (¢)/ha	Revenue (¢)/ha	Net Revenue (¢)/ha	Discount factor	Discounted Net Revenue (¢)/ha	Discounted Revenue (¢)/ha	Discounted Cost (¢)/ha	Total Labour Cost (¢)/ha	Discounted Labour Cost (¢)/ha
0	1019789.06	0.00	-1019789.06	1.000	-1019789.06	0.00	1019789.06	376789.06	376789.06
1	1906300.00	0.00	-1906300.00	0.992	-1891219.15	0.00	1891219.15	671900.00	666584.56
2	285940.00	0.00	-285940.00	0.984	-281433.72	0.00	281433.72	262500.00	258363.12
3	0.00	0.00	0.00	0.976	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.969	0.00	0.00	0.00	0.00	0.00
5	218750.00	0.00	-218750.00	0.961	-210233.11	0.00	210233.11	218750.00	210233.11
6	0.00	0.00	0.00	0.953	0.00	0.00	0.00	0.00	0.00
7	218750.00	0.00	-218750.00	0.946	-206919.93	0.00	206919.93	218750.00	206919.93
8	0.00	0.00	0.00	0.938	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.931	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.924	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.916	0.00	0.00	0.00	0.00	0.00
12	337022.22	0.00	-337022.22	0.909	-306383.84	0.00	306383.84	319022.22	290020.20
13	45315.00	0.00	-45315.00	0.902	-40869.55	0.00	40869.55	21875.00	19729.04
14	0.00	0.00	0.00	0.895	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.888	0.00	0.00	0.00	0.00	0.00
16	135087.33	0.00	-135087.33	0.881	-118966.42	0.00	118966.42	135087.33	118966.42
17	0.00	0.00	0.00	0.874	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	0.867	0.00	0.00	0.00	0.00	0.00
19	162516.67	715000.00	552483.33	0.860	475095.33	614847.80	139752.47	162516.67	139752.47
20	25025.00	1072500.00	1047475.00	0.853	893626.13	914975.56	21349.43	25025.00	21349.43
21	4170.83	178750.00	174579.17	0.846	147759.43	151289.52	3530.09	4170.83	3530.09
22	2085.42	89375.00	87289.58	0.840	73295.25	75046.33	1751.08	2085.42	1751.08
23	2085.42	89375.00	87289.58	0.833	72715.41	74452.64	1737.23	2085.42	1737.23
24	339107.64	89375.00	-249732.64	0.826	-206390.61	73863.64	280254.25	321107.64	265378.21
25	48234.58	125125.00	76890.42	0.820	63043.08	102591.02	39547.93	24794.58	20329.28
26	2502.50	107250.00	104747.50	0.813	85203.91	87239.50	2035.59	2502.50	2035.59
27	3336.67	143000.00	139663.33	0.807	112706.47	115399.12	2692.65	3336.67	2692.65
28	137589.83	107250.00	-30339.83	0.801	-24290.15	85864.64	110154.80	137589.83	110154.80
29	4170.83	178750.00	174579.17	0.794	138662.84	141975.60	3312.76	4170.83	3312.76
30	12512.50	536250.00	523737.50	0.788	412697.61	422557.28	9859.67	12512.50	9859.67
31	162516.67	715000.00	552483.33	0.782	431904.85	558952.55	127047.70	162516.67	127047.70
32	16683.33	1072500.00	1055816.67	0.776	818856.91	831795.96	12939.05	16683.33	12939.05
33	4170.83	178750.00	174579.17	0.769	134326.76	137535.93	3209.17	4170.83	3209.17
34	2085.42	89375.00	87289.58	0.763	66632.05	68223.94	1591.89	2085.42	1591.89
35	2085.42	89375.00	87289.58	0.757	66104.92	67684.21	1579.30	2085.42	1579.30
36	360982.64	89375.00	-271607.64	0.751	-204062.84	67148.76	271211.60	342982.64	257687.93
37	26359.58	125125.00	98765.42	0.745	73616.89	93264.56	19647.67	2919.58	2176.17
38	2502.50	107250.00	104747.50	0.739	77458.10	79308.63	1850.53	2502.50	1850.53
39	3336.67	143000.00	139663.33	0.734	102460.43	104908.29	2447.86	3336.67	2447.86
40	137589.83	107250.00	-30339.83	0.728	-22081.96	78058.77	100140.72	137589.83	100140.72
-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-
132	5351283.97	26973375.00	21622091.03	47.319	11202420.79	13979238.45	2776817.67	5061203.97	2625753.57

B/C Ratio = 2.4, EAV = ¢1,680,654.00, IRR = 49%% and Discounted Return to Labour (DRL) = 2.9

Appendix 17c: Plantain-Natural fallow

Period (months)	Cost (¢)/ha	Revenue (¢)/ha	Net Revenue (¢)/ha	Discount Factor	Discounted Net Revenue (¢)/ha	Discounted Revenue (¢)/ha	Discounted Cost (¢)/ha	Total Labour Cost (¢)/ha	Discounted Labour Cost (¢)/ha
0	1019789.06	0.00	-1019789.06	1.000	-1019789.06	0.00	1019789.06	376789.06	376789.06
1	687550.00	0.00	-687550.00	0.992	-682110.75	0.00	682110.75	453150.00	449565.10
2	264065.00	0.00	-264065.00	0.984	-259903.46	0.00	259903.46	240625.00	236832.86
3	0.00	0.00	0.00	0.976	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.969	0.00	0.00	0.00	0.00	0.00
5	218750.00	0.00	-218750.00	0.961	-210233.11	0.00	210233.11	218750.00	210233.11
6	0.00	0.00	0.00	0.953	0.00	0.00	0.00	0.00	0.00
7	218750.00	0.00	-218750.00	0.946	-206919.93	0.00	206919.93	218750.00	206919.93
8	0.00	0.00	0.00	0.938	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.931	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.924	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.916	0.00	0.00	0.00	0.00	0.00
12	163833.33	0.00	-163833.33	0.909	-148939.39	0.00	148939.39	145833.33	132575.76
13	45315.00	0.00	-45315.00	0.902	-40869.55	0.00	40869.55	21875.00	19729.04
14	0.00	0.00	0.00	0.895	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.888	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.881	0.00	0.00	0.00	0.00	0.00
17	145833.33	0.00	-145833.33	0.874	-127414.00	0.00	127414.00	145833.33	127414.00
18	0.00	0.00	0.00	0.867	0.00	0.00	0.00	0.00	0.00
19	11666.67	500000.00	488333.33	0.860	419931.02	429963.50	10032.48	11666.67	10032.48
20	17500.00	750000.00	732500.00	0.853	624913.38	639843.05	14929.67	17500.00	14929.67
21	2916.67	125000.00	122083.33	0.846	103328.28	105796.87	2468.59	2916.67	2468.59
22	1458.33	62500.00	61041.67	0.840	51255.42	52479.95	1224.53	1458.33	1224.53
23	1458.33	62500.00	61041.67	0.833	50849.94	52064.78	1214.84	1458.33	1214.84
24	19458.33	62500.00	43041.67	0.826	35571.63	51652.89	16081.27	1458.33	1205.23
25	47356.67	87500.00	40143.33	0.820	32913.85	71741.97	38828.12	23916.67	19609.47
26	147583.33	75000.00	-72583.33	0.813	-59040.87	61006.64	120047.51	147583.33	120047.51
27	2333.33	100000.00	97666.67	0.807	78815.72	80698.69	1882.97	2333.33	1882.97
28	1750.00	75000.00	73250.00	0.801	58644.15	60045.20	1401.05	1750.00	1401.05
29	2916.67	125000.00	122083.33	0.794	96967.02	99283.64	2316.62	2916.67	2316.62
30	8750.00	375000.00	366250.00	0.788	288599.73	295494.60	6894.87	8750.00	6894.87
31	157500.00	350000.00	192500.00	0.782	150487.22	273613.13	123125.91	157500.00	123125.91
32	11666.67	525000.00	513333.33	0.776	398124.56	407172.85	9048.29	11666.67	9048.29
33	2916.67	87500.00	84583.33	0.769	65081.10	67325.28	2244.18	2916.67	2244.18
34	1458.33	43750.00	42291.67	0.763	32283.12	33396.33	1113.21	1458.33	1113.21
35	1458.33	43750.00	42291.67	0.757	32027.73	33132.13	1104.40	1458.33	1104.40
36	165291.67	43750.00	-121541.67	0.751	-91316.05	32870.02	124186.08	147291.67	110662.41
37	47356.67	61250.00	13893.33	0.745	10355.69	45653.98	35298.29	23916.67	17826.79
38	1750.00	52500.00	50750.00	0.739	37528.33	38822.41	1294.08	1750.00	1294.08
39	2333.33	70000.00	67666.67	0.734	49641.92	51353.71	1711.79	2333.33	1711.79
40	1750.00	52500.00	50750.00	0.728	36936.90	38210.58	1273.69	1750.00	1273.69
-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-
84	210000.00	1350000.00	1140000.00	26.920	785687.73	935145.29	149457.55	210000.00	149457.55

B/C Ratio = 1.2, EAV = ¢122,000.00, IRR = 20% and Discounted Return to Labour (DRL) = 1.3

Appendix 18: Cash flow analysis for cocoa-planted shade tree technology

Appendix 18a: Summary cash flow –traditional practice, planted and without planted cocoa tree shade options

ITEM	Without planted shade trees 50% yield decline	Without planted shade trees 25% yield decline	Traditional (insufficient shade)	With planted shade trees 25% yield increase	With planted shade trees 50% yield increase)
Receipts					
Gross return					
Food crops	5949433	6373393	5949433	5949433	5949433
Cocoa	101246015	154509732	207492472	259365589	311238707
Total returns	**107195448**	**160883125**	**213441904**	**265315022**	**317188140**
Expenses					
Land cost	321725	321725	321725	321725	321725
Agrochemicals (fungicides & insecticides)	0	0	0	0	0
Sprayer rental	0	0	0	0	0
Planting materials					
Food crops(Plantain, maize, cassava, cocoyam)	818525	818525	818525	818525	818525
Cocoa seedlings & transport	1512500	1512500	1512500	1512500	1512500
Indigenous tree seedlings &transport	0	0	64815	64815	64815
Labour					
General land preparation & maintenance	13811486	13811486	13811486	13811486	13811486
Food crops (planting, harvesting& haulage)	474835	474835	474835	474835	474835
Cocoa(planting,disease & pests control, harvesting & processing)	66228489	84337713	99929325	99929325	99929325
Indigenous tree seedlings (planting)	0	0	52232	52232	52232
Marketing costs	0	0	0	0	0
Total expenses	**83167560**	**101276785**	**116985444**	**146231804**	**175478165**
Net cash flow	*24027887*	*59606340*	*96456461*	*119083218*	*141709975*

Appendix 18b Discounted cash flow analysis for cocoa- shade tree technology (traditional practice)

Year	Cost	Revenue	Net Revenue	Discount factor (10%)	Discounted cost	Discounted revenue	NPV	LEV
0	4555484	1031636	-3523848	1.00000	4555484	1031636	—	–
1	623746	3900293	3276547	0.90909	567042	3545721	–	–
2	461852	1017504	555652	0.82645	381696	840912	-85953	-495253
3	398540	0 00	-398540	0.75131	299429	0 00	-385382	-1549679
4	499523	335344	-164179	0.68301	341181	229045	-497519	-1569526
5	598813	581541	-17272	0 62092	371816	361091	-508243	-1340733
6	753164	902793	149629	0.56447	425142	509603	-423782	-973035
7	797917	1292420	494503	0 51316	409457	663216	-170024	-349238
8	1012562	1739162	726600	0 46651	472368	811332	168940	316669
9	1247825	2228816	980990	0.42410	529200	945235	584976	1015756
10	1496176	2745709	1249533	0.38554	576841	1058590	1066725	1736046
11	1749974	3273940	1523966	0.35049	613355	1147496	1600866	2464744
12	2001927	3798331	1796404	0.31863	637876	1210265	2173256	3189542
13	2245425	4305125	2059700	0.28966	650420	1247041	2769877	3899392
14	2474754	4782427	2307673	0 26333	651680	1259363	3377560	4584910
15	2685212	5220455	2535243	0.23939	642818	1249735	3984477	5238542
16	2873154	5611619	2738465	0.21763	625282	1221252	4580447	5854572
17	3035966	5950480	2914514	0.19784	600650	1177271	5157068	6429014
18	3172002	6233613	3061611	0.17986	570512	1121170	5707725	6959442
19	3280493	6459415	3178922	0.16351	536387	1056166	6227505	7444787
20	3361432	6627874	3266442	0.14864	499655	985191	6713040	7885112
21	3415460	6740322	3324863	0.13513	461533	910824	7162331	8281402
22	3443743	6799188	3355445	0.12285	423050	835253	7574534	8635352
23	3447859	6807755	3359896	0 11168	385051	760278	7949761	8949190
24	3429692	6769944	3340252	0.10153	348202	687323	8288882	9225507
25	3391334	6690110	3298776	0 09230	313007	617470	8593346	9467123
26	3335002	6572865	3237863	0.08391	279825	551499	8865020	9676971
27	3262963	6422931	3159968	0.07628	248891	489926	9106055	9858001
28	3177480	6245015	3067534	0.06934	220337	433050	9318768	10013111
29	3080755	6043701	2962946	0.06304	194209	380991	9505551	10145091
30	2974898	5823379	2848481	0.05731	170487	333729	9668793	10256583
31	2861890	5588176	2726286	0.05210	149101	291137	9810829	10350053
32	2743573	5341922	2598349	0.04736	129942	253006	9933893	10427778
33	2621628	5088117	2466489	0.04306	112879	219078	10040092	10491837
34	2497570	4829915	2332345	0.03914	97761	189055	10131386	10544109
35	2372749	4570124	2197375	0.03558	84432	162624	10209578	10586281
36	2248348	4311209	2062860	0.03235	72732	139464	10276309	10619853
37	2125392	4055299	1929907	0.02941	62504	119260	10333065	10646151
38	2004751	3804209	1799458	0.02673	53597	101705	10381173	10666336
39	1887154	3559454	1672300	0.02430	45866	86510	10421817	10681423
40	1773196	3322273	1549076	0.02209	39179	73405	10456044	10692289
–	–	–	–	–	–	–	–	–
–	–	–	–	–	–	–	–	–
41-80	24383279	36017502	11634223	0.216067	221692	381833	424018696	426327598

Discount rate	10%
B/C Ratio	1.56
NPV	10616185
LEV	10621371
IRR	30%
Max NPV	10617418
Max LEV	10707101
Age of maximum NPV (yrs)	64
Age of maximum LEV (yrs)	44

Appendix 18c: Discounted cash flow analysis for traditional cocoa technology (with planted shade trees)-25% yield increase

Year	Cost	Revenue	Net Revenue	Discount factor (10%)	Discounted cost	Discounted revenue	NPV	LEV
0	4555484	1031636	-3523848	1.00000	4555484	1031636	-	-
1	623746	3900293	3276547	0.90909	567042	3545721	-	-
2	461852	1017504	555652	0.82645	381696	840912	-85953	-495253
3	398540	0.00	-398540	0.75131	299429	0.00	-385382	-1549679
4	499523	419180	-80343	0.68301	341181	286306	-440258	-1388884
5	598813	726926	128113	0.62092	371816	451364	-360710	-951543
6	753164	1128491	375327	0.56447	425142	637004	-148847	-341764
7	797917	1615525	817608	0.51316	409457	829020	270715	556063
8	1012562	2173953	1161390	0.46651	472368	1014165	812512	1523005
9	1247825	2786019	1538194	0.42410	529200	1181544	1464856	2543585
10	1496176	3432136	1935960	0.38554	576841	1323237	2211253	3598712
11	1749974	4092424	2342451	0.35049	613355	1434370	3032268	4668575
12	2001927	4747914	2745987	0.31863	637876	1512832	3907224	5734371
13	2245425	5381406	3135981	0.28966	650420	1558802	4815606	6779339
14	2474754	5978034	3503280	0.26333	651680	1574203	5738129	7789293
15	2685212	6525569	3840357	0.23939	642818	1562169	6657480	8752840
16	2873154	7014524	4141370	0.21763	625282	1526565	7558763	9661355
17	3035966	7438100	4402134	0.19784	600650	1471588	8429701	10508814
18	3172002	7792016	4620014	0.17986	570512	1401463	9260652	11291533
19	3280493	8074268	4793776	0.16351	536387	1320207	10044472	12007852
20	3361432	8284842	4923411	0.14864	499655	1231489	10776306	12657808
21	3415460	8425403	5009943	0.13513	461533	1138529	11453302	13242811
22	3443743	8498985	5055242	0.12285	423050	1044066	12074318	13765334
23	3447859	8509694	5061835	0.11168	385051	950347	12639615	14228644
24	3429692	8462431	5032738	0.10153	348202	859153	13150567	14636551
25	3391334	8362637	4971303	0.09230	313007	771838	13609398	14993211
26	3335002	8216081	4881079	0.08391	279825	689374	14018947	15302948
27	3262963	8028664	4765701	0.07628	248891	612408	14382464	15570116
28	3177480	7806268	4628788	0.06934	220337	541313	14703439	15798995
29	3080755	7554626	4473871	0.06304	194209	476239	14985470	15993703
30	2974898	7279223	4304326	0.05731	170487	417162	15232144	16158144
31	2861890	6985220	4123330	0.05210	149101	363921	15446964	16295963
32	2743573	6677403	3933830	0.04736	129942	316258	15633280	16410523
33	2621628	6360146	3738518	0.04306	112879	273847	15794249	16504896
34	2497570	6037393	3539823	0.03914	97761	236319	15932806	16581862
35	2372749	5712655	3339906	0.03558	84432	203280	16051654	16643912
36	2248348	5389011	3140662	0.03235	72732	174330	16153252	16693265
37	2125392	5069124	2943732	0.02941	62504	149075	16239822	16731879
38	2004751	4755262	2750510	0.02673	53597	127131	16313356	16761472
39	1887154	4449317	2562163	0.02430	45866	108138	16375628	16783543
40	1773196	4152841	2379645	0.02209	39179	91757	16428206	16799388
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
41-80	24383279	45021877	20638598	0.216067	221692	477292	666253627	669881151

Discount rate	10%
B/C Ratio	1 87
NPV	16683806
LEV	16691955
IRR	35%
Max NPV	16684496
Max LEV	16820541
Age maximum NPV (yrs)	68
Age maximum LEV (yrs)	44

Appendix 18d: Discounted cash flow analysis for traditional cocoa technology (with planted shade trees)-50% yield increase

Year	Cost	Revenue	Net Revenue	Discount factor (10%)	Discounted cost	Discounted revenue	NPV	LEV
0	4555484	1031636	-3523848	1.00000	4555484	1031636	–	–
1	623746	3900293	3276547	0.90909	567042	3545721	–	–
2	461852	1017504	555652	0 82645	381696	840912	-85953	-495253
3	398540	0 00	-398540	0.75131	299429	0.00	-385382	-1549679
4	499523	503016	3493	0.68301	341181	343567	-382996	-1208242
5	598813	872311	273498	0.62092	371816	541636	-213176	-562352
6	753164	1354189	601025	0.56447	425142	764404	126087	289506
7	797917	1938629	1140713	0.51316	409457	994823	711453	1461364
8	1012562	2608743	1596181	0 46651	472368	1216998	1456083	2729341
9	1247825	3343223	2095398	0 42410	529200	1417853	2344737	4071414
10	1496176	4118563	2622388	0.38554	576841	1587884	3355781	5461379
11	1749974	4910909	3160936	0.35049	613355	1721244	4463669	6872406
12	2001927	5697497	3695570	0 31863	637876	1815398	5641192	8279200
13	2245425	6457688	4212262	0.28966	650420	1870562	6861334	9659285
14	2474754	7173641	4698887	0 26333	651680	1889044	8098698	10993677
15	2685212	7830683	5145470	0.23939	642818	1874603	9330483	12267138
16	2873154	8417429	5544275	0.21763	625282	1831878	10537079	13468138
17	3035966	8925720	5889754	0.19784	600650	1765906	11702335	14588615
18	3172002	9350419	6178417	0.17986	570512	1681755	12813578	15623624
19	3280493	9689122	6408630	0.16351	536387	1584249	13861440	16570917
20	3361432	9941811	6580379	0.14864	499655	1477787	14839571	17430505
21	3415460	10110483	6695024	0.13513	461533	1366235	15744274	18204220
22	3443743	10198782	6755039	0.12285	423050	1252879	16574103	18895316
23	3447859	10211633	6763774	0.11168	385051	1140416	17329469	19508097
24	3429692	10154917	6725224	0.10153	348202	1030984	18012251	20047595
25	3391334	10035165	6643830	0.09230	313007	926206	18625450	20519299
26	3335002	9859297	6524295	0.08391	279825	827249	19172874	20928925
27	3262963	9634397	6371434	0.07628	248891	734889	19658872	21282232
28	3177480	9367522	6190042	0 06934	220337	649575	20088111	21584878
29	3080755	9065552	5984796	0.06304	194209	571487	20465389	21842315
30	2974898	8735068	5760170	0.05731	170487	500594	20795496	22059705
31	2861890	8382264	5520374	0.05210	149101	436705	21083100	22241872
32	2743573	8012884	5269310	0 04736	129942	379510	21332667	22393267
33	2621628	7632175	5010547	0 04306	112879	328617	21548405	22517955
34	2497570	7244872	4747302	0.03914	97761	283582	21734226	22619615
35	2372749	6855186	4482437	0.03558	84432	243936	21893730	22701544
36	2248348	6466813	4218465	0.03235	72732	209196	22030194	22766677
37	2125392	6082949	3957557	0.02941	62504	178889	22146579	22817607
38	2004751	5706314	3701563	0.02673	53597	152558	22245540	22856608
39	1887154	5339181	3452027	0.02430	45866	129766	22329439	22885662
40	1773196	4983409	3210213	0.02209	39179	110108	22400369	22906486
–	–	–	–	–	–	–	–	–
41-80	24383279	54026252	29642974	0.216067	221692	572750	908488559	913434703

Discount rate	10%
B/C Ratio	2.19
NPV	22751427
LEV	22762539
IRR	38%
Max NPV	22751842
Max LEV	22933981
Age of maximum NPV (yrs)	71
Age of maximum LEV (yrs)	44

Appendix 18e: Discounted cash flow analysis for traditional cocoa technology (without planted shade trees)-25% yield decline

Year	Cost	Revenue	Net Revenue	Discount factor (10%)	Discounted cost	Discounted revenue	NPV	LEV
0	4448587	1031636	-3416951	1.0000	4448587	1031636	-	-
1	613597	3900293	3286696	0.9091	557815	3545721	-	-
2	461852	1441464	979612	0.8264	381696	1191293	380551	2192700
3	398540	0.00	-398540	0.7513	299429	0 00	81122	326203
4	496320	290124	-206196	0 6830	338993	198158	-59713	-188376
5	588800	494933	-93867	0.6209	365599	307314	-117997	-311273
6	731859	757756	25897	0.5645	413115	427733	-103378	-237365
7	760362	1071829	311466	0.5132	390186	550018	56453	115958
8	953749	1427113	473364	0.4665	444931	665759	277281	519746
9	1163057	1811649	648592	0.4241	493250	768316	552347	959099
10	1381373	2212734	831360	0.3855	532579	853105	872872	1420560
11	1601883	2617848	1015965	0.3505	561450	917540	1228962	1892148
12	1818250	3015352	1197102	0.3186	579350	960784	1610395	2363470
13	2024875	3394957	1370082	0.2897	586534	983398	2007259	2825790
14	2217044	3748005	1530961	0.2633	583817	986967	2410409	3272040
15	2391001	4067594	1676593	0 2394	572387	973750	2811772	3696743
16	2543947	4348583	1804636	0.2176	553637	946378	3204514	4095901
17	2674001	4587515	1913514	0.1978	529037	907615	3583092	4466831
18	2780117	4782467	2002351	0.1799	500028	860169	3943233	4807992
19	2861988	4932879	2070891	0.1635	467958	806565	4281840	5118805
20	2919941	5039350	2119408	0.1486	434031	749067	4596876	5399474
21	2954824	5103435	2148611	0.1351	399287	689630	4887219	5650818
22	2967896	5127451	2159555	0 1228	364594	629887	5152512	5874125
23	2960730	5114285	2153555	0 1117	330649	571154	5393017	6071017
24	2935116	5067229	2132112	0.1015	297989	514453	5609481	6243340
25	2892986	4989829	2096842	0 0923	267011	460541	5803011	6393066
26	2836339	4885758	2049419	0.0839	237984	409942	5974969	6522218
27	2767184	4758708	1991524	0.0763	211074	362983	6126878	6632813
28	2687493	4612301	1924808	0 0693	186360	319832	6260350	6726810
29	2599161	4450021	1850860	0.0630	163850	280527	6377027	6806079
30	2503982	4275161	1771179	0.0573	143500	245003	6478531	6872377
31	2403624	4090784	1687161	0.0521	125226	213124	6566430	6927335
32	2299614	3899701	1600087	0 0474	108915	184699	6642214	6972446
33	2193337	3704452	1511115	0 0431	94438	159502	6707278	7009065
34	2086026	3507303	1421277	0.0391	81652	137285	6762910	7038411
35	1978767	3310250	1331482	0.0356	70413	117792	6810290	7061569
36	1872501	3115020	1242519	0.0323	60574	100768	6850484	7079500
37	1768031	2923091	1155060	0.0294	51995	85963	6884452	7093047
38	1666032	2735701	1069669	0.0267	44541	73139	6913050	7102946
39	1567056	2553865	986809	0 0243	38086	62070	6937034	7109834
40	1471548	2378399	906852	0.0221	32514	52551	6957071	7114260
-	-	-	-	-	-	-	-	-
41-80	20852608	25306301	4453694	0 2161	185306	270199	281426035	282959578

B/C Ratio	1.40
NPV	7041963
IRR	30%
LEV	7045402
Max NPV	7044317
Max LEV	7117530
Age of maximum NPV (yrs)	60
Age of maximum LEV (yrs)	42

Appendix 18f: Discounted cash flow analysis for traditional cocoa technology (without planted shade trees)-50% yield decline

Year	Cost	Revenue	Net Revenue	Discount factor (10%)	Discounted cost	Discounted revenue	NPV	LEV
0	4448587	1031636	-3416951	1 00000	4448587	1031636	–	–
1	613597	3900293	3286696	0.909091	557815	3545721	–	–
2	461852	1017504	555652	0 826446	381695	840912	30171	173843
3	398540	0.00	-398540	0.751315	299429	0.00	-269258	-1082727
4	491804	235352	-256453	0.683013	335909	160748	-444419	-1402012
5	574968	392091	-182877	0 620921	357010	243457	-557971	-1471914
6	702918	588392	-114526	0.564474	396779	332132	-622618	-1429577
7	710091	817944	107854	0.513158	364389	419735	-567272	-1165208
8	876027	1072523	196497	0.466507	408673	500340	-475605	-891493
9	1052321	1342994	290673	0 424098	446287	569561	-352331	-611790
10	1232955	1620123	387168	0.385543	475357	624627	-203061	-330472
11	1412239	1895181	482942	0.350494	494981	664250	-33793	-52028
12	1585081	2160356	575275	0.318631	505056	688356	149508	219422
13	1747152	2409004	661853	0.289664	506087	697802	341223	480368
14	1894962	2635775	740813	0.263331	499002	694081	536302	728010
15	2025877	2836625	810748	0.239392	484979	679065	730389	960270
16	2138084	3008773	870689	0 217629	465309	654796	919876	1175755
17	2230521	3150591	920070	0.197845	441298	623329	1101907	1373683
18	2302796	3261475	958679	0.179859	414179	586606	1274334	1553798
19	2355083	3341693	986610	0.163508	385075	546394	1435653	1716278
20	2388026	3392235	1004209	0.148644	354966	504235	1584922	1861643
21	2402644	3414662	1012018	0.135131	324672	461427	1721676	1990678
22	2400233	3410962	1010730	0.122846	294859	419023	1845840	2104351
23	2382288	3383432	1001144	0 111678	266049	377855	1957646	2203758
24	2350432	3334558	984126	0.101526	238630	338544	2057560	2290060
25	2306348	3266925	960576	0 092296	212867	301524	2146218	2364447
26	2251732	3183132	931400	0.083905	188932	267081	2224367	2428098
27	2188247	3085734	897487	0.076278	166915	235374	2292825	2482159
28	2117495	2977186	859691	0.069343	146833	206447	2352439	2527720
29	2040985	2859804	818819	0.063039	128662	180279	2404057	2565804
30	1960122	2735744	775622	0.057309	112333	156783	2448507	2597358
31	1876191	2606976	730786	0.052099	97748	135821	2486580	2623248
32	1790351	2475281	684930	0.047362	84795	117234	2519020	2644258
33	1703635	2342242	638606	0.043057	73353	100850	2546516	2661094
34	1616949	2209248	592299	0 039143	63292	86477	2569700	2674382
35	1531077	2077502	546425	0.035584	54482	73926	2589144	2684676
36	1446683	1948026	501342	0.032349	46799	63017	2605362	2692461
37	1364326	1821673	457347	0.029408	40122	53572	2618812	2698161
38	1284461	1699144	414683	0.026735	34340	45427	2629899	2702140
39	1207450	1580994	373544	0.024304	29346	38424	2638977	2704714
40	1133573	1467651	334078	0.022095	25046	32428	2646359	2706151
–	–	–	–	–	–	–	–	–
41-80	16988072	15204010	-1784061	0 216064	145118	163983	106682227	107264422

B/C Ratio	1.17
NPV	2665224
IRR	20%
LEV	2666526
Max NPV	2670989 8
Max LEV	2706679
Age of maximum NPV (yrs)	52
Age of maximum LEV (yrs)	41

Appendix 19: Cash flow analysis for planted tree fallow technology

Appendix 19a: Summary cash flow analysis maize following *Gliricidia sepium* & natural fallows

	Gliricidia fallow	Natural fallow
Receipts		
Gross return	**4615368.32**	**1410024.27**
Maize	4285368.32	1410024.27
Stakes	330000.00	0.00
Expenses		
Land	0.00	0.00
Farm tools		
Machete	40000.00	40000.00
Chisel	6000.00	0.00
Gliricidia seedlings	330000.00	0.00
Maize seed cost	80000.00	80000.00
Maize sacks	126000.00	42000.00
Labour for land preparation to plant gliricidia seedling	108953.72	0.00
Labour line, peg, dig planting holes, transport & plant Gliricidia seedlings	350000.00	0.00
Labour for ring weeding gliricidia	189934.08	0.00
Labour clearing gliricidia fallow	126000.00	0.00
Labour clearing natural fallow	0.00	125828.72
Labour for planting maize	60000.00	60000.00
Labour for weeding 1 (maize after fallow)	150000.00	150000.00
Labour for weeding 2 (maize after fallow	0.00	150000.00
Labour harvesting maize	110982.61	36516.85
Labour carting maize home	150000.00	100000.00
De-husking	50000.00	50000.00
Shelling	126000.00	42000.00
Bagging	35000.00	17500.00
Loading at farm gate (1000cedis/bag)	21000.00	7000.00
Assembly tax (waybill) at village (500cedis/bag)	21000.00	7000.00
Transportation to market		
Maize (5000/bag)	210000.00	70000.00
Farmer (in & out=4000cedis)	4000.00	4000.00
Market tax (500 cedis/bag)	21000.00	7000.00
Potering at market (500 cedis/bag)	21000.00	7000.00
Total expenses	**2336870.41**	**995845.58**
Net Cash Flow	**2278497.91**	**414178.69**

Appendix 19b: Discounted cash flow analysis for *Gliricidia sepium* fallow-maize rotation

Period (months)	Total cost	Total revenue	Net revenue	Discount factor (10%)	Discounted cost	Discounted revenue
0	154954.00	0.00	-154954.00	1.00000	154954.00	0.00
1	680000.00	0.00	-680000.00	0.99209	674621.00	0.00
2	189934.00	0.00	-189934.00	0.98424	186941.00	0.00
3	0.00	0.00	0.00	0.97645	0.00	0.00
4	0.00	0.00	0.00	0.96873	0.00	0.00
5	0.00	0.00	0.00	0.96107	0.00	0.00
6	0.00	0.00	0.00	0.95346	0.00	0.00
7	0.00	0.00	0.00	0.94592	0.00	0.00
8	0.00	0.00	0.00	0.93844	0.00	0.00
9	0.00	0.00	0.00	0.93101	0.00	0.00
10	0.00	0.00	0.00	0.92365	0.00	0.00
11	0.00	0.00	0.00	0.91634	0.00	0.00
12	0.00	0.00	0.00	0.90909	0.00	0.00
13	0.00	0.00	0.00	0.90190	0.00	0.00
14	0.00	0.00	0.00	0.89476	0.00	0.00
15	0.00	0.00	0.00	0.88769	0.00	0.00
16	0.00	0.00	0.00	0.88066	0.00	0.00
17	0.00	0.00	0.00	0.87370	0.00	0.00
18	0.00	0.00	0.00	0.86678	0.00	0.00
19	0.00	0.00	0.00	0.85993	0.00	0.00
20	0.00	0.00	0.00	0.85312	0.00	0.00
21	0.00	0.00	0.00	0.84637	0.00	0.00
22	126000.00	330000.00	204000.00	0.83968	105800.00	277094.00
23	0.00	0.00	0.00	0.83304	0.00	0.00
24	140000.00	0.00	-140000.00	0.82645	115703.00	0.00
25	0.00	0.00	0.00	0.81991	0.00	0.00
26	0.00	0.00	0.00	0.81342	0.00	0.00
27	150000.00	0.00	-150000.00	0.80699	121048.00	0.00
28	0.00	0.00	0.00	0.80060	0.00	0.00
29	562983.00	0.00	-562983.00	0.79427	447160.00	0.00
30	333000.00	4285368.00	3952368.00	0.78799	262399.00	3376809.00

B/C Ratio = 1.77

NPV= ¢1,585,279.00

EAV = ¢747,722.00

Monthly IRR = 4%

IRR = 62%

Appendix 19c: Discounted cash flow analysis for natural fallow-maize rotation

Period (months)	Total cost	Total revenue	Net revenue	Discount factor (10%)	Discounted cost	Discounted Revenue
0	0.00	0.00	0.00	1.000000	0.00	0.00
1	0.00	0.00	0.00	0.992089	0.00	0.00
2	0.00	0.00	0.00	0.984240	0.00	0.00
3	0.00	0.00	0.00	0.976454	0.00	0.00
4	0.00	0.00	0.00	0.968729	0.00	0.00
5	0.00	0.00	0.00	0.961066	0.00	0.00
6	0.00	0.00	0.00	0.953463	0.00	0.00
7	0.00	0.00	0.00	0.945920	0.00	0.00
8	0.00	0.00	0.00	0.938436	0.00	0.00
9	0.00	0.00	0.00	0.931012	0.00	0.00
10	0.00	0.00	0.00	0.923647	0.00	0.00
11	0.00	0.00	0.00	0.916340	0.00	0.00
12	0.00	0.00	0.00	0.909091	0.00	0.00
13	0.00	0.00	0.00	0.901899	0.00	0.00
14	0.00	0.00	0.00	0.894764	0.00	0.00
15	0.00	0.00	0.00	0.887686	0.00	0.00
16	0.00	0.00	0.00	0.880663	0.00	0.00
17	0.00	0.00	0.00	0.873696	0.00	0.00
18	0.00	0.00	0.00	0.866784	0.00	0.00
19	0.00	0.00	0.00	0.859927	0.00	0.00
20	0.00	0.00	0.00	0.853124	0.00	0.00
21	0.00	0.00	0.00	0.846375	0.00	0.00
22	139243.00	0.00	-139243.00	0.839679	116919.00	0.00
23	0.00	0.00	0.00	0.833036	0.00	0.00
24	115703.00	0.00	-115703.00	0.826446	95622.00	0.00
25	122986.00	0.00	-122986.00	0.819908	100837.00	0.00
26	0.00	0.00	0.00	0.813422	0.00	0.00
27	121048.00	0.00	-121048.00	0.806987	97684.00	0.00
28	0.00	0.00	0.00	0.800603	0.00	0.00
29	214863.00	0.00	-214863.00	0.794269	170659.00	0.00
30	94164.00	1111079.00	1016915.00	0.787986	74200.00	875514.00

B/C Ratio = 1.38

NPV = ¢303,072.00

EAV = ¢142,949.00

Monthly IRR = 9%

IRR = 184%

Appendix 20: Monitoring visit –data sheet for periodic assessment of farmer experiments

Village……………………………………Period of Assessment………………………………

Plot №	Farmer name	Technology type	Food/tree types(s) planted	Planting pattern (Anyhow/lines)	Date food/tree planted	Condition of growth of maize/plantain/tree (poor, fair, good). Give brief description of status of the field	Timeliness of weeding (on time/ delayed) & date of weeding	Any reason(s) for observed condition

Appendix 21: Checklist for group farmer evaluation of technologies

A. On-station demonstration plot

Ask farmers how they will assess species with respect to farm production

Ability of species to spread/extent of coverage
Ability of species to form thick carpet or produce mulch/biomass on soil surface
Ability of species to smoother weeds
Ability of species to reduce labour required for weeding and its implications
Ability of species to increase soil fertility (and its effects on crop performance/yield/income) based on biomass production, etc.
Species suitability for different farm types (mono or mixed, etc.)
Preferred species and reasons
What are the potential advantages and disadvantages if species are to be on the plot?

B. Farmer experiments

1st year evaluation (2001)

Clarification on suitable time for weeding for cover crop under sowing (check with 4 weeks & 8 weeks planting on station).
Possible reasons farmers showed partial attitude to participation
Cover crop establishment:
Ability of species to spread/extent of coverage
Ability of species to form thick carpet or produce mulch/biomass on soil surface
Ability of species to smoother weeds
Which weeds were smothered and which were not and reasons
Problems envisaged
Benefits envisaged (labour/weeding reduction, etc)
Any suggestions? Or way forward

2nd year evaluation (2002)

Crop performance/growth
Labour requirements (increased/decreased)
Cost requirements (increased/decreased)
Yield/income (increased/decreased)
Soil fertility status or soil improvement as seen from tillage/workability, crop performance/yield, etc.
Constraints
Benefits
Any suggestions?

Appendix 22: Farmer evaluation of on-farm experiments

Appendix 22a: Farmer evaluation of maize-legume relay technology

1. Sheet code..................District..........................Village...................................
2. Farmer name...Gender ....Age............
3. Residential status...........................Home town...........................Region..........
4. Tenure for technology plot....................Tenancy period...............Sharecrop arrangement...................Rented land cost...............................
5. Legume species planted ....

6. Scoring of indicators

6a. Legume 1( ) versus Control

Indicator	**Much worse**	**Worse**	**Same**	**Better**	**Much better**
Soil fertility improvement					
Crop yield					
Weed suppression					
Labour requirement					
Soil moisture conservation					

6b. Legume 2 (   ) versus Control

Indicator	Much worse	Worse	Same	Better	Much better
Soil fertility improvement					
Crop yield					
Weed suppression					
Labour requirement					
Soil moisture conservation					

6c. Legume 1 versus legume 2

Indicator	Much worse	Worse	Same	Better	Much better
Soil fertility improvement					
Crop yield					
Weed suppression					
Labour requirement					
Soil moisture conservation					

Appendix 22b: Farmer evaluation of plantain-legume technology

1. Sheet code……………..District……………………..Village……………………………
2. Farmer name……….……………………………Gender ………………Age…………
3. Residential status……………………..Home town……………………..Region……….
4. Tenure for technology plot………………..Tenancy period……………Sharecrop arrangement………………..Rented land cost…………………………..
5. Legume species planted ……………………………………………………………

6. Scoring of indicators

6a. Legume 1(   ) vrs Control

Indicator	Much worse	Worse	Same	Better	Much better
Soil fertility					
Crop yield					
Weed suppression					
Planting material availability					
Lodging					
Labour requirement					
Soil moisture conservation					

6b. Legume 2 (   ) vrs Control

Indicator	Much worse	Worse	Same	Better	Much better
Soil fertility					
Crop yield					
Weed suppression					
Planting material availability					
Lodging					
Labour requirement					
Soil moisture conservation					

6c. Legume 3 (   ) vrs control

Indicator	Much worse	Worse	Same	Better	Much better
Soil fertility					
Crop yield					
Weed suppression					
Planting material availability					
Lodging					
Labour requirement					
Soil moisture conservation					

Appendix 22c: Farmer evaluation of planted tree fallow technology

1. Sheet code................District.........................Village...............................
2. Farmer name..Gender ....Age............
3. Residential status.........................Home town.........................Region.........
4. Tenure for technology plot...................Tenancy period...............Sharecrop arrangement...................Rented land cost..............................
5. Legume species planted ....

6. Scoring of indicators

Technology versus farmers own practice

Indicator	**Much worse**	**Worse**	**Same**	**Better**	**Much better**
Increased yield					
Reduce weeds/weeding labour					
Wood (stakes, fuelwood)					
Control deforestation/erosion					

Appendix 22d : Farmer evaluation of cocoa – shade tree technology

1. Sheet code.................District...........................Village...................................
2. Farmer name...Gender ....Age............
3. Residential status...........................Home town...........................Region..........
4. Tenure for technology plot.....................Tenancy period................Sharecrop arrangement...................Rented land cost................................
5. Legume species planted ....

6. Scoring of indicators

Technology versus farmers own practice

Indicator	Much worse	Worse	Same	Better	Much better
Increased yield					
Shade					
Timber					

Appendix 22e: Farmer's perception of technology design and adoption potential

1. Which aspects of the trial design did you like? Why?...

....

2. Which aspects of the trial design you didn't like? Why?...................................

....

3. Will the results obtained so far contribute to achieve the objective of the trial (technology)? If yes, how? If no, why?...

....

4. Do you think that the trial (technology) design needs any modification? If yes, why and what modifications?..

....

5. Are you willing to or thinking of adopting the technology in other parts of your farm- land? ? If yes, which aspects of the technologys are likely to be adopted and why?.........

....

....

6. In your experience, will other farmers in the village adopt/adapt the technologys under trial? If yes, which aspects of the technologys are likely to be adopted and why?..............

....

....

7. Have you learnt anything new from implementing the technology trial? If yes, what are those?...

....

8. Have you shared or passed on your new findings/knowledge to others? If yes, to whom and where (in or outside the village)?...

....

9. Has anybody in or outside the village has adopted or adapted any aspects or whole of the trial (technology) design you are testing? If yes, please give his/her details.....................

....

10. Your comments/suggestions for the improvements required in the trial designs.........

....