THE ROLE OF CO-OPERATIVES IN REDUCING GREENHOUSE GAS EMISSIONS AND ENHANCING SINKS THROUGH LAND USE, LAND-USE CHANGE AND FORESTRY IN TANZANIA

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EXTENDED ABSTRACT

This thesis contributes to the literature by exploring the role of co-operatives in reducing greenhouse gas (GHG) emissions and enhancing sinks through land use, land use change and forestry (LULUCF) in agroforestry systems and miombo woodlands in Moshi and Urambo districts respectively. Specifically, the study sought to examine the drivers of land use and land use-change and their implications on GHG emissions and carbon sinks, to explore co-operatives' actions or lack thereof linked to greenhouse emissions and carbon removals through LULUCF, to estimate the contribution of co-operatives in enhancing carbon storage through community carbon enhancement activities in agroforestry and *miombo* woodlands ecosystems and to examine how the co-operative business model may apply to carbon trading with special emphasis on community carbon enhancement activities. A sample of 297 households was systematically selected in 16 villages from which data on land use and land-use change were collected using questionnaire survey and remote sensing. Land use change was analysed by interpretation of satellite images. Binary logistic regression analysis was undertaken to explore co-operatives' activities or lack thereof linked to carbon emissions and carbon sinks. The contribution of co-operatives in enhancing carbon storage was determined by comparing the proportion of carbon stocks in the land use systems with co-operatives' activities to total carbon stock.

The study showed that intensive farming, establishment of woodlots, use of energy efficient stoves, agroforestry practices, tree planting, and conservation of natural forests were important drivers of land use and land use changes. Co-operative actions significantly linked to carbon emissions and carbon removals through LULUCF were marketing of agricultural products, supply of agricultural inputs, provision of agro-credits and extension services, promotion of agroforestry practices and supply of improved seeds. Quantitatively co-operatives' actions contributed significantly to 76% of the existing carbon stock per hectare in agroforestry systems and 31% of the total carbon stocks per hectare in the miombo woodlands. The results further indicated that farmers through co-operatives' activities generate tradable carbon credits, a commodity that can be traded through co-operatives. The study concludes that co-operatives' actions have apparently high potential to mitigate GHG emissions and enhance carbon sinks through LULUCF sector. The co-operatives business model offers a framework for smallholder famers to come together as a strong entity to gain collective bargaining power to achieve benefits in terms of creating avenues for marketing carbon credits generated through activities with co-operative actions.

The study recommends that vigorous knowledge on co-operatives' agricultural practices that reduce emissions and enhance carbon stocks through training and environmental/climate change extension services by different stakeholders. Efforts to mitigate climate change through LULUCF sector should be built on co-operatives' activities. It further recommends that co-operatives need additional support to effectively engage in carbon trading in terms of technical expertise and calls for awareness creation for smallholder farmers to recognize new opportunities in carbon trade.

DECLARATION

I, Justinian Mushumbusi Bamanyisa, do hereby declare to the Senate of Sokoine University of Agriculture that this thesis is my own original work done within the period of registration and that it has neither been submitted nor being concurrently submitted in any other institution

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DEDICATION

To my children Sophia, Joan and Asimwe

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CHAPTER ONE

Introduction

1.1 Background

Land use, land-use change and forestry (LULUCF) sector merit consideration in GHG mitigation strategies because they can be both sources and sinks of carbon dioxide, the most abundant greenhouse gas (GHG). Currently the land use, land-use change and forestry makes up the second-largest source of carbon dioxide (CO_2) emissions, after fossil fuel combustion. According to the Intergovernmental Panel on Climate Change (IPCC), land-use change contributes to approximately 20 per cent of global CO_2 emissions annually (Nabuurs *et al.*, 2007). For the decade that ended 2010 land-use and land-cover change accounted for approximately 12% of all anthropogenic carbon emissions (Houghton *et al.*, 2012). Within LULUCF, tropical deforestation mainly due to the conversion of forests to agricultural uses is the main source of CO_2 emissions, accounting for around 10–15 percent of global CO_2 emissions (Denman *et al.*, 2007; van der Werf *et al.*, 2009; Friedlingstein and Prentice, 2010; Peters *et al.* 2012; Harris *et al.*, 2012).

In the tropics, Tanzania included, emissions of GHGs from land use and cover change account for 20 to 25% of the total global emissions (IPCC, 2007). The bigger part of these emissions is due to deforestation and forest degradation (FAO, 2010). Conversion of forestland to agricultural land has been one of the main proximate causes of tropical deforestation (Kissinger *et al.*, 2012).

LULUCF is distinct from the other sources of CO_2 (energy, industry, agriculture and waste) in that it is the only sector that GHG removals from the atmosphere occur because of biomass growth thereby reducing such emissions through provision of renewable energy; substitution for more fossil carbon-intensive products; reduction of non-CO_2 gases; sequestration of carbon through enhancement and conservation of exiting terrestrial carbon stocks (Schlamadinger *et al.,* 2007:4). Available options in LULUCF management activities include conserving the existing carbon pools on the land, reducing deforestation and forest degradation and expanding carbon storage in forest ecosystems (Cowie *et al.*, 2007). Other options include increasing storage in durable wood products and substituting sustainably grown wood for energy intensive products (e.g. bio-fuels, construction materials) (Winjum *et al.,* 1998). Reducing emissions from deforestation and forest degradation through LULUCF is considered to be an important intervention that is necessary for sustainable reduction of GHG emissions (Huberman, 2007; Hall, 2008; 2009; Munishi *et al.,* 2010).

Addressing direct and indirect land use changes arising from agricultural production is one of the important measures to reduce emissions from deforestation and forest degradation (REDD+) with positive impacts on people's livelihoods that depend on natural resources. Therefore, addressing emissions from LULUCF, agriculture in particular offers an opportunity for payments associated with emissions reductions and maintenance of forest carbon stocks (2004; Angelsen, 2009; Munishi *et al.*, 2010).

Co-operatives have played a long and venerable role in promoting social welfare aims. From the ancient guilds in Babylon and Egypt, to the Rochdale Society of Equitable Pioneers during the Industrial Revolution, to the United Nations' declaration on the International Year of Co-operatives, the contribution of co-operatives to harmonize economic and social aims has long been recognized and harnessed by groups of people (Fitzgerald, 2013). Co-operatives, as economic enterprises and as self-help organizations, play a meaningful role in uplifting the socio-economic conditions of their members and their local communities. With their concern for their members and communities, co-operatives represent a model of economic enterprise that places high regard for democratic and human values and respect for the environment (Rwekaza and Bikolimana, 2016). As the world today faces unstable increased insecurity of food supply, growing inequality worldwide, rapid climate change and increased environmental degradation, it is increasingly compelling to consider the model of economic enterprise that co-operatives offer, especially with regard to environment and climate change.

Co-operatives, agricultural marketing co-operatives in particular, play a fundamental role in the increase or decrease of cultivated area because they influence members' production decisions, consumption behaviour (Cook *et al.*, 2004) and dissemination of agricultural information and technologies. As such co-operatives have the potential to contribute to reducing GHG emissions from deforestation and forest degradation (Birchall, 2003) through afforestation programmes and intensification of agriculture that reduces the need to clear new land for agricultural expansion. Co-operatives, therefore, stand a good chance in mobilizing communities to effectively participate in LULUCF emission reduction initiatives. Evidence suggests that co-operatives create an opportunity for members to gain not only economic benefits but also facilitate societal development including improvements in environmental health, quality of life and community economic stability (Acharya, 2017).

Considerably in Tanzania, the co-operatives are one of the formidable pillars holding the economic system. They have a wide pool of activities that range from production and marketing of agricultural products to other activities such as savings and credit. The most predominant activities of co-operatives are the marketing of cash crops such as coffee, cotton, cashew nuts, tea and tobacco, and offering extension and financial services among many others (Msonganzila, 2004). Furthermore, co-operatives do also provide solutions through collective action in other areas, such as fisheries, forestry, minerals and housing (Bibby, 2006). According to Maghimbi (2010), co-operatives are still the most numerous organizations in the rural areas, they participate in poverty reduction, cooperate with each other, utilize part of their surplus to pay for community projects, such as water and education activities.

Given the ability of co-operative to harness strengths to build capacities that enhance communities' economic and social conditions (Ferguson, 2012), it is increasingly compelling to consider the model of economic enterprise that co-operatives offer so as to foster community participation in LULUCF activities in an endeavour to reduce pressure on forests thereby enhancing forest potential to sequester carbon and reduce GHG emissions. In a number of ways, co-operatives play important role in global and national economic and social development. With regard to economic and social development, co-operatives promote the "fullest participation of all people" and facilitate a more equitable distribution of the benefits of globalization (Dogarawa, 2010). This study sought to explore the role of co-operative activities in reduction of GHG emissions and enhancing carbon stocks through LULUCF in agroforestry cropping systems in Moshi District and *miombo* woodland agro-ecosystems in Urambo District.

Deliberate land-use change (agroforestry, afforestation or reforestation) has been accepted as a mechanism to remove CO_2 from the atmosphere and sequester carbon in trees and soils (Betts, 2000). Compared to climate change mitigation options in the energy and transport sector, activities in the LULUCF sector provide a relatively cost-effective way of offsetting emissions and enhancement of terrestrial Carbon stocks or conservation of existing ones (Schlamadinger *et al.,* 2007; Kindermann *et al.,* 2008). Thus, in the land use, land use change and forestry sector, opportunities exist to reduce GHG emissions and increase the potential to sequester carbon from the atmosphere by curbing deforestation and enhancing sinks. Furthermore, forests are currently increasingly being protected, better managed, and restored under the auspices of a carbon payment mechanism termed as REDD+ (reducing emissions from deforestation and forest degradation, plus the conservation, sustainable management, and enhancement of forest carbon stocks) (Cerbu *et al.*, 2011).

