Contribution of soil fertility replenishment agroforestry technologies to the livelihoods and food security of smallholder farmers in central and southern Malawi

by

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DECLARATION

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ABSTRACT

This study sought to examine the effects of soil fertility replenishment (SFR) adoption on household security and poverty reduction in smallholder farming households of central and southern Malawi by assessing food security, asset status, and household income generating activities in Kasungu and Machinga Districts during 2007.

The results showed that households had been able to significantly increase maize production by an extra 382 kg per year in Kasungu and 242 kg per year in Machinga Districts, which constitutes approximately 35% and 22% of average household maize requirements for the year for each district, respectively. This reduced the critical annual hunger periods from 3.46 months to 2.80 months per year in Kasungu and from 4.31 months to 3.75 months in Machinga. Respondents also reported a significant increase in assets and an increase in income. Despite these positive changes, households were found to still be living in extreme poverty. Selling physical assets was the most common response to shocks and any increase in income was allocated to the purchase of food, household supplies, and other items necessary to immediate survival.

This study revealed that while food security is paramount to the sustainable livelihoods of smallholder farmers, livelihood security and poverty reduction depend on more than increased food production. SFR technologies are fulfilling their primary role as a means to food security, but their adoption does not lead to significant livelihood improvements. Achieving lasting impacts requires that initiatives take an integrated approach and address not only household food production, but the multifaceted dynamics of social institutions, markets/economy, and policy. The long-term impacts of the current agroforestry programs in the study areas will emerge only with time. Livelihood improvements will depend on several factors. First, market inefficiencies must be remedied and economic barriers must be broken down. Second, the challenges identified by the respondents, especially access to resources and training, need to be addressed in a participatory way that promotes education and empowerment. As these two issues are tackled, households will become better equipped to manage the complexities that arise from SFR adoption and livelihood diversification. It is recommended that future research and initiatives should focus on identifying and removing economic barriers to markets, addressing farmer-identified challenges such as access to seed, water, and education and training, supporting households in managing multiple livelihood strategies, and continuing research to identify appropriate agroforestry species and technologies.

OPSOMMING

Hierdie studie het die invloed van die gebruik van grondvrugbaarheidsaanvulling (GVA) op huishoudelike voedselvoorsiening en die verligting van armoede in huishoudings van kleinhoeweboerderye in Sentraal- en Suid-Malawi ondersoek deur in 2007 die gewaarborgde produksie van voedsel, die bate-status en aktiwiteite wat huishoudelike inkomste genereer in die Kasungu- en Machinga-distrik te evalueer.

Die resultate het getoon dat huishoudings in staat was om mielieproduksie aansienlik te verhoog met ’n ekstra 382 kg per jaar in die Kasungu-distrik, en 242 kg per jaar in die Machinga-distrik, wat onderskeidelik ongeveer 35% en 22% van die gemiddelde jaarlikse behoefte aan mielies in huishoudings in elke distrik verteenwoordig. Dit het die jaarlikse kritieke hongersnoodtydperk van 3,46 na 2,80 maande per jaar in Kasungu en van 4,31 na 3,75 maande in Machinga laat afneem. Respondente het ook ’n beduidende toename in bates en ’n verhoogde inkomste gemeld. Ten spyte van hierdie positiewe veranderings, is daar egter gevind dat huishoudings steeds in die uiterste armoede leef. Om tasbare bates te verkoop was die algemeenste reaksie op skokke, en enige ekstra inkomste is gebruik om kos en huishoudelike voorraad te koop, asook ander items wat noodsaaklik is vir onmiddellike oorlewing.

Hierdie studie het aan die lig gebring dat al is die gewaarborgde voorsiening van voedsel van die allergrootste belang vir die volhoubare bestaan van kleinhoeweboere, die gewaarborgde lewensonderhoud en die verligting van armoede van meer afhanklik is as bloot ’n toename in voedselproduksie. GVA-tegnogie vervul sy primêre rol as ’n manier om voedsel te waarborg, maar die gebruik daarvan lei nie tot ’n betekenisvolle verbetering in lewensbestaan nie. Om ’n blywende impak te maak, sal vereis dat inisiatiewe ’n geïntegreerde benadering volg, en nie net aandag sal gee aan huishoudings se voedselproduksie nie, maar ook aan die veelkantige dinamika van sosiale instellings, die mark en ekonomie, en beleidsrigtings. Die langtermynimpak van die huidige agrobosbou-programme in die betrokke gebiede van die studie sal eers mettertyd sigbaar wees. Verbeterings in lewensbestaan sal van verskeie faktore afhang. Eerstens, die ondoeltreffendheid in die mark moet reggestel word, en ekonomiese hindernisse moet afgebreek word. Tweedens, die uitdagings wat deur die respondente geïdentifiseer is, veral toegang tot hulpbronne en opleiding, moet aangepak word op ’n deelnemende manier wat opvoeding en bemagtiging bevorder. Wanneer daar aandag aan hierdie twee probleme gegee word, sal huishoudings beter toegerus word om die ingewikkelde probleme wat ontstaan weens die gebruik van GVA en die diversifisering van lewensonderhoud te kan hanteer. Daar word aanbeveel dat toekomstige navorsing en inisiatiewe daarop sal fokus om hindernisse ten opsigte van die mark te identifiseer en te verwyder, om die uitdagings wat boere geïdentifiseer het, soos saad, water, opvoeding en opleiding, aan te pak en huishoudings só te ondersteun om veelvuldige lewensonderhoudstrategieë te benut, en om voort te gaan met navorsing om gepaste agrobosbou-spesies en tegnologieë te identifiseer.

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ACRONYMS

ADD	Agricultural Development Division
ADMARC	Agricultural Development and Marketing Corporation
AEDC	Agricultural Extension Development Coordinator
EPA	Extension Planning Area
ETIP	Extended Targeted Input Program
GDP	Gross Domestic Product
ICRAF	World Agroforestry Centre
IGA	Income Generating Activity
IHS	Integrated Household Survey
MT	Metric Tonne
MWK	Malawi Kwacha
PRA	Participatory Rural Appraisal
RDP	Rural Development Project
SFR	Soil Fertility Replenishment
SLF	Sustainable Livelihoods Framework
SOM	Soil Organic Matter
SPP	Starter Pack Program
TIP	Targeted Input Program

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Chapter 1
Introduction

1.1 Introduction

Agriculture is the livelihood backbone of millions of people around the world and is the primary livelihood strategy for 85% of the rural population in developing regions (Dixon *et al.*, 2001). The expanding information on agroforestry research and development around the globe shows that agroforestry is being promoted and implemented as a means to improve agricultural production for smallholder farmers with limited labor, financial, and land capital (Franzel & Scherr, 2002; Kwesiga *et al.,* 2003; Nair, 1993; Singh *et al.*, 1995). In Africa, and particularly southern Africa, the main constraint to agricultural productivity is soil nutrient deficiency, especially nitrogen and phosphorous (Sanchez *et al.*, 1997; Scoones & Toulmin, 1999). In fact, Sanchez, *et al.* (1997) reported that an estimated 600 kg N ha^{-1}, 75 kg P ha^{-1}, and 450 kg K ha^{-1} was lost from 200 million ha of cultivated land in Africa between 1967 and 1997. For this reason, agroforestry research in the region has focused on integrated soil fertility replenishment (SFR) technologies and the adoption and scaling-up of these practices is the main thrust of the ongoing research (Akinnifesi *et al.*, 2007).

Malawi poses a unique challenge to SFR implementation. The country relies heavily on agriculture, which contributes 36.3% of the GDP and 90% of all export revenues. The smallholder agricultural sector is responsible for approximately 70% of the country's agricultural output while the estate sector makes up the remaining 30% (Harrigan, 2003). There is a 60% poverty rate in Malawi's Southern Region and a 44% poverty rate in the country's Central Region (Malawi National Statistical Office, 2005). With a population density estimated to be 146 people per km^2 in 1998 (Malawi National Statistical Office, 2005) and land holdings that are often only 0.1 to 0.5 ha (Chirwa *et al.*, 2003; Kwesiga *et al.*, 2003), subsistence farmers in these regions have been forced to abandon traditional fallow practices and engage in intensive, continuous cultivation. Continuous cultivation has accelerated soil degradation and led to severe N and P deficiencies (Akinnifesi *et al.*, 2007). Soil N and P deficiencies are seen as the most limiting factors to the staple food maize (*Zea mays*) production (Akinnifesi *et al.*, 2007). Henao and Baanante (1999) reported annual nutrient depletion rates of 48 kg N ha^{-1} yr^{-1}, 7 kg P ha^{-1} yr^{-1}, and 37 kg K ha^{-1} yr^{-1} for agricultural soils in Malawi. The high costs, long transportation distances, and inconsistent supplies of inorganic fertilizers have made them an impractical soil fertility management option for most rural farmers (Sanchez *et al.*, 1997). Inorganic fertilizers cost approximately US$90 per metric ton in Europe. By the time the fertilizer reaches Malawi the cost is at least six times greater, averaging US$500 to US$770 per metric ton (Sanchez, 2002).

Increasing populations, decreasing land holdings, declining soil fertility, and declining maize yields have led to chronic food insecurity for the majority of Malawi's rural poor. The National Environmental Action Plan for Malawi (1994) identified soil degradation as the most serious environmental problem in the country. According to Sanchez (2002), Malawi's food deficit is directly related to poor crop production, rather than inadequate distribution. There is simply not enough food being produced. There has been an increase in governmental resources dedicated to identifying and promoting low-input and low-cost soil fertility improvement methods (Malawi, 2002), with an emphasis on various agroforestry technologies. Due to the prevalence of chronic poverty, poor soil fertility, and food scarcity, rural Malawians stand to realize great benefits from proper SFR adoption.

1.2 Justification and Problem Identification

There has been a recent surge in research that addresses issues of adoption and scaling-up of SFR technologies. Recent research has explored the role of various cultural, environmental, political, and economic factors that affect the adoption and scaling-up of agroforestry technologies (Ajayi *et al.*, 2003; Franzel, 1999; Keil *et al.*, 2005; Phiri *et al.*, 2004; Thangata & Alavalapati, 2003) with the aim of understanding the complex interplay of biophysical and socio-economic factors that influence farmer adoption. These studies have led to a greater understanding of farmer decision making and have allowed research and extension personnel to evaluate dissemination efforts to better facilitate farmers and increase the numbers of adopters. The World Agroforestry Centre (ICRAF) has also identified integrated soil fertility management as a focus area for improving rural livelihoods (World Agroforestry Centre, 2007b). Similarly, there is a growing pool of literature on the potential economic, biological, and social advantages of SFR technologies. There is a growing body of research which investigated the biophysical (Ajayi *et al.*, 2006; Akinnifesi *et al.*, 2007; Chirwa *et al.*, 2003; Phiri *et al.*, 1999), economic (Franzel, 1999; Kuntashula *et al.*, 2004), and social/institutional issues (Ajayi & Kwesiga, 2003; Thangata & Alavalapati, 2003) that either promote or inhibit SFR adoption. Work is well underway to increase adoption and promote the scaling-up of these technologies. The Southern Africa Programme of the World Agroforestry Centre envisions that 2 million farmers in the southern Africa region will be using agroforestry technologies by the year 2010 (ICRAFSA, 2007).

Agroforestry is promoted as a viable, low-input, and sustainable means to replenish soil fertility, increase crop yields, increase food security, and ultimately help bring people out of poverty (World Agroforestry Centre, 2007a). The effects of SFR technologies on crop yields are well documented (Ajayi *et al.*, 2006; Akinnifesi *et al.*, 2007; Chirwa *et al.*, 2003). Despite the amount of both biological and socio-economic research being done, there is a lack of research that addresses how SFR adoption affects farmer livelihood decisions and the research that has been done is largely theoretical (Ellis *et al.*, 2003; Sunderlin *et al.*, 2005). A study by Cramb *et al.*, (2004) in Vietnam used the community livelihoods profile to assess, in part, if wealth contributed to the adoption of forage technologies. They found that those in the higher wealth categories were more likely to have adopted the technologies, but they did not explore whether or not adoption had led to a change in wealth status. Place *et al.*, (2003) conducted an extensive survey on the impacts of SFR on the rural poor in western Kenya where they found that adoption increased social capital of some farmers but also that the increased productivity of an adopting farmer could stir up jealousy among non-adopters. Furthermore, they concluded that the full potential of SFR to reduce poverty may not be realized if farmers do not have the initial resources to fully implement and maintain the system (Place *et al.*, 2003). Thus, there is a need for more research into the long term effects of SFR adoption on livelihoods and sustained poverty relief.

Research needs to go beyond maize yields and adoption rates to investigate the resulting livelihood impacts of SFR. With the current emphasis on promoting agroforestry adoption, it is important to revisit those farmers who are now well-established in their use of agroforestry systems to investigate how (or if) the technologies have facilitated any shift in their livelihoods that would indicate progress along the path of wealth creation and a permanent migration out of poverty. By using both qualitative and quantitative methods within the vulnerability context of the livelihood strategies framework (Chambers & Conway, 1992; Ellis, 2000; Scoones, 1998), this study investigated the links between SFR use and poverty reduction in farming households of central and southern Malawi.

1.3 Objectives and Research Questions

The research aim was to investigate whether SFR adoption has resulted in household wealth creation and a sustained movement along the pathway out of poverty. The objective of this study was to investigate the links between SFR adoption and poverty reduction in farming households of central and southern Malawi by assessing food security, asset status, and household income generating activities. The hypothesis was: if SFR use increased food production, decreased hunger, and opened pathways to new income generating activities, then households would show a marked reduction in vulnerability and increase in security. The main objective was further narrowed down into the following specific objectives and research questions.

<u>Specific Objective 1: Evaluate changes in food security resulting from increased yields associated with SFR adoption</u>

Research Question 1:

Is there a reduction in hunger vulnerability due to SFR use?

Research Question 2:

Is there a significant increase in crop production, especially maize, due to SFR use?

<u>Specific Objective 2: Determine if there is a pattern of SFR adoption and changes in household assets</u>

Research Question 1:

What assets did the household have prior to SFR adoption and what assets do they have now?

Research Question 2:

Have households been able to increase and/or diversify their assets?

<u>Specific Objective 3: Determine if SFR adoption has allowed households to diversify their income generating activities</u>

Research Question 1:

What are the various household income sources during the year?

Research Question 2:

Have households been able to diversify their income sources since SFR adoption?

Research Question 3:

Have households been able to increase their income amounts through SFR related activities? If so, how do they use the additional income?

Specific Objective 4: Determine if SFR adoption has an effect on the household's level of vulnerability and its ability to absorb and cope with various household and environmental shocks.

Research Question 1:

Has SFR adoption either provided a buffer against, or diminished the household's capacity to cope with, various household and environmental shocks?

1.4 Thesis Structure

This thesis is divided into six chapters. Following Chapter 1, Chapter 2 provides a review of the currently available literature regarding the history of, and current issues facing Malawi soil fertility, an overview of various integrated soil fertility management technologies, and a discussion of the livelihoods framework. Chapter 3 describes the specific study site characteristics and field and data analysis methods. Chapter 4 provides the results of the research, which are then discussed and synthesized in Chapter 5. The final chapter draws conclusions from the results and discussion chapters and identifies recommendations and opportunities for further research as well as providing some specific recommendations regarding each of the study sites.

Chapter 2
Literature Review

2.1 Malawi Soil Fertility

Soil fertility is considered one measure of soil health and is a function of both natural phenomenon and human management (Donovan & Casey, 1998). Soil fertility can be compromised by nutrient depletion and the degradation of soil physical, chemical, and biological properties. Throughout sub-Saharan Africa, soils tend to have low soil organic matter (SOM) and are inherently low in nitrogen (N), phosphorous (P), potassium (K), sulfur (S), magnesium (Mg), and zinc (Z), (Donovan & Casey, 1998), which are critical nutrients for plant growth. Soil organic matter is critical for efficient water infiltration, soil structure, and root development. A deficiency in SOM results in deterioration of the soil structure. This leads to a loss of topsoil through increased erosion and runoff. Poor soil structure also increases susceptibility to compaction which reduces nutrient and water availability and retards root growth. These consequences, both individually and in combination, result in reduced crop yields (Donovan & Casey, 1998; Malawi, 2002).

In Malawi, soil fertility is predominantly confined to the top soil and consequently relies heavily on SOM (Malawi, 2002). However, an erosion rate of 20 MT ha^{-1} yr^{-1} (Bishop, 1995; Malawi Ministry of Agriculture and Food Security, 2008), and nutrient depletion rates of around 48 kg N ha^{-1} yr^{-1}, 7 kg P ha^{-1} yr^{-1}, and 37 kg K ha^{-1} yr^{-1} for agricultural soils (Henao & Baanante, 1999) significantly compromise the productivity of these already inherently low-fertility soils. Soil fertility is declining as a result of the minimal use of fertilizers, abandonment of traditional fallows (shifting cultivation), increased cultivation on unsuitable land, and intensified continuous cultivation (Donovan & Casey, 1998; Kanyama-Phiri *et al*., 2000). Historically, farmers in Malawi practiced long fallows, or shifting cultivation, which allowed the nutrients in agricultural soils time to be replenished (Snapp *et al*., 1998). However, the country's population is approaching 13 million people (Malawi Ministry of Agriculture and Food Security, 2008), population densities are increasing (Malawi National Statistical Office, 2005), and land holding sizes are decreasing, with the average smallholder farmer owning between 0.1 and 0.5 ha (Chirwa *et al.*, 2003; Kwesiga *et al.*, 2003). This means that the traditional long fallow periods are now impractical for most smallholder farmers. Additionally, mineral fertilizers are prohibitively expensive for the majority of Malawi's subsistence farmers. Inorganic fertilizers often cost up to six times more in Malawi than in Europe (Sanchez, 2002). Consequently, as soil fertility has declined, so too has food production. Bishop (1995) reported that between 1955 and 1963 unfertilized maize yields declined by 49%, translating to an average annual yield decline of 9.1%. Similarly, Bishop (1995) also reported a 2% annual reduction in maize yields between the periods of 1957-1962 and 1985-1987. More recently, the Malawi government reported that during the 1960s unfertilized maize yields were approximately 1700 kg ha^{-1} and are now less than 1000 kg ha^{-1} (Malawi, 2002). In Malawi, soil fertility is the major constraint to agricultural, and therefore food, production (Bowers, 2002; Malawi, 2002; Sanchez, 2002).

Only 32% of Malawi's land is considered suitable for rain-fed cultivation. However, during the 1989/1990 season an estimated 48% of the total land area was under cultivation, meaning that 16% of agricultural activities were occurring in unsuitable areas, and without proper soil conservation measures (Malawi, 2002). Due to the demands of an increasing population on a fixed amount of available land, household landholdings are decreasing and intensive, continuous cultivation is now the norm.

2.1.2 Malawi Soil Fertility Management Policy

Since independence in 1964, Malawi has sought to be food-self-sufficient. Unfortunately, a combination of climatic shocks, declining maize yields, and an increasing population have resulted in a country where more than half of the population is considered to be both poor and food insecure (Harrigan, 2008; Malawi, 1995). The period between 1964 and 1970 was one of economic growth and general food security. The agricultural estate sector largely contributed to Malawi's economy with the export of goods such as tea and tobacco, while the smallholder sector supported food production (Harrigan, 2008). During this time, smallholder production was supported by the state marketing board (ADMARC), which provided subsidized seed and fertilizer. In the 1980's pressure from the World Bank and other donors forced policy restructuring and led to the eventual phasing out of subsidies (Chinangwa, 2006; Harrigan, 2008). The government discontinued the fertilizer subsidy program in the 1994/1995 season. As a result of market liberalization, currency devaluation, and the removal of subsidies, fertilizer prices increased dramatically during the 1990's while fertilizer use correspondingly decreased (Chinangwa, 2006; Harrigan, 2008).

Since the removal of subsidies in 1994/1995, there have been several initiatives aimed at increasing smallholder production. The Starter Pack Program (SPP) was introduced in the 1998/1999 season. It provided smallholder farmers with packages containing 2 kg of hybrid maize seed, 15 kg of fertilizer, and 1 kg of legume seeds, which was enough to cultivate 0.1 ha (Harrigan, 2008). The starter packs reached 2.8 million farmers and were estimated to increase maize production by between 100 and 150 kg per farmer, or an estimated 280 000 to 420 000 MT for the country (Harrigan, 2008). The SPP was scaled down in 2000 and renamed the Targeted Input Program (TIP). The new TIP reached 1.5 million farmers in the 2000/2001 season and 1 million farmers in the 2001/2002 season (Harrigan, 2008). In response to the 2002/2003 food crisis, the government implemented an Extended Targeted Impact Program (ETIP) that assisted 2.8 million farmers in 2002/2003 and 1.7 million in 2003/2004. Fertilizer subsidies were reinstated in 2004 (Harrigan, 2008). Currently, the government provides vouchers for 100 kg of fertilizer to approximately 50% of the smallholder sector and vouchers for 4 kg of improved seed to all smallholder farmers (Malawi Ministry of Agriculture and Food Security, 2008). In 2005/2006, a combination of adequate rains and the return of fertilizer subsidies resulted in an 87% increase in maize yields from the previous season and produced a surplus of 250 000 MT for export (AfDB/OECD, 2007; Malawi Ministry of Agriculture and Food Security, 2008). The government continued the fertilizer subsidy program for the 2006/2007 season with the distribution of approximately 150 000 MT of fertilizer (AfDB/OECD, 2007). This distribution costs roughly MWK 5.5 million and accounts for one third of the total agricultural budget (AfDB/OECD, 2007).

In response to the declining soil fertility and crop yields, the Government of Malawi is, in addition to the various fertilizer subsidies and TIPs, actively promoting several low-input soil fertility methods including: the use of improved fallows of *Tephrosia vogelii* and *Sesbania sesban*, intercropping with *Faidherbia albida* and legumes, and composting with green manure (Malawi, 2002). In addition, soil conservation measures such as the use of vetiver hedgerow planting, box ridging, and raising foot paths and boundaries are also being promoted (Malawi, 2002). Considering that one third of the country's agricultural budget goes towards input subsidies, it seems that both farmer and government would greatly benefit from the appropriate research, development, and implementation of low-input, low-cost alternatives such as agroforestry technologies.

2.2 Agroforestry defined

Agroforestry is a collective name for land-use systems and technologies where woody perennials (trees, shrubs, palms, bamboos, etc.) are deliberately managed on the same land units as agricultural crops and/or animals, in some form of spatial arrangement or temporal sequence. A key aspect of agroforestry systems is that there are both ecological and economical interactions between the different components (Nair, 1993). Gold *et al.*, (2000) identify four criteria that distinguish agroforestry practices from other land use systems. First, agroforestry is the *intentional* combination of trees, crops, and/or livestock that are designed and managed to work together to produce multiple benefits. Second, agroforestry systems are *intensively managed* in order to sustain their productivity and functionality. Third, the various components are combined in space and function to comprise an *integrated* management unit that fully utilizes the production potential of the site. Finally, agroforestry systems are *interactive.* That is, they utilize and manipulate biophysical processes in order to maximize the desired products and/or services. There are three main classifications of agroforestry systems. An agrisilviculture system refers to technologies that integrate crops, and trees or shrubs. Silvopastoral systems are those that integrate pasture/animals and trees. Agrosilvopastoral systems combine crops, pasture/animals, and trees. This study is concerned with the agrisilviculture system in general, and in particular, integrated soil fertility replenishment technologies.

2.3 Integrated soil fertility replenishment (SFR)

Integrated soil fertility replenishment (SFR) encompasses a range of agroforestry practices aimed at improving soil nutrients, especially N and P, and thereby increasing crop productivity, through either growing nitrogen-fixing trees directly on agricultural land such as improved fallows, relay cropping, and intercropping, or through biomass transfer which incorporates outside biomass into crop soils (Akinnifesi *et al.*, 2008; Kwesiga *et al.*, 2003). In addition to soil fertility and increased crop production, agroforestry provides other ecological and economic products and services.

2.3.2 Wood Production

One of the most important products of SFR, to the smallholder farmer, is woody biomass production. Wood for fuel and construction are critical to the livelihoods of rural farmers. An estimated 85% of the rural population in developing countries depends on woodlands and forests to sustain their livelihoods (Dixon *et al.*, 2001). As population pressures and deforestation rates increase, there is an increasing demand for wood, but a decreasing supply. In Tanzania, for example, deforestation rates caused by activities associated with agriculture, illegal harvesting, and expanding settlements have reached 91 000 ha per year (Meghji, 2003). In Malawi, high population pressures have stressed the natural resources base, and especially the forest and woodland resources. The country's wood demand was evaluated to exceed the available supply by one third (Malawi, 2002; MEAD, 2002). Additionally, Malawi's forest cover decreased by 2.5 million ha between 1972 and 1992 and the current rate of deforestation is approximately 2.8% per year (MEAD, 2002). As a result of these trends, those who rely on wood for fuel, construction, and other livelihood activities are spending more time collecting and transporting wood to the detriment of other important household activities. Considering that fertilizer tree systems have been shown to produce up to 10 MT of woody biomass per hectare (Kwesiga & Coe, 1994), it is easy to see that the secondary benefit of wood production by agroforestry trees is an important, positive externality to these technologies.

Two important species for wood production include *Sesbania sesban* and *Gliricidia sepium*. *S. sesban* produces a high volume of woody biomass in a short amount of time, making it ideal for fuelwood production (AFT, 2008). In eastern Zambia, a *Sesbania sesban* improved fallow produced over 10 MT ha^{-1} (Kwesiga *et al*., 1999). Kwesiga & Coe (1994) reported fuelwood harvests of 15 and 21 MT ha^{-1} following 2 and 3 year *Sesbania* fallows, respectively. Furthermore, Franzel *et al.* (2002) reported that a 2-year *Sesbania* fallow resulted in 15 MT of fuelwood. The woody biomass of *Gliricidia sepium* is suitable for both fuel and construction. As fuel, the wood of *G. sepium* burns slowly and with little smoke. Alternatively, the hard, durable wood is termite resistant and is used in fence, home, and tool construction (AFT, 2008). Chirwa *et al.,* (2003) reported that *G. sepium,* when grown in an unpruned woodlot, or as an improved fallow, produced 22 MT ha^{-1} yr^{-1} of fuelwood. The same study reported fuelwood production amounts of 1 MT ha^{-1} after a 2 year *Gliricida/*maize intercrop and 3.3 and 5.0 MT ha^{-1} after 3 years of *Gliricida*/maize/pigeon pea and *Gliricidia*/maize intercrop, respectively (Chirwa *et al*., 2003). A 5 year *Gliricidia* rotational woodlot in Tanzania was found to produce over 30 MT of woody biomass (Kimaro *et al*., 2007). *Faidherbia albida* and *Leucaena leucocephala* are two other SFR species planted in the southern Africa region that are managed for the dual purpose of soil fertility and woody biomass production (AFT, 2008).

2.3.3 Pest Management

Another added benefit to some SFR agroforestry species is a pest management quality. *Striga* (*S. asiatica* and *S. hermonthica*) is a parasitic plant that thrives in nutrient starved soils (Ajayi *et al*., 2007; Berner *et al*., 1995; Gacheru & Rao, 2001; Sileshi *et al*., 2008). It attacks several of the major food crops, including maize, millet, rice, and sorghum. Seedlings attach to the roots of the host plant where they continue to grow underground for four to seven weeks; it is during this period that they cause the most damage (Berner *et al*.¸ 1995). A single *Striga* plant can produce over 50 000 seeds and these seeds can remain viable in the soil for 10 to 14 years (Berner *et al.*, 1995; Gacheru & Rao, 2001). Yield losses of 32% to 50% and 18% to 42% from *Striga* infestations have been reported in on-station trials in Kenya and Tanzania, respectively (Massawe *et al.*, 2001). For smallholder, subsistence farmers, losses can be up to 100% with heavy infestation (Berner *et al.*, 1995; Gacheru & Rao, 2001; Massawe *et al.*, 2001).

High populations have necessitated the use of continuous cultivation, this leads to soil nutrient depletion and has caused an increase in the severity and spread of *Striga* infestations (Gacheru &

Rao, 2001). Several agroforestry species have shown potential in combating *Striga.* For example, on moderately-infested sites in western Kenya *Desmodium distortum, Sesbania sesban, Sesbania cinerascuns, Crotalaria grahamiana,* and *Tephrosia vogelii* fallows were found to decrease *Striga* by 40% to 72% and increase maize yields by 224% to 316% when compared to continuous maize plots (Gacheru & Rao, 2005). Additionally, Kwesiga *et al*. (1999) found less than 6 *Striga* plants 100 m^{-2} following 3 year *Sesbania* fallows in two experiments from Zambia. This is in stark contrast to the 1532 and 195 *Striga* plants 100 m^{-2} found in two experiments of continuously cultivated and unfertilized maize (Kwesiga *et al*., 1999).

Tephrosia vogelii has also been found to be effective as both a repellant and insecticide against *Callosobruchus maculates*, the main pest infecting stored cowpea. In a laboratory study conducted by Boeke *et al*. (2004), beetles exposed to tubes treated with *T. vogelii* powder laid fewer eggs in the first 24 hour period than beetles in the control. The *T. vogelii* powder was also found to reduce the parent beetle lifespan (Boeke *et al*., 2004). Another study reported that the juice of *T. vogelii* was effective in managing maize stem borer (*Chilo partellus*) populations in southern Tanzania and northern Zambia (Abate *et al*., 2000). Similarly, in Uganda, the presence of *T. vogelii* plants in sweet potato fields was reported to protect the potatoes from mole and rat damage (Abate *et al*., 2000). The dry, crushed *Tephrosia vogelii* leaves are also documented to be effective against lice, fleas, tics, and as a molluscicide (AFT, 2008).

2.3.4 Carbon Sequestration

The Kyoto Protocol recognizes agroforestry as a greenhouse gas mitigation strategy and allows industrialized nations to purchase carbon credits from developing countries (Orlando *et al.*, 2002). In this context, agroforestry not only plays a part in mitigating the effects of global climate change through carbon sequestration (Ajayi *et al*., 2007; Ajayi & Matakala, 2006), but also has the potential to contribute to farmer incomes through the sale of carbon credits (Takimoto *et al*., 2008). Several initiatives have recently been developed to support and encourage farmers who adopt land use practices that render environmental services (Ajayi *et al*., 2007).

While there is increasing interest in the global warming mitigation potential of agroforestry, research has lagged behind in quantifying this potential for various systems (Albrecht & Kandji, 2003; Makumba *et al*., 2007). While the volume of research on agroforestry and climate regulation is limited, there have been a few studies that reveal the carbon sequestration potential for some systems. For example, a *Gliricidia*/maize intercropping system in Malawi was found to sequester between 123 and 149 MT of C ha^{-1} in the first 0 to 200 cm of soil through a combination of root turnover and pruning application (Ajayi *et al*., 2007; Makumba *et al*., 2007). In a separate report, Montagnini & Nair (2004) estimated that the potential carbon sequestration for smallholder agroforestry systems in the tropics range from 1.5 to 3.5 MT ha^{-1} of C yr^{-1}. Albrecht & Kandji (2003) have calculated the carbon sequestration potential to be between 12 and 228 MT ha^{-1} for similar systems. Between fuel and pole wood production, pesticide qualities, and climate regulation, it is clear that agroforestry offers benefits beyond improved soil characteristics and crop yields. Table 2.1, adapted from Ajayi *et al*. (2007), highlights some of the private and social benefits of SFR technologies.

TABLE 2.1 Benefits of Integrated SFR Technologies

	Private	**Social**
Benefit	Yield increase	Carbon sequestration
	Stakes for tobacco curing	Suppresses noxious weeds
	Improved fuel wood availability	Improved soil structure, reduced erosion and run-off
	Fodder	Promotes biodiversity
	Bio-pesticide	Potential for community income diversity
	Suppresses weeds	
	Improved soil structure, reduced erosion and run-off	
	Diversification of farm production (cash crops)	

Source: Adapted from Ajayi, *et al*., (2007)

There are a variety of agroforestry technology options that are being researched, tested, and adopted throughout the world. The type of SFR technology that is acceptable, appropriate, and sustainable to a particular setting is determined by a battery of ecological (climate, soil and terrain characteristics) and societal factors such as available land and labor and institutional support and regulations. As a result of the various ecological and social boundaries in the study area, the respondents in this study used a combination of one or more of the following SFR technologies: intercropping, relay cropping, improved fallow, and biomass transfer.

2.4 SFR Technologies

2.4.1 Intercropping

Intercropping is the simultaneous cultivation of two or more crops on the same field. Usually, this involves maize as the main crop, and species such as pigeon pea (*Cajanus cajan*), *Tephrosia vogelii, Faidherbia albida, Leucaena leucocephala,* or *Gliricidia sepium. Gliricidia*/maize intercropping is an especially prominent agroforestry system. *Gliricidia* is a coppicing legume with a foliage nitrogen content of up to 4% (Kwesiga *et al.*, 2003). It is native to Central America and is currently being used in the intercropping technologies throughout southern Africa (Böhringer, 2001). In the intercropping system, *Gliricidia* is planted along with the maize crop. The trees are pruned at crop planting and again at first weeding and the pruned biomass is incorporated into the soil. The advantage of this system is that, because of its coppicing ability, the trees can be maintained for 15 to 20 years (Akinnifesi *et al.*, 2007), eliminating the need to plant each year, as is the case in the relay cropping system. However, it takes 2 to 3 seasons of intercropping before there is a significant positive response in maize yield (Böhringer, 2001; Chirwa *et al.*, 2003) and the technology is labor intensive because of the required pruning (Kwesiga *et al.,* 2003).

The benefits of intercropping on maize yields have been shown to be highly substantial. Akinnifesi *et al*. (2006) reported soil fertility levels in *Gliricidia/*maize systems to be significantly greater compared to sole maize. In the second cropping season, maize yields in the intercropping plots were twice what the sole maize plots produced. Additionally, maize yields in the intercropping systems maintained an average of 3.8 MT ha^{-1} over a ten year period, compared to an average 1.2 MT ha^{-1} in the sole maize plots (Akinnifesi *et al.,* 2006). Results from Makoka Research Station in southern Malawi showed that by the fourth year, maize yields in the intercropping system were double those of the controls (sole maize) (Kwesiga *et al.,* 2003). Table 2.2, adapted from Kwesiga *et al.* (2003), illustrates the potential yield benefits of the intercropping technology.

TABLE 2.2 Maize grain yields from a *Gliricidia/*maize intercropping system with different levels of fertilizer from 1992 to 1997 at Makoka, Malawi.

% of recommended fertilizer	1992-1993		1993-1994		1994-1995		1995-1996		1996-1997	
	SM	G/M	SM	G/M	SM	G/M	SM	G/M	SM	G/M
	MT ha^{-1}									
0	2.0	1.60	1.20	2.50	1.10	2.10	1.07	4.72	0.56	3.28
25	3.4	3.10	1.60	3.00	2.20	2.90	3.49	6.34	2.11	4.23
50	4.2	4.00	2.40	3.20	2.40	2.90	4.23	6.70	1.89	4.39

SM=sole maize, G/M= Gliricida/maize intercropping recommended fertilizer rates: 96 kg N and 40 kg P ha^{-1}.
Source: Kwesiga, *et al*., 2003

2.4.2 Relay Cropping

Relay cropping is a system whereby nitrogen-fixing trees, shrubs, or legumes such as *Sesbania sesban, Tephrosia vogelii, S. macrantha, Crotalaria spp.,* or perennial pigeon pea (*Cajanus cajan*), are grown as annuals and planted 3 to 5 weeks after the food crop. Staggering, or relaying, the agroforestry species and crop plantings reduces competition (Akinnifesi *et al*., 2007; Kwesiga *et al.*, 2003). The agroforestry species are allowed to grow and develop beyond the main crop harvest. At the beginning of the second season they are felled and the woody stems are collected for use as fuel while the remaining biomass is incorporated into the soil as green manure. Early reports reviewed by Snapp *et al*., (1998) indicated that after 10 months of growth, *Sesbania* produced 30 to 60 kg N ha^{-1} and 2 to 3 MT ha^{-1} of leafy biomass, plus valuable fuelwood from the stems. In southern Malawi, Phiri *et al*., (1999) found a significant influence of *Sesbania* relay cropping on maize yields at various landscape positions. In another study, tree biomass production averaged 1 to 2.5 MT ha^{-1} for *T. vogelii,* and 1.8 to 4.0 MT ha^{-1} for *S. sesban* and a corresponding average maize grain yield of 2 MT ha^{-1} (Kwesiga *et al.,* 2003).

Relay cropping is suitable for areas of high population density and small farm sizes because it does not require farmers to sacrifice land to fallow. The drawback of this system is that the trees are felled and must therefore be re-planted each year. Furthermore, the technology relies on late-season rainfall in order for the trees to become fully established (Böhringer, 2001).

2.4.3 Improved Fallow

Traditionally, farmers practiced rotational cultivation and allowed agricultural plots to lie in fallow for several years in order to replenish soil nutrients (Kanyama-Phiri *et al*., 2000; Snapp *et al*., 1998). With increasing populations and decreasing land holdings, many smallholder farmers can no longer afford to completely remove land from cultivation. For this reason, improved fallow technology has emerged as a promising alternative to traditional fallows. In an improved fallow, fast-growing, nitrogen fixing species such as *Sesbania sesban , Tephrosia vogelii, Gliricidia sepium,* and *Leucaena leucocephala* are grown for 2 to 3 years in the fallow plot after which, they are felled. The leaf matter can then be incorporated into the soil as green manure, and the woody stems can be used for fuel wood or construction materials. Farmers have also intensified this practice by intercropping during the first year of tree growth (Böhringer, 2001). Improved fallows are being used extensively in Eastern Zambia (Ajayi & Kwesiga, 2003; Ajayi *et al.*, 2003) as well as in parts of Malawi, Kenya, Zimbabwe, and Tanzania (Kwesiga *et al.*, 2003; Place *et al.*, 2003). Improved fallows are perhaps the most widely adopted SFR practice in southern Africa. Kwesiga *et al.* (2003) estimated that by 1998 over 14 000 farmers were experimenting with improved fallows in eastern Zambia, and that by 2006 a total of 400 000 farmers in southern Africa would be using the technology.

In trials at Chipata, Zambia, maize yields increased from 2.0 MT ha^{-1} in an un-fallowed plot to 5.6 MT ha^{-1} after a 2 year *S. sesban* fallow (Kwesiga *et al*., 2003). The same study also reported yield increases of 191% after a 2 year *T. vogelii* fallow and a 155% yield increase following a 2 year fallow with *C. cajan* (Kwesiga *et al.*, 2003). Despite the shorter fallow period, compared to traditional fallows, the success of improved fallow technology depends, in part, on the farmer's ability to remove land from crop production for a period of 2 to 3 years. In places where landholdings are small, fallows may not be a viable option for farmers. Other constraints include water availability, especially during tree establishment, and pests in the case of *Sesbania* (Böhringer, 2001). For this reason, intercropping and relay cropping have become the dominant SFR practices in central and southern Malawi (Kwesiga *et al.*, 2003; Thangata & Alavalapati, 2003).

2.4.4 Biomass Transfer

In the biomass transfer technology, green manure is mulched and/or incorporated into agricultural soils. Biomass transfer is common in Zimbabwe, Tanzania, western Kenya, and northern Zambia where green biomass is grown in *dambos* (shallow, seasonally waterlogged wetlands) or on sloping land and areas that are unsuitable for agricultural production and where labor is not a limiting factor (Kwesiga *et al.*, 2003; Place *et al.*, 2003). The technology is labor intensive as the mulch must be collected, transported to the agricultural field, and then incorporated into the soils. The amount and cost of labor associated with biomass transfer is the major limiting factor to the technology (Kuntashula *et al*., 2004). The advantage of this technology is that it allows for continuous cultivation as the incorporated green manure provides sustained soil nutrient replenishment (Place *et al*., 2003).

Typically, *Tithonia diversifolia, Leucaena leucocephala, Senna spectabilis, Gliricidia sepium,* and *Tephrosia vogelii* are the most prominent species used in biomass transfer systems (Place *et al*., 2003). The technology has been reported to increase maize yields by up to 114% (Place *et al*., 2003). A compilation of independent studies in Malawi showed that green manures increased maize yields by 115.8%, when compared to unfertilized maize (Ajayi *et al*., 2007). Similarly, Ajayi *et al*. (2007) reported that incorporating 3.4 MT ha^{-1} of dry weight *Gliricidia* manure produced up to 3 MT ha^{-1} of maize. Aside from the common use in maize production, biomass transfer is an important technology used in dambo cultivation of high-value cash crops, such as vegetables *(*Kwesiga *et al.,* 2003).

Dambo cultivation is an important supplement to upland cultivation. Vegetable gardens (*dimbas*) grown in dambos provide additional food and supplemental income (Kuntashula *et al*., 2004). Kuntashula *et al*. (2004) tested the effects of incorporating *Gliricidia sepium* and *Leucaena leucocephala* green manure into onion and cabbage being grown in dimbas in eastern Zambia. They found that the addition of the green manure produced significantly higher vegetable yields, and resulted in higher net income values than the unfertilized controls (Table 2.3) (Kuntashula *et al*., 2004). In fact, the net income value of cabbage treated with 12 MT ha^{-1} *Gliricidia* green manure was comparable to the net income of cabbage treated with the full recommended amount of inorganic fertilizer (Table 2.3). The study revealed that, in dambo cultivation, the biomass transfer system not only improves vegetable yields but is also economically beneficial. Despite the economic benefits of this technology, the study also found that the net income values of the biomass transfer treatments were substantially reduced by labor costs. This was especially true for *Leucaena* due to the fact that it is more management intensive than *Gliricidia* (Kuntashula *et al*., 2004).

TABLE 2.3 Vegetable yields in MT ha^{-1} and (net income value/ha $US after labor costs)

Treatment	Cabbage	Onion
Manure (10 MT ha^{-1}) + ½ recommended amount of fertilizer	66.8 ($12400)	96.0 ($5400)
Fully fertilized	57.6 ($10400)	57.1 ($2090)
Gliricidia 12 MT ha^{-1}	53.6 ($9700)	79.8 ($4100)
Gliricidia 8 MT ha^{-1}	43.1 ($7730)	68.3 ($3200)
Leucaena 12 MT ha^{-1}	32.6 ($5500)	
Control	17.0 ($2700)	28.1 ($165)

Source: Kuntashula, *et al*., (2004)

2.5 Livelihoods Framework

The concept of livelihood analysis has been evolving as an integrated way of monitoring and evaluating the effectiveness or ineffectiveness of rural development research policies and programs (Cramb & Ho, 2004; Ellis, 2000). This has come about as the result of the recognition that rural households do not solely focus on increasing crop or livestock production (Cramb & Ho, 2004), rather, rural households "construct an increasingly diverse portfolio of activities and assets in order to survive and improve their standard of living", a process known as rural livelihood diversification (Ellis, 2000). Within this context, Ellis has formulated the following definition of livelihood: "A livelihood comprises the assets (natural, physical, human, financial, and social capital), the activities, and the access to these (mediated by institutions and social relations) that together determine the living gained by the individual or household" (Ellis, 2000). Furthermore, a livelihood is sustainable when it can "cope with and recover from stresses and shocks, maintain or enhance its capabilities and assets, while not undermining the natural resource base" (Scoones, 1998).

The Sustainable Livelihoods Framework (SLF) is a dynamic, robust, people-centered approach to understanding the livelihoods and livelihood decisions of people, households, and communities (depending on the unit of analysis). Within the context of this study, livelihoods were evaluated at the household level. The SLF is used to understand the livelihood profiles of the poor in an effort to identify appropriate solutions to poverty (DFID, 1999). The framework consists of five main components (Figure 2.1). The framework begins by viewing households within a *vulnerability context*, households then have access to various *assets*, which are given value and meaning through social and institutional *transforming structures and processes*. Based on the various assets and institutional structures and processes, households then employ various *livelihood strategies* in order to achieve desired *livelihood outcomes* (DFID, 1999).

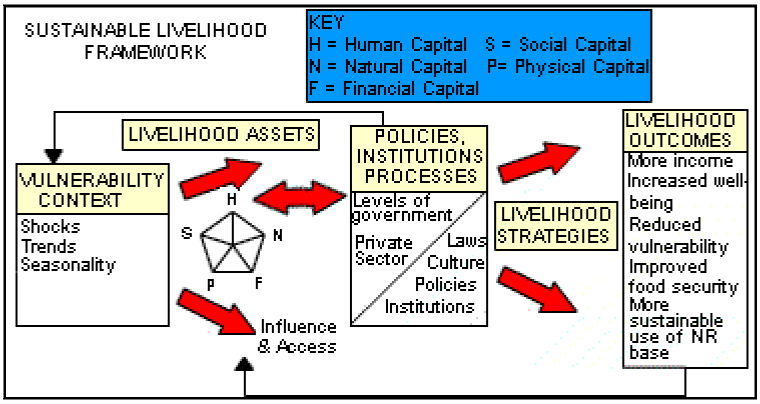


FIGURE 2.1 Sustainable Livelihoods Framework
Source: DFID, 1999

The vulnerability context refers to the external environment in which people live and various factors such as shocks (fire, illness, theft), trends (population trends, economics, political trends), and seasonality (crop/market prices, labor demand and employment opportunities) over which they have little or no control (DFID, 1999). The vulnerability context is important because shifts or changes in trends and seasonality or the occurrence of unexpected shocks have a direct effect on a household's assets and coping abilities. For example, fire or theft may result in the loss of structures or productive farm tools. Seasonal fluxes in food prices may influence a household's income derived from crop sales, or may affect their ability to purchase food.

Within the SLF, assets fall into five categories. Natural capital includes the natural environment, both its products (air, trees, land, and water) and its services (nutrient cycling, pollution control, carbon sequestration) (Ellis, 2000; Scoones, 1998). Physical capital includes assets such as tools, housing, and infrastructure and is the result of economic production (Ellis, 2000; Scoones, 1998). Adequate access to transport, housing, clean water and sanitation, energy, and information are essential physical capital components of a sustainable livelihood (DFID, 1999). A lack in these resources directly increases vulnerability. Human capital refers to the skills, knowledge, and abilities of individuals, households, or populations, depending on the scale of the research (DFID, 1999). It also includes aspects of education and health (Ellis, 2000; Scoones, 1998). Financial capital refers available financial resources that can be used to achieve the desired livelihood outcomes (DFID, 1999) or used toward the purchase of goods and services (Ellis, 2000; Scoones, 1998). Financial capital falls into two categories. Available stocks include cash savings, livestock, or jewelry. They are forms of financial capital that do not have liens or liability attached to them (DFID, 1999). Regular inflows of money include earned income, pensions, and remittances (DFID, 1999). Finally, social capital refers to the various associations, networks, and institutional relations that people engage in. These can include farmer groups, social groups, religious groups, family relations, and general community dynamics (Ellis, 2000; Scoones, 1998).

Transforming processes and structures are the governmental, organizational, and institutional bodies that drive livelihoods and have a direct impact on the value of assets (DFID, 1999). In the context of this study, for example, government fertilizer subsidies or TIPs have a direct influence on farmer's access to credit and fertilizer inputs, which will influence crop production. Additionally, access to extension officers and agroforestry training can directly affect SFR use and the effectiveness of the technology. While these transforming processes and structures are not directly evaluated in this study, they are addressed in terms of farmer perceptions of access to and the influence of this dimension.

The combination of a household's vulnerability context, asset status, and the role of transforming processes and structures result in the overall livelihood strategy. The livelihood strategy is the way in which the above SLF components are combined and implemented to achieve livelihood goals (DFID, 1999). Household livelihood strategies are multidimensional. While the households in this study are primarily subsistence farmers, they diversify their livelihoods through other activities such as crop sales and seasonal off-farm labor. A household's livelihood strategies are framed around achieving various livelihood outcomes. These goals or outcomes may include food security, increased income, maintaining a sustainable resource base, or reducing vulnerability.

A full livelihood analysis, that is evaluating all five components of the SLF and all five sources of capital, is a large undertaking and is not necessarily always appropriate, it is important therefore to identify a proper scale of analysis (Scoones, 1998). Scoones (1998) points out that it is often appropriate to conduct research under the premise of optimal ignorance, that is, exploring and identifying only what is necessary to make informed decision and recommendations. This study looks at how SFR adoption has affected the assets (capital) and livelihood strategies of households to determine the effects of adoption on household vulnerability and livelihood outcomes.

Chapter 3
Methods

This chapter deals with the specific study areas, data collection, and data analysis methods. It begins with a country overview then discusses each of the study areas. Each area is addressed in terms of soil and climate characteristics, farming activities and food production, and wealth and income. The methodology outlines the specific survey methods including questionnaire development and execution, various ranking and charting activities, as well as sources of secondary data. The data analysis section describes the various statistical techniques used to organize, code, and analyze the data.

3.1 Study Areas

Malawi is a landlocked country with a total area of approximately 118 484 km² of which 20% is covered in water, mainly Lake Malawi (Malawi, 2002; Msuku *et al.*, s.d). It is bordered by Mozambique on the east, south, and south-west, Zambia on the north-west, and Tanzania on the north. The climate is tropical and characterized by a dry and rainy season. The dry season runs from May to October and the rainy season from November to April. The rains start in the southern region and move north. Annual precipitation ranges from 700 to 1800 mm and temperatures range from 12°C to 32°C.

Forty-eight percent of the land area in Malawi is under cultivation. However, only 32% of this is classified as suitable land for rain fed agriculture (Malawi, 2002). Agricultural land increased from 3 million ha to 4.5 million ha between 1976 and 1990 while the average land holding size decreased from 1.53 ha in 1968/1969 to 0.8 ha in 2000 (Malawi, 2002).

In order to achieve its various goals and objectives, the Ministry of Agriculture established a National Rural Development Programme that divides the country into various management units. There are eight Agricultural Development Divisions (ADD) within the country, each ADD is divided into several Rural Development Project (RDP) areas, these RDPs are further divided into Extension Planning Areas (EPA) and then finally into smaller Sections. This study was conducted in two different RDPs, Kasungu in the Central Region and Machinga in the Southern Region (see Map 1). Within the Kasungu RDP the Chipala EPA was chosen and interviews were carried out in three different Sections (Figure 3.1). The interviews in Machinga were carried out in the Mikhole Section of Nanyumbu EPA (Figure 3.1). These districts were selected in collaboration with technical staff from ICRAF who work in the areas and were also based on time constraints, availability, and prevalence of agroforestry use. In both districts, subsistence farming is the dominant livelihood strategy, with maize (*Zea mays*) being the most important crop.

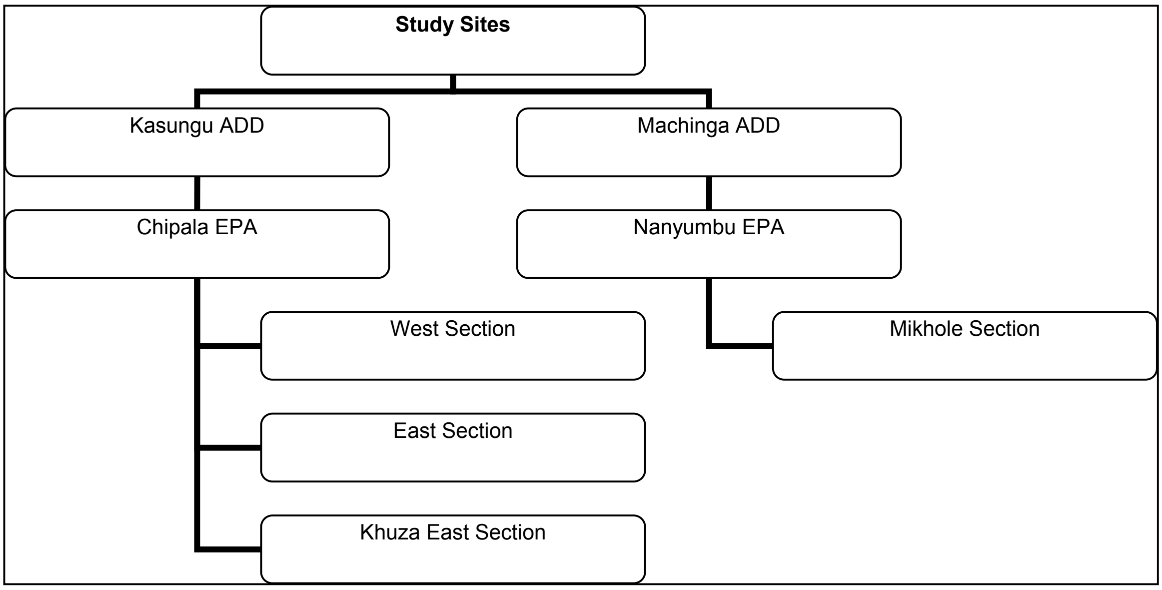


FIGURE 3.1: Study sites

Map 1 Research Sites

3.1.2 Farming Practices

In both Kasungu and Machinga, field preparation begins with land clearing between the months of June and August followed by ridging in October and November. Maize is planted at the onset of the rains, usually at the end of November in the Southern Region and in December in the Central Region.

Maize is generally planted at a spacing of 90 cm within rows and 75 cm between rows and intercropped with pigeon pea (*Cajanus cajan*). The crop is weeded twice; the first weeding occurs three to four weeks after planting and a second weeding is done in February. Harvesting of beans begins in January and February, and groundnuts (*Arachis hypogaea*) and maize are harvested between April and June (Msuku *et al.*, s.d.).

3.2 Kasungu Chipala EPA, Central Malawi

3.2.1 Climate and Soils

Kasungu is in the Central Region and is part of the Lilongwe Plains (also knows as the Central Region Plateau) at S 13°2'0", E 33°29'0" and an elevation of 1327 m a.s.l.. Average annual temperature is 21.8°C (Chavula, 2008) (Figure 3.2). This area is characterized by broad valleys and interluves, and is drained by dambo streams (Malawi, 2002). The plateau varies in elevation from 1000 to 1600 m above sea level and has a semi-arid to sub-humid climate (Msuku *et al.*, s.d.). There is one wet season between November and March and average annual rainfall is 700-1000 mm (Figure 3.3) (Msuku *et al.*, s.d.). The vegetation is dominated by miombo woodlands and *Brachystegia* and *Julbernadia* woodlands (Msuku *et al.*, s.d.). The dominant soils are sandy ferrallitic (Lowole, 1983; Malawi, 2002; Msuku *et al.*, s.d.). These soils are highly weathered yellowish to reddish-brown, and have a poorly defined structure. They are well to excessively drained and have low inherent fertility (Msuku *et al.*, s.d.).

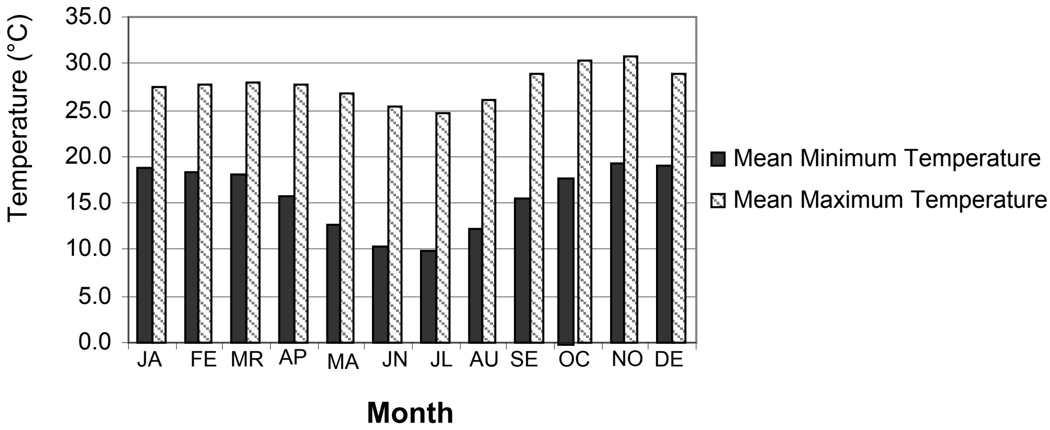


FIGURE 3.2: Mean minimum and maximum temperatures for Kasungu

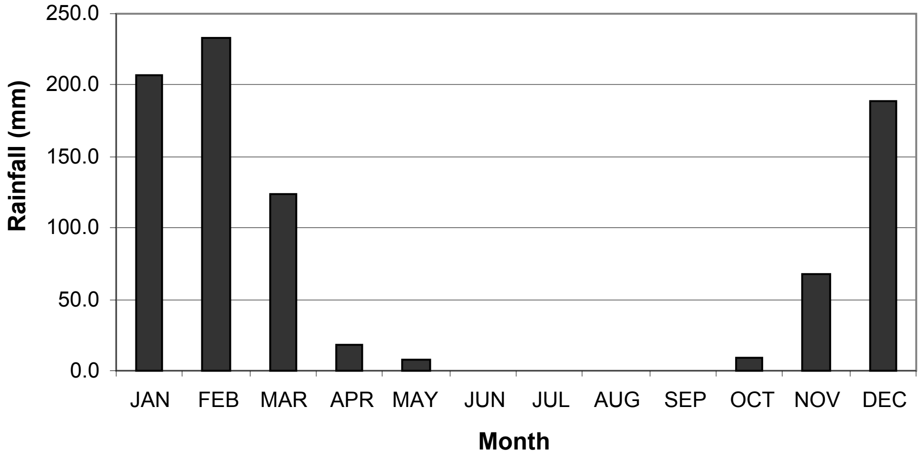


FIGURE 3.3: Mean monthly precipitation for Kasungu

3.2.2 Farming Activities and Food Production

The primary source of food in the area is from local crop production, with availability being lowest between January and February. During this time the poor rely on in-kind labor wages. Maize (*Zea mays*) is the most important food crop and is cultivated by an estimated 95.9% of the population of Kasungu District (Malawi National Statistical Office, 2005). Groundnuts (*Arachis hypogaea*), rice (*Oryza sativa*), pulses and, to a lesser extent cassava (*Manihot esculenta*) are also important crops with 55.3%, 48%, 41% and 12.3% of the population cultivating these crops respectively (Malawi National Statistical Office, 2005). Due to its relative drought tolerance, there has been an increase in cassava cultivation since the food crisis of the 2001/2002 season (MVAC, 2005). Maize, groundnuts, sweet potatoes (*Ipomoea batatas*), and pulses are harvested between March and July while *dimba* (wetland gardens usually cultivated during the dry season) crops such as vegetable and maize are cultivated between May and January. The main cash crop, tobacco (*Nicotiana tabacum*) is harvested in February and March and sold on the Lilongwe markets between April and September (MVAC, 2005).

3.2.3 Wealth and Income

According to the Malawi Baseline Livelihood Profiles (MVAC, 2005), wealth in the region is heavily reliant on access to food and credit. Households with access to credit are more likely to have a larger land holding from which they can cultivate and harvest a higher crop yield. These households may also be able to purchase livestock such as cattle which can be used for meat, milk, farming, or sold for cash in times of stress. Overall, those considered “better-off” cultivate twice as much land, may own as many as 10 head of cattle, and/or own twice as many goats and chickens as those considered “poor” (MVAC, 2005).

Crop sales are the primary source of income in the region, with tobacco constituting 65% to 85% of the average household income (MVAC, 2005). Approximately 64% of the population of Kasungu District grows tobacco (Malawi National Statistical Office, 2005). It is the most important cash crop in the region with an estimated 45% of the yearly tobacco sales in the country coming from Kasungu ADD, and 60% of this comes from Kasungu RDP (Mwasikakata, 2003). Among the poor, cash and in kind wages from *ganyu*[1] work are the second most important source of income, while for those households considered to be either middle or better-off, food crops and livestock sales are the secondary sources of income (MVAC, 2005).

3.2.4 Kasungu Chipala Agroforestry Program

According to the Kasungu Chipala Agricultural Extension Development Coordinator (AEDC), there are a reported 41 143 farming families in the community, with an average land holding size of 1.0 ha (Mbale, 2007). The Kasungu Chipala Agroforestry Program began during the 1997/98 growing season when 18 farmers visited Chipata District in the Eastern Province of Zambia to observe and learn about improved fallow agroforestry practices. The AEDC reported that the average maize yield prior to agroforestry was approximately 1.5 MT ha^{-1} and has increased to between 2.5 and 3.0 MT ha^{-1} (Mbale, 2007.).

3.3 Machinga Nanyumbu EPA, Southern Malawi

3.3.1 Climate and Soils

Machinga is in the Southern Region at S14° 58’ 00”, E35° 31’ 00”. The Southern Region of Malawi includes both the Upper and Lower Shire Valley areas (Malawi, 2002). It is an area of high population density with over 150 people per km^2 (Msuku *et al.*, s.d.). The area ranges in elevation from 800 m in the Lower Shire Valley to 1300 m in the Upper Shire Valley and is considered part of the Shire Highlands Land-Use System (Malawi, 2002; Msuku *et al.*, s.d.). Temperatures average 31.6 °C in November and 13.5 °C in June (Figure 3.4) (Chavula, 2008). The climate is semi-arid with an average annual rainfall of 800 to 1300 mm (Figure 3.5) (Msuku *et al.*, s.d.). There is one primary rainy season between November and April, but there may be a period of light rains called “chiperonis” during May, June, and July (Msuku *et al.*, s.d.). Vegetation is characterized by lakeshore savanna grasslands and thickets in the Upper Shire Valley and by semi-arid savanna grasslands and thickets further south (Msuku *et al*., s.d.). Soils are predominantly ferrallitic (ferralsols) (Lowole, 1983; Msuku *et al.*, s.d.). The ferrallitic soils have a sandy loam top soil and low inherent fertility (Lowole, 1983; Msuku *et al.*, s.d.). The low-fertility, sandy soils in the area make households especially vulnerable to poor crop production (MVAC, 2005).

[1] Ganyu refers to casual labor or piecework and is paid for with either cash or in kind upon completion of the job

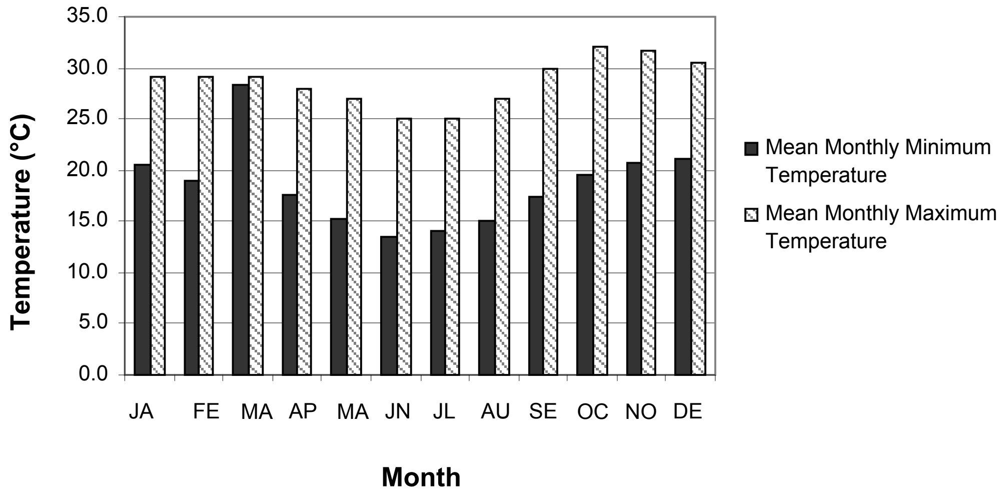


FIGURE 3.4: Mean monthly temperatures for Machinga taken at Ntaja

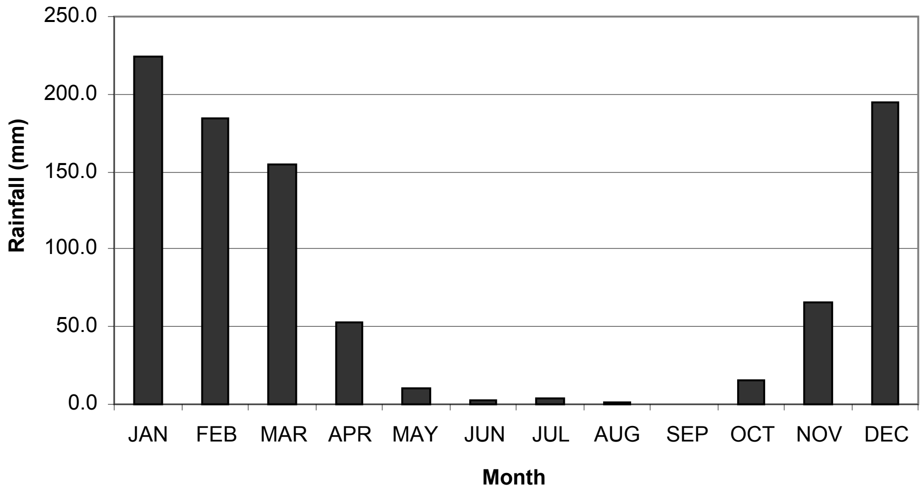


FIGURE 3.5: Mean monthly rainfall for Machinga taken at Ntaja

3.3.2 Farming Activities and Food Production

Most households are subsistence farmers whose main crops are maize, cassava, and rice (MVAC, 2005). Almost 98% of households in Machinga cultivate maize, 67.7% grow pulses, 38.6% grow groundnuts, 42.1% cultivate rice, and 26.6% cultivate cassava (Malawi National Statistical Office, 2005). Traditionally, households engage in a multiple cropping or maize/pulse farming system (Msuku *et al.*, s.d.). Relay planting, the inclusion of N-fixing legumes, and incorporation of crop residues into the soil are common soil fertility management practices (Msuku *et al.*, s.d.). Most farmers cannot afford inorganic fertilizers, consequently, only about 20% of households use fertilizers, pesticides, or improved seed (Msuku *et al.*, s.d.). While most plots are intercropped, tobacco is grown in pure stands (Msuku *et al.*, s.d.). Tobacco is an important cash crop for those who cultivate it, but it is grown by only about 22% of the population (Malawi National Statistical Office, 2005).

The busiest agricultural period is from November to April. Land preparation usually begins in June and continues through October. Planting then occurs between November and January. Maize is planted first, followed by intercropping with beans, groundnuts, and pumpkins (*Cucurbita moschata*) (Msuku *et al.*, s.d.). Green harvest begins in February, followed by groundnuts in April, the maize harvest occurs between May and June (MVAC, 2005). Weeding, a critical activity in the agricultural cycle, occurs during the months of December and January, this coincides with the time of year when many households experience food scarcity. This presents a livelihood decision dilemma; households must decide between tending to the weeding and hiring out labor for food (MVAC, 2005).

3.3.3 Wealth and Income

The average landholding size throughout the region is 0.4 ha (Msuku *et al.*, s.d.; MVAC, 2005). Households who, according to the Malawi Baseline Livelihood Profiles, are considered "poor" own between 0.4 ha and 1.0 ha, while for those deemed to be better-off, land holdings average between 1.2 ha and 2.4 ha (MVAC, 2005). In terms of livestock, poor households tend to own 4 to 6 chickens, while their better-off neighbors own more than 15 chickens, and also 8 to 15 goats (MVAC, 2005). Among the households in Machinga, 90.1% own chickens, 25.4% own goats, 4.6% own sheep, and only about 2% own cattle (Malawi National Statistical Office, 2005; Msuku *et al.*, s.d.). Even after household production and in kind payments, poor households still face a 33% food deficit. This is compounded by the poor soil fertility and a lack of adequate infrastructure, which severely hinders market access in the area (MVAC, 2005).

Despite low soil fertility and market access problems, crop sales are the most important source of income in the area. Crops such as groundnuts (*Arachis hypogaea*), sweet potatoes (*Ipomoea batats*), and soya beans (*Glycine max*) are sold mainly in the local markets (MVAC, 2005). Other major income sources include labor and firewood sale.

According to the Malawi Integrated Household Survey of 2005, Machinga District has a 73.7% poverty rate and only 36.7% of the population has an adequate food supply. The sandy soils, poor infrastructure, and high population density, make poverty relief and hunger alleviation especially challenging.

3.4 Methodology

3.4.1 Survey Methods

Two RDPs were used in the study, Kasungu in the Central Region and Machinga in the Southern Region. The sites, communities, and individual households were selected using purposive sampling strategies (Babbie & Mouton, 2001) based on information provided by ICRAF and local extension officers. Typically, the sample size (n) would be determined by Equation 3.1 and is dependant on the level of required precision, level of confidence or risk, and the degree of variability within the population. However, time constraints prevented the use of a proper sample size calculation. In total, 131 household interviews were conducted, 65 from Kasungu and 66 from Machinga.

Equation 3.1: Sample Size

$$n = \frac{N}{1 + N(e)^2}$$

Where: $n =$ sample size; $N =$ population size; $e =$ confidence interval

Interviews were carried out with the help of the local extension workers and a translator hired by ICRAF for the study. The extension workers were crucial in identifying farming households and organizing the interviews. The translator was necessary to translate the questionnaire into the local languages (Chichewa in Kasungu and Yao in Machinga).

For the purposes of this study, the unit of analysis was the household, with the main respondent being the household head. When the household head was not available, another adult member of the household was interviewed. A household was defined as "a group of people who eat from a common pot, and share common stake in perpetuating and improving their socioeconomic status from one generation to the next" (FAO, 1992). Farmers were selected with the guidance of local extension officers and on the basis of length of agroforestry use. It was requested that study participants had been adopters of SFR technologies for at least five years. This was to ensure that farmers had been using the technologies for a long enough period to realize any benefits, especially an increase in maize yield.

Prior to the interviews, the questionnaire was drafted and then pre-tested in Kasungu (farmers in the pre-test were not re-interviewed for the study). This pre-test helped identify ambiguous or extraneous questions, following the pre-test the questionnaire was amended and finalized (Babbie & Mouton, 2001).

3.4.2 Data Collection

Secondary data and participatory rural appraisal (PRA) methodologies, including household interviews, were used to capture both qualitative and quantitative data. The primary source of data collection was through the household interviews. These interviews consisted of a series of open- and closed-ended questions, as well as ranking exercises and were formed around the basis of participatory rural appraisal techniques. Participatory Rural Appraisal (PRA) is a battery of exercises and activities aimed at allowing community members to identify their own issues and be active participants in the research and data collection. According to Chambers (1994) PRA is "a family of approaches and methods to enable rural people to share, enhance, and analyze their knowledge of life and conditions, to plan and to act." Using PRA exercises, based on the work of Chambers (1997) helped illuminate trends and changes that occurred over time as a result of SFR adoption.

Based on the guidelines set out by Babbie & Mouton (2001), surveys and semi-structured interviews were conducted to gather qualitative information about household size, income sources and amounts, asset ownership, land use, crop production, and general household livelihood activities. Respondents were also asked to identify any shocks they experienced over the previous year and how they dealt with the crisis. Identifying shocks and coping strategies was important in exploring the household's level of vulnerability. If a household had been successful in moving out of poverty, it was expected that they would be better able to cope with unexpected shocks. Alternatively, if shocks occurred during a time of high vulnerability, such as a hunger period, or if households were forced to employ coping strategies that depleted any of their capital bases, it may threaten the household's security and could retard the movement out of poverty.

The surveys were divided into seven sections (Appendix 1). The first section asked questions relating to the household's land capital and use of SFR technologies. The second section related to crop production. The third section asked about shocks and coping strategies. The fourth section addressed questions about income, both amounts and sources. The fifth section of the survey looked at household assets. The sixth section captured household demographic information. The final section was a set of open-ended questions aimed at allowing the respondent to voice their opinions, questions, and concerns regarding their experiences with the agroforestry technologies and processes.

3.4.3 Ranking Exercises

Ranking exercises were used for understanding vulnerability, asset status, and income attributes. Respondents ranked crops in terms of importance for consumption and for sale; they also ranked sources of income in order of importance. Finally, participants were asked to rank their various assets, such as tools, household items, and livestock in terms of importance. Ranking assets provides an indication of what assets are instrumental in both household functioning and wealth status (DFID, 2000; Wilde, 2001). For example, a change in the number or type of tools may indicate that the household is able to be more efficient with its farming strategies, while replacing a thatched roof with a corrugated iron roof may indicate a change in social or economic status.

3.4.4 Income Activity Charts

Calendars were used to identify the various income generating activities that the households engage in over the course of a year. Farmers were asked to create charts to represent the household's current income generating activates and income activities prior to SFR adoption. Information from the charts was used to understand any changes in income due to SFR adoption, for example if the added sale of agroforestry seeds or wood had provided an additional source of income.

3.4.5 Secondary Data

Secondary data, such as public records, EPA reports, and data from ICRAF were consulted. When possible, interviews with key informants, such as the AEDC were conducted. These sources were beneficial in establishing baseline information on community history, household economics, land holding tenure, and as another source of triangulation to verify data. Using a combination of data collection methods allowed for triangulation and helped to mitigate potential problems associated with analyzing impact over time (Thassim *et al.*, 2005). Accurately capturing indicators of impact over time is difficult. Issues of inaccurate recall, true causal-effect relationships, seasonal variations, and short term adjustments versus long term adaptations add a challenge to this kind of study (Babbie & Mouton, 2001; Thassim *et al.*, 2005).

3.5 Data Analysis

Survey data was analyzed using the Microsoft Excel, Statistica 8 and SAS software packages (Microsoft, 2003; SAS Institute, 2007; StatSoft Inc., 2008). The use of different packages was necessary as there was no single software available that had all the required analytical tools. Surveys were coded as far as possible to allow for appropriate statistical analysis (Babbie & Mouton, 2001).

Data collected from PRA exercises was evaluated using descriptive and inferential analysis techniques (Babbie & Mouton, 2001). Household characteristics such as number of household members and landholding size were summarized using basic descriptive statistics. Frequency tables and descriptive statistics were used to identify and evaluate trends in: SFR use, crop production, shocks, assets, and income.

Due to the fact that much of the data was ordinal, coded, and/or ranked, non-parametric statistics were used for comparing pre- and post-adoption characteristics e.g. changes in yields, changes in income. Sign and Signed Rank Non-parametric (also called Wilcoxon Matched Pairs test) analysis was used to test for a change in the crop yield and asset variables between pre- and post-adoption (see Equation 3.2) (Clewer & Scarisbrick, 2006).

Equation 3.2: Wilcoxon Signed Rank Method: to test for a change between pre- and post-adoption ordinal variables and/or variables which are not normally distributed

H_o: Distribution Y_1 = Distribution Y_2

Where Y_1 and Y_2 are post-adoption and pre-adoption values, respectively and D_i is the difference

(i) Determine all differences: $D_i = y_{1i} - y_{2i}$

(ii) Ignore all $D_i = 0$. There are then n D_i's $\neq 0$

(iii) Rank all $|D_i|$

(iv) Let: $R_+ = \sum$ positive ranks

$R_- = \sum$ negative ranks

T = minimum (R_+, R_-)

(v) Calculate:

$$Z = \frac{\left|T - \frac{1}{4}(n)(n+1)\right| - 0.5}{\sqrt{\frac{1}{24}n(n+1)(2n+1)}}$$

Reject Ho if: $|z| > z_{\alpha/2} = 1.96$ for $\alpha = 0.05$

Because changes in income and crop yields were recorded as either "increased" or "did not increase" and the addition of a given income source was recorded as either "yes" or "no", the test for equality of proportions (see Equation 3.3) (Clewer & Scarisbrick, 2006) was used to examine the probability of an increase in income amount, number and type of income sources, and maize yields as a result of SFR adoption. This tested the null hypothesis that the proportion of respondents reporting an increase in the given variable was 0.5. Formally, $H_o : p = 0.5$

Equation 3.3: Test statistic for equality of proportions

$H_o : p = 0.5$ Where $p =$ proportion reporting an increase in the test variable

$$Z = \frac{\hat{p} - p_0}{\sqrt{p_0 q_0 / n}}$$

Where $p_0 = \frac{1}{2}$ and $q_0 = 1 - p$

Logistic regression (Equation 3.4) (Nel, 2008) was used on some "yes or no" dichotomous/categorical response variables to identify which continuous input variables caused significant changes in the odds for the response variables. Specifically, this method was used to determine if the odds that a household would sell assets (categorical response) in response to shocks increased as asset ownership (continuous input variables) increased.

Equation 3.4: Logistic Regression model

H_0: $\beta=0$

$p(x) = e^{(\alpha+ßx)}/ (1+ e^{(\alpha+ßx)})$

$p(x)/ (1-p(x)) = ODDS(x) = P(Y=1) / P(Y=0) = e^{(\alpha + ßx)}$

$\log (p(x)/ (1-p(x)) = Logit (p(x))$

$Logit(p(\underline{x})) = \alpha + ß_1x_1 + ß_2x_2 + ...+ ß_kx_k + \varepsilon$ Where β=slope and ε = error term

Chi-square analysis was used to determine if there was an influence of the addition of agroforestry related activities on both the amount and number of sources of household incomes. Among those that reported an increase in either income amount or number of sources, the test for equality of proportions (see Equation 3.3 above) was used to further examine the probability that agroforestry related activities made a significant contribution to household incomes.

Chapter 4
Results

This chapter presents the results of the investigation on the effects of integrated soil fertility management agroforestry technologies on farmer livelihood decisions. It begins with an overview of household demographics and agroforestry use. The chapter is then broken into sections dealing with the benefits and challenges of SFR use, household crop production, hunger and shocks, household assets, and income. The final two sections of this chapter address the responses to two open-ended questions. The first question dealt with changes in the activities of household members as a result of SFR adoption. The second question allowed respondents to express any final questions, concerns, issues, or affirmations about their experiences with the technologies.

4.1 Household Characteristics

The average household size was 6.5 members and the majority of households (80.9%) were headed by men. All households were subsistence farmers and diversified their livelihoods through crop sales and off-farm labor wages. The average farm size in Kasungu was 1.88 ha of which 0.28 ha was under SFR management. In Machinga, farm sizes were significantly smaller (t-value=1.75, p<0.01), averaging 0.91 ha. Consequently, area under SFR cultivation was also significantly smaller in Machinga than Kasungu (t-value=4.81, p<0.01), averaging 0.16 ha. Overall, 96.2% of respondents had completed some formal education. However, respondents in Kasungu had attended a mean 6.5 years of school while Machinga respondents averaged 3.3 years of formal schooling. Table 4.1 displays various household characteristics.

TABLE 4.1 Household mean (and SD) characteristics

	Kasungu	Machinga	P-value	Whole Sample
Household Size	6.4 (1.90)	6.5 (2.38)	0.77	6.5 (2.15)
% Male Headed Households	80	81.8		80.9
Years of Education*	6.52 (2.31)	3.29 (1.58)	<0.01	-
Farm Size (ha)*	1.88 (0.92)	0.91 (0.49)	<0.01	-
Area Under SFR (ha)*	0.28 (0.19)	0.16 (0.08)	<0.01	-

* Indicates a significant difference between the values at the two sites and results could not be pooled

4.2 Household Use of Integrated Agroforestry Technologies

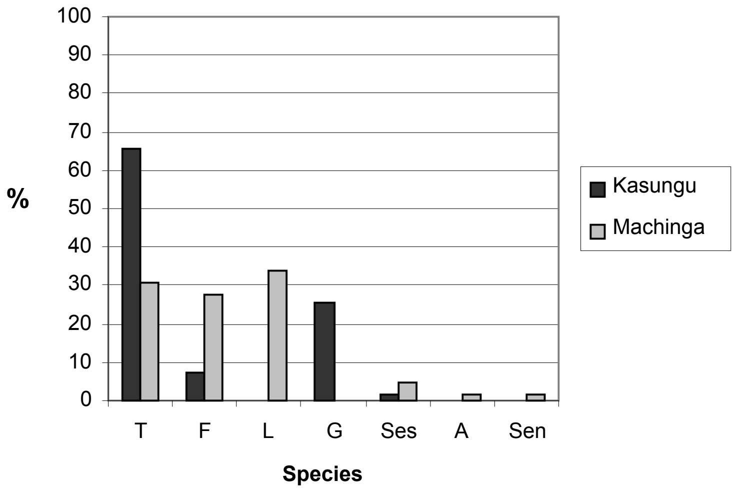
Table 4.2 shows the frequency and mean number of years used for each of the technologies, by site. In general, respondents had adopted at least one of the SFR technologies for a period of 5.3 years. There were no significant differences in years since adoption between the sites either by technology or by maximum years since adoption. The average number of years of technology use in Kasungu was 5.20 years while in Machinga it was 5.45 years. The most frequently reported technology in both districts was intercropping (86.26%), followed by relay cropping (50.38%) and biomass transfer (50.38%). Only 34.35% of the respondents reported using improved fallows.

TABLE 4.2 Percent of respondents reporting SFR technology use

	Kasungu			Machinga			Whole Sample		
Technology	%	n	Mean years (SD)	%	n	Mean years (SD)	%	n	Mean years (SD)
Intercrop	84.62	55	4.47 (1.51)	93.94	62	4.87 (1.29)	86.26	113	4.69 (1.40)
Relay crop	44.62	29	4.41 (1.15)	56.06	37	4.70 (1.54)	50.38	66	4.58 (1.38)
Improved fallow	44.62	29	4.86 (1.27)	24.24	16	4.81 (1.38)	34.35	45	4.84 (1.29)
Biomass transfer	61.54	40	5.18 (1.45)	39.39	26	4.92 (1.44)	50.38	66	5.08 (1.44)
All technologies	100	65	5.20 (1.47)	100	66	5.45 (1.35)	100	131	5.33 (1.41)

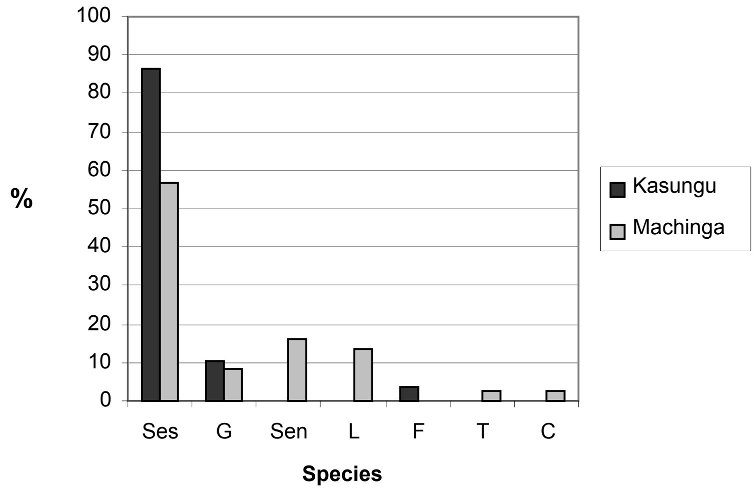
Note: %=percent of respondents reporting use; n=number of respondents reporting use; mean years=average number of years the respondent has been using the technology

In Kasungu, 65.5% of respondents cited *Tephrosia vogelii* as the preferred agroforestry species for intercropping followed by *Gliricidia sepium* (25.5%) (Figure 4.1). While originally intended for use in alley cropping, those practicing intercropping in Machinga predominantly used *Leucaena leucocephala* (33.9%), followed by *T. vogelii* (30.6%) (Figure 4.1). *Sesbania sesban* was the preferred species for relay cropping at both sites, followed by *G. sepium* in Kasungu and *Senna spp.* in Machinga (Figure 4.2). Approximately 79% of those using improved fallows in Kasungu and 69% in Machinga favored *T. vogelii* (Figure 4.3). This was followed by *G. sepium* in Kasungu (10.3%) and *L. leucocephala* (18.8%) in Machinga (Figure 4.3). *Sesbania* and *Gliricidia sepium* were the two most commonly grown species for biomass transfer systems at both sites (Figure 4.4). However, in Kasungu 72.5% of those using biomass transfer reported using *Sesbania* followed by *Gliricidia* (27.5%) while in Machinga *Gliricidia* was the preferred species (76.9%) followed by *Sesbania* (11.5%) and *Senna* (11.5%) (Figure 4.4).



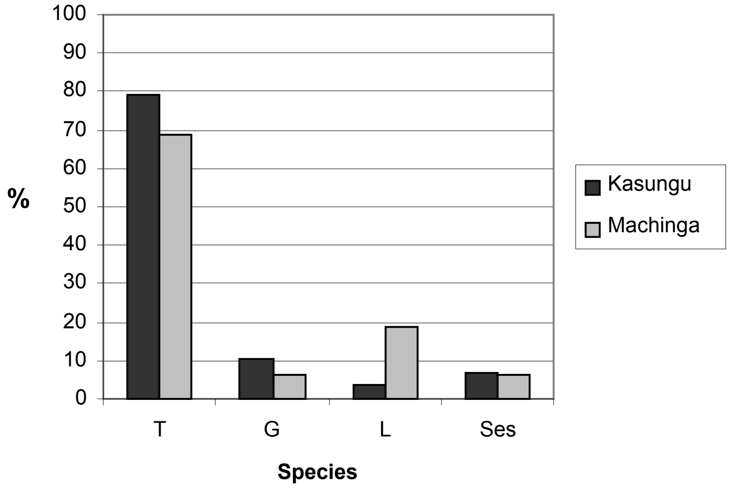
T= *Tephrosia vogelii*; F=*Faidherbia albida*; L= *Leucaena leucocephala*; G= *Gliricidia sepium;* Ses= *Sesbania sesban;* A= other *Acacia spp.;* Sen= *Senna spectabilis*

FIGURE 4.1 Percent of respondents using various species in intercropping in Kasungu and Machinga



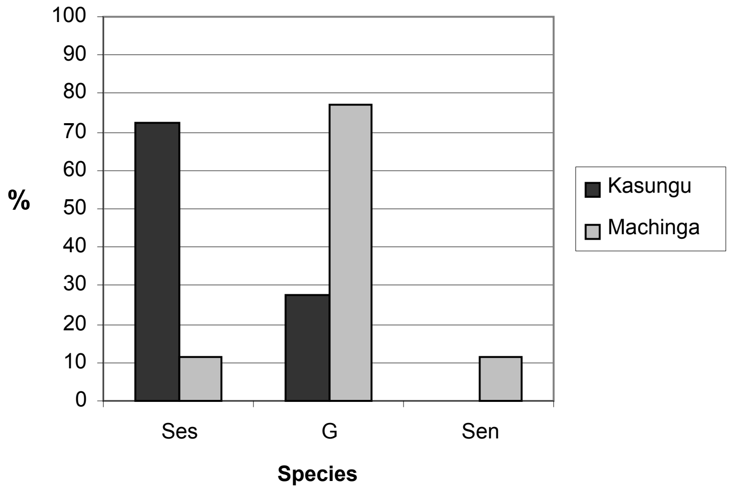
Ses= *Sesbania sesban;* G= *Gliricidia sepium;* Sen= *Senna spectabilis;* L= *Leucaena leucocephala;* F=*Faidherbia alba;* T= *Tephrosia vogelii;* C= *Calliandra calothyrsus*

FIGURE 4.2 Percent of respondents using various species in relay cropping in Kasungu and Machinga



T= *Tephrosia vogelii;* G= *Gliricidia sepium;* L= *Leucaena leucocephala;* Ses= *Sesbania sesban*

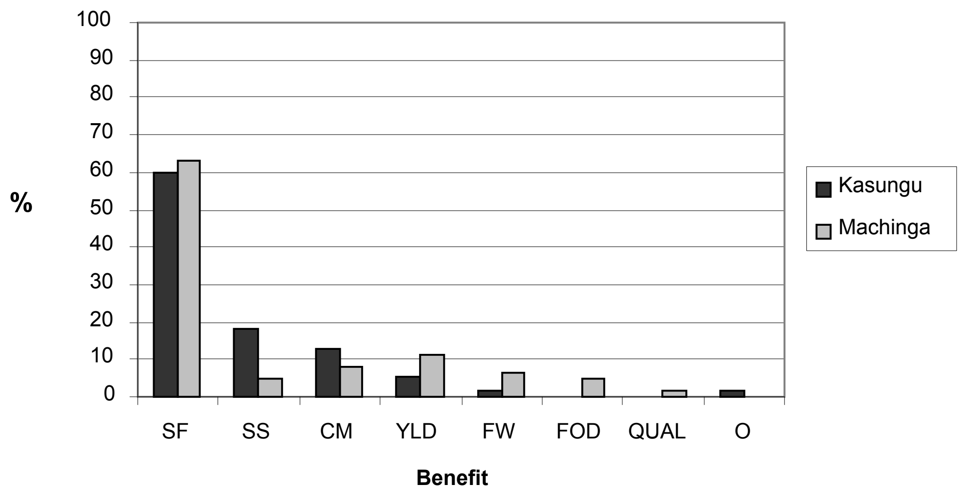
FIGURE 4.3 Percent of respondents using various species in improved fallows in Kasungu and Machinga



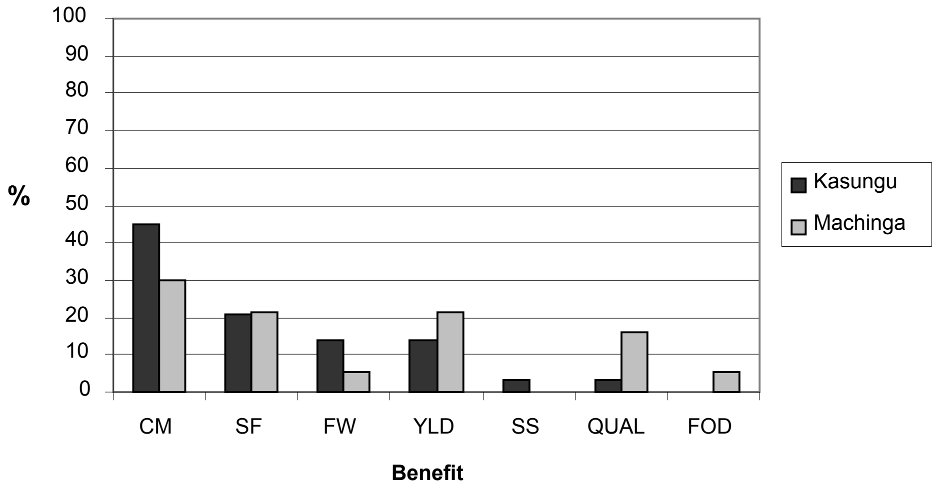
Ses= *Sesbania sesban;* G= *Gliricidia sepium;* Sen= *Senna spectabilis*
FIGURE 4.4 Percent of respondents using various species in biomass transfer in Kasungu and Machinga

4.3 Benefits and Challenges of SFR Technologies

Farmers were asked to identify the greatest benefit they derived from each technology used (Figures 4.5-4.8). Of those practicing intercropping, improved soil fertility was the main benefit identified at both sites (Figure 4.5). Both Kasungu (44.8%) and Machinga (29.7%) residents who used relay cropping identified construction materials as the most important benefit (Figure 4.6). For Kasungu adopters of improved fallows, 27.6% and 24.1% identified seed production and increased yields as the greatest benefits, respectively (Figure 4.7). While in Machinga, increased yields was the most commonly reported benefit (31.3%) followed by improved soil fertility and fodder production, both with 18.8% (Figure 4.7). In Kasungu, 57.7% of those using biomass transfer reported that wood for construction materials was the greatest benefit (Figure 4.8). In Machinga, construction materials and improved soil fertility were both reported by 30.8% to be the greatest benefit to biomass transfer (Figure 4.8).

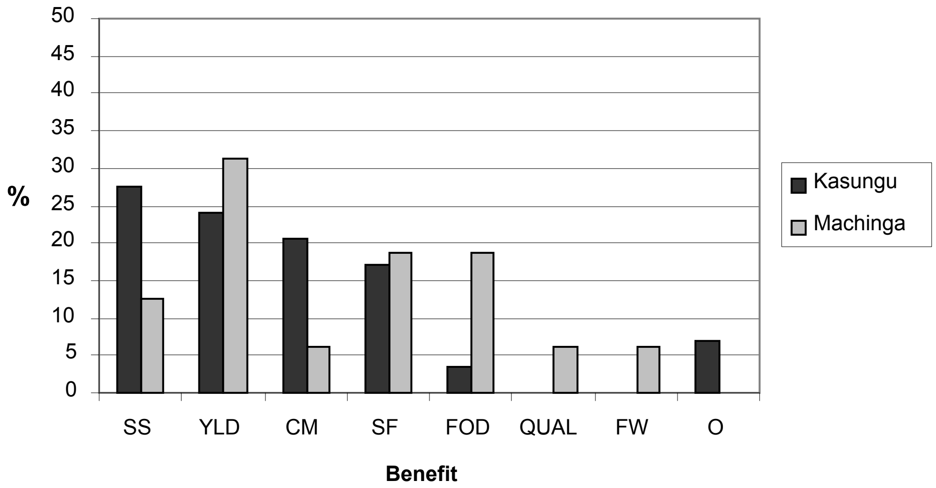


SF=Improved soil fertility, SS=Production of saleable seed, CM=Production of construction materials, YLD=Improved crop yield, FW=Fuelwood, FOD=Fodder, QUAL=Improved crop quality, O=Other
FIGURE 4.5 Percent of respondents who identified various benefits to intercropping in Kasungu and Machinga



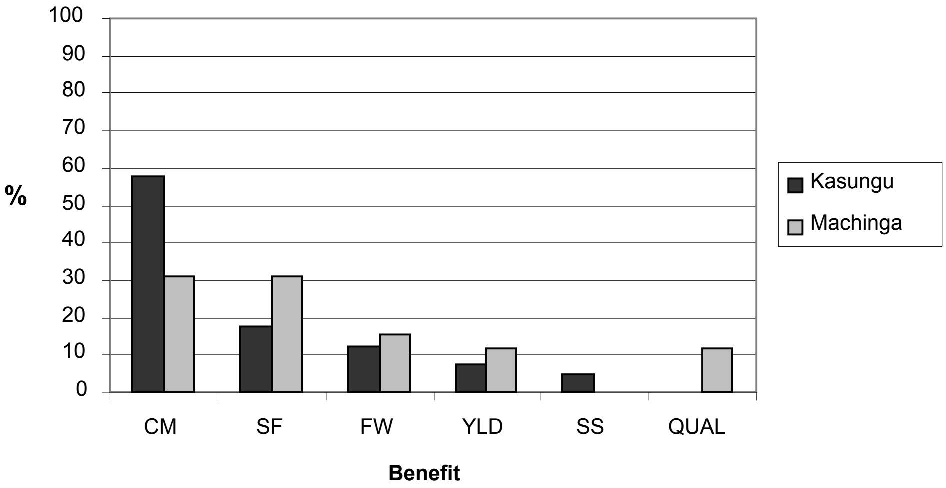
CM=Construction materials, SF=Improved soil fertility, FW=Fuelwood, YLD=Improved crop yield, SS=Production of saleable seed, QUAL=Improved crop quality, FOD=Fodder

FIGURE 4.6 Percent of respondents who identified various benefits to relay cropping in Kasungu and Machinga



SS=Production of saleable seed, YLD=Improved crop yield, CM=Construction materials, SF=Improved soil fertility, FOD=Fodder, QUAL=Improved crop quality, FW=Fuelwood, O=Other

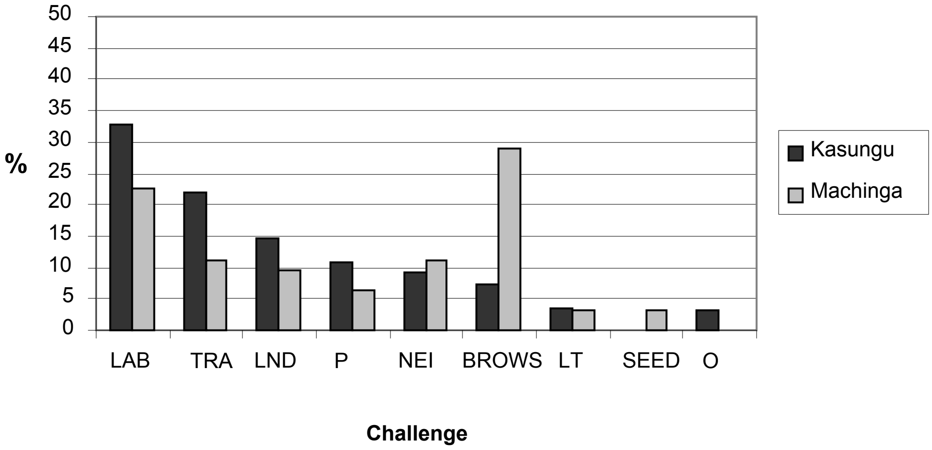
FIGURE 4.7 Percent of respondents who identified various benefits to improved fallows in Kasungu and Machinga



CM=Construction material, SF=Improved soil fertility, FW=Fuelwood, YLD=Improved crop yield, SS=Production of saleable seed, QUAL=Improved crop quality

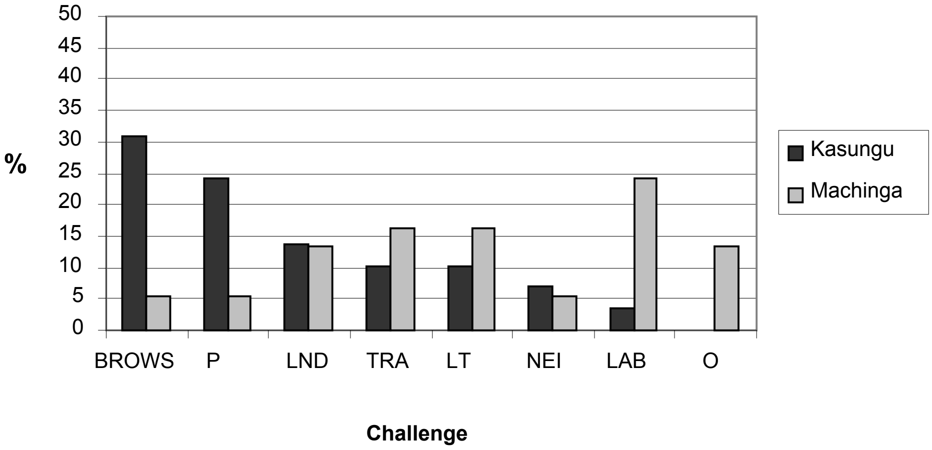
FIGURE 4.8 Percent of respondents who identified various benefits to biomass transfer in Kasungu and Machinga

Respondents were also asked to identify the greatest challenge presented by each technology (Figures 4.9-4.12). In Kasungu, labor requirements were the most frequently identified challenge to intercropping (32.7%) followed by a lack of training (21.8%) (Figure 4.9). Browsing was identified as the biggest challenge to intercropping by 29% of those using the technology in Machinga, followed by labor requirement (22.6%) (Figure 4.9). Browsing and pests were the most commonly identified challenges for relay cropping in Kasungu, with 31% and 24% of users identifying these challenges, respectively (Figure 4.10). In Machinga, labor demands (24.3%), followed by a lack of training and the lag time between technology implementation and the resulting effects on crops (16.2%) were the challenges most commonly associated with relay cropping (Figure 4.10). At both sites, lag time, followed by jealousy from neighbors were the two most noted challenges to improved fallows (Figure 4.11). Similarly, lag time and lack of training were the most commonly identified challenges to biomass transfer at both sites (Figure 4.12).



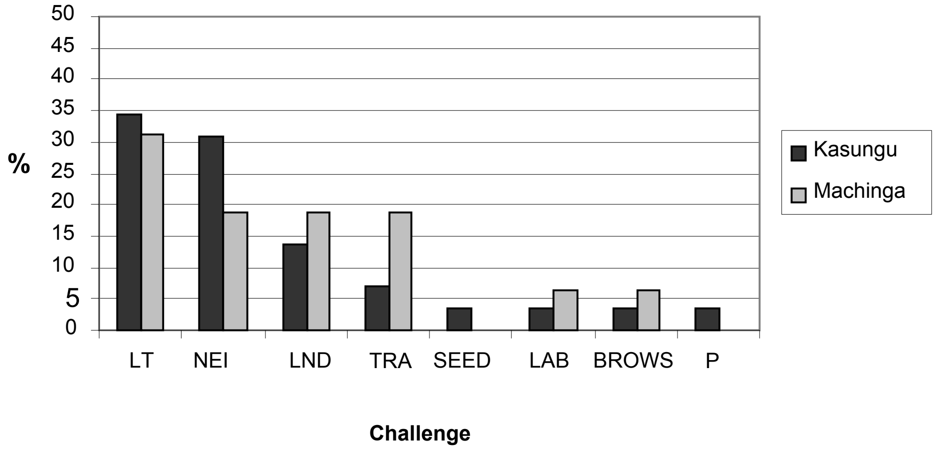
LAB=Labor requirements, TRA=Lack of training, LND=Land size requirements, P=Pests, NEI=Neighbor jealousy, BROWS=Livestock browsing, LT=Lag time, SEED=Lack of adequate access to seeds, O=Other

FIGURE 4.9 Percent of respondents who identified various challenges to intercropping in Kasungu and Machinga



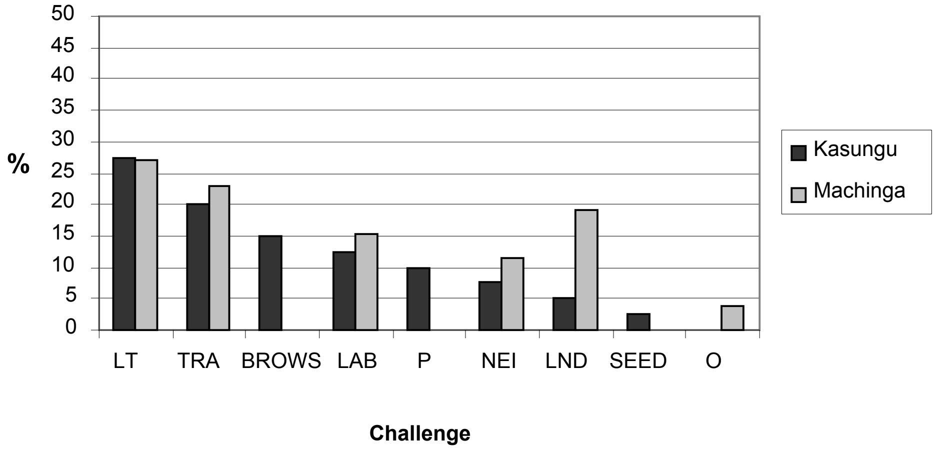
Brows=Livestock browsing, P=Pests, LND=Land size requirements, TRA=Lack of training, LT=Lag time, NEI=Neighbor jealousy, LAB=Labor requirements, O=Other

FIGURE 4.10 Percent of respondents who identified various challenges to relay cropping in Kasungu and Machinga



LT=Lag time, NEI=Jealous neighbors, LND=Land size requirements, TRA=Lack of training, SEED=Inadequate access to seeds, LAB=Labor requirements, BROWS=Livestock browsing, P=Pests

FIGURE 4.11 Percent of respondents who identified various challenges to improved fallows in Kasungu and Machinga



LT=Lag time, TRA=Lack of training, BROWS=Livestock browsing, LAB=Labor requirements, P=Pests, NEI=Jealous neighbors, LND=Land size requirements, SEED=Inadequate access to seeds, O=Other

FIGURE 4.12 Percent of respondents who identified various challenges to biomass transfer in Kasungu and Machinga

All of the respondents from Kasungu (100%), and the majority of respondents from Machinga (87.9%), said that they would continue using the SFR technologies. Eight respondents (6%) from Machinga said they were going to abandon the technologies for reasons associated with labor and land requirements as well as pest problems. While four of these households had been using the technologies for 4 years or less and may not have seen any benefits, the other four households had been adopters for 5 or more years.

4.4 Changes in Crop Production

The results showed that maize was cultivated by 100% of the respondents; furthermore, all respondents were growing maize under one or more SFR technologies. Just over 23% of respondents from Kasungu and 3% of respondents from Machinga said that they had been able to diversify their crop production (growing crops that they were unable to cultivate prior to adoption). Cassava and vegetables were the only other crops, aside from maize, reported to be cultivated under SFR technologies. Three percent of Machinga respondents who had been able to diversify their crop production had added vegetables. Among those who had diversified their crops in Kasungu, 53.3% had added vegetables, 26.7% added cassava, 13.3% added millet, and 6.7% added tobacco. Out of 121 respondents who grew cassava, 17.4% cultivate the cassava using SFR technology. Of those who cultivated vegetables, 62.1% grew them with the use of SFR technologies. The percentage of respondents who cultivated various crops is shown in Table 4.3.

TABLE 4.3 Percent (%) and number of respondents cultivating various crops in Kasungu and Machinga districts

Crop	Kasungu (n=65)	Machinga (n=66)	Whole Sample (n=131)
Maize	100 (65)	100 (66)	100
Groundnuts	95.4 (62)	98.5 (65)	97
Rice*	4.6 (3)	89.4 (59)	-
Pulses*	32.3 (21)	78.8 (52)	-
Cotton*	18.5 (12)	3 (2)	-
Potatoes*	90.7 (59)	68.2 (45)	-
Cassava	93.8 (61)	90.9 (60)	92.4
Tobacco	43.1 (28)	50 (33)	46.6
Sorghum*	1.5 (1)	62.1 (41)	
Millett*	20 (13)	4.5 (3)	-
Vegetables*	61.5 (40)	27.3 (18)	-

* indicates that the difference between means at the two sites is significant at Fisher's Exact p<0.05 and pooled means could not be calculated

Overall, 65% of the respondents reported an increase in maize yields since the adoption of SFR. Twenty-eight percent of respondents reported no change in maize yields and 6.8% said they had suffered a decline in yields. Machinga represented 78% of those who reported either no change in yield or a decrease in yield. Of those who reported an increase in maize, farmers in Kasungu reported an average whole harvest yield increase of 381.5 kg, while Machinga farmers reported an average increase of 241.7 kg (Table 4.4). Considering that the average household requires 1099 kg of maize per year, 381.5 kg and 241.7 kg represent approximately 34.7% and 22% of the annual household maize requirements, respectively. Only one respondent in Machinga reported an increase in cassava yields. In Kasungu, of those who reported an increase, the average whole harvest increase in cassava yields was 188.2 kg (Table 4.4). There was no significant difference in vegetable increases between the two sites. Overall the average seasonal increase in vegetable yield was 29.36 kg (Table 4.4). Non-parametric sign and signed rank analysis found that all increases in yields were significant (p<0.05).

TABLE 4.4 Mean increases (kg) (and SD) of crops in Kasungu and Machinga districts

Crop	Kasungu	Machinga
Maize*	381.5 (192.4)	241.7 (126)
Cassava*	188.2 (92.75)	50
Vegetables	34.1 (28.60)	17.1 (6.98)

* Indicates that differences between sites are significant at p<0.05

In Kasungu, maize (100%), cassava (93.8%), and potatoes (89.2%) were the three crops most frequently cultivated for consumption. In Machinga, maize, (100%), cassava (87.8%), and rice (84.8%)

were the three most common crops for consumption. Maize was ranked as the most important crop for consumption at both sites. This was followed by cassava, potatoes, and groundnuts in Kasungu and rice, cassava, and sorghum in Machinga (Table 4.5).

TABLE 4.5 Percent (%) of respondents cultivating, mean rank, and standard deviation (SD) of consumption crops for Kasungu and Machinga districts

Crop	Kasungu		Machinga	
	%	Mean Rank (SD)	%	Mean Rank (SD)
Maize	100	1.00 (0)	100	1.02 (0.12)
Cassava	93.8	2.25 (0.65)	87.9	3.29 (1.21)
Rice	4.6	3.00 (1.00)	84.8	3.05 (1.07)
Sorghum	1.5	6.0#	59.1	3.38 (1.74)
Groundnuts	73.8	3.67 (1.12)	57.6	3.66 (1.30)
Potatoes	89.2	3.66 (1.18)	59.1	4.92 (1.09)
Vegetables	61.5	4.20 (0.85)	27.3	4.27 (1.27)
Pulses	29.2	4.23 (1.09)	63.6	4.76 (1.19)
Millett	2.0	4.69 (0.95)	4.5	7.00 (1.00)

Rank of 1 is considered the most valued crop
#Only 1 respondent cultivated this crop for consumption

Groundnuts were the most commonly cultivated cash crop in both districts. This was followed by cassava and potatoes in Kasungu and rice and tobacco in Machinga (Table 4.6). When the cash crops were ranked, tobacco was shown to be the most important income generating crop in Kasungu, followed by groundnuts. The reverse was true in Machinga, where groundnuts were the most important cash crop followed by tobacco. Maize had the third most important rank in Machinga, but only 3% of respondents reported selling maize (Table 4.6).

TABLE 4.6 Percent (%) of respondents cultivating, and mean ranking of, cash crops in Kasungu and Machinga districts

Crop	Kasungu		Machinga	
	%	Mean Rank (SD)	%	Mean Rank (SD)
Groundnuts	86.2	2.11 (1.22)	92.4	1.54 (0.79)
Cassava	64.6	2.95 (1.46)	30.3	3.05 (1.05)
Potato	56.9	3.59 (1.36)	25.8	3.47 (0.94)
Maize	52.3	2.76 (1.07)	3.0	2.0 (0)
Vegetables	46.2	3.07 (1.55)	7.6	2.2 (1.3)
Tobacco	43.1	1.50 (0.88)	50.1	1.82 (1.07)
Cotton	18.5	2.25 (1.48)	3.0	5.0 (0)
Pulses	15.4	3.90 (1.10)	45.5	3.13 (1.67)
Millett	4.6	3.33 (2.52)	0	-
Rice	0	-	65.2	2.60 (1.00)
Sorghum	0	-	10.6	3.57 (1.13)

A rank of 1 is considered the most important

4.5 Changes in Hunger Periods and Ability to Cope with Shocks

Hunger was, overall, the most frequently reported shock. However, there were significant differences ($p < 0.05$) between the sites. In Kasungu, 47.6% of respondents had experienced a hunger period over the previous year, as opposed to 86.4% in Machinga. Generally though, all respondents (100%) reported some form of hunger periods both prior to and since the adoption of SFR. While hunger was still present in all of the households interviewed, there was a significant decrease in the average length of annual hunger periods since SFR adoption. The average number of hunger months prior to SFR adoption for the two sites was 3.88 months. Post-adoption hunger months significantly dropped (z=5.51, p<0.05) to an average of 3.28 months (Figure 4.13). The trend was the same when hunger months were analyzed by district. Hunger months dropped from 3.46 to 2.80 (z=4.19, p<0.05) in Kasungu and from 4.31 to 3.75 (z=3.60, p<0.05) in Machinga.

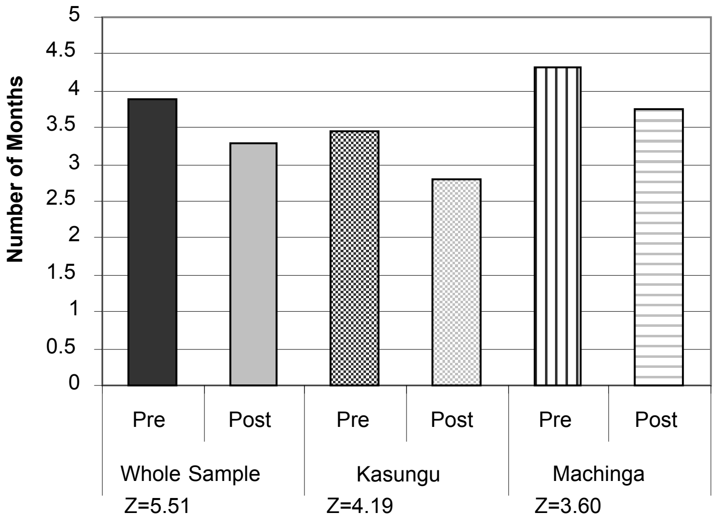


FIGURE 4.13 Average number of hunger months before (Pre) and after (Post) SFR adoption. All differences are significant at p<0.05

Table 4.7 shows the percent of "yes" responses to various shocks for each district. Almost 91% of Kasungu respondents had suffered crop loss over the previous year. This is in stark contrast to the 33% of Machinga respondents who reported crop loss (p<0.05). There was also a significant difference in the number of respondents reporting theft (p<0.05). In Kasungu 43.08% of respondents had been victims of theft, while in Machinga 15.2% had been victimized. There was also a significant difference in repots of labor shortages (p<0.05). In Kasungu 55.4% of respondents reported experiencing a shortage in labor, while 19.7% of Machinga respondents dealt with this problem. Differences in reports of job loss (p=0.03) and structure loss (p=0.006) were also significant between the sites. While there were no reports of either job or structure loss in Machinga, 7.7% of Kasungu respondents reported a job loss and 10.8% reported losing a structure. There were no significant differences in reports of either illness or death between the two sites. Almost 62% of Kasungu respondents and 53% of Machinga respondents had dealt with an illness in the household. There were no reports of a death in Machinga, and only 4.6% of Kasungu respondents had suffered a death in the household.

TABLE 4.7 Percent of respondents reporting various shocks

Shock	Kasungu	Machinga	Whole Sample
Hunger*	47.6	86.4	-
Crop Loss*	90.7	33.3	-
Illness	61.5	53.0	57.25
Death	4.6	0	2.29
Theft*	43.1	15.2	-
Structure Loss*	10.8	0	-
Labor Shortage*	55.4	19.7	-
Job Loss*	7.7	0	-

* Indicates a significant difference (Fisher's exact p-value<0.05) between the sites and means could not be pooled

Selling physical assets was the most common coping strategy for all shocks. Logistic regression, which tests the effects of continuous input variables on categorical response variable, was used to determine if the odds that a household would sell assets (categorical response) in response to shocks increased as asset ownership (continuous input variables) increased. The results of the logistic regression showed no significant correlation between the amount of assets a household owned and the probability that the household would sell assets as a response to shocks (Table 4.8). Respondents were just as likely to sell assets regardless of their asset status.

TABLE 4.8 Results of logistic regression showing the significance between asset ownership and the probability of selling assets in response to shocks

Individual Units	Shock	p-value	Odds Ratio	Wald's χ^2
	Hunger	0.52	1.07	0.41
	Illness	0.95	0.99	0.003
	Theft	0.42	1.02	0.64
	Labor Shortage	0.61	1.02	0.26
	Crop Loss	0.68	1.01	0.17
Total Type				
	Hunger	0.29	1.78	1.11
	Illness	0.55	1.22	0.36
	Theft	0.55	0.87	0.36
	Labor Shortage	0.86	1.05	0.03
	Crop Loss	0.08	1.28	3.03

Individual Units: the total number of individual assets owned, e.g. total number of chickens, bicycles, and bed mats
Total Type: the variety of assets owned

There were differences between sites when dealing with hunger and crop loss. In Kasungu, selling assets was a more significant coping strategy to crop loss than in Machinga ($p<0.05$) (Table 4.10), the trend was similar in dealing with hunger ($p=0.04$) (Table 4.9). Following selling assets, migration was the next most commonly identified coping mechanism for hunger in Machinga (55%) while no one in Kasungu reported migration as a hunger coping strategy (Table 4.9).

TABLE 4.9 Percent (%) of respondents employing various coping strategies in response to hunger

	Kasungu	Machinga
Selling Assets	90.3	100
Selling Labor	90.3	52.6
Migration	0	54.7
Selling Crops	19	1.9

All differences between sites are significant at Fisher's exact $p<0.05$

TABLE 4.10 Percent (%) of respondents employing various coping strategies in response to crop loss

	Kasungu	Machinga	Whole Sample
Selling Assets*	70.7	36.4	-
Migration	0	4.5	1.2

* Indicates a significant difference (Fisher's exact p-value<0.05) between the sites and means could not be pooled

When faced with illness (Table 4.11), selling physical assets was again the most important coping strategy at both sites (96%). Selling crops was another important coping strategy in Kasungu, with 79.5% of those who had dealt with illness employing this strategy. Twenty percent of respondents who had suffered illness in the household in Machinga sold crops in response to the shock.

TABLE 4.11 Percent (%) of respondents employing various coping strategies in response to illness

	Kasungu	Machinga	Whole Sample
Selling Assets	97.3	100	96
Selling Labor	2.6	0	1.4
Selling Crops*	79.5	20.0	-
Migration	2.6	2.9	2.7

* Indicates a significant difference (Fisher's exact p-value<0.05) between the sites and means could not be pooled

There were no significant differences between sites in relation to coping with theft. When recovering from theft, 78.9% chose to sell physical assets, 63.2% hired out labor, and 50% sold crops, 5.3% of theft victims were forced to migrate (Table 4.12). Labor shortages were dealt with through the sale of assets in both Kasungu and Machinga (Table 4.13). Crop sales were also an important coping strategy in Kasungu.

TABLE 4.12 Percent (%) of respondents employing various coping strategies in response to theft

	Kasungu	Machinga	Whole Sample
Selling Assets	78.6	80.0	78.9
Selling Labor	67.9	50.0	63.2
Selling Crops	46.4	60.0	50
Migration	0	20.0	5.3

TABLE 4.13 Percent (%) of respondents employing various coping strategies in response to labor shortages

	Kasungu	Machinga	Whole Sample
Selling Assets	88.6	100	91.7
Selling Crops*	77.1	3.8	-

* Indicates a significant difference (Fisher's exact p-value<0.05) between the sites and means could not be pooled

4.6 Changes in Assets

All of the respondents reported owning at least one bed mat. Chickens, radios, and bicycles were the next most commonly owned assets with 57%, 50%, and 50% of respondents owning at least one unit, respectively (Table 4.14). The only significant differences in asset ownership between the two sites were radios and bank accounts. A significantly higher percentage of Kasungu residents reported having at least one radio (p=0.01) and/or one bank account (p<0.05) than Machinga residents (Table 4.14). There were no respondents who reported owning a motor bike, plow, or ox-cart.

TABLE 4.14 Percent of respondents reporting asset ownership

Asset	Kasungu (n=65)	Machinga (n=66)	Total (n=131)
Iron Roof	9.2	6.1	7.6
Radio*	61.5	39.4	-
Bicycle	46.2	53	49.6
Bank Account*	18.5	0	-
Bed Mats	100	100	100
Goats	27.7	28.8	28.2
Chickens	64.6	48.5	56.5
Cattle	1.5	0	0.7
Other	32.3	7.6	19.8

* Indicates a significant difference (Fisher's exact p-value<0.05) between the sites and means could not be pooled

The Wilcoxon non-parametric matched pairs tests showed that there was, overall, a significant increase in assets ($p<0.05$) between pre- and post-adoption in both the number of individual units (e.g. purchasing additional chickens) and in the type/diversity (e.g. purchasing a first bicycle). There was also a significant increase in the number of radios, bicycles, bed mats, goats, and chickens in Kasungu and a significant increase in the number of radios, bed mats, goats, and chickens in Machinga from pre- to post-adoption ($p<0.05$) (Figure 4.14).

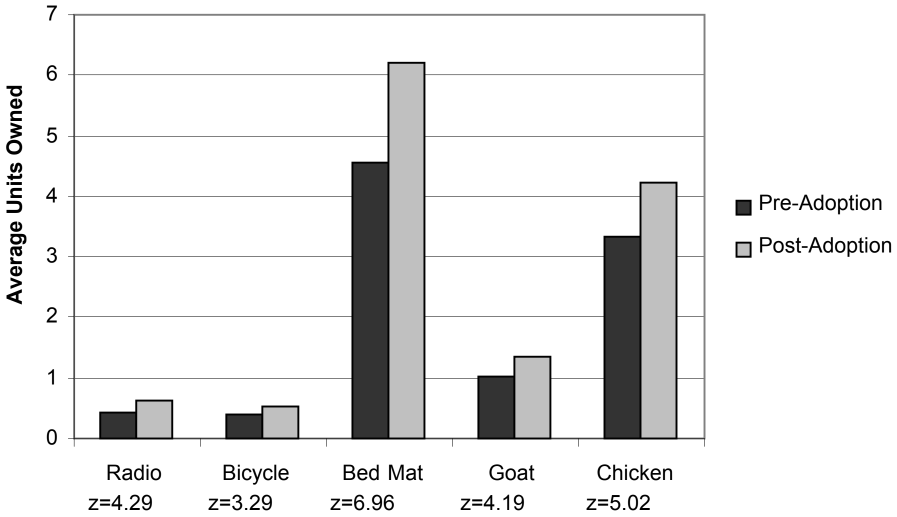


FIGURE 4.14 Average number of units owned
All Changes are significant at p<0.05

Respondents ranked their assets in order of how important or valuable each asset was, with a rank of 1 being the most important asset the household owned. At both sites, those who owned an iron roof ranked it as being very important with an average ranking of 1.17 at Kasungu and 1.00 at Machinga (Table 4.15). Bed mats, bicycles, and radios were the next most valued assets at both sites (Table 4.15). Respondents also tended to purchase more bed mats over other assets. For assets purchased after SFR adoption, the majority of respondents (85% to 100%, depending on the asset) said that they attributed the benefits of SFR to their ability to purchase additional assets.

TABLE 4.15 Average household ranking (and standard deviation) of assets

Asset	Kasungu	Machinga
Iron Roof	1.17 (0.41)	1.00 (0.00)
Bed Mat	2.12 (1.48)	1.49 (1.03)
Bicycle	2.80 (1.58)	2.57 (1.09)
Radio	2.93 (1.54)	2.31 (0.79)
Goat	2.94 (1.66)	2.89 (1.19)
Cattle[#]	3.00	
Chicken	3.07 (1.61)	2.66 (1.26)
Bank Account	3.67 (1.77)	

[#] Only one household owned cattle

4.7 Changes in Income Sources and Amounts

Seasonal calendars of income generating activities (IGA) (Figures 4.15 -4.17) showed that, overall, crop sales are a substantial source of income between the months of May and September (Figure 4.15) with as many as 93% of all households engaging in crop sales during the month of August. From

October through March, household income is heavily dependant on off-farm labor wages and for some households, income is also supplemented by the sale of wood and tobacco (Figure 4.15). Between November and February, an average 66% of households engage in off-farm labor. Wood sale occurs mainly between June and December (Figure 4.15). The tobacco season runs from February through August (Figure 4.15).

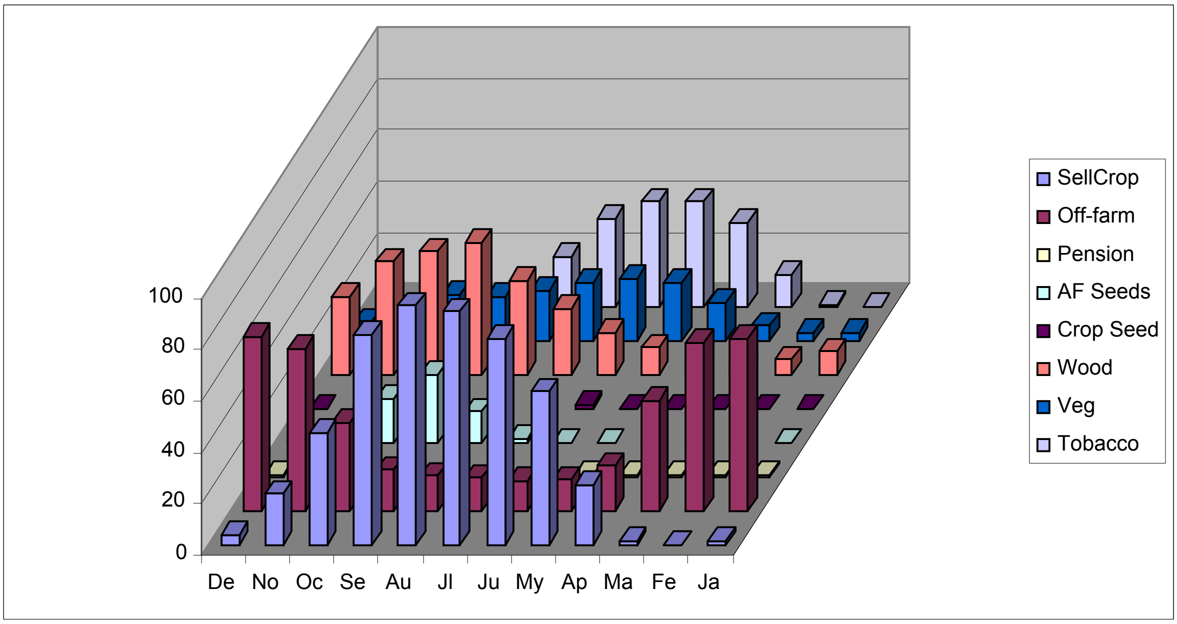


FIGURE 4.15 Income sources by month for the whole sample

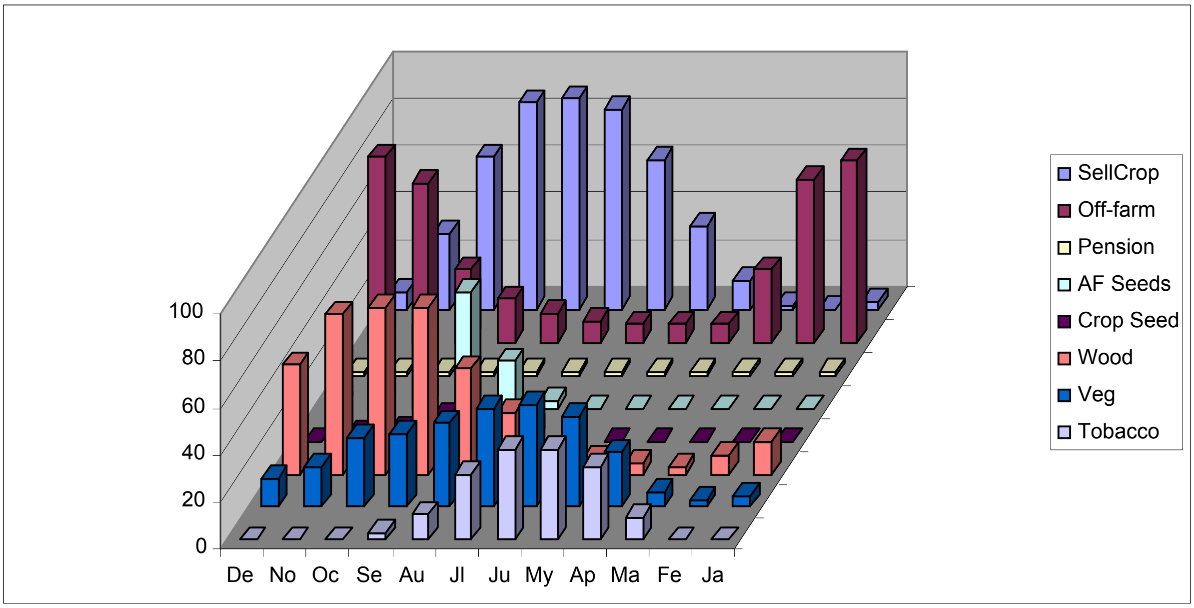


FIGURE 4.16 Income sources by month for Kasungu

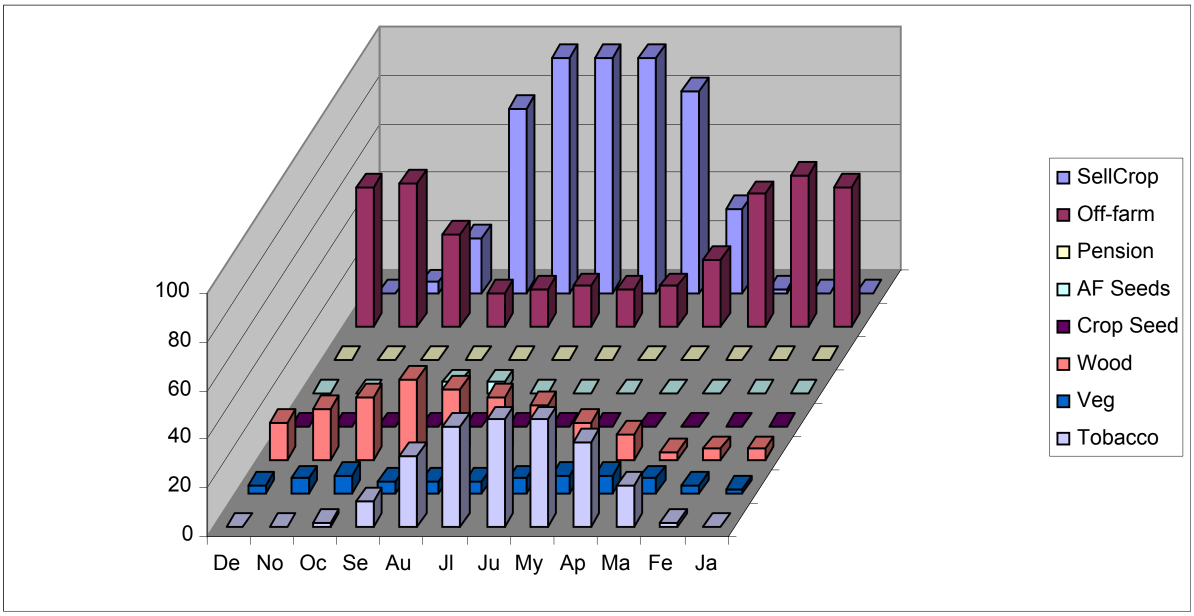


FIGURE 4.17 Income sources by month for Machinga

A Student's t-test revealed that households from Kasungu showed a significantly more diverse income portfolio than those from Machinga (p<0.01). The average number of income generating activities for any given month in Kasungu was 7.83 (±1.03) while in Machinga the average number of activities for a given months was 4.67 (±0.98).

Overall, crop sales (non-vegetables) were the most frequently reported (92.4%) and highly valued source of income. This was followed by off-farm wages (81%) and the selling of fuel and/or construction wood (52.6%), agroforestry seeds (42.7%), tobacco (42%), vegetables (29.7%) and maize (27.5%). Respondents did not identify the sale of crop seeds and pension as highly rated sources of income. Table 4.16 shows the percentage of respondents reporting each source of income, followed by the average rank of that income generating activity.

TABLE 4.16 Percent of respondents reporting and average ranking of various income sources

	Machinga (n=66)		Kasungu (n=65)		Whole Sample (n=131)	
Income Source	%	Average Rank (SD)	%	Average Rank (SD)	%	Average Rank (SD)
Sell Crops	95.5	1.51 (0.76)	89.2	2.60 (1.38)	92.4	2.03 (1.22)
Off-farm wages	71.2	1.87 (0.85)	90.7	2.56 (1.59)	81	2.25 (1.35)
Sell Wood	33.3	2.77 (0.61)	72.3	3.43 (1.49)	52.6	3.22 (1.32)
Sell AF seeds	6.1	2.75 (0.50)	80.0	3.48 (1.49)	42.7	3.43 (1.45)
Tobacco	44.0	2.10 (1.01)	40.0	3.08 (2.12)	42	2.56 (1.69)
Sell Vegetables	12.1	3.13 (1.25)	47.7	3.58 (1.43)	29.7	3.49 (1.39)
Sell Maize	3	2.50 (0.71)	52.3	2.94 (1.32)	27.5	2.92 (1.29)
Sell crop seeds	0		10.7	5.00 (1.83)	5.3	5.00 (1.83)
Other	0		3.1	2.00 (0.00)	1.5	2.00 (0.00)
Pension#	0		1.5	2.00	0.76	2.00
Sell Other#	0		1.5	6.00	0.76	6.00

Rank of 1 indicates most important source of income
#Indicates only one household reported this sources of income

Respondents were asked about changes in both the number of household income generating activities and amount of income generated since adoption. Fifty-one percent of respondents reported an increase in the number of income sources, 47.3% said the number of sources had remained the same, and 1.5% reported a decrease in income generating activities. Overall, there was no significant increase in the number of income sources from pre- to post-adoption. When analyzed by district however, 86.2% of Kasungu respondents reported an increase and the test for equality of proportions showed that the probability of residents in Kasungu reporting an increase in the number of income sources following SFR adoption was significantly higher than the probability of reporting no increase ($p<0.05$). The number of income sources reported by residents in Machinga did not increase significantly. Only 16.7% of respondents in Machinga reported an increase in the number of income sources, the equality of proportions test confirmed that the probability of Machinga respondents reporting an increase in the number of income sources following SFR adoption was not significantly different from 0.5.

There was a similar trend when changes in amount of income were analyzed. The equality of proportions test showed that overall, the probability that a household would report an increase in income amount since SFR adoption was significantly greater than 50% ($p=0.028$), but when reported by district, only households from Kasungu showed a significant increase ($p<0.05$) in the amount of income. In Machinga there was no significant probability of either an increase or decrease in income amounts ($p=1.54$). Results from the test for equality of proportions are shown in Tables 4.17 and 4.18.

TABLE 4.17 Test for equality of proportions showing changes in number of income sources from pre- to post-adoption.

	% Reporting (n=65) Kasungu	% Reporting (n=66) Machinga	% Reporting (n=131) Whole Sample
Increase	86.2	16.7	51.1
Stayed the same	12.3	81.8	47.3
Decreased	1.5	1.5	1.5
$\hat{p}_i$	0.862	0.167	0.51
p-value	**<0.01**	2.0	0.793

Tests the hypothesis that the probability that a household would report an increase was the same as the probability that the household would report no increase. Ho:$P_{increase}$=0.5; H1:$P_{increase}$≠0.5

TABLE 4.18 Test for equality of proportions showing changes in income amount from pre- to post-adoption

	% Reporting (n=65) Kasungu	% Reporting (n=66) Machinga	% Reporting (n=131) Whole Sample
Increase	73.8	45.5	59.5
Stayed the same	23.1	53.0	38.2
Decreased	3.1	1.5	2.3
$\hat{p}_i$	0.738	0.455	0.595
p-value	**<0.01**	1.539	0.029

Tests the hypothesis that the probability that a household would report an increase was the same as the probability that the household would report no increase. Ho:$P_{increase}$=0.5; H1:$P_{increase}$≠0.5

In trying to identify the influence of SFR adoption on income, chi-square and equality of proportions analysis was carried out to see if agroforestry related activities, such as selling crops, agroforestry seeds/seedlings, and either fuel or construction wood, corresponded to changes in income. The analysis showed that for those who reported an increase in income amount there was no significant probability that this increase would be the result of any *single* agroforestry related activity. However, when the various agroforestry related income sources were combined (i.e. considering crop, seed/seedling, and wood sale together), it was found that all households who reported an increase in income amount attributed this to one or more of these agroforestry related activities. The results were similar when analyzing changes in the number of income sources. When agroforestry income activities were analyzed individually, among those reporting an increase in the number of sources of income, agroforestry seed/seedling sale was the only *single* activity found to make a significant contribution. However, when wood, crop and seed/seedling sale were combined, it was found that these activities were responsible for 100% of the reported increases in the number of income sources.

If respondents indicated an increase in income amount since SFR adoption, they were then asked to identify how they allocated the additional income (Table 4.19). Most respondents (95%) allocated additional income to paying debts and all respondents (100%) used income to purchase household items. Food and agricultural supplies were also important investments with 99% and 98% of respondents using money to purchase these items, respectively. These were followed by paying medical fees, school fees, and finally putting the income into savings. The only significant difference in income allocation between the two sites was in paying school fees (p=0.038). In Kasungu, 35.4% of those reporting an increase in income used some of the additional income to pay school fees, while in Machinga 13.3% allocated additional income to paying school fees.

TABLE 4.19 Percent of respondents reporting various allocations of additional income
Values are the percent of "yes" responses from those who reported an increase in income.

Allocation	Kasungu (n=48)	Machinga (n=30)	Whole Sample (n=78)
Savings	16.7	6.7	12.8
Pay Debts	93.8	96.7	94.8
Purchase Household Items	100	100	100
Purchase Food	97.9	100	98.7
Purchase Agricultural Supplies	97.9	96.7	97.4
Medical Fees	47.9	53.3	50
School Fees*	35.4	13.3	-

* Indicates a significant difference (Fisher's exact p-value<0.05) between the sites and means could not be pooled

4.8 Changes in Household Activities

With the introduction of a new farming system, in this case integrated soil fertility replenishment agroforestry technologies, it was expected that household members would find it necessary to adjust their various activities to accommodate the new practices. As part of a series of open-ended questions, respondents were asked how, specifically, SFR adoption had influenced the activities of household members, either positively or negatively. The responses were organized into the following categories:

- *Support*: respondent noted that all members support the continued use of the technologies
- *Cooperation*: respondent stated that SFR adoption had led to increased solidarity and cooperation among household members
- *Division*: SFR use had caused controversy among household members as some members support the technology and some do not
- *Time*: adoption had resulted in an increase, either positive, negative, or neutral, in the amount of time spent working in the fields
- *No Change*: respondents said that adoption had not affected household activities

Figure 4.18 illustrates the number of responses for each of these categories. There were significant (p=0.02) site differences in the "cooperation", "division", and "no change" categories. In Kasungu, 12.3% of respondents said the technologies had promoted cooperation among household members; this was in contrast to 1.5% in Machinga. Similarly, 16.9% of Kasungu respondents said that adoption had caused division within the household, while there were no indications of this in Machinga. In each of the cases where "division" was identified, the separation occurred along gender lines. It was either the men or the women of the household who were opposed to the technology, usually because of the time and labor requirements associated with the technology use. Almost 22% of Kasungu residents reported "no change" in household activities, while in Machinga a significantly (p=0.000) higher proportion (68.2%) of respondents indicated that adoption had not influenced daily household activities. Approximately 37% of all respondents said that all household members supported the technologies (43.1% in Kasungu and 31.8% in Machinga). While these responses do not identify specific changes in the day-to-day activities of household members, they point to changes that have occurred among and between household members and family relationships as a result of SFR adoption.

Almost 12% of respondents reported a noticeable increase in the amount of time they were spending working in the fields, the "*Time*" category. Among those who reported an increase in the amount of time spent in the fields, some viewed it as a positive change, some saw it as a negative change, and some regarded it as neutral. Among those whose responses were in the "*time"* category, four respondents (26.7%) saw this as a positive change; furthermore, all of these positive responses were from Kasungu. One woman said that the increased time in the field had reduced the time she spent in "unproductive activities". Another woman reported that SFR adoption had "positively influenced the ability to work hard during cultivation months as it requires more hours to be spent in the field." Finally, a third woman reported that the technologies had "assisted in reducing…leisure time as I spend more time in the field…[SFR technologies] demand more care, hence I spend more time in the field and in so doing am [removed] from other factors that affect life in the village, for example gossiping." While these women appreciated the changes associated with the technologies, 53% of those who reported an increase in the amount of time spent working in their fields were unhappy with the increased time demands, as it took time away from other important activities. One woman reported that "most members are unwilling to continue because of less returns, hence they prefer to engage in business other than spending more time in the field." While another woman expressed that SFR adoption "has negatively affected off-farm activities due to more time spent in the field." For those that found the additional time requirements to be a negative change, the main reason seemed to be that it distracted them from other important household activities.

Six percent of the respondents indicated that SFR adoption had allowed household members to diversify their activities and/or provided for a positive shift in wealth. For example, one woman said that her household supported the technologies because "off-farm income is saved from buying fertilizer". In other words, the household was now spending less of its income on inorganic fertilizers. One man said that his household was able to diversify their crop productivity and that his wife was now growing vegetables. Another man said that SFR adoption had provided for an increase in income, through the sale of agroforestry seeds, and as a result it "has positively contributed to supporting other farming activities as we are able to hire labor and free time to do development (community) activities." Three respondents from Kasungu also mentioned that because of the wood production from the agroforestry species, their wives were spending less time searching for and collecting fire wood.

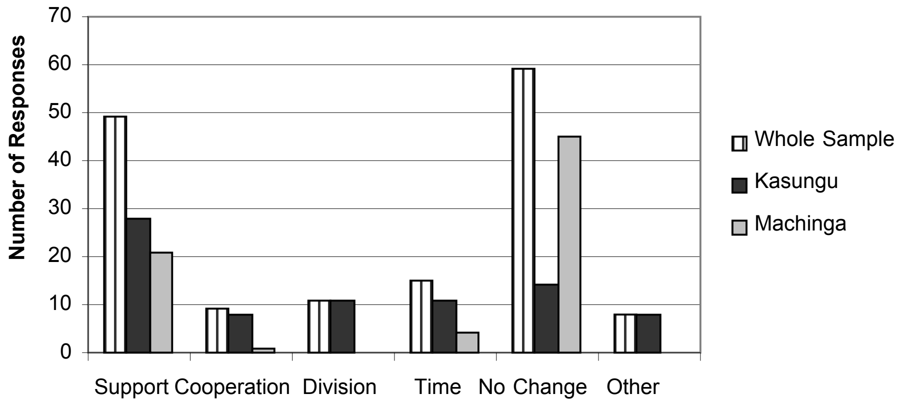


FIGURE 4.18 Changes in household activities as a result of SFR adoption

4.9 Final Comments on SFR Technologies

The concluding question of the survey gave respondents the opportunity to make any final comments regarding their experiences with SFR adoption. This broad, open-ended question generated a wealth of varying comments and provided some insight into how respondents felt about the SFR technologies, what was working for them, and what they felt was retarding the use and adoption of the technologies. As with the previous question regarding household activities, the responses to this question were grouped and coded as far as possible into the following categories:

- *New Species*: respondents expressed the need/desire for new agroforestry species that would decrease the time required between adoption and increased crop yields.
- *Support*: respondents wanted more support from extension officers. Many respondents indicated the desire for specific forms of support and often respondents from the same communities identified the same support needs. For these reasons, this category was further divided into specific forms of support and is presented in Section 4.9.2
- *Field Trips*: respondents wanted to visit farmers in other areas and be exposed to new technologies and gain encouragement from others' successes.
- *Markets*: respondents expressed the need for better access to agroforestry-related markets. They cited the lack of synergy between agroforestry seed supply and demand (both in time and quantity), and/or poor access to markets to sell cash crops and/or wood.
- *Satisfied*: respondents were satisfied with the technologies and all aspects of adoption.

Overall, the need for some form of support was the most prevalent response (74.8%), followed by the desire for new species (24.4%), and field trips (22.1%). While the need for support was the most common response in both districts, a significantly higher percentage of respondents from Machinga (87.9%) identified this need when compared to those from Kasungu (61.5%, $p<0.05$). There were no other significant differences in response categories between the two sites (Table 4.20).

TABLE 4.20 Percent of responses in various concluding comments categories

Comment	Kasungu (n=65)	Machinga (n=66)	Whole Sample (n=131)
New Species	26.2	22.7	24.4
Support*	61.5	87.9	-
Field Trips	20	24.2	22.1
Markets	10.8	6.5	8.4
Satisfied	7.7	1.5	4.6

* Indicates a significant difference (Fisher's exact p-value<0.05) between the sites and means could not be pooled

For those who sell agroforestry seeds (42.7% of respondents), market availability is important. Eleven respondents (8.4%) reported the need for better access to or availability of agroforestry seed markets. The desire for field trips to other farms was also a prevalent request among respondents (22.1%). Respondents wanted to visit farmers in other areas to see what they were doing and to learn from those who have been practicing SFR agroforestry for longer periods of time and perhaps using different technologies and/or species. Some respondents expressed a need to be encouraged by seeing the success of other farmers.

Finally, 24.4% of farmers stressed the need for new agroforestry species. Farmers voiced the need for further research into new species that would provide results in a shorter amount of time. While 95.4% of respondents identified some gaps in the system, there were 6 respondents who were satisfied with the technologies and expressed the need to encourage further adoption.

While these open-ended questions inherently resulted in a broad range of responses, respondents from the same areas tended to provide similar responses. For example, 100% of those who said they required support during hunger periods came from Machinga and 79.5% of those expressing the need for more farm inputs also came from Machinga. In Kasungu, responses were similar within the various sections.

4.9.2 Support Needs

Table 4.21 shows the percent of respondents who identified the need for various forms of support. The majority of respondents (61.5% of Kasungu respondents and 88% of Machinga respondents) said that they desired more support from extension workers. Some respondents did not specify what kind of support they wanted, and 29% said they wanted general encouragement and/or incentives for adoption, but many people were specific about the kind of support they felt they needed. Support needs were divided into the following categories:

- *Education and training*
- *General encouragement and incentives*: respondents wanted extension officers to provide more general support and/or incentives or rewards to farmers who were using the technologies
- *Seeds*: respondents said they needed more agroforestry seeds at the right times
- *Water*: respondents identified a lack of access to clean water
- *Inputs*: respondents wanted extension officers to supply more agricultural inputs such as fertilizer and tools

- *Hunger*: respondents wanted extension workers to provide support during hunger periods, in the form of either food or cash

General encouragement, seed supplies, and water were the most commonly desired forms of support (Table 4.21). Of the 44 respondents who mentioned the need for inputs, 79.5% of these were from Machinga. Fifty-three percent of all respondents from Machinga expressed the desire for support in the form of agricultural inputs, in contrast to 13.8% of Kasungu respondents. Respondents from Machinga (34.8%) were also the only ones to indicate that they needed/wanted some form of support during hunger periods. There were no other significant differences between the sites.

TABLE 4.21 Percent of responses in the various support categories

Support	Kasungu	Machinga	Whole Sample
Education	10.8	3.0	7.4
Encouragement	29.2	28.8	29.0
Seed Supply	24.6	16.7	20.6
Water	16.9	16.7	16.8
Inputs*	13.8	53.0	-
Hunger*	0.0	34.8	-

* Indicates a significant difference (Fisher's exact p-value<0.05) between the sites and means could not be pooled

Appropriate timing and amount of agroforestry seed supply was also an issue that was raised in both Kasungu (20.6%) and Machinga (16.7%). Overall, almost 21% of respondents said that the availability of agroforestry seeds did not coincide, either in time or quantity, with their needs.

Chapter 5
Discussion

This chapter draws on the results of the current study and existing literature to address the research objectives and discuss the findings. The chapter addresses food production, assets, income, vulnerability, and farmer-identified benefits and challenges.

5.1 Changes in food security resulting from increased yields associated with SFR adoption, Objective 1

5.1.1 Hunger Vulnerability

All households reported experiencing some form of hunger periods both prior to and since SFR adoption. However, for the 2006/2007 season, almost 33% of households reported no hunger period. This may be the result of a combination of good rains and the return of fertilizer subsidies in the 2005/2006 and 2006/2007 seasons that saw an increase in maize production to the point at which the country was able to export some of the maize (AfDB/OECD, 2007; Malawi Ministry of Agriculture and Food Security, 2008). In fact, maize yields in 2005/2006 increased by 87% over the previous year (AfDB/OECD, 2007) and less than 900 000 Malawians required food aid in 2006, the lowest number in four years (AfDB/OECD, 2007). Maize production in the 2006/2007 season reached 3.5 million tons (Malawi Ministry of Agriculture and Food Security, 2008). Despite the apparent maize surplus over recent years, the fact that 67% of respondents still reported a hunger period during the 2006/2007 season indicates that food security is still a real threat to rural Malawians. Fertilizer subsidies cannot reach everyone, and a good rainy season is never guaranteed. With these potential vulnerabilities in mind, it seems prudent to continue the use of low-input soil fertility improvement systems.

The main goal of agroforestry is to reduce hunger and improve household nutrition. Akinnifesi *et al* (2007) reported that through the domestication and propagation of indigenous fruit trees, households in Zimbabwe were able to reduce hunger vulnerability by 33%. Respondents in this study also reported significant changes in annual hunger periods. While hunger is still a threat to all of the households interviewed, respondents did report a significant ($z=5.51$, $p<0.05$) decrease in the number of hunger months experienced during the year since SFR adoption (Figure 4.13) presumably due to the reported increase in maize yield. However, there was a significant difference between sites. While 67% of the respondents reported experiencing hunger during the previous year (2006/2007), the large majority of these came from Machinga (Section 4.5 and Table 4.7). Furthermore, Machinga respondents reported a 13% reduction in annual hunger months, while in Kasungu, the number of hunger months dropped by 19%. One possibility for the significant differences between the sites is that while household sizes did not differ between sites (Table 4.1), land holding and cultivated land areas were significantly smaller in Machinga than Kasungu (Table 4.1). The average total farm size in Kasungu was 1.88 ha, while respondents from Machinga owned an average 0.91 ha. So, while households in both areas are feeding the same numbers of people, those in Machinga have a much smaller environmental capital base from which to do it. Despite the significantly longer hunger periods in Machinga, the results of the data analysis reveal sufficient evidence to say that overall, hunger periods have significantly decreased since SFR adoption. In answer to Objective 1, it can be said that both crop production and food security have improved significantly since SFR adoption.

Malawi requires 2.1 million MT of maize annually to feed its citizens (Malawi Ministry of Agriculture and Food Security, 2008). This means an average requirement of approximately 169 kg per person, and with an average household size of 6.5 people in this study, the average household requires 1099 kg of maize each year. The reported annual production increases of 382 kg in Kasungu and 242 kg in Machinga represent 34.7% and 22% of the household's annual maize requirements, respectively. It would seem then that hunger months would have decreased by more than the reported 0.66 months in Kasungu and 0.56 months in Machinga. It is not uncommon for respondents to provide answers that, while not entirely untrue, are skewed to solicit possible benefits such as food aid or other inputs. In this case, respondents may have underreported the drop in annual hunger months in hopes of receiving additional support. Additionally, increases in crop yields bring a host of other livelihood and management challenges for farmers. Households must make decisions about selling or storing crops that are not needed for immediate consumption. Often times a household will choose to sell crops for immediate cash income, the consequence then is that that food is not available for household consumption later on. So, while the household may have sufficient production, they liquidate that asset rather than storing it for later in the season when food supplies begin to diminish. Furthermore, if a household does decide to store the additional yields, there must be an adequate storage system that will prevent the harvest from going bad, if proper storage is not available, rotten or pest-infested maize will be no use late in the season.

Despite these constraints, and possible challenges associated with surplus crop management, the reported decrease in annual hunger periods is significant. However, there are two potential problems with attributing SFR adoption to a significant reduction in hunger vulnerability. For one, the substantial country-wide increase in maize for the previous two seasons (2005/2006 and 2006/2007) was fresh in the respondents' minds. It is possible that the recent good years of high maize yields and low hunger would factor in more strongly in the self-reporting of average hunger months than earlier years of poor harvests and longer periods of food scarcity. Had the previous two seasons been especially bad ones, the average number of self-reported hunger months could have been higher. Secondly, it was not possible to assess how or if hunger periods decreased in relation to the time since SFR adoption. This would have required recording the number of food-insecure months each year for all successive years since the time of first adoption. As such, this study only had two reference points for hunger periods, before adoption and presently, and these were based on memory recall. These data constraints limit the research from making overall conclusions about direct links between SFR adoption and hunger eradication, however, the results do support the hypothesis that hunger vulnerability has decreased at both sites since SFR adoption.

5.1.2 Crop Production

The majority of respondents (65%) reported an increase in maize yield due to SFR use with an average total yield increase of 381.5 kg in Kasungu and 241.7 kg in Machinga (Section 4.4 and Table 4.4). Here again, the difference between sites is likely due to the fact that respondents in Machinga cultivate much smaller areas. In this study, respondents only provided information about the amount of yield increase, there was no baseline information pertaining to yields per hectare so the reported increases cannot be extrapolated to kg per hectare. It is therefore impossible to say if the production at one site is significantly better or worse than production at the other. However, the maize yield increases are substantial and are consistent with other studies that have shown increases of over 100% (Ajayi *et al*., 2007; Phiri *et al.* 1999; Place *et al*., 2003) for various agroforestry technologies. These results are also consistent with a study that found maize yields to increase by 2 MT ha^{-1} under a *Sesbania* relay cropping system (Kwesiga *et al.,* 2003).

The other two crops to be cultivated under SFR technologies, cassava and vegetables, also showed significant increases in yield since adoption (Table 4.4). Respondents at both sites grew vegetables for consumption and sale. However, the sale of vegetables was a much more common source of income in Kasungu than in Machinga (Table 4.6). The use of biomass transfer in dambo cultivation of high value cash crops such as vegetables has been shown to provide a potential net profit of US$700 to US$1000 per hectare (Ajayi *et al*., 2006). Ajayi and Matakala (2006) reported that in Zambia the use of *Leucaena* biomass in cabbage cultivation resulted in a net profit of US$5 469 per hectare. It is likely that, when compared to Machinga, the larger land holdings in Kasungu has allowed the more prevalent use of biomass transfer, and resulted in the production of larger quantities of cash crops (vegetables) which has also contributed to a more diversified income portfolio.

The UNIVARIET procedure in SAS Enterprise Guide found all changes in yield to be significant (Table 4.4), with the sign and signed rank p-values less than 0.05. The results confirm what the existing literature has already established, that integrated soil fertility technologies do cause a significant increase in crop production (Ajayi *et al*., 2007; Akinnifesi *et al.,* 2006; Kwesiga *et al.,* 2003; Phiri *et al*., 1999). It should be pointed out though, that no data was collected on the use of inorganic fertilizers among the respondents. The current government fertilizer subsidy program supplies 100 kg of inorganic fertilizer to approximate 50% of the smallholder farming sector (Malawi Ministry of Agriculture and Food Security, 2008) and it is likely that some of the respondents in this study were recipients of these subsidies. The use of both organic and inorganic fertilizer options are complementary and will contribute to increasing crop yields.

5.2 Patterns of SFR adoption and changes in household assets, Objective 2

5.2.1 Changes in Assets and Wealth

Bed mats were the most commonly owned and commonly purchased asset at both sites (Table 4.14). They were valued second only to iron roofs. Radios, bicycles, and chickens were also common assets (Table 4.14). The 2005 Integrated Household Survey (IHS) (Malawi National Statistical Office, 2005) also reported radios, bicycles, and chickens to be common assets in Malawi's Central and Southern regions. The IHS (Malawi National Statistical Office, 2005) reported that in Malawi's Central region, the percent of households owning a radio, bicycle, and/or chickens was 52.5%, 37.7% and 95.8%, respectively. While in the Southern region 55.6%, 35.7%, and 90.1% of households owned these assets, respectively. The results of this study, while affirming the commonality of these assets, showed substantially different percentages of ownership than the IHS. This is likely due to the fact that the IHS had a much larger sample size than this study and the IHS covered both rural and urban households throughout the entire region.

Ownership of bed mats, bicycles, radios, goats, and chickens increased significantly ($p<0.05$) between pre- and post-SFR adoption (Section 4.6 and Figure 4.14). Studies from Ellis *et al.* (2003) and the Malawi Baseline Livelihood Profiles (MVAC, 2005), found that changes in livestock ownership may indicate a change in wealth. Through wealth-ranking exercises in Zomba and Dedza districts of Malawi, Ellis *et al.* (2003) found that households considered to be "well-off" owned, among other things: 5 or more cattle, 3 to 5 goats, and at least one bicycle. Similarly, using livestock ownership as one indicator of wealth, the Malawi Baseline Livelihood Profiles (MVAC, 2005) reported that in Kasungu district those considered poor owned zero to 5 goats or chickens, those in the middle wealth bracket owned zero to 3 cattle and up to 6 goats and chickens, and those considered better-off owned 3 to 10 cattle and 5 to 10 goats and/or chickens. The same study reported that for Machinga district, households classified as poor owned 4 to 6 chickens, those in the middle owned 1 to 4 goats and/or 4 to 6 chickens, and the better-off households owned up to 15 goats and 15 or more chickens.

Due to time constraints, it was not possible to hold focus group discussions to identify local wealth indicators in this study. Therefore the literature from Ellis *et al.* (2003) and the Malawi Baseline Livelihood Profiles (MVAC, 2005) provided the guidelines for associating asset status and wealth. Within the context of this literature and considering that the average household owned less than 5 chickens and fewer than 2 goats, the vast majority of responding households can still be classified as poor, regardless of site. Households did report an increase in the number of units of various assets and in the diversity of assets as a result of SFR adoption and respondents generally attributed SFR adoption to the ability to purchase additional assets. Using asset, and especially livestock, ownership as an indicator of wealth, it does not appear that respondents from either community have been able to move from the "poor" wealth bracket to the "better off" bracket, but there has been a shift along this line.

5.2.2 Changes in Number and Type of Assets

The results show that the majority of respondents (85% to 100%) attributed an increase in asset ownership to SFR use. Assets increased both in number (purchasing additional chickens, for example) and in diversity (for example, purchasing a first radio). However, as with hunger, it was not possible to determine if asset status was directly correlated to the number of years since adoption. This would have required taking asset inventories at regular intervals, e.g. annually, over time. It is therefore impossible to determine if there is a relationship between assets and years of SFR use. It can however, be said that there is a significant change in asset status between pre- and post-adoption.

There are at least two factors which may contribute to the still "poor" asset status of many households. First, the study found that when faced with a crisis or shock, households often sell assets to generate additional income. Since many households already lack the essential physical capital needed to maintain a secure livelihood, the sale and therefore loss of any productive assets will further hinder household security, causing the household to be even more vulnerable to future shocks. When households rely on “self-insurance” such as selling assets or hiring out labor, they do so at the cost of investing in future capital (Eriksen *et al.*, 2005; Skoufias, 2003). The result of this is a positive feedback situation which only perpetuates poverty. The relationships between coping strategies and poverty are discussed further in Section 5.4. Secondly, the majority of household income is invested in resources and assets directly related to survival, such as purchasing food and farming necessities. Households make purchases that are critical to survival over purchasing luxury items which may improve their perceived wealth and social status. In a study of the impacts of SFR on poor households in western Kenya, Place *et al.* (2005) found only moderate increases in the assets of some households. In fact, they found a general deterioration in overall welfare. They attributed the lack of livelihood improvement to small land holdings, the fact that the immediate need for cash prevented households from converting income into livelihood assets, and the poor performance of the local economy. The increase in assets that has been demonstrated in this study however indicates some shift towards wealth and security. Whether this movement is sustainable and will eventually result in a permanent change will depend on the complex relationships among markets, education, policy, economy, and social institutions.

5.3 SFR adoption and diversity of income generating activities among households, Objective 3

5.3.1 Seasonal Income Generating Activities

Crop sales were the most common and most important sources of income at both sites (Section 4.7). This is consistent with the Malawi Baseline Livelihood Profiles (MVAC, 2005) which reported that crop sale is the largest source of income in both the Kasungu Lilongwe Plain and Phalombe Plain and Lake Chilwa Basin (which includes the Machinga site) areas. The majority of crop sales occur between the months of May and September (Figure 4.15). This is expected since these are the months during which groundnuts, maize, potatoes, and various vegetables are harvested (MVAC, 2005).

Consistent with the Malawi Baseline Livelihood Profiles (MVAC, 2005), the study found off-farm wages to be especially important sources of income between November and March (Figure 4.15), this coincides with the annual food shortages and hunger periods experienced by many subsistence farmers. These months are also times of high labor demand as it is during these months that land preparation, land clearing, ridging, and finally planting occur (MVAC, 2005). Farmers are therefore faced with the dilemma of hiring out labor for payment or working on their own plots. If household labor resources are constrained, the loss of an active household member to off-farm labor may be to the detriment of household land preparation and subsequent crop production (Place *et al.*, 2007). However, the additional income (either cash or in-kind) from off-farm labor may be more critical to meeting the household’s immediate needs.

Tobacco sale in Kasungu was the most highly ranked cash crop (Table 4.16) although it was not as common an income source as would have been expected based on the literature. While 43% of respondents from Kasungu sold tobacco, this is far below the 64% reported by the IHS (Malawi National Statistical Office, 2005). Surprisingly, 50% of Machinga respondents grew tobacco; this is more than twice the number of growers reported by the IHS. These discrepancies may be due to differences in scale. The IHS survey was conducted over a large population and land area while this study was confined to a much smaller population and geographical area. The MVAC report (2005) also identified tobacco as the most important cash crop in Kasungu district, accounting for 65-85% of the income across all wealth groups. The high ranking of tobacco in the present study supports the results from Mwasikakata's (2003) study which found nearly 45% of the yearly tobacco sales in Malawi come from Kasungu ADD, and 60% of this comes from Kasungu RDP (Mwasikakata, 2003). Only one person reported collecting a pension. This is not surprising since the main household income generating activities were subsistence farming and casual or seasonal labor, neither of which provide a pension. One woman in Kasungu owned a tea room.

5.3.2 Income Diversity and SFR Adoption

With agroforestry adoption come other income generating opportunities. For example, wood from the agroforestry species can be sold for fuel or construction materials; seeds can be collected and sold; and if increased crop yields produce a surplus those crops can also be sold. It was therefore hypothesized that SFR use would promote the diversification of income generating activities (IGAs). Responses from Machinga showed that there was no significant diversification of income sources (Section 4.7). While a few households did report an increase in the number of income sources, the majority said the number had remained the same. The results from Kasungu, however, showed a significant number of respondents reporting an increase in the number of household income sources (Section 4.7). Because Kasungu respondents were cultivating larger plots, and more respondents used improved fallows and biomass transfer than in Machinga, they may have more income generating resources available to them. For example, the use of improved fallows requires more land than relay cropping and the resulting woody biomass yield will be greater in a plot that is dedicated to an improved fallow than in a plot where woody growth shares the same space as food crops. Therefore, the resulting volume of saleable wood will be greater from an improved fallow than from a relay cropping system.

Every household that reported an increase in the number of IGAs attributed the increase to the addition of one or more agroforestry-related IGAs (Section 4.7). In response to Objective 3, the fact that over half of the entire sample, and over 85% of respondents from Kasungu did report an increase in the number of income sources, and that all the reported increases derived from agroforestry practices, indicates there is evidence that SFR adoption can provide additional sources of income, however it seems that this potential is either limited or is not being fully realized.

5.3.3 Income Amount

The probability that a household in Kasungu reported an increase in income since SFR adoption was significant, but there was no evidence to indicate that households in Machinga had been able to increase their incomes. Considering that income sources did not change significantly in Machinga, it is not surprising that income amount did not change either.

As with income diversification, among those who reported an increase in income amount, there was no statistically significant probability that this increase was the result of any single agroforestry-related activity. However, all households who reported an increase in income did attribute this to the addition of one or more agroforestry IGAs. So, while it cannot be said that any single agroforestry activity promotes an increase in income, the results show that overall, SFR adoption has led to an increase in household income.

Those who reported an increase in income were then asked how they used this additional income. The responses showed that households used money for things directly related to survival and livelihood strategy such as purchasing household items, food, agricultural supplies and paying on debts (Table 4.19). In fact, the IHS reported that 51.2% of household income in Kasungu and 56.4% of household income in Machinga goes to purchasing food (Malawi National Statistical Office, 2005). Income did not increase enough to allow respondents to put money away into savings or to pay school fees. The IHS (Malawi National Statistical Office, 2005) also reported that only 1.8% of total earned income from households in Kasungu and 0.9% in Machinga went towards school fees. This study found that 35.4% and 13.3% of Kasungu and Machinga respondents used additional earned income to pay school fees. The differences between the results presented in this study and those reported by the IHS are due to measures of scale, although the general trends are the same. The IHS reported the percentage of *total household income* allocated to education, while this study reports the percentage of those respondents who reported allocating *any* amount of income to school fees, and even then, only among those who had reported an increase in income.

Incidents of income allocation to school fees and savings were higher in Kasungu. There are at least two possible explanations for this. The first is that Kasungu residents appear to be gaining a greater benefit from SFR adoption than those in Machinga. In Kasungu, there were higher incidents of reported increases in income, assets, and crop yields (though this may be due to larger land holdings), and a larger decrease in number of hunger months than in Machinga. It is understandable that Kasungu respondents would also be more likely to allocate income towards things that are not necessarily critical to immediate survival. As for education, there may be religious and cultural reasons for the differences between sites. Machinga residents are mostly Yao, and Muslim, while Kasungu is predominantly Chichewa and Christian. The Muslim community may place a higher value on “informal” education through religious education and ethical training than on “formal” government schools (Daun, 2000). In fact, at the district level, 93.7% of primary school attendance in Kasungu is at government schools and 5.7% of primary school children attend religious schools. In Machinga district, 60.3% of primary school children attend government schools and 39.7% attend religious schools (Malawi National Statistical Office, 2005). So, while respondents from Machinga in this study may not have the resources to send their children to school, there are also cultural factors that may be at work.

Even though the results show an increase in income and a decrease in the length of hunger periods, households are still living in poverty and many are barely getting by. The reported increases in income have not been enough to provide any type of buffer or cushion as indicated by the various coping strategies that households choose to rely on. Households are still forced to sell already limited assets and labor, rather than being able to fall back on savings. Any increase in income is just enough to help support basic household necessities.

5.4 Effects of SFR adoption on household vulnerability and coping strategies, Objective 4

Vulnerability is the potential to be adversely affected by an event or change and is a robust function of the interaction between and among natural or environmental variability, socio-economic processes, and policy (Eriksen *et al*., 2005). Within the livelihoods framework, the vulnerability context refers to external shocks, trends, and seasonality over which people have little or no control (DFID, 1999). While some changes to these external forces can have a positive influence in reducing vulnerability, many interactions among external shocks, trends, and seasonal processes provide a positive feedback into increased vulnerability (DFID, 1999). For example, an illness or death in a household means the loss of labor. If the household member was employed outside the farm, then there will also be a loss of wages and income. If the household is unable to fall back on insurance or savings, the loss in income may have severe consequences on the household's ability to purchase necessary items, such as food. Households may then be forced to sell either livestock or other important assets to generate cash. This depletes the already limited household capital and further hinders the household's ability to make any livelihood gains. Case studies from an investigation of SFR livelihood impacts conducted by Place *et al.* (2007) in western Kenya revealed that shocks and coping strategies were key causes of poverty. Therefore, this study looked for any changes in the household's ability to cope with shocks as an indication of increased security and decreased vulnerability.

Hunger is by far the most prevalent shock or crisis facing smallholder farmers, as illustrated by the fact that all of the respondents in this study were still vulnerable to several months of food insecurity each year. It was hypothesized that if SFR adoption had enabled households to increase crop production and diversify their livelihoods, then they would also have been able to invest in various adaptation and coping strategies that would mitigate the adverse effects of any shock or crisis that arose. Despite the gains in food security, brought about by a significant increase in crop yields (Table 4.4), a marked decrease in hunger periods (Figure 4.13), and in some cases a more diversified income portfolio and asset inventory, there is still an obvious lag in household security, the ability to absorb and cope with shocks, and overall improved welfare.

When households live on the margin of survival, livelihood strategies focus more on addressing immediate needs and surviving shocks than progressing out of poverty (Eriksen *et al*., 2005). The results revealed that where households were able to increase their income, the added income was reinvested into activities that support the household's immediate needs (Table 4.19), rather than invested in any form of insurance. In a study of household budgets in western Kenya, David (1997) found that up to 87% of all household expenditure went towards purchasing food and non-food necessities, while only 7% went towards farm inputs such as hired labor, fertilizer, and seed. This study agrees with David's (1997) conclusion that resource-poor farmers have little or no savings and households give priority to investments which yield short-term returns.

Households allocated income to the purchase of household items, agricultural supplies, and food. These items have an immediate and direct effect on the wellbeing and security of household members. Investing additional income or resources into savings, non-essential assets, or school fees are investments that have long-term implications to the household's well-being, but may be at the expense of immediate needs. It was not expected that households in this study would have become fully food self-sufficient, but rather that they would have been able to spend less money to meet immediate needs and be able to put more income towards non-essential investments, such as savings, or school fees. The results show that households who had seen an increase in income are able to allocate income to a variety of areas, though they still rely heavily on purchasing food and non-food necessities. A full economic analysis at the household level would be necessary to determine if households have realized any significant financial relief since SFR adoption.

The use of various coping strategies provides another indication of a household's vulnerability. Ideally, households would have some form of insurance or "safety net" to rely on in difficult times. The literature reports that in the absence of formal security measures however, households are likely to sell productive assets, reallocate time to increase income, or a previously non-working member may enter in the labor market (Jacoby & Skoufias, 1997; Skoufias, 2003) in response to unexpected challenges. It is not surprising then that in this study, households at both sites relied heavily on selling assets, crops, and labor as a response strategy. When households choose to sell their physical assets or crops as a coping mechanism in response to a shock, they may be able to mitigate the immediate effects of the crisis, but to the detriment of future stability. This observation is supported in the literature by Skoufias (2003) who observed that "poor households may be forced to use coping strategies that ultimately prevent movement out of poverty". The sale of physical capital and/or crops as a primary coping strategy may alleviate the immediate effects of the current shock, but a decrease in the household's already limited resources may make it impossible for the household to realize the full potential of its livelihood strategies. It will not only prevent a movement out of poverty, but will actually contribute to the problem.

In a study conducted in Kenya and Tanzania, Eriksen *et al.* (2005) found that reliable access to cash and credit were key components to mitigating vulnerability. In this study, few households engaged in activities that supported a reliable source of income. Income was mainly generated through *ganyu* labor, which is piecework and variable in time and payment. While some households demonstrated a positive change in income, crop yield, and assets, this does not appear to have been significant enough to allow for any substantial reduction in vulnerability, except for perhaps a shorter annual hunger period, the significance of which should not be ignored. It is difficult to separate the effects of hunger, illness, labor shortage, and crop loss as the presence of one can directly affect another. An illness may cause a decrease in the family's available labor, which may retard crop production, causing a food shortage and hunger.

5.5 Benefits, challenges, and concerns

The reported increases in crop yield support the basic premise associated with SFR technologies: that SFR replenishes soil fertility and results in increased crop yields. Households overwhelmingly identified improved soil fertility as an important and crucial benefit to the technologies. This acknowledgement points to the conclusion that farmers have an understanding of the importance of soil fertility and the currently low soil nutritional status. Other studies have also found that even in the absence of knowledge about the chemical or structural properties of soils, farmers are keenly aware of, and have noticed detrimental changes in various aspects of their local environments such as rainfall patterns, and soil performance over time and soil analysis consistently supports farmer perceptions of soil fertility (Desbiez *et al*., 2004; Mairura *et al*., 2007; Murage *et al*., 2000; Thomas *et al*., 2007). The other benefits identified by farmers, such as the production of saleable seed and wood for fuel or construction, are not surprising and are common benefits identified throughout the literature (Franzel *et al*., 2002; Kuntashula & Mafongoya, 2005). The fact that fodder production was only identified as the greatest benefit by 3% of those practicing relay cropping and that browsing was identified as a major challenge in all technologies reiterates the fact that households are engaged in agrarian based livelihood strategies and not in a pastoral dominated strategy.

The challenges identified in the current study such as the availability of land, labor, seed, and access to training and education (Section 4.3), are the same as those identified elsewhere in the literature (Ajayi *et al*., 2007; Ajayi *et al*., 2003; Franzel, 1999). Farmers identified land and labor constraints as the greatest challenges to implementing technologies. However, when allowed to comment freely on their experiences with SFR adoption, respondents repeatedly mentioned the need for better access to seed and education/training. A synthesis by Ajayi *et al.* (2003) highlighted the positive influence of group membership on the decision to plant improved fallows. Place *et al.* (2003) also discussed the importance of social networks on both a farmer's decision to adopt and in the overall welfare impacts of adoption. Farmer decisions on adoption and management are not only influenced by the availability of land, labor, and inputs, but also by perceived costs and benefits, and the desire to belong, or the fear of isolation (Place *et al*., 2003). The networking associated with group membership encourages, among other things, training and education. Considering the desire for more education and training at both sites, and the perceived lack of formal training and limited access to extension and support staff, group membership may be beneficial to Machinga and Kasungu residents. It is apparent that despite the repeated confirmation of the challenges associated with land, labor, seed and training, little has been done to find solutions to these issues.

The results of this research indicate that the adoption of integrated soil fertility agroforestry technologies have had some positive impact on the livelihoods of small holder farmers in central and southern Malawi. Specifically, there has been a marked increase in crop production, especially maize, a significant decrease in the average number of annual hunger months, and an increase in income and assets. Kasungu residents seem to be doing better than those in Machinga, as illustrated by larger changes in crop yields, more significant increases in assets and income, and more diversified sources of income. Despite this, households in Kasungu still suffer annual hunger periods, and are inhibited by limited access to education, empowerment, seed, markets, and agricultural inputs and other forms of institutional support. Machinga residents appear to have gained less from the SFR adoption than their Kasungu counterparts, this despite the fact that, as a whole, Machinga farmers have been adopters longer than Kasungu farmers.

The difference between the two sites is likely to be a combination of several factors. First, while household size is not significantly different between the two sites, farm sizes are smaller in Machinga than in Kasungu. This means that households in Machinga must feed the same number of people as those in Kasungu, but with much less land. Secondly, from responses generated by the open-ended questions, it appears that Machinga residents feel that a lack of access to agricultural inputs and a lack of support during hunger periods are two elements contributing to their vulnerability. Insufficient resources, whether environmental, human, or physical, will prevent even the most persistent farmer from realizing the full benefits of SFR adoption. Place *et al.* (2003) found that the lack of resources was one of the major constraints to SFR adoption and to realizing an improvement in overall welfare. Thirdly, income sources from agroforestry related activities are not nearly as prominent in Machinga as in Kasungu. The fact that 100% of those who indicated an increase in either income amount or number of sources attributed the change to agroforestry related activities draws attention to the significance of agroforestry related IGAs to livelihood diversification strategies and poverty reduction. Agroforestry is important not only as a yield-improver and conservation measure but also as an income-generator. For example, Akinnifesi *et al.* (2007) reported on a study from Zimbabwe that found income derived from the cultivation of indigenous fruit trees reduced household vulnerability to hunger and poverty by 33%. Ajayi and Matakala (2006) reported that the use of *Gliricidia* biomass in dimba cabbage production in Zambia resulted in a profit of US$7728 per ha. Another study from Belize found that through a combination of local agroforestry practices, farming households were able to meet almost all of their own food and wood needs and that the various services and products derived from the agroforestry practices provided approximately 62% of the household income (Levasseur & Olivier, 2000). Examples such as these accentuate the important role that agroforestry related IGAs can play in poverty relief. SFR adoption is having some positive impact on the farmers of Machinga and Kasungu, but has not resulted in any substantial welfare improvement.

Chapter 6
Conclusions and Recommendations

6.1 Introduction

This study has confirmed that agroforestry, and specifically integrated soil fertility replenishment technologies have the ability to increase crop production and provide additional income. Hunger months have decreased, and in many cases, income has increased. However, the respondents in the two study areas still live on the margins of survival. While there have been significant improvements in food production, improved welfare and security will only come as a holistic approach is employed to address challenges in farmers' economic, social, political, and natural environments. The results of this study confirm what Place *et al.* (1995) concluded from their study of SFR adoption and livelihood impacts in western Kenya. They found that impact was modest due to small land holdings and poor economy and concluded that poverty relief programs must address issues beyond increasing crop production. This study revealed that while food security is paramount to sustaining the livelihoods of smallholder farmers, livelihood security and poverty reduction depend on more than increased food production. SFR technologies are fulfilling their primary role as a means to food security, but their adoption does not lead to significant livelihood improvements. Achieving lasting impacts requires that initiatives take an integrated approach and address not only household food production, but the multifaceted dynamics of social institutions, markets/economy, and policy.

While agroforestry alone cannot completely bring households out of poverty, it can play a significant role by improving food security and providing additional income opportunities. The long-term impacts of the current agroforestry programs in the study areas will emerge only as time since adoption increases. Livelihood improvements will depend on several factors. First, market inefficiencies must be remedied and economic barriers must be broken down. Second, the challenges identified by the respondents, especially access to resources and training, need to be addressed in a participatory way that promotes education and empowerment. As these two issues are tackled, households will become better equipped to manage the complexities that arise from SFR adoption and livelihood diversification, such as managing crop surplus and additional income. It is hoped that households will be able to move away from weak forms of "self-insurance". A secure ability to respond to shocks will be a critical factor in relieving poverty. Based on these conclusions the following recommendations are presented.

6.2 Identify and remove economic barriers

Based on personal observation, the communities in Machinga were physically separated from markets by distance and inadequate infrastructure. Addressing the poor infrastructure in the Machinga area will be critical in enabling market access. In Kasungu, potential entrepreneurs may benefit from training and education in marketing, value-adding, and general economics. Farmer groups or business groups would be beneficial at both sites as a means of information dissemination and as a positive support and social networking institution. A thorough examination of the current agroforestry market and the existing social networks is beyond the scope of this study, but should be an important consideration in future studies and projects if agroforestry is to make significant contributions to household livelihoods.

Implementing appropriate market related income generating activities would be beneficial at both sites. It will be crucial though that these programs involve elements of education and empowerment, and take into account the current infrastructural limitations. Initiatives should also ensure compatibility among the various community or household resources in terms of labor, time, and space. Benefits must feed back into promoting further sustainable development.

6.3 Address farmer-identified challenges

In agriculturally based livelihoods the lack of resources is a major hindrance to success (Place *et al.*, 2003). The sustainability of the agroforestry programs in Kasungu and Machinga depend on consistent and reliable access to seed, water and labor and are further influenced by policy at both the community and national level. Considering the lack of synergy between times of agroforestry seed demand and supply in the study areas, there is a potential niche for the proper development and management of community or private nurseries to support the seed supply and contribute significantly to both a self-sustaining agroforestry program and income generation. Furthermore, the development of a community water program may help communities to solve water access issues, support nursery management, and create jobs.

The expressed desire for more training opportunities, field visits, and contact with extension workers indicates that respondents feel they are not realizing the full potential of the current agroforestry programs. Where contact with extension workers is limited, farmer groups may help fill the information transfer gap. Encouraging group membership may help with education and information dissemination as well as providing social support and networks to help in times of crisis.

6.4 Support households in managing multiple livelihood strategies

Farmers need support from both local resources and external organizations to help them make the best decisions in managing livelihood activities. This will become especially important as households begin to manage multiple income generating activities, make decisions about how to allocate income and how best to utilize increased crop yields. Supporting institutions must maintain a well-rounded view of livelihood strategies, keeping household welfare, rather than private interests, as the primary focus. For example, it is possible that for the time and labor associated with managing an intercropping or biomass transfer system, the household may in fact be better off earning labor wages and purchasing fertilizer. While this may not be a popular view among agroforestry promoters, these kinds of issues need to be explored if research is aimed at reducing poverty. It is generally thought that a diverse set of livelihood activities and income sources improve household security and will lead to reduced poverty. However, this is a simplistic view and the fact is that some livelihood strategies compete for resources, the result of which is overall poor livelihood security (Place *et al.*, 2003).

6.5 Continue research to identify better species and improve technologies and ensure adherence to recommendations

At the research level, identification of other SFR agroforestry species is needed. Species should be evaluated based on their ability to improve soil fertility (and crop yields) within one or two seasons, environmental suitability, pest resistance, ease of management and propagation, and ability to provide for multiple benefits such as food, wood, and saleable seed. On-farm trials must take into consideration the associated risks to the testing farmers. Testers must be provided with the necessary insurance and support in case of poor crop performance. Technologies, practices, and policies need be thoroughly scrutinized to ensure they are both feasible and acceptable. The desire to belong and the fear of isolation play a large role in adoption decisions and the social implications of testing and/or adopting new innovations must be handled with care. From the adoption and dissemination side, it is important that farmers are properly educated in the methods that have proven successful in the research. While some farmer adaptation is to be expected, it is important that farmers adhere to the research supported practices and procedures of the technologies. This not only helps to ensure the success of the technology, but will also help in identifying and solving any problems that may arise.

While integrated soil fertility management agroforestry technologies may not be the be-all and end-all solution to poverty, they play an important part by providing improved soil fertility in a manner that is environmentally sensitive, sustainable, is of low input and low-cost to farmers and provides opportunities for additional income. Promotion should continue, however researchers and extension officers must take an integrated and holistic approach that considers the feasibility, acceptability, and sustainability of agroforestry programs.

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APPENDIX 1
Household Survey

Impact of soil fertility replenishment agroforestry technology adoption on the livelihoods of farmers in central and southern Malawi

Household Survey

Thank you for taking the time to meet with me and share information about your farming system and livelihood. Please be assured that the information you share will be treated with respect and confidentiality. The information you provide will be used to evaluate the effects of agroforestry-based soil fertility replenishment technologies on farming systems and livelihood decisions.

Household Characteristics:

Date of Interview:________________ **HH Ref. No:**________________ **District:** ________________

EPA:________________ **Section:** ________________

Respondent's Name: ________________________ **Gender:** ____________

Name of HH Head: ________________________ **(if different) Translator's Name:** ________________

HH Head's highest level of education: ________________

A. Soil Fertility Replenishment (SFR) Use

1.) What SFR technologies do you use?

Technology	Yes=1, No=2
Intercropping	
Relay cropping	
Improved fallow	
Biomass transfer	
Other (specify)	

2.) Rank the technologies that you use in order of importance with 1 being the most important; enter 0 if technology is not used. List crop and AF species you use in each technology.

Technology	Rank	AF Species	Main Crop
Intercropping			
Relay cropping			
Improved fallow			
Biomass transfer			
Other (specify)			

3.) How many years have you been using the technology? (record maximum number of years for HH)
   i. Intercropping________________
   ii. Relay Cropping ______________
   iii. Improved Fallows______________
   iv. Biomass Transfer_____________
   v. Other technology (specify) ________________

4.) Will you continue to use the technology? Give reason for why or why not?
   i. Yes
   ii. No
   Reason:____

5.) What has been the greatest advantage to using the technologies? (choose one for each technology used)

	Advantage							
Technology	Increased crop yield	Increased crop quality	Fodder	Construction materials	Increased fuel wood availability	Seed sale	Improved soil fertility	Other (specify)
Intercropping								
Relay cropping								
Improved Fallow								
Biomass transfer								
Other (specify)								

6.) What has been the biggest challenge to using the technologies? (choose one for each technology used)

	Challenge								
Technology	Takes 2-3 seasons to see increase in crop yield	Lack of AF training opportunities and information	Requires larger land holding	Pests	Labor intensive	Access to seeds	Experience jealousy from neighbors who are not using the technology	Livestock browsing	Other
Intercropping									
Relay cropping									
Improved Fallow									
Biomass transfer									
Other (specify)									

B. Land Capital (Farm maps and transect walks will provide information about how the property is used e.g. size of various crop plots, water sources, dwellings, etc.)

1.) Do you own or lease the land you live and farm on?
   i. Own
   ii. Lease

2.) How large is your landholding? ________________________

3.) How much of your land is under SFR use? ________________

C. Crop Production

1.) What crops do you grow and for which crops do you use SFR?

Crop	Cultivation (Yes=1, No=2)	SFR Use (Yes=1, /No=2)
Maize		
Groundnuts		
Rice		
Pulses		
Cotton		
Potato		
Cassava		
Tobacco		
Sorghum		
Millett		
Vegetables		
Other (specify)		

2.) Do you use the harvest for consumption, sale, or both? (check all that apply)

Crop	Consumption	Sale
Maize		
Groundnuts		
Rice		
Pulses		
Cotton		
Potato		
Cassava		
Tobacco		
Sorghum		
Millett		
Vegetables		
Other crop (specify)		

3.) Rank each crop you cultivate in terms of importance for each consumption and sale with 1 being the most important.

Crop	Consumption Rank	Sale Rank
Maize		
Groundnuts		
Rice		
Pulses		
Cotton		
Potato		
Cassava		
Tobacco		
Sorghum		
Millett		
Vegetables		
Other crop (specify)		

4.) For the crops you cultivated before adopting SFR technologies and that you now cultivate using the technologies, has your crop yield increased, stayed the same, or decreased since you began using the technologies?

Crop	**Decreased**	**Stayed the same**	**Increased**	**How much has your yield changed on average per year?**
Maize (No. of 50 kg bags)				
Groundnuts (No. of 20 kg pails)				
Rice (No. of 50 kg bags)				
Pulses				
Cotton (kg)				
Potato (No. of 20 kg pails)				
Cassava (No. of 50-75 kg bags)				
Tobacco (kg)				
Sorghum				
Millett (No. of 20 kg baskets/pails)				
Vegetables				
Other (specify)				

5.) Has SFR use allowed you to diversify the types of crops you grow? i.e. Do you grow crops now that you couldn't grow before adopting SFR technologies?
   i. Yes
   ii. No

6.) From the list above, what crops do you grow now that you couldn't grow before you started using SFR technologies? ____

D. Shocks

1.) Which of the following problems did your household experience during the last year?

Shock	**Yes=1, No=2**
Hunger	
Illness	
Death	
Loss of job	
Theft	
Damage to or loss of dwelling or other structures	
Shortage of labor	
Other (specify)	

2.) For each household problem you experienced, how did you deal with the situation? (choose all that apply)

	Coping Strategy				
Shock	**Sold Physical Assets**	**Sold Labor**	**Sold Crops**	**Migration**	**Other (specify)**
Hunger					
Illness					
Death					
Loss of income					
Labor shortage					
Theft					
Loss of/damage to structures					
Other					

3.) If you experienced any crop loss in the last year, what was the cause, what crop(s) was/were affected, and how much did you lose?

Reason for loss	**Crop affected**	**Amount lost (include units)**
Pests		
Fire		
Seedling mortality		
Drought		
Too much rain		
Flood		
Other (specify)		

4.) How did you deal with the crop loss? (record Yes=1 or No=2)

Coping Strategy	**Yes=1, No=2**
Sold physical assets	
Sold labor	
Sold other crops	
Migration	
Other (specify)	

5.) Currently, how many months of the year do you suffer from hunger or food insecurity, i.e. not able to provide enough food for all members of your household? ___________

During which months do you suffer from food insecurity?

____

6.) Since SFR adoption have your hunger periods: (choose one)

Decreased	**Stayed the same**	**Increased**

During which months did you suffer from food insecurity prior to SFR adoption?

____

E. Income

1.) Rank your sources of income with 1 being the most important.

Income Source	**Rank**
Selling maize	
Selling other crops	
Off-farm labor wages	
Pension	
Selling AF seeds	
Selling crop seeds	
Selling wood	
Selling vegetables	
Selling tobacco	
Selling other goods	
Other (specify)	

2.) Since SFR adoption, has the number of HH income sources: (choose one)

Decreased (specify how)	**Stayed the same**	**Increased (specify how)**

3.) Since SFR adoption, has HH income amount: (choose one)

Decreased	**Stayed the same**	**Increased**

3b.) If income amount has **increased**:

1. What do you think has contributed to your increased income?

____

2. What do you do with the additional income?

Option	**Yes=1, No=2**
Put it in savings	
Payment on outstanding debts	
Purchase HH items	
Purchase food	
Purchase agricultural supplies	
Pay medical fees	
Pay school fees	
Other (specify)	

3c.) If income amount has **decreased**: (Skip if this is not applicable) *Coping mechanism for reduced income is addressed in Q: D2*

1. What do you think has contributed to your decreased income?

____

4.) During which months did your household engage in each income generating activity (IGA) before adopting SFR technologies?

	Month											
IGA	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Selling crops												
Off-farm labor												
Pension												
Selling AF seeds												
Selling crop seeds												
Selling wood												
Selling vegetables												
Selling tobacco												
Selling other goods												
Other (specify)												

5.) During which months does your household currently engage in each IGA?

	Month											
IGA	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Selling crops												
Off-farm labor												
Pension												
Selling AF seeds												
Selling crop seeds												
Selling wood												
Selling vegetables												
Selling tobacco												
Selling other goods												
Other (specify)												

F. Physical Assets

1.) Which of the following do you own? Indicate the number of units enter “0” if no units are owned

Asset	# Units	How many were purchased after SFR adoption	Has adoption of SFR contributed to your ability to purchase? (yes=1/no=2)
Iron roof			
Radio			
Bicycle			
Motor bike			
Bank account			
Plough			
Ox-Cart			
Bed mats			
Goats			
Chickens			
Cattle			
Other (specify)			

2.) Please rank your assets in terms of how important they are to you with 1 being your most valued asset

Asset	Rank
Iron roof	
Radio	
Bicycle	
Motor bike	
Bank account	
Plough	
Ox-Cart	
Bed mats	
Goats	
Chickens	
Cattle	
Other (specify)	

G. Demographics

HH Member	Relationship to HH Head	Gender	Age (yrs)
HH Head	Self		

H. Concluding questions

1.) In what specific ways do you feel SFR adoption influenced the activities of your household and the household members, either positively or negatively?

____

____

2.) In what areas of your farming system do you feel SFR use has been helpful?

____

____

3.) In what areas of your farming system do you feel SFR use has presented challenges?

____

____

4.) Is there anything else you would like to say about your use of SFR? Questions, comments, concerns?

____

____

Thank the respondent for their time