Climate-smart agriculture and rural livelihoods: the case of the dairy sector in Malawi

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Declaration

I Irina Arakelyan declare that:

a) This thesis was composed by myself,

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c) The work has not been submitted for any other degree or professional qualification.

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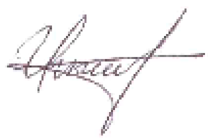

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Abbreviations

AES – Agricultural Extension Services

AF – Agroforestry

AGRF – Africa Green Revolution Forum

AI – Artificial Insemination

AIDS - Acquired Immune Deficiency Syndrome

ASWAP - Agricultural Sector Wide Approach

CH4 – Methane

CA – Conservation Agriculture

CCAFS – Climate Change, Agriculture and Food Security

CDD – Climate-compatible development

CDM - Clean Development Mechanism

CO2 – Carbon dioxide

COP – Conference of Parties

CS – Climate-smart

CSA – Climate-smart agriculture

CSP(s) – Climate-smart practice (s)

DEAS – Department of Agricultural Extension Services

FAO - Food and Agriculture Organization of the United Nations

FBO – Farmer Based Organisation

FPCM – Fat and protein corrected milk

GCF – Green Climate Fund

GDP - Gross Domestic Product

GEF – Global Environment Facility

GHG – Greenhouse Gas

GNI - Gross National Income

GoM – The Government of Malawi

HIV - Human immunodeficiency virus

IFAD ASAP - International Fund for Agricultural Development Adaptation for Smallholder Agriculture Programme

IFC – International Finance Corporation

INDC – Intended Nationally Determined Contribution

IPCC – The Intergovernmental Panel on Climate Change

KACP – Kenya Agriculture Carbon Project

LDCs – Least Developed Countries

MBG – Milk Bulking Group

MDI – Malawi Dairy Industries

MMM – Malawi Milk Maketing

MRV - Monitoring, reporting and verification

NACSA - Nationally Appropriate Climate Smart Action

NAMA – Nationally Appropriate Mitigation Action

NAP - National Adaptation Plan

NAPA - National Adaptation Programme of Action

NDDP - Malawi’s National Dairy Development Programme

N2O – Nitrous oxide

NGO - Non- Governmental Organizations

NSO – National Statistical Office (of Malawi)

ODA – Overseas development aid

PES - Payment for ecosystem services

PHL – Post-harvest loss

SI – Sustainable intensification

SSA – Sub-Saharan Africa

UNFCCC – United Nations Framework Convention on Climate Change

WHO – World Health Organization

Abstract

Over the last decade climate-smart agriculture (CSA) has been promoted as a new approach to deal with the impacts of climate change on agriculture while simultaneously trying to mitigate emissions and improve food security. This approach suggests that these multiple goals – adaptation, mitigation and food security - could be achieved simultaneously by adopting specific technologies. At its core, CSA describes agricultural interventions that can 1) sustainably increase agricultural productivity, and hence food security and farm incomes; 2) help adapt and build resilience of agricultural systems to climate change; and 3) reduce greenhouse gas emissions from agriculture (including crops, livestock and fisheries).

The main focus of CSA is on smallholder producers, many of whom are already marginalized by existing food production systems, their livelihoods increasingly affected by changes in climate. Unsustainable agricultural practices are common amongst these groups. However, there is an increasing awareness of the need to sustain the natural resource base in order to maintain or increase productivity.

Malawi is one of the poorest and least developed countries in the world, with chronic food insecurity affecting large parts of the population, and climate variability increasingly noticeable across the country. Agriculture is practiced predominantly on small holdings, with more than 80% of the population depending on land-based income. In this context, the introduction of climate-smart projects and technologies with the potential to deliver triple wins could improve farmers' incomes and food security, increase their resilience to climate change impacts, as well as deliver global benefits via climate change mitigation.

This dissertation looks at the adoption levels of various, potentially climate-smart agricultural practices by smallholder dairy farmers in Malawi, with the view of establishing the current level of engagement in these practices, and identifying the factors that influence adoption.

Results show the importance of the socio-economic and institutional factors in explaining the probability of adopting different agricultural practices. In particular, the findings indicate the importance of well-informed and targeted extension support as one of the major enabling factors for the adoption of improved practices. The findings further show that farmers' climate change perceptions play a key role in the adoption of climate-smart practices.

Overall, the thesis concludes that a number of currently unsustainable dairy farm management practices could be improved upon to achieve double or triple-win benefits within a reasonably short timescale, many of them at low cost. In addition, limited adoption rates of several sustainable practices that are already in place could be improved with the provision of more training, knowledge sharing and extension advice and support on the benefits of these practices. However, the thesis argues that before implementing projects and policies that promise triple wins, a careful evaluation of benefits, including mitigation, adaptation, and food security, and risks must be carried out, as triple wins will not be achievable in many cases due to the local and external constraints including lack of skills and knowledge, and lack of funding. In this respect, whether climate-smart agriculture could become a globally sustainable approach to the climate change problem in agriculture, remains to be seen.

Chapter 1 **Introduction**

1.1 The role of smallholder agriculture in Sub-Saharan Africa

Agricultural growth in the developing world has long been considered an important step toward economic development and transformation. This has indeed been the case in many Asian and Latin American countries where agriculture-led growth played a significant role in economic transformation (Diao et al. 2007). This transformation, however, has not occurred in Africa[1]. In most low-income African countries[2] the economy is largely dependent on agriculture (Plaat and Aftoni 2015), with agricultural growth being paramount for the survival of the majority rural population[3] directly depending on agriculture for their livelihoods. However, despite the economic importance, factor productivity in African agriculture remains staggeringly low, lagging far behind the rest of the world (Diao et al. 2007).

Between 2001 and 2010 productivity growth in Africa has only been 1% per year (USAID 2014). This has already led to Africa becoming a net food importer (USAID 2014). If productivity is not improved, and with the current 1.1 billion population on the continent projected to more than double by 2050, Africa will be able to meet only 25% of its total food demand in 2050 (PRB 2013; USAID 2014).

This poor performance of agriculture could be directly linked to a number of factors, including policy distortions, weak state institutions and poor or non-existent infrastructure resulting from underinvestment in physical, institutional, and human capital (Rakotoarisoa et al. 2011; Hazell 2007; Plaat and Aftoni 2015). Another factor to consider is that about 55% of the continent is unsuitable for cultivated agriculture (Livingston et al. 2011), while the productive capacity of the remaining 45% has been declining steadily due to the losses in nutrients, biodiversity and soil structure, caused by poor farm management practices (Livingston et al. 2011). Finally, changes in weather variability caused by climate change, and the HIV

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1 *Here and elsewhere in the thesis "Africa" refers to "Sub-Saharan Africa".*
2 *More than 90 percent of Africa's population lives in low-income countries where per capita incomes average 1 dollar per day (Diao et al. 2007).*
3 *Two-thirds of the population in SSA live in rural areas (Dercon and Gollin 2014).*

epidemic on the continent both play a significant role in the underperformance of the sector.

In most sub-Saharan economies, agriculture is the largest sector in terms of employment (Livingston et al. 2011). According to the World Bank (2014a), agriculture in Sub-Saharan Africa (SSA) employs 65% of the population, and generates about a third of the combined GDP. Agriculture also plays an important role in supplying food and export earnings (Livingston et al. 2011).

As the largest employer in most African countries, agriculture can have a large impact on poverty reduction, and be a key component of a country's overall growth and development. In these countries, agriculture has an essential role to play in promoting food security, which leads to improved nutrition, and reducing dependence on imports (Diao et al. 2007).

Subsistence smallholder[4] agriculture dominates the sector in most African countries. According to Wiggins (2009) smallholder farms represent 80% of all farms in SSA, and contribute up to 90% of the production in some SSA countries (80% in total in Africa). Development of this sector has a real potential to alleviate poverty and stimulate growth, especially considering that 70% of all smallholders are women (Diao et al. 2007; Dercon and Gollin 2014; Livingston et al. 2011). Broad participation of smallholder farmers and their direct contribution to the growth process will be essential for unlocking this potential (Diao et al. 2007).

There are a number of characteristics that shape the dynamics of the African smallholder sector. These include inadequate access to resources, inputs and services, including veterinary services and extension advice, which largely explains the extremely low level of output. Further, the small farms in a number of African countries have no access to fertilizers due to the removal of fertilizer subsidies. These problems had the most significant impact on small farms in remote or isolated regions with poor infrastructure and market access (Hazell 2007).

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4 *Smallholder farms are defined as having land of two ha or less (Livingston et al. 2011).*

Another key feature shaping the African smallholder sector are the changing and more stringent market requirements, both from domestic and international markets, in terms of food standards including quality and safety. Small farmers already have a major disadvantage in markets in comparison with commercial farms because of the small volumes and often sub-standard quality products they trade in, and little or no access to market information (Hazell 2007). More stringent market requirements can often exclude smallholders who already struggle to diversity into higher value products, from competing in markets (Hazell 2007).

African smallholder agriculture is characterised by limited or no access to credit. As a result of financial reforms undertaken as part of structural adjustment programmes in many countries in Africa, smallholder farmers lost access to seasonal credit, with their only remaining source of credit coming from micro finance institutions (Hazell 2007). Even then, their limited ability to borrow is further undermined by the seasonal nature of farm output amongst other factors. Most small farmers have to rely on self-financing or family financing, using livestock and household assets as a collateral (Hazell 2007).

Other characteristics of smallholder production systems include the use of rudimentary technologies, with very low mechanisation (based on FAO data (FAO 2005a) human labour accounts for 65% of farm energy used in SSA), and high seasonal labour fluctuations all these contributing to poor agricultural productivity (AGRA 2014).

Finally, the HIV/AIDS crisis in Africa is having a significant impact on smallholder agriculture, changing population and gender dynamics (Topouzis undated). The loss of labour supply and assets are some of the primary adverse effects of HIV/AIDS on the sector significantly contributing to reduced agricultural output (Topouzis 2003).

Agricultural production in Africa is particularly vulnerable to climate change due to its dependence on rain-fed agriculture (only 6% of SSA cropland is irrigated (You et al. 2010) thus making it highly affected by unpredictable rains and droughts (IFAD 2011). Poorly developed infrastructure exacerbates Africa's vulnerability to climate change (IPCC SPM 2014). Additional factors include weak water and land related policies, and a low adoption of key production technologies that have the potential to enhance adaptation to climatic change (AGRA 2014).

The direct impacts of climate change have already been observed across the continent resulting in increased temperatures (Nelson et al. 2014). Nelson et al. (2014) provide evidence of progressive warming from the 1980s to the 2000s across most of the SSA stations observed during this period. Temperatures are projected to increase further, thus posing significant constraints to farm-level production. The optimum temperatures for crop growth and yield are often exceeded in many parts of SSA (AGRA 2014). Climatic shocks and extreme weather events such as droughts and floods have become more commonplace in Africa over the last decade. There are marked shifts in the growing seasons, with the length of the growing season projected to decrease by 20% by 2050 (Sarr 2012).

The changes in temperatures and weather variability will lead to the projected yield declines for most staple crops. According to The Intergovernmental Panel on Climate Change (IPCC) climate change in SSA will reduce crop yields by 8% by 2050 (Porter et al. 2014). Based on IPCC (2007) the yield reduction on rain-fed cropland could reach 50% by 2020. As one of the most vulnerable crops, maize yields are estimated to decrease by 19% on average, or between 18% to 30% depending on the country (Zinyengere et al. 2013; Thornton et al. 2011).

Climate change is also expected to cause a decline in the area suitable for crop production in SSA by 3% (Lane and Jarvis 2007). This will potentially lead to the switch from crop farming only, to combined crop-livestock, or livestock only systems. Jones and Thornton (2008) predict that, by 2050, 35 million farmers in SSA will switch from mixed crop-livestock systems to livestock only systems.

Although having less pronounced impacts on livestock systems, climate change is expected to reduce availability of forage for grazing animals, and increase prevalence of animal pests and diseases. Overall, the impacts of climate change on both crop and livestock farming systems are projected to become more pronounced within the next 2 decades. Increase in climate variability warrants changes in types of crops grown, animals raised, and shifts in planting dates (AGRA 2014).

Climate change has direct socio-economic impacts on smallholder livelihoods, reducing their incomes and increasing cost of food and poverty levels, increasing economic uncertainty, gender disparity, leading to conflicts over the use of land and natural resources, especially water. In the past decade, these impacts have become increasingly noticeable leading many smallholders to adopt coping or adaptation strategies (Deressa et al. 2010).

1.2 The emergence of the climate-smart agriculture approach

As well as being significantly affected by climate change, agriculture is also a major contributor to greenhouse gas emissions (IPCC 2014). Africa's agricultural GHG emissions currently account for about 15% of the global agricultural GHG emissions (Tubiello et al. 2014). Given the importance of productivity growth for increasing food security to satisfy the essential needs of the growing population, SSA's agricultural emissions are projected to grow by about 30% between 2010 and 2030 (USEPA 2012).

The strongly pronounced local need to address the food security challenges under the new realities of climate change has led to the introduction of the climate-smart agriculture (CSA) approach. The operational definition of the concept was first introduced by Food and Agriculture Organization of the United Nations (FAO) at The Hague Conference on Agriculture, Food Security and Climate Change in 2009 (Lipper et al. 2010). This led to the publication of 'Climate-Smart Agriculture: Policies, Practices and Financing for Food Security, Adaptation and Mitigation' in 2010 (Lipper et al. 2010). Here, FAO defined CSA as a three-pillar approach to agriculture that: 1) sustainably and efficiently increases productivity and incomes (adaptation); 2) reduces or removes greenhouse gases (mitigation); and 3) enhances achievement of national food security and development goals (development) (Lipper et al. 2010). These three pillars are seen as a "triple win" of climate-smart agriculture – adaptation, mitigation, and increased food security. By jointly addressing food security and climate-related challenges, the three pillars are also seen to integrate the three dimensions of sustainable development – economic, social, and environmental. Furthermore, the CSA concept is considered to be an effective approach to achieving of food security under climate change (AGRA 2014; Lipper et al. 2010). Some of the key elements of the original CSA concept, however, were to: adopt an ecosystem-based approach; work at landscape scale, and conserve and produce suitable breeds and varieties (Lipper et al. 2010).

In recent years, the definition of CSA has become somewhat broader, and incorporated building resilience to climate change as part of the concept. In the Climate-smart Agriculture sourcebook (FAO 2013a), FAO presents the three pillars of CSA as “sustainably increasing agricultural productivity and incomes; adapting and building resilience to climate change; and reducing and/or removing greenhouse gases emissions, where possible”.

The sourcebook is the most comprehensive guidance on climate-smart agriculture published to date where FAO elaborated a suite of best practices underpinning CSA (FAO 2013a). These include, but are not limited to the use of agroforestry practices and conservation agriculture; integrating crop, livestock and agroforestry systems; integrated pest control; the restoration of degraded lands; improved management of livestock waste; taking an ecosystem approach to fisheries and aquaculture; early warning systems and climate—forecast products; and strengthening women participation in promoting climate-smart farming practices amongst others. The benefit of the CSA approach is the possibility of using a mixture from the list of these and other practices and technologies to achieve the desired outcomes in any given region (AGRA 2014). The best options would be those that could achieve multiple benefits such as increased resilience and productivity, reduced emissions, reduced food wastage, both post-harvest, and along value chains, and improved access to markets (FAO 2013a). However, it is recognized that the choice of practices will differ depending on agro-ecological conditions and socioeconomic barriers hence it is essential to invest in site-specific assessments of the benefits of a given technology (FAO 2013a; Lipper et al. 2010).

There is a wide range of technologies and practices that could be labelled climate-smart and that are currently in use in many African countries, including Malawi, Zambia, Zimbabwe, Niger, Kenya and Ethiopia, among others. Most of these practices focus on adaptation and resilience, with mitigation as a co-benefit. Some of the most commonly encountered practices are conservation agriculture, agroforestry and mixed livestock and cropping systems. Most of these practices are currently applied at the local level only. However, Southern Africa has been identified as a region most suitable for scaling-up of these approaches (UNDP 2013; FANRPAN 2012).

Overall, however, being predominantly subsistence in nature, smallholder farming systems in Africa have been driven by traditional technologies and practices (Salami et al. 2010; Kristjanson et al. 2012). Apart from lack of funds and knowledge, risk-aversion of smallholders further hinders adoption of new practices and technologies that might not be compatible with their existing practices and production systems (De Pinto et al. 2013; Lybbert and Sumner 2012).

Research has shown that at the local level, key determinants of adoption of new improved practices include socio-cultural and economic factors (Deressa et al. 2009; Sections 5.3 and 5.4), including farmer level of education, lack of funds and income labour availability and the need for extra inputs and extra equipment, security of tenure and cultural norms (Andersson and D'Souza 2014; Sections 5.3 and 5.4). The presence of strong regional and national agricultural policies as well as a strong institutional support are also key factors to adoption. These factors usually act in combination to influence or hinder farmers' adoption decisions.

Identifying these constraints will be important in order to develop economically attractive and environmentally sustainable management practices that have adaptation, mitigation and food security benefits (Neufeldt et al. 2011).

1.3 The case of Malawi

Malawi is one of the poorest and least developed countries in the world - its 2015 Human Development Index rank was 173 out of 188 countries (UNDP 2015). The Gross National Income (GNI) per capita was $747 in 2014 (UNDP 2015), and according to the most recent data for 2010 72.2% of the population lived below the poverty line of USD1.25 a day (UNDP 2015). The highest proportion of poor and ultra-poor population is concentrated in the Southern and Northern regions of the country (IFAD 2011).

The population of Malawi is currently 17.0 million but projected to almost double by 2025 (GoM 2015; World Bank 2014b; Benin et al. 2008), making it one of the most densely populated countries in Africa (IFAD 2009). Life expectancy is low at 62.8 years (UNDP 2015) and child mortality is high, with 64 deaths per 1,000 births for children under 5 (World Bank 2015). 22% of the population were classified as being undernourished between 2011 and 2013, and 42.4% of young children have been affected by stunting due to chronic malnutrition between 2011 and 2015 (World Bank 2014b).

The country faces a number of major environmental concerns, including having one of the highest levels of deforestation in the region, caused by pressure from rapidly increasing population and agricultural expansion due to declining soil fertility and crop yields (Hyde and Seve 1993; Place and Otsuka 2001). According to FAO (2010) Malawi lost 659,000 hectares of forest between 1990 and 2010. In addition, climate change has increasingly manifesting itself in the past decade, resulting in an increased incidence of droughts and floods in the country (Maplecroft 2011).

In comparison with many other countries in SSA the urbanisation in Malawi is very low, with only 15.7% of the population living in cities in 2011 (CIA 2016). Agriculture is the main source of livelihood, with nearly 90% of the population being engaged in agricultural activities (NSO 2012a). Malawi's internal economy is mostly non-monetized and depends on substantial inflows of economic assistance from the IMF, the World Bank, and individual donor nations who provided 36% of the government revenue between 2010 and 2015 (Kerr 2012; Index Mundi 2014). Agriculture accounts for more than 80% of Malawi's export revenues (GoM 2006a,b). Tobacco attracts about 70% of the country's export revenues and contributes to up to 13% of the country's GDP, thus making Malawi the most tobacco-dependent economy in the world, which in turn makes the country highly vulnerable in light of projected decline in the world demand in tobacco (Kerr 2012). Other agricultural exports include tea, sugar, coffee, cotton, paprika, and macadamia nuts (Kerr 2012).

Most of the agriculture is rain-fed, with irrigated land occupying only about 0.5% of Malawi's cultivated area, and used for high-value crops grown on large agricultural estates (Mkandawire 1999). Because of population density, the size of land holdings is extremely small - Malawi's 2006-07 National Census of Agriculture and Livestock found that only 8% of land holdings were 2 hectares or larger (NSO 2012a).The overwhelming majority (more than 90% of the rural population) practice smallholder agriculture, with less than 1ha of land, and with customary land tenure (IFAD 2011). In the Southern region, which is the most densely populated region in Malawi, the average landholding is as small as half a hectare, which is close to the minimum limit necessary for food self-sufficiency. Subdivision of plots with each successive generation, and unequal land distribution further exacerbate lack of available land (Ellis et al. 2003).

There is very limited scope for agricultural extensification in Malawi - the currently cultivated area comprises 49% of available land area in Malawi; however, 18% of the cultivated area is not suitable for agriculture (GoM 2001). Due to the limited land availability, and small holding sizes, smallholders practice continuous cropping, leading to declining levels of soil fertility and reduction in crop yields (Sanchez and Swaminathan 2005). This is further exacerbated by the fact that maize – the most cultivated crop in Malawi, occupying over 80 per cent of cultivated land and providing two-thirds of all calories consumed – has high nutrient demands (Kerr 2012; IFAD 2011).

Population pressures, environmental and land degradation and climate change all play a role in making the country highly food insecure, with regular occurrence of famine, and a population having to rely on foreign food aid (Section 5.4). Additional pressures include poor infrastructure, lack of purchasing power to purchase food and the inputs to produce it, lack of information, government disincentives and conflicting agricultural policies that have discouraged the development of internal trade (Dorward and Kydd 2004; Ellis et al. 2003; Kerr 2012). Lack of access to markets, lack of available credit (only 12% of population have access to credit (IFAD 2011)), and poor quality and limited availability of services such as education and health care, as well as agricultural services including extension services and veterinary advice, further threaten smallholder livelihoods (Jayne et al. 2006). A particular problem in Malawi is lack of transport infrastructure (GoM 2006 a,b), which is due to inadequate investment, and due to Malawi being landlocked and mountainous.

Malawi has one of the highest rates of HIV prevalence in the world - between 11% to 13% (PRB 2012). de Waal and Whiteside (2003) suggest that the this is leading to the emergence of "new variant famine," whereby communities are more easily affected, and less able to recover from the drops in food production caused by biophysical and economic factors. The AIDS epidemic also reduces labour availability, which is a major issue in the country with a very low mechanisation (Kerr 2012)

All these factors combined discourage small farmers from investing more in major land improvements and from adopting more sustainable technologies for managing their crops and livestock (Hazell 2007).

In order to diversity their activities and increase income, an increasing numbers of smallholders in SSA already combine crop and livestock activities (PPLIP 2005). Being less weather-dependent and more reliable than crop production, livestock could not only contribute to increasing incomes, but also supply inputs and services for growing crops thus reducing the risks resulting from seasonal crop failures (Chapter 3). By providing draft power and manure, livestock also play an important role in the process of the agricultural intensification (AGRA 2014).

Despite the importance of livestock and livestock products in many other SSA countries, livestock ownership in Malawi is very low compared with other countries in the region (IFAD 2011). Livestock accounts for approximately 10 per cent of the country's agricultural gross domestic product (GDP) (NSO 2012a), with only 13 per cent of smallholder farmers in Malawi owning cattle (CISANET 2013). Performance of the livestock sector is often affected by low productivity of the cropping sector due to many smallholders extending cropping into grazing areas (IFAD 2011). Per capita meat and milk consumption in Malawi is one of the lowest in Africa (Tebug 2012).

Due to poor farm management practices, milk production in Malawi is also very low, between 5-9l per dairy animal. However, it has been suggested that this can be increased to up to 40l per day via the use of improved practices (Zimba et al. 2010). The low productivity of the sector is both the cause of and affected by the heavy reliance on bulk imports - most milk consumed in Malawi is imported in a powdered form from Europe (mainly Ireland), and used in dairy production instead of domestic fresh milk (Revoredo-Giha et al. 2013). This has significant impact on prices paid by the dairy processors to the smallholder producers, which acts as a disincentive to diversify into dairy farming (Revoredo-Giha et al. 2013).

Despite dairy farming not being a traditional method of farming in Malawi, in recent years there has been an increasing recognition from the government of the need to diversify out of standard agricultural practices to support and improve farmer livelihoods affected by the poor performance in the cropping sectors. Recent national agricultural policy recognises dairy as a key investment sector, and dairy development has become a government priority in recent years (GoM 2016; MIPA 2011). There has been an increasing trend in dairy cattle numbers, mostly as a result of programmes run by international donors. There have been targeted investments into the dairy sector by a number of international governments, including the UK, US, Japan and Norway. Further, the largest manufacturer and marketer of milk and dairy products in Malawi - Dairibord Malawi Pvt Limited (DML) - has recently announced an investment of $3 million in small-scale dairy development, and the set-up of three large-scale commercial anchor farms[5], as well as the purchase of equipment for value addition targeting both domestic and export markets (UK Government 2014). These interventions are supported by a steadily increasing demand for milk and dairy products, which has led to a 40% increase in consumption between 1980 and 2002 (Tebug 2012a).

There are a number of factors calling for a targeted investment into and development of the dairy sector in Malawi. Dairy farming does not require much land, which is

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5 *The anchor farm model uses an anchor farm – a large commercial farm which serves as a hub to bring smallholder farmers together, providing access to knowledge, markets and other services, and helping farmers to increase yields and incomes from their land.*

ideal in a country like Malawi, with shrinking land holdings, and it is less affected by the changes in weather. It provides a year-round income, whereas crop farming is highly seasonal. Further, milk is a good source of protein, especially for children commonly affected by stunting due to the lack of protein. There is thus a clear need to address barriers to sector development, which include poor cold supply chain and infrastructure, poor herd health and milk quality, and poor access to markets. However, supply of raw milk remains one of the main challenges in the Malawi dairy sector.

Increasing milk supply warrants investment in both increasing the number of dairy animals and, more importantly, increasing the current low production rates, i.e. intensifying milk production. The former, is also in the national interest but is likely to lead to an increase in GHG emissions. However, increased milk production via the use of smarter farm management practices will lead to reduced emissions per unit of product, thus contributing to global mitigation.

1.4 Research aims and objectives

In Malawi's poor and slow growing agriculturally dependent economy there are limited opportunities to diversify into high value products and non-farm sources of income. With crop yields being increasingly affected by changes in climate and deteriorating environmental conditions, the need to diversify into higher paid and less weather-dependent farm activities is more urgent. Malawi largely relies on food aid to support the needs of their population (Diao et al. 2007). This is an unsustainable situation, as Sukume et al. (2000) showed that it typically costs more than US$250 of donor funds for each ton of cereals delivered in rural areas, while smallholder production costs are typically much lower at US$100 or less (Diao et al. 2007). This shows that income diversification and growth-oriented investment in agriculture can be a more efficient effective alternative to poverty reduction, and increasing rural incomes (Diao et al. 2007).

In this context, the introduction of climate-smart projects and technologies in the dairy sector could improve farmers' incomes and food security, increase their resilience to climate change impacts, and deliver global benefits via climate change mitigation.

However, despite the importance of the dairy development highlighted in national policy documents in recent years, and the recognition of the various constraints to the sector development, factors necessary to facilitate the sector development have not been studied, and remain a “grey” area. In particular, the role of the socio-economic factors in the adoption of various dairy farm management practices that could contribute to the development of the dairy sector has largely been ignored by the government and the donor agencies. Further, there has not been a large scale baseline study of smallholder dairy farmers to identify the current farm management practices deployed by farmers, and to assess the sustainability and potential climate-smartness of these strategies, or the potential for adopting new improved practices. This could prove detrimental if large scale attempts to develop the sector go ahead without understanding the underlying factors and unsustainable practices that might thwart the applied efforts and potential significant investments.

This dissertation aims to fill the gap by exploring the current adoption levels of various, potentially climate-smart agricultural practices by smallholder dairy farmers in Malawi, with the view of establishing the current level of engagement in these practices, and to identify the factors that influence or hinder adoption of improved pracices. The thesis focuses on analysing adoption of locally-driven adaptations, and reflects on the possibility of their adoption as policy-driven adaptations. This bottom-up approach, adapted to local circumstances, is important to improve our understanding of how people adapt on the ground, via understanding factors that influence local practices, and integrating their strengths into national policy (World Bank 2011; Stringer et al. 2009).

Further, the review of existing adaptation policy in Malawi shows that farmers views and perceptions of climate vulnerability and climate change have not been taken into account when designing adaptation strategies, i.e. the strategies were designed with a top-down rather than bottom-up approach. This means that these strategies are more likely to be unsuccessful. An improved understanding of farmers’ perceptions of climate change, and how these affect the adaptation (medium to long-term) and coping (short-term) strategies they employ on their farms could have important practical application to national policies aimed at promoting successful adaptation in the dairy sector. Hence one of the objectives of this study is to provide the Government of Malawi (hereafter, GoM), and the research community, with the views of dairy farmers on climate change, and their current adaptation practices which will be very useful when designing future adaptation programmes and updating the country's National Adaptation Programme of Action (NAPA).

Hence, the main objectives of this study are: 1) to identify the existing adaptation and coping strategies used by dairy farmers across Malawi, and the current level of engagement in these practices; 2) to identify the current unsustainable practices deployed by the farmers which could be improved upon to become an entry point to the development of dairy sector Nationally Appropriate Mitigation Actions (NAMAs); 3) to assess climate change perceptions of dairy farmers across Malawi; 4) to investigate the links between climate change perceptions of dairy farmers and the use of adaptation and coping strategies; 5) to investigate the adoption of agroforestry practices by the dairy farmers; 6) to identify other determinant factors that influence the choice of whether to adapt.

The main hypothesis bridging the entire thesis is that the current farming practices deployed by the dairy farmers in Malawi are not climate-smart, and do not contribute to farmers' adaptation to climate change, or to climate change mitigation. Importantly, these practices do not support increasing milk production and improving farmers' livelihoods. It is also hypothesised that the adoption of improved farming practices is low.

The dissertation does not attempt to provide a comprehensive analysis of all of the challenges and opportunities associated with smallholder dairy farming in Malawi but rather, to provide a robust analytical baseline for the broader discussion of the future development of the smallholder dairy sector.

1.5 Key thesis contributions

To our knowledge, this is the first attempt to explore the current farming practices in the dairy sector in Malawi, at the national level, with the view of establishing their climate-smartness. By fulfilling the research aim and objectives, this thesis contributes to academic debates on climate-smart agriculture and climate change adaptation, as well as wider climate change, environment and development discourses. This study aims to contribute to the growing literature on agricultural adaptation, including, among others, Asfaw et al. 2014; McCarthy et al. 2011; Apata 2011 and Wollni et al. 2010. In particular, it contributes to the understanding of factors influencing adoption of improved technologies in the dairy sector via using a comprehensive large, nationally representative survey with rich socio-economic information. This allows us to evaluate the role of household socio-economic and institutional variables in determining farmers' choice of farming practices.

The thesis also makes a substantial applied contribution by presenting a suite of potential dairy sector NAMAs that can prove useful in informing the national agricultural NAMA submissions of Malawi. Another applied contribution is the generation of the vast national dairy database containing key socio-economic information on the smallholder dairy sector that can be used for informing and developing sectoral and national policies.

The thesis findings help generate recommendations that can help policy makers, key donors and the major stakeholders develop a sustainable approach to the dairy sector development.

1.6 Thesis outline

The thesis is divided into six chapters. Following this introductory chapter, literature that discusses sustainable agriculture, climate change adaptation and the role of extension support. This chapter provides a critical review of the climate-smart agriculture approach to agricultural development looking at past and present evidence from a number of climate-smart projects, and whether climate and production objectives can be adopted as part of current or traditional 'good' farm practice. Chapter 3 discusses the role of the dairy sector in Malawi, the main constraints to the sector development, as well as the current use of farming practices by smallholder farmers. This chapter addresses pressing research gaps that were used to help develop the research presented in this thesis. The survey design, implementation and also data collection and analysis methods are presented in Chapter 4, various sections of which set out the specific analytical methods used to achieve the research objectives. Chapter 5 presents and discusses the results of empirical research, presented in 5 separate sections. Each section analyses separate parts of the smallholder dairy survey. Section 5.1 presents descriptive statistics from the survey. Section 5.2 provides an overview of the current dairy farm management practices, with the attempt to identify climate-smart practices that might be included under the definition of agricultural Nationally Appropriate Mitigation Actions. The section outlines elements relevant to the development of triple-win agricultural NAMAs in the smallholder dairy sector in Malawi, and offers survey evidence identifying pro-poor mitigation practices, technologies and policies for the dairy sector by assessing the current baseline, and analysing barriers to adoption.

Section 5.3 studies the socio-economic determinants of adoption of five climate-smart practices using logistic regression analysis. Section 5.4 explores farmers' self-reported knowledge and perceptions of climate change and how these influence their uptake of climate-smart practices discussed in Section 5.3. This section investigates the determinants of dairy farmers' adoption of various strategies using a logistic regression and a multinomial logit models. Section 5.5 examines the significant socioeconomic factors that are likely to influence the adoption of agroforestry practices by dairy farmers, with a particular focus on the role of gender of household head. Finally, conclusions and policy recommendations are presented in Chapter 6.

Chapter 2 **Literature review**

2.1 Introduction

Climate change is already having a significant impact on agriculture through greater weather variability and the increasing frequency of extreme events, both of which are expected to increase over the coming decades (FAO 2013a). Climate change seriously compromises food security in some of the least developed countries and there is an urgent need to enhance local adaptive capacity to minimise impacts and to maintain the required levels of food production (Rosenzweig and Tubiello 2007). As a largely man-made adjunct to the natural environment, agriculture is highly exposed to these changes and much of the international climate discourse has focussed on the sector's vulnerability, resilience and adaptive capacity for given projected climate scenarios (Nelson et al. 2009).

While being directly impacted by climate change, agriculture is also a significant source of greenhouse gas emissions, estimated to contribute around 10 to 14% of the total global emissions (Smith et al. 2007a), and approximately a third of total global anthropogenic greenhouse gas emissions if emissions from land use change and deforestation are taken into account (IPCC 2014). Agriculture is also the largest source of non-CO2 greenhouse gas (GHG) emissions (De Pinto et al. 2013). To meet the demands of a growing world population, agricultural production also needs to grow and, in the absence of a step-change in the emissions intensity per unit product, this will almost inevitably lead to an increase in GHG emissions and in the sector's contribution to climate change (The Meridian Institute 2011). Assuming the sector can adapt, one of the most important areas where trade-offs might occur in coming decades is between GHG mitigation and food security.

Agriculture is a conduit for affecting the wellbeing of a large proportion of the world's poorest. But it is also biophysically heterogeneous and institutionally diverse between countries and regions; conditions that complicate the definition of climate-smart interventions. Nevertheless, agricultural systems can be better designed to include farm management measures that combine complementary mitigation, adaptation and food security or poverty alleviation outcomes. These can build on practices and technologies that are already available but need to be tailored to specific contexts including smallholder systems that characterise the sector in many developing countries. A key point is that these actions must offer a net-benefit to farmers and be easily incorporated within farm practice.

These climate challenges overlap a growing concern about global food security, which highlights additional stressors including demographic changes, natural resource scarcity, plus economic convergence in consumption preferences, particularly livestock products. The Food and Agriculture Organisation of the United Nations (FAO) estimates that to meet the demands of a larger population (expected to reach 9 billion by 2050) food supply will need to grow by 60 percent (FAO 2012b). Other estimates suggest an increase of 70–100% (e.g. Godfray et al. 2010). This imperative has led to calls for a new green revolution, or a contemporary equivalent, sustainable intensification (SI), which implies a step-change to do more with less while minimising harmful externalities. The concept of climate smart agriculture (CSA) is arguably nested within the SI concept, mainly addressing the climate dimensions and imperatives and reconciling these with productivity objectives, predominantly in developing countries. How these objectives can be balanced and what they imply for farming systems in developing and developed country farm systems has recently become the focus of much scrutiny.

The following sections explores the concept of sustainable agriculture, and how it can be linked with the adoption of new agricultural practices and modern technologies. The chapter discusses the need for agricultural adaptation and assesses whether the principles and practices for the adoption of new practices and technologies in the developed world are relevant and transferable to the African continent. Further, the chapter discusses the role of extension support in the adoption of improved agricultural practices, and introduces the concept of climate-smart agriculture providing a critical review of the concept and an overview of a number of agricultural practices, which are most commonly branded as “climate-smart”. The chapter concludes with a discussion on Nationally Appropriate Mitigation Actions (NAMAs).

2.2 What is sustainable agriculture?

The definition of sustainable agriculture has changed over the decades and can be expressed in a variety of ways, depending on a context. Sustainable agricultural systems can be low input, organic, biodynamic, free range, and agro-ecological. (Conway 1997; Clements & Shrestha 2004; Cox et al. 2004; Gliessman 2005). However, there is continuing debate about whether agricultural systems using some of these terms can qualify as sustainable, or whether they should possess all of these characteristics in order to be sustainable (Altieri 1995; Trewevas 2002).

One of the most commonly acceptable definitions of sustainable agricultural systems is *systems that make the best use of environmental goods and services while not damaging these assets* (Conway 1997; Gliessman 2005; Swift et al. 2004; Scherr & McNeely 2008; Kesavan & Swaminathan 2008). Agricultural sustainability does not mean that the use of new technologies and practices is not allowed; rather, it can incorporate these as long as they improve productivity and do not harm the environment (Pretty 2008). These new technologies and practices, however, need to be locally adapted.

Sustainable agricultural systems tend to be multifunctional within landscapes and economies (Dobbs & Pretty 2004; MEA 2005), jointly producing food and other goods for farmers and markets, but also contributing to a range of valued public goods, such as clean water, wildlife and habitats, carbon sequestration, flood protection, groundwater recharge, landscape amenity value and leisure/tourism. In this way, sustainability implies a balance between a range of agricultural and environmental goods and services. The uniqueness of agriculture as an economic sector lies in the fact that it is both affected by, and has an impact on, natural, social, human, physical and financial capital, i.e. the very assets essential for its success (Worster 1993).

Innovation is a key component of sustainable agricultural systems, especially considering the level of uncertainty agricultural systems are facing due to the climate change threat and weather uncertainties. The higher the level of social and human assets the higher the ability of agricultural systems will be to innovate in the face of uncertainty (Olsson & Folke 2001; Pretty & Ward 2001). This implies that agricultural sustainability can be achieved through various pathways, comprising various configurations of technologies and inputs, the choice of which will depend on specific circumstances of different agricultural systems.

Despite the common assumption that agricultural sustainability implies a net reduction in input use, thus making such systems essentially extensive (i.e. requiring more land to produce the same amount of food), empirical evidence shows that agricultural sustainability initiatives can be more successful with intensification of resources, i.e. making better use of existing resources (e.g. land, water, biodiversity), and producing more with the same amount of land (Conway & Pretty 1991; Buttel 2003; Tegtmeier & Duffy 2004). The question that arises here is the type of intensification required. Pretty (2008) describes sustainable intensification as "*Intensification using natural, social and human capital assets, combined with the use of best available technologies and inputs (best genotypes and best ecological management) that minimize or eliminate harm to the environment…"* ".

Taking into account the growing world population, and the already significantly manifested negative impacts of climate change, a key challenge, for both developed and developing countries, is to find ways not only to maintain but also to enhance food production, while eliminating any negative side effects. This is a major challenge, as experience shows that both externalities and mulftifunctionality of agriculture have been ignored in agricultural development.

A question that has been addressed many times is productivity trade-offs of sustainable agroecosystems. Productivity is likely to be affected by the need to protect and maintain environmental goods and services, which means more land will be needed to produce the same amount of food, which, in turn, will affect natural capital (Green et al. 2005). Sustainable intensification of all resources could help improve food production; however, this is not always the case. For example, food productivity in organic production systems is lower for both crop and livestock systems (Lampkin & Padel 1994; Caporali et al. 2003).

Technological innovations and adoption of new farming systems (such as integrated livestock/farming systems) and new farming practices could help address this problem (Wilkins 2008). As mentioned above, the idea of agricultural sustainability does not mean rejection of new technologies provided they can improve productivity and not cause undue harm to the environment or increase farmers' vulnerability to risk. Many of these technologies are multifunctional, and could lead to positive changes in several components of the farming system at the same time (Pretty 2008). For example, integrated soil fertility management practice can be significantly improved by using a mixture of organic and inorganic fertilizers, which will increase the water-holding capacity of soils while simultaneously increasing the efficiency of fertilizer use by crops (Evanylo et al. 2008; Toenniessen et al. 2008).

The importance of agriculture to the livelihoods of some of the poorest people on the planet is not better manifested anywhere else but on the African continent. In Sub-Saharan Africa in particular, entire countries depend on the agricultural sector as the main or one of the main contributors to their economy, with the contribution of agriculture to gross domestic production in African countries varying from 10 to 70 percent (World Bank 2008).

More than 750 million people in SSA rely on subsistence agriculture as their main source of food and income, and nearly three quarters of the people depend on farming for their livelihood (FAO 2006; Diao et al. 2007; Toenniessen et al. 2008; World Bank 2008). Despite this huge reliance on agricultural production, Sub-Saharan Africa continues to show a decline in food security and agricultural productivity per capita and an increase in undernourishment since 1990 (FAO 2006).

Unlike in Asia and Latin America, where the introduction of Green Revolution technologies in the 1960s dramatically increased agricultural output, raised farm-level income, and reduced food costs for urban consumers, as well as greatly reduced the incidence of chronic famine and the threat of starvation, the Green Revolution largely bypassed Africa (The National Academies 2010). There was no positive agricultural transformation in SSA (The National Academies 2010). Smallholder farmers in SSA countries did not experience major gains in productivity, as the new technologies associated with Green revolution were aimed at large farms with access to irrigation, inorganic fertilizers, and improved crop varieties, which smallholder farmers did not have, nor could afford. Further the technology development process did not take into account the perspectives and knowledge of African farmers' (InterAcademy Council 2004), which resulted in the non-applicability and failure of many modern agricultural practices that were successful elsewhere. In addition, Green Revolution technologies were not suited for rain-fed environments with depleted or severely depleted soils, which is the case in many SSA countries (Cassman 1999).

With the lessons having been learnt from the failures and successes of the first Green Revolution, many organizations and governments in Africa are now calling for a second Green Revolution (Toenniessen et al. 2008; AGRF 2017; IAASTD 2009), and African Green Revolution Forum (AGFR) was set up with the specific aim of doubling agricultural productivity and increasing farmer resilience to climate change by 30% (AGFR 2017). As they argue, this should take into account local farming systems and the realities of farming in diverse agro-ecological zones, with specific technologies developed to suit various conditions. It should be noted that due to the lack of investment into agricultural research and development, the SSA countries themselves often lack the capacity to adapt modern agricultural practices to local conditions.

There have been numerous studies that documented practical experiences of sustainable agriculture programmes in developing countries. Many of them argued that high priority should be given to developing technologies that limit the use of non-renewable inputs, which can make farmers more vulnerable to input cost fluctuations (IAASTD 2009; Pretty 2008; NRC 2008). However, even if the use of non-renewable inputs is kept at a minimum, small farming systems might still become too reliant on external inputs which will make them very vulnerable to sudden cost increases or shortages. This happened, for example, in 2007, when oil and fertilizer prices reached record highs affecting livelihoods of millions of smallholder farmers (The National Academies 2010). It can also be observed when governments eliminate subsidies on agrochemicals as part of structural adjustment programmes, as was the case in Malawi (Denning et al. 2009).

Despite many successful programs in the development and adoption of innovative sustainable approaches in many resource-poor contexts, there are a number of barriers to more widespread implementation. Despite the proven benefits of the adoption of new technologies in terms of their impacts on yields and farmer livelihoods, there is limited adoption of these technologies, particularly in the global South. The main reason for this is the cost of these new technologies which includes the cost of learning, as well as the cost of new technology and, often, long waiting periods to see the expected benefits as the on-farm biological processes take time to be established (e.g. conservation agriculture, see Section 2.5.5) (Bawden 2005; Chambers 2005; Kesavan & Swaminathan 2008; Firbank et al. 2008; Kibblewhite et al. 2008; Wade et al. 2008).

The second Green Revolution is unlikely to happen without substantial funding from the international donor community. However, last few years showed the decline of the CGIAR Centres, which have been active in promoting programmes focussed on the adoption of sustainable agricultural technologies, due to severe budget cuts. Support has also been decreasing to other development programs and non-governmental organizations (NGOs) such as CARE, Heifer International, Rodale, and to local institutions dedicated to developing innovative approaches in agriculture and natural resource management (The National Academies 2010).

Another major barrier to the adoption of new technology is lack of information and management skills. These barriers prevent millions of farmers to adopt new technologies necessary to improve yields and practice sustainable farming. However, it has also been argued that these farmers should be compensated for conserving environmental goods and services the use of which is associated with intensive farming hence making them more likely to adopt resource-conserving technologies (Dobbs & Pretty 2004). Other significant barriers include lack of infrastructure and high transportation costs that often inhibit access to outside resources and markets.

2.3 The role of adaptation in sustainable agricultural development

In its latest global report, the Intergovernmental Panel on Climate Change set emission reduction targets in order to stop the most devastating impacts of climate change (IPPC 2014). However, even if these are achieved, which seems unlikely at present, climate change will not be reversed for many decades to come (IPPC 2014). Given agriculture's vulnerability to climate change impacts, and the fact that it is an important source of GHG emissions, there is a clear need to balance mitigation efforts aimed at reducing greenhouse gas emissions with robust adaptation strategies. The latter will enable farmers to cope with the effects of climate change and thus safeguard the resilience of agricultural systems (Niles and Lubell 2012; Ostrom and Cox 2010; Reganold et al. 2011).

Climate change is already having a major impact on agriculture and livelihoods of the rural population in Sub-Saharan Africa, by increasing weather-related risk to agricultural production (Kandji et al. 2006). Future projections predict significant yield losses of staple crops in SSA, such as maize, sorghum, millet and cassava (Schlenker and Lobell 2010). Climate change increases vulnerability of the communities depending on agriculture for their livelihoods, due to their limited ability to adapt, and their high poverty levels.

In this context, the importance of building resilient and adaptable systems cannot be overstated. This is particularly the case in Africa, where global climate change is likely to make challenges to agriculture more pronounced (IPCC 2014). IPPC predicts a higher rainfall variability and uncertainty, especially in arid and semiarid areas; and a higher frequency of extreme events like floods and droughts, as well as increase in average temperatures in Sub-Saharan Africa (IPPC 2014). The unpredictable weather patterns will particularly affect the rain-fed systems which is the majority of land in Sub-Saharan Africa.

But what is adaptation in the context of agricultural systems, and how could it be achieved?

Adaptation refers to "*adjustments in ecological, social, or economic systems in response to actual or expected climatic stimuli and their effects or impacts. It refers to changes in processes, practices, and structures to moderate potential damages or to benefit from opportunities associated with climate change*" (IPCC 2001, p. 879)

Along with mitigation, adaptation is also an important policy response option, which could help manage the risks of climate change. Adaptation has the potential to substantially reduce at least some of the adverse impacts of climate change and enhance beneficial impacts. Impact and vulnerability assessments should contain estimates of likely future adaptations. The degree of vulnerability of ecosystems to climate change will depend both on exposure to changes in climate, and on the ability of the impacted system to adapt, i.e. its adaptive capacity or adaptability (Smithers & Smith 1997). In case of communities, the latter is determined by their socio-economic characteristics (TERI 2006). Adaptive capacity could be enhanced in order to help systems and communities to better cope with climate uncertainties, and to reduce vulnerability.

Most systems and communities can reasonably easily adapt to gradual changes in average conditions; however, extreme changes in the frequency and/or magnitude of conditions leave them more vulnerable (TERI 2006).

Traditionally, adaptations have been classified into autonomous, locally-driven (or reactive) adaptations and managed or planned, policy-driven (or anticipatory) adaptation (Smithers & Smith 1997; Smith 1996; TERI 2006). The former involves adapting to the change in prevailing weather conditions and based on experience rather than the awareness of climate change. The type of adaptation also varies depending on the system in which they occur, the climatic stimuli that prompts them, their timing, functions, forms, and effects, as well as on who undertakes them (IPCC 2001).

The majority of human systems have evolved a wide range of strategies to cope with climatic risks, and will tend to adapt autonomously to changes in climate conditions (Smit & Pilifosova 2000). However, when climatic variations and extremes occur, autonomous adaptation is often not sufficient to offset the damages. The ecological, social, and economic costs of relying on reactive, autonomous adaptation to the cumulative effects of climate change can be substantial (Smit & Pilifosova 2000). In this case, vulnerability could be reduced by planned anticipatory adaptation which could be implemented regardless of autonomous adaptation.

Implementation of adaptation policies, programmes, and measures will usually have both immediate well as future benefits. These programmes and measures are not without cost; however, the costs of adaptation often are marginal to other management or development costs, and significantly less than the economic, ecological and social costs to the systems and communities had the adaptation not occurred.

The adaptive capacity of systems and communities varies considerably among regions, countries, and socioeconomic groups, as well as over time. The most vulnerable systems and communities are those with high exposure to climate change effects, and with limited adaptive capacity (TERI 2006). These communities and systems are usually based in countries with limited economic resources, poor infrastructure, low levels of technology, lack of information and skills, inequitable empowerment and access to resources, unstable or weak institutions, as well as climate highly susceptible to the negative impacts of climate change (TERI 2006).

Enhancement of adaptive capacity is a required condition for reducing vulnerability, and this can achieved by implementing initiatives that promote the welfare of the poorest members of society—for example, by improving food security and facilitating access to safe water and other resources (Smit & Pilifosova 2000). Rigorous evaluation of planned adaptation options, measures, and policies requires a good knowledge base. However, there is currently insufficient knowledge of adaptation and adaptive capacity, and although climate change vulnerability studies usually consider adaptation, they usually only go as far as identifying potential adaptation options (NRC 2008). Most current studies do not consider the dynamics of adaptation in human systems, the role of non-climatic factors, and the processes of adaptation decision- making. The existing evaluations of adaptation options mostly focus on economic costs and benefits, which in themselves are not sufficient to determine how appropriate the adaptation measures are (Smit & Pilifosova 2000).

The current knowledge base needs to be expanded to expertly evaluate the feasibility of proposed adaptation initiatives, and constraints and opportunities for enhancing adaptive capacity.

2.3.1 Adapting to climate change via the introduction of novel agricultural practices and technologies

In smallholder systems, adapting to climate change will often require introduction of new or improved practices and modern technologies. Adaptation at a farm level could include use of multiple cropping instead of monoculture, the use of improved varieties better suited to climatic stresses, diversification of farming systems and products to buffer farmer from fluctuating weather and prices. The new systems and practices need to be designed to ensure adequate productivity for short-term survival, but also to prevent yields falling below critical levels over the longer term (The National Academies 2010). Another priority is resource stabilisation, e.g. building soil organic matter and increasing soil nutrient content (The National Academies 2010).

To date, the largest study examining farming systems that adopted sustainable agricultural practices aimed to increase productivity in developing countries has been done by Pretty et al. (2006), who analyzed more than 286 agricultural projects in 57 developing countries, covering 37 million hectares and involving 12.6 million farmers. All of these projects used a variety of "*sustainable farming technologies and practices*" (Pretty et al. 2006). The main objective of this evaluation was to determine the impact of various low-cost and locally available technologies on increasing crop producitivity/farming outputs. Another objective was to analyse the impact of those methods on carbon sequestration, pesticide use and water use efficiency (Pretty et al. 2006).

The findings showed that with the adoption of improved agricultural practices and increased resource availability, crop yields increased by an average of 79 per cent (Pretty et al. 2006). The adopted practices broadly fitted under the tree types of technological improvements: technologies that improved water-use efficiency in both dryland and irrigated farming; technologies that improved organic matter accumulation in soils and carbon sequestration; technologies to manage pests, weeds, and diseases (Pretty et al. 2006). More specifically, technologies used included effective use of locally available natural resources such as water harvesting, conservation agriculture and composting, use of livestock manures, and irrigation management); sustainable intensification and efficient use of non-renewable inputs and external technologies such as improved crop varieties and livestock breeds, non-toxic pesticide sprays, and machinery. Combinations of various practices and technologies showed the greatest positive outcome. In addition, positive results were achieved by developing farmer and community participatory processes, farmer education, improved access to markets, infrastructure, and affordable finance (Pretty et al. 2006).

Technology development is essential in order to provide new tools and practices, which will help increase agricultural production and improve rural livelihoods. 18 high-priority technologies have been recommended by the US National Academies of Science, Engineering and Medicine as most likely to have a significant impact on agricultural productivity in SSA (NRC 2008). The recommended technologies focus on natural resource management, improving genetics of crops and animals, overcoming biotic constraints, and energy production (NRC 2008).

However, it has been recognized that the use of new technology and improved practices is not sufficient in order to improve agricultural productivity, economic security, environmental quality, and social welfare at the same time (IAASTD 2009). One of the most important factors in making any agriculture related research locally relevant and increasing project and programme impact is farmer participation. This can be achieved by consulting with, and involving farmers early on in the design of the project, rather than following the earlier paradigms that tried to fit farmers into the liner top-down structures of research-development-extension. The latter worked well for major cash crops, but had little success with small-scale farms (IAASTD 2009).

There are many other important considerations, which are essential for effective adaptation interventions. These include the need to build appropriate infrastructure, which is often lacking in some of the poorest countries in Africa (Turner et al. 2003; Nelson et al. 2007); strengthening social and institutional networks; greater access to markets; putting into place, or improving postharvest storage and handling facilities to avoid loss and to ensure quality standards of agricultural products (The National Academies 2010).

2.3.2 Farmer perceptions of climate change

Due to agriculture's role in providing food security for some of the poorest people in the world, negative impacts of climate change on the sector can have especially significant and long-lasting impacts (Smit & Skinner 2002). While effective adaptation programmes can greatly reduce vulnerability of most farming systems (Brown & Crawford 2009; Maddison 2007), they cannot have a significant impact without smallholder farmers recognizing that climate change is happening, and is having adverse impacts on their economic livelihoods. As discussed above, adaptation is inherently a response action.

Adaptation can significantly reduce vulnerability to climate change by making rural communities better able to adjust to climate variability, and cope with adverse consequences (IPCC 2001). Whether planned or autonomous, adaptation is usually influenced by socio-economic, institutional, geographical, as well as cultural and political factors (Eriksen et al. 2011). Among these factors, perceptions of climate change and knowledge about climate change can play a major role (Smithers and Smit 2009).

In order to adapt, however, farmers need to perceive that climate change and its associated risks is actually occurring, and affecting their livelihoods. Farmer awareness and perceptions of climate change can be major drivers of change in their practices directly influencing their adoption of adaptation strategies which can help alleviate the negative impacts of climate change (Kalungu et al. 2013). Maddison (2006) argues that perception is a necessary prerequisite for adaption.

Adaptation to changing environments is not new. For generations, smallholder farmers have been implementing and utilizing a range of farming strategies to deal with weather variability (Adger et al. 2007; Nzeadibe et al. 2012). Implementation of these strategies varies based on, amongst other factors, farmer's perceptions of climate change, and their location (Arendse & Crane 2011). Further, as shown by

Adger et al. (2007) the implementation of new practices is often limited due to the lack of knowhow. New climate change adaptation practices often involve the use of innovative technology thus requiring information, knowledge and skills for them to be implemented successfully (Ngigi 2009; Khamis 2006; Nangoma 2008; Nzeadibe et al. 2011; Pangapanga et al. 2012). The latter is limited among smallholder farmers. The lack of knowledge and information is exacerbated by a limited uptake of new technology due to poverty (Tambo & Abdoulaye 2012). However, a number of studies including by Maddison (2006, 2007), Nhemachena and Hassan (2007), Onyeneke and Madukwe (2010), and Ozor and Cynthia (2010) suggested that a free extension advice on climate change supported by the government and non-governmental organisations, as well as community groups and farmer based organisations, can play a crucial role in promoting adaptation and increasing update of adaptation practices, by improving farmer knowledge and awareness.

SSA is a region known for a large deficit of information and knowledge on climate change amongst rural farmers (McSweeney et al. 2010). In terms of climate change awareness, African countries have been rated as the least aware in the developing world (Pelham 2009), which can clearly have a negative impact on the adoption of appropriate adaptive technologies (Kalungu et al. 2013).

A number of recent studies looked at the farmer perceptions of climate change in Africa, and how they affect and shape adaptation strategies (see, for example, Bryan et al. 2010; Kristjanson et al. 2012; Nyanga et al. 2011; Osbahr et al. 2011; Rao et al. 2011 and Silvestri et al. 2011). According to several of these studies, farmers' adaptation behaviour is often shaped more by their perceptions of climate change, rather than by the actual climate patterns (Adger et al. 2009; Mertz et al. 2009). In a study conducted in the Sudano-Sahelian zone of West Africa Mertz et al. (2010) reported that 30–50 percent of respondents stated perceived climate changes as a reason for making changes to their farming practices. Bryan et al. (2013) reported that 80 percent of farmers consulted in Kenya stated changing their practices in response to perceived climate changes. Nyanga et al. (2011) also found that smallholder farmers' adoption of conservation agriculture in Zambia is significantly associated with their perceptions of climate change.

A number of climate change models have been developed which visualize potential future outcomes and pathways and evaluate options for potential adaptation to climate change (McSweeney et al. 2010). These models are often used for planning and decision making at the national level (Crane 2010; Ziervogel et al. 2008). The models, however, do not adequately (if at all) address smallholder knowledge and perceptions which are used to make informed decisions on how to respond to climatic variability at the local level (Eigenauer 2004). Many authors (e.g. Archer et al. 2008; Ogalleh et al. 2013) agree that smallholder practical knowledge of climate change can help to generate locally applicable climate forecasts and determine which adaptation strategies are most suitable for specific localities.

The next section discusses the role of extension support in informing and building the adaptive ability of smallholder farmers to effectively adapt to, and mitigate climate change.

2.4 The role of agricultural extension support in facilitating the adoption of improved agricultural practices, and smallholder farmer adaptation to climate change

Agricultural extension has always played a key role in promoting knowledge, information and skills, which could help change farmers attitude, especially when adopting new programmes and initiatives (Rivera & Qamar 2003; Spielman & Davis 2008). Extension organisations usually provide information and knowledge covering a wide range of activities, such as production of crops, raising of livestock, agroforestry, health and sanitation, climate change adaptation, gender and literacy (Chowa et al. 2013). This information is delivered via different methods such as field demonstrations, village meetings, field days, classroom training programmes, and radio messages. Extension agents also use informal, interpersonal communication channels to help smallholders change their attitudes and behaviours (Chowa et al. 2013).

The main aim of agricultural extension systems is to link people and institutions to promote learning and to generate, share and use agriculture- related technology, knowledge and information (FAO 2001). According to one of the oldest interpretations, the "*only purpose of agricultural extension is to disseminate information to raise the production and profitability of the farmers*" (FAO 2001). In reality, however, agricultural extension provides a whole range of agricultural development tasks, such as credit, supplies, marketing, as well as access to markets (agricultural process development).

Various definitions of agricultural extension exist, with most of them emphasizing an educational dimension. Most recently, Ozor and Cynthia (2011), and Leeuwis (2004) defined agricultural extension as a "*series of embedded communicative and educational interventions that are meant among others to develop and/or induce innovations that supposedly help resolve problematic situations*". Davis (2009) defined agricultural extension as "*the entire set of organizations that support people involved in agrarian production and facilitates farmer efforts and other players in the agricultural value chain obtain information, skills, and technologies to improve their incomes*" (p.2).

The organisations involved in extension work can be government agencies, NGOs, producer organisations (such as Milk Bulking Groups in Malawi, see Chapter 3), other farmer organisations, as well as private sector actors (Davis 2008).

Extension services should not be viewed as a linear, technology transfer approach (Mkisi 2014). In the last decade, there has been a shift towards recognizing the multiple roles of extension services, which makes them more responsive to farmer demands (Garforth 2011).

Traditionally, a variety of agricultural development goals were achieved through agricultural extension (Mkisi 2014). As reported by Swanson and Rajalahti (2010) achieving food security in many countries has been facilitated by agricultural extension promoting technology transfer for food crops and farmer capacity building in proper use of natural resources. Another role of agricultural extension has was helping smallholder farmers increase their farm income thus improving their livelihoods; this goal was often achieved through organising farmers into producer and community groups, and diversifying their production systems (Swanson & Rajalahti 2010). Additionally, extension services often served as a link between smallholder farmers and agricultural research institutions, which has proven very useful for adopting improved practices for climate change adaptation (Mkisi 2014).

Increasingly, in the context of climate change impacts on agriculture affecting farming livelihoods, agricultural extension is beginning to play a prominent role in the dissemination of knowledge on climate change and adaptation practices. There is a need to provide farmers with wide-ranging advice on improved farming practices, which can increase farming profits while not posing additional risks (FAO 2013a). Farmers need two types of advice: firstly, advice on available adaptive farming practices, including technology and market, and secondly, advice on climate change and weather variability, including seasonal weather forecasts (FAO 2013a).

A number of studies on the role of agricultural extension in crop production and productivity have indicated that extension has had a positive impact on productivity and knowledge acquisition, via, for example, farmer field schools as an agricultural extension approach in East Africa (Davis et al. 2010), and increasing farmer awareness and adoption of soil management technologies in Kenya (Bunyatta et al. 2005). These studies show that agricultural extension is an important tool not only for promoting agricultural growth but also for promoting climate change adaptation practices (Maddison 2007; Nhemachena & Hassan 2007; Onyeneke & Madukwe 2010; Ozor & Cynthia 2010).

Further, studies conducted in a number of countries in Sub-Saharan Africa and South East Asia have shown that often climate change adaptation initiatives and programmes are often not adopted because of the lack of good extension support (Pangapanga et al. 2012; Khamis 2006; Nangoma 2008; Nzeadibe et al. 2011).

In a study conducted in Malawi by Msiki (2014), smallholder farmers in Central Malawi were asked about the role of agricultural extension in building smallholder farmer capacity to adapt to climate change. There was a general agreement on the importance of extension support in raising awareness of climate change and its impacts on farming activities, providing information and training farmers on new adaptation technologies, providing information on new drought and disease resistant crop varieties and livestock breeds. All these activities have a potential to increase adaptive capacity of smallholders.

Idrisa et al. (2012) have shown that exposure to extension training programmes can positively influence the adoption of agricultural technologies. The adoption of new technologies is also affected by accessibility of extension services as well as frequency of interactions between smallholder farmers and extension personnel (Mazvimavi & Twomlow 2009; Sarker et al. 2008). It is important that extension support and training is delivered both through government supported extension programmes, and through non-governmental organization based extension services (Mazvimavi & Twomlow 2009; Sarker et al. 2008).

In order to operate efficiently, extension services need access to resources such as technical knowledge, skills, and information (Eisenack & Stecker 2011). These resources, in turn, can influence smallholder behaviour and enable smallholders to implement adaptive activities (Ziervogel et al. 2008). Effective extension services can help smallholder farmers overcome barriers to adaptation, which have been described as "*a set of conditions that hinder the implementation of specific adaptation but are not necessarily absolute limits to adaptation*" (Eisenack & Stecker 2011, p251).

Today, extension services are provided through public sector, civil society and private sector institutions (FAO 2013a). The public sector institutions through which extension support is delivered stretch from national ministries (primarily Ministries of Agriculture) to regional, sub-regional and local offices (FAO 2013a). The public sector extension support is top-down in structure, and hence less likely to attend to the needs of specific farmer groups when formulating their extension advice. On the other hand, civil society institutions are more horizontal in their structure and are generally better placed to foster bottom-up engagement (FAO 2013a).

Due to general decrease trend in public investment in agricultural extension, most extension systems have a short-term, project-based, more localized approaches to extension (FAO 2013a). On one hand, this tendency towards localized projects is fitting given that Climate-Smart Agriculture (Section 2.5) needs context-specific solutions. However, a project-based approach to extension support makes it more difficult to ensure consistency and long-term continuity across projects.

2.5 Climate-Smart Agriculture: A critical review

2.5.1 **Background and definitions of CSA**

The term CSA was first coined by FAO as '*agriculture that sustainably increases productivity, resilience (adaptation), reduces/removes GHGs (mitigation), and enhances achievement of national food security and development goals*" (Lipper et al. 2010, p.ii). The concept nominally addresses the challenges of climate change in agriculture while simultaneously trying to increase food security. In that respect, the concept is not dissimilar from the concepts of climate resilience, and climate compatible development (CCD) which articulate the same idea of a single policy with multiple benefits for climate change adaptation, mitigation and development (Tompkins et al. 2013); unlike the other, broader concepts, however, CSA has a specific focus on agriculture unlike the other, broader concepts.

CSA encompasses a variety of farm practices including soil management, crop selection, livestock management and energy use measures (Table 2.1). Note that there is no definitive taxonomy of CSA measures for the food supply chain (i.e. within and beyond the farm gate). Instead, CSA interventions will be as varied as the diversity of farm regions, with applicability varying according to the type, location and scale of the production system. To some extent many of these measures have long been part of traditional farm practices in many parts of the world (Richards et al. 2014). In terms of implementation, measures should be judged by clear criteria of technical and cost-effectiveness (or economic efficiency) and social acceptability. While there is a general view of these measures applying within the farm gate, the use of some (e.g. reduced use of synthetic fertiliser) will imply wider supply chain effects that need to be incorporated into any evaluation of CSA costs and benefits.

Steenwerth et al. (2014) provides an extended definition of CSA, including provision for food security, poverty reduction and contributing to economic development. The authors also mention increasing productivity and resilience of agricultural ecosystem functions, as well as negotiating trade-offs in meeting these objectives. In this definition CSA is described as a continuous process of adaptive management in which stakeholders, researchers and policymakers come together to meet the challenges of climate change and help transform agricultural and food systems towards sustainability goals. This is obviously a more aspirational long-term agenda, which is less specific about what measures to apply where, and what transformation actually means in developed and developing country food systems. Nevertheless, a major focus is on smallholder farmers in developing countries as a group in most need to increase food security.

Table 2.1 Examples of potential CSA measures

Measure	Adaptation/Resilience	Mitigation	Productivity
On-farm tree planting	Shelter/shade for livestock	Carbon sequestration	Reduced heat stress for livestock
Planting hedgerows and buffers	Preventing drought through reducing run-off	Carbon sequestration	Avoided pasture/crop loss
Soil management practices	Increased crop/pasture resilience	Increased soil organic Carbon	Avoided pasture/crop losses
Manage animal health and disease	Avoid disease outbreaks	Unwell animals are less efficient and emit more methane per unit	Avoided mortality and illness
Diet management	An appropriate diet can reduce heat stress	Appropriate diet can reduce methane emissions	Avoided mortality or reduced production
Natural flood management (e.g. woodland and peatland restoration, riparian planting)	Reduced flood damage	Carbon sequestration	Avoided or reduced pasture/crop/livestock loss

CSA has gained significant traction among governments of developing countries, as well as bilateral and international donor agencies. In the latter case the concept has fitted seamlessly into the overlapping space between aid for rural poverty, pro-poor climate (adaptation) assistance and sustainable development more generally. CSA projects around the world have been facilitated by FAO and the World Bank and their partners. The importance of the approach on the global agricultural development agenda has been endorsed with the foundation of the Global Alliance on Climate-Smart Agriculture launched in September 2014 at the United Nations climate summit. The Alliance was set up as a '*voluntary, farmer-led, multi-stakeholder, action-oriented coalition committed to the incorporation of climate-smart approaches within food and agriculture systems*' (Climate Summit 2014).

Despite these developments, the CSA concept has come under critical scrutiny from major Non- Governmental Organizations (NGOs), charities, some farmer organisations and governments. Criticism has focussed on the potentially disproportionate emphasis given to mitigation in CSA, the focus on growth, and the long-term sustainability of the entire approach. There is also concern regarding the perceived misappropriation of the term by multinational agribusinesses seeking to rebrand existing practices under a more benign label taking advantage of the fluidity of definitions and lack of criteria (e.g. Civil Society 2015), where CSA can mean everything and nothing simultaneously (Lilliston 2015). Some opponents of CSA suggest that the concept of '*agro-ecology*' has a more established scientific grounding, and responds both to climate change and wider environmental and social challenges facing agriculture (Civil Society 2015). When it comes to smallholder systems, there is also a more mundane debate about whether CSA measures can or will, as assumed by some aid donors, actually be adopted, and whether specific information and incentives need to be improved to increase uptake. This is reminiscent of an older debate on technology adoption in global agriculture, drawing attention to the need to consider the nature of supply chains beyond the farm gate and how these can influence the on-farm choices made by farmers.

2.5.2 **CSA critique**

The appeal of CSA as a driving concept by the range of organisations and governments described previously is largely due to the inclusivity of the term and its broad aims. The promotion of productivity as a pillar alongside mitigation and adaptation accords with a productivist market-oriented focus for the sector that is common in most developed countries but is also recognized as a priority in many developing countries suffering from chronic food insecurity and famine. An acknowledgment that this agenda can easily accommodate climate change obligations and challenges without radical policy changes means that the term is politically palatable, or at least unthreatening to the agricultural lobby. At the same time, the vagueness of the term allows a broad range of stakeholders to take ownership, at least nominally.

The main objectives of CSA throw up individual critiques that warrant scrutiny for their practical, political and ethical framing in both developed and developing counties; more generally because agriculture is often seen as exceptional when it comes to addressing climate change. Fundamentally agriculture is exceptional in the sense that it comprises thousands of small businesses each working in biophysically different and often challenging conditions, with individual farmer behaviours driven by a diversity of economic and social motives. These conditions mean that there is considerably greater uncertainty about the technical effectiveness of either mitigation or adaptation measures when applied in some farming conditions. This also implies that governments tend to avoid regulation that can be costly to implement and monitor for an uncertain outcome.

Exceptionalism has also been used to argue that GHG mitigation cannot be a priority for farmers in a world where food production arguably needs to increase. This argument would possibly be more robust were there a more even distribution of current production, or if there were less food waste (see Box 1), but the logic has nevertheless gained considerable traction among politicians in many countries with strong agricultural lobby groups. Much the same argument can be made for diverting existing support or development assistance towards agricultural adaptation, which can be branded as climate-smart, while apparently targeting food and livelihood security. Both arguments are possibly worth challenging in the sense that most adaptations and some types of mitigation are often in the best self-interest of any individual producer. That is, adaptation measures aim to avoid losses resulting from climate impacts, and some mitigation measures are demonstrably win-win in terms of saving input costs and reducing emissions (or vulnerability). Perhaps the more subtle essence of CSA therefore is to identify specific current or future double or triple-win measures, and to tease out where climate and production objectives can be adopted as part of current or traditional ‘good’ farm practice. Put another way, the main emphasis of CSA is about overcoming a form of information failure that impedes the adoption of relevant measures. Resolving this failure is a shared objective of both public and private sector stakeholders.

Box 1

The role of food security and post-harvest food waste in developing countries

Increasing food security is recognized as the most important goal of climate-smart agriculture in the developing world (Lipper et al. 2010). Agricultural yields in many developing countries, particularly in Africa, are very low, hence the common approach is to expand onto marginal and forest lands to increase the land cover for agriculture (Pye-Smith 2011). However, there is still vast potential for increasing productivity in the current land (Godfray et al. 2010). CSA aims to increase yields without expanding the agricultural land area, by achieving higher efficiency and productivity per hectare. This can be a significant means of jointly achieving mitigation and food production in agriculture, providing that the resulting spared land sequesters more carbon or than farmland (Wollenberg et al. 2011).

However, it is recognised that future food security will largely depend on the rate of yield gains for major cereal crops which will require constant improvement in crop yields (Fischer and Edmeades 2010). This will not be easy to achieve, considering that the growth in yields has been slowing down, from about 3% a year for staple crops in the 1960s to around 1% currently (Sasson 2012; Grassini et al. 2013). Further, intensification, however sustainable, can potentially cause environmental impacts that could weaken capacities to produce food in the long-run (Wollenberg et al. 2011). In many cases intensification and efficiency can lead to local expansion of agriculture by creating incentives for expansion, especially if increased demand for production is possible and labour is available (Angelsen 2010; Rudel et al. 2009). On the other hand preventing agricultural expansion without providing alternative sources of livelihoods for subsistence farmers could exacerbate poverty (Wollenberg et al. 2011).

Another important fact to consider is that increasing food production does not necessarily lead to food security. In 2011, FAO reported global annual loss of 1.3 billion tons of food, as well as food losses in Sub-Saharan Africa exceeding 30% of total crop production (Gustavasson et al. 2011). Other reports show that currently *there is enough food produced to feed the entire world population, had it not been for the food waste (World Food Programme 2015).*

Postharvest management at farm level is the critical starting point in the agricultural supply chain. Every year, millions of smallholder farming families are affected by food insecurity caused by poor postharvest practices and inefficiencies which represent one of the largest contributing factors to food insecurity in the developing world (Costa 2014).

Improvements in this sector could have a direct impact on improving food security and rural livelihoods. Overall, with a relatively modest investment, supply chain efficiencies can achieve multiple objectives, post-harvest loss (PHL) reduction being just one of them (additional benefits will include improved income, as well as food safety and quality) (Costa 2014). Considering that there is no evidence to suggest that the growth approach which forms an intrinsic part of the concept of CSA, could be the solution to the climate problem, rather than its cause, it is likely that promoting food security through PHL reduction can be more cost effective as well as sustainable in the long term than a corresponding increase in production (The World Bank 2011).

In the context of emissions mitigation the aforementioned arguments tend to be common in both developed and developing countries. Traditionally, climate change mitigation has not been a driver of farmers' decisions, and it is unlikely to become a major driver in the future, especially if mitigation efforts do not lead to short-term increases in income or welfare (Mbow et al. 2014b). In developed countries, where agriculture is an important contributor to the economy (New Zealand and Ireland being specific examples), but a significant source of emissions, mitigation obligations tend to be resisted because of their perceived potential effect on production. Here the rhetoric tends to focus on increased efficiency and thereby reducing emissions per unit of product (i.e. emissions intensity) rather than attempting to reduce overall emissions from the sector (e.g. New Zealand Agricultural Greenhouse Gas Research Centre 2014). While efficiency is undoubtedly laudable, some evidence suggests that any emissions savings from efficiency will likely be offset by increased production, the so-called Jevons' Paradox (Alcott 2005); and ultimately, emissions need to fall in absolute terms if dangerous climate changes are to be prevented (IPCC 2014). These countries argue further that if they reduce their (efficient) production, other, less efficient producers will simply fill the supply gap leading to an increase in global emissions, the carbon leakage argument (Lee et al. 2006). Meanwhile, as noted, low income countries, particularly those with subsistence farmers who struggle to meet their own food requirements, also argue that mitigation as a largely global problem is less urgent than national food security. In these countries, farmers are unlikely to get involved in any mitigation activity that involves investing resources or labour unless this activity is either profitable without any investment, or is subsidized (Mbow et al. 2014b).

In this regard there is concern among some organisations (e.g. see Civil Society statement signatories, Civil Society 2015), that development aid is being repackaged and made conditional on projects being climate-smart and meeting all three pillars of CSA, leading to increased vulnerability among smallholder farmers.

Further, there are also issues with the scale of mitigation activities. For significant mitigation impact, measures need to be implemented over a large land area, or have a high impact per unit of activity (Havemann and Muccione 2011). As the majority of smallholder farmers (particularly in Sub-Saharan Africa) farm on a land under 2ha, any mitigation activity they could adopt is unlikely to generate significant volumes of mitigation per individual farm (Havemann and Muccione 2011). Here, aggregation will be a key; this, however, raises additional questions with regards to conflicts over land and the security of land tenure (Sharma and Suppan 2011). With respect to the latter, concerns have also been raised about the sustainability of climate-smart investments by smallholders who might have insecure land tenure. This often prevents them from obtaining credit necessary to become involved in or to sustain a CSA activity and securing potential benefits from CSA projects in the long term (Hilger et al. 2013; McCarthy and Brubaker 2014).

The lack of conceptual clarity extends to some of the defining practical attributes of CSA and the nature of policies to achieve balanced outcomes or to mediate trade-offs between the objectives. The issues are both spatial and temporal. The spatial challenge relates to whether the three objectives need to apply simultaneously at the farm scale, or whether within-sector specialisation can occur to allow some producers to focus on increasing mitigation potential and others to focus on intensive production. The temporal challenge relates to the timescale over which goals are considered, which may alter the outcome of the measure. For example, practices that increase productivity in the short term may be unsustainable in the longer term, possibly even leading to reversals in productivity, particularly if adaptation or resilience are not also considered. Alternatively, measures to increase soil carbon may reduce emissions in the short term but may be less stable over the longer term once carbon storage has reached a saturation point, usually within 20 to 100 years, after which net emissions from the sector will increase (Climate Focus 2011). This leads to question over the technical mitigation potential of a carbon sequestration activity.

A further institutional issue is how farmers are rewarded for above baseline (or business as usual) activities such as carbon sequestration. On current evidence many farmers are resistant to climate change arguments and there is limited evidence on real double or triple wins. Accordingly there is a need for some incentive to adopt climate-smart measures. Since most of agriculture is currently outside existing carbon markets, activities need to be developed in relation to the voluntary carbon market or in anticipation of public (i.e. government) payments for ecosystem services. In either case there is a need for baseline information and institutions to monitor, verify and report (MRV) on performance in terms of inputs or outcomes. Such institutions have yet to be developed in any country although there is considerable on-going research to develop simplified farm calculators for emissions.

MRV in climate-smart agriculture can be a challenge when attempting to measure the mitigation benefit across a large population of smallholders. This can be highly complex and uncertain depending on the accurate accounting of land area involved and uncertainty arising from emission factors attributed to mitigation actions and other factors (FAO 2012b; Havemann and Muccione 2011). There is a general lack of consensus on measurements in CSA particularly when it comes to choosing quantitative indicators, as resource limitations prevent more thorough comparisons on the advantages of any particular system. The lack of an agreed MRV methodology as common basis for the offset credits (Sharma and Suppan 2011), and international understanding of MRV concepts and practical design is limited (Sharma and Suppan 2011; Climate Focus 2011). All this leads to large uncertainties with quantification (Gattinger et al. 2011). Another issue associated with MRV is financing. With no current consensus on the MRV for international financing, all future decisions in this regard are likely to affect the costs and viability of different agricultural mitigation activities (FAO 2012b).

It is also important to consider the cultural/gender context in which CSA activities promoted. Some activities, such as conservation agriculture, might lead to an increased burden due to an increased labour for weeding which is traditionally done by women in many African countries (FAO 2013d). CSA practices are unlikely to be sustainable in the long-term if they do not take these issues into account at the project design stage.

Finally, despite the guiding FAO principle with respect to CSA being the 'no-regrets' approach (FAO 2013a), as with any project, there is always a risk that a CSA project will fail. As smallholder farmers have neither an asset base nor surplus capital to offset risks from project failure (such as unexpectedly low returns, delayed returns or high labour requirements) they can only commit to long-term participation in CSA projects if their exposure to project risks is minimised (Shames et al. 2012). However, project failure risks are usually not assessed at the design stage of most CSA projects.

2.5.3 Current application of CS measures

All climate-smart (CS) measures face multiple challenges because of their inherent complexity (Shames et al. 2012). However, despite numerous donor-funded climate-smart projects that are being implemented globally, there is limited evaluation evidence to judge the outcomes (Westermann et al. 2015). Most of the available literature reports only anticipated outcomes rather than actual results, partly due to many of the projects still in the implementation stage. To date the majority of this evidence comes from projects implemented in Sub-Saharan Africa. The examples below discuss some of this evidence.

2.5.4 The role of conservation agriculture

Conservation agriculture (CA) is promoted as one of the most important, triple-win, CSA practices, and includes the three core principles of minimum soil disturbance; permanent soil cover; and crop rotation. CA has been shown to reduce soil erosion and retain water in the soil, hence leading to higher crop yields (McCarthy and Brubaker 2014). However, emerging evidence shows that the ability of CA to achieve higher yields and sequester carbon is highly site-specific, dependent on the weather, fertiliser, as well as herbicide and labour availability (Andersson and D'Souza 2014; Thierfelder et al. 2012; Giller et al. 2009) (see Box 2). In Malawi, for example, nearly three-quarters of CA promotion projects promote the use of herbicides to save labour (due to the increased need to do weeding), despite their high cost and limited availability (Andersson and D'Souza 2014), which leads to questions about the role of partnering herbicide companies in these projects (Ito et al. 2007). Adoption of CA involves long-term investment costs including purchase of necessary tools (such as hand tools, animal traction or tractor equipment, particularly for direct seeding and planting in non-tilled soil), which are not readily available in many markets in SSA (Meybeck and Gitz 2012), as well as high opportunity costs due to diverting residues from other traditional uses (e.g. the use of crop residues as feed for animals). More importantly, while CA sometimes increases yields in the long term, farmers may need to wait 3 to 7 years (some studies suggest up to 10 years) to see yield increases (Richards et al. 2014; McCarthy and Brubaker 2014). Overall, the evidence suggests that CA can often generate negative outcomes including no yields or even reduced yields for the first 5-10 years of practicing (Gattinger et al. 2011; McCarthy and Brubaker 2014), while the high costs of adoption affect projects from early on. In addition, benefits of adoption are highly dependent on agro-ecological conditions and sustained investments (Pervin et al. 2013).

Further, the role of CA in carbon sequestration has been questioned as evidence is lacking or inconclusive (Andersson and D'Souza 2014). Even if benefits do occur, they are restricted to the upper 10 cm of the soil, while no sequestration – or even a carbon deficit – has been found at soil depths below 20 cm (Gattinger et al. 2011).

In summary, agricultural carbon sequestration projects (Boxes 2 and 3) require a significant up-front investment associated with employing scientists, consultants, and field surveyors to be deployed in monitoring, reporting and verification activities (Shames et al. 2012), as well as purchasing seeds, fertilizers and tools and equipment if necessary[6]. The benefits in terms of increased yields, however, might be achieved several years later, and carbon revenues (however small) can be received only after carbon is certified (Shames et al. 2012).

Box 2

Conservation agriculture in Malawi and Zambia

Conservation agriculture is widely promoted in Malawi and Zambia, largely due to it being a "donor-approved" practice supported by FAO and other donors. In 2012, FAO-EC introduced a €5.3-million three-year programme "Climate Smart Agriculture: capturing the synergies among mitigation, adaptation and food security". The aim of the programme was to strengthen technical, policy and investment capacities of its three partner countries – Malawi, Vietnam and Zambia - to enable sustainable increases in agricultural productivity and incomes, resilience of agricultural and food systems to adapt to climate change and opportunities to reduce GHGs in order to meet their national food security and development goals (FAO 2014). One of the flagship projects of this partnership was the promotion of conservation agriculture in Malawi and Zambia.

Initial project findings showed that many farmers in the two countries had difficulties adopting CA, with reasons including the need to use crop residues for animal feed instead of soil cover, and many of the farmers being too poor to wait for the promised increases in yields for at least several seasons (FAO 2014, 2013e). Although the adoption rates of CA in Zambia are relatively higher than

[6] *For the duration of the project, these costs are usually born by the donor organisation promoting the project*

other Sub-Saharan African countries, these are still lower than expected (with high dis-adoption rates) (Kaczan et al. 2013). The findings showed only modest evidence of yield benefits, as well as financial and livelihood benefits, which are only achievable in medium to long-term (Kaczan et al. 2013). The findings also showed considerable constraints to the adoption of conservation agriculture in both countries with the most important being labour constraints resulting in a very limited adoption of the practice.

Box 3

Agricultural carbon from smallholder farmers in Kenya

The Kenya Agriculture Carbon Project (KACP) is the flagship World Bank project on agricultural carbon finance in Africa, which was set up in 2010 to increase agricultural productivity and encourage private sector investment in agricultural enterprises, with the addition of a carbon component (World Bank 2012-2014). Carbon sequestration activities include various elements of conservation agriculture including reduced tillage, residue management, targeted application of fertilizers, and agroforestry. The project aims to provide technical support to about 60,000 farmers aggregated in farmer groups, managing a total of 45,000 hectares in the Nyanza and Western provinces in Kenya. The project is implemented by the Swedish Cooperative Center, ViAgroforestry, and uses an input-based carbon-accounting methodology.

According to the World Bank, the use of improved agricultural practices for this project could potentially sequester about 60,000 tons of CO2-equivalents per year, with the added benefits of increased yields and incomes, and reduced vulnerability (The World Bank 2012-2014). The carbon credits generated by this project are to be purchased by the BioCarbon Fund - a public-private initiative administered by the World Bank.

However, the evidence shows that the targeted number of farmers has not been achieved, with the target subsequently being revised downwards (Lang 2011). The total financing for the project amounted to US$2.5 million, 40% of which will go to various intermediaries in transaction costs. However, farmers involved in the project would receive an average of around US$1 per year over 20 years. Further, the exact amount of carbon that will be sequestered is still uncertain (Lang 2011). Although the World Bank reports stated that the main benefits will be increased yields (in the long-term) and reduced vulnerability to climate change, rather than the carbon payments, the failure to get many farmers on board of the project, and the increasing dropout rate shows that the dominant donor -driven narrative about "triple wins" does not always resonate well with local circumstances (Atela 2012; Sharma and Suppan 2011).

2.5.5 Agroforestry practices as a climate-smart approach

Agroforestry (AF) is another farming technique that is well aligned with the goals of CSA. Agroforestry refers to land use practices in which trees and shrubs are integrated with agricultural crops (Branca et al. 2011). The practice offers potential synergies between food security and climate change mitigation (Mbow et al. 2014b).

Multiple benefits of agroforestry have been documented including increase and diversification of farm income, minimizing the effects of extreme climate events such as erratic and heavy rains and droughts, prevention of erosion, improvement and enrichment of land (Meybeck and Gitz 2012). Overall, a successful agroforestry system can help farmers adapt to climate change, improve their livelihoods by increasing yields and diversifying their incomes, and sequester significant amounts of carbon via extended tree cover (Mbow et al. 2014b).

In comparison with other practices (such as afforestation, deforestation, and improved grassland management practices), agroforestry is also less likely to have a negative effect on other ecosystem-services such as biodiversity conservation, or water cycle regulation (Mbow et al. 2014b; Ravindranath 2007). However, while the benefits of agroforestry have been well-documented in several parts of the world, there are a number of technical, economic and social issues that often prevent its widespread adoption by farmers (FAO 2013d).

Box 4

Natural regeneration in Niger

Eighty-four percent of the population in Niger depends on agriculture for survival and half the population has a low level of food security (Pye-Smith 2011). In the 1990s, the government revised its forestry regulations, giving farmers the right to decide how to manage trees on their land. Farmers started planting Faidherbia albida, a tree which is known for improving soil fertility. Other species of trees were also planted providing fruit, fodder for livestock and fuelwood. This tree expansion programme spread, resulting in a major transformation of landscapes, especially in the Maradi and Zinder regions of Niger. After more than two decades, over 5 million hectares of land have been transformed, benefiting 4.5 million people. In participating areas, sorghum yields have increased by 20-85 percent, millet yields - by 15-50 percent. The trees diversify farmers' incomes and provide alternatives to famine in case of drought. The system is also sequestering significant quantities of carbon (although this has not been quantified), mainly due to its aggregated impacts and helps farmers adapt to climate change (Pye-Smith 2011).

Box 5

Natural regeneration in Ethiopia

In Ethiopia, the over-exploitation of forest resources has affected more than 95 percent of the country's native forests (Pye-Smith 2011). Deforestation has caused severe erosion resulting in floods and affecting groundwater reserves which provide people with potable water. In Humbo region in Ethiopia where the majority of the population depend on agriculture for their livelihoods, an increased occurrence of droughts and floods both as a result of climate change *and as a consequence of reduced tree cover can increase vulnerability. Humbo Assisted Natural Regeneration Project, facilitated by World Vision and the World Bank, established seven cooperatives to sustainably manage and reforest the surrounding land. Since the start of the project, more than 90 percent of the Humbo project area has been reforested using the Farmer-Managed Natural Forest Regeneration technique. This has resulted in increased production of wood and tree products, as well as fodder, and an increase in incomes. Furthermore, the regeneration of the native forest has led to reduced soil erosion and flooding, and provided an important habitat for the local biodiversity. Due to the project's mitigation impact it has become the first large-scale forestry project in Africa to be registered with the United Nations Framework Convention on Climate Change (UNFCCC).*

Although not originally intended as climate-smart, the examples in Box 4 and Box 5 highlight that buy-in and ownership by local communities is essential for any climate-smart project to be sustainable and successful in the long run. It is clear that economic, social, cultural and environmental trade-offs are unavoidable in order to achieve climate-smart outcomes. But following an integrated approach, some of these practices can increase long-term productivity, create synergies between adaptation and mitigation initiatives and reduce the necessary trade-offs (Bromhead et al. 2013).

In all the examples above, the temporal scale of evaluation is important, i.e. whether sustained adoption actually occurs (Coe et al. 2014). There have been recorded cases of pseudo-adoption, where farmers adopted a technology only for the duration of the project (Kiptot et al. 2007). Pseudo-adoption of various technology options is relatively easy to achieve, while donor funding and project associated benefits are in place. Sustained adoption, however, may require more significant changes beyond the farm gate including changes in access to the markets and market function, service delivery, as well as institutional and policy changes to create a more enabling environment (Van Ginkel et al. 2013).

2.6 Policies and institutions for achieving Climate-Smart Agriculture

The policy context is extremely important for agricultural development and food security in Africa (Pretty 2008). Policy decisions have the potential to affect millions of smallholder families. Policy instruments could be used to subsidise agricultural inputs in a number of African countries, and could have a major impact on the levels of food production, and hence, smallholder livelihoods (Pretty 2008). One example are the subsidies provided for fertilizers and other agricultural inputs in Malawi. Removal of these subsidies following structural adjustment led to a decline in production, and the subsequent need to reintroduce the subsidies in order to avoid widespread hunger (Denning et al. 2009). Subsidising agricultural inputs, however, cannot be sustainable as a long-term approach, and other measures, such as providing incentives for introducing soil improvement and water-saving approaches will be needed in the near future (The National Academies 2010).

Further, the majority of African countries lack well-funded and well-equipped research and education institutions (World Bank 2008). For example, China and India tripled their investment in agricultural research over the past 20 years, but in Sub-Saharan Africa it only increased by one-fifth (The National Academies 2010).This is a particular problem because due to their intrinsic agroecological complexity, the farming systems in SSA are less able to benefit from international technology transfers (World Bank 2008). A major investment in institution building and education will be necessary to advance African agriculture (InterAcademy Council 2004). Improving education of research and extension personnel in particular is a critical element in improving agriculture in Africa (World Bank 2008).

Overall, adaptation in agriculture requires an integrated approach which should consider the specific goals and objectives of farming households; how farming practices might be affected by farmers access to land, inputs, and irrigation; the structure of agricultural input and output markets; and the prevailing policy environment (FAO 2013a). It will be essential to keep in mind that to agriculture has multiple functions beyond food production, such as improvement of livelihoods, provision of ecological services, as well as the maintenance of social and cultural traditions (The National Academies).

Even provided all the enabling factors for introducing climate-smart practices are in place at the farm level (including the farmer willingness to embrace these practices), this will be impossible to achieve without strong institutional and policy support, which is needed to make the transition to CSA (FAO 2013a). Existing policies and institutions are inadequate for making this transition.

CSA cross cuts the existing agricultural policy landscape that has historically focussed on production in both developed and developing countries. Climate change is a relatively new consideration for agriculture and many countries have assigned a low priority to defining its mitigation potential and to rolling out adaptation practices. This can be explained in part by the biological complexity previously mentioned and also lack of national and global institutional structures governing mitigation and adaptation policy. For example, agricultural mitigation is not central to UNFCCC submissions, and is generally kept outside of mandatory emissions reductions targets in most countries. Governments can choose to reward mitigation using existing support policies where these exist, but the uncertainties surrounding the quality and permanence of agricultural mitigation (plus MRV costs) mean that few countries are making much progress. The same problems are delaying the development of carbon credits in the sector and the penetration of carbon trading more generally in agriculture.

Thinking more broadly, vulnerability of global food systems is a real possibility and this highlights a more general lack of global governance of global food systems. Accordingly, does the global food-security need suggest that there should be a global architecture supporting CSA practices? What would this look like? Evidence from historical and existing policy interventions illustrates the difficulty of achieving policy-coherence and avoiding unintended consequences. Well-meaning policies intended to support vulnerable farmers to maintain production under challenging circumstances, notably the use of input subsidies (for example fertiliser subsidies in Indonesia (Osario et al. 2011) and water subsidies in Spain and India (GSI 2010), often result in continued production in areas that are no longer appropriate, creating barriers to adaptation and transformation, as well as a host of environmental problems, including increased emissions, and are generally known to be inefficient and inequitable mechanisms for transferring resources. Environmental-focused policies can also lead to serious distortions: Biofuel policy for example, aiming to reduce emissions from fossil fuel combustion, has led to a number of 'emergent' risks, including increased food insecurity, through competition with food crops for land, as well as several environmental concerns (see Oppenheimer 2014 for summary). And policies that aim to increase resilience to climate changes may in the short term have negative effects on productivity as well as GHG emissions (for example extensification and/or diversification).

So would it be best to avoid wading in with enthusiastic policy instruments to facilitate CSA, and hope that market-based solutions will emerge? Certainly, the development of carbon prices and credits for mitigation measures would be a powerful incentive for the development of MRV protocols in developed and developing countries. Countries are unwilling to act first (New Zealand for example, has stated that it will only introduce emissions reduction obligations if its international competitors also do so), therefore a level playing field - achieved through binding commitments, at least within developed countries, to introduce carbon charges on agriculture - is essential. And before that, the UNFCCC method of recording emissions must be adjusted so that farmers are given credit for the changes they do make. But there is no guarantee that the resulting systems would be climate resilient.

There is general agreement that longer term capacity building is more effective than a focus on short term specific actions, so that local actors are able to make appropriate decisions for their individual circumstances. Rather than creating new policies, communicating the basic principles and aims of CSA and removing potential barriers, and then allowing actors at different scales to make their own decisions may be the most effective approach. Adaptation already tends to be integrated or 'mainstreamed' into existing policies (e.g. as outlined in the Adaptation White Paper/ EU Adaptation Policy), in a recognition of this principle.

2.7 Financial mechanisms for achieving Climate-Smart Agriculture

Many CSA activities, whether short- or long-term, need financing. Experience so far shows that the bulk of financial flows associated with climate change activities are sourced domestically - either from the government budgets or from the private sector.[7] However, there are also funding opportunities from facilities and funds set up to support climate change activities in developing countries which are expected to gain more importance in the future. A number of these funds, such as the Green Climate Fund (GCF), the Global Environment Facility (GEF), the Adaptation Fund and the International Fund for Agricultural Development Adaptation for Smallholder Agriculture Programme (IFAD ASAP) and the NAMA facility focus on CSA as one of their areas of interest. The GEF, in particular, is expected to become the world's largest climate fund with a specific focus on CSA in Africa, with the equal allocation of resources between mitigation and adaptation. Other funding sources for CSA activities include international private sector and public-private partnerships, and voluntary carbon markets (Basak 2015; Gledhill et al. 2012). There are also some emerging sources of funding, which include, for example, climate bonds.

However, there are significant funding gaps in terms of what is available, and what is needed for financing and scaling up CSA activities, and the amount of finance currently channelled to CSA is highly uncertain (Gledhill et al. 2012). Further, the amount of funds dedicated to climate change in agriculture is very small compared with total climate finance or with total overseas development aid (ODA) for agriculture (Gledhill et al. 2012). Also, past experience with climate finance shows significant difference in the amount of funds pledged, deposited and disbursed (Lipper et al. 2010) This also seems to be the case with the specific funding for climate-smart activities; for example, only a fraction of National Adaptation Plans of Action (NAPAs) and National Mitigation Actions (NAMAs) submitted by Least Developed Countries (LDCs) and focussing on agriculture have been funded so far (UNFCCC 2016; UNEP 2016).

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[7] *This, however, does not apply to SSA/LDC countries which rely almost exclusively on foreign assistance to implement CSA activities*

Further, there are significant financing gaps in the provision of resources for agriculture in general, with even wider gaps projected for the future (Lipper et al. 2010). FAO (2009) suggests that the share of agriculture in ODA declined drastically from 19 percent in 1980 to 3 percent in 2006, later rising to 6 percent. This has already had serious implications in terms of agricultural development in some of the least developed countries. As agriculture is largely excluded from the main climate change financing mechanisms, it is highly unlikely that the sector's overall investment requirements will be met in the foreseeable future (Lipper et al. 2010).

In Sub-Saharan Africa, the majority of climate-smart projects and programmes in recent years have been funded by international public and private finance, including development banks, multilateral organisations and their private partners. The role of domestic public and private finance in funding this sort of projects has been rather insignificant as the least developed countries struggle to invest in improved agricultural practices, and domestic private finance for agriculture does not generally consider climate change (Gledhill et al. 2012).

Considering the current low level of public spending on agriculture in developing countries – between 4 to 10 percent of agricultural GDP in agriculture-based economies (Lipper et al. 2010) – the importance of public investment in agriculture from overseas development agencies cannot be underestimated. In this not very enabling environment, it has been suggested that "*mitigation finance can play a key function in leveraging other investments to support activities that generate synergies*" between mitigation, adaptation and food security for climate-smart projects (Lipper et al. 2010). This leads to the possibility of donor countries and agencies stipulating agricultural mitigation as a condition of providing development aid and financing for climate-smart agricultural projects and programmes. Further, there is evidence that emphasising 'triple-wins' in climate-smart projects could potentially lead to development funders only focussing on those areas where adaptation, mitigation and poverty reduction coincide thus drawing them away from their core area of development (Tompkins et al. 2013).

2.7.1 Smallholders and climate-smart practices

Smallholder agriculture is still the main economic activity in much of SSA, the livelihoods of millions being closely linked to farming (Pye-Smith 2011). But smallholders are often unable to practise sustainable land management, either due to a lack of resources or knowhow (Havemann and Muccione 2011).

Smallholder systems can potentially play an important role in both mitigation, and adaptation to climate change. Whereas they may be inclined to perceive private benefits to adaptation, smallholders are unlikely to be motivated to reduce emissions without demonstrable net benefit or an incentive (Havemann and Muccione 2011). This is particularly so if such action requires a change from current practices. Net benefits can be tangible, for example, an increased profit from their agricultural activities achievable in a relatively short time frame, risk reduction, or payment for environmental services (PES); the latter involving cash payments to the smallholder to take part in conservation activities. Benefits linked to mitigation can also be indirect, such as access to training programmes and institutional support, for example, through cooperative organisation, extension services and increased tenure security (Havemann and Muccione 2011).

Further, although a failure to reduce agricultural GHG emissions would put future food security at risk, no government will adopt measures to reduce greenhouse gas emissions if they threaten a nation's current ability to feed its population (Pye-Smith 2011). The main challenge is to increase food production without increasing (or even reducing) greenhouse gas emissions from agricultural activities. Thus, the recent focus on climate-smart agriculture. FAO (2012) define "climate-smart" technologies as those delivering multiple benefits, specifically, "food security and development benefits together with climate change adaptation and mitigation co-benefits".

The implementation of CSA does not presuppose a unique role for smallholders, and the challenges of monitoring actions on thousands of holdings add substance to arguments about the relative inefficiency of small-scale production (Collier and Dercon 2009). But smallholdings occupy large areas of land offering potentially cost-effective mitigation potential, and associated financing offers the potential for poverty alleviation. Unlocking this through climate-smart practices will require considerable investment, institutional and financial support, and capacity building. In many countries, these climate-smart practices can potentially be developed under Nationally Appropriate Mitigation Actions.

2.7.2 NAMAs as a financing mechanism for mitigating climate change

To date, agricultural mitigation has not been a focus of international negotiation in developed or developing countries. The costs related to the adoption of mitigation practices, as well as potential difficulties associated with the monitoring, reporting and verification (MRV) of mitigation measures all contribute to maintaining agriculture's position as a non-priority sector for climate change mitigation (FAO 2013b).

Recognising the mitigation potential available in non Annex 1, the Bali Action Plan (UNFCCC 2008) following COP 13 introduced a funding modality that potentially allows developing countries to propose voluntary mitigation actions termed NAMAs, which may be verified for potential bilateral or multilateral funding. NAMAs can be described as actions that contribute to the economic development of the country without contributing further to climate change or, indeed, reducing GHG emissions from a given sector (Wang-Helmreich et al. 2011). UNFCCC (2010) describe NAMAs as voluntary mitigation actions undertaken by developing countries "in the context of sustainable development, supported and enabled by technology, financing and capacity building, in a measurable, reportable and verifiable manner, aimed at achieving a deviation in emissions relative to 'business as usual' emissions in 2020" (CCAFS 2012b).

Three main types of NAMAs have been described: unilateral NAMAs involving actions that a country plans to pursue for reasons other than reductions in GHG emissions; conditional/supported NAMAs that would only be agreed by a developing country if developed countries provide financial or technological support; and credited/market-oriented NAMAs that can generate credits that will be sold on the global carbon market (CCAP 2009). Each of these three types of NAMAs can be project based, sector based or at a national scale.

NAMAs are expected to be assessed based on the performance, and to be linked to real and measurable emission reductions. Apart from unilateral NAMAs, the other two types involve high costs and stringent MRV requirements. Where NAMAs are implemented with international support, they are subject to both national and international measurement, reporting and verification (CCAFS 2012a). There are no defined rules for international support to NAMAs, but it is clear that public sector finance alone will not be able to fully finance NAMAs in developing countries, and private sector involvement will be necessary (CCAFS 2012a).

Although NAMAs are expected to contribute towards mitigation, they should not be independent of a developing country's national priorities, such as poverty alleviation and economic growth (Upadhyaya 2012). This raises an obvious question about the definition of potential agricultural sector NAMAs that can be anticipated as a promising instrument for advancing climate change abatement policies (Branca et al. 2012).

Agricultural NAMAs can provide additional benefits for agriculture, including adaptation and food security, i.e. they should not be considered in isolation as a stand-alone mitigation tool. Adding further to the related nomenclature, some commentators suggest that NAMAs may become Nationally Appropriate Climate Smart Actions (NACSAs) and, potentially, be incorporated in the country's National Adaptation Plans (NAPs). The question is how to ensure that these multiple objectives are achieved simultaneously (Upadhyaya 2012).

Some countries have been proactive in proposing agricultural NAMAs motives of which vary. NAMAs could be an entry point for a transition to a low-carbon development, with some governments seeing them as an opportunity to access new sources of finance for sustainable growth. In other cases countries could use NAMAs to meet voluntary national emission reduction via agricultural mitigation. To date agricultural mitigation has been mentioned only in 5 percent of 165 NAMA submissions to the UNFCCC Secretariat, mainly by African countries (Gardiner et al. 2015). The main focus of these submissions is on agricultural technologies and practices, including agroforestry, restoration of degraded land, use of improved seed varieties, and conservation agriculture, all of which provide some ancillary adaptation benefits. Increasing agricultural productivity is at the centre of the majority of proposed agricultural NAMAs.

Chapter 3 The role of the dairy sector in Malawi

3.1 Introduction

Malawi is one of the poorest and least developed countries in the world, with a per capita Gross National Income (GNI) in 2014 of just US$ 250, one of the lowest in Sub-Saharan Africa (hereafter, SSA) (World Bank 2014c). Like some other countries in SSA, Malawi is particularly vulnerable to climate change, mostly due to its low adaptive capacity (World Bank 2010; GoM 2012), and a heavy reliance on natural resources (GoM 2012). The occurrence and frequency of climatic shocks, such as droughts, floods and dry spells, in the country has been steadily increasing in the past decade (Chinsinga 2012; GoM 2012). These factors, often in combination, make Malawi one of the most threatened countries in Africa, with annual events of flooding, frequent droughts occurring on average every 3 to 5 years and persistent dry spells becoming more common, especially in the southern parts of the country (EM-DAT 2015). The World Bank synthesis of climate data in the period from 1960 to 2012 indicated that mean annual temperature in Malawi in that period increased by almost 1°C (World Bank 2012b).

Malawi has experienced a number of major droughts over the past 2 decades, which significantly affected agricultural production leading to the loss of livelihoods for many farmers (GoM 2008; FEWS NET 2004-2015). In particular, the Famine Early Warning Network (FEWS NET 2004-2015) reported prolonged dry spells and erratic and poor rains in the Southern region in the last few years. Delayed start of the season (by one to two months) was also reported in many areas in the last 3 years (MVAC 2004-2014; FEWS NET 2004-2015). Frequent floods have also had a severe impact on rural livelihoods in several districts in Malawi (GoM 2015).

Apart from climatic changes, Malawi experiences other stresses, most notably poverty (GoM 2006a; Stringer et al. 2009). This is further exacerbated by the fact that Malawi, despite its small size, is the third most densely populated country in SSA (after Rwanda and Burundi), with its current 17.0 million population expected to almost double by 2035 (GoM 2015; World Bank 2014b; Benin et al. 2008).

Malawi's vulnerability is further increased by its landlocked location, which limits the options for food transfer (Stringer et al. 2009).

The agricultural sector plays a central role in the economy of the country supporting nearly 90% of population, with almost 85% of all smallholder farmers growing maize as a primary croup (GoM 2011a,b; FAO 2012a). Rain fed agriculture practiced by the majority of smallholders - 99% of 3 million ha of agricultural land in Malawi are rain dependent (FAOSTAT 2011) - is particularly vulnerable to climate change and the increasing incidence of droughts and erratic rainfall. Over the past decade, changes in climate and weather variability put a steadily increasing pressure on subsistence farmers, affecting agricultural production and threatening farmer livelihoods (Chinsinga 2012). Changing weather patterns have led to an increase in food security risks (Global Facility for Disaster Reduction and Recovery 2011), with the country applying for an emergency food relief following the droughts in 2001 and 2005.

Fluctuations in rainfall have led to fluctuations in food production, and even dramatic reductions in agricultural output as a result of droughts or flooding. Decrease in agricultural productivity due to climate change in parts of Malawi has already been shown by Chadza and Tembo (2012) and Khamis (2006). The climatic changes have been commonly cited as one of the reasons for failed harvests; the others being declining soil fertility, limited use of improved agricultural technologies/practices and poor agricultural extension services (World Bank 2010). This makes the country particularly vulnerable as Malawi has one of the highest rates of population's dependence on subsistence agriculture (GoM 2015; Collier et al. 2008).

Increasing food security has been a Government strategic priority for the last few decades, and sectoral policy has been focused especially on increasing food security at the household level, via improving access to essential inputs (GoM 2011b). With the climate threat, there is an urgent need for the Malawian farmers to diversify their agricultural practices, in order to have access to a reliable income stream and to maintain food security. The dairy sector is ideal for this, since it is less weather-dependent than arable cropping. Assisting the development of the dairy industry in

Malawi could have a positive impact on the livelihoods of the rural population, which is the poorest in the country.

The development of the dairy sector has multiple benefits for a low-income country like Malawi. Milk is an important source of protein for young children who are widely affected by malnutrition and stunting (Chikhungu & Madise 2014). Dairy farming can also provide good supplementary income to poor farming households, especially when considering the global fall in the prices of tobacco, which is the main cash crop in Malawi, with monthly payments and relatively easy work often undertaken by women. (Nyekanyeka 2011). Smallholders can earn on average more than $300/year from milk sales (USAID 2008), thus earning a regular and relatively high income, as well as diversifying their livelihood sources. This is because income from dairying is less affected by the change in weather patterns compared to maize and tobacco. Dairying has an added advantage of being successfully practiced in areas with limited land, less labour supply and even in poor rainfall environments (CISANET 2013).

Malawi's National Dairy Development Programme (NDDP) aims to contribute to improved livelihoods of both producers and consumers, as well as provide economic benefits for the national economy. NDDP aims to increase the total milk production in Malawi from around 30,000 metric tons to 61,000 tons per annum by 2017 (GoM 2011b).

Due to the above-mentioned reasons, dairy is key investment sector within agriculture for the Government of Malawi (MIPA 2011), and dairy development has become a government priority and a flagship of the livestock sector aimed at enhancing household livelihoods. The new Malawi National Agriculture Policy 2016-2020 (GoM 2016) aims to "*strengthen the capacity of the dairy industry to market dairy products locally and internationally*" (p.38).

Most recently, the dairy sector in Malawi has also been widely supported and promoted by international donors and NGOs that have developed business models for up-scaling breeding, livestock management, value chain and risk insurance support.

3.2 The development of the dairy sector

Dairy production in Malawi was first started by colonial settlers the Southern Region, before independence in 1964. The primary activity of settlers was growing crops but they also kept dairy cattle, mostly Jerseys, Ayrshires and Friesians. The establishment and growth of townships of Blantyre and Zomba increased the demand for milk (Munthali et al. 2005), leading to the establishment of intensive smallholder dairy production in 1969. The demand for milk led to the installation of milk processing plants in Blantyre (1969), Lilongwe (1973) and Mzuzu (1974), organised by what was then known as Malawi Milk Marketing (MMM) (Nyekanyeka 2011).

Around this time, farmers were organized into milk bulking groups (MBGs) – centres for collecting, checking and cooling milk. Following a structural adjustment programme in 1985 MMM was reorganized into a statutory body called Malawi Dairy Industries (MDI), which was given mandate to operate on commercial lines (Imani Development Consultants 2004). The main purpose of MDI was to improve and multiply livestock for the production, manufacturing, processing and distribution of milk products. Following privatisation between 1998 and 2000, MDI was split into three separate companies: Dairiboard Malawi Limited in Blantyre, New Capital Dairy in Lilongwe and Northern Dairies Limited in Mzuzu (Nyekanyeka 2011).

Throughout the past decades, the Government of Malawi as well several development agencies working in Malawi have implemented projects to improve dairy technologies in order to increase milk production (Phiri 2007). The largest of this so far was the National Livestock Development Project implemented in 1990 and focused on the introduction of improved dairy breeds. Hundreds of improved dairy cattle breeds have been imported for dissemination to farmers on a heifer loan scheme. During this time, the dairy sector benefited from activities such as provision of improved extension messages on pasture establishment and fodder conservation, as well as supplementary feeding and homemade dairy mash; promotion of zero grazing systems for dairy cattle; artificial insemination (AI) and improved veterinary services; advice on the construction of appropriate housing for dairy animals; and provision of training to dairy farmers (Nyekanyeka 2011; Phiri 2007; Banda 2008).

Most recently, a number of NGOs, including Land O'Lakes, Small Scale Livestock Development Partnership (SSLP), the Clinton Foundation and the Agricultural Research and Development Programme (ARDEP) have all played a role in the dairy sector development through introduction of improved breeds and promotion of improved management practices (Chindime 2007; Nyekanyeka 2011). Between 1999 and 2006, Land O'Lakes have implemented one of the largest dairy development programmes in Malawi - Malawi Dairy Business Development Programme. The main aim of the programme was to increase the availability of highly productive dairy cows, as well as supplemental feed stations, vitamin supplements and veterinary pharmaceuticals (Phiri 2007).

However, despite all the development efforts, Malawi dairy sector is still under-developed and makes a small contribution to the livestock sub-sector: livestock accounts for about 10 per cent of the country's agricultural Gross Domestic Product (GDP) (National Statistical Office of Malawi 2012); however, the exact contribution of the dairy sector to the GDP has not been estimated.

Diary productivity (i.e. milk output per cow) in Malawi is generally low, even for improved breeds. Nakagava (2009) estimates the average production per day between 5.7 and 9 litres per cow, mainly produced by the local Zebu breed. This is mainly due to the lack of good husbandry practices, long calving intervals, lack of good quality feed and insufficient veterinary and artificial insemination and extension services (CISANET 2013). Productivity depends on breed choice with non-native Friesians being most productive, but also on the management quality (Chagunda et al. 2010). Zimba et al. (2010) estimate that although individual farmers produce about 7 litres of milk a day on average, there is a potential to produce up to 40 litres by changing current management practices.

Based on the Malawi livestock census data, the total production of milk was estimated at 64,747 tonnes in 2014 (Revoredo-Giha & Toma 2016); 25 per cent of this was produced by the zebu cows and the remainder - by improved breeds. Most of the milk – about 58 per cent - was produced in the Southern region, with the Central and Northern region having produced about 27 per cent and 15 per cent, respectively (Revoredo-Giha & Toma 2016).

The total milk supply is well below the demand, which results in a need to import milk and milk products from the neighbouring countries, mainly Zimbabwe. According to the most recent available data, Malawi imports about 38 percent of the amount of milk consumed in the country annually (FAO 2005b).

Despite boosting the production with imports, milk consumption in Malawi is very low, estimated at 4-6 kg/capita/year (Tebug 2012). This is much lower than the Africa average of 15 kg/capita/year, and significantly lower than 200 kg/capita/year recommended by the World Health Organisation (WHO) and FAO (Banda 2008). In other sub-Saharan countries, such as Kenya, milk consumption is 95 kg/capita/year with smallholder dairy farming playing a key role (Tebug 2012). Low consumption is partly explained by the limited supply of milk (CYE Consult 2009), leading to some of the highest consumer prices for milk products in Africa (The Dairy Task Team 2010; USAID 2012).

Tebug et al. (2012a) suggest that factors like population and income growth, as well as dietary change and urbanization have led to increased milk demand in Malawi in the recent years, consumption increasing by 40 per cent between 1980 and 2002 (FAOSTAT 2011). As Malawi's population is predicted to grow from the current 17.0 million to 37 million by 2050 (GoM 2015; GoM 2012a; The World Bank 2012), the demand for dairy products is likely to increase further. There is thus a clear need to address barriers to sector development.

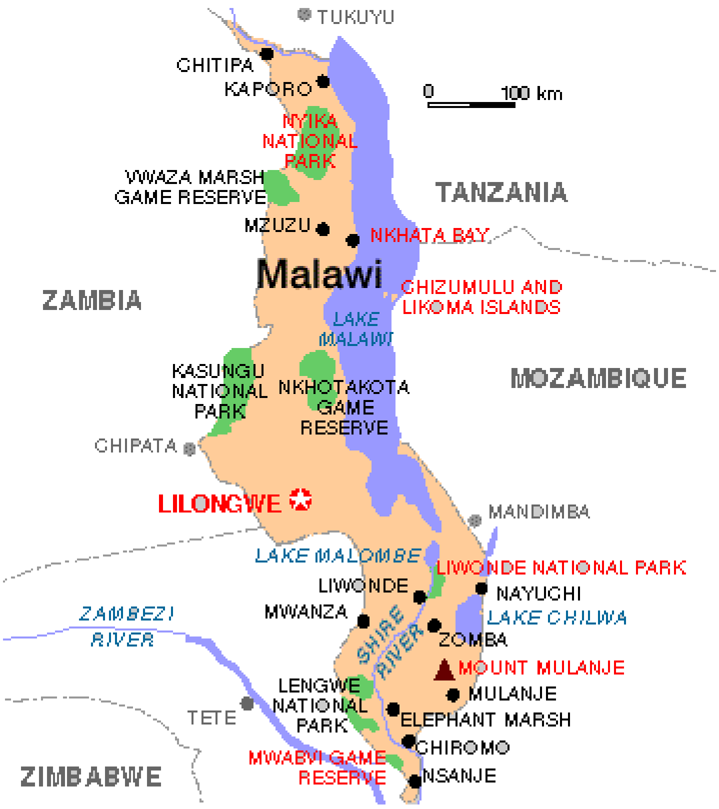
3.3 The current structure of the dairy sector

Like any other agricultural sub-sector in the country, the dairy sector is dominated by small scale farmers (Chitika 2008). There is also a limited number of larger farmers, with the main difference between the two categories being the size of the holding, the genotype of cattle raised and the level of management applied (Nyekanyeka 2011). Finally, apart from individual farmers, there are a number of private large-scale dairy farms/estates (Nyekanyeka 2011).

As reported by Chindime (2007), there are two categories of farmers amongst smallholder farmers: modern, or improved dairy farmers who use exotic/improved breeds of cows, feed animals with dairy meal and mineral supplements, and use artificial insemination; and traditional, or local dairy farmers who own only local zebu cows, practice open grazing with no fodder conservation, do not use artificial insemination and do not provide improved animal housing.

Most of the milk in the country is produced by smallholder dairy farmers. The majority of dairy farmers are situated around the three large cities in Malawi: Blantyre (the Southern Region), Lilongwe (Central Region) and Mzuzu (the Northern Region), where they are organised into milk bulking groups (MBGs) (Figure 3.1). As mentioned above, the MBGs are centres for collecting, checking, bulking and cooling milk, where milk is centrally collected from farmers within a radius of 8-10km. Most MBGs in the past were local farmer associations; however, a group of independent MBGs (called "traders") appeared in 2009 and became especially prominent in the Southern region. This group now represents more than 50 per cent of milk delivery to processors in the South (Revoredo-Giha & Toma 2016).

Figure 3.1 Dairy production regions



Source: FAO, http://www.fao.org/ag/AGP/AGPC/doc/counprof/malawi/Malawi.htm

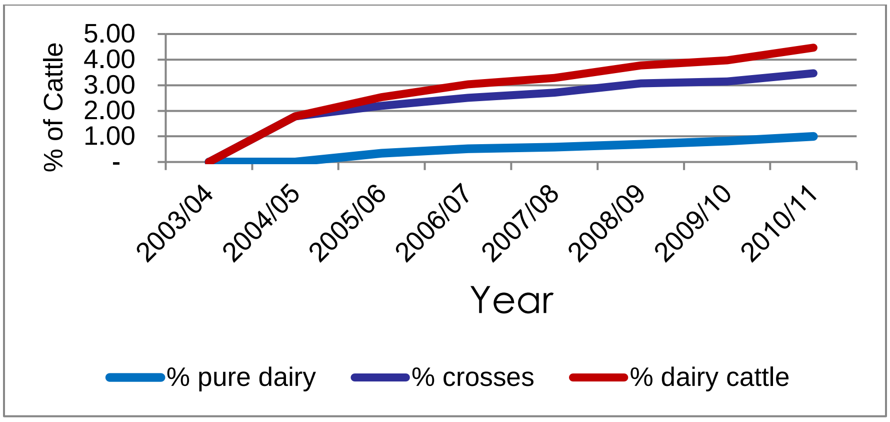
According to the data received from 3 main milk producing associations in Malawi, in 2012, smallholder farmers produced around 13.5 million litres of milk marketed through the formal channel, 91 per cent of which was produced in the Southern region. A further 16.5 million litres is estimated to have been produced in the informal sector, which is currently the dominant marketing channel (Imani Development Consultants 2004). The two channels differ in the way milk reaches the final consumer. In the formal sector, milk is processed and sold to the consumer via retail outlets; in the informal sector milk is sold raw (and often diluted) to either vendors or direct to consumers (Chitika 2008).

The exact number of smallholder dairy farmers in Malawi is not clear; however, based on various sources, there are between 9,584 and 16 thousand dairy farmers in the three milk producing regions of Malawi, with 61 per cent of them located in the Southern region (Revoredo-Giha & Toma 2016; CISANET 2013). This number is a subject to regular fluctuations, due to farmers regularly dropping in and out of dairy farming due to the loss/acquisition of animals. Further, this number does not include farmers selling milk only outside the formal sector, which, for example, is mostly the case in the Northern region of Malawi, where the formal dairy sector is largely under-developed (Revoredo-Giha & Toma 2016).

The majority of smallholder farmers own between one and four dairy cows, mostly obtained via pass-on schemes (farmer-to-farmer sales of dairy cows are rare) (Chitika 2008). The most common breed of dairy cows used by smallholder farmers in Malawi are crossbred cows with a high milk production potential.

Official estimates show an increasing trend in the number of dairy cattle in the country partly through import of animals into the country (Figure 3.2). Banda et al. (2012) estimate that there has been a 65 per cent increase in dairy cattle numbers between 2004 and 2010, mainly due to the government and aid donor support. Data provided by the Ministry of Agriculture and Food Security of Malawi shows that milk production has been steadily increasing in recent years (FAOSTAT 2011). This can be attributed to increasing cattle numbers, successful development efforts, and to a desire of many smallholders to diversify out of standard agricultural practices and to earn a reliable income.

Figure 3.2 Increasing trend in dairy cattle numbers in Malawi since 2003



Source: USAID (2012)

The country’s new National Agriculture Policy (GoM 2016) gives the baseline of 63, 000 dairy animals in the country. However, despite the growth in dairy cattle numbers (currently comprising about 5 per cent of the national cattle population), only 13 per cent of smallholder farmers in Malawi own cattle (CISANET 2013), reflecting a lack of emphasis on livestock in official agricultural strategies and policies. Moreover, poor performance in the arable sector has caused many farming families to expand their arable cultivation into areas traditionally grazed by livestock (CYE Consult 2009).

The most recent data received from the milk producers’ associations show that there are 54 registered MBGs in Malawi which belong to the regional milk producers’ association (Revoredo-Giha & Toma 2016). Being the most developed in terms of diary production, The Shire Highlands Milk Producers Association (SHMPA) in the Southern Region has the highest number of milk bulking groups - 25 (46 per cent of total), while the Central Region Milk Producers Associations (CREMPA) has 17 milk bulking groups. The number of MBGs in the Northern region is the lowest in the country, with Mpoto Dairy Farmers Association (MDFA) in the North including 12 MBGs (or 22 per cent of total), as of 2014 (Revoredo-Giha & Toma 2016). It is worth mentioning that some of the registered MBGs are only partly (or not at all) operational, hence the absolute numbers reported here should be treated with caution (Revoredo-Giha & Toma 2016).

Farmers deliver milk to the MBGs either by bike, or more frequently, on foot. The MBG staff then test milk for adulteration (with a lactometer) and acidity (using an alcohol test). No other tests, such as bacterial count or fat percentage test, are carried out (CYE Consult 2009). MBGs only accept milk which passes the adulteration and acidity tests. If all or part of the milk delivered by the farmer does not pass these basic tests it is rejected by the MBG, with farmers having an option to sell it to the street vendors, through the informal marketing channel (CYE Consult 2009).

It is worth noticing that the sale of raw milk to the consumers is illegal in Malawi, due to the health risks involved (Revoredo-Giha & Toma 2011). This, however, is still a common practice in the country, due to various reasons including often higher prices paid for milk, immediate payment (instead of having to wait for at least 1 month to be paid by the MBGs in the formal sector), and no quality control for accepting the milk which means an almost guaranteed sale (Revoredo-Giha & Renwick 2016). Further, sometimes farmers do not have other choice but to sell through the informal market which, for example, is the case in the Northern region where the last remaining major dairy processor closed down in 2012 (Tebug 2012). Other farmers, however, prefer to sell milk through the formal market, which allows to smooth out consumption patterns due to the (mostly) regular monthly payments for the milk, and also allows farmers to sell higher volumes of milk and even, in some cases, offers a reward system for larger volumes of milk. Further, the sale through the formal channel reduces farmer transaction costs in search for potential buyers (Chitika 2008).

The volume of the milk accepted by the MBG is measured and recorded against the name of the farmer, and all delivered milk is mixed together in the cooler. Some MBGs pay a bonus for the higher volumes of milk delivered by farmers, but this is not a regular occurrence (Chagunda et al. 2006). Further, there is no extra payment for milk delivered during the dry or low season[8] when milk production is reduced due to a shortage of feed (CYE Consult 2009).

[8] *Low season is from December to May; High season is from June to November*

The dairy farmers are paid by the MBGs on a monthly basis. A small fee for each litre of milk is deducted from farmers' pay in order to pay for the running and maintenance cost of the cooling plant, as well as the administrative costs (CYE Consult 2009). Further, as MGBs also act as centres for veterinary and livestock feed supplies, artificial insemination services and credit, and usually have extension officers attached to provide extension advice, deductions are also made for any services or credit provided to farmers (Revoredo-Giha & Toma 2016).

The milk is then collected by the dairy processor, usually by bulk tankers or churn lorries. The collection should happen on a daily basis; however, due to the poor road networks and frequent breakdowns of the collecting trucks, there is often more than a day between collections (Chitika 2008; CYE Consult 2009). The milk is then transported to the nearest process plant in each milk shed area.

There are three types of dairy processors in Malawi: commercial dairies, of which there are two in the Southern region, and two in the Central region: these primarily collect milk from the MBGs; privately owned small scale dairies which keep their own dairy herd for milk production but also, on occasion, collect from MBGs; and a limited number of mini dairies managed by smallholder farmers (Revoredo-Giha & Toma 2016). Processors mainly produce pasteurised milk, flavoured and plain yoghurt (chambiko), cream, butter and cheese (Sindani 2012).

3.4 Constraints to the dairy sector development

Economic development and livelihoods are the key objectives of agricultural development. In capitalising on the synergies in dairy sector development it is important to recognise and reconcile the key policy drivers and extant constraints affecting sector development. A number of constraints have been reported to the development of the dairy sector in Malawi at the farm level (Tebug et al. 2012b). These include poor farm management practices, including inadequate feed and feeding technologies often leading to low production of milk, and poor manure management, as well as poor animal health and high mortality rates of the dairy cattle (Sindani 2012). It has been shown that during peak cropping seasons, it is not uncommon for dairy animals to be underfed, and for kholas[9] to be neglected, as labour and resources are often directed towards crop production, and fertilisers intended for pasture are used for growing crops (Munthali et al. 2005).

Additionally, there are important "beyond farm gate" constraints to the growth of the dairy sector in Malawi which include low milk prices paid to farmers by dairy processors, which discourage farmers from investing into or expanding their dairy production. Another constraint is the low purchasing power of the population, which does not drive demand. Further, in spite of the willingness of many smallholders to get involved in dairy farming, there is a limited availability of dairy cows. Government cattle farms have a very low productivity, and non-governmental organisations (such as the Clinton foundation) can not provide cows to all the farmers who want them. While waiting to receive their dairy animal, farmers' pastures overgrow and become too old for subsequent use and the kholas begin to collapse (Munthali et al. 2005).

Addressing these barriers offers opportunities for pro-poor development in the sector, through improving food security (i.e. availability of safe and affordable dairy products) and smallholder incomes.

Projected future climate trends for Malawi indicate increase in temperatures by 1.1^{o}C to 3.0^{o}C by the year 2060 and 1.5^{o}C to 5.0^{o}C by the year 2090 (McSweeney et al. 2010). This will have an impact on livestock leading to reduced feed and water availability and more frequent outbreaks of livestock diseases, as well as increased cattle mortality (FAO 2011; JotoAfrica 2009). These impacts can be significantly reduced by improving current farm management practices, or adopting new, low cost or no cost practices.

If, as projected by the Government of Malawi, milk production increases, either by increasing herd size in the smallholder sector – the current government aim is to more than triple the number of dairy cattle to 200,000 by 2020, from the current 63,.000 (GoM 2016) - or via increasing the number of smallholder farmers

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9 *Animal house*

diversifying into the dairy farming, this, while in the national interest, will almost inevitably lead to an absolute increase in GHG emissions. It has been calculated that the current farm levels emissions will double with doubling total milk production (Wilkes et al. 2012). FAO estimated that in 2007 the contribution of global milk production, processing and transportation to total anthropogenic emissions (excluding meat) was estimated at 2.7 per cent of total anthropogenic GHG emissions reported by IPCC (FAO 2010). The study showed that emissions per unit of milk product varied greatly across regions; with the highest emissions estimated for Sub-Saharan Africa (SSA) with an average of 9.0kg CO2-eq per kg fat and protein corrected milk (FPCM) at the farm gate. This compares to a global average estimated at 2.8 kg CO2-eq (/FAO 2013c). This disparity exists because of low protein production in SSA – ruminants have a very high emission intensity, and low protein output (i.e. low milk production) leading to higher emissions per kg of milk in SSA than in North America or Western Europe (FAO 2013c).

However, despite the present danger of climate change, Malawi, like any non Annex 1 country, is unlikely to adopt mitigation measures if they compromise food security and country's economic growth and unless there is some form of international compensation. Further, current lack of economic incentives for livestock farmers in Malawi to reduce GHG emissions means that any mitigation which lowers emissions at the expense of productivity is certain to be non-viable (CCAFS 2012a). The main challenge therefore is to control greenhouse gas emissions without negative impacts on the economy (van Asset et al. 2010). Agricultural adaptation and (pro-poor) mitigation agendas are thus convergent in a country like Malawi, which offers a context to explore climate-smart interventions. These can be defined to encompass actions that will help implement these technologies on the ground, or via, for example, policy interventions at the national level or via regional projects (e.g. supply chains) that can nevertheless deliver local benefits.

3.5 The role of extension support in the dairy sector

The Malawian Agricultural Extension Services (AES), funded by the government, has always played a big role in the development of agriculture in Malawi (Nyekanyeka 2011). Traditionally, AES used various educational methods and approaches to transfer agricultural-based research information, knowledge, and skills to small scale farmers (GoM 2010b). However, as AES relies on public funds distributed by the Department of Agricultural Extension Services (DEAS), there has been some significant under-investment, both financial and in terms of recruitment and training of the extension officers (GoM 2000, 2010a; Noordin et al. 2001). This has led to the weakening of the extension services in Malawi.

Political changes in 1990s led to a paradigm shift in provision of agricultural extension resulting in decentralisation of the service, and promotion of pluralistic and demand-driven extension system (Chowa et al. 2013; Masangano & Mthinda 2010). Current players in the extension services include, apart from government ministries, NGOs, Farmer-Based Organization (FBOs), multilateral organizations, private sector organizations and semi-autonomous organizations (GFRAS 2011). At the national level, Malawi public extension comprises 2,175 staff members managed by a team of 18 senior staff (GFRAS 2011). The majority of staff (92%) are field level extension workers.

However, implementation of pluralistic agricultural extension has received a mixed response in Malawi (Chinsinga 2008; Masangano & Mthinda 2010). On one hand, the availability of multiples players in advisory agricultural services increased the diversity of the services provided. On the other hand, there have been significant coordination challenges caused by competition amongst multiple players (Chinsinga 2008). In fact, there is no effective interaction between public, private and NGO extension services in Malawi due to the weak monitoring mechanism and coordination (Poulton et al. 2010).

Despite a number of players in the field, the majority of smallholder farmers have to rely on public extension support, which is often inadequate (Chowa et al. 2013). The early adopters of dairy farming were pressed to purchase crossbred cows by extension workers who praised the advantages of crossbreds over the Malawi Zebu and provided advice on how to look after the dairy animals (Munthali et al. 2005). However, experience showed that farmers often did not follow advice, that they either under-fed or over-fed their dairy cows, and that the money made from dairy farming was invested into non-related activities, instead of being reinvested in the dairy operation. This was specifically the case among farmers who, apart from dairy farming, grew food crops or tobacco (Munthali et al. 2005).

Even if extension workers are available, there is a general lack of contact between farmers and extension workers (Munthali et al. 2005). The establishment of MBGs was partly intended to increase contacts between extension officers and farmers; however, this has resulted in extension agents spending time at the cooling centres instead of visiting farmers. Furthermore, farmers tend to send children or employees to deliver milk, hence do not have direct contact with extension agents (Munthali et al. 2005). The low contact rate is further compounded by the lack of transportation or fuel: even if fully trained extension officers are in place, they often lack modes of transport (such as bicycles) to reach the farmers who might live a long distance away.

The animal husbandry extension workers, as a rule, lack sufficient knowledge to provide advice to farmers on formulating suitable diets to increase animal productivity (Munthali et al. 2005). Herd health support extension services are also inadequate (Munthali et al. 2005), and mostly focus on providing advice on East Coast fever, but not on gastro-intestinal parasites and pneumonia, which particularly affects calves.

Overall, the current approach of agricultural extension services is often not responsive to the needs of farmers (Chowa et al.2013; Anderson & Feder 2004; Brookfield 2008).

3.6 The use of improved farming practices in the dairy sector

Adaptation of the agricultural systems, via improving current practices or the adoption of new farming practices is essential for protecting the livelihoods of the poor and ensuring food security (Wang et al. 2009). Several studies showed that agricultural technology adoption can be a pathway to escape poverty in rural Malawi (McCarthy et al. 2011). Effective adaptation measures potentially allow integration of climate-related opportunities into developmental objectives, both at the local and national scale (IPCC 2007). However, a new technology adoption leading to a transformative change is expected to be limited in Malawi due to the poverty and long standing problems with food security (GoM 2012; 2011; 2006). Hence the main focus of increasing the sustainability of smallholder dairy sector in the country should be on trying to make incremental changes to existing systems.

Improving or changing farming practices is one important means of adaptation to current or expected climate variability and changing climate conditions. Examples of farm level adaptations include crop diversification via the use of early and drought-resistant varieties or new cultivars (Matiya et al. 2011); shifting planting and harvesting dates, as well as winter cropping to adjust to the changes in the raining season (Akponikpè et al. 2010; Matiya et al. 2011); conservation agriculture and switching from planting high water-requirement to low water requirement crops (de Wit and Stankeiwicz 2006); and from arable to livestock farming (Kurukulasuriya and Mendelson 2006; Deressa et al. 2008). Adaptation depends on many factors, not least on farmer's capacity and incentives to respond to changes and undertake adjustments in farming practices, i.e. their adaptive capacity. Adaptive capacity depends in turn on the capacity of the farmers to understand and implement improved technologies (Zander et al. 2013).

There is a significant body of adaptation literature focussing on the adoption of adaptation methods by smallholder farmers practicing crop farming (Bryan et al. 2013; McCarthy et al. 2011; Acquah de Graft and Onumah 2011; Gbetibouo et al. 2010; Deressa et al. 2008). However, the current research on adaptation is highly fragmented and context-specific, focussing mostly on arable crops. There has been much less research focussing on the adaptation measures by livestock farmers and, specifically, by dairy farmers.

As mentioned above, dairy farming in Malawi has been growing in importance in recent years as it is less susceptible to climate shocks than crop farming and often provides a reliable source of income, especially as crop farming no longer entirely supports the needs of the farmers' in many parts of the country (FTF 2011; FEWS NET 2004-2015). Both the Malawi National Adaptation Programme of Action (NAPA) (GoM 2006a) and the country's Agricultural Sector Wide Approach (ASWAP) (GoM 2011b) advocate diversification of current livelihood options of smallholder farmers, with dairy farming playing a prominent role. NAPA also strongly encourages education in the form of awareness raising about potential adaptation options and techniques to enhance adaptation capacity (GoM 2006a). Improvement of livestock production and identification of drought-tolerant livestock, as well as training farmers and extension workers in agricultural husbandry techniques is included in both ASWAP and NAPA (GoM 2006a).

However, despite increasing donor funding in adaptation and a number of adaptation programmes being carried out by FAO, international donor agencies, NGOs and grassroots organisations in Malawi (CCAPS 2013), considerable development efforts undertaken, amongst others, by Land O Lakes, SSLP, ARDEP and Malawi Government, and directed at disseminating improved dairy farming technologies among farmers, as well as the availability of a number of easy to implement management practices, especially with relation to animal health and feeding, the adoption rates of improved agricultural practices have generally been low (Nyekanyeka 2011; Phiri & Saka 2008; Wollni et al. 2010).

Further, despite the current national focus on smallholder dairy farming as a means of diversifying livelihood sources and achieving food security, there have been limited advances in understanding of what influences uptake of improved practices in the sector. In particular, very little attention has been given to exploring the relationship between household socioeconomic characteristics and the uptake of improved practices.

One of the promising climate-smart practices is the use of agroforestry discussed in more detail below.

3.7 The use of agroforestry practices in the dairy sector

Malawi has one of the highest deforestation rates in Africa (Oxfam 2012). Being once heavily forested, the forest cover currently comprises only 27.2% of the total land area of the country (FAO 2013f). According to Cassells (2011), between 2001 and 2009, Malawi annually lost 3.49 per cent of its forest area.

One of the main reasons for this high level of deforestation is the pressure on land from the rapidly increasing population (currently 17.0 million but projected to almost double by 2025) (GoM 2015; World Bank 2014b; Benin et al. 2008). The predominantly rural population - 84 per cent of Malawians live in rural areas – (World Bank 2014a) depends on land to sustain their livelihoods, with fuel wood/charcoal being the only source of energy for cooking and heating needs (Sibale et al. 2013).

In addition, climate change has resulted in changes to the rainfall patterns and temperature within Malawi, directly affecting livelihoods of the poor smallholders (Maplecroft 2011). Within the last 2 decades, Malawi has suffered increasingly frequent cases of wide-spread famine caused by drought, with millions of people requiring food aid in order to survive (Kaczan et al. 2013), and with the famine in 2002 and 2005 being some of the most significant in the past 50 years.

Amongst other things, the lack of food security in rural Malawi has been directly linked to declining soil fertility, with nitrogen deficiency being the main limiting factor (World Agroforestry Centre 2008; 2005). In order to increase food security, the government reintroduced fertilizer subsidy programme for inorganic fertilizer which had a significant positive impact on yields (Gilbert 2012; Dorward and Chirwa 2011). One of the disadvantages of the programme, however, is its cost - up to 16 percent of the national government budget annually, depending on the year (Denning et al. 2009; World Bank 2007). Further, the use of inorganic fertilizer may lead to soil nutrient depletion and deterioration of soil quality in the long term (Kaczan et al. 2013). Despite the success of the fertilizer subsidy program, it was estimated that about 80 percent of smallholders still suffer from food insecurity between November and February (low season) (Denning et al. 2009; ICRAF 2008; World Bank 2007).

In this context, agroforestry could be a cost-effective way to support livelihoods of the rural population. Agroforestry could complement the use of inorganic fertilizer, or, in some cases replace it completely (Ajayi et al. 2008). Multiple benefits of agroforestry have been widely documented and include providing food products, improving soil fertility and reducing erosion, being a source of fuel food for cooking and heating, as well as providing essential fodder for livestock (Sibale et al. 2013;

Kaczan et al. 2013). This is especially important in the context of dairy farming. As low quality and quantity of animal feed is a major constraint limiting livestock productivity among smallholder farmers in Malawi, growing fodder trees and shrubs can play a major role in improving dairy cow productivity, as well as farmers' incomes and livelihoods (Ayantunde et al. 2005; Franzel et al. 2014). The farm-grown fodder can increase milk production and can substitute for externally purchased dairy meal. Apart from improving livestock diets and increasing milk yields, fodder trees provide a range of other benefits (Ayantunde et al. 2005; Franzel et al. 2014). Fodder tress have nitrogen-fixing properties, which can help increase soil fertility; they can provide firewood for cooking and pollen for honey bees. Fodder trees are also used to control erosion on steep slopes. It has been estimated that the net income of a farmer with one cow and 500 fodder trees, which cost less than US$8 to establish, can be increased by US$60–115 a year (Pye-Smith 2010; Place et al. 2009). This is a significant sum of money in rural Malawi ; the questions here, however, is whether there is enough land available to plant a large number of trees, considering the shrinking land holding sizes of Malawian farms.

In addition to helping smallholders adapt to climate variability, agroforestry systems could also sequester significant amounts of carbon, making it an important climate-smart practice, often simultaneously increasing resilience/adaptation, improving food security and reducing greenhouse gas (GHG) emissions (PROFOR 2011; Mbow et al. 2014a; Mbow et al. 2014b).

Agroforestry has been recognized by the UNFCCC as a key mitigation strategy within agriculture (Smith et al. 2008). Following this, the Comprehensive African Agricultural Development Programme (CAADP) developed an agriculture climate change adaptation and mitigation framework, which features agroforestry as one of its key components, and which was endorsed by African ministers in 2010 (AU-NEPAD 2010). Based on recent research, agroforestry practices can offer high potential to sequester carbon; there is, however, very little evidence specific to Malawian conditions (Kaczan et al. 2013)[10].

Despite being named as one of the key strategies in the 2005 National Agricultural Agenda (Kaczan et al. 2013), there is almost no reference to agroforestry in the national policy documents. A review of policy documents in Malawi (Place et al. 2012) shows that that agroforestry very rarely features in the sectoral policy documents. There is a strong dichotomy within the policy documents, with the key agricultural policies in the country supporting the extension of cropland, while forestry policy is promoting conservation and full afforestation (FAO 2013f; Place et al. 2012). Nevertheless, GoM has been aware of the importance and benefits of agroforestry systems (especially with regards to improving yields) for supporting the livelihoods of rural population. In the past decade, in an attempt to increase food security, and to complement the fertilizer subsidy programme, the Government, with support from development partners has implemented a number of agroforestry and sustainable forest management initiatives, including devolving control over forests to community forest management groups and encouraging communities to engage in commercial on-farm tree planting (Sibale et al. 2013; Kaczan et al. 2013). One of the flagship programmes of GoM in recent years has been the ‘Agroforestry Food Security Program’, which is a joint Government-ICRAF initiative to provide tree seeds, nursing materials and extension advice for farmers (ICRAF 2011). The Programme has been promoting trees with multiple benefits (fertilizer trees that could also provide fruit, fodder and fuelwood) (World Agroforestry Centre 2008; 2005). As a direct impact of these initiatives, over 180,000 farming households have started practicing agroforestry on their farms (Garrity et al. 2010; Mbow et al. 2014a).

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[10] *It is important to note, however, that some agroforestry practices such as shifting cultivation and pasture maintenance by burning, nitrogen fertilization and animal production may actually raise GHG emissions (Mbow et al. 2014a). Overall, the mitigation benefits will be highly variable depending on different soil and climatic conditions, tree species, tree densities and plot maturity (see Kaczan et al. 2013). Hence an integrated management approach will be needed to make sure that the benefits of agroforestry systems outweigh the potential drawbacks (Mbow et al. 2014a).*

Despite increasing recognition of the benefits of agroforestry, and extensive promotion by the government, adoption rates remain low (Kaczan et al. 2013; Thangata 2002). Further, it is unclear whether the success of "Agroforestry Food Security Program" could be maintained without direct subsidy (Kaczan et al. 2013). Agroforestry uptake is particularly complex due to the multiple components (for example fruits trees, shrubs, fertilizer trees, crops, herbaceous and wood perennial plants could all be a part of agroforestry systems) and many years it takes to realise the benefits (Kaczan et al. 2013).

There is also growing literature on agroforestry adoption in Southern Africa, addressing the reasons for the low adoption rates (Ajayi et al. 2008; Mercer 2004). Several authors suggest that a key reason is that agroforestry projects are generally slow to become self-sustaining (Mercer 2004; Ajayi et al. 2008). Some agroforestry systems, such as *F. albida* require a long 'investment period' in which trees need to "mature" to contribute to improved yields (Kaczan et al. 2013).

Based on a number of empirical studies Ajayi et al. (2007), Ajayi et al. (2008), Akinnifesi et al. (2008) and Akinnifesi et al. (2010) summarized consistent determinants of agroforestry adoption across southern Africa. These include labour and land availability (households with more access to labour or larger land holdings are more likely to adopt), and whether agroforestry systems provide an additional marketable product (e.g. nuts or fruit from fertilizer trees). Other constraints include soil quality, limited access to extension, and the level of household wealth/assets (Pattanayak et al. 2003). In addition, tenure insecurity, bush fires, livestock browsing and poorly functioning fertilizer tree seed market (for both purchasing and selling of seed) contribute to the low adoption rates (Kaczan et al. 2013). Another constraint is the lack of access to improved legume genotypes (Kaczan et al. 2013).

Factors influencing adoption include farmers' socio-economic characteristics (such as level of income), access to ecosystem services (such as water supply, and soil structure and fertility), and the level of food security, as well as behavioural and cultural issues (Mbow et al. 2014b; Kaczan et al. 2013). Also, the country policies often discourage the adoption of sustainable land practices, with agricultural product price supports or favourable credit terms often being granted for certain agricultural activities but almost never for agroforestry (FAO 2013f). This, coupled with fertilizer subsidies, act as another disincentive for farmers to adopt agroforestry systems.

Overall, most studies show that adoption is constrained by the need for a short-term increase in food security and provision of fuel wood. Long-term soil regeneration does not appear to play a major role, with carbon sequestration quality of agroforestry systems not even featuring on the radar of poor smallholders (Kaczan et al. 2013).

There is very limited research looking at the adoption of agroforestry practices in Malawi (Thangata and Alavalapati 2003), and there is no research looking at this in the context of dairy systems. In one of the most recent studies by Sirrine et al. (2010) looked at the adoption of agroforestry by farmers in Southern Malawi. The findings showed that the main determinants of adoption were immediate livelihood benefits, rather than long-term benefits such as improvement in soil quality. In the study conducted in the Domasi valley of southern Malawi, Thangata and Alavalapati (2003) investigated characteristics that influenced adoption of agroforestry practices. They found that younger farmers and those with frequent contact to extension staff were more likely to adopt. They also found that larger households were more likely to adopt, likely due to the higher labour requirements of some agroforestry practices relative to monocropped maize. The studies conducted in Malawi all seem to agree that younger, wealthier farmers with greater access to land and labour are more likely to adopt (Kaczan et al. 2013).

The role of gender in the adoption of agroforestry practices

As one of the most important socio-economic characteristics, gender of the household head could play an important role in the adoption of agroforestry practices. Women provide 50% of the agricultural labour force in sub-Saharan Africa (FAO 2012c), but often have limited access to education, labour resources, financial and commodity markets, and extension services, which can significantly affect and influence their income (Thangata 2002; Kiptot and Franzel 2011). As a result, African women farmers get lower crop yields than men (Quisumbing 1995 & 1996). However, given the same resources, Adesina and Djato (1997) found that male- and female-headed households achieved the same level of efficiency. According to

Kiptot and Franzel (2011), if women had access to the same resources as men, there will be a 10-20% increase in food production[11].

Despite the key role of women in African agriculture, their contribution has been largely ignored by policy makers (Kiptot and Franzel 2011). Women farmers in SSA remain disadvantaged due to cultural, sociological and economic factors, and have limited access to resources and household decision-making (Kiptot and Franzel 2011). It is widely agreed that addressing gender imbalances could decrease poverty and food insecurity in Africa while simultaneously delivering environmental services and mitigating climate change (Ibnouf 2011; World Bank 2009).

In most of the studies on agroforestry adoption conducted in SSA, and in almost all of the limited number of studies on agroforestry conducted in Malawi, the role of gender as one of the determinants of adoption has been largely ignored. There are very few studies on gender and agroforestry, most with very small samples sizes (Kiptot and Franzel 2011).

Agroforestry, as a relatively low cost and low labour technology, which requires minimal inputs and offers multiple benefits, could provide opportunities to female-headed households who are unable to adopt more high cost and labour-intensive technologies, such as conservation agriculture (Kiptot and Franzel 2011). However, the uptake of agroforestry practices by women may be hampered by limited access to land, capital and labour, and little or infrequent contact with extension services, amongst other constraints (Kiptot and Franzel 2011).

A number of agroforestry adoption studies have demonstrated that gender is an important factor affecting the uptake of agroforestry practices (Ndayambaje et al. 2012; Phiri et al. 2004; Wambugu et al. 2001). Kiptot and Franzel (2011) reviewed 10 studies undertaken in Kenya, Zambia, Uganda and Malawi on factors likely to affect the adoption of improved fallows, biomass transfer and mixed intercropping technologies. The review showed that in eight studies gender did not significantly influence the use of soil fertility technologies for soil fertility management provided

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[11] *However, it does not necessarily follow that equal distribution of resources will lead to poverty reduction in rural Africa (O'Laughlin 2007).*

men and women had a similar access to inputs. In the study of the differences between woodlots owned by female-headed and male-headed households in Malawi Chikoko (2002) found that female-headed households had half as many trees on their woodlots as male-headed households, unsurprisingly due to their land holdings being half the size of those owned by males. This agrees with other studies showing that women who adopted agroforestry technologies often had smaller plots and fewer trees (Keil et al. 2005; Schreckenberg et al. 2002; Wanyoike 2001).

In a study conducted in central Malawi, Thangata et al. (2002) showed that adoption of improved fallow as an agroforestry practice was determined by available land and access to labour resources, with gender of the household head being inconsequential. Other studies, however, showed that gender does influence the uptake of certain types of improved fallow (Kaczan et al. 2013).

A few studies on agroforestry adoption in Malawi discussed above concern limited geographical areas which makes it difficult to draw general conclusions. Overall, knowledge gaps in agroforestry adoption in Malawi are greater than the actual body of knowledge on most aspects.

Chapter 4 **Methodology**

4.1 The rationale behind conducting a dairy farmer household survey

In the past two decades there has been an increasing demand for up-to-date and detailed socio-economic data for households and individuals in developing countries (UN Stats 2005; World Bank 2000). Such data is indispensable in economic and social policy analysis and development planning, and can inform decision-making at all levels. Household surveys are an important tool to meet this demand, and can form a central and strategic component in the formulation of national policies. Household surveys are now a dominant form of data collection in most developing countries, and can provide important indicators to inform development policies (UN Stats 2005; World Bank 2000).

Up-to-date data from household surveys is necessary for governments to measure and monitor, for example poverty, employment, health and nutritional status, and living standards (World Bank 2000). Sound economic and social policy decisions are impossible to take in the absence of this data.

The National Statistical Office (NSO) In Malawi regularly collects data on population health and demographics, as well as generic agricultural data on the country (NSO 2017). Further, every 5 years the World Bank and the NSO conduct integrated household surveys in Malawi, the 3d of which was implemented in 2010-2011 (NSO 2012b). None of the NSO surveys, however, has a specific focus on dairy farming. The World Bank surveys, while quite comprehensive; mostly collect information on various aspects of welfare and socio-economic status of the population of Malawi; they do not, however, collect detailed data on the dairy farming sector. Hence prior to this study, there had not been a comprehensive survey of smallholder dairy farming sector in Malawi, covering the entire country. The absence of this information is a big gap in the statistical output of Malawi, especially considering the importance of the dairy sector in the country’s future agricultural development. Rectifying this could help provide the most up-to-date and accurate information on the baseline conditions of dairy farmers which could help inform future sectoral policies.

The overall objective of the dairy sector survey conducted for the purpose of this research was to provide data to inform our understanding of the smallholder dairy sector and to provide insights into the type of farm management practices adopted by smallholder dairy farmers in Malawi. A more specific aim was to explore mitigation and adaptation practices that could inform national policies and potential NAMA development. The survey was designed to underpin and inform the whole study, provide data for the analysis and inform recommendations.

The design and implementation of the survey is discussed below

4.2 Survey design and implementation

4.2.1 Designing the questionnaire

Prior to designing the survey questionnaire the objectives of the study were discussed in order to clearly define the research question. It was agreed that the main aim of the study was to explore the current dairy farm management practices in Malawi, and both on-farm and post farm gate issues that influenced milk production. Additionally, the survey aimed to explore the farmers' views on climate change and its impacts on their dairy farms and livelihoods, and to understand the main constraints to the dairy development, as perceived by smallholder farmers.

With the main objectives agreed, an extensive review of relevant literature was conducted, including published and unpublished studies, statistical data and academic, as well as gray literature. Findings from similar dairy sector studies conducted in Vietnam, Zambia and Kenya were also consulted, to inform the design of the questionnaire. This review provided valuable information on substantive issues and allowed to generate a list of questions that could be used in planning the survey. This set of questions was developed into the 1st draft of the survey questionnaire. The 1st draft was then shared with the experts at SRUC, whose views were sought on the design of the questionnaire, and the importance of the questions asked. Following this review, the 2nd draft was produced which was shared with external experts, including colleagues from Mitigation of Climate Change in Agriculture (MICCA) and The Economics and Policy Innovations for Climate-Smart Agriculture (EPIC) programmes at FAO. FAO took a decision to part-fund the survey implementation, and became actively involved in all stages of survey design. As well as providing valuable input, the FAO colleagues also added a number of additional questions which were of particular importance to FAO; these questions, however, were not directly relevant to this study. Further, a number of questions on food security were added by our partners at Bunda College of Agriculture in Malawi, which were not originally included in the questionnaire. Finally, the colleagues at SRUC who were involved in a parallel project in Malawi on dairy marketing and supply chain, contributed to one of the modules of the questionnaire on dairy marketing chain and market access. The draft questionnaire went through multiple revisions by external and internal experts until it was considered robust for the purpose of the study. Overall, the development of the questionnaire from the initial design stage to completion took approximately 8 months.

Having to combine a number of parallel agendas and priorities resulted in the questionnaire being much larger than originally envisioned. The final questionnaire consisted of 168 questions, with many questions having multiple subsections.

Both open-ended and close-ended questions were used in the questionnaire. The questionnaire consisted of 5 modules: 1) Module on Basic Household Information; 2) Module on Dairy Farm Management and Milk Production; 3) Module on Dairy Marketing Chain and Market Access; 4) Module on Access to Animal Health and Livestock Extension Services; 5) Module on Food Security and Climate Change. The questionnaire included elements on dairy farm management and milk production, the dairy marketing chain and market access, access to animal health and livestock extension services. Further sections sought information on household structure, animal numbers and breeds kept, milk sales, and feeding methods and constraints faced in production, as well as farmers' perceptions of climate change.

The final questionnaire was translated into Chichewa which is the main language spoken in Malawi.

4.2.2 Sampling strategy

Sampling is one of the most critical aspects of any survey (UNStats 2005). The correctly selected sampling strategy forms the basis for the key claim of generalizability, which is the main strength of quantitative research.

The sampling strategy for the survey was developed using information provided by the MBGs and the University of Malawi and covered selected MBGs in the three milk producing regions - Mzuzu Milk Shed Area in the Northern region, Lilongwe Milk Shed Area in the Central region and Blantyre Milk Shed Area in the Southern region. The sample included only smallholder farmers who were members of an MBG. Inactive MBGs (those no longer actively involved in marketing milk) were excluded from the sample. Stratified random sampling was used for the survey, based on the available farmer lists, with the number of female farmers in the milk shed areas taken into account where available, in order to ensure the gender balance. The sample size was originally intended to include 100 dairy farming households; however, due to the involvement of FAO and a parallel SRUC project the sample size was increased to 460 dairy farmers. This made the survey of the dairy farmers the largest survey of its kind in Malawi, as well as the most comprehensive.

4.2.3 Survey planning, preparation and training

The survey was implemented by Bunda College of Agriculture, University of Malawi, on behalf of SRUC and FAO, with the involvement of colleagues from the Malawi Institute of Management. 12 survey enumerators - 4 for each region - all students from the University of Malawi, were recruited prior to the survey implementation. All enumerators were fluent in Chichewa, the local language spoken by the majority of the farmers. In addition, 3 supervisors were recruited to supervise the enumerator work. The supervisor were mostly more senior colleagues from the University of Malawi, experienced in conducting fieldwork. Each supervisor was responsible for supervision and quality assurance (such as checking of the questionnaires at the end of each day for completion and internal inconsistencies) of the work of the enumerators in 1 region. The enumerators and the supervisors received a targeted training at Bunda College based on the enumerator manual designed by the author (Appendix B). Training of enumerators included basic interview techniques (e.g., polite, respectful behaviour and attitude; how to avoid asking questions in a leading way); explanation of the goals of the research; and discussion of survey protocols; the meaning and purpose of each survey question, and protocols to follow in case respondents did not understand questions or refused to answer.

Prior to the main survey implementation, the questionnaire was field-tested via a small scale pilot, targeting 30 dairy farming households. The pilot was conducted in February 2013 in Central Malawi (Lilongwe area), in order to test the effectiveness of the questionnaire, the ease of completion, and tease out any elements that did not work. The feedback from the pilot stage was then used to improve the questionnaire.

The pilot survey showed that each questionnaire, due to being large and highly detailed, took around 2 hours to complete, and each enumerator was able to complete between 4 to 5 questionnaires a day. In general, experience shows that the quality of information that survey respondents provide declines significantly after more than 30 minutes (UNSTATS 2005). This created certain reservations regarding the length of the questionnaire. However, the information provided by the colleagues at Bunda College of Agriculture was that the farmers/population in Malawi are very used to being surveyed, and responding to long questionnaires. The pilot showed that the farmers did not object to the length of the questionnaire and responded patiently to all the questions. Still, some doubts remain with regards to the overall quality and the accuracy of the data collected, especially in the last, 5th Module of the questionnaire.

4.2.4 Survey implementation

The main survey was implemented during a 3-week period in February/March 2013, by the group of trained enumerators, whose daily work was checked and supervised. Completed questionnaires were shipped back to the UK, where data entry was carried out by an external company. Due to the size and the complexity of the questionnaire, the data entry took more than 2 months. The populated database was then sent to SRUC for data analysis, and shared with the colleagues at FAO.

4.3 Data analysis

Data was analysed using Statistical Package for Social Sciences (SPSS) 21.0 computer software package. A number of analytical techniques such as chi-square analysis, binary logistic regression, and multionomial logit modelling were used for analysing various sections of the survey.

4.3.1 Dairy sector NAMAs

To inform the design of the dairy sector NAMAs (section 5.1), the survey was analysed in order to explore both on-farm and post farm gate issues that influenced milk production and which could become potential entry points for NAMA design. A more specific aim was to explore mitigation and adaptation practices that could inform national policies and potential NAMA development.

In terms of mitigation options to inform NAMA design, the survey focused on baseline practices related to practical measures identified in the IPCC Fourth Assessment Report (Smith et al. 2007b); specifically livestock feeding practices, including grazing management, pasture improvement, manure management and biogas production from manure.

4.3.2 Adoption of climate-smart practices by dairy farmers in Malawi

The sections of the survey used to inform the findings in Section 5.2 were those on household socio-economic and demographic characteristics, as well as adoption of improved feeding and animal health practices.

Section 5.2 is focussed on analysing the determinants of the adoption of five different climate-smart agricultural practices, namely, use of concentrate feed, use of crop by-products, feed conservation, use of vaccination service and use of breeding service. Climate-smartness of these practices is due to the fact that adoption of any of the practices (or their combination) could improve productivity, and contribute to the higher resilience of dairy systems (after Asfaw et al. 2014). Additionally, adoption of these practices can contribute to reducing emissions per unit of product, via achieving increased productivity. Another outcome of adoption, as observed in Asfaw et al. (2014), might be to decrease downside loss in yields that can be expected if the practices are not adopted. A further important feature of these practices is that they provide almost immediate benefits with respect to increased milk yields and improved animal health, unlike some other practices that provide benefits to farmers only after a considerable period of time (such as conservation agriculture).

Empirical models

The dairy farmers were categorized into two categories - adopters and non-adopters of improved practices. A characterisation was done using contingency tables (cross tabulation) to compare the proportion of adopters and non-adopters in respect of a particular characteristic. Adoption at the farm level was quantified using a binary variable (adoption of improved feeding = 1, non-adoption = 0). Chi-square tests were carried out to assess relationships between adoption and socio-economic variables. A standard logistic regression model (logit model) was used in a binary choice (adoption versus non-adoption of practice) of outcomes. The model provides empirical estimates of how change in the socio-economic and exogenous variables influences the probability of adoption and assesses the effectiveness of the adoption of improved practices (Nkonya et al. 1997).

A logistic function including odds ratios was used to derive coefficients of explanatory variables likely to influence farmer's attitudes to the adoption of improved practices. Adoption level is a dichotomous (adopter = 1/ non-adopter = 0) variable and 5 of the independent variables (out of 10) are also categorical.

5 different models were used for the study, looking at the impact of the independent variables on five climate-smart practices.

The binary logistic model used in the study is specified as follows (adapted after Quddus 2012):

$$P = p\left(Y = \frac{1}{X}\right) = \frac{e^{\beta 0 + \sum_{i=1}^{10} \beta i X i}}{1 + e^{\beta 0 + \sum_{i=1}^{10} \beta i X i}}$$

And,

$$1 - P = p\left(Y - \frac{0}{X}\right) = \frac{1}{1 + e^{\beta 0 + \sum_{i=1}^{10} \beta iXi}}$$

Where Yi (the dependent variable) is the level of technology adoption (1 = adopters, 0 = non-adopters);

A transformation of P known as the logit transformation and is defined as:

$$\text{Logit P} = \log\left[\frac{P}{1 - P}\right] = \beta o + \sum_{i=1}^{10} \beta iXi$$

Dependent and explanatory variables

This section describes the dependent variables and the factors hypothesised to have influenced farmer adoption of a climate-smart practice (CSP). The main hypotheses for each explanatory variable are presented in Table 4.1.

Table 4.1 Explanatory variables and the summary hypotheses

Explanatory variables	Hypotheses
X_1: Region: Southern region (takes the value of 1; Central and Northern regions take the value of 0);	Significant impact on the adoption of CSP, with Southern region farmers being more likely to adopt due to longer experience in dairy farming and a larger share of income stream from dairy farming in the total household income
X_2: Gender of the household head (takes the value of 1 if male and 0 otherwise)	Female-headed households are less likely to adopt due to the cost or labour requirements
X_3: Education of the household head in years (continuous)	Higher level of education has a positive impact on the adoption
X_4: Land plot in ha (continuous)	Larger land plots have a positive impact on the adoption

Table 4.1 Explanatory variables and the summary hypotheses	
X_5: Number of dairy cows (continuous)	Higher number of dairy animals has a positive impact on the adoption
X_6: Farm total income in Malawi Kwacha (continuous)	Higher level of income (whether on-farm or off-farm) has a positive impact on the adoption
X_7: Access to credit in the past 12 months (takes the value of 1 if access and 0 otherwise)	Access to credit has a positive impact on adoption
X_8: Access to extension services (takes the value of 1 if access and 0 otherwise)	Access to extension has a positive impact on adoption
X_9: Experience in dairy farming in years (continuous)	Longer experience in dairy farming has a positive impact on adoption
X_{10}: Perceived level of knowledge in dairy farming (1 if good; 0 otherwise)	Higher level of knowledge has a positive impact on adoption

4.3.2.1.1 Dependent variables/Improved practices

The dependent variables are the three improved feeding technologies (use of concentrate, use of crop by-products and feed conservation), and two technologies related to animal health and breeding (use of vaccination and artificial insemination).

4.3.2.1.2 Independent variables

Based on the review of literature on the adoption of new technologies (see Deressa et al. 2009; Apata 2011; Apata et al. 2009; Gbetibouo 2009) and data availability, a range of household and farm characteristics, as well as institutional factors was selected that are hypothesised to influence farmers' adoption choice. These include: region, gender and education of the head of the household, size of land plot, total household income, number of dairy animals, dairy farming experience, and perceived knowledge of dairy farming; and access to extension and credit services. A description of the theoretical relationships between these variables and adoption of improved technologies is presented below.

4.3.2.1.2.1 Household and farm characteristics

Based on the review of previous studies (see Gbetibouo 2009; Apata 2011), the household characteristics considered in this study to have differential impacts on adoption or adaptation decisions are location, gender and level of education level of the head of the household, level of wealth, and years of faming experience.

Geographic location is an important factor in influencing the adoption of CSP. The majority of dairy farmers in Malawi are based in the Southern region where smallholders have traditionally been more involved in dairy farming (mostly due to small land plots, which are not sufficient for arable farming). Small land plots mean that farmers in the Southern region have a higher dependence on the income provided by dairy farming as opposed to the farmers from the other two regions, and in this study a higher proportion of their total income comes from dairy farming. Further, in this study the mean dairy farming experience in the Southern region is 8.9 years, which is 29% greater than in the Northern and 43% more than in the Central region. Thus the hypothesis is that the farmers from the Southern region will have a higher adoption rate of CSP than farmers from the Northern and Central regions.

Based on the review of a number of previous studies in Africa, the influence of the gender of the household head on the willingness to adopt improved practices appears to be ambiguous. In most studies, female heads of households have limited access to cash, land and labour, which can seriously undermine their ability to adopt new technologies, especially if these technologies are either cash- or labour-intensive (Acquah-de Graft and Onumah 2011; De Groote and Coulibaly 1998; Quisumbing et al. 1995). However, a recent study by Nhemachena and Hassan (2007), finds that female-headed households in South Africa are more likely to take up improved technologies, with the possible explanation of women being more involved in agricultural work and thus having more information on the advantages of various management practices and their impact on the food security of the household. In this study, the hypothesis is that female-headed households are less likely to take up improved technologies.

A number of studies, including studies by Acquah-de Graft and Onumah (2011) and Daberkow and McBride (2003) find that a higher level of education increases the probability of adopting new technologies via increasing farmers' ability to receive and understand information relevant to making decisions on adoption. In this study education of the head of household is also hypothesised to positively adoption of improved farming practices.

Wealth related variables (including the size of land plot, number of dairy animals and total income) are hypothesised to positively influence the adoption of CSP. Gbetibouo (2009) demonstrated that adoption of improved technology is more likely to take place on a larger farm. Further, households with greater income are in general in a better position to adopt CSP especially if this requires financial investment. A number of studies demonstrated that likelihood the adoption of improved technologies by farmers was strongly associated with the level of wealth as well as livestock ownership (Semenza et al. 2008; Gbetibouo 2009). Accordingly, the hypothesis is that the higher number of dairy animals will positively affect the farmer decisions on adoption, also due to the increased probability of investment and risk-taking by the owners.

Farming experience usually increases the probability of the uptake of all CSPs because experienced farmers will have better knowledge and information on livestock management practices (Acquah-de Graft and Onumah 2011; Nhemachena and Hassan 2007). In the literature on the adoption of improved technologies, many studies use the age of the head of the household as a proxy to farming experience (Apata 2011). However, as the majority of the surveyed dairy farmers started practicing dairy farming later than arable farming, age in this study does not necessarily signify experience. Thus, dairy farming experience (in years) is used instead as an explanatory variable. The hypothesis is that farmers with longer experience in dairy farming have a higher likelihood of adopting climate-smart practices.

Perceived knowledge of dairy farming is hypothesised to have a positive impact on the adoption of CSP, as farmers with more perceived knowledge (whether learnt through training, from the extension services, or from friends, neighbours and relatives involved in dairy farming) will have more information on the benefits of improved practices.

4.3.2.1.2.2 Institutional factors

Access to extension services and access to credit are two of the most important institutional factors often considered in literature to influence adoption of new technologies (Gbetibouo 2009). This section (4.3) argues that access to extension services and credit are major determinants of farm practice choice.

Agricultural extension is widely recognized to have a positive impact on the efficiency of making adoption decisions (Apata 2011; Fosu-Mensah et al. 2010; Deressa et al. 2009; Nhemachena and Hassan 2007; Maddison 2006). Based on these studies, I hypothesise that access to extension services is positively related to the adoption of new technologies by exposing farmers to new information and technical skills, and by providing access to inputs and services.

Access to credit has also been shown to have a positive effect on adaptation behaviour (Fosu-Mensah et al. 2010; Gbetibouo 2009), particularly if the adoption of a technology requires an investment. Thus it is hypothesised that access to credit positively affects adaptation of CSP.

It is important to note that other factors such as household size, security of land tenure, and local agro-ecological conditions (including local climate and soil fertility) might be potentially significant for the adoption of CSP; some of these are studied in later sections as variables for other modelling exercises based on the survey.

4.3.3 Dairy farmer perceptions of climate variability and the use of adaptation strategies

This analysis was conducted to inform Section 5.3 and focused mainly on questions asking farmers on their perceptions of climate change and use of adaptation practices.

Questions on climate variability included farmer perceptions of climate change and weather variability, and its perceived impacts on their dairy farms. Farmers were asked to report any changes with respect to more frequent droughts and flooding, changes in rainfall patterns, cattle disease occurrence and milk yields over the past 5 years. This time period was selected for two reasons. The first is that the average experience of the respondents in dairy farming was just over 7 years, so 5 years was a reasonable period to recall climatic events and impacts on dairy farms based on their memory of the events. Another reason is that this study relies on farmers' recall of climatic changes, and it could have been difficult for most farmers to remember past events. Additionally, a number of studies have shown that when forming their perceptions of climate risk which, in turn, inform their adaptation decisions, farmers place greater emphasis on recent climate events rather than the events in more distant past (Maddison 2007; Gbetibouo 2009).

Climate change was defined as perceived changes in average temperature, average rainfall or rainfall variability over the last 5 years. Open-ended questions asked about farmer perceptions of climate change were grouped into several categories – more frequent droughts, more frequent flooding, erratic rainfall, increase in temperature and no change.

A binary and a multinomial logit (MNL) models were used in this study. A binary choice model was used to estimate the factors influencing farmers' perceptions of changes in weather variability which they believe to be associated with climate change (after Bryan et al. 2013).

$$R_i^* = X_{i\alpha}a + \varepsilon_i$$

Where R* is the latent variable, ε is the error term, and X denotes the set of explanatory variables or factors that influence farmers' perceptions of weather variability. The binary outcome is equal to one (Pi=1) if farmer perceives a change in rainfall variability over the past 5 years and 0 otherwise (Pi=0).

As farmers' observations of the impacts of climate change on their dairy farms fall into several categories, a multinomial model was used to analyse the factors affecting these perceptions. MNL is a common analytical approach used in adoption studies involving multiple choices (Tazeze et al. 2012). This approach allowed the analysis of multiple responses over a chosen base category; in this case, the "no change" option was selected as the base for the model. The model was used to analyse the socio-economic factors affecting the perceived impacts of climate change on dairy farms, including impacts on animal feed, water availability and animal diseases. Additionally, chi-square tests were used to determine how climate change perceptions influence farmers' choice of adaptation/coping strategies.

The choice of the variables in the MNL model was dictated by data availability and available adaptation literature. The main hypothesis tested in the model was that socio-economic differences between farmers as well as their perceptions of weather variability influence farmers' perceptions of climate change impacts on dairy farms.

Before running the MNL model, all 10 explanatory variables in the model were checked for multicollinearity using Variance Inflation Factor (VIF) and Contingency Coefficient (CC) for continuous explanatory variables and discrete variables, respectively. VIF for all variables were less than 10 (1.17–2.23), which allows us to safely assume that multicollinearity is not a serious problem in the model. Hence all the hypothesized explanatory variables were included in the model.

The explanatory variables and their expected signs are presented in Table 4.2.

Table 4.2 Description of explanatory variables and the expected signs			
Model 1. Factors influencing farmers' knowledge and perceptions of climate change			
Variable	Description	Expected sign	Hypothesis
X_1	Gender of household head, 1 (female), 0 (male)	-	Females are less likely to perceive changes in weather variability as a sign of climate change, due to significant

Table 4.2 Description of explanatory variables and the expected signs			
			gender gaps in education levels and access to sources of information
X_2	Age of household head	+	Older farmers will have more accumulated knowledge of the impacts of climate change
X_3	Education level (years of schooling)	+	Farmers with more years spent in schooling are more likely to associate weather variability with climate change
X_4	Access to extension, 1 – yes, 0 - otherwise	+	Farmers with frequent access to extension are more likely to be aware of climate change and its impacts
X_5	Region of the respondent, 1 (Southern), 0 – otherwise	+	Respondents from the Southern region are more likely to have noticed changes in weather variability based on the recent climatic trends in the region
Model 2. Factors influencing perceived impacts on dairy farms			
X_1	Gender of household head, 1 (female), 0 (male)	-	Females are less likely to notice a connection between changes in weather variability, and the impact on dairy farmers, due to a limited access to knowledge
X_2	Age of household head	+	Older farmers are more likely to report impacts
X_3	Education level (years of schooling)	+	Farmers with more years spent in schooling are more likely to report impacts
X_4	Access to credit, 1 – yes, 0 - otherwise	-	Farmers with access to credit are less likely to report impacts
X_5	Access to extension, 1 – yes, 0 - otherwise	-	Farmers with access to extension are less likely to report impacts
X_6	Experience in dairy farming (years)	+	Farmers with more experience are more likely to report impacts
X_7	More frequent droughts, 1 – yes, 0 - otherwise	+	Farmers are more likely to report drought related impacts on dairy farms
X_8	Erratic rainfall, 1 – yes, 0 - otherwise	+	Farmers are more likely to report rainfall related impacts on dairy farms

Table 4.2 Description of explanatory variables and the expected signs			
X_9	Flooding, 1 – yes, 0 - otherwise	+	Farmers are more likely to report flooding related impacts on dairy farms
X_{10}	Increase in temperature, 1 – yes, 0 - otherwise	+	Farmers are more likely to report heat related impacts on dairy farms

4.3.4 Adoption of agroforestry practices

Key questions of interest to this section (See Section 5.4 in the Results and Discussion chapter) related to farmer participation in agroforestry and community forestry practices, types of agroforestry practices adopted and the number of years practicing, and questions on the number of local and exotic trees planted at the farm. The section also investigated the reasons for non- adoption. Key household socioeconomic variables included age, gender, education level, importance of income from livestock and the number of workers at the farm.

Empirical model

A logit model has been estimated to predict the probability of adoption of the agroforestry practices. For the description of a similar empirical model see Section 4.3.2.

4.3.4.1.1 Explanatory variables

This section describes the explanatory variables hypothesized to have influenced farmer adoption of agroforestry practices.

Table 4.3 Descriptive statistics for variables used in the empirical model				
Explanatory variables	**Description**	**Continuous variable**		**Categorical variable (%)**
		Mean	Std Dev	
X_1: GENDER	Gender of the head of household. 1 =			1=83.3%; 0=16.7%

Table 4.3 Descriptive statistics for variables used in the empirical model				
	male, 0 = female			
X_2: AGE	Age of the household head in years	49.9	13.5	
X_3: EDUC	Education of the household head in years	7.26	3.9	
X_4: LAB	Household access to labour (number of workers at the farm)	3.5	1.9	
X_5: LAND	Size of land holding in ha	1.1	0.8	
X_6: TEN	Land tenure status, 1 if freehold, 0 otherwise			1=12.6%; 0=87.4%
X_7: LINC	Livestock as the source of income: 1= Livestock is the main source of income; 2=Livestock is the secondary source of income			1=70.8%; 2=29.8%
X_8: CRED	Access to credit in the past 12 months (takes the value of 1 if access and 0 otherwise)			1=40.9%; 0=59.1%
X_9: EXT	Access to extension services (takes the value of 1 if access and 0 otherwise)			1=90.7%; 0=9.3%

Table 4.3 Descriptive statistics for variables used in the empirical model				
X_{10}: REG	Region of the respondent; 1 – Northern, 0 - otherwise			Central region=32.6%; Southern region=58.0%; Northern region=9.4%

The explanatory variables in the model are: gender of the head of household (GENDER), age of the household head (AGE), education of the household head in years (EDUC), household access to labour (LAB), size of land holding (LAND), land tenure security status (TEN), importance of livestock as the main source of income for the household (LINC), access to credit in the past 12 months (CRED), the availability of extension officers in the area (EXT), and region of the respondent (REG). Summary hypotheses for the independent variables included in the analysis and the discussion for the expected signs for their coefficients is provided below:

•GENDER. Based on the literature findings it is hypothesised that female-headed households are less likely to practice agroforestry, due to the restricted access to resources/inputs and information (this includes smaller land holdings, lower income, limited access to extension and credit services, and limited labour resources).

•AGE. It is hypothesized that younger farmers are more likely to adopt agroforestry, as they might be less risk averse, and more willing to invest energy and resources in improving long-term productivity of the soil (Alavalapati et al. 1995; Kaczan et al. 2013).

•EDUC. Based on studies discussed above, it is hypothesized that higher number of years spent in schooling increases the likelihood of agroforestry adoption as farmers are more prone to knowledge intake.

•LAB. Based on the findings by Thangata and Alavalapati (2003) discussed above, and due to some forms of agroforestry being labour intensive, it is hypothesized that households with a higher number of farm workers (including members of the household as well as paid workers (ganyu) are more likely to adopt agroforestry.

•LAND. Again, based on the findings from previous research discussed above, it is hypothesized that households with larger land plots are more likely to adopt agroforestry.

•TEN. Insecurity of tenure has been shown to negatively influence adoption of new farming practices requiring long-term investment of inputs and labour, and longer waiting times to gain the benefits (McCarthy and Brubaker 2014). Hence it is hypothesized that households with freehold land/secure tenure are more likely to adopt agroforestry than households with customary or leased land.

•LINC. As all the households interviewed in the survey practiced dairy farming, it was expected that some or most of their income to come from livestock. For some households livestock income made up a greater part of budget than for others which were more reliant on income from crops, fishing, or other activities. Hence it is hypothesized that households where livestock is the primary source of household income are more likely to adopt agroforestry practices due to an increased need to source fodder.

•CRED. Based on the findings by Fosu-Mensah et al. (2010) and Gbetibouo (2009), who argued that the adoption of a technology requires an investment, it is hypothesized that access to credit positively affects adaptation of agroforestry.

•EXT. Previous studies (see above) have shown that contact with extension services increases farmer access to knowledge, advice and information. Thus it is hypothesized that households with a (frequent) contact with extension services are more likely to adopt.

•REG. Taking into account that practicing agroforestry usually requires land availability, and that the farming households in the Northern region have the largest land holdings, it is hypothesized that farmers in the Northern region are more likely to practice agroforestry than those in the other 2 regions.

Chapter 5 Results and Discussion

5.1 Farm household characteristics and descriptive statistics

The general summary characteristics of the sample (at the farm and the household level) are shown in Table 5.1.

Table 5.1 Household socio-economic characteristics

Socio-economic characteristic	**Mean**	**SD**
Size of Household, *people*	5.46	2.08
Age of the head of the household, (*year)*	50.0	13.557
Land plot, (*ha)*	1.1	0.8
Total income from all agricultural activities, (*thousand MK/month)*	43.0	40.4
Income from dairy farming, *thousand (MK/month)*	20.7	15.3
Number of cows per household	1.6	.768
Years of experience in dairy farming	7.9	7.11

The majority of respondents (92.4%) owned small land holdings – under 1ha – of mostly customary land dominated by cereals, mainly maize, which is the staple crop in Malawi. Farmers' main activity was dairy farming combined with rain-fed farming. Dairy farming was also the main source of income for 70.8per cent of respondents. The average household size was 5.5(±2.1) people.

The average age of respondents was 50 (± 13) with the majority being between 35 to 56 years old. Females accounted for 53.3 per cent of respondents and males – 46.7

percent. The majority (67.3 per cent) had not more than 8 years of schooling. About 6 percent of all farmers were illiterate.

80.2% of farmers had less than 10 years of dairy farming experience. The majority of respondents (about 90%) owned only 1-2 dairy animals – mostly of pure or cross breed (mostly Holstein Friesian or Holstein Friesian crosses), that is, of high genetic production potential.

40.9 per cent of respondents received credit in the 12 months prior to the survey.

Table 5.2 Summary descriptive statistics by region

	Region					
	Central (N=150)		Southern (N=267)		Northern (N=43)	
Household (HH) Characteristics (N=460)	Mean	SD	Mean	SD	Mean	SD
Age	52.2	13.8	48.8	13.5	49.7	12.6
Holding size, ha	1.49	0.81	0.8	0.67	1.70	1.0
HH size, number	5.8	2.1	5.2	1.9	5.6	2.3
Dairy farming experience, years	6.2	4.0	8.9	8.5	6.9	4.4
Number of cows	1.5	0.7	1.7	0.7	1.4	0.6

5.2 Targeting mitigation and food security in Malawi via agricultural NAMAs

Developing dairy sector NAMAs can be an important option for accessing climate finance opportunities directed at scaling up best practices in agriculture. Malawi has been active in exploring the potential for agricultural NAMAs, with a 2012 UNFCCC submission proposing actions on biogas for energy and manure waste management (GoM 2011b; 2012b). As yet there has been no specific analysis to guide the potential inclusion of the dairy sector though its mitigation potential is recognised.

The section presents survey data to describe the current situation in the Malawian dairy sector and outlines potential opportunities for the development of dairy sector NAMAs.

5.2.1 NAMA development: baseline survey evidence from smallholder agriculture

Key response data on relevant survey questions are summarised in Table 5.3:

Table 5.3 Main survey questions and summary observations

Question	Proportion of respondents	Observations on current constraints and barriers
Pasture production and Feed management		
Pasture size	50% of surveyed farmers did not own pasture land, and 90.9% of those who did owned areas of less than 1ha	Absence of established pastures leading to common feed shortages.
What type of grazing do you practice?	95.4per cent of respondents practiced zero grazing (or cut and carry) feeding regime	Low digestibility grass/forage leading to high methane emissions.
Do you make conserved feeds, (e.g. hay)?	59.5% did not make conserved feeds	Feed is not efficiently utilized as feed conservation practices such as hay making are not often practiced leading to frequent feed shortages.
Do you regularly experience a shortage of feed?	50.0per cent of respondents regularly experienced shortage of feed	Feed shortages are a significant limitation to increasing animal productivity.
Do you have enough fodder for your animals for the whole year?	53.4per cent of respondents did not have enough fodder for their animals	Lack of fodder can have a significant impact on animal productivity.
Do you purchase crop by-products during the year (as feed for the dairy animals)?	78.1% did not purchase crop by-products	Crop by-products contribute to the higher yields in dairy cows leading to reduced emissions per kg of milk.

Table 5.3 Main survey questions and summary observations		
Do you use concentrated feed?	Only 35.6% of farmers used concentrated feed	Concentrated feed improves yields and thus reduces emissions per kg of milk.
Milk production		
Do you plan to increase the amount of milk you produce?	89.5per cent of respondents planned to increase milk production, the majority via producing or buying more feed	Farmers appreciate the importance of improved feeding practices for increasing milk production.
Do you think there are significant constraints to dairy production on the farm?	93.0per cent of respondents believed there were significant constraints on production, the most important being low market prices of milk, low milk yield, high price of concentrate feed, and prevalence of animal disease or infertility (Figure 2.3). Other constraints mentioned included delay in payment of milk from MBGs, milk souring due to the absence of storage, lack of transport/long distance from MBGs and poor extension and veterinary support	High price of concentrates and supplements reduce productivity and contribute to higher emissions as animals then rely on less easily digestible grass from pastures or *dambos* (hydromorphic areas owned by the whole community). Low milk prices indicate how supply chain structure (i.e. post farm gate) also influences production decisions.
Manure management		
Most common manure storage system?	Dry lot/heap storage used by 54.7% of farmers; pit storage – by 37.7%	Uncovered manure heaps are a source of CH_4 emissions that can be reduced by changing manure management system.
Biogas production from manure?	The majority of farmers did not produce biogas	The technology requires high up-front costs but can be greatly beneficial to farmers and help reduce emissions.
Agroforestry		
Are you involved in any agro-forestry work?	59.5% of all respondents were not involved in any agro-forestry work	Lack of knowhow and lack of awareness of the benefits of agro-forestry (such as providing fuel and feed for the animals) are the main reasons for farmers not practicing.

Table 5.3 Main survey questions and summary observations		
Animal Health		
Did you see any diseased animals on your farm in the past 12 months?	43.8% had seen diseased animals on their farm in the past 12 months. 12% of the respondents had experienced dairy cattle deaths.	Poor animal health is a major issue, mainly associated with lack of knowledge and training in animal health.
Supply chain		
Do you have difficulties selling your milk?	91.2% of farmers regularly experienced difficulties when selling their milk ; 70% of these –due to the poor quality and low price of milk	Poor quality milk often leading to milk wastage is mainly due to the lack of the refrigeration facilities at dairy farms, milk souring while being delivered to the MBG, because of the distances and fresh milk souring after having been delivered to the MBG as a result of frequent power cuts. This, coupled with the low milk prices offered by the dairy processors irrespective of the season does not provide incentives for farmers to produce more milk.
Do you have your milk rejected by an MBG?	66.1per cent of respondents regularly experienced their milk being rejected by the MBGs	Although farmers might deliver good quality milk to the MBG, and milk is initially accepted, it may later be rejected by the processors if it gets sour due to frequent power outages and generator break downs. This wastage encourages some farmers to sell outside the formal market.
Do you experience delays in getting paid for the milk sold?	88.6% experienced delays in getting paid for the milk, with 48.5% experiencing delays of up to 1 month	Delays in payments often lead to farmers turning to the informal market for selling their milk, as the price is paid up-front. This leads to a significant amount of milk being sold outside the formal channels.
Are there any incentives in your local MBG for delivering milk in low season?	93% of all MBGs did not have any incentives in place to reward farmers delivering milk in low season, or producing higher amounts of milk	The absence of incentives often makes farmers sell in the informal market, where the price paid per litre is higher.

Table 5.3 Main survey questions and summary observations		
Are there any dairy cooperatives (apart from MBGs) that you are a member of?	More than 99% of farmers did not belong to any dairy cooperatives	Lack of farmer organisations makes farmers more vulnerable and unable to negotiate better payment conditions with the dairy processors.

The survey observations point to a number of key observations relevant to NAMA design.

Pasture production and feed management

Feeding practices are clearly relevant to animal productivity and hence emissions, but current inefficiencies have much to do with limited plot sizes, the use of cut and carry forage of low digestibility and customary tenure systems working against any improvement incentive. Pasture improvement and hay-making are not often practiced.

Although supplemental feeding is becoming more common among dairy farmers, with maize bran being the most common supplement, the price of dairy mash and other supplements as well as the availability of minerals and molasses constrain regular use. A very small proportion of the households reported using minerals or molasses.

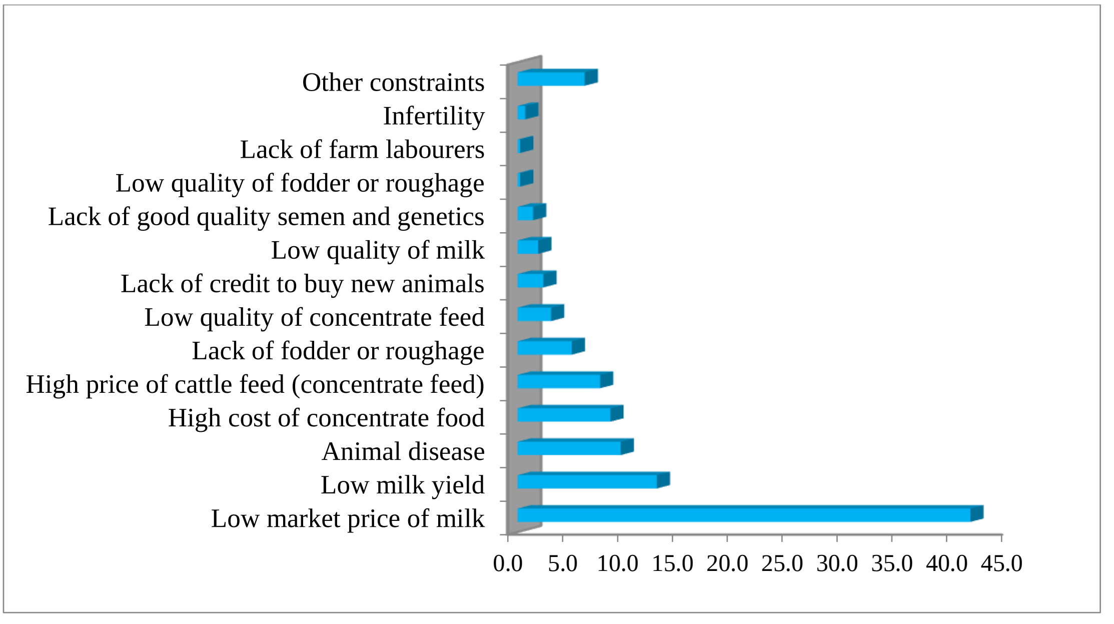
Increased use of crop by-products and feed supplements has been suggested as an economical way of ensuring access to adequate supplies of nutrients (Mtimuni 2012). Capacity building of farmers on locally available and potential feed resources and the importance of these in improving production efficiency will be essential.

Size of herd and milk production

A revealing survey finding is that a high proportion - > 80% - owned pure breed cattle rather than cross or local Zebu cattle. The latter breed is better adapted to local conditions, but milk production from Zebu is lower than from cross breed or pure breed cows, which largely explains farmer breed preferences. Around 80% of the sample also owned only one animal, thus limiting production with obvious implications for the types of dairy cattle-related investments they can be expected to make.

The majority of respondents thought there were significant constraints on production; the most important being low milk yield and market prices, high price of concentrate feed, as well as animal disease including infertility (Figure 5.1).

Figure 5.1 Main constraints facing dairy farms, % (N=427)



<u>Manure management and biogas production</u>

Manure is an important source of methane, whereas manure excreted during grazing, as well as emissions from livestock sheds is one of the most important sources of the N2O. The most common manure storage system is dry lot - followed by pit storage. More than 80 per cent of this manure is produced when the cattle are housed.

CH4 emissions from manure management greatly depend on the time manure is stored inside sheds or kholas or in outdoor manure stores (Chadwick et al. 2011).The majority of surveyed farmers stored manure between 6 and 8 months before use or disposal. Removal or manure from animal housing into outside storage is infrequent, and the storage areas are normally not covered. More than 90 per cent of farmers did not cover manure with any material, and more than 40 per cent mix it with other material. It has been shown that emissions from cattle housing can be reduced through a more frequent removal of manure to a closed storage system (Monteny et al. 2006).

Unsurprisingly for this sample, the majority of surveyed farmers did not produce biogas on their farms, although only 19 per cent of surveyed farming households had access to electricity (including solar power), and biogas production can generate energy (heat or electricity) and produce residual fertilizer. However, digesters involve significant capital costs and finance and farmer cooperation are barriers that would need to be overcome.

Agroforestry practices

Agroforestry is important both for both mitigation (carbon sequestration, improved feed and consequently reduced enteric methane) and for adaptation (improving the resilience of agricultural production to climate variability by using trees to intensify and diversify production and buffer farming systems against hazards) (FAO 2013a). Shade trees reduce heat stress on animals and help increase productivity. Trees also improve the supply and quality of forage, which can help reduce overgrazing and curb land degradation (Thornton and Herrero 2010). Furthermore, crop by-products and co-products from agro-forestry can be used as low-emission feeds for cattle.

More than half of respondents were not involved in any agro-forestry work; the majority of these mentioned lack of knowledge/training or knowhow as the main reason for not practicing agro-forestry.

Animal health

The survey revealed that nearly half of all respondents had detected diseased animals on their farm in the previous 12 month leading to cattle deaths on 12% of farms.

Better nutrition, improved animal husbandry, regular animal inspection and use of antibiotics can improve reproduction rates and reduce mortality (Tebug 2012). All of these measures can therefore increase animal productivity at relatively low cost.

Supply chain efficiency

Some of the most revealing survey responses related to supply chain relationships. The survey revealed that low milk procurement prices and quality requirements were a considerable barrier to participation in formal milk marketing by smallholders. The current supply chain structure means that smallholders are reliant on conditions for quality and prices set by the MBGs. Since the latter do not return milk that fails a quality threshold, there is a risk for small producers who lack the equipment and expertise to reach these thresholds. On the other hand, reliance on informal marketing does not always guarantee higher prices or a more regular outlet for produce. An added disadvantage is that smallholders involved in the informal marketing are unable to access credit as a basis for livestock improvement (Sindani 2012).

There is also a lack of farmer organisations / cooperatives at the level below Milk Bulking Groups (CISANET 2013). Survey results showed that the majority of all respondents were not part of any dairy or farmer co-operative, mostly due to the lack of these. The establishment and participation of effective and representative farmer organisations that are able and willing to communicate on behalf of their members is essential. However, establishing such groups requires support and capacity development.

Overall, the survey indicates that supply chain efficiency is as important as on-farm measures for increasing productivity, and hence reducing emissions. A NAMA approach that considers the entire dairy supply chain is essential.

5.2.2 **Potential dairy sector NAMAs**

Findings summarised above indicate considerable scope for NAMA design, with mitigation options available along the entire supply chain. The most immediate and low cost options are likely to be targeted to feed production, enteric fermentation and adopting composting, improved manure handling and storage, as well as adoption of different application techniques. Most of these will not require any capital costs, but farmer training and knowledge dissemination will be essential.

Most on-farm interventions aim to improve basic farm productivity and resource use. For example the use of improved feeding technologies, manure management (e.g.

composting) and agroforestry, are readily available for implementation, and have been successfully trialled in other parts of Sub-Saharan Africa (FAO 2013b).

It has been shown that a relatively small change in the efficiency of dairy feeding can have a major effect on animal productivity and farm profitability (Gerber et al. 2011). A feeding intervention NAMA will need to focus on capacity building for farmers on the benefits of introducing improved feeding techniques.

Improved manure management via deployment of technology for biogas-based electricity generation is also a promising basis for a NAMA helping to reduce CH4 emissions from manure, and provide smallholder households with much needed energy. Introduction of this technology would require credit agencies or donors to cover costs for purchasing bio-digesters, as well as training of farmers on bio-gas production. In this regard the NAMA objective overlaps with that of The Clean Development Mechanism (CDM), which is a longer established financing mechanism that can be used for producing biogas energy. Most recently CDM funding was used, for example, in the Nepal Biogas support programmes (Doyle 2013). Experience with biogas CDM projects has demonstrated practical MRV approaches that can clearly facilitate NAMA development (FAO 2013b).

An agroforestry NAMA will need to focus on knowledge dissemination, awareness raising and training of farmers on the benefits of agroforestry for the productivity of the farm and income generation, provision of seeds to farmers, and follow up work with farmers to achieve returns in terms of improved resilience and increased household incomes. Again, because of overlapping objectives, payment for environmental services mechanisms could also be explored to encourage farmers to participate in agroforestry practices. But like PES mechanisms, institutional (e.g. legal and policy) reforms would be necessary to foster the development of agroforestry and recognize its contribution to national development, and mainstreaming of agroforestry in national policies.

Animal health intervention NAMA should focus on farmer training on animal health related issues, and provision of higher quality extension advice and artificial insemination and veterinary services. Poor farm management practices may be partly addressed by improved access to information including breeding and veterinary services; the latter could have a significant impact on reducing animal mortality.

Overall, improving the efficiency of the dairy supply chain is an explicit barrier emerging from the survey, since one of the most important constraints to increasing productivity is low price paid for milk, which is an underlying reason for the lack of investment in animal productivity, thus locking farmers into a downward spiral that ultimately retards investment in animals as a capital asset. These barriers can be overcome with specially targeted supply chain and policy interventions, such as extension work, farmer training and financing mechanisms, including improving access to credit and payment for environmental services. Supply chain interventions can offer verifiable interventions that may be amenable to coordinated government and donor interventions. This is paramount for sector development and increasing production as current oligopolistic structure of bulking groups is a potential target for concerted intervention between government and donors.

The initial supply chain NAMA could focus on organising the dairy co-operatives where dairy farmers will have a stronger collective voice and can negotiate with the MBGs and, directly, with the dairy processors regarding the prices paid per unit of milk and reducing wastage, access to feed and feeding supplements, and negotiate with the credit organisations with regards to obtaining credit for dairy farming. Higher prices paid for milk will encourage farmers to increase investment in dairy farming, and to improve their knowledge of dairy farming and management practices. Furthermore, it is important for any supply chain NAMA to focus on improving links between multiple stakeholders within the supply chain and providing greater coordination among the different stakeholders.

It is important to stress that from both national and international funders' perspectives, a robust system of measuring, reporting and verifying is essential for effective monitoring of the NAMA implementation, and for assessing its impact in terms of greenhouse gas emissions reductions, cost effectiveness and other co-benefits (UNEP 2013).

Proposed NAMAs are summarised in Table 5.4 below. At the current time, it is important to improve the evidence base to demonstrate that measure implementation can reduce emissions and improve or maintain smallholder livelihoods. This might require specific farm scale modelling of identified options. Even then some of the identified options, such as using more concentrated feed or biogas production from manure will require financial assistance to implement, and capacity building will be necessary to make farmers more aware of the potential benefits of these strategies.

Table 5.4 Proposed NAMAs for the smallholder dairy systems in Malawi

Sector	Proposed NAMA	Benefits to farmers	Constraints
Feeding practices	Use of improved feed and feeding technologies, increased use of crop by-products, supplements and concentrated feed	Higher yields, improved animal health	High cost for purchasing concentrates, supplements and vitamins. Lack of established pastures to grow feed with a low-carbon output
Manure management	Activities aimed at composting, improved manure handling and storage	Higher crop yield if using manure as a fertilizer	Lack of knowledge and incentives
Biogas production	Provision of grants to farmers to purchase bio-gas digesters, training and follow-up support	Improved farmer livelihoods through access to energy	High capital costs, lack of knowledge and incentives
Animal health	Targeted farmer training on maintenance of animal health and improved animal husbandry	Improved reproduction rates, reduced mortality, increased productivity	Lack of knowledge and knowhow, poor animal management practices, limited access to extension and veterinary advice
Agroforestry	Provision of training on agro-forestry practices targeted at dairy farmers, provision of seeds and follow up support	Improved feed and resilience, increased animal productivity.	Limited land, lack of knowledge and know-how

Table 5.4 Proposed NAMAs for the smallholder dairy systems in Malawi			
Supply chain	Organising dairy-cooperatives/farmer organisations at a level below MBG level.	Empowering farmers to negotiate higher milk prices, access to credit to purchase more animals or feed, accessing high-quality extension advice as a group	Lack of knowledge and knowhow, inertia

5.2.3 **Conclusions to Section 5.2**

Current farm management practices in the smallholder dairy sector in Malawi offer significant options for agricultural-based NAMAs that could potentially reduce emissions and improve livelihoods. The smallholder survey found a number of farm management practices that could be modified to be climate-smart and potentially funded under a NAMA modality. These options can initially be implemented as pilot project-based NAMAs; a climate change mitigation modality that has the potential to dovetail with a range of existing development aid objectives.

But development of agricultural NAMAs requires further analysis. Specifically, the adoption of measures by farmers must be locally appropriate and clearly beneficial before behavioural change can be expected. At present the evidence on the farm scale profitability of measures is unproven in all cases.

Many of the available options could build on, or scale up, current practice; however, in some cases (such as biogas production) technical innovations may be required. Although a diversity of mitigation options provides flexibility, it creates extra challenges in measuring, reporting, and verification.

Furthermore, the potential mitigation strategies need to be thoroughly assessed in terms of their emission reduction, additionality and cost-effectiveness. Specific interventions might only make sense and achieve a net mitigation effect if greater on-farm efficiency does not instead displace emissions to other parts of the food chain.

Finally the proximity of NAMA and climate-smart agendas suggest that the former need to be designed with clear reference to the ongoing agenda on climate change adaptation. This places emphasis on combinations of mitigation and adaptation practices adapted to specific production systems and environments (e.g. interventions addressing the management of feed, genetic resources and manure). The potential aggregated effects that changes in farming systems may have on food security and the use of natural resources at the regional level also need to be better understood. It will be essential for the NAMA interventions to take into consideration whole production systems and supply chains, as addressing mitigation or adaptation issues requires paying attention to spillover and feedback effects along the chain.

5.3 Factors influencing the adoption of climate-smart practices by dairy farmers in Malawi

This sections presents findings from Modules 2 and 3 of the smallholder survey.

As discussed above, many of the studies in this field take engaging in agricultural practices or technologies that increase incomes and productivity as a measure of adaptive capacity (see Teklewold et al. 2013; Falco and Bulte 2011). This approach agrees with the definition of climate-smart agriculture (CSA) offered by the Food and Agriculture Organization of the United Nations (FAO), which recognizes productivity enhancement as one of the key elements of CSA; defining climate-smart agricultural practices as those that increase agricultural productivity and incomes, increase farm adaptive capacity and resilience in the face of climate shocks, leading to a better food security, and mitigate GHG emissions where possible (FAO 2013a). Following this definition, in this section climate-smart practices (hereafter, CSP) are defined as improved practices which have the potential to increase incomes of smallholder farmers, provide resilience and increase adaptation of dairy systems to climate change, whilst at the same time resulting in a fewer GHG emissions.

Figure 5.2 presents current adoption levels of five improved practices, based on the survey findings.

Figure 5.2 Current adoption levels of improved practices

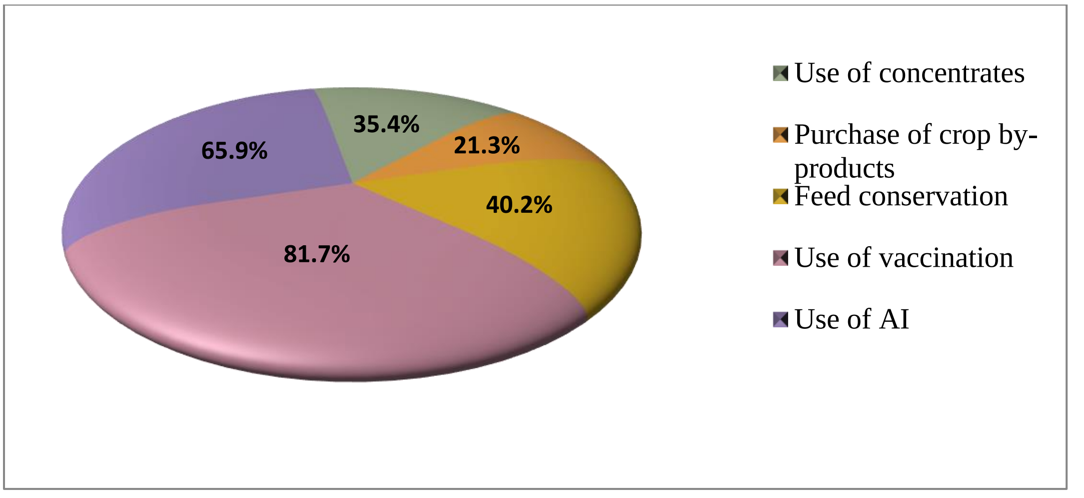


Figure 5.2 shows that vaccination is the most widely adopted practice among the five studied practices. This is consistent with the findings of Quddus (2012) who demonstrated that health care practices such as vaccination are often adopted by smallholder farmers to a relatively good degree because of the visibility of results.

Tables 5.5 and 5.6 present the relationship between the key farm and external characteristics and the adoption of the improved technologies. The findings show that adopters of improved feeding technologies in this study achieved higher milk production than non-adopters highlighting a significant relationship ($p<.000$) between adoption of the practice and increase in milk yield. The difference in milk yield between adopters and non-adopters of improved practices is widely recognized (Quddus 2012; Toolsee and Boodoo 2001; Reynolds et al.1996). Kilay (2002) showed that higher level of technology adoption is associated with better milk yield regardless of the breed of cattle owned by the farmers.

Table 5.5 Use of improved feeding practices and conserved feeds									
	Use of concentrate feed (CSP1)			**Use of crop by-products (CSP2)**			**Making conserved feed (CSP3)**		
	Adopters	Non-adopters	Chi-square	Adopters	Non-adopters	Chi-square	Adopters	Non-adopters	Chi-square
Region									
Central	52.7	47.3	29.103***	4.0	96.0	65.981***	68.7	31.1	87.014***
Southern	26.6	73.4		34.5	65.5		30.3	69.7	
Northern	30.2	69.8		0.0	100.0		2.3	97.7	
Gender									
Male	36.8	63.2	1.904	21.1	78.9	.033	39.7	60.3	.268
Female	28.6	71.4		22.1	77.9		42.9	57.1	

Table 5.5 Use of improved feeding practices and conserved feeds

Level of education									
Primary	34.2	65.6	1.897	22.1	77.9	19.477***	40.2	59.8	5.769
Secondary	40.6	59.4		13.5	86.5		45.8	54.2	
Did not attend school	29.6	70.4		40.7	59.3		29.6	70.4	
Land plot, *ha*									
<0.5	23.3	76.7	2.640	36.7	63.3	2.753	10.0	90.0	15.957***
>0.5	36.5	63.5		20.5	79.5		42.8	57.2	
Number of cows									
1	57.4	42.6	26.280***	15.5	84.5	10.592**	57.7	42.3	51.247***
2	64.9	35.1		28.7	71.3		62.3	37.7	
3 and more	66.5	33.5		24.1	75.9		61.1	38.9	
Average milk yield per day, *l*									
<10	31.0	69.0	23.820***	12.5	87.5	14.448**	31.5	68.5	13.501***
10-20	39.1	50.9		29.6	70.4		47.8	52.2	

Table 5.5 Use of improved feeding practices and conserved feeds

>20	60.0	40.0		43.6	56.4		62.5	37.5	
Total income, *thousand MK/month*									
<30	25.4	74.6	34.656***	6.5	93.5	15.121**	32.7	67.3	5.985
31-60	37.7	62.3		14.0	86.0		61.5	38.5	
61-90	52.2	47.8		21.2	78.8		63.0	37.0	
>91	63.5	36.5		27.4	72.6		47.7	52.3	
Access to credit in the past 12 months									
Yes	45.9	54.1	17.951**	28.7	71.3	20.438***	36.2	63.8	2.166
No	31.7	68.3		16.2	83.8		43.0	57.0	
Access to extension services									
Yes	42.7	57.3	10.068***	42.7	57.3	18.682***	52.4	47.6	27.386***
No	28.5	71.5		28.5	71.5		28.5	71.5	
Dairy farming experience, *years*									
<10	36.1	63.9	2.147	20.9	79.1	5.272	41.8	58.2	1.845
11-20	35.9	64.1		15.6	84.4		34.4	65.6	

Table 5.5 Use of improved feeding practices and conserved feeds

21 and above	22.2	77.8		37.0	63.0		33.3	66.7	
Level of knowledge									
Good/Very good	62.1	37.9	17.484***	6.9	93.1	12.932***	48.3	51.7	23.775***
Fair	32.4	67.6		29.0	71.0		31.7	68.3	
Needs to be improved	25.4	74.6		23.8	76.2		30.2	69.8	

Table 5.6 Use of vaccination and breeding service						
	Use of animal vaccination (CSP4)			Use of artificial insemination (CSP5)		
	Adopters	**Non-adopters**	**Chi-square**	**Adopters**	**Non-adopters**	**Chi-square**
Region						
Central	86.5	13.5	10.307***	75.9	24.1	30.489***
Southern	74.0	26.0		41.9	58.1	
Northern	79.1	20.9		55.3	44.7	
Gender						
Male	82.8	17.2	1.622	65.8	34.2	1.048
Female	76.6	23.4		67.1	32.9	
Level of education						
Primary	80.7	19.3	2.939	66.9	33.1	5.724
Secondary	82.3	17.7		58.3	41.7	
Did not attend school	92.6	7.4		81.5	18.5	
Land plot, *ha*						

Table 5.6 Use of vaccination and breeding service

<0.5	96.7	3.3	4.793	83.3	16.7	4.402
>0.5	80.7	19.3		64.7	35.3	
Number of cows						
1	78.7	21.3	3.158	61.1	38.9	5.668
2	85.0	15.0		72.5	27.5	
3 and more	85.2	14.8		66.7	33.3	
Total income, *thousand MK/month*						
<30	65.4	34.6	14.360***	62.9	37.1	13.496**
						.
31-60	78.1	21.9		75.8	24.2	
61-90	85.5	14.5		83.1	16.9	
>91	89.1	10.9		83.9	16.1	
Access to credit in the past 12 months						
Yes	88.8	76.8	10.709**	73.4	26.6	8.029**
No	11.2	23.2		60.7	39.3	
Access to extension services						

Table 5.6 Use of vaccination and breeding service

Yes	90.7	9.3	12.550***	66.9	33.1	12.133**
No	60.8	39.2		35.8	64.2	
Experience in dairy farming, *years*						
<10	76.6	23.4	10.096**	62.0	38.0	14.331**
10-20	82.1	17.9		79.7	20.3	
20 and above	88.9	11.1		88.9	11.1	
Level of knowledge						
Good/Very good	89.7	10.3	7.949**	48.3	51.7	4.999
Fair	83.4	16.6		66.9	33.1	
Needs to be improved	73.8	26.2		69.8	30.2	

5.3.1 **Improved feeding practices (Models 1-3)**

The results of the logistic regression models (see Section 4.3.2 for the description of the models) give insights into the significant explanatory variables which act as the main driving forces behind farmers' adoption decisions.

Table 5.7 shows the results of the logistic regression analysis for the three improved feeding practices.

A test of full models against constant only models was statistically significant for all 3 models, showing a strong explanatory power ($\chi2=55.886$, $p<.000$ for Model 1; $\chi2=114.520$, $p<.000$ for Model 2; and $\chi2=148.750$, $p<.000$ for Model 3).

Nagelkerke's pseudo-R2 values for all three models indicated a moderately strong relationship between prediction and grouping. Prediction success overall was 82.4 % for Model 1, 80.9% for Model 2 and 86.3% for Model 3.

The results for Model 1 demonstrated that the region of a farmer, total household income, number of dairy animals, access to credit and extension services and self-ranked knowledge in dairy farming are factors that have significantly affected the probability of adoption. Exp (B) value indicates that farmers from the Central region were 5 times more likely to adopt the use of concentrated feed than farmers in the other 2 regions. This rejects the hypothesis about the farmers from the Southern region being more likely to adopt improved practices. However, as both purchase of concentrates and purchase of crop by-products require financial input, this finding can be explained by the difference in mean income among the three regions - the farmers from the Central region had the highest mean total income per household, nearly 36% higher than farmers from both Southern and Northern regions.

As was expected, total household income and access to credit significantly influence adoption of CSP1. Increase in income by 10K led to a 4-fold increase in the likelihood of adoption for CSP1, and farmers who had access to credit were 7 times more likely to adopt the use of concentrate feed. This also agrees with the fact that one of the most significant constraints to the adoption of concentrate feed reported by the farmers in the survey was the high cost of feed and supplements. Further, the ownership of a higher number of dairy cows also had a significant positive relationship with the high adoption level - increasing the number of cows by 1 led to a 6-fold increase in the probability of adoption, suggesting that the farmer had more resources to invest in his dairy farm by adopting improved practices.

Farmers with access to extension services were 4 times more likely to adopt the use of concentrated feed. This suggests that information and advice on improved practices, or access to improved feeds through extension play an important role in adoption (Gbetibouo 2009). However, given that more than 80% of all farmers had access to extension services, suggests that the low uptake of improved feeding practices was not because of a lack of contact with extension services but rather due to the character of the messages and the way they were delivered. Farmers with the highest self-ranked knowledge were 3 times more likely to adopt improved practices than those whose knowledge required improvement.

For Model 2, again, coefficients for geographic location, total income and access to credit were positive and significant suggesting that these variables play a significant role in adoption. The adoption likelihood increased more than 3-fold both for farmers with access to credit, and with a 10K increase in income. For this model, farmers from the Central region were 3 times less likely to adopt the use of crop by-products than farmers from the other 2 regions, which again can be attributed to higher income of the farmers from the Central region.

On the other hand, gender and size of the land plot were not significant predictors for the first 2 models. The former finding does not agree with the fact that female-headed households surveyed in the study were more resource poor in comparison with male-headed households, with their mean total income being approximately between 11 to 20% less than that for male-headed households, making them less likely to invest in purchasing extra feed and concentrate. The latter finding could be attributed to the fact that adoption of improved practices is plot-specific, so it is not the size of the farm, but the specific characteristics of the farm that dictate the need for a specific adaptation method as documented by Deressa et al. (2009). Negative association with the size of the land plot is also consistent with the findings of Quddus (2012), who, however, also showed a positive association between the level of farmer's education and dairy farming experience, and adoption of improved dairy technologies – findings not supported by the results of this study.

However, gender and size of land plot, as well as total income, number of dairy animals, access to extension services, and self-ranked knowledge contributed significantly to the prediction in Model 3. Female-headed households were more than 2 times more likely to adopt this practice than males suggesting females were more aware of the benefits of feed conservation in improving animal diets and also had less income than male-headed households for purchasing alternatives such as crop by-products or concentrates during the lean season. Increase in land plot by 1 ha increased the likelihood of adoption by 1.3 times suggesting that many farmers with bigger land plots used their own land as the main source of fodder and grass for hay making. Access to credit and the household income did not play a significant role in the adoption of conservation practices which is not surprising given the fact that this practice does not require financial contribution. As in Model 1, farmers from the Central region were 3 times more likely to adopt feed conservation than farmers from the other two regions, which can be explained by larger land plots of the farmers in the Central region - the mean size of land plot was 50% bigger in the Central region than in the Southern region - and, possibly, by more effective extension or NGO support on livestock management. As it was the case for the first two models, access to extension services increased the likelihood of adoption by more than 3-fold.

Interestingly, and contrary to the expectations, the level of education and years of dairy farming experience did not contribute to any of the three models. The former contradicts the findings of many studies including one by Kilay (2002) who demonstrated a significant correlation between the rate of technology adoption and increased education level. The latter suggests that more years of dairy farming experience do not necessarily mean better knowledge in dairy farming (which could be received via extension services, NGOs and other support networks).

Table 5.7 Results of logistic regression analysis predicting likelihood of adoption of improved feeding practices

	Adoption of improved feeding practices								
Characteristic	**Model 1: Use of concentrate feed (N=460)**			**Model 2: Use of crop by-products (N=460)**			**Model 3: Making conserved feeds (N=460)**		
	Coefficient	**S.E.**	**Exp (B)**	**Coefficient**	**S.E.**	**Exp (B)**	**Coefficient**	**S.E.**	**Exp(B)**
Constant	5.962	1.430	.187	4.416	1.127	1.089	4.519	1.756	1.006
Region	1.625***	.492	5.270	.-751***	.137	3.025	.511***	.119	3.251
Gender (head) (1)	.115	.298	.891	.226	.348	.879	-.960***	.319	2.612
Education (head) (1)	.133	.258	1.195	-.467	.367	1.003	.184	.286	.991
Total land	.050	.055	1.051	.003	.079	1.330	.106**	.062	2.484
Total income	.903***	.222	4.562	.395***	.582	4.230	.792***	.145	1.557
Experience in dairy farming	-.013	.016	1.225	.020	.016	.798	-.009	.016	.981
Number of cows	1.626***	.225	6.227	.711	.138	.825	.234**	.079	2.520

Table 5.7 Results of logistic regression analysis predicting likelihood of adoption of improved feeding practices

Access to credit (1)	.289***	.005	7.026	.386**	.098	2.732	.365	.380	.207
Access to extension services (1)	1.134***	.127	4.031	.298	.077	2.265	.395***	.007	3.694
Knowledge of dairy farming	.390***	.003	3.749	.298	.077	1.236	.473***	.156	3.372
Model χ2	55.886***			114.520***			148.750***		
H-L test	.863			.919			.778		
Nagelkerke pseudo-R^2	.437			.342			.373		

*Note: *** significant at 1% level, ** significant at 5% level, * significant at 10% level*

5.3.2 **Animal health and breeding (Model 4 and Model 5)**

Both in terms of household socio-economic characteristics, and institutional factors, the results of the logistical regression analysis for Models 4 and 5 (presented in Table 5.8) are mostly similar to those presented in Models 1-3.

Both logistic regression models were statistically significant, $\chi2(10)=39.248$, $p<.000$ for Model 4; $\chi2(10)=56.510$, $p<.000$ for Model 5. The pseudo-R2 for the regression indicates that 53.3% of the variation in adoption is explained by the regression equation for Model 4, and 56.0% for Model 5. Model 4 correctly classified 85.9 % of cases and Model 5 correctly classified 76.3% of cases, which is a considerable improvement from the null models (52 and 55% of cases respectively were correctly classified in the null models).

Table 5.8 Results of logistic regression analysis for the adoption of animal health and breeding services

	Use of vaccination and artificial insemination					
Characteristic	**Model 4: Use of vaccination (N=460)**			**Model 5: Use of artificial insemination (N=460)**		
	Coefficient	S.E.	Exp(B)	Coefficient	S.E.	Exp(B)
Constant	1.787	.990	1.001	1.437	.707	.812
Region	.904***	.168	2.374	.726***	.292	2.003
Gender (head) (1)	.575	.332	1.001	.052	.296	.951
Education (head)	-.013	.019	.779	.251	.325	1.000
Total land	-.038	.062	.524	-.050	.053	.991
Total income	.669***	.187	5.215	.904***	.213	4.801
Experience in dairy farming	.305**	.0055	2.516	.314**	.133	2.460
Number of cows	.148	.177	.493	-.009	.142	.775
Access to credit (1)	.603***	.123	4.202	.512***	.125	3.386

Table 5.8 Results of logistic regression analysis for the adoption of animal health and breeding services

Access to extension services (1)	.388**	.145	4.548	.480**	.128	3.259
Knowledge of dairy farming	-.500	.667	1.215	.648	.437	.918
Model $\chi 2$		39.248***			56.510***	
H-L test		.956			.748	
Nagelkerke pseudo-R^2		.533			.560	

*Note: *** significant at 1% level, ** significant at 5% level, * significant at 10% level*

Of the ten predictor variables only five – region, income, dairy farming experience, access to credit and extension services – were statistically significant in both models. Exp (B) value indicates that farmers from the Central region had 2 times higher odds to adopt the use of vaccination and AI than farmers in the other 2 regions. As both practices require financial investment this suggests, again, that the difference in mean income between the regions plays a significant role. Level of income and access to credit both played a significant role in the adoption of vaccination and AI, with regression coefficients being large and significant at p<.000. Increase in income by 10K led to a nearly 2-fold increase in the likelihood of the adoption of vaccination, and a 4 times increase in the likelihood of adoption of AI. Farmers with access to credit and extension services had a higher likelihood of adoption for both models (4x and 3x respectively). The role of extension support in this case can also be explained by the fact that local extension offices usually have veterinary and, sometimes, AI officers attached increasing the likelihood of farmer adoption if the service is available. Yet again, these findings highlight the importance of the role of extension support and its effectiveness in affecting adoption of improved technologies. Unlike in Models 1-3, increasing farmer experience did play a role and was positively correlated with an increased likelihood of the adoption of both practices. The level of knowledge, however, was not a significant predictor of adoption, with the coefficient of this variable being not significant for the adoption of either practice.

As in the Models 1-3, the findings show that gender and education status of the household head did not significantly contribute to either of the models, the latter contradicting, among others, the findings of Teklewold et al. (2013) and Cicek et al. (2007) who demonstrated that the education level of the producer plays a positive role in adoption of the technological innovation in dairy cattle breeding.

5.3.3 Conclusions to Section 5.3

The main objective of this section was to examine factors that hinder or accelerate the adoption of adaptation strategies by dairy farmers in rural Malawi. Results show the importance of the socio-economic and institutional factors in explaining the probability of farm households' decision to adopt different agricultural practices.

Three important findings emerge from the analysis of adoption of the improved practices. First, that the probability of adoption of all five climate-smart practices studied above was very much influenced by the provision of extension support. Among other benefits, access to extension services can facilitate the exchange of information and mitigate transaction costs, which will enable farmers to access inputs. The adoption of improved feeding and animal health management strategies among farmers could be increased by improving extension services, matching them with local conditions and making extension messages more targeted to respond to farmers needs. Provision of farmer training and farmer to farmer knowledge transfer will also be important.

Secondly, the wealth related variables including the number of dairy animals, the level of wealth/income and access to credit are important in explaining adoption (with the only exception of the adoption of feed conservation practice). This suggests that the wealthier households have the necessary equity to purchase the inputs or pay for the services required for the adoption of improved practices. The findings also established a significant relationship between access to credit and technology adoption rates. Overall, this suggests that wealth effects and access to credit should be considered when screening new technologies for promotion. Increase in adoption levels could be achieved by policy intervention that provides access to credit and information. These interventions will need to take account of the limited access smallholder farmers have to resources and inputs, as well as a limited capacity for risk-taking.

Finally, the levels of adoption are significantly different across the regions, which could be explained not only by a difference in the level of wealth in the three regions but also potentially by a difference in the effectiveness of extension messages delivered in various parts of the country. Further, the difference in the adoption of improved feeding technologies across regions might be explained by region-specific agro-ecological conditions.

5.4 Dairy farmer perceptions of climate variability and the use of adaptation strategies in Malawi

5.4.1 Respondents knowledge and awareness of climate change

This section presents findings from Module 5 of the survey, and links them with the findings presented in Section 5.3 above.

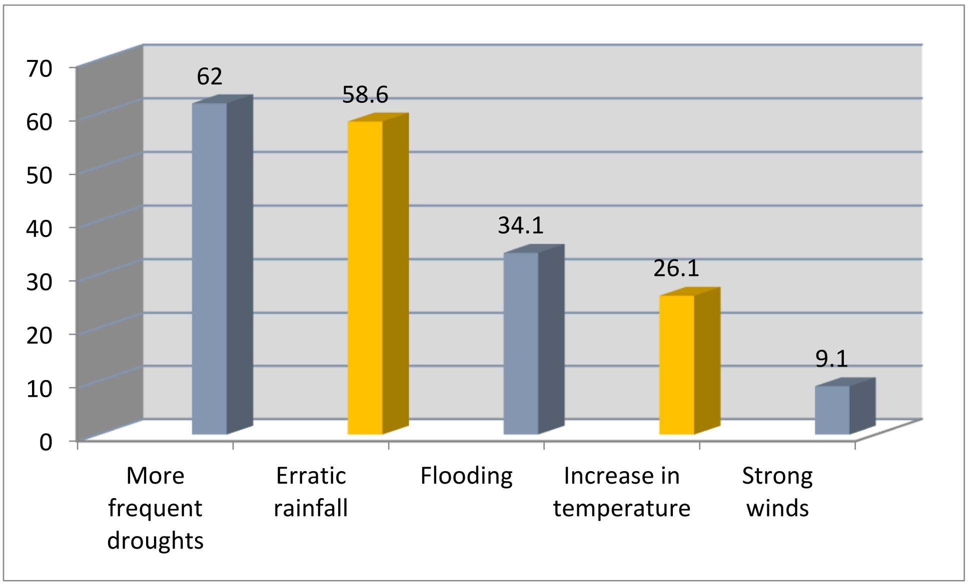
When asked whether they had heard about climate change, 93.5 per cent of farmers responded positively, and 92.2 per cent of all respondents believed that climate change is affecting Malawi. There was a noticeable regional segregation, with the highest number of farmers perceiving negative impacts of climate change on Malawi coming from the Southern region – 250 farmers or 93.6 percent of all respondents in the Southern region. The Southern region has long been recognized as the country's most vulnerable location in terms of climate change impacts (GoM 2005). MVAC (2013) forecast shows the Southern region is the region most affected by changes in weather patterns. For the past decades, it has been a subject to frequent climatic shocks including flooding and droughts, erratic rains and wind extremes. This region is also considered as the area in greatest need of adaptation projects (GoM 2006b).

These findings are supported by the recent meteorological data, showing an increased occurrence in the number of floods and droughts in the Southern region, and a general increase in climatic variability (MVAC 2004-2014; FEWS NET 2004-2015). The Shire River Basin in the Southern region is particularly vulnerable, with many districts experiencing torrential rains and flooding in recent years impacting thousands of households each year displacing people and washing away crops and livestock (Start Network 2015). Some other parts in the Southern region have experienced unusually dry weather for several consecutive years due to the low rainfall (AFIDEP and PAI 2012).

Farmers' main observations of climate variability effecting Malawi included changes in rainfall patterns including delays in the onset of the rainy season; increased number of droughts and floods, and an increase in average temperature and wind intensity (Figure 5.3). The results show that the majority of farmers perceived more frequent droughts and erratic rainfall (62 per cent and 58.6 per cent respectively) over the last 5 years while only 34.1 and 26.1 per cent of households observed flooding and an increase in temperature, respectively, over the recall period. 9.1 percent of farmers reported an increase in wind intensity.

Overall, farmers perceptions are consistent with the meteorological data for Malawi reported in many sources (see MVAC 2004-2014; FEWS NET 2004-2015), which shows changes in rainfall patterns in many regions of Malawi, a late onset of the rainy season and decline in crop yields in recent years. Additionally, there has been a reported increase in the number of floods and droughts in parts of the country as described by the farmers in this study (FEWS NET 2004-2015).

Figure 5.3 Perceived impacts of climate change on Malawi, per cent of respondents (N=460)*

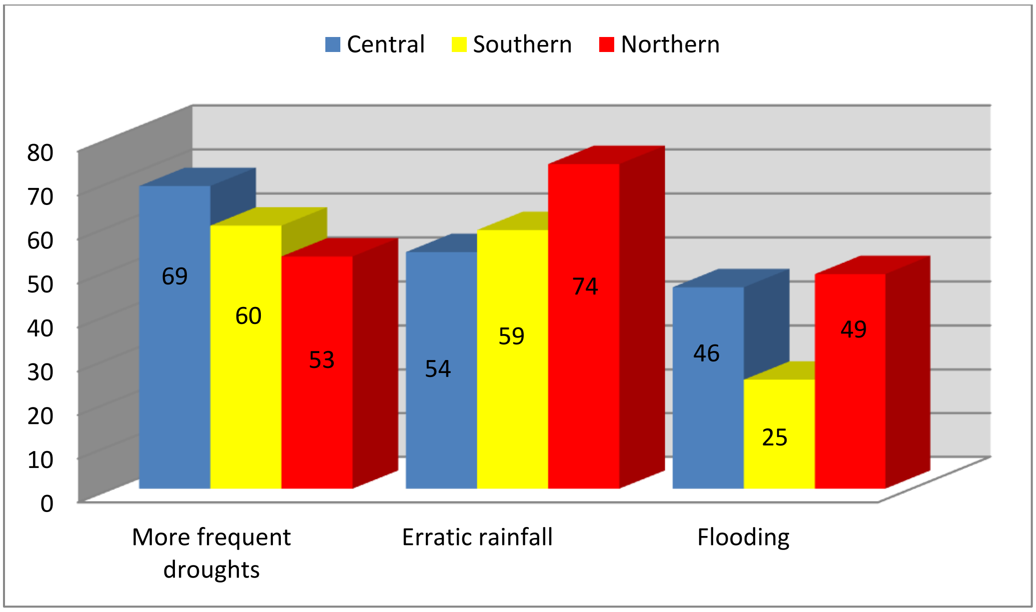


**multiple response*

Perceived increase in temperature, reported by 26.1 percent of all farmers, is corroborated by a number of reports on climate change in Malawi, in particular by the findings of McSweeney et al. (2010), who reported an increase in the mean annual temperature by 0.9°C between 1960 and 2006 - an average rate of 0.21°C per decade. In an earlier study conducted in the lower Shire area in the Southern region, Phiri & Saka. (2008) observed that mean temperatures in the area had increased by 2.3 percent, while mean maximum temperatures increased by 2 percent between 1970 and 2002.

Despite differences in agro-ecological conditions, overall the climate change perceptions of farmers were consistent across the surveyed regions. The regional distribution of perceived changes in weather patterns shows that the majority of respondents in the Central and Southern regions reported increased frequency of droughts, and erratic rainfall, followed by flooding (see Figure 5.4).

Figure 5.4 Perceived changes in regular weather patterns by region, percent of respondents (N=460)



The majority of respondents from the Northern region (74 percent) reported an increase in rainfall variability as one of the main impacts of climate change. This is corroborated by the recent meteorological data for the region. Erratic rainfall in parts of the Northern region was reported in the latest Malawi Food Security Outlook updates (FEWS NET 2004-2015). The actual rainfall data for the Northern region analysed by Kasulo et al. (2013) shows that the rainfall amount has been steadily decreasing over recent years. Further, in December 2013, IRIN reported that large parts of Northern Malawi had not received any rain since February 2013, which led to severe water shortages in the region (IRIN 2013).

Farmer perceptions by gender

Table 5.9 shows the gender segregation of farmers' perceptions. The majority of male and female respondents agreed that the climate in Malawi is changing. There are only marginal differences between male and female respondents with regards to the main parameters of weather variability. Interestingly, the proportion of men who perceived the changes in weather was marginally lower for all parameters, except increased frequently of flooding. However, the difference in perception between males and females by the Pearson chi-square test was not statistically significant for any of the weather-related parameters. These findings seem to indicate that in this study there was no association between perceptions and gender, and men and women were equally likely to perceive weather related changes.

Table 5.9 Farmer perceptions of weather variability over the past 5 years, segregated by gender, per cent of respondents (N=460)

Main characteristics	**Agree**	
	Female	Male
Climate change generally noticed	92.2	92.1
More frequent droughts	62.9	61.4
Erratic rainfall	60.0	57.2
Flooding	32.7	35.3
Increase in temperature	27.8	21.5
Increase in wind intensity	11.4	8.5

The results from the logit regression (marginal effects) on the determinants of farmers' perception of climate change are presented in Table 5.10.

Table 5.10 Factors influencing farmers' perception of climate change, marginal effects

Variable	Climate change generally noticed	More frequent droughts	Erratic rainfall	Flooding	Increase in temperature	Increase in wind intensity
Gender of hh head	0.017	-0.021	0.039	-0.014	0.012	0.050
Age of hh head	0.002*	0.014**	0.050**	0.000*	0.000*	0.000*
Education of hh head	0.047	-0.036	0.000	0.012	0.029	0.112
Extension field visits	0.011***	0.016**	0.001*	0.002*	0.007**	-0.003
Region (base Central/Northern)	0.003	0.002**	-0.017	0.008**	0.000	0.077
N	460	460	460	460	460	460

**p < .1; **p < .05; ***p < .01.*
Abbreviations: household (hh) .

The analysis of the factors influencing farmers' perceptions of climate change confirmed most of the hypotheses for Model 1, with the exception of gender and education influencing farmers' climate change perceptions. The results in Table 5.10 show that older farmers were more likely to have noticed climate change in general, and to perceive period changes in all weather-related parameters, due to a higher level of knowledge accumulated over the years. Those with a regular contact with extension agents were more likely to have noticed climate change in Malawi and perceive weather variability as its manifestation. This suggests that households without access to extension services possess less knowledge on the general discourse in the country that climate is changing.

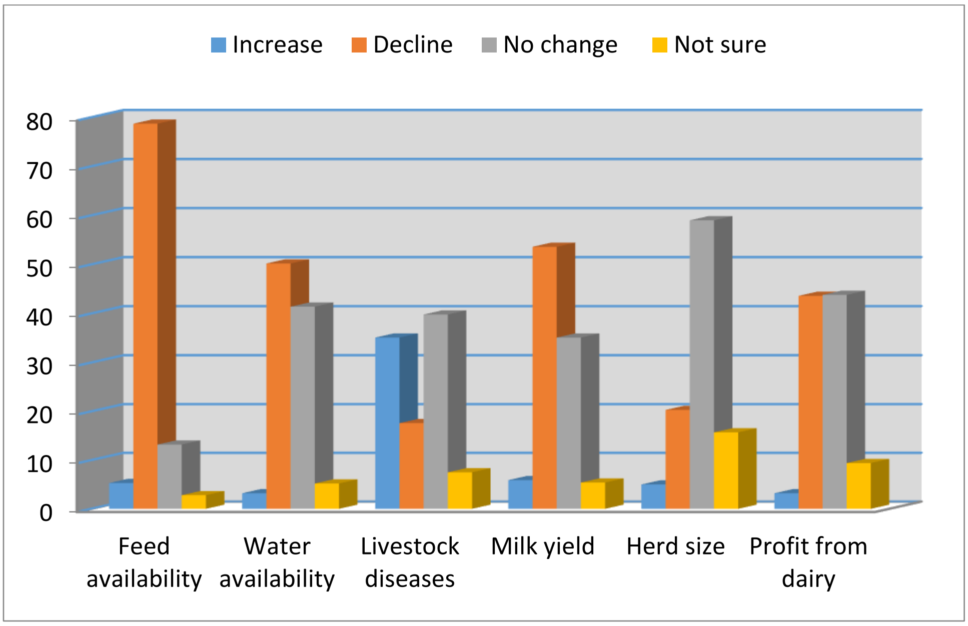
Gender and education of the head of the household did not appear to play a role, with female-headed households being as likely to have a general knowledge about climate change, and to perceive changes in weather variability, as male-headed households.

Households in the Southern region which has been most affected by changes in weather variability in the recent decade were more likely to perceive an increased frequency of droughts and floods than households in the Central and Northern region. However, for all other weather related parameters, as well as the general knowledge of climate change, there was no significant difference between the Southern and Central and Northern regions.

5.4.2 Perceived impacts on dairy farms and dairy farming attributes

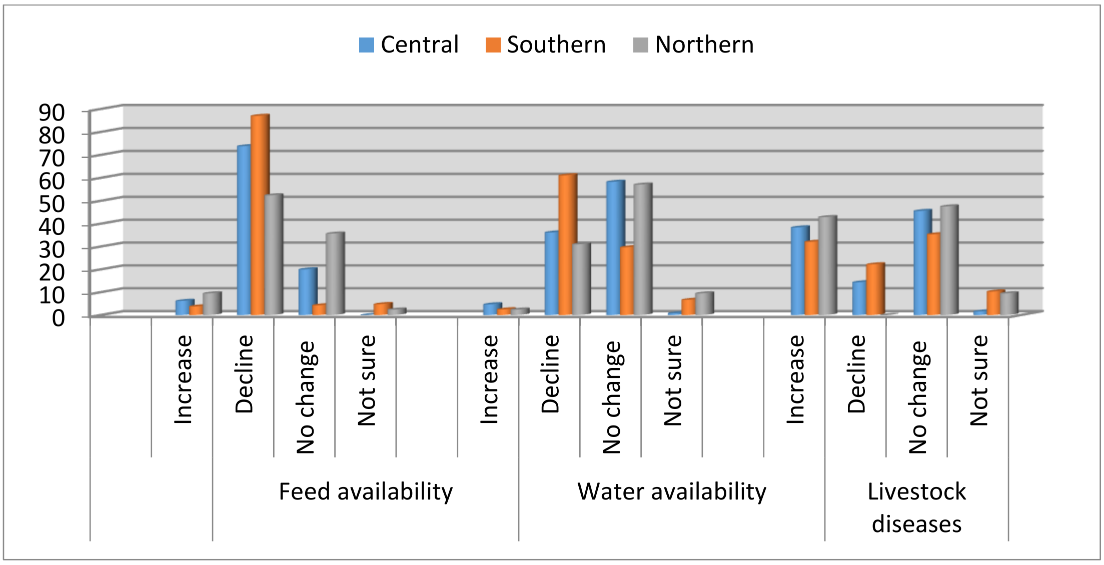
Figure 5.5 presents the impacts of climate change on dairy farms as perceived by respondents in all three regions. The majority of respondents reported scarcity of animal feed and water as an impact of climate change. Decline in feed and water availability was reported by 78.7 per cent and 50.2 per cent of all respondents, respectively. 35.1 per cent reported an increase in the occurrence of livestock diseases, and 43.6 per cent reported a noticeable decline in milk yield associated with changes in any of the three mentioned attributes (feed availability, water availability, animal diseases) or their combination.

Figure 5.5 Perceived impacts of climate change on dairy farms, per cent of respondents (N=460)



In terms of regional segregation, the highest proportion of respondents reporting decline in feed and water availability were from the Southern region – 87.0 and 61.1 per cent of all respondents in the region, respectively (Figure 5.6). This correlates with the fact that this region also has the highest number of respondents reporting noticeable changes in weather variability, as discussed above. A high proportion of respondents from the Southern region also reported a decline in milk yields (reported by 57.5 of respondents in the region) and profits from dairy in the last 5 years, as a direct consequence of the decline in water and feed availability. Considering that the Southern region has the highest of number of dairy farmers in Malawi, with dairy farming being the main source of income for the majority of them, these reported impacts are likely to lead to the loss of livelihoods for many smallholders.

Figure 5.6 Effect of climate change on dairy farming attributes by region, per cent of respondents



The Chi-square test (Table 5.11) showed significant association between a region of the respondent and the perceived impacts on dairy farming attributes (p-value= .000 for most attributes).

Table 5.11 Regional distribution of perceived impacts of climate change on dairy farming attributes, per cent of respondents

Dairy farming attributes		Perceived change (percent)			χ2-value
		Central	Southern	Northern	
Feed availability	Increase	6.2	3.8	9.5	47.979***
	Decline	73.8	87.0	52.4	
	None	20.0	4.3	35.7	
	Not sure	0.0	4.8	2.4	
Water availability	Increase	4.7	2.5	2.4	41.536***
	Decline	36.2	61.1	31.0	
	None	58.3	29.7	57.1	

Table 5.11 Regional distribution of perceived impacts of climate change on dairy farming attributes, per cent of respondents					
	Not sure	0.8	6.7	9.5	
Livestock Diseases	Increase	38.4	32.1	42.9	24.194***
	Decline	14.4	22.2	0.0	
	None	45.6	35.4	47.6	
	Not sure	1.6	10.3	9.5	
Milk yield	Increase	7.2	5.7	2.4	22.991***
	Decline	52.2	57.5	35.7	
	None	40.6	29.6	50.0	
	Not sure	0.0	7.3	11.9	
Herd size	Increase	1.7	7.6	0.0	55.721***
	Decline	36.4	10.5	29.3	
	None	58.7	59.2	58.5	
	Not sure	3.3	22.7	12.2	
Profit from dairy	Increase	1.6	4.2	2.4	46.757***
	Decline	35.2	50.6	28.6	
	None	62.4	31.0	61.9	
	Not sure	0.8	14.2	7.1	

Table 5.12 shows the results of the multinomial logit model including a number of socio-economic variables, and farmers' perceptions of climate change (for description of the model, and the main variables, see Section 4.3.3).

The analysis showed no association between the perceived impacts of climate change on dairy farms and the gender of the respondent; that is the farmers in this study viewed impacts in the same way irrespectively of the gender. As expected, older and more experienced farmers were more likely to report having observed a decrease in feed and water availability, as well as milk yield; however, we found no association between farmers' age and experience, and change in the frequency of the occurrence of livestock diseases. Contrary to the expectations, access to credit did not appear to play a role in the farmers' perceptions of impacts on dairy farms suggesting that other factors play more prominent role in shaping farmers' perceptions.

Households with frequent access to extension services were less likely to report a decrease in feed and water availability which suggests that extension advice and support play a valuable role in helping farmers to identify new sources of food and water for their animals in times of scarcity, either via extension agents, or via facilitating the local farmer-to-farmer support. Unsurprisingly, the same households were less likely to report an increase in the occurrence of livestock diseases.

Further, farmers who perceived changes in weather variability in terms of increased incidence of droughts and flooding, erratic rainfall, and increased temperature over the past 5 years were also more likely to have perceived negative impacts on dairy farms in the same period. This shows that farmers' perceptions of weather variability directly influenced their observations of weather-related negative impacts on their dairy farms.

Table 5.12 Factors influencing farmers' perceptions of impacts on dairy farms, marginal effects												
Variable	Feed availability (base: no change)			Water availability (base: no change)			Diseases (base: no change)			Milk yield (base: no change)		
	Increase	Decrease	Not sure	Increase	Decrease	Not sure	Increase	Decrease	Not sure	Increase	Decrease	Not sure
Gender of hh head	0.025	0.012	0.075	0.044	0.024	0.072	-0.006	0.004	0.072	0.051	-0.082	0.007
Age of hh head	0.001	0.012**	0.055	0.025	0.001**	0.054	0.008	-0.007	-0.014	0.042	0.000***	0.003
Education of hh head	0.400	0.038	0.008	0.001	0.369	0.016	0.031	0.029	0.024	0.026	0.007	0.041
Years involved in dairy farming	0.040	0.025**	0.036	0.020	0.126**	0.036	0.109	0.074	0.014	0.718	0.165**	0.545
Access to credit	0.024	0.012	0.022	0.010	0.222	0.400	0.250	0.072	0.007	0.304	0.076	0.041
Extension	0.765	-0.133**	0.602	0.014	-0.177**	0.024	0.710	0.087	0.554	0.051	0.004	0.075
Perceived increase in	0.076	0.004***	0.044	0.082	0.400	0.596	0.520	0.077	0.304	0.250	0.006**	0.775

Table 5.12 Factors influencing farmers' perceptions of impacts on dairy farms, marginal effects												
frequency of droughts												
Perceived increase in rainfall variability	0.002	0.036**	0.079	0.003	0.020**	0.042	0.512	0.022	0.444	0.320	0.001***	0.240
Perceived increase in frequency of flooding	0.535	0.123***	0.512	0.018	0.127**	0.724	0.510	0.187	0.534	0.351	0.204	0.275
Perceived increase in temperature	0.234	0.003***	0.400	0.114	0.007***	0.007	0.710	0.044	0.650	0.021	0.008	0.875
N	380			408			410			427		

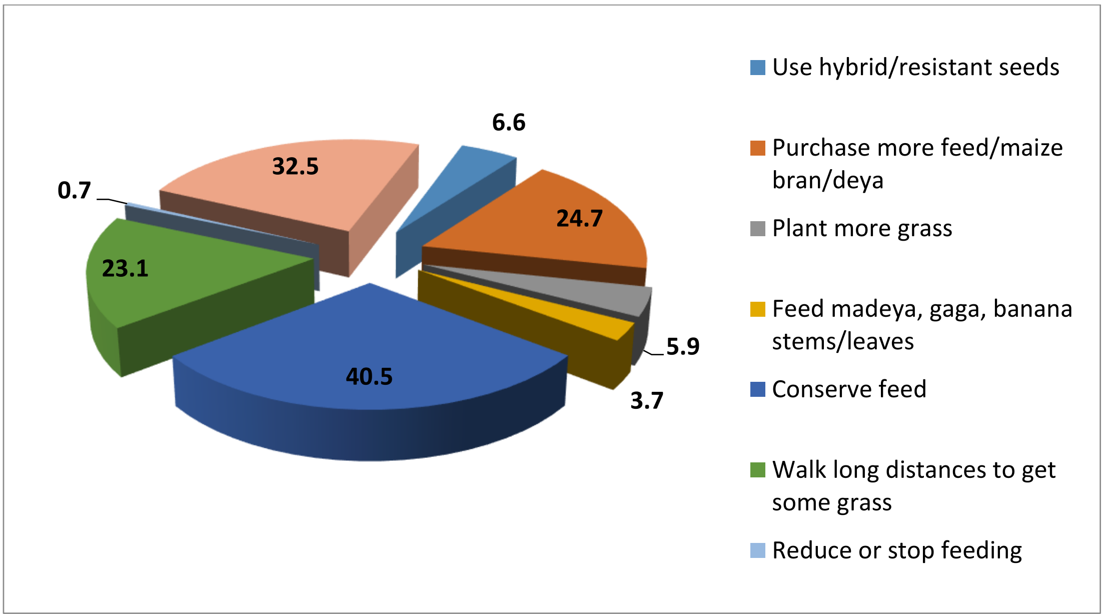
**p < .1; **p < .05; ***p < .01*
Abbreviations: household (hh)

5.4.3 Adaptation and coping strategies adopted by dairy farmers

Farmer adaptations to the decline in feed availability

The strategies used to mitigate the effects of decrease in feed availability included feed conservation (40.5 per cent), purchasing more feed (24.7 per cent), walking long distances to get some grass (23.1 per cent), the use of hybrid/resistant seeds (6.6 per cent), planting more grass (5.9 per cent), using alternative feeds such as banana stems (3.7 per cent), and reducing or stopping feeding altogether (0.7 per cent) (Figure 5.7).

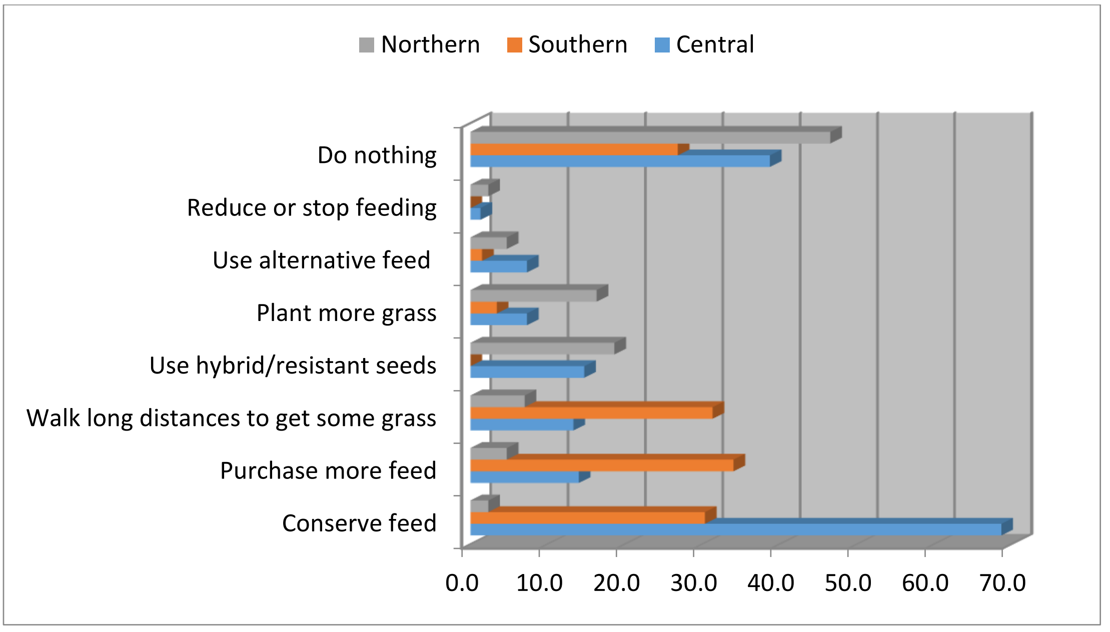
Figure 5.7 Adaptation/coping strategies used to cope with the decrease in feed availability, per cent of respondents (N=458)*



**multiple response*

Feed conservation is clearly the dominant adaptation strategy used by dairy farmers. The majority of dairy farmers who conserve feed come from the Central region (68.7 per cent of all respondents in the region) (Figure 5.8). Only 30.3 per cent of the respondents in the Southern region conserve feed. In the Northern region, only 1 respondent (2.3 per cent) reported conserving feed, and generally farmers give preference to other adaptations strategies such as the use of more expensive hybrid crops. The latter is a strategy not deployed at all by respondents in the Southern region who also have the lowest average income from all three regions. These results suggest that farmers in the Central region were more aware of the importance of feed conservation practices, possibly via more effective extension advice and involvement in governmental and NGO programmes aimed at promoting adaptation. Overall, the adapting households often chose a combination of strategies to reduce the negative impacts of climatic and weather variability on dairy farms.

Figure 5.8 Adaptation strategies (feed availability) by region, percent of respondents



A significant proportion of farmers - No=149 or 32.5 per cent of all farmers - did not use any adaptation strategies to cope with the lack of animal feed although 78.8 per cent of all farmers reported a noticeable decline in feed availability. This shows that perceived changes in animal feed availability did not always lead to changed practices, possibly due to the lack of funds, knowhow, poor extension advice, and general inertia.

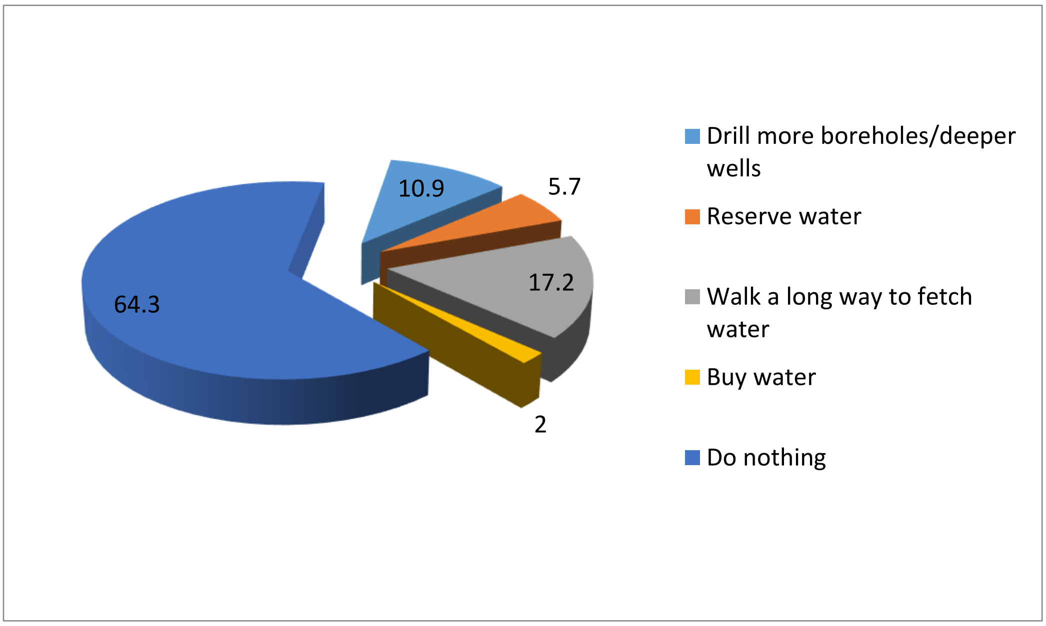
The highest proportion of farmers (46.5 per cent) who did not deploy any adaptation strategies were based in the Northern region, which also had the lowest proportion of farmers (52.4 per cent) reporting decline in feed availability, and climate change impacts.

An important finding is that despite the widely reported decline in animal feed and water availability, as well as increase in the occurrence of livestock diseases, the overwhelming majority of respondents (more than 80 per cent) owned temperate pure dairy breeds such as Holstein Friesian. It is widely recognized that introduced breeds of cows have higher feed and water requirements than the indigenous breed (Malawi Zebus) (Chagunda et al. 2010; Chagunda and Wollny 2002). Introduced breeds are also less heat tolerant and more susceptible to tropical diseases, while Zebus are more tolerant to both (Chagunda et al. 2010; Chagunda and Wollny 2002). However, none of the respondents in this study reported switching from introduced to local breed or cross breed cows as a strategy to adapt to the reported negative impacts on dairy farms. The main reason for most dairy farmers preferring to own more expensive to keep exotic breeds is the higher yields they provide (in comparison with Zebu) which, however, are not achievable in times of feed and water stress. Prestige appears to be another reason for preferring pure breeds over Zebus (personal communication with the colleagues at Bunda college of Agriculture).

Farmer adaptations to the decline in water availability

Figures 5.9 and 5.10 show the nation-wide and regional distribution of the adaptation strategies adopted by farmers to cope with the decrease in water availability. The coping strategy that is used most in the Southern region is walking a long way (further than usual) to fetch water – a strategy usually used by the women in the household. Interestingly, no respondents in the Northern region reported doing this, which is contrary to the recent reports on water scarcity in parts of the Northern region, where women in the affected areas were reported leaving their homes in the early hours of the morning and walking up to 40 minutes to fetch water from the nearest source (IRIN 2013).

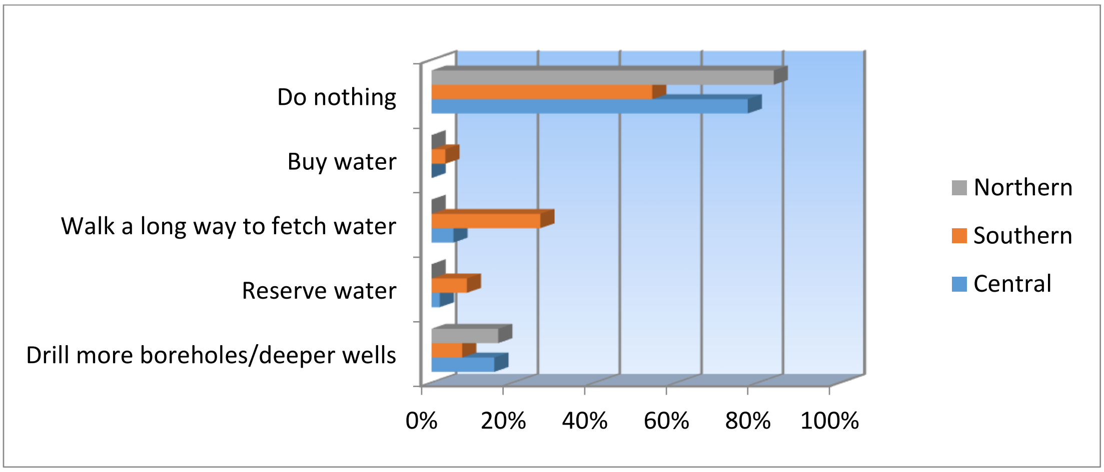
Figure 5.9 Adaptation/coping strategies used to cope with the decrease in water availability, per cent of respondents (N=460)*



**multiple response*

The majority of respondents (64.2 per cent) did not deploy any adaptation strategies, although 50.2 per cent reported a decline in water availability. Again, most of the non-adapters –83.7 pe rcent - were in the Northern region, which agrees with the smallest number – 31 per cent - of dairy farmers in the North reporting a decline in water availability, in comparison with the other two regions. Drilling more boreholes and reserving water were reported as other adaptation techniques employed by only a minority of the farmers.

Figure 5.10 Adaptation/coping strategies (water availability) by region, per cent of respondents, (N=460)*



**multiple response*

Factors influencing farmers' choice and adoption of adaptation practices

Table 5.13 shows the results of Chi-square test analysing association between socio-economic characteristics of farming households, and farmers' perceptions of climate change with regard to their adoption of adaptation practices.

Table 5.13 Chi-square test results between the characteristics of the household head, and the use of adaptation or coping practices, *p-values*

	Decrease in feed availability					
Variables	Use of hybrid seeds	Purchase more feed	Plant more grass	Feed alternative feed	Conserve feed	Reduce or stop feeding
Gender of hh head	0.320	0.034	0.000***	(-) 0.012***	(-)000***	0.038
Age of hh head	0.326	0.208	0.375	0.030	-0.001	0.842
Education of hh head	0.702	0.204	0.312	0.220	0.620	0.502
Years involved in dairy farming	0.044	(-)0.069	.002**	.000***	-0.210	0.168
Extension	0.010	(-)0.036	0.425	.0002**	0.001**	-0.026

Table 5.13 Chi-square test results between the characteristics of the household head, and the use of adaptation or coping practices, *p-values*

Access to credit	.002**	0.000***	0.204	0.401	(-)0.017	0.312
Perceived increase in frequency of droughts	0.006	(-)0.077	(-)0.001	0.001***	0.000***	0.001
Perceived increase in rainfall variability	0.000***	0.005	(-)0.222	0.007	0.000***	0.003
Perceived increase in frequency of flooding	0.000***	0.025	(-)0.240	0.776	0.000***	0.002
Perceived increase in temperature	0.000***	0.000***	(-)0.167	0.108	(-)0.220	0.018
Perceived increase in wind intensity	0.09	(-)0.024	0.126	0.240	(-)0.088	0.416
Southern region	0.144	0.364	0.175	0.015**	0.022**	0.222
Northern region	(-)0.2796	0.144	0.236	0.444	0.206	0.317
No	458	458	458	458	458	458

	Decrease in water availability			
Variables	Drill more boreholes	Reserve water	Purchase water	Walk long distances to fetch water
Gender of hh head	1.215	(-)0.001***	2.003	(-)0.001**
Age of hh head	0.121	1.115	1.046	1.032

Table 5.13 Chi-square test results between the characteristics of the household head, and the use of adaptation or coping practices, *p-values*

Education of hh head	0.036	0.13	0.095	(-)0.201
Years involved in dairy farming	0.350	0.713	0.652	0.213
Extension	0.332	0.1383	0.082	(-)0.072
Access to credit	0.022	0.124	0.448	0.257
Perceived increase in frequency of droughts	0.000***	0.000***	0.222	0.230
Perceived increase in rainfall variability	0.031	0.000***	0.485	0.250
Perceived increase in frequency of flooding	0.412	0.000***	0.313	0.121
Perceived increase in temperature	0.345	0.000***	0.320	0.750
Perceived increase in wind intensity	0.331	0.402	0.204	0.312
Southern region	0.320	0.446	(-)0.529	0.276
Northern region	0.512	0.270	0.204	0.412
No	460	460	460	460

The main findings are discussed below.

Gender: Gender had a significant relationship across a number of adaptation/coping measures. Female-headed households were more likely to use alternative feed in times of feed scarcity, and to conserve feed for future use. Females were also more likely to reserve water, or to walk long distances to the nearest water source, the latter agreeing with the fact that this is a job normally performed by women in rural Malawi. However, males were more likely to plant more grass in order to prepare for future food scarcity, which is possibly due to the fact that male-headed households owned 25% more land per household on average than female headed households who did not have spare land to plant more grass. Overall, these results suggest that female-headed households were more likely to take up measures not requiring financial investment or land use, while relatively better off male-headed households appear to be investing more resources in their adaptation efforts.

Age and Education of Household head: Contrary to the expectations, the results suggest that farmer age and level of education did not influence the adoption of adaptation practices. Although a number of previous studies (see Deressa 2010; Onubuogu and Esiobu 2014) showed that having a higher level of education reduces farmer risk aversion and increases the likelihood of farmer adoption of adaptation measures, as well as their knowledge and awareness of climate change, this was not confirmed by the findings of this study. This shows that other factors such as a longer dairy farming experience and access to extension services might have played a more important role in farmer adoption of adaptation measures.

Dairy farming experience: Farmers with a longer dairy farming experience had an increased likelihood of planting more grass to prepare for future food scarcity, and using alternative feed in times of feed scarcity. This shows that more experienced farmers can better anticipate and prepare for future food scarcity. However, across any other adaptation and coping strategies, dairy farming experience did not appear to play a role.

Access to extension: The access to extension services had a significant and positive relationship with the likelihood of choosing alternative feed, and feed conservation.

This implies that farmers who had access to extension services were more likely to be aware of changing climatic conditions and to have more information on potential adaptation measures. A number of authors showed that limited or no access to extension services have a negative impact on the adoption of adaptation practices (e.g. Nhemachena and Hassan 2008; Acquah-de Graft and Onumah 2011; Sofoluwe et al. 2011; Deressa et al. 2008). These studies have shown that farmers with access to and a frequent contact with extension services are more aware of changing climatic conditions, and have more information on potential adaptation measures (Deressa et al. 2009; Gbetibuou 2009). However, extension contact did not appear to play a role in adapting to the reduced water availability.

Access to credit: Lack of funds is a major constraint to the adoption of improved practices. Even when farmers are aware of and are willing to adopt various adaptation options, many of them require either initial or continuous financial inputs the lack of which acts as a major constraint to adoption (Gbetibouo 2009; Nhemachena and Hassan 2008; Deressa et al. 2008). As expected, access to credit had a significant and positive relationship with using hybrid seeds, and purchasing extra feed, both measures requiring financial investment. This highlights the importance of institutional support in promoting the use of adaptation options to reduce the negative impact of climate change.

Climate change perceptions: The results showed a significant association between perceived knowledge of climate change and its impacts on dairy farms, and farmer adoption of a number of adaptation strategies. Famers who perceived increased frequency of droughts in the last 5 years, were more likely to feed alternative feed, to conserve feed, and to reserve water. Farmers perceiving changes in rainfall variability and increased frequency of flooding were more likely to use hybrid seeds and conserve feed, and more likely to reserve water. Farmers who perceived an increase in average temperature, were almost more likely to use hybrid seeds, to purchase more feed, and to reserve water. These findings indicate that farmers' perceptions of changing climate do seem to influence their adoption of adaptation practices. Hence in future programmes promoting adaptation it will be essential to improve farmers' knowledge of climate change and its potential impacts on their livelihoods while offering them a range of adaptation options.

Region: The results indicate a strong association between 2 of the adaptation options – feeding alternative feed, and the use of feed conservation, and a region of the farmer. Farmers from the Southern region were more likely to adopt these measures in comparison with the other 2 regions – an important finding as the majority of the dairy farmers in Malawi are based in the Southern region suggesting that this region should receive a targeted approach with regards to the adaptation to climate change, and the available adaptation options.

5.4.4 **Conclusions to Section 5.4**

This section investigated the determinants of dairy farmers' adoption of various adaptation options to climate change. In particular, the section was concerned with how farmers' climate change perceptions influence their uptake of adaptation strategies. The findings show that the majority of male and female dairy farmers were aware of climate change and their perceptions largely resonate with scientific meteorological data. Both male and female farmers had observed that the rainfall had decreased; floods, droughts, and strong winds had become more frequent; and temperatures had increased.

The main findings indicate that despite observing noticeable negative impacts on their dairy farms caused by the changes in climate, the majority of farmers did not adapt and carried on with the "business as usual" scenario. The study found the non-adoption to be significantly influenced by institutional factors such as farmers' access to extension services and credit, as well as farmer perceptions of climate change. Further, the adaptation practices that were used were mostly short term, did not appear very robust and are likely to be insufficient under future climate change scenarios where impacts of climate change will be more negative and extreme.

Taking these findings into account, it is recommended that in order to be effective, government policies and adaptation programmes should focus on creating awareness of climate change through extension agents and should support farmers' access to affordable credit schemes and subsidized agricultural inputs in order to increase their adaptive capacity. Extension services, in particular, could become a focal point for providing climate change information and advice on longer term adaptation and collective adaptation strategies, including the use of animal breeds better adapted to the local conditions. Moreover, as regional agro-ecological conditions appeared to play a significant role both in farmers' perceptions of weather variability, and in their choice of adaptation strategies, future adaptation programmes should aim at providing region-specific advice on adaptation technologies and adaptive measures. Information about farmers perceptions of climate change, and their choice of adaptation strategies gathered during this study can be a useful tool for policy makers working on minimizing the most severe impacts of climate change by engaging with rural population and integrating their knowledge and concerns in designing technological and policy interventions.

5.5 Adoption of agroforestry practices by smallholder dairy farmers in Malawi, and the role of gender

This section presents and discusses the findings from Module 5 (Section 5-B) of the survey.

5.5.1 Main characteristics of male and female-headed households in the survey

Table 5.14 presents the main characteristics of male- and female-headed households in the survey. Overall, the proportion of female-headed households in the sample (16.7%) was lower than the national average (27.8%) (World Bank 2012a).

Table 5.14 Main characteristics of male and female-headed households

Total N	**Male**	**Female**	Pearson χ^2
	383	77	
Education, *years*			
Mean	7.4	6.7	14.481
SD	3.9	3.8	
Land, *ha*			
Mean	1.3	1.0	39.547***

Table 5.14 Main characteristics of male and female-headed households			
SD	0.9	0.7	
Income, *thsd MK/month*			
Mean	43.8	39.1	7.596
SD	52.2	40.5	
Number of workers at farm			
Mean	3.5	3.3	9.929
SD	1.9	1.9	
Access to Extension services, *yes*	91.1%	88.3%	5.598
Frequency of contact with extension services in the past 12 months			5.550
Mean	2.68	2.62	
SD	.84	.85	
Access to credit in the last 12 months, *yes*	40.7	41.6	.018
Are you involved in any agro-forestry work, *yes*	58.5%	67.5%	12.186**
Are you involved in any community forestry work, *yes*	49.7	55.8	9.956
Trees planted in the last 2 years, *yes*	21.9%	32.5%	13.396**
Total numbers of trees at the farm			
Mean	41.5	24.1	92.764***
SD	58.4	28.9	

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

Education

The results in Table 5.14 show that although males on average spent more time in schooling than females (7.4 years for males versus 6.7 years for males; which largely agrees with the lower national average of 44 per cent of literacy rate for women, versus 72 per cent for men, ADF 2005); however, there is no significant relationship between gender and the level of education.

Size of land holding

On average, male-headed households owned 23.1 per cent more land than female-headed households, with their households' total incomes being nearly 20 per cent higher than that for the female-headed households. This agrees with many previous studies conducted in Sub-Saharan Africa, which have shown that female-headed households often had limited land and income, in comparison with male-headed households.

Access to labour

Labour is necessary for adopting certain types of agroforestry, such as planting fertilizer trees which has to be done at the onset of the rainy season, when farmers have competing demands on their time (see Mafongoya 2006; Sirrine et al. 2010). In the context of smallholder production in Malawi where farm mechanization is virtually non-existent, the quantity of available family labour directly affects own-farm production (Takane 2007). A number of studies have shown that, in Sub-Saharan Africa, female-headed households are disadvantaged in terms of access to labour, in comparison with male-headed households (Swinkels et al. 2002) Female-headed households are often unable to obtain much needed male labour, and they are also unable to hire external help due to cash restrictions (Swinkels et al. 2002).

Despite the findings of previous research, our findings showed only a marginal difference between the numbers of farm workers in male- and female-headed households. This included both the household members of working age, and also the hired help (ganyu). Male-headed households had only a marginally higher access to labour, which did not have a significant correlation with gender.

Access to extension and credit services

Previous research has shown that women have less access to agricultural extension than men (Kiptot and Franzel 2011). In research conducted in Malawi, Gilbert et al. (2002) showed that only 19 per cent of women had access to extension compared to 81 per cent of men. In terms of frequency of contact with extension services, studies have shown that women on average have less frequent contact than men. Through the review of a number of studies, Kiptot and Franzel (2011) demonstrated that men in general receive more extension visits than women, partly due to the bias of extension workers towards men (Kiptot and Franzel 2011). In a study conducted in Uganda, Katungi et al. (2008) showed that women had 1.13 contacts with extension compared to men's 2.03.

The findings show that female-headed households in the sample did have a lower access to extension (88.3 per cent versus 91.1 per cent by men); the difference, however, was small, with no significant relationship between gender and access to extension. This high access to extension for the sample overall could be explained by the fact that the sampled lists of farmers were received from the Milk Bulking Groups of which these farmers were members, with the majority of the MBGs usually having extension officers attached. The frequency of annual contacts with extension was marginally higher for men than for women (2.68 contacts versus 2.62, correspondingly).

With respect to access to credit, surprisingly, female-headed households had a slightly higher use of credit services – with 41.6 per cent of female-headed households using credit services or having used them in the past 12 months, versus 40.7 per cent of male-headed households in a similar position. This finding contradicts the typical argument that females generally have less access to credit than males.

Participation in agroforestry practices

The survey data revealed that 40 per cent of the total sample of farmers adopted agroforestry practices. Contrary to our expectation, a higher proportion of female-headed households - 67.5 per cent - were involved in practicing agroforestry, versus 58.5 per cent of male-headed household, with a significant correlation between gender and agroforestry adoption. This is an interesting finding, considering that male-headed households had more land and labour available at their disposal, and higher average incomes to be able to adopt new technologies. Further, a higher number of female-headed households were involved in community forestry work - 55.8 per cent versus 49.7 per cent. 10.6 per cent more female-headed households planted trees on their farms in the past 2 years, than male-headed households, indicating a recent shift towards agroforestry in female-headed households. However, male-headed households had on average 17.4 trees more on their farms than female-headed households, which is not surprising considering the larger size of land holdings of the male-headed households.

Involvement in agroforestry practices by type

Respondents were asked to indicate the type of agroforestry practice they use. The description of the three main types of agroforestry practices studied in this research are provided below and are based in part on Swinkels and Scherr (1991):

•In *alley cropping* leguminous trees are grown in rows in cropland with regular spacing between the rows. The spacing is designed to accommodate matured trees while leaving space for agricultural crop to grow. The trees are intensively managed by being cut back at frequent intervals. The annual income is provided by the agricultural crop till the tree crop matures.

•In *hedging/live fencing* lines of trees or shrubs are planted on farm boundaries or on the border of home compounds, pastures, fields or animal enclosures. Their primary purpose is to control the movement of animals or people and for wind protection. Depending on the species used, live fences could also provide fuelwood and fodder, and enrich the soil.

•In intercropping two or more crops are grown together in close proximity, and also managed at the same time. Depending on spatial arrangement, there could be a number of different types of intercropping (Sullivan 2003).

Respondents were also asked whether they used a combination of practices of any of the above practices.

The findings show that intercropping was the most popular practice adopted by both male and female households, followed by hedging, with no significant differences in the adoption rates of any of these practices by males and females (Table 5.15).

Table 5.15 Types of agroforestry systems by gender

	Intercropping	Alley cropping	Hedging	Combination of two systems	Pearson χ^2
Female	54.2	16.7	29.2	0.0	2.383
Male	45.2	12.7	35.7	6.4	

Table 5.16 shows the regional adoption patterns of agroforestry practices. Against our expectations, the highest number of farmers practicing agroforestry was in the Southern region, with fewest practicing in the North. The most common agroforestry practice was intercropping adopted by 46.4 per cent of the sample farmers, with the adoption rate being highest in the Northern and Central regions.

Table 5.16 Adoption of agroforestry practices by region

	Central	**Northern**	**Southern**	Pearson χ^2
Total N	**150**	**43**	**267**	
Practicing agroforestry, yes	34.7%(52)	20.9%(9)	46.1%(123)	12.389 ***
Type of agroforestry practiced				
1. Intercropping	60.8%	87.5%	37.7%	16.434*
2. Alley cropping	13.7%	12.5%	13.1%	
3. Hedging	19.6%	0.0%	43.4%	
4. Combination of two systems	5.9%	0.0%	5.7%	

Note: Numbers in brackets are numbers of farmers practicing a particular type of agroforestry.
*Note 2: *** significant at 1% level, *significant at 10% level.*

Types of trees planted on the farms

The most frequently encountered trees on farmers' land were *Faiderbia*, *Acacia polyacantha* and *Acacia Albida*, blue gum (Eucalyptus species), as well as mango and avocado pear. The average number of trees on their land was 41 (SD 52) for males and 36 (SD 57) for females.

Reasons for not practicing agroforestry

Table 5.17 shows the main reasons for not practicing agroforestry as reported by respondents, categorised by gender and region of the respondent.

Table 5.17 Reasons for not practicing agroforestry, by gender and region

Reasons for not practicing agroforestry	Central	Northern	Southern	Male	Female
Limited land	23.2% (22)	3.0% (1)	18.4% (25)	19.2% (41)	13.7% (7)
Lack of seeds	10.5% (10)	6.1% (2)	10.3% (14)	10.3% (22)	7.8% (4)
Lack of knowledge	42.1% (40)	45.5% (15)	38.2% (52)	39.0% (83)	47.1% (24)
Enough trees on the farm	6.3% (6)	6.1% (2)	0.7% (1)	4.2% (9)	0.0% (0)
Enough local trees to suit the purpose	0.0% (0)	12.1% (4)	0.0% (0)	1.4% (3)	2.0% (1)
Not enough time	4.2% (4)	15.2% (5)	0.7% (1)	4.7% (10)	0.0% (0)
The trees shade crops in the garden	3.2% (3)	0.0% (0)	19.1 (26)	10.3% (22)	13.7% (7)
Planning to start soon	5.3% (5)	12.1% (4)	0.0% (0)	2.8% (6)	5.9% (3)
Not interested/Don't see the importance of agroforestry	5.3% (5)	0.0% (0)	12.5% (17)	8.0% (17)	9.8% (5)

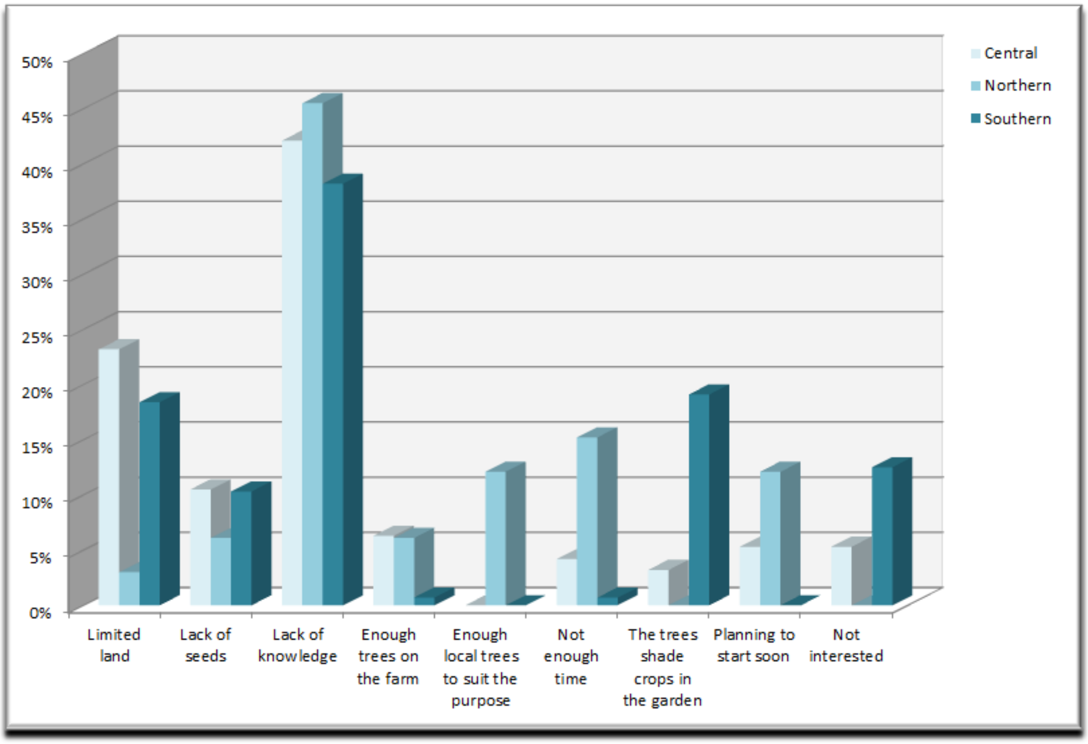
Table 5.17 Reasons for not practicing agroforestry, by gender and region

Total N	95	33	136	213	51
Pearson χ^2		91.687***		7.976	

Note: Numbers in brackets are numbers of farmers corresponding to the proportions.

*Note 2: *** significant at 1% level.*

Figure 5.11 Reasons for not practicing agroforestry, by region, per cent of respondents

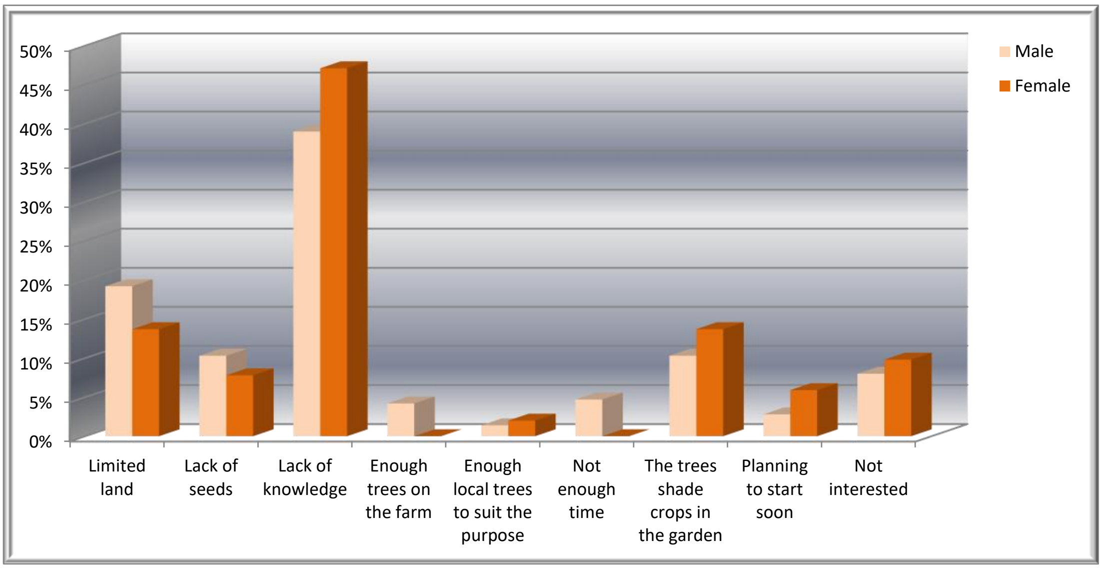


The main reason for not practicing agroforestry in all 3 regions was the lack of knowledge. The second most important reason in the Central and Southern region was the lack of land; this, however, was reported as a constraint to agroforestry adoption by only 3 per cent of the respondents in the Northern region, where respondents had bigger land plots in comparison with the other 2 regions. The second most important constraint in the Northern region was the lack of time, reported by 15.2 per cent of all respondents.

A large minority – 12.5 per cent - of the respondents in the Southern region reported not being interested in agroforestry due to this not being an important practice (in terms of providing benefits for the farm). Also, 19.1 per cent of all respondents in the Southern region reported the trees shading crops in the farm as a constraint to adopting agroforestry. Seed availability was another significant constraint reported by the farmers in all three regions.

Figure 5.12 shows the gender split of the constraints to agroforestry adoption. Again, the majority of respondents, both male and female, cited lack of knowledge, followed by land constraints. Interestingly, more females reported lack of knowledge (47.1 per cent versus 39.0 per cent), while more males reported lack of land (19.2 per cent versus 13.7 per cent), despite male-headed households having on average larger land holdings. Also, 9.8 per cent of all female-headed households reported not being interested in the practice, against 8.0 per cent of male-headed households. As was the case for the regional segregation, seed availability was reported as a major constraint to agroforestry adoption by both male- and female-headed households.

Figure 5.12 Reasons for not practicing agroforestry, by gender of household head, per cent of respondents



5.5.2 Model results

A logistic regression was performed to model the determinants of adoption of agroforestry practices (For the description of the model, see Section 4.3.4). Table 5.18 shows the significant explanatory variables.

The logistic regression model was statistically significant, $\chi2(13) = 24.614$, $p < .026$, showing a strong explanatory power The model explained 33.0% (Nagelkerke R2) of the variance in the adoption of agroforestry practices and correctly classified 70.9%

of cases (prediction success rate). The negative constant implies that in the absence of the socio-economic and institutional factors studied in the model, the adoption of agroforestry practices would be declining.

Of the ten explanatory variables five were statistically significant: gender, access to labour, access to credit, importance of livestock as a source of income, and the respondent's region.

Gender of the household head was inversely related to the probability of agroforestry adoption, rejecting our hypothesis of male-headed households being more likely to adopt agroforestry. Female-headed households in our study were twice as likely to adopt agroforestry practices as male-headed households suggesting that other factors rather than only the differences in the amount of land owned, mean income, access to extension and education levels play a role in the adoption of agroforestry practices.

As expected, access to labour was a significant predictor, increasing the likelihood of the adoption of agroforestry five-fold with each extra worker employed at the farm.

Against expectations, the size of the land holding was not a significant predictor for the model. This could be explained by the fact that most agroforestry practices require relatively little land as trees can be planted around the homestead and on field boundaries (Mbow et al. 2014a).

Access to credit, was found to be positively related to adoption. Respondents who had access to credit had 1.6 times higher odds of adopting agroforestry versus respondents without access, which proves our hypothesis of the importance of credit facilities for the adoption of new technologies.

Exp (B) value indicates that respondents from the Southern region had nearly 3 times higher odds of adopting agroforestry than farmers from the other two regions. This rejects our hypothesis about the farmers from the Northern region being more likely to adopt improved practices due to the greater size of land holdings. This can have two possible explanations. One explanation is that the farmers in the Southern region predominantly depend on dairy farming for their livelihoods, and, with a lack of fodder being a major constraint to dairy production (see Sections 5.2-5.4), fodder trees could provide dairy animals with much needed feed and sustain the level of milk production necessary to support the households' income. Another possible explanation is that the majority of agroforestry promotion programmes have been focussed traditionally in the Southern region, as this is the region most affected by climate variability, and with the highest number of poorest smallholders who might significantly benefit from the practice.

We found no relationship between farmer's age and years spent in education and the adoption of agroforestry practices, thus rejecting our a priori hypotheses about the importance of these factors.

Our hypothesis of the security of tenure playing role in the adoption of agroforestry was also rejected in the model. This might be due to the fact that although the majority of smallholder farmers in Malawi have customary rights on their land, with no formal ownership or land title, the land, however, normally passes from generation to generation and in theory should not stop farmers from implementing long term sustainable practices at the farms. The only time when security of tenure will be important is when applying for credit or a loan where land serves as collateral.

Livestock as a source of income. The importance of livestock as a source of income had a significant positive relationship with the adoption of agroforestry practices. Farmers whose primary source of income was dairy farming were 4 times more likely to adopt agroforestry practices than farmers for whom dairy farming was a secondary income. This indicates that, as discussed in the case of regional differences, fodder scarcity did play a major role in adoption.

Access to extension. The findings did not indicate a relationship between access to extension and adoption of agroforestry practices, most likely due to the type of extension messages received. As mentioned above, due to extension officers being attached to milk bulking groups it is likely that extension support and advice were more focussed on animal health and feeding rather than on the introduction of sustainable land management practices such as agroforestry. Hence the availability of extension services and the frequency of contact do not necessarily mean that extension officers delivered messages or provided advice on the benefits or implementation of agroforestry practices. Several studies conducted in Africa have showed that extension agents do not have sufficient knowledge of sustainable land management practices such as agroforestry and hence these messages are much less likely to be disseminated to farmers (e.g. in Zimbabwe - Chitakira and Torquebiau (2010); in Nigeria - Banful et al. (2010); in Zambia- Sturmheit (1990)). This creates an information bias towards other types of practices such as growing conventional or cash crops. Further, some agroforestry practices are knowledge-intensive so even if the messages are delivered by extension officers trained in agroforestry practices, they do not have the same impact as other technologies (Place et al. 2012).

Table 5.18 Results of logistic regression analysis predicting likelihood of adoption of agroforestry

Characteristic	Adoption of agroforestry		
	Total N=460		
	Coefficient	S.E.	Exp(B)
Constant	-2.117**	.751	2.120
Gender (head) (1 if male)	-1.3174***	.285	2.262
Age	.003	.008	1.003
Education (head)	.035	.027	1.036
Labour	1.4848 ***	.054	5.018
Land	.109	.053	1.085
Tenure (1 if freehold)	.136	.301	1.146
Livestock income	1.0119 ***	.225	4.115
Access to credit (1)	0.30349 *	.211	1.589
Access to extension	-.007	.349	.993

Table 5.18 Results of logistic regression analysis predicting likelihood of adoption of agroforestry			
services (1 if yes)			
Region	0.9448 ***	.252	2.893
Model χ2	24.614**		
H-L test	.892		
Nagelkerke pseudo-R^2	.337		

*Note: *** significant at 1% level, ** significant at 5% level, * significant at 10% level*

5.5.3 **Conclusions to Section 5.5**

The findings presented in Section 5.5 highlight the importance of incorporating socio-economic factors for an effective design and implementation of agroforestry programmes.

The findings showed that a number of household and farm characteristics, including gender played a significant role in the farmer adoption of agroforestry practices. Results showed a positive relationship between access to credit and adoption of agroforestry which suggests that microfinance could be one way of helping farmers invest in agroforestry technologies. Microfinance schemes will need to be appropriately targeted to the local conditions and take into consideration that there is a time lag between planting trees and realising the benefits.

Despite not finding a relationship between access to extension, and agroforestry adoption in this study, the importance of extension services should not be underestimated. Practicing agroforestry often requires learning of advanced cultivation methods, and extension support and advice here will be paramount. A key task here will be to identify extension methods that are most effective for promotion of climate-smart agroforestry systems. Agroforestry activities could be promoted by providing advice on the benefits of agroforestry, access to seeds and other planting material. The role of extension is especially important as the majority of respondents named lack of knowledge as the main constraint to the adoption of agroforestry. It will be important to provide all extension staff with the knowledge and skills to address men and women farmers equitably.

Although agroforestry has the potential to contribute to both poverty alleviation and better food security, it is important to remember that the benefits of the practice could be uncertain and long-term, while the most important issue on most farmers' agenda is increasing their short-term food security. Provision of adequate support to invest in agroforestry practices will be crucial. It is also essential that national policies are more oriented towards promoting agroforestry systems as exclusion of agroforestry could be a critical constraint to wider adoption. Without government involvement in providing greater incentives, the level of private investment in agroforestry will be less than socially optimal.

We suggest that future research on agroforestry should concentrate on long-term analyses of specific practices as well as farmer behaviour change, which need to be considered alongside farmer characteristics. Further, other factors including but not limited to the region/area-specific agro-ecological conditions, regional climate, attributes of the particular agroforestry technology, and involvement in the national and international programmes promoting agroforestry should be considered alongside the socio-economic and farm characteristics.

Chapter 6 **Conclusions**

Motivated by the need to seek opportunities for income diversification in Malawi's poor and slow growing economy, with climate change already having a noticeable negative impacts on smallholder agricultural production throughout the country, this dissertation set out to investigate the current farm management strategies used by dairy farmers, and how these strategies could be improved upon, while also being mindful of the sector's adaptation and mitigation needs.

Compared to other sectors, agriculture has an advantage in that many mitigation technologies and practices are already relatively well-understood and available (CCAFS 2012b; Ogle et al. 2013). But important knowledge gaps persist in terms of the technical applicability of measures at significant scale across smallholdings. Furthermore, there is currently little information on the acceptability of measure implementation by low income householders.

This thesis investigated the autonomous adaptation of new or improved farming practices by dairy farmers in Malawi. In doing so, it has contributed new insights to the climate change adaptation literature. To date, there has been a lack of empirical research that studies the adoption of improved farming practices in the dairy sector in Malawi, particularly practices that simultaneously pursue development, mitigation and adaptation goals. Considering the importance of the dairy sector in Malawi's agricultural development, this thesis fills a major gap by providing valuable insights into the current adaptation baseline, and suggesting ways to improve farmer livelihoods and to simultaneously adapt to climate change, by adopting improved dairy farming practices.

6.1 Main research findings

6.1.1 Improvement of the current farm management practices in the smallholder dairy sector in Malawi offers significant options for agricultural-based NAMAs

Evidence of a number of climate-smart interventions carried out in smallholder sector in Malawi shows that these often ignore the potential to develop and improve on current farm management practices, focussing instead on new technical solutions to improve food security and mitigate climate change. While the introduction of new practices certainly has a role to play, significant gains can be achieved by improving current practices and development interventions; for example animal feeding and manure management practices could be improved relatively cost-effectively if all farmers adopt hay/feed conservation and sustainable manure storage, the latter also leading to decreased GHG emissions. In this respect, knowledge transfer, sharing and training opportunities will be paramount.

Thesis findings showed that there are a number of unsustainable farm management practices deployed by the dairy farmers in Malawi, and that the adaptation practices used are mostly short term, did not appear very robust and are likely to be insufficient under future climate change scenarios. A number of the current practices could be modified to be climate-smart and potentially funded under a NAMA modality. This has a strong potential to reduce emissions from the sector and improve dairy farmers' livelihoods.

The recent Intended Nationally Determined Contribution (INDC) of the Republic of Malawi (Republic of Malawi 2015) highlights capacity building in order to implement and monitor agricultural NAMAs as one of the intended policy based actions. Although the document states that the overall mitigation potential in the agricultural sector in Malawi is small, however, the promotion of sustainable intensification pathways for the livestock sector, including improved feeding, breeding and veterinary services as well as improved manure management are all mentioned as the main mitigation pathways for the sector. Most of these options were discussed in Section 5.2 as potential sectoral NAMAs that could significantly contribute to the development of the sector and be aligned with the climate-smart development agenda.

6.1.2 Supply chain efficiency is as important as on-farm measures for increasing productivity and hence reducing emissions.

The current supply chain structure acts as a considerable barrier to participation in formal milk marketing, and any potential dairy sector NAMA should consider the entire dairy supply chain and production system. Any NAMA approach to address mitigation, adaptation and food security issues that focuses solely on farm-level interventions in isolation will be at risk of being unviable as a result of the supply chain structure currently acting as a disincentive for famers' continued involvement in the sector.

6.1.3 The adoption of climate-smart practices by dairy farmers is significantly influenced by the socio-economic and institutional factors

The findings presented in Sections 5.3 and 5.5 showed that the probability of adoption of a number of climate-smart practices is influenced by the provision of extension support and wealth related variables, as well as access to labour and credit. These findings highlighted the importance of considering a number of socio-economic and institutional factors when designing climate-smart interventions in the sector.

In particular, the findings highlight the importance of agricultural extension services in Malawi in helping smallholder farmers adapt to climate change. The Malawi Department of Agricultural Extension Services can help farmers identify cost-effective technologies that can help increase resilience to climate change and improve their livelihoods. DEAS agents also have an important role to play in increasing farmer involvement in dairy farming, by assessing a farmer's interest in dairy farming and recommending them for "pass on" programmes. With existing dairy farmers, it will be important for the dairy extension officers to assess their success or performance, and provide advice and recommendations, for example, on feeding, hygiene, general management of animals, and establishing pastures. To successfully achieve these objectives, a significant capacity building of dairy extension officers will be needed, in order to improve their practical skills and knowledge.

6.1.4 Farmer climate change awareness does not always lead to an improved adoption rate of climate-smart practices

The findings in Section 5.4 showed that climate change awareness does not necessarily lead to adaptation, i.e. despite the majority of dairy farmers being aware of climate change and having observed noticeable changes in weather variability and associated negative impacts on their dairy farms, the majority of "climate-aware" farmers did not adapt. This has implications in terms of designing and delivering climate change messages to farmers in Malawi, which usually happens either via public broadcasting services (e.g. radio), or through extension agents. The messages need to be more targeted and focused, highlighting the importance of adaptation and adoption of improved practices in preserving and improving farming livelihoods.

This also emphasizes the critical importance for effective programmes to be implemented to promote adoption of strategies and technologies to limit the impacts of climate change on smallholder farming households.

6.1.5 Security of tenure does not appear to play a role in the adoption of agroforestry practices by dairy farmers

Section 5.5 revealed that the security of tenure did not play role in the adoption of agroforestry practices. Although it is generally expected that having insecure tenure reduces the likelihood of adoption of new land-based, long-term practices, this does not appear to be the case in Malawi where the majority of smallholder farmers have only customary (non-documented) rights on their land.

This has potential implications for future policy development with regards to climate-smart agriculture. The climate-smart agenda usually highlights the importance of securing land rights as an important step to achieve prior to designing and scaling up climate-smart interventions. However, if (documented) security of land tenure in Malawi does not play a significant role in the adoption (or otherwise) of long-term adaptation practices this will have a potential to speed up any future interventions rather than having to wait for the entire tenure system to be redesigned.

6.1.6 Regional differences play a significant role in the adoption of climate-smart practices

The findings suggest that dairy farmer adoption of climate-smart practices was significantly different across the 3 regions of Malawi. This could be explained by the difference in the level of wealth across the regions, a difference in the effectiveness of extension messages delivered in various parts of the country, as well as region-specific agro-ecological conditions. This has important implications for scaling up climate smart practices in Malawi, as regional differences will need to be taken into account for the successful application of any climate-smart intervention.

6.1.7 The establishment of effective and representative farmer organisations at a level below MBG level will be important for empowering farmers

Research findings showed that that there are no farmers organisations in place which could negotiate on farmers behalf to achieve higher milk prices paid the MBGs/processors, access to credit to purchase more animals or feed, and provide access to high-quality extension advice. This is an issue of concern, as the above factors were given in the smallholder survey as significant constraints to the continued involvement in the dairy sector. The establishment of farmer organisations or cooperatives could be extremely beneficial by providing farmers with knowledge and skills necessary to get into and be successful in dairy farming. This could also give the smallholders the buying power they need to obtain key inputs at competitive prices.

The involvement in farmers organisations will encourage to articulate their demands and can also address farmers' challenge of market access, by linking farmers with market players. The assurance of a ready market can trigger farmers' motivation and willingness to invest in farming.

6.2 Policy implications

Smallholder dairy sector development in Malawi offers a viable and pro-poor option for agricultural development. However, as small farms are increasingly challenged by a number of factors, there is a need for a concerted effort by GoM, NGOs and donors to create a more equitable and enabling economic environment for development of the sector. This must include assistance in forming effective marketing organizations and farmer cooperatives, targeted agricultural research and extension, an overhaul of financial systems to meet small farm credit needs, and improved risk management policies. These interventions are possible and could unleash significant benefits in the form of pro-poor growth in the dairy sector. Without these interventions, it is unlikely that smallholder dairy farming in Malawi will have a viable future. Such interventions should be designed to assist farmers in better risk management and to improve their productivity and incomes, but without creating incentives that lead to inappropriate land uses and environmental degradation.

These interventions could be designed in a way that benefits farmers while achieving climate change mitigation as an incidental benefit. However, government and policy actions aimed at improving livelihoods and reducing climate vulnerabilities can often be paralysed in the absence of full knowledge. This thesis provides supporting knowledge to contribute to improved policy making in the agricultural sector in Malawi.

It is important to note that public interventions are not without cost, nor does the Malawi government necessarily have the capacity to intervene effectively in the ways they desire. For any intervention to be successful, the net economic and social benefits must be sufficient to justify the costs. This is especially important as the dairy sector development will require significant investment in public infrastructure and services. In the long run, the development of the sector will depend on developing supply chains, improving rural infrastructure, transport systems and education, distributing key technologies and inputs, and promoting producer marketing organizations that can link small farmers to the new market chains. The currently restrictive oligopoly of milk bulking/procurement is an essential factor to be addressed, with market liberalisation being a potential option to explore.

Context is also very important when designing appropriate interventions to improve livelihoods of dairy farmers. It is clear that different situations and contexts will need different, specifically targeted approaches.

It is also important not to overgeneralize the findings of the research presented in this thesis. More research is needed to accurately assess the factors influencing smallholder uptake and use of climate-smart practices. Also, it is important to remember that the findings in this thesis are drawing on a sample that, although representative of the smallholder dairy farmers involved in the formal milk supply chain, cannot, however, be considered as representative of wider rural society in Malawi, likely because of dairy farmers having more diversified and less weather dependent sources of income, and hence being less marginalised and poverty-stricken than other segments of the rural society.

6.2.1 Bottom up approach to the design of climate-smart interventions

The experience with climate-smart interventions in SSA so far shows that these have been predominantly donor driven, i.e. had a top-down rather than bottom-up design. Due to the farmers not having vested interest in or being consulted at the design stages of these interventions this approach is likely not to be sustainable in the long term and could lead to high rates of dis-adoption, maladaptation and other negative impacts. This, for example, has happened during the Kenya agricultural carbon project (Section 2.5.5).

By involving local communities in the design and delivering of dairy sector interventions, these could be targeted in an efficient manner that corresponds to local needs and constraints. Overall, the sustainable growth and improved performance of the dairy sector will depend on the broad participation of small farmers.

6.3 Research impact and implications for the literature

In Malawi, a primary goal of dairy sector development must be to identify livelihood-enhancing interventions in the sector that cope well with current climate variability while also buffering against future climate change. The research presented in this thesis goes some way to answer that need. In addition to the provision of some directions for future research, my study has made three novel contributions to the area of research.

Firstly, prior to this study there had not been a national scale smallholder survey of dairy farmers in Malawi. The survey generated a wealth of information, which will be very useful for guiding decision making and interventions in the sector. The database is already being used by the Ministry of Environment and Climate change management which is responsible for developing NAMA contributions for Malawi, as well as NAPs. The database is also being used by Malawi Ministry of Agriculture and Food Security. This shows that this research has a potential for generating a high policy impact.

Secondly, the study presented potential dairy sector NAMAs which are also being used to inform the development of agricultural NAMAs in Malawi. Feedback received from the Ministry of Environment and Climate Change Management showed that the discussion on potential NAMAs presented in Section 5.2, together with the data contained in the database will be very useful for informing the dairy sector NAMA which is currently being developed. Further, Malawi INDC names several options for the development of agricultural NAMAs which could be directly linked to the suite of NAMAs proposed in this thesis.

Finally, this thesis makes contribution to the development of CSA literature and literature on climate change adaptation by exploring and analysing the use of farming strategies in the dairy sector in Malawi which could be used as a basis for developing climate-smart interventions. Despite the growing research in the field of climate change adaptation, there is very little research that has focused on the adoption of climate-smart interventions.

Climate-smart agriculture professes to be a ‘triple-win’ approach that aims to help, in particular, poor farming communities improve their lives in the face of climate threats without aggravating these threats for future generations, while, simultaneously, improving farming livelihoods. Yet a scarcity of research that critiques the operationalisation of climate-smart interventions means the potential of CSA to meet these claims has received little scrutiny. CSA strategies and interventions are increasingly operationalised, often with limited understanding of their consequence for the most vulnerable farming households.

This thesis has contributed to the nascent body of critical CSA research by presenting by identifying and researching a suite of climate-smart practices that could achieve double or triple-wins for the dairy farmers in Malawi. Insights from this research have been used to develop a suite of recommendations that can help current and future CSA projects to encourage adoption of improved practices. Further, findings presented herein also have important implications for the international development concepts with links to CSA; climate change adaptation and mitigation discourses; and the operationalisation of the post-2015 climate change and development agenda.

6.4 Limitations of the study

The findings of this study are restricted/limited to a fraction of the data generated by the smallholder dairy survey. This research addressed only the role of certain practices that are most frequently discussed in the adaptation and mitigation literature and designing climate-smart interventions in Sub-Saharan Africa with relation to the dairy sector. However, the study generated a wealth of data not explored as part of this research. This includes data on types of crops planted and crop yields, other livestock kept at the farm, herd dynamics, and food security. This could be explored in future studies/PhD projects. Although the findings are conclusive for the data studied, it is possible that when the overall survey is analysed and, when looking at the bigger picture, this might shed more light on, and, potentially, alter the relationships between some of the conclusions presented in this thesis.

Another limitation is that the survey targeted only smallholder dairy farmers involved in the formal milk supply chain, i.e. those registered with and selling their milk through MBGs. The government reports show that there is a significant number of dairy farmers not participating in the formal milk supply chain. Some sources suggest that much of the dairy sector activity takes place outside the formal sector, and the number of “informal” farmers exceeds those that are involved in the formal milk supply chain. However, due to these farmers not being registered anywhere, it was not possible to obtain lists of these farmers for sampling and surveying purposes. This means that the sample drawn for this study does not include the most marginal farmers which are outside the formal sector. As the government discourages selling milk in the informal sector, there is an added reason for these farmers not to come forward. Further, the government and donor interventions in the dairy sector in Malawi only target farmers involved in the formal milk supply chain, which is also the focus of this thesis. It is clear, however, that to contribute to the sector development, it will be important to attract dairy farmers from the informal sector into the formal sector which could be done by removing some of the constraints at the MBG and the processor level, communicated by dairy farmers in the survey (such as lower milk prices in the formal sector and late payments for milk).

Finally, as mentioned in the Methods Chapter (Chapter 4) the length and the complexity of the survey questionnaire potentially led to the farmers experiencing interview fatigue. This could have resulted in the quality of some data collected being compromised.

6.5 Further research

Findings presented in this thesis identify a number of further research gaps that require investigation.

Despite the growing use of the concept of triple wins as an inherent component of climate-smart agriculture there is little empirical evidence so far of triple wins, with the majority of existing climate-smart projects only delivering double-wins. The introduction of new climate-smart practices, including the trade-offs between mitigation and risk reduction in climate-smart activities, could potentially generate unexpected negative outcomes not suited to the reality of the smallholder sector, which include increased reliance on technology and external inputs and, in some cases, maladaptation thus worsening poverty. Further research that explores what type of trade-offs might be justifiable would make a useful contribution to the CSA literature, and would help provide guidance to practitioners.

It is clear that there will be multiple challenges when designing climate-smart interventions, especially at scale. Firstly, relative to other sectors (e.g. transport and energy), emissions mitigation in agriculture is biophysically more complex and dependent on specific farm conditions. Moreover, trying to address the actions of millions of smallholders confronts behavioural and socioeconomic barriers that need to be understood in order to facilitate monitoring and verification of emission reductions.

It is suggested that before carrying out any climate-smart interventions, especially those that promise triple wins, it will be essential to conduct an in-depth research carefully evaluating the mitigation, adaptation and food security benefits of these interventions, and assess project risks. All this should be done while taking into account the spatial and temporal costs of climate-smart activities, and region specific characteristics ((Tompkins et al. 2013). A combination of approaches (such as the use of modelling exercises, survey instruments, understanding cultural and behavioural specificities of local communities by involving and integrating community members from early on in the projects) should be considered here, as no single approach would be sufficient.

Further, it will be essential to explore where climate and production objectives could be adopted as part of current or traditional ‘good’ farm practice and to shift the focus from a short-term increase in an on farm productivity to the longer-term and more sustainable approach of improving supply chain efficiency. It is also important to keep in mind that survival remains the main priority of millions of smallholder farmers in the developing world targeted by CSA interventions, and that triple wins will not be achievable in many cases due to the local and external constraints including lack of skills and knowledge, and lack of funding. Future research aimed at reducing these barriers is urgently needed.

A future research agenda that systematically critiques the origins and operationalisation of the CSA concept is needed to facilitate improved understandings of whether and how it should be used to underpin a new mitigation and adaptation agenda. Policymakers and practitioners should proceed with caution until the implications and benefits of adopting CSA interventions are better understood.

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Appendix A Dairy baseline survey

Questionnaire for the Dairy Baseline Survey in Malawi

THE SURVEY IS BEING CONDUCTED BY BUNDA COLLEGE OF AGRICULTURE AND SCOTTISH RURAL COLLEGE

INTRODUCTION

Good (morning, afternoon). My name is __________. I am conducting a study concerning dairy production issues in your neighbourhood on behalf of Bunda College. The aim of this study is to understand dairy production systems, marketing and identify problems you encounter in your enterprise. This study will be conducted in all milk-shed areas throughout the country. While the general conclusions of the study may be used to help formulate government policy recommendations for improving dairy production in the country, all the specific information about you, your family and undertakings will be treated confidentially. We hope that you will be willing to help us in this study.

MAWU OYAMBA

Dzina langa ndi__________________. Tafika mdela lanu lino pakafukufuku amene tikupanga wokhudza ulimi wa ng'ombe za mkaka mmalo mwa sukulu yazaulimi ku Bunda.Cholinga cha kafukufukuyi ndi kufuna kudziwa za mmene ntchito ynu ikuyendera, mmene mumagulitsira mkaka wanu ndinso mavuto amene mumakomana nawo. Kafukufukuyi achitika mmalo momnse momwe amalandilira mkaka mdziko lonse lino. Ngakhale kuti zomwe mutiyankhe zithandiza boma kukonza ndondomeko zothandizira alimi an ng'ombe za mkaka kuno ku Malawi, zomwe mutiuze zokhudza inu, banja lanu ndinso zomwe mumachita pakhomo panu, zidzasungidwa mwachinsisi. Chonde khalani okasuka kutiuza zonse mukudziwa ndi zomwe mumachita zokhuza ulimi wanu.

Enumerator's Name: ……..

Date of Interview (DD/MM/YY): ……..... /……........……/ 2012

Time Started:………..…………… Time Ended:…………………………..

Cross-checked by (Enumerator's Name)………………………………………………….

Final check by (Supervisor's Name): ………………………………………….……….

MODULES:

Module 1: **Basic Household Information**

Module 2: **Dairy Farm Management and Milk Production**

Module 3: **Dairy Marketing Chain and Market Access**

Module 4: **Access to Animal Health and Livestock Extension Service**

Module 5: **Food Security and Climate Change**

Module 1: **Basic Household Information**

Section 1-A. Background information

1) Respondent's Name: ……………………………...………

2) Gender of the respondent: ☐ Male (1) ☐ Female (2)

3) Age of the respondent:……….…………..….……….…years old

4) Farm address: Village..Traditional authority...

District/Township………………………………………

Milkshed area…..………………….………….............

Extension planning area………………………………….

5) Respondent's position in the household (with respect to the head):

☐ Husband (1) ☐ Wife (2) ☐ Daughter (3)

☐ Son (4) ☐ Relative living in a house (5)

☐ Farm labourer (6) ☐ Other (7), please specify…………………………

6) Respondent's educational background:

☐ Primary school (1) ☐ Secondary school (2)

☐ Vocational school (3) ☐ College / University (4)

☐ Other (5), please specify………………………….

7) Number of years spent in school……………………………….years

Section 1-B. Household socio-economic background

8) Size of the household……………………………………………………….people

9) Household composition by age

Male (tick)	Female (tick)	Position in the household (with respect to the head)	Age at the time of the survey, years

10) Land ownership

Land type	Ha	How acquired 1 Given by parents 2 Given by chief 3 Given by Govt. 4 Rented land 5 Borrowed for free 6 Purchased	If rented, how much rent do you pay, *MK (please specify whether it is per month, per year etc)*	Land tenure status 1 Customary 2 Freehold 3 Leased 4 Public 5 Other, please specify)……………..	When acquired, year	Can you pass on your land to familymembers? ☐ Yes (1) ☐ No (0)
Agricultural land						
Pasture land						
Forest land						
Fallow land						
Dimba						
Other types						

11) Ownership of house

☐ Own house (1) ☐ Rented (2) ☐ Host with family or relatives (3)

☐ Temporary shelter (4) ☐ Other (5), please specify……………………………………….…….

12) Does your house have?

a) Electricity (ESCOM) ☐ Yes (1) ☐ No (0)
b) Electricity (Solar) ☐ Yes (1) ☐ No (0)
c) Access to water ☐ Yes (1) ☐ No (0)
d) Toilet/Latrine ☐ Yes (1) ☐ No (0)
e) Iron sheet roof ☐ Yes (1) ☐ No (0)
f) Burnt brick walls ☐ Yes (1) ☐ No (0)
g) Cemented / Tiled floor ☐ Yes (1) ☐ No (0)

13) Do you / your household own any of these (choose as many as apply)?

Implements:

a) Hoe ☐ Yes (1) ☐ No (0)
b) Treadle pump ☐ Yes (1) ☐ No (0)
c) Axe ☐ Yes (1) ☐ No (0)
d) Sickle ☐ Yes (1) ☐ No (0)
e) Slasher ☐ Yes (1) ☐ No (0)
f) Sprayer ☐ Yes (1) ☐ No (0)
g) Protective equipment ☐ Yes (1) ☐ No (0)
h) Dip tank (either household or communal, please specify……………………)
☐ Yes (1) ☐ No (0)
i) Watering can ☐ Yes (1) ☐ No (0)

Machinery:

a) Ox cart / ox plough ☐ Yes (1) ☐ No (0)
b) Cultivator ☐ Yes (1) ☐ No (0)
c) Generator ☐ Yes (1) ☐ No (0)
d) Motorised pump ☐ Yes (1) ☐ No (0)

Structures / Buildings:

a) Livestock khola ☐ Yes (1) ☐ No (0)
b) Chicken house / poultry kraal ☐ Yes (1) ☐ No (0)
c) Shed / Storage house ☐ Yes (1) ☐ No (0)
d) Granary ☐ Yes (1) ☐ No (0)
e) Cattle crush (either household or communal, please specify…………………..)
☐ Yes (1) ☐ No (0)

Durable goods:

a) Chair ☐ Yes (1) ☐ No (0)
b) Bed ☐ Yes (1) ☐ No (0)
c) Table ☐ Yes (1) ☐ No (0)
d) Stove ☐ Yes (1) ☐ No (0)
e) Mobile phone ☐ Yes (1) ☐ No (0)
f) Refrigerator ☐ Yes (1) ☐ No (0)
g) Radio ☐ Yes (1) ☐ No (0)
h) TV ☐ Yes (1) ☐ No (0)
i) Satellite dish ☐ Yes (1) ☐ No (0)
j) Bicycle ☐ Yes (1) ☐ No (0)
k) Car ☐ Yes (1) ☐ No (0)
l) Motorcycle ☐ Yes (1) ☐ No (0)
m) Bank account ☐ Yes (1) ☐ No (0)
n) Watch ☐ Yes (1) ☐ No (0)
o) Sewing machine ☐ Yes (1) ☐ No (0)

14) If you don't have a khola, where do you keep your animals?

☐ Open ground (1)

☐ Parents' khola (2)

☐ Communal khola (3)

☐ Other (4), please specify...

15) Livelihood sources

15a. Income sources of the family	15b. Rank (max. 5) of your sources of household income in ascending order as follows: (1 = most important to 5 = least important)	15c. Average amount per month in the High season[12], Kwacha	15d. Average amount per month in the Low season[13], Kwacha
1. Dairy farming			
2. Other livestock / Beef fattening/ rearing livestock			
3. Crop (Agriculture) (maize, barley, tobacco)			
4. Fisheries			
5. Government employment			
6. Private sector employment			
7. Daily labour			
8. Trade / Shopkeeper			
9. Social support			
10. Forest products			
11. Other…………………………………………			

16) How much of the following staple food crops did you plant this year? ………………. Bags of 50 kg

Crop	Unit of measure	Number of units	Weight per unit, kg	Yield, kg/ha
Maize				
Fresh Cassava				
Cassava dried				
Rice				
Irish potato				

[12] High season is from June to November
[13] Low season is from December to May

Sweet potato				
Millet, kg				
Sorghum (kg)				

17) How much of the following staple food crops did you harvest this year? ………………. Bags of 50 kg

Crop	Unit of measure	Number of units	Weight per unit, kg	Kg harvested
Maize				
Fresh Cassava				
Cassava dried				
Rice				
Irish potato				
Sweet potato				
Millet, kg				
Sorghum (kg)				

18) How much of the crops harvested was for your own consumption, and how much was sold? ………………. Bags of 50 kg

Crop	Used for own consumption	Sold	Unit of measure	Number of units	Weight per unit, kg
Maize					
Fresh Cassava					
Cassava dried					
Rice					
Irish potato					
Sweet potato					
Millet, kg					
Sorghum (kg)					

Module 2: Dairy Farming

Section 2-A. General

19) When did you start dairy farming? ....years (Enumerator to calculate the number of years)

20) Did you have prior knowledge of dairy farming? ☐ Yes (1) ☐ No (2)

21) If yes, from where? ....

22) How did you start dairy farming?

- ☐ Encouraged by parents/relatives/friends (1)
- ☐ Introduced by Govt./NGO/Donors (2), please specify........................
- ☐ Self-motivated (3)
- ☐ Inherited (4)
- ☐ Other (5), please specify)…………………………………………..

23) Do any members of your family / friends practice dairy farming? (choose as many as apply)

- ☐ Parents (of husband / wife) (1)
- ☐ Brother / sisters (of husband / wife) (2)
- ☐ Friends (of husband / wife) (3)
- ☐ Other (4), please specify………………………………………………….
- ☐ None of the above (5)

24) Why did you start dairy farming? (choose up to 2 options)

- ☐ To increase income (1)
- ☐ To increase food security (2)
- ☐ To diversify sources of income (3)
- ☐ Other (4), please specify…………………………………………..

Section 2-B. Dairy farm structure, facilities and management

25) Number of dairy cattle kept on farm

25a. Type of animals	25b. Local breed	25c. Crossbreed	25d. Pure breed – *Yachizungu*
	Number of animals	Number of animals	Number of animals
1.Lactating (milking) cows - *Zokamidwa*			
2. Dry cows (pregnant) - *Zosiya kukama*			
3. Dry cows (not pregnant) – *Zozisiyitsa kukama pa zifukwa zina*			
4. Heifers (more than 1 year old) – *Misoti*			
5. Female calves (less than 1 year old)			
6. Male calves (less than 1 year old)			
7. Male fattening cattle (>1 year old) – *Zothena*			
8. Bull (more than 2 years old) – *Nkhunzi*			

26) Number of other livestock kept on farm

Type of animals	Number of animals
1.Ox	
2. Donkey	
3. Mule / Horse	
4. Goat	
5.Sheep	
6. Pig	
7. Chicken	
8. Turkey	
9. Duck	
10. Guinea fowl	
11.Beehive	
12.Other, please specify…………………………………………………	

27) How did you get the (dairy) animals when you first set up your dairy farm?

☐ Credit by government (1) ☐ Pass on credit by NGO (2)

☐ Purchased myself (3) ☐ Inherited (given by) from relatives (4)

☐ Donated (5)

☐ Other (6), please specify...

28) Who owns the (dairy) animals/farm? (multiple choices possible)

☐ Husband (1) ☐ Wife (2) ☐ Both husband and wife (3) ☐ Daughter (4) ☐ Son (5)

☐ Relative (6) ☐ Farm labourer (7)

☐ Other (8), please specify)…………………………………………..

29) Who manages the (dairy) animals/farm? (multiple choices possible)

☐ Husband (1) ☐ Wife (2) ☐ Both husband and wife (3) Daughter (4) ☐ Son (5)

☐ Relative (6) ☐ Farm labourer (7)

☐ Other (8), please specify)…………………………………………..

30) Are the animals used for milk, or meat purposes?

30a. Animal Breed	30b. Milk only	30c. Meat only	30d.Milk and Meat [14]
	Number of animals	Number of animals	Number of animals
Crossbreed			
Holstein/Friesian – *Black & white in colour*			
Zebu – *local*			
Ayrshire /Jersey – *Greyish in colour*			
Other, please specify……………….			

[14] i.e. used for milk, and culled later in life plus bull calves fattened for meat

31) Herd dynamics

31a. Type of animals	31b.Total number	31c. Number born (in the last 12 months)	31d. Number dead (in the last 12 months)			31e. Cause of death, please specify (in the last 12 months)	31f. Number of stillbirths	31g. Number of newborn deaths (in the last 12 months)	31h. Culling (in the last 12 months) *Kuchotsa*		
			No	Sex of the animal	Age when died				No	Sex of the animal	Age culled
Local breed											
Cross breed											
Pure breed											

	31i. Slaughtering for home consumption (in the last 12 months)			31j. Number of animals sold (in the last 12 months)	31k. Number of animals transferred (in the last 12 months)	31l. Number of animals received as gifts (in the last 12 months)	31m. Number of animals given as gifts (in the last 12 months)	31n. Number of (dairy) animals stolen from the farm (in the last 12 months)
	No	Sex of the animal	Age slaughtered					

Local breed								
Cross breed								
Pure breed								

32) Characteristics of each cow on your farm:

Cow No.	32a. Cow Name or ID number (if applicable)	32b. Cow breed 1. Crossbreed 2.Zebu 3. Holstein/Friesian 4.Ayrshire /Jersey 5.Other	32c. Sex 1=Male 2=Female	32d. Date of birth (dd/mm/yy).	32e. Weight when fully grown, kg	32f. How many kg of feed a day they consume when fully grown	32 g. Milk-ing status (1) In milk (2) Not in Milk	32h. If not in milk, the last date when the cow gave milk (dd/mm/yy)	32i.If in milk when did it start giving milk (dd/mm/yy)	32j. Milk yield, litres per day			32k. Date of drying (dd/mm/yy)	32l. Date of last calving (dd/mm/yy)	32m. Date of last insemination (dd/mm/yy)	32n. How many times did the cow have to be inseminated before getting pregnant?.	32o. Duration between insemina-tions (days)	32p. Pregnant status (1) Yes (0) No
										At calving to 30 days	At pe-ak, 30 – 60 days	At the e-nd, after 60 days						
1																		
2																		
3																		
4																		
5																		
6																		
7																		
8																		
9																		
10																		

Section 2-C. Labour use in dairy farming

33) How many workers do you have at the (dairy) farm, i.e. contributing to the dairy enterprise?

33a.Type of employment	33b. Male (No. of persons)	33c. Female (No. of persons)	33d.Total
Self-employed or unpaid workers (family member, i.e. husband, wife, son, daughter or relatives)			
Paid workers / ganyu			
How much is a worker paid in a month? (Kwacha/ person)			

34) Who regularly performs the following activities on your dairy farm?

Activity	Person responsible (multiple choices possible)
Feeding	
Fetching water (for drinking, cleaning, etc)	
Milking	
Cleaning	
Dipping	
Marketing	
Khola maintenance	

Codes for the responses: ☐ Farm Manager (1) ☐ Husband (2) ☐ Wife (3) ☐ Workers (4) ☐ Male children (5) ☐ Female children (6)

Section 2-D. Feeding

35) Which type of grazing do you practice (for your dairy animals), and for how many months a year?

☐ Free grazing (in pasture) (1); *Months of grazing in this category each year………months*

☐ Free grazing in communal land (dambos) (2); *Months of grazing in this category each year………months*

☐ Semi-zero grazing (3) – Kudyetsa ku dambo kapena m'khola; *Months of grazing in this category each year………months*

☐ Zero grazing (4) – Kudyetsera m'khola; *Months of grazing in this category each year………months*

☐ Other (5), please specify………………………………………………………………………………

Months of grazing in this category each year………months

36) Do you practice fertilisation of grazing land?
☐ Yes (1) ☐ No (0)

37) If yes, please specify the amount and type of fertilizer applied (multiple choices possible)

Type of fertiliser	Amount, *kg/ha*
Synthethic (1)	
Manure (2)	
Compost (3)	
Legumes (4)	

38) If you use community land (dambos) for grazing, how much of total feed quantity does this provide? ....% (Enumerator to calculate % if necessary)

39) Have you undertaken any land improvement and conservation measures during the last 2 years?
☐ Yes (1) ☐ No (0)

40) If Yes, please indicate the type of conservation you have undertaken (choose as many as apply)

☐ Soil or stone bunds (1); ………….ha

☐ Terraces (2); ………………………ha

☐ Drainage ditches (3);……………..ha

☐ Fences (4); ………………………...ha

☐ Planting trees (5); …………………Number

☐ Other (6), please specify………………………………; ……………………ha

41) Which grass do you grow on the farm?

Name	Grass yield[15]	
	kg of dry matter per ha	kg of fresh weight per ha
Ruzi grass (1)		
Panicum grass (2)		
Guinea grass (3)		
Napier grass (4)		
Rhodes grass (5)		
Centrocema (6)		
Thatch grass (7)		
Star grass (8)		
Plicatulum grass (9)		
Other (10), please specify......................................		

15 Enumerator to use either dry matter per ha or fresh weight per ha as specified by the farmer.

42) Feed / Fodder (roughage) (multiple choice possible)

42a.Type of feed	Yes (1) or No (0)	42b.Source (1) Plant yourself or (2) Natural pasture or (3) Purchase	42c.Feeding practice 1) Gra-zing 2) Stall-feed 3) Both	42d. How many times do you feed your cows per day?	42e.How much do you feed (per cow per day)? *Unit Code:*		42f.If purchase, please indicate average price, Kwacha per unit (please specify unit)	42g.If purchase, please indicate amount purchased per month, see unit codes below		
					Unit and wt (kg)	Quan-tity ~ no of units	Price per unit	High season	Low season	Unit
Concentrate feed (1) (e.g. dairy mash) – *Zosakhala zaudzu*										
Grass (grazing) (2)										
Grass (cut and carry) (3)										
Hay (4) – *udzu wofutsa*										
Maize bran (5) – *Madeya*										
Groundnut haulms (6) – *Masangwi*										
Feed supplements (7)										

42a.Type of feed	Yes (1) or No (0)	42b.Source (1) Plant yourself or (2) Natural pasture or (3) Purchase	42c.Feeding practice 1) Gra-zing 2) Stall-feed 3) Both	42d. How many times do you feed your cows per day?	42e.How much do you feed (per cow per day)? *Unit Code:*		42f.If purchase, please indicate average price, Kwacha per unit (please specify unit)	42g.If purchase, please indicate amount purchased per month, see unit codes below		
					Unit and wt (kg)	Quan-tity ~ no of units	Price per unit	High season	Low season	Unit
Do you produce Silage (8) – *Udzu owoletsa*										
Forage (9) – Legumes N*yemba*										
Fodder[16] (10) – *Masamba ochokera m'miteng*										
Other (11) a)………………										
b)......................										
c)......................										

[16]e.g. from agroforestry

Note: *Unit Code:* Kilogram = 1; Basket of ____kg = 2; Pale of 20 liters=3; Bag of ____ kg=4; Other = 5, please specify……………………………….

43) Do you purchase crop by-products during the year?

☐ Yes (1) ☐ No (0)

44) If you purchase crop by-products, which crop by-products did you purchase for the farm over the last 12 months?

44a.Type of crop by-product	44b.Price per kg	44c. Quantity purchased				44d. Which month is it available?
		44c1.Unit of measure	44c2. Number of units	44c3. Weight per unit, kg	44c4.Total kg	
Ground nut haulms						
Maize stalks						
Soybean haulms						
Banana stems						
Rice straws						
Cassava leaves						
Other, please specify..................						

Note: *Unit Code:* Kilogram = 1; Basket of ____kg = 2; Pale of 20 liters=3; Bag of ____ kg=4; Other = 5, please specify……………………………….

45) Do you have enough fodder for your animals for the whole year?
☐ Yes (1) ☐ No (0)

46) Do you regularly experience a shortage of feed?
☐ Yes (1) ☐ No (0)

47) If yes, which season / month do you experience the most severe shortage...

48) How do you obtain feed when experiencing a shortage of feed, please

explain...................................…………………………………………………

49) Do you make conserved feeds (e.g. hay) ☐ Yes(1) ☐ No(0)

50) If yes, how much hay do you make? …………………………………………...(specify quantity and units)

51) Have you experienced differences in feed availability over the past ten (10) years?
☐ Yes(1) ☐ No(0)

52) a) Do you have enough water for your animals throughout the day?
☐ Yes (1) ☐ No (0)
b) Amount of water consumed………………………..litres (convert if buckets)

c) Total monthly cost of water……………………Kwacha

53) What is the source of water for the animals (choose up to 2)? Indicate the distance for each source indicated (multiple responses are possible)

☐ On-farm well (1) Dist_______m ☐ Piped public water supply (2) Dist_______m

☐ Rain catchment (3) Dist_______m ☐ River / stream (4) Dist_______m

☐ Other (5), please specify……………………………………… Dist_______m

Section 2-E. Milk production and milking practice

54) How many times a day do you milk your cows?
☐ Once (1) ☐ 2 times (2) ☐ 3 times (3)

55) Do you clean hands before milking? ☐ Yes (1) ☐ No (0)

56) Do you clean milking utensils before milking? ☐ Yes (1) ☐ No (0)

57) Average milk per day in the high season……… kg or litre, from ……………..… (number of milking) cows

58) Average milk per day in the low season………..kg or litre, from ……………..… (number of milking) cows

59) Do you mix evening and morning milk before you send it to the MBG every morning?

☐ Yes (1) ☐ No (0)

60) Do you plan to increase the amount of milk you produce? ☐ Yes (1) ☐ No (0)

61) If yes, how do you plan to increase your milk production? (choose up to 3)

☐ Increase the number of dairy cows (1)

☐ Improve the grade of animals (2)

☐ Produce more feed (3)

☐ Buy more feed (4)

☐ Spend more on controlling animal disease (5)

☐ Depends on extension advice (6)

☐ Change farm management practices (e.g.feed) (7)

☐ Don't know (8)

☐ Other (9) (please explain)………………………

62) Do you think there are any significant constraints to the (dairy) production of the farm?

☐ Yes (1) ☐ No (0)

63) If answered yes, which are the three main constraints you are facing with your dairy farm (choose 3 and rank from 1 to 3 in the order of importance, with 1 being the most important)?

☐ Lack of fodder or roughage (1), ranking…….

☐ Low quality of fodder or roughage (2), ranking……

☐ Low quality of concentrate feed (3), ranking……

☐ High cost of concentrate feed (4), ranking……

☐ Lack of credit to buy new animals (5), ranking……

☐ Lack of farm labourer/s (6), ranking……

☐ Low quality of milk (7), ranking……

☐ Low milk yield (8), ranking……

☐ Low market price of milk (9), ranking……

☐ High price of cattle feed (concentrate feed) (10), ranking……

☐ Infertility (11), ranking……

☐ Animal disease (12), ranking……

☐ Good quality semen and genetics (13), ranking……

☐ Other (14), please specify,

a)…………………………………………,ranking………………………

b) …………………………………………,ranking………………………

c)……………………………………,ranking………………………

d) ……...………………………………,ranking………………………

Section 2-F. Manure management

64) How much time a day do the cows spend grazing?

Type of an animal	Hours per day
Calves	
Gestating cows	
Lactating cows	

Bulls	

65) How much time <u>a day</u> do the cows spend housed?

Type of an animal	Hours per day
Calves	
Gestating cows	
Lactating cows	
Bulls	

66) When not grazing, how is the manure stored? ....

67) When not grazing, how is the manure removed?...

68) How long is the manure stored before using?.........................………………

69) Is the stored solid (if any) manure covered by, kept with or mixed with any material?

a) Covered by other material ☐ Yes (1) ☐ No (0)

b) Kept with other material (but not mixed) ☐ Yes (1) ☐ No (0)

c) Mixed with other material ☐ Yes (1) ☐ No (0)

70) Common manure storage system

☐ Lagoon (1) ☐ Solid storage facility (2)

☐ Dry lot (heap) (3) ☐ Pit storage (4) ☐ Daily spread (5)

☐ Other (6), please specify……………………………………………….………

71) Common manure storage system (multiple choices possible)

Manure Management During Housed Period (adult females only)	% of Manure Stored in this System (Enumerator to calculate if necessary)
Liquid / slurry (with crust) (1)	

Liquid / slurry (without crust) (2)	
Lagoon (3)	
Solid manure (4)	
Drylot (5)	
Daily spread (6)	
Burned (7)	
Anaerobic digestion (8)	
Other (9) (please specify)...	

72) Do you use manure or cattle slurry? ☐ Yes (1) ☐ No (0)

73) If yes, for what? (multiple choices possible)

☐ In pasture (grass) field (1) ☐ In other crop field (2) ☐ Fuel (3)

☐ Biogas (4) ☐ Other (5), please specify..…………………………

74) What proportion of manure produced when the cattle are housed is applied on your fields?..

75) What proportion of manure you produce is used as fuel?..

76) Do you sell manure? ☐ Yes (1) ☐ No (0)

77) If yes, what proportion of manure is sold?..

78) What is the price per unit (e.g., bag, ox-cart, etc)? Kwacha________ /_______ (indicate unit)

79) If don’t use and don’t sell manure, what is done with manure?

Please explain...

80) Do you produce biogas on your farm?

☐ Yes (1)   ☐ No (0)

☐ No, but intend to (2)

☐ Other (3), please explain...

81) Are any cattle also used for traction or work?   ☐ Yes (1)   ☐ No (0)

82) If yes: how many?...heads

83) If yes: for how many hours a day?..............................hours

Module 3: Dairy Marketing Chain and Market Access

Section 3-A. Marketing

84) Disaggregated milk quantities

Category	Average litres per day	
	High season	Low season
Total production		
Home consumption		
Milk wastage		
Milk given to calves		
Milk sold through the MBG		
Milk sold locally		
Milk sold through the dairy cooperative (other than MBG)		
Other, please specify..		

85) Selling price in the MBG, per kg or litre…………………………………..........Kwacha

86) If the selling price in MBG is different in low season, please indicate..Kwacha

87) Selling price locally, per kg, litre or local unit ………………………………(if in local units, please indicate the number of litres or kg per unit)

88) How far do you live from the MBG/collecting centre or market? ……………………. kilometres, or ……………………. hours walking

89) What mode of transport do you normally use to get to the MBG?

☐ Go by foot (1)

☐ Bicycle (2)

☐ Ox-cart (3)

☐ Own vehicle (4)

☐ Hired vehicle (5)

☐ Other (6), please specify...…………………………………………

90) What are the costs incurred during production and marketing of your milk over the last 12 months?

	Item	Total Cost
1	Processing costs	
2	Costs for using extension and veterinary services	
3	Transport costs	
4	Storage cost	
5	Market costs (fees)	
6	Electricity costs (lighting, storage, processing)	
7	Other costs, please specify…………………………………………	

91) Do you ever have difficulties selling your milk? ☐ Yes (1) ☐ No (0)

92) If yes, what are the difficulties?

☐ Poor quality of milk/sour milk (1)

☐ No market (2)

☐ Low price (3)

☐ Lack of transportation (4)

☐ Other (5), please specify...……………………

93) What is the (average) quantity of your milk rejected by MBG/Coop in the last month? ....litres

94) Do you ever have a delay in getting paid for milk sold?

☐ Yes (1) ☐ No (0)

95) If you do have delays, how many days on average per month (in the last 6 months)? ....days

96) Does your MBG or dairy cooperative have an incentive system (additional payment) paid to farmers who have better quality of milk?

☐ Yes (1) ☐ No (0)

97) If yes, how much do they pay for the:

Standard (normal) milk…………………………Kwacha/litre

Better quality of milk…………………………Kwacha/litre

98) What do you do to increase the quality of milk you sell?

……………………………………………………………………………

<u>Section 3-B. Milk bulking groups and dairy co-operatives</u>

99) Are you (or any members of your family) a member of a dairy co-operative (other than MBG)?

☐ Yes (1) ☐ No (0)

100) If no, why (please explain)……………………………………………….

101) What services of the MBG or dairy co-op do you use (choose all that apply)?

Services	Yes (1) or No (0)
Milk collection	
Veterinary services and livestock extension	
Feed	
Veterinary drugs	
Artificial insemination	
Other farming inputs	
Credit	
Other (please specify)………………………..	

Section 3-C. Access to credit/finance

102) Do you have (or have you had in the past 12 months) access to credit to support your dairy farm?

☐ Yes (1) ☐ No (0)

103) If yes, where did you get the credit from?

☐ Regional/international NGO (1)

☐ Malawi Rural Finance Company (2)

☐ Malawi Rural Development Fund (3)

☐ Formal lending agencies (4)

☐ Credit union (5)

☐ Friends/relatives/neighbours (6)

☐ Other (7), please specify............................……………………………………………………

104) If no, would you consider borrowing to invest in your (dairy) farm?

☐ Yes (1) ☐ No (0)

105) If no, why (please explain)………………………………………………………………………..

106) What is the maximum amount you think you could borrow?..Kwacha

107) Do you know what the interest rate is / would be?..%

108) Did you try to access credit in the past but did not obtain it?

☐ Yes (1) ☐ No (0)

109) Can you identify any constraints when trying to get credit (choose up to 3)?

☐ High interest rate (1)

☐ No formal documentation for the land (2)

☐ Credit organizations not willing to lend to smallholders (3)

☐ Other (4), please specify...

Section 3-D. Theft and security

110) If you have had any dairy animals stolen in the last 12 months, what impact did it have on you as a dairy farmer? (choose up to 3)

☐ No impact (1)

☐ Less willing to invest money in dairy farming (2)

☐ Moved / will move to practicing other agricultural activities (3)

☐ Labour constraints (if animals were used for traction) (4)

☐ Increased food insecurity (5)

☐ Other (6), please specify

a)……………………………………

b)……………………………………

c)……………………………………

111) How do you plan to tackle theft in the future, please explain?

………………………………………………..

Module 4: Access to Animal Health and Livestock Extension Service

Section 4-A. General

112) Support for the dairy farm over the last 12 months

	From the Government	From your MBG	From NGOs	From Development agencies	From other organisation, please specify......................
Do you receive support for your dairy farm,					

Yes (1) or No (0)					
Are you satisfied with the level of support you receive, Yes (1) or No (0)					

113) Who provides dairy extension services in your village/region?
☐ Government (1) ☐ NGO (2) ☐ Both (3)

☐ No extension services available (4)

☐ Other (5), please specify……………………………………………….

114) Is there an extension worker at your local MBG? ☐ Yes (1) ☐ No (0)

115) If yes, how often did you have contact with them in the last 12 months?
☐ Once (1) ☐ Twice (2) ☐ More than twice (3) ☐ Never (4)

☐ Other (5), please specify……………………………………………….

Section 4-B. Animal health service

116) Do you vaccinate your animals? ☐ Yes (1) ☐ No (0)

117) If yes, against which diseases?
☐ East Coast Fever (1)

☐ Foot and mouth disease (2)

☐ Other (3), please specify

a)..

b)..

c)..

118) Who vaccinates your animals?

☐ Yourself (1)

☐ Relatives/neighbours (2)

☐ MBG/extension support veterinarian (3)

☐ Private veterinarian (4)

☐ Community Animal Health Worker (5)

☐ Other (6), please specify……………………………………………….

119) Do you pay for vaccination? ☐ Yes (1) ☐ No (0)

120) If you do pay for vaccination, how much do you pay? ....Kwacha

121) Do you de-worm your animals each year? ☐ Yes (1) ☐ No (0)

122) If yes, how much does it cost (per annum)?…………………………………Kwacha

123) During last 12 months, did you see any diseased animal on your farm?

☐ Yes (1) ☐ No (0)

124) If yes, what kind of disease was it?

☐ East Coast Fever (1)

☐ Foot and Mouth Disease (2)

☐ Haemorrhagic Septicaemia (3)

☐ Black leg or Black quarter (4)

☐ Anthrax (5)

☐ Tuberculosis (6)

☐ Brucellosis (7)

☐ Not sure (8)

☐ Other (9), please specify…………………………………………….…………

125) Who provides treatment to your animals in case of sickness?

☐ Yourself (1)

☐ Relatives/neighbours (2)

☐ MBG/extension support veterinarian (3)

☐ Private veterinarian (4)

☐ Community Animal Health Worker (5)

☐ Other (6), please specify……………………………………………………

126) During the last year, has there been any death of the cattle on your farm?

☐ Yes (1) ☐ No (0)

127) If yes, list the details as per Table below

Cattle ID	Sex	Cause of death			How did you dispose?	Value if it were to be sold, Kwacha
		Disease ~ list	Parasites ~ list	Other ~ list	1 = burnt ; 2 = buried; 3 = sold; 4 = eaten	

128) Where are some veterinary services available?

☐ In local MBG (1)

☐ Government district veterinary offices (2)

☐ Government EPA / Dip Tanks (3)

☐ Other (4), please specify……………..………………………..…

129) Are you satisfied with veterinary services you use? ☐ Yes (1) ☐ No (0)

130) Do you have any suggestions on how to increase the effectiveness of the services you use, please explain?

…………………………………………………………………………………………

Section 4-C. Reproduction and breeding service

131) Have you been trained on heat detection? ☐ Yes (1) ☐ No (0)

132) Do you use artificial insemination (AI)? ☐ Yes (1) ☐ No (0)

133) Do you pay for AI service? ☐ Yes (1) ☐ No (0)

134) If yes, how much do you pay for each service?...Kwacha

135) Do you use a bull for the whole herd? ☐ Yes (1) ☐ No (0)

136) Who is inseminating the cows?

☐ Government inseminator (1) ☐ Private inseminator (2)

☐ Farmer AI Technician (3) ☐ Veterinarian (4)

☐ Other (5), please specify……....................………..…….

137) How many times do you observe your animals per day to see if a cow is on heat?

☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ More than 4

138) How many times did you inseminate your cows when they became in heat?

☐ 1 time ☐ 2 times

139) Average number of services per conception? ……………………………..

140) Are you satisfied with the AI / breeding services you use?

☐ Yes (1) ☐ No (0)

141) Do you have any suggestions on how to increase the effectiveness of the services you use, please explain?

…………………………………………………………………………………………

Section 4-D. Record keeping and level of knowledge

142) Do you practice record keeping on your farm? ☐ Yes (1) ☐ No (0)

143) If yes, select the type of information you record in Table below

Type of record	Code
Individual cow records (1)	
Breeding/fertility/reproduction records (2)	
Milk production records (3)	
Milk sales records (4)	
Costs (5)	
Other (6), please specify..	

144) From whom did you (the farmer) get most of his knowledge on dairy farming

☐ Other dairy farmers (1)

☐ Government official (2)

☐ Cooperative extension (3)

☐ Local/International NGO (4)

☐ Other (5), please specify……………………………………………

145) Please rank your knowledge on dairy feed and feeding

☐ Very good (1) ☐ Good (2) ☐ Fair (3) ☐ Needs to be improved (4)

146) What kind of knowledge/information you would like to receive more via training? (multiple choices possible)

☐ General farm management (1)

☐ Feed and feeding (2) ☐ Artificial insemination (7)

☐ Animal disease (3)

☐ Farm accounts/record keeping (8)

☐ Udder management (4)

☐ Quality of milk (9)

☐ Mastitis (5)

☐ Breeding (10)

☐ Marketing (6)

☐ Other (11), please specify……

<u>Module 5:</u> **Food Security and Climate Change**

<u>Section 5-A. Food security</u>

147) During the last 7 days how many meals did the household take per day?

☐ 1 (1)

☐ 2 (2)

☐ 3 (3)

☐ More than 3 (4)

☐ Other (5), please specify..

148) How many meals a day do you have during the lean periods (on average)

☐ 1 (1)

☐ 2 (2)

☐ 3 (3)

☐ More than 3 (4)

☐ Other (5), please specify..

149) Describe the food security level in your household

☐ Food secure throughout the year (1)

☐ Secure for most of the year / seasonal food security (2)

☐ Food insecure for most of the year (depend on the outside aid) (3)

150) Months of food inadequacy[17] per year (on average)?.........................months

---

[17] i.e. not having enough food to satisfy daily needs

151) Did your household have to undertake any of these strategies in the last 12 months (choose up to 3):

☐ Storing food from the harvest season (1)

☐ Reducing the consumption of food/consuming green maize (2)

☐ Food aid from relatives (3)

☐ Dependent on food aid from the Government (4)

☐ Dependent on food aid from NGOs (5)

☐ Reducing number of meals per day (6)

☐ Cutting of trees and sale for charcoal (7)

☐ Working for other people in exchange for food (8)

☐ Other (9), please specify…………………………………………..

152) In the past 7 days, what were the sources of food for the household?

☐ Own produce (1)

☐ Purchase from market (2)

☐ Casual labour paid in food (3)

☐ Wild food (4)

☐ Gift (5)

☐ Food for work (6)

☐ Free food (7)

☐ Winter/irrigated own food (8)

☐ Barter of household assets (9)

☐ Barter of livestock (10)

☐ Other (11), please specify…………………………………………………………..

153) In the past 7 days, what income sources did the household use to provide for the food consumed?

☐ Sale of own staple food crop (1)

☐ Sale of own other food crops (2)

☐ Sale of own cash crops (3)

☐ Sale of own livestock / fish / milk (4)

☐ Sale of firewood (5)

☐ Ganyu (6)

☐ Income from business work (7)

☐ Income from paid job (8)

☐ Remittances (9)

☐ Sale of household assets (10)

☐ Other (11), please specify…………………………………………

154) Please indicate the types of food eaten over the last 7 days (choose as many as applicable):

Item	Code
Cereals, Grains and Cereal Products (1)	
Roots, Tubers and Plantains (2)	
Legumes / Vegetables (3)	
Nuts and Pulses (4)	
Meat, Fish and Animal Products (5)	
Milk and Milk Products (6)	
Fruit (7)	
Fats / Oil (8)	

Sugar / Sugar products (9)	
Spices / Condiments (10)	
Wild foods (11)	
Other (12), please specify	

Section 5-B. Climate change

155) Have you heard about climate change? ☐ Yes (1) ☐ No (0)

156) Describe features that, in your opinion, indicate climate change

……………………………………………………………………………………

157) Do you think climate change is affecting Malawi?

☐ Yes (1) ☐ No (0)

158) If yes, in what way (please explain)?..

159) Did you notice any change in the regular weather patterns in the last 5 years (choose all that apply)? *Mwaonapo kusintha kwa nyengo kodabwitsa kotani pa zaka zisanu zapitazi kufika panopa?*

☐ More frequent droughts (1)

☐ Flooding (2)

☐ Erratic rainfall (3)

☐ Changes in crop yields (4)

☐ Changes in disease outbreaks (5)

☐ Did not notice any change (6)

☐ Other (7), please specify…………………………………………

160) Do you think the events identified in the question above have had an impact on your dairy farm?

☐ Yes (1) ☐ No (0)

161) If yes, how (please explain)?
....

162) Do you think these events (identified in the question 159 above) affected any of the following?

a. Factor	Effect ~ 1 = Increase; 2 = decline ; 3 = no change; 4 = do not know	If yes, how do you cope?	How does the change affect you your household?
b. Feed availability			
i. Grass			
ii. Legumes			
iii. Crop residues			
iv. Concentrate			
c. Cattle diseases			
d. Milk yield			
e. Milk quality			
f. Herd size			
g. Water availability			
h. Profit from dairy			

163) As a dairy farmer, are you aware that your activities can contribute to climate change or reduce the impacts of climate change?

☐ Yes (1) ☐ No (0)

164) Are you involved in any community forestry work?

☐ Yes (1) ☐ No (0)

165) How many trees do you have on your farm?

a) Local trees (number)…………..Please specify names:

a. ....

b. ....

c. ....

b) Exotic trees (number)…….. …...Please specify names

a. ....

b. ....

c. ....

166) Are you involved in any agro-forestry work?

☐ Yes (1) ☐ No (0)

167) If yes, what system of agro-forestry (and mention species used)?

Agroforestry system	Species used	Amount of land under this system, *ha*	Years practicing this system

168) If no, why are you not involved in any agro-forestry activities?

……………………………………………………………………………………………………
………………………

Before the enumerator leaves the farmer, he/she must rank the general condition and cleanliness of the khola with respect to

Condition	**Ranks range between 1and 3:** **1=Poor 2=Fair 3=Good**
Condition of the animal (degree of thinness, fatness)	
Condition of the pens (size, ventilation, strength of structure, etc)	

Condition of the roof (iron sheets, grass thatched with plastic paper, leakage, exposure to direct sunshine, etc)	
Condition of the floor (whether concrete or mad floor or bedding)	
General cleanliness (presence of dung, feed, urine)	

THANK YOU VERY MUCH FOR YOUR TIME AND ANSWERS

Appendix B Enumerator manual for the dairy baseline questionnaire

Dairy Baseline Survey, February 2013

As part of the Dairy Baseline Survey (DBS), all sample smallholder households that are identified as being involved in dairy production and livestock management will be given a Dairy Baseline Questionnaire.

The Dairy Baseline Survey has been developed in order to assess and analyse the baseline conditions at the smallholder dairy farms in the Central, Northern and Southern regions of Malawi. The survey aims to produce an in-depth assessment of the current dairy farm management practices at the smallholder farms in Malawi. The survey will cover 400 households in 3 regions.

All information and data collected from the households is absolutely confidential, and is only to be used for statistical and research purposes. It will not be used for tax imposition or for other purposes.

The Dairy Baseline Questionnaire collects information on a household's dairy and agricultural activities. Table 1 provides a description of the contents of the questionnaire.

Table 1: Contents of the Dairy Baseline Questionnaire

Module	Description	Comments
Module 1: Basic Household Information	The module covers background information on the household and its socio-economic background (including ownership of the assets), livelihood sources and planted and harvested crops	
Module 2: Dairy Farm Management and Milk Production	This module collects information on the smallholder's general dairy farming practices, dairy farm ownership, structure, facilities and management, number of dairy cattle on the farm, herd dynamics, the use of labour in dairy farming, feeding and milking practice on the farm and manure management.	
Module 3: Dairy Marketing Chain and Market Access	Module 3 contains information on dairy marketing, milk bulking groups (MBGs) and dairy-cooperatives, access to credit, as well as information	

	on theft of the dairy cattle and associated security measures.	
Module 4: Access to Animal Health and Livestock Extension Service	This module collects information on animal health and livestock extension services, including reproduction and breeding service, and farmer record keeping.	
Module 5: Food Security and Climate Change	The last module contains questions on the farmer household food security and asks probing questions on the farmer's understanding of climate change and adaptation and mitigation practices being used.	

a) **Questionnaire Translation:**

The questionnaire is produced in English. Most of the households to whom you will administer this questionnaire will not be able to respond to the questions if they are asked in English. Consequently, you must translate the questions into a language in which the survey household members are fluent.

If you find that you have been assigned to conduct household interviews in an area in which most survey households are only fluent in a language in which you are not fluent, you must immediately inform your field supervisor. The field supervisor will immediately transfer you to another area or household, and an enumerator fluent in the language of that area will be assigned to conduct the interviews in your original area or household.

When completing the questionnaires, the enumerator MUST ensure that all the answers are recorded in English rather than Chichewa or any other local language they have been answered in.

These terms should always be translated into local languages using the exact same words. Study the questions so that you can ask them in a consistent and natural manner. If this is not done, the responses to the same question may not be comparable. During enumerator training, attention should be paid to the translations that should be used for these terms in the various languages.

Finally, do not assume that your skills in Chichewa will allow you to conduct interviews throughout Malawi. Although Chichewa is the national language of Malawi, many rural residents are not fluent in the language. This is particularly the case in northern Malawi where Chichewa is not commonly spoken and in the lakeshore areas, where Yao is the predominant language spoken in the villages. If you know that because of language difficulties you will be unable to efficiently and accurately administer the questionnaire in the area to which you have been assigned, you should immediately make this fact known to your field supervisor.

b) Definition of a Household

A household may be either a person living alone or a group of people, either related or unrelated, who live together as a single unit in the sense that they have common housekeeping arrangements (that is, share or are supported by a common budget). A standard definition of a household is: "a group of people who live together, pool their money, and eat at least one meal together each day". It is possible that individuals who are not members of the household may be residing with the household at the time of the survey. In most cases, but not all, someone who does not live with the household during the survey period is not a current member of the household. The definition of who is and who is not a household member is given below.

It is important to recognize that members of a household need not necessarily be related by blood or by marriage. On the other hand, not all those who are related and are living in the same compound or dwelling are necessarily members of the same household. Two brothers who live in the same dwelling with their own wives and children may or may not form a common housekeeping arrangement. If they do not, they should be considered separate households.

In the case of polygamous men and extended family systems, household members are distributed over two or more dwellings. If these dwelling units are in the same compound or nearby (and necessarily within the same EA) and they have a common housekeeping arrangement with a common household budget, the residents of these separate dwelling units should be treated as one household.

The head of household is the person commonly regarded by the household members as their head. The head would usually be the main income earner and decision maker for the household, but you should accept the decision of the household members as to who is their head. There must be one and only one head in the household. If more than one individual in a potential household claims headship or if individuals within a potential household give conflicting statements as to who is the head of household, it is very likely that you are dealing with two or more households, rather than one.

Some important notes to keep in mind when listing household members:

- It is possible that the household head may not be residing in the dwelling at the time of the interview. He or she may be living and working, temporarily or permanently, in another part of Malawi or in another country.

- Boarding school students who are residing at boarding school but are still dependent on the household should be listed.
- Do not include military personnel, prisoners, or other individuals who are residing elsewhere (in such institutions) and are not primarily dependent on the household for their welfare.
- Some household members may not be a relative of the household head. For example, a servant who lives in the household and does not keep a household elsewhere.
- Servants, other hired workers, and lodgers (individuals who pay to reside in the dwelling of the household) should not be listed if they have their own household elsewhere which they head or upon which they are dependent.
- Children who are living with other relatives (for example, an aunt or uncle) should not be listed. They would be listed in the aunt/uncle's household.

c) Professional Conduct

1. In order to avoid the household members refusing to respond or only giving simple or superficial answers the enumerator must be good at presenting themselves, clearly stating the purposes and demands of the survey before putting specific questions to the household. Explain clearly to the household that the statistical information and data collected through the survey are to be kept confidential. The individual data from each household will not be utilized separately and will not be made available to other government departments or to any other organisation.
2. The enumerator MUST clearly communicate to the respondent that the survey does not have any links with the Government or governmental departments; otherwise the respondents might be less willing to answer certain questions (such as those on informal sales of milk or household income).
3. Often, households do not want to waste time answering the survey. In order to avoid taking up too much time or making multiple visits, the enumerators MUST develop good interview plans, producing specific timetables for each household. If necessary, they can contact and work with the household at any time at the convenience of the survey household members (including noon, evening and Sunday). In the case that the interviewer has tried to explain and convince the household and that the household remains hesitant and worried, you MUST further attempt to persuade the household to participate, probing as to the reasons why the household will not participate. Households should be replaced ONLY AFTER all methods to convince them to participate have been used.
4. The enumerator MUST be willing to answer any questions the respondents ask him / her about the survey and its particular contents.
5. At the start of the interview, the enumerator should always determine if the respondent has any appointments in the next hour or two. If there is sufficient time available to complete several modules of the questionnaire before the respondent's appointment elsewhere, you MUST proceed and complete as much of the interview as possible. When the respondent must leave, the enumerator must

arrange for another meeting later in the same day or the next day during which the interview can be completed.

6. The enumerator MUST seek to develop a smooth-flowing interviewing style so that he / she can obtain all of the information required from an individual as efficiently as possible. This MUST NOT come at the expense of correctly administering the module.
7. The enumerator MUST NOT unnecessarily test the respondent's patience by delaying the interview in any way, particularly through excessive probing on questions that the respondent feels that they have already answered to the best of their ability and recollection.

d) General Guidelines on Completing the Questionnaire

1. In conducting an interview, if it is clear that the respondent has understood the question you have asked, you must accept whatever response the respondent provides you. Probing questions can be used to make sure the respondent understands the key element of the question being asked. There are many questions across the Questionnaire for which you are allowed to list more than one response. In these cases, please probe the respondent further as to collect more information, if applicable.
2. You MUST never second-guess the respondent or make the assumption that you have a better understanding of the condition of the individual or household than the respondent does. The function of the enumerator is NOT to verify that the information provided is correct. It is always possible that the respondent will lie to you or provide inaccurate information, but you, as the enumerator, should not make any judgements on the information provided. This is a problem for the analyst to take care of and NOT the enumerator.
3. Record monetary amounts in Kwacha with no decimal point. Do NOT include tambala. For any tambala amounts, round to the nearest Kwacha. Do NOT write a K before the value.
4. For any amounts over MK 1,000, include a comma.
5. We do NOT expect to see considerable number of un-answered questions or "Don't Knows" (DK) recorded across the questionnaire. It is your responsibility to probe and help the respondent to determine the answer, and only accept DK as a last resort.
6. If a question is not asked, the cell MUST be blank. A blank cell indicates that the question was NOT asked. Otherwise, every asked question MUST have a response.
7. You MUST NEVER enter "Not Applicable" as a response. In questions such as 16 & 17 (on the amount of staple food crops planted and harvested), enter "None" where a certain crop (e.g. rice or sorghum) has not been planted or harvested.
8. On certain questions, such as those in the climate change section, emphasize to the farmer that these are hypothetical questions. They may be difficult for the respondent to answer. If the respondent is unable to answer, try asking probing questions.

9. Whenever up to 2 answers could be solicited, the enumerator MUST probe the respondent for a second response. At the same time the enumerator should not force the respondent to have a second response if only one is applicable.
10. If a question asks to choose several answers that apply, the enumerator MUST ensure that the respondent answers it in full, i.e. provides all the answers that apply, rather than considering the answer complete after having obtained 1 response.
11. Where a question asks to estimate the amount of land in ***ha***, the enumerator, if having received an answer in acres or fractions of acres, MUST convert acres to ***ha***. The enumerator MUST also make sure that the decimals are correctly registered in order to avoid data entry errors at a later stage. Note the following conversions:

    1 acre = 4000 m^2 = 0.4 hectares

    1 hectare =10,000 m^2 = 2.5 acres

    If any other local area measurement unit is used, it should be converted into ha and recorded.

12. A number of questions ask about an <u>average</u> production of milk per day, <u>average</u> prices paid, <u>average</u> income per month etc. The enumerator should know that this question is tricky in a Malawian set up where the average is not commonly used by so many smallholder farmers. However, the accuracy of the information will depend on you as an enumerator.
13. In order to include all possible responses that may be provided, many questions include a response option of OTHER (PLEASE SPECIFY) for the enumerator to be able to record responses that are not covered by any of the pre-coded responses. When using this code, the enumerator MUST provide a brief explanation of the category; i.e. in answering "other" as a response to any of the questions (that contain "Other" as one of the answers) the enumerator MUST ensure that it is specified in the entry what this "other" is, and not simply tick the box.

<u>Notes for the Field Supervisors</u>

<u>Supervisors MUST:</u>

1. Study the contents of the enumerator manual on a daily basis to be able to assist with technical issues in a timely and effective manner
2. Ensure that smallholder interviews are conducted within the time necessary for the successful completion of daily / weekly workload

3. Conduct an initial review of completed questionnaires for completeness, accuracy and consistency, and discuss with the enumerator any mistakes found, and either correct if it obvious, or send the enumerator back to the household to collect or verify the data.
4. Check each Dairy Baseline Questionnaire upon completion by the enumerator to ensure that the questionnaires have been completed comprehensively. Review each module and look for any inconsistencies, omissions, irrational responses, or other errors.
5. Immediately upon the completion of the interview, meet and discuss the interview with the enumerator. This is done in order to draw lessons from the experience together, and to address weaknesses and shortcomings in data collection in order to guarantee good quality.
6. If there during the interview, pay attention to the respondents. By observing and assessing the process of how survey household members respond to the questions, you will be able to help in the assessment of the questions. It is possible that some of the questions are not clearly understood by some respondents and so their responses may not be appropriate. The Supervisor should focus on the following factors:

- Was the wording used in the questionnaire appropriate?
- Were any concepts posed to the respondent ambiguous?
- Were there any questions left unanswered or to which evasive answers were given because they dealt with private matters or sensitive issues?
- Attention MUST be paid to these aspects and any other problems that arise during the interview so that you will be in a position to (a) help enumerators resolve the problems, and (b) bring them to the attention of Bunda College and SRUC for general synthesis and guidance for all interview teams.