1.2 Statement of the Problem

Former UN Secretary General Ban Ki Moon in his Message on the International Day of Co-operatives of 5 July 2008 succinctly observed how, "co-operatives have long fostered inclusive and sustainable approaches to economic and social development at the local level. It is in keeping with this focus that co-operatives are expanding their development efforts creatively, into areas such as environmental sustainability and carbon neutrality, as communities around the world are struggling to adapt to climate change and strengthen their resilience against its impacts" (Ban Ki Moon, 2008). Anchored in local communities and guided by their core values and principles, even in difficult circumstances, co−operatives have continued to provide livelihoods for communities around the world (Roelants, 2013). They play a significant role in many facets of human interaction that include, *inter alia,* income generation, risk reduction, social networking, education, information sharing, and public service provision. By pooling capital, labour, goodwill, and other resources, co-operative members carry out profitable activities, which, if undertaken by individuals, would involve greater transaction cost, risk, and efforts.

Works on co-operatives (Sizya, 2001; Majee and Hoyt, 2011 and Bharadwaj, 2012; Wanyama, 2016; Suh, 2015) acknowledge the critical role by co-operatives in sustaining socio-economic existence of many communities. Despite of co-operatives being formidable pillars holding the economic system; their contribution to reducing GHG emissions and enhancing carbon sinks through LULUCF is largely unknown. To better understand the contribution of co-operatives in mitigating climate change, the study explored co-operatives' activities linked to GHG emissions and enhancement of carbon sinks through LULUCF in agroforestry cropping system in Moshi District and miombo woodlands agroecosystems in Urambo District. The main question was how co-operatives have played and can play their part in the global campaign on reducing emissions and enhancing carbon sinks through land use, land use change and forestry. To date, there are no studies of the role of co−operative movement and climate change services in Tanzania so this thesis will also provide information and insights which have previously been unavailable.

1.3 Objectives

1.3.1 General objective

The general objective of the study was to determine the role of co-operatives in reducing greenhouse gas emissions and enhancing sinks through land use, land use change and forestry in Tanzania.

1.3.2 Specific objectives

Specifically, the study sought to:

(i) Assess the drivers of land use and land-use changes associated with co-operative actions linked to carbon emissions reduction and enhancing carbon sinks,

(ii) Examine the extent to which co-operative efforts/activities have contributed to mitigating (weaning) GHG emissions from land use change,

(iii) To determine the contribution of co-operatives in maintaining carbon stocks in agroforestry cropping systems and *miombo* woodland agro-ecosystems, and

(iv) Assess the potential of co-operative marketing approach in enhancing carbon trading in community managed carbon enhancement activities.

1.4 Research Questions

(i) What are the drivers of land use and land use changes associated with co-operative actions that reduce carbon emissions and increase carbon sinks?

(ii) To what extent have co-operative efforts/activities contributed to mitigating GHG emissions from land use and land use change?

(iii) What is the contribution of co-operatives in maintaining carbon stocks in agroforestry cropping systems and *miombo* woodland agro-ecosystems?

(iv) Does the co-operative business model approach apply to carbon trading and what are the research and managerial implications of this?

1.5 Justification of the Study

Co-operative actions have been in operation for a long time. Their contribution to mitigate carbon emissions, however, has not been acknowledged. The findings of this study will contribute knowledge to understanding of the role of co-operatives in realm of climate change particularly in LULUCF offsets which has not been the focus of the co-operative business model. As such, the thesis provides basic information on the role of co-operatives in GHG emission and climate change mitigations. Furthermore, the study examines drivers of land use change that can be addressed through co-operative approaches. Understanding such drivers is critical in formulating effective co-operative policies as well as agricultural and environmental interventions and GHG emission mitigation strategies. The study findings contribute to scientific knowledge on the participation of co-operatives in reducing emissions and enhancing carbon sinks through LULUCF, and in particular on solving problems arising from deforestation and at the same time playing a part in global schemes to grapple with climate change. Finally, the study findings create awareness among the co-operatives about the carbon offset business opportunities and thus improving community livelihoods.

1.6 Literature Review and Theoretical Framework

1.6.1 The concepts

1.6.1.1 Co-operatives

The word co-operative was founded from Latin word "co-operari" where 'co' means together and 'operari' means working together (Bharadwaj, 2012). Working together for members is the initial concept of co-operatives. Given the wide variety of co-operative ventures, different definitions and terms have been used to identify member owned, member-run and member-serving businesses which provide collective market power and human and social capital for the promotion of community development (Grace, 2014). The United States Department of Agriculture defines a co-operative as a user-owned, user-controlled business that distributes benefits based on use (Majee and Hoyt, 2009). Porter and Scully (1987) view co-operatives as "voluntary closed organizations in which the decision-control and risk-bearing functions repose in the membership, and decision management reposes in the agent (manager), who represents the principal's interests". The International Co-operative Alliance (ICA), a non-governmental organization that was created in London in 1895 as an apex organization for co-operatives worldwide, defines co-operatives as "autonomous associations of persons united voluntarily to meet their common economic, social, and cultural needs and aspirations through a jointly-owned and democratically-controlled enterprise" (ICA, 2018). For the analytical purpose of this thesis the study adopted the ICA definition.

The proponents of the co-operative movement view co-operatives as a means of progress through social network benefits, especially among rural dwellers (Agbonlahor *et al.*, 2012). Along the same line, Chambo (2009) and Maghimbi (2010), assert that co-operatives are about peoples' organizations to capture different opportunities in the economy where they can address their economic needs and aspirations.

1.6.1.2 Land use, land use change and forestry sector

Land use, land-use change and forestry (LULUCF) is defined by the United Nations Framework Convention on Climate Change Secretariat as "A GHG gas inventory sector that covers emissions and removals of greenhouse gases resulting from direct human-induced land use, land-use change and forestry activities" (UNFCCC, 2014). The key GHGs include carbon dioxide (CO_2), methane (CH4), Nitrous Oxide (N_2O) and Oxides of Nitrogen (NO_2). The sector includes emissions and removals of GHGs from six types of land uses: forests, cropland (only CO_2), grasslands (only CO_2), wetlands, settlements and other lands. The LULUCF sector is important for climate change mitigation as it has the potential to reduce GHG emissions and sequester carbon. Land use and forestry are intricately linked to how and where people live and sustain themselves, and LULUCF measures can provide global environmental benefits while addressing community benefits (IPCC, 2000; Burke *et al.*, 2013).

1.6.2 Theoretical perspectives

A number of competing theories was proposed to try to understand the potential role of co-operatives in reducing emissions and enhancing carbon sinks through LULUCF. Basing on the nature of the study, it was necessary to use four different theories so as to suit the specific objectives of the study. The justification for use of each theory has been provided in the respective manuscripts.

The political ecology approach has been used to guide manuscript one which examines drivers of land use and land use-changes linked to GHG emissions and carbon sink enhancement through LULUCF in chapter two. The Economic theory of co-operatives as developed by Helmberger and Hoos (1962) guided manuscript two in chapter three, the manuscript that explored and analysed current and projected co-operatives' actions linked to GHG emissions and carbon sequestration through LULUCF in agroforestry and *miombo* woodland agro-ecosystems. Finally, the Marxist classic theory of co-operation by Jossa (2005) and the human development theory advanced by Amartya Sen (1997), were used to guide manuscript four which examines how the co-operative business model may apply to carbon trading with special emphasis on community carbon enhancement activities in chapter five of this thesis.

1.6.2.1 The political ecology approach

The political ecology approach is closely tied to both political economy and the examination of biophysical processes alongside social and economic factors (Bryant and Bailey, 1997). Numerous studies under this framework (Bryant, 1998), stress the social relations of production influencing land users' choices and access to environmental resources. These foci within political ecology are very compatible with a study of the drivers of land use, land use changes that reduce GHG emissions and increase carbon sinks. The political ecology approach engages with the social world and views the environment as not simply a stage or arena in which struggles over resource access and control take place, but also consider nature or biophysical processes that play an active role in shaping human environmental dynamics. Under this approach the resource systems are typically viewed as utilized ecosystems that are by nature in ever-changing interactions with human activities e.g. people – vegetation, people- wildlife, that are typically differentiated by power relations associated with gender, ethnicity, class or wealth categories (Zimmer and Basselt, 2003).

1.6.2.2 Economic theory of co-operatives

Helmberger and Hoos (1962) can be regarded as having developed the first complete mathematical model of behaviour of a co-operative. Their model is considered "a landmark in the economic theory of co-operatives." In their model, the co-operative's optimization objective is to maximize benefits to members by maximizing "the per unit value or average price by distributing all earnings back to members in proportion to their patronage volume or use" (Torgerson *et al.*, 1998). The model clearly distinguishes between short- and long-run behaviour in a co-operative. Similarly, according to Chambo and Cronery (2015), economic theory of the co-operative enterprise is based on cost minimization; it puts emphasis on the improvement of members' livelihood objectives than profit maximization. While human society is broad, the co-operative organization is a set of individuals of the same human society, who have been organized in order to meet their cultural, economic and social aspirations within the framework of sustainable development.

1.6.2.3 Marxist class theory of co-operation

The Marxist class theory of co-operation states that a system of co-operative firms is not only feasible, but bound to assert itself in history and that it gives rise to a new production mode in which wage labour is swept away and the means of production (capital) is no longer used to enslave workers. In a system of co-operatives, workers (co-operative members) not only cease being exploited but also feel free and happy to work for firms owned by them. The system of producer co-operatives envisaged by Marx is a market system whereby workers become 'their own masters' (Mill, 1871) and where owners of capital are deprived of decision-making power concerning production activity. Under this theory of cooperation, co-operatives are necessary for addressing the poverty conditions of small farmers and how co-operatives can assist them to access market advantages than when they are on their own, especially their protection against price exploitation.

1.6.2.4 The human development theory

Human development theory advanced by Anand and Sen (1997), emphasizes that human development should, among other things, be measured by the enhancement of human capabilities through education and training in order to avail themselves with existing opportunities to remove impediments to their own development. One of those impediments was poverty. Entering the carbon trade industry with small farmers, through co-operative marketing, is a process of competence building and raising the stock of knowledge for small farmers' enhanced capabilities and searching for opportunities to enter competitive markets and address environmental threats. The emphasis here is the fact that entering and navigating the carbon market as an individual land user (farmer) may not be easy and requires expertise and knowledge. It needs prepared members as they enter into a new carbon commodity trade in competitive markets, but most importantly it needs a big player with enough carbon to negotiate on behalf of many members.

The theories of co-operation go in line with two important principles of co-operatives, namely principle number five that putt emphasis on enhancing the stock of knowledge for raising their business capacity through education, training and experimentation and principle number seven concern for the community (Zeuli, *et al.,* 2004). Thus, putting emphasis on sustainable development encouraging members of co-operatives to do business which sustains current and future generation.

1.6.3 Overview of LULUCF and climate change mitigation

The growing levels of carbon dioxide (CO_2) and other GHGs in the atmosphere are now directly and unequivocally linked to the global climate changes (Change, 2007). There are both natural and anthropogenic sources of GHG emissions, one of them being the conversion of natural forests and woodlands into crop land. According to the Fourth Assessment Report of the IPCC, published in 2007, CO_2 emissions caused by changes in land use are equivalent to 17% of the total global emissions and LULUCF is the second largest source of emissions after emissions from fossil fuels and industry (IPCC, 2007).

About 15 to 17 per cent of global GHG emissions originate from forest related activities (Denman *et al.,* 2007) and occur when forest carbon stocks are depleted and released to the atmosphere through changes in woody biomass, conversion of forests and grasslands, forest fires, and abandonment of managed lands (Engel and Palmer, 2008).

Continuous global discussions have concluded that appropriate forest management can help both to reduce GHG emissions from deforestation and forest degradation and to increase carbon removals (Barbier and Tesfaw, 2012). It was, however, determined under the Kyoto Protocol that forestry projects be restricted to afforestation and reforestation and set a limit on their use (Oyebo, 2011). Avoided deforestation as an emission reduction strategy, on the other hand, was excluded under the Kyoto Protocol (Hepbum, 2007), though it has since been brought in and embraced as REDD+ under the Paris Agreement (UNFCCC, 2015).

Beginning with the Bali Conference in 2007 and concretely agreed to in the 2009 CoP 15 in Copenhagen, the world recognised the crucial role of reducing emissions from deforestation and forest degradation and the need to enhance carbon removals. It was further agreed on the need to provide positive incentives to such actions through the immediate establishment of a mechanism to enable the mobilization of financial resources from developed countries (UNFCCC, 2010). Hence, the recognition of REDD+ that includes sustainable management of forest, forest enhancement, and forest conservation and its potential as a win-win-win situation, with reduction of carbon emissions, enhanced poverty alleviation and biodiversity conservation within one policy (Parker *et al.*, 2009; Skutsch, 2011; Vatn and Vedeld, 2011). Under REDD+, many developing countries stand to benefit from climate change deals that account for emissions from forests and other land uses (Minang *et al.*, 2014).

It is based on the principle that developing countries that are keen and able to reduce their deforestation and forest degradation at a reference time period receive financial compensation in terms of carbon credits (Laurance 2007; cited by Ebeling and Yasue, 2008). Carbon credit transfers are based either on foregone opportunity costs or on the value of carbon market prices (UN-REDD 2009). Hence, REDD+ is being publicized not only as a tool for resolving climate change problem but also as an instrument for addressing social issues such as poverty alleviation, improvement of livelihoods of local communities and derivation of benefits from preserving biodiversity and other ecosystem services. While carbon emission mitigation may be considered a public good, REDD+ has positivity because it gives the mitigation process a market value. Thus, REDD+ has provided a new framework for LULUCF to curb the trends of deforestation by bringing sustainable forest management activities under global carbon market, for which previous global approaches have had limited success.

Deforestation and forest degradation are the cause of about 20% of GHG emissions responsible for global warming (Houghton, 2005). In recognition of this, at the 13th Conference of Parties (COP 13) to the UNFCCC in Bali (2007), and subsequent COPs, it was agreed that Reducing Emissions from Deforestation and Degradation (REDD) should be considered for inclusion in a post-Kyoto mechanism. This internationally-agreed performance-based system for forest carbon trading provide additional incentives to countries that address REDD+. This proposed mechanism forms part of an international move to include emissions from habitat change (especially the loss of carbon-rich ecosystems, such as forests) in a more comprehensive agreement under the UN Framework Convention on Climate Change.

1.6.4 Co-operatives and community development

Co-operatives are viewed as important vehicles for community development because they mobilize local resources into a critical mass and their structure allows them to be more community-oriented (Fairbairn *et al.,* 1991; Wilkinson and Quarter, 1996). Co-operative businesses are found in nearly all countries, existing in numerous and varied sectors of the economy, thus co-operative action plays a significant role in many facets of human interaction that include, among others, income generation, risk reduction, social networking, education, information sharing, and public service provision. By pooling capital, labour, goodwill, and other resources, co-operatives' members can carry out profitable activities, which, if undertaken by individuals, would involve greater transaction cost, risk, and efforts (USDA, 2004; Grazhdaninova and Lerman, 2005). Co-operatives are considered to be potential contributors towards sustainable development because of their particular ways of organizing and doing business (ICA, 2013). For example, their local nature is a crucial aspect to their ability to target community needs and contribute to solving social, economic and environmental issues through the social interaction between their members (Burjorjee *et al.*, 2017). Moreover, they function in diverse ways including organization of labour resources for production, mobilization of material resources (savings and credit) to help produce more, influencing policy institutions that affect them, and cementing social relationships, among other functions.

In recent years, there has been a resurgence of interest in the co-operative movement by rural dwellers, policy makers, and funding agencies, as an option for accelerating rural development. Evidence suggests that co-operative group projects are increasingly relied upon by national governments, foreign development agencies, and Non-Governmental Organizations as the preferred model for rural development, project implementation and poverty alleviation (Basu *et al.*, 2004).

Globally, involvement of co-operatives in natural resources management is not new; co-operatives provide strategies for reaching increasingly diverse and numerous forest landowners with forest management advice and profitable management services (Ashton *et al.*, 2008). In countries like the Netherlands, Germany and Australia; agri-co-operatives are becoming an important actor to negotiate collective environmental management contracts which at the same time convert them into effective means to self-regulate the farming practices of their members (Renting and Van der Ploeg, 2001; PragerandVanclay, 2010). According to Hull and Ashton (2008), communities' participation in forest management through co-operatives thrives in at least 17 countries. A variant of those co-operatives, forest landowner co-operatives claim to provide members with unique services that may not be available through other assistance programmes (Kelly and Kusel, 2015). Typical services offered by forestry co-operatives include forest product marketing, supplies, equipment, and services offered at reduced costs because of economies of scale (Lidestav and Arvidsson, 2012). Other services are management to improve forest productivity and profitability, and enhanced social relationships by bringing together like-minded landowners with similar goals who learn from their interaction with each other (Corbia, 1989).

Co-operatives have the potential to reach the community where they are active to broaden their membership base and build networks, in the form of horizontal integration (Blinn *et al.,* 2007). According to CDS (2012), agricultural, consumer, financial or other community owned co-operatives may involve new groups of members, and therefore expand their membership to other groups of people than forest owners only (Blinn *et al.*, 2007). Furthermore, forest owner co-operatives may involve the customers of their products and grant discounts on the products and services (Blinn *et al*., 2007). Similarly, Viana *et al.* (2012) consider co-operatives as a potential opportunity to improve forest governance and financial flows. Co-operatives not only have the potential to lead the sustainable management of natural resources but also their governance model shows positive impacts on sustainable development through transparency, participation and cooperation with local communities, enterprises and local and international governments (Wanyama, 2016; Cato, 2009).

Tanzania stands as a key stakeholder in addressing LULUCF related emissions, partly due to a long historical track record performance of agricultural co-operatives. Tanzania Mainland is estimated to have a total of 48 million hectares of forest, which is 51 per cent of the total area, with woodlands occupying about 90 per cent of the total forest area and the remaining comprising of mangrove forests, montane forests, small patches of coastal forests, and plantations of softwood and hardwood (NAFORMA, 2014). Furthermore, Tanzania has 16 million hectares of forestland that is still unmanaged that can potentially be sustainably utilized and managed (are these out of the 48 million ha). These facts are considered worthwhile since collective a LULUCF mitigation programme will reduce unwanted human activities in forest resources, particularly the *miombo* woodland agro-ecosystems, a very extensive vegetation type in Tanzania with increasing pressure and resultant deforestation and the evergreen montane forests on Mt. Kilimanjaro. While the *miombo* woodlands are increasingly being converted to other uses such as farmlands, fuelwood and hardwood extraction zones (Araya and Hofstad, 2014), the evergreen montane forests on Mt. Kilimanjaro, on the other hand, are heavily impacted by illegal logging of indigenous trees in most areas, fire occurrences on the south eastern slopes, livestock grazing and extension of agricultural fields into the forests (Lambrechts *et al.*, 2002; Rutten *et al.*, 2015).

1.6.5 Conceptual framework for co-operative role in reducing emissions

In the conceptual framework diagram (Fig. 1.1), the contribution of co-operatives in reducing emissions and enhancing sinks from LULUCF starts by perceptions and understanding of the inherent collective power of co-operatives in addressing socioeconomic needs. Then the role ought to be vivid in activities co-operatives are involved in at organisational and individual levels. The activities do not only address management of forests, but also actions that reduce pressure from demands on forest products. Meaningful participation by farmers is based on the fundamental premise that the following factors are available. These, as shown in the diagram, include international funding, compliance (offset) markets, voluntary markets, buyers of credits for trading purposes (brokers), capacity development, planning, basic monitoring capacities, setting reference levels, training and advice and land-use change regulations. These serve as moderating variables. In this conceptual framework community-led co-operatives engagement in avoiding deforestation and forest degradation will in turn lead to enhanced sustainable management of trees on farms, forests, and woodlots, conservation and restoring of graded forests, increased carbon stock and hence reduced emissions and rural poverty. This further leads to emissions reduction and enables the community to generate carbon credits which are marketed by co-operatives in the carbon market. Part of the revenues that accrue from carbon credits is in turn invested in activities that address forest management and poverty alleviation at community level.

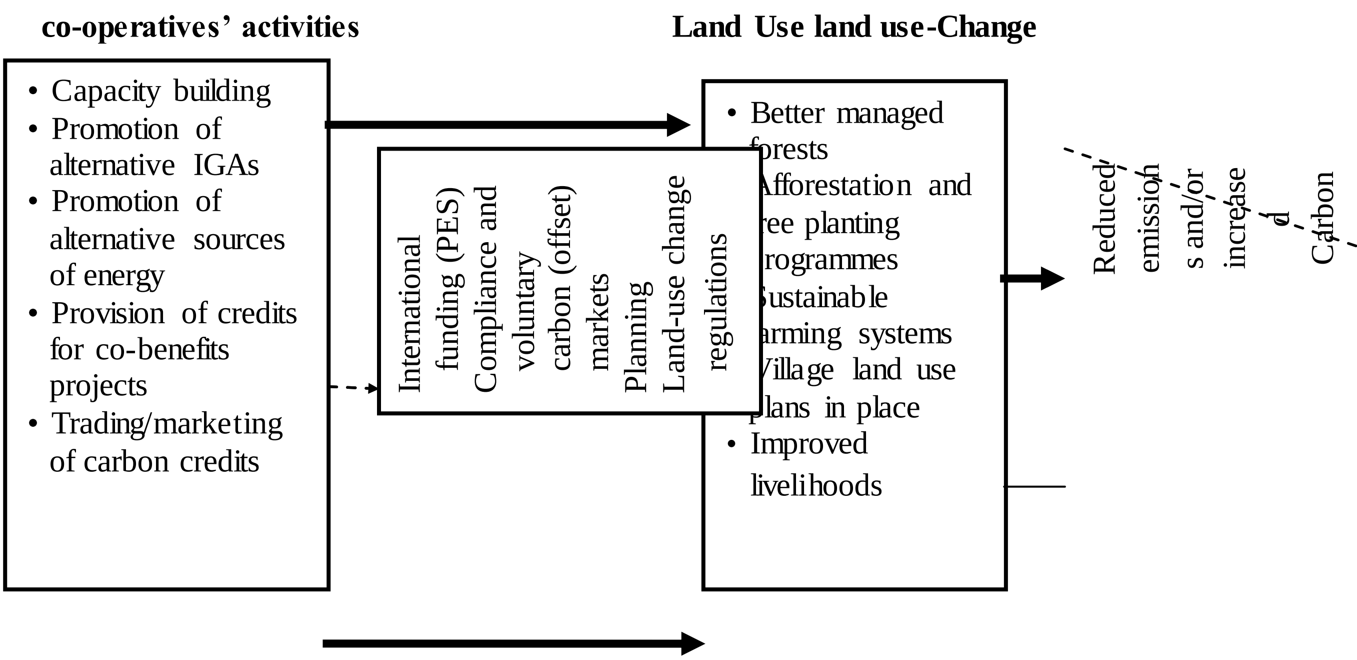

Figure 1.1: The conceptual framework diagram

A synthesis from literature

1.7 Study Methodology

1.7.1 Geographical location and description of the study area

Two different geographical areas were selected. These are Urambo District in Tabora Region and Moshi District in Kilimanjaro Region (Fig. 1.2). In Urambo District the study focused on *miombo* woodlands where shifting cultivation, which involves clearing land for tobacco growing is the major farming system that exerts pressure on the forests. In Moshi District the focus was on evergreen Montane Forests on a volcanic mountain combined with agro-economic systems, mainly comprising of agroforestry on the slopes of the tallest mountain in Africa at 5895 metres above sea level.

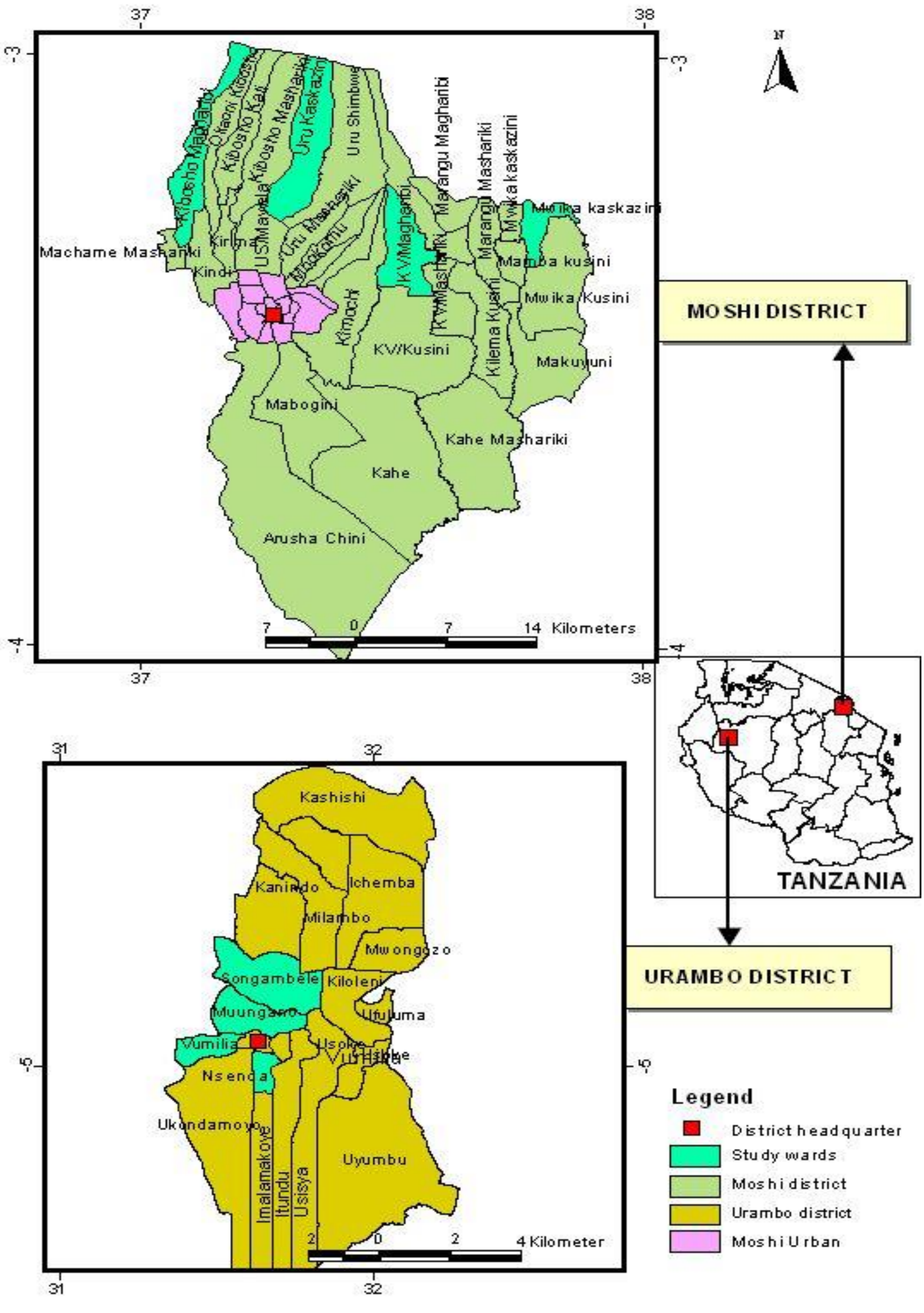

Figure 1.2: Study area map

The study here looked into how co-operative actions on agro-ecosystems have contributed to GHG emissions and enhancement of carbon sinks. The study was conducted in 16 villages eight villages from each district: Kifuni, Umbwesinde, Njari, Mfuni, Kanango, Iwa, Kinyanvua, and Maring'a from Moshi district and Motomoto, Nkokoto, Muungano, Kalemela A, Nsenda, Itebulanda, Songambele and Jionee Mwenyewe from Urambo District.

The districts were chosen because both districts have a significant and historical co-operative activities tied to LULUCF. In the districts there are intimate relationships between the farmers and the surrounding ecosystems which have GHG emissions and/or Carbon sinks components. Furthermore, both districts have active agricultural marketing service co-operatives. While in Moshi District the coffee co-operatives are the strong marketing institutions of coffee grown by smallholder farmers, in Urambo Tobacco farming which for decades has exerted pressure on *miombo* woodlands; is facilitated by Agricultural marketing co-operatives. Thus, the districts provide an opportunity to examine how the co-operatives have contributed to reducing GHG emissions in two differing ecological systems.

1.7.1.1 Moshi district

Moshi District lies between longitude 37° to 38° East and latitudes and 2°30' - 50° latitudes South of the equator. The district covers an area of 1713 sq. km. or 171 300 ha of which 124 254 ha is arable land; 338 126 ha is land covered by natural forests (Kilimanjaro forest reserve, 37 019 ha, Rau ha 570, Kahe I - 885 ha; Kahe II 202 ha) and 8920 ha is non-arable land occupied by rocks, hills and gullies. The land currently under cultivation is 108 389 hectares or 87.2% of the total arable land (124 254). About 68 718 households are engaged in full time agriculture which is the main economic activity of the district.

The district's population, according to the 2012 Tanzania National Census was 466 737, out of which 225 767 were males and 240 970 are females. The population is growing at the rate of 1.51 per year, and the population density is 258.9 persons per km^2.

Ecologically, the district is characterized by mountainous topography on the northern part which forms the Kilimanjaro Mountain, while moving towards the South are the lowlands. Rainfall pattern is highly dependent on altitude. Traditionally, the district used to receive two rain seasons, the short rains coming between October and December while the normal rain season used to occur from March to June. In more recent years, possibly due to global climate change, the short rains have been inconsistent. The lowlands receive an average of 600 mm, the central part 1100 mm and the high lands 1600 mm. The district has an average daily temperature of 26ºC. The highest temperatures occur in the months of February, March, April, September October and November during which the mean maximum temperatures are around 31º while the mean minimum temperatures are in June, July, December and January when the temperatures go down to about 15ºc.

With regard to agro-ecological zones, the district is divided into three (3) agro-ecological zones: lower zone (lowland), middle or central zone and upper zone (highland). The lower zone (lowlands) lies between altitudes of 700 – 900 metres above sea level where people are engaged in paddy production through irrigation, maize and free-range cattle grazing. The middle/central zone has the altitude ranging from 901 – 1500 metres above sea level. People here are engaged in agriculture, the main crops being banana, coffee, maize, beans, fruits and dairy cattle keeping at zero grazing system. This is less populated as compared to the highlands. The highlands zone is located on the upper slopes of Mt. Kilimanjaro and is the most densely populated area with the altitude ranging from 1501 – 2500 metres above the sea level, above which is the domain of Kilimanjaro montane tropical forest. People in this highland zone are mainly engaged in agriculture. The main crops are coffee, banana, fruits and dairy cattle.

1.7.1.2 Urambo district

Urambo is one among the seven districts of Tabora Region of Tanzania and is located in the mid-western part of Mainland Tanzania on the central plateau between latitudes 4° - 5° 55'' South of the Equator and longitudes 31° -34° East of Greenwich, with the total area of about 5 415.8 sq. km.

According to the 2012 Tanzania National Census, the population of the Urambo District had192 781 inhabitants, out of whom 95 997 were males and 96 784 were female. The district has a population density of 35.6 persons per square kilometre.

The district receives an annual rainfall ranging from 900 mm to 1200 mm which starts in November and ends in April and this is the main crop-growing season. A long dry spell normally occurs from January to February. With regard to temperature, the district has an annual mean maximum temperature of 30° C and a mean minimum temperature of 16.4° C. The temperatures are highest in October just before the start of the rain season, and fall gradually in December and remain relatively constant until May.

Topographically, Urambo District falls in the central plateau of Tanzania, an area of low relief lying between 1100 m and 1200 m above sea level. The district land is plain sloping gently down the Malagarasi swamps in the West, with mostly a well-drained medium textured soil. The topsoil is loamy sand while the sub-soil texture is sandy clay loam. In areas where soils are liable to flooding (*mbuga*), the soils are deep and predominantly sandy clay loam and clay textured. With regard to vegetation, the upland vegetation in the district is Miombo woodlands, mixed with wetland vegetation of *mbuga* wooded grasslands and *mbuga* grasslands. The district has no permanent rivers although pools of water remain during the dry season in the Igombe River in the North and Ugalla River in the Southern parts of the district and Lake Sagara which lies on the western part of the district.

With regard to agro-ecological zones, the district is divided into three agro-ecological zones: Eastern, Central and the Western zone. The zones differ in climate, topography, soil characteristics as well as types of crops grown.

Eastern Zone: The altitude of the eastern zone is medium, and the soils are dominantly loamy sand and sandy loam, well drained with medium texture. The soil fertility and available water holding capacity are low. The *mbuga* areas are dominated by sandy clay loam and clay. The rainfalls in this zone are well distributed and are monomodal (one season) that measures between 700 and 1000 mm per annum. There are four months (December to March) of wet season and seven months (May to November) of dry season. The crop growing season is from December to April. The principle crops grown include maize, cassava, sweet potatoes rice/paddy, sorghum and legumes, tobacco, cotton, sunflower and groundouts (Mkenda, 2011).

Central Zone: The altitude of this zone is low to medium. The soils are less fertile reddish clay loam with moderate water holding capacity. There are also *mbuga* soils, dominated by black clay loam and clay. The rainfall, which is monomodal, varies from

600 mm to 1000 mm per annum and falls from December to April which is the crop growing season. The dry season lasts from June to November. The principal crops grown are maize, cassava, groundnuts, tobacco, sweet potatoes, beans, sunflower, oil palm and simsim.

Western zone: The altitude of this zone is low to medium. The soil fertility is high with medium water holding capacity and the soil texture is clay loam. The zone gets an annual average of 600 mm of rainfall the months of November, December, March and April. The dry season lasts from June to November. The principal crops grown include maize, cotton, oil palm, cassava, rice, sunflower, simsim, banana and oranges.

1.7.2 Sampling design and sample size

The target population for the study included primary co-operatives in the two districts. In order to achieving the study objectives, the researcher required three samples. The first sample represented administrative wards; eight wards were selected four wards from each district. The second sample represented the co-operative organizations, and the third sample represented the heads of households in the villages in which co-operatives operate. The study focused on household heads because co-operatives also serve non-members. Two primary agricultural marketing co-operative societies were chosen from each ward, making a total of 16 agricultural marketing primary co-operatives in the sample. Because the study could not be undertaken where there are no co-operatives, wards and farmer co-operatives were purposely selected with the assistance of District Co-operative Officers (DCOs). From one village among villages in which co-operatives serve, household representatives were systematically selected from the village register.

To ensure that the findings of the study could be used to make reliable statistical inference at standard confidence level (95%), the sample size was arrived at by using the formula by Fisher *et al.* (1991) for calculating the desired sample size for a population greater than 10 000 as shown below. It was considered adequate at 95% confidence level, 5% margin of error and 50% skewness level.

$n = z^2pq/d^2$

Where:

n - The desired sample size (assuming the population is greater than 10 000)

z - The standard normal deviation, set at 1.96, which corresponds to 95% confidence level

p - The proportion in the target population estimated to have a particular characteristic. If there is no reasonable estimate, then use 50% (the study used 0.50).

q = 1.0 – p

d = the degree of accuracy desired, here set at 0.05 corresponding to the 1.96 standard normal deviation.

In substitution:

n = 1.962 x 0.5 x (1-0.5)/ 0.052 = 384

However, the response rate was 77.3% (297 dully filled questionnaires) in view of the resources and logistical limitations. The response rate was generally good, capable of producing useful results and conforms to the stipulation by Mugenda and Mugenda (2003) that a response rate of 50% is adequate for analysis and reporting; a rate of 60% is good and a response rate of 70% and above is excellent. Purposive sampling was employed to select co-operative organizations and respondents for focus group discussions and key informant interviews.

1.7.3 Data and data collection techniques

Both primary and secondary methods of data collection were used based on their applicability and usefulness. Techniques for data collection varied according to objectives. The collection of primary data for this study was undertaken from January to November 2016 for both districts.

To assess the drivers of land use and land use changes associated with co-operative actions linked to emission reduction and enhancing carbon sinks, cover change analysis resulting from economic activities associated with co-operative actions using remote sensing over the periods 1995, 2005 and 2015 for Moshi District and 2005, 2010 and 2015 for Urambo District were used. Additional information supporting the interpretations was obtained through interviews with extension officers. Remote sensing was supplemented by field assessment and household survey. Field assessment involved measurement of tree diameter at breast height (dbh), assessment of the quality of trees, numbers, and types.

To gather information on the extent to which co-operatives' activities had contributed to mitigating (weaning) carbon emissions from land use change, a questionnaire survey, focus group discussions (FGDs), key informants and observation techniques were used.

Structured questionnaire survey: Questionnaire survey was considered to be the "main entry point for getting the data, thus an important instrument for assessing farmers perceptions on land use and land use-change and their drivers over time. Therefore, household survey (structured interviews) was conducted in order to learn how co-operatives' activities, contribute to GHG emissions and/or enhancement of carbon sink through LULUCF. The questionnaires for the survey had both closed- and open-ended questions; and the respondents were mainly household representatives.

The predetermined sample size 384. Of these samples, some households were dissolved or were not at their homes when visited. The study, therefore, managed to interview 297 households. Most of the interviews were conducted at the respondents' households. However, in some cases where it was difficult to go to the homes due to, for instance, poor organization and difficult terrain, interviews were done at the co-operatives' offices.

Focus group discussion: In this study, we conducted one FGDs in each study village. A total number of 16 FGDs were conducted. Each group comprised of approximately 8-12 participants with a mixture of men and women. This size of group participants was based on the arguments by (Gill *et al.*, 2008) that the optimum size for a focus group discussion is six to eight participants (excluding researchers), but focus groups can work successfully with as few as three and as many as 14 participants. Purposive sampling was used to get FGD participants since focus group discussion relies on the ability and capacity of participants to provide relevant information (Morgan, 1988). FGD participants were seleceted on the likelihood that they would provide useful information. The participants included farmers and co-operative leaders. The farmers youth and elders were selected after consulting co-operative leaders. They included youth and elders; both men and women. An FGD lasted for about an hour. The basic purpose of these FGDs was to ascertain the historical development of the survey co-operatives, their business operations, and their salience to members in the locality as well as to address the co-operative governance aspects. In addition, it enriches and supplements the data from the questionnaire survey.

Key informant interviews: also known as resource person interviews – is a type of qualitative interviews that involve face to face interview with a key individual in the community (Bryman, 2012). In this study, key informant interviews played a crucial role because it was mainly through these interviews that we understood co-operatives' activities and land use, land-use practices. Moreover, the interviews provided a comprehensive knowledge about the LULUCF and co-operatives activities in the villages as well as state of agroecosystems.

A total of 34 key informant interviews were conducted. Key informant interviewees included leaders, managers, founders and farmers who are part of the co-operative's organizations. Others were village chairpersons, village executive officers, ward executive officer, agricultural extension officers, district co-operative officers and district natural resources officers. The selection of the interviewees was made based on the following criteria: member and/or leader of a co-operative, experience and expertise with at least two of the four topics (co-operative leadership and management, agriculture, forestry, land use and land-use changes). In conducting key informant interviews, checklist of interview guides used. During the key informant interviews, the researcher used interview guides, which were already designed (Appendix 2 the participants for key informant interviews were purposely selected.

Participant observation: Participant observation, as the name suggests, is a method of data collection whereby the researcher records what he/she sees (in his /her research log) rather than what the respondents tell him/her. Thus, a participant observation technique complements the focus group discussions, structured and semi-structured interviews in the sense that it gives the researcher a further understanding of the study area in terms of its people, culture and topography (Bryman, 2012). In this study, participant observation was important as it gave the researcher a contextual insight of the LULUCF activities, ongoing co-operatives activities in the agroecosystems. Such activities were farming, marketing of agricultural produce at auctions, conservation and management of land resources. Here, information collected included co-operative operations, agricultural systems, farm and non-farm activities, and co-operatives' measures to address deforestation and forest degradation.

To determine the contribution of co-operatives in maintaining carbon stocks in agroforestry cropping systems and *miombo* woodland agro-ecosystems, field assessment involving measurement of tree diameter at breast height (DBH), assessment of the quality of trees, numbers, and types and use of allometric equations to estimate carbon stock were deployed.

With regard to assessing the potential of co-operative marketing approach in enhancing carbon trading in community managed carbon enhancement activities, main data collection techniques included key informant interviews and documentary reviews. The key documents consulted include UNFCC documents, COPs reports, UN-REDD+ reports and the Tanzania 2013 Co-operative Act.

1.7.4 Data analysis methods

Both quantitative and qualitative methods of data analysis were employed. In remote sensing, the study used Landsat TM (1995/2005) and ETM (2010/2015) to examine changes in land use/cover types. The images were freely downloaded, processed and analysed by visual interpretation for land use change classification through a screen digitizing. The main criteria for choosing images were availability, avoiding the peak of rain season (March/April) and avoiding images with cloud cover above 20%.

Quantitative survey data were subjected to descriptive statistics where measures of central tendency particularly mean, frequencies and percentages were computed. A logistic regression model was used to assess factors affecting chances of influencing land use change in the study area. The researcher sought the aid of Statistical Package for Social Sciences (SPSS) version 20 to analyse survey data. The qualitative data were interpreted using content and context analysis techniques. The data were organized into different themes based on the conceptual description of ideas which were expressed by interviewees.

1.7.5 Validity and reliability

A pilot study was carried out before data collection in two villages, one from each district different from the sampled villages in order to determine validity and reliability. Information obtained from pilot study helped to identify ambiguities in the questionnaire and modified to reflect the objectives of the study. The pilot study was conducted twice at an interval of two weeks that used the same sample and instrument producing two sets of scores. These sets of the scores were used to calculate reliability correlation coefficient which determined stability of the results over a period of time. The reliability coefficient was found to be 0.74 which is above 0.70; the value above which the data collection instrument is often considered sufficiently reliable to make decisions based on observed scores (Phelan and Wren, 2005).

1.7.6 Challenges

Challenges and limitations are encountered in most fieldwork. Usually researchers complain of time and resource constraints, something that this study also experienced. Besides these 'usual' constraints, there were few other challenges and limitations. Firstly, there were some problems with some respondents in Moshi District who wanted financial compensation for their time. In such cases, only those willing to be interviewed without demanding compensation were interviewed and later given a thank you token of one thousand Tanzanian shilling. Secondly, data collection coincided with planting season in Moshi District and tobacco auctions in Urambo. It was difficult to get the respondents; most of the potential respondents went either at their farms or at the auctions. To address this some, interviews were conducted in the evenings. Some interviews, however, were postponed or totally missed. Although this study, like any other study, had its limitations, it also contributes to the extensive literature and provides opportunities for more future research regarding co-operatives and climate change services; the limitations were mitigated.

1.7.7 Ethical considerations

It is difficult to accept the findings of any research if the researcher is known to be dishonest or if the quality of the methods is apparently low (Walliman, 2015). Ethical principles, for instance honesty and openness, are core issues in any research and were, therefore, an integral part of this study. To ensure ethically sound research, the researcher should avoid harming the respondents; there should be prior and informed consent, respect for respondents' private life and should not deceive the respondents (Bryman, 2012). In this study, there was no harm to anyone involved in the research process, or affected by it or its results and respect for privacy. Anonymity and confidentiality were guaranteed while in the study area and after the fieldwork. In the case of the household survey, anonymity was ensured through using questionnaire serial numbers instead of respondents' names. Concerning prior and informed consent, respondents were informed about the study and the purpose of the data collected. The primary co-operative societies and/or village leaders introduced the researcher and research assistants to the informants prior to the interviews, and the researcher also informed the respondents of who he was, the purpose of his visit and respondents' right to accept or refuse to be interviewed at the beginning of every interview session. The researcher tried his best to uphold the ethics of respect, honesty and privacy throughout this research.

1.7.8 Organization of the thesis

This thesis contains four publishable manuscripts which are presented as chapters. The whole thesis is organized into six chapters. The first chapter contains the general introduction of the study, statement of the problem, study objectives, as well as a review of the theoretical and empirical literature and a description of the methodology employed. Chapter two contains the first manuscript that examines the drivers of LULUCF that influence carbon emission and carbon sinks in Moshi and Urambo Districts. Chapter three presents the second manuscript that analyses co-operatives' actions or lack thereof linked to GHG emissions and carbon removals through LULUCF. Chapter four contains the third manuscript that discusses quantitative contribution of co-operatives in carbon emissions mitigation through carbon stock enhancement activities in agroforestry and *miombo* woodland agro-ecosystems. Chapter five presents the fourth manuscript that delves into how the co-operative business model may apply to carbon trading with special emphasis on community carbon enhancement activities. Finally, Chapter six summarizes the findings, and draws conclusion and recommendations.

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CHAPTER TWO

Paper one

Drivers of land use and land-use changes and their influence on carbon sinks in agroforestry and miombo woodland agro-ecosystems in Tanzania

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Abstract

Land use, land-use change and forestry (LULUCF) play a key role in terrestrial carbon stock changes. The contribution of LULUCF to greenhouse gas (GHG) emissions is approximately 20% of the total global GHG emissions. Activities in the LULUCF however, can provide effective ways in which GHGs removals from the atmosphere occurs. This paper examined the drivers of land use and land-use changes (LULUC) that reduce emission and enhance carbon sinks in Moshi and Urambo Districts. Specifically, the study sought to understand the nature and extent of land use changes as well as examining their drivers and implications on reducing emissions and increasing carbon stocks in different pools. A sample of 297 households was systematically selected from 16 villages. The study involved a questionnaire survey for collecting socio-economic data and satellite images for remote sensing data. Binary logistic regression analysis was used to assess factors which have influence on LULUC. Land-use change was analyzed based on the interpretation of satellite images. Change Detection Matrix showed a replacement of tree crops by herbaceous crops (1995-2005) and an expansion of cultivation of tree crops at the expense of herbaceous crops (2005-2015) for Moshi District and an increase of land under closed vegetation in Urambo District (2010 – 2015). Intensive farming, establishment of woodlots, use of energy efficient stoves, agroforestry practices, population growth and tree planting were among the important drivers of land use and land-use change. The study concludes that drivers of land use and land use change in Moshi and Urambo districts are strongly related to GHG emissions and carbon sinks. Rigorous knowledge on agricultural practices that reduce emissions and enhance carbon stock should be encouraged.

Key words: *Land use, land-use change, land use change drivers, co-operatives, carbon emissions, carbon sinks and binary logistic regression.*

2.1 Introduction

The LULUCF sector plays a key role in limiting GHG concentration in the atmosphere. The contribution of LULUC to anthropogenic carbon emissions were about 33% of total emissions over the previous 150 years (Houghton, 1999), with a diminishing share as the emissions from the energy and industrial sectors grew, thus 20% of total emissions in the 1980s and 1990s (Denman *et al.*, 2007), 12.5 % of total emissions over 2000 to 2009 (Friedlingstein *et al.*, 2010) and 12% for the decade that ended 2010 (Houghton *et al.*, 2012). According to the United Nations Intergovernmental Panel on Climate Change (UN IPCC), the estimated global net flux due to land use change is approximately 20% of global CO_2 emissions in each year (Nabuurs *et al.*, 2007). Deforestation and forest use in the tropics such as conversion of forests to agricultural uses is responsible for 10 to 15% of the global carbon emissions each year (Denman *et al.*, 2007; van der Werf *et al.*, 2009; Peters *et al.*, 2012; Harris *et al.*, 2012).

LULUCF affects the amount of carbon entering and leaving the atmosphere and, therefore, provide opportunities to reduce emissions and mitigate climate change (Sleeter *et al.*, 2012). Scientific literature has highlighted that LULUCF sector plays a key role in reducing emissions to the atmosphere by enhancing the sequestration of carbon in terrestrial reservoirs, substituting carbon intensive products and reducing emissions from deforestation and degradation (Cowie *et al.*, 2007; Reyer *et al.*, 2009; Forsell *et al.*, 2016). Thus, activities in LULUC provide effective ways in which greenhouse gas (GHG) removals from the atmosphere occur, via carbon sequestration during biomass growth (Schlamadinger *et al.*, 2007). Studies show that with appropriate interventions such as long-term storage of carbon in wood products, expansion of forest carbon storage and substitutions in fuel woods, it is possible to reduce emissions from deforestation and forest degradation through LULUC with (Huberman, 2007; Cowie *et al.*, 2007, Hall, 2008).

It is widely accepted that LULUC is a potential source of carbon dioxide to the atmosphere (Noble *et al.*, 2000), but the question of whether the LULUC drivers can be addressed in ways that will significantly enhance carbon pools in order to mitigate climate change. Although it is well established that there are drivers of land use and land use changes that can enhance carbon pools (Lambin *et al.*, 2001; Blodgett and Parker, 2007; Raupach *et al.*, 2007; Zak *et al.*, 2008; Houghton, 2012; Kissinger *et al.*, 2012; Meyfroidt *et al.*, 2013), such as smart agriculture and agroforestry cropping systems are rarely acknowledged.

The objective of this paper was to examine the drivers of land use, land-use change and forestry that reduce GHG emissions and enhance carbon sinks. Specifically, the paper sought to understand the extent of land use changes and the drivers of land use changes linked to co-operatives activities in agroforestry cropping systems and miombo woodland agro-ecosystems. The results will identify potential interventions and practices by co-operatives that reduce carbon emissions and enhance carbon sequestration in the LULU sector. The findings are expected to guide decisions and to inform policy makers about the current status of land use and land use changes and co-operative practices, which are very crucial in the global carbon cycle and resource management in the agroforestry ecosystems and the *miombo* woodland agro-ecosystems.

The contention that LULUC provide effective ways in which carbon dioxide removals from the atmosphere occur (Noble *et al.*, 2000) raises the question of whether the drivers of LULUC can be addressed in ways that will significantly enhance carbon pools. Hence the main question is what are the drivers of land use and land-use changes associated with protecting and enhancing carbon sinks? The focus was on agroforestry and *miombo* woodland agro-ecosystems as they have experienced dramatic land-use changes in the last decades.

Examining the drivers of land use, land-use changes associated with enhancing carbon pools in these ecosystems will lead to a more robust understanding of the dynamics of land-use and land use changes, and therefore, to more appropriate policy interventions affecting carbon sinks. Improved understanding of drivers of LULUC is also required to assess and project the future role of land-use and land-use changes in the global campaign on reducing emissions from deforestation and forest degradation (REDD+).

The paper used political ecology approach to examine drivers of land uses that reduce GHG emissions and increase carbon sinks. The political ecology approach engages with the social world and views the environment as not simply a stage or an arena in which struggles over resources access and control take place, but also consider nature or biophysical processes that play an active role in shaping human environmental dynamics. Under this approach the resource systems are typically viewed as utilized ecosystems that are, by nature in ever-changing interactions with human activities e.g. people – vegetation, people- wildlife, that are typically differentiated by power relations associated with gender, ethnicity, class or wealth categories (Zimmer and Basselt, 2003).

2.2 Materials and Methods

2.2.1 Study area description

The study was conducted in Moshi and Urambo Districts in Kilimanjaro and Tabora Regions respectively (Fig. 2). The two districts were purposively selected due to the prevalence of agricultural marketing co-operatives since the early 1980s. This provides a good case in identifying co-operatives' potential impacts on GHG emissions and carbon sinks in the districts. Moshi District is one of the seven districts of Kilimanjaro Region. It occupies an area of 1713 square kilometres on Southern slopes of Mount Kilimanjaro and, according to 2012 National Census, the district has a human population of 466 737; of which 25 767 are males and 240 970 are females (URT, 2013). The district lies between longitudes 37° and 38° East and latitudes 2°30' and 50° South of the Equator at an elevation of 1200 m above sea level. Moshi District is characterized by Kilimanjaro Mountain on the Northern part and lowland plains on the South. The rainfall pattern is highly dependent on altitude, whereby the lowlands receive an average of 600 mm per year; the central part 1100 mm per year, and the highlands 1600 mm per year. The district has an average daily temperature of 26ºC (URT, 2017). The highest temperatures occur in the months of February, March, April, September, October and November during which the mean maximum temperatures are around 31º while the mean minimum temperatures are in June, July, December and January when the temperatures go down to about 15ºC. In Moshi District the study focused on the highland zone (coffee-banana belt and home-garden area) between 1200 and 1800 m above sea level and the midlands (maize-bean belt) between 900 and 1200 m above sea level. Before human settlement began, over 2000 years ago, the southern elevation belt between 1000 m and 1800 m was covered by tropical lower sub-montane forest (Fischer *et al.,* 2015). Today, to a large extent, these forests have been converted into agroforestry systems, grasslands or coffee plantations (Fischer *et al.,* 2015). The remnants of sub-montane forest and agro-ecosystems in the district are strongly not only impacted by burning or logging, but they are also subject to climate change (Hemp, 2009).

Urambo District is located in the mid-western part of Mainland Tanzania on the central plateau between latitudes 4° and 5°55' South of the Equator and longitude 31° and 34° East of Greenwich Meridian. It has a total area of about 5 415.8 square kilometres and a human population of 192 781 of which 95,997are males and 96,784 are females. The district falls in the central plateau of Tanzania, an area of low relief lying between 1100 m and 1200 m above sea level, generally characterized by a flat land with small hills and scarce undulating landscapes with an annual rainfall range from 900 mm to 1200 mm and temperatures which range from 21 –33^0C. The temperatures are highest in October just before the start of the rain season, and fall gradually to December and remain relatively constant until May. From May to August the district experiences low temperature. The dominant vegetation is *miombo* woodland with scattered bushes and thickets, mixed with wetland vegetation of *mbuga* wooded grassland and *mbuga* grassland. In Urambo District the focus was on *miombo* woodlands where shifting cultivation is the major farming system that exerts pressure on these woodlands. Miombo woodlands form an integral part to socio-economic and cultural aspects of local communities (Lupala *et al.*, 2014). In Tanzania, *miombo* woodlands support the livelihoods of estimated 87% of urban and rural population (Abdallah and Monela, 2007; Milledge *et al.,* 2007). The woodlands are also important for carbon storage and sequestration (Grace *et al.*, 2006; Williams et *al.,* 2008). The most common species are *Pterocarpus angolensis, Brachystegia spiciformis, Afzelia quenzensis, Albizia harveyi, Burkea africana, Calotropis procera and Combretum adenogonium*. Yet, despite all these, the woodlands are being steadily converted to other uses such as pasture, fuel wood extraction zones, and farmlands which can generate greater private economic returns (Araya and Hofstad, 2016). Thus, land use and land use changes in the *miombo* woodlands remain an enormous challenge with concomitant social, environmental, and economic implications (Milledge *et al*., 2007).

2.2.2 Research design and sampling

The study adopted descriptive cross-section design in examining drivers of land use, land-use change associated with enhancement of carbon sinks. A socio-economic survey and remote sensing techniques were employed to generate data on drivers of carbon sinks and extent of land use land cover changes. The target population included all primary co-operatives in the two districts. Multistage sampling was adopted where the first stage represented administrative wards. Eight wards were selected four wards from each district. The second stage represented the co-operative organizations, and the third stage represented the households' representatives from villages in which co-operatives operate. Two primary agricultural marketing co-operative societies were chosen from each ward, making a total sample of 16 agricultural marketing primary co-operatives. Wards and farmer primary co-operatives were purposely selected with the assistance of District Co-operative Officers. Household's representatives were systematically selected from the village register. The sampling frame for social survey data was the list of all households in the village register. For villages where the list was not available it was generated by the help of leaders of villages and hamlets (*vitongoji*). The sample was calculated using Fisher *et al.* (1991) formula for population greater than 10 000. A total of 297 respondents were interviewed. The minimum age for the respondents was taken to be 18 years.

2.2.3 Data collection

A questionnaire was administered to a total of 297 household representatives. The survey was undertaken using a structured questionnaire that included both open-ended and close-ended questions, and it was supplemented with key informant interviews and focus group discussions. In the survey, the respondents were asked to state whether there had been land use changes or not within the previous ten years; and if yes, they were further asked to select from the list of drivers (developed from literature) what they perceive to be the drivers of land use and land-use changes.

The socio-economic survey was supplemented with remote sensing data. Freely downloaded Landsat TM (1995/2005) and ETM (2010/2015) images were used to examine changes in land use/cover. The main criteria for choosing images were availability, avoiding the peak of rain season (March/April) and avoiding images with cloud cover above 20%. To reflect changes in land use/cover in the two districts, the land sat scenes in Table 2.1 were used.

Table 2.1: Land sat scenes

District	Scene	1995	2005	2015
	168/62	30/01/1995	16/10/2005	14/01/2015
Moshi	168/63	27/09/1995	6/2/2005	6/2/2015
	167/63	1/7/1995	22/08/2005	1/4/2015
	Scene	**2005**	**2010**	**2015**
Urambo	1717/63	7/6/2005	14/12/2010	5/2/2015
	171/64	7/6/2005	14/12/2010	23/07/2015
	170/64	18/07/2005	11/4/2010	1/8/2015

Due to the high regenerative capacity of the *miombo* woodlands (Chidumayo, 2013; Lupala *et al.*, 2014), the study used an interval of five years between the land sat scenes. *Miombo* woodlands produce dense coppices in 2 to 5 years after clearing and become mature woodlands in 6 to 8 years (Frost, 1996). Tables 2.2 and 2.3 present land use land-use change classes used in the study. Land use and land-use change classes were classified in accordance with Anderson's land use and land cover classification system for use with remote sensing data (Anderson, 1976). The difference in cover classes shown in

Tables 2.2 and 2.3 is due to the fact that Moshi District is mainly a montane forest area while Urambo District is in Miombo woodlands.

Table 2.2 : Land use/cover types used for Moshi District

Land Use	Description
Bushed grassland	Land area dominated by grasses with seasonally cultivated crops, mainly maize, sunflower, and fodder
Bushed with scattered crop land	Medium height wooded grassland seasonally cultivated with crops mainly maize and sunflower
Cultivation with herbaceous crops	Mixture of non-woody crops with scattered perennial tree crops mainly banana and planted trees
Cultivation with tree crops	Mixture of annual crops with perennial tree crops such as coffee, banana planted trees and remnants of natural trees
Dense bush land	The vegetation is most woody plants with multiple stems and form bushes or small bush like trees with a few emergent trees of up to 20 m high.
Grassland with scattered cropland	Area of grasses mixed with shrubs, few trees and with some crops mainly maize, beans and sunflower
Inundated grassland	Land cover dominated by grass and herbs with scattered shrubs
Mixed cropland	Areas of farming where there is a mixture of annual crops with perennial tree crops
Natural forest	Multi-layered vegetation dominated by trees (largely evergreen montane forests)
Open woodland	Land covered with vegetation species (plants higher than 5 m to 20 m classified as woodland trees
Swamp	Areas inundated with water with some patches of cultivation mainly rice, and some vegetables
Urban area	Settlement area designated as town centres
Woodland with scattered cropland	Land covered with vegetation species (plants higher than 5 m to 20 m classified as woodland trees with patches of crops

Table 2.3: Land use/cover types used for Urambo District

Land Use change	Description
Closed woodland	Closed *miombo* woodlands less disturbed
Open woodland	Woodland with trees higher than 5 meters and canopy cover of between 10% – 40 or with a combined cover of shrubs, bushes and trees above 10%.
Woodland with scattered cropland	Woodland with patches of crops mainly tobacco and maize
Open bushland	Land composed of bush or shrubs (plants lower than 5 m are classified as bush land)
Bushland with scattered cropland	Land composed of bush or shrubs (plants lower than 5 m are classified as bush land) with patches of crops mainly tobacco, maize, potatoes and sunflower
Bushland with emergent trees	Land composed of bush or shrubs (plants lower than 5 m are classified as bush land)
Cultivation with herbaceous crops	Mixture of annual crops with perennial tree crops mainly mangoes
Mixed cropland	Crop fields with rural settlements; there is a mixture of annual crops with perennial tree crops
Wooded grassland	Land cover dominated by grass and herbs with scattered trees and shrubs (*mbuga* wooded grassland)
Open grassland seasonally inundated	Semi-permanent and seasonal waterlogged land dominated by grass and herbs with scattered trees and shrubs
Wooded grassland seasonally inundated	Seasonal waterlogged land dominated by grass and herbs with scattered trees and shrubs
Bushed grassland seasonally inundated	Semi-permanent and seasonal waterlogged land with less than 10% of vegetation cover (flood plains comprised of herbs, grass and dwarf bushes)
Urban area	Settlement area designated as town centres

2.2.4 Data analysis

2.2.4.1 Theoretical and empirical model

In this paper, a logistic regression model was used to assess the factors/drivers contributing to land use and land-use changes in the study area. It was assumed that land use and land-use changes (binary choice: "Yes" = 1 if there was land-use change and "No" = 0 if there was no land-use change) were dependent variables Table 2.4. Drivers such as farming, animal husbandry, tree planting, grazing, afforestation, reforestation and wood harvest were independent variables.

That is:

$$L_i = ln\left(\frac{P_i}{1-P_i}\right) = \beta_1 + \beta_2 X_i + \varepsilon_i$$

$$\ln(odds) ln = \ln(Y/(1-y)) = a + bX)$$

Where P_i is the predicted probability of the event land use change which was coded with 1 (causing/influencing land use change) rather than with 0 otherwise. X_i is our predictor or explanatory variables. The binary logistic regression was used because the dependent variable was dichotomous, and when compared to logistic models, they generate predicted probabilities that are almost identical. Aldrich and Nelson (1984) indicate that in practice the two models yield estimated choice probabilities that differ by less than 0.02. The social survey data was analysed using the statistical package for social sciences (SPSS) version 20.

Table 2.4: Description and expected sign of variables included in the Land-use change Model

Variable Name	Variable coding	Expectations: Land-use Change Models	Sign
Intensive farming	1, otherwise	Reduce GHG emissions and increase carbon sinks	+
Crop rotation	1, otherwise	Increases carbon sinks	+
Woodlots	1, otherwise	Enhances carbon sinks	+
Expanding farmlands	1, otherwise	Reduces carbon sinks	-
Soil conservation	1, otherwise	Enhances carbon sinks	+
Firewood collection	1, otherwise	Reduces carbon sinks	-
Timber and poles harvest	1, otherwise	Reduces carbon sinks	-
Migration	1, otherwise	Increases emissions, reduces carbon sinks	-
Conservation of natural forests	1, otherwise	Enhances carbon sinks	+
Energy saving stoves	1, otherwise	Enhances carbon sinks	+
Environmental pressure groups	1, otherwise	Enhances carbon sinks	+
Bylaws and regulations	1, otherwise	Reduce GHG emissions and increase carbon sinks	+
Population growth	1, otherwise	Increases emissions, reduces carbon sinks	-
Tree Planting	1, otherwise	Enhances carbon sinks	+
Planting fodder	1, otherwise	Enhances carbon sinks	+
Agroforestry	1, otherwise	Enhances carbon sinks	+

The empirical logit model for this study is specified as follows:

$$\log Y = bo + \sum_{i=1}^{16} \beta_i X_i + \epsilon_i$$

Where:

Y = Land use change

X_1 = Intensive farming

X_2 = Crop rotation

X_3 = Woodlots

X_4 = Expanding farmlands

X_5 = Soil conservation

X_6 = Firewood collection

X_7 = Timber and poles harvest

X_8 = Migration

X_9 = Conservation of natural forests

X_{10} = Energy saving stoves

X_{11} = Environmental pressure groups

X_{12} = Bylaws and regulations

X_{13} = Population

X_{14} = Tree planting

X_{15} = Planting fodder

X_{16}=Agroforestry

2.2.4.2 Interpretation of satellite images, images analysis and change detection

Satellite images were pre-processed using Erdas Imagen software. Since the images obtained were from different dates, the study areas (Moshi and Urambo Districts) scenes and pre-processing were crucial to rectify illumination within the images. The images were also geo-rectified using already existing datasets like roads and ground truth points. Rectified and geo-referenced images were then processed in ArcGIS using on-screen classifier. Pre-processing was done using Erdas Imagen remote sensing software. Although it was time consuming, the on-screen interpretation and classification was opted over supervised or unsupervised machine classification due to high heterogeneous nature of the two districts and availability of personnel with good and reliable knowledge on land cover in the two districts. At first the major topographic features and other general/broad categories of land use/cover types/classes were identified, and later verified in the field. Field data included GPS points taken in various locations, known road network within the two districts and detailed existing topographical maps.

2.3 Results

2.3.1 Socio-demographic characteristics of the respondents

Respondents from the two districts were predominantly males, with more males from Urambo District (133) as compared to Moshi District (110). There was no big difference between the age distributions of the respondents from the two districts, although those from Moshi District appeared to be older than their counterparts in Urambo District. The mean age for all of them (297) was 52.7 (minimum 22, maximum 94, range 72, sd 14.67). With regard to education, standard VII (primary education) was the highest education level for most of the respondents from the two districts 50.7% for Moshi District and 63.8% for Urambo District. The major income generating activity was farming followed by animal husbandry and small businesses.

3.3.2 Awareness on land use and land-use changes

The majority of the respondents (78.8%) were aware of land use and land-use changes occurring in the two districts. The prominent changes, according to their perceptions, were: increase in forestland (66.1%), soil conservation (60.3%), intensive farming (60.2%), tree planting (57.9%), water catchment conservation (57.6%), crop rotation

(53.5%) and expansion of farm lands (52.9%) (Table 2.5). Further analysis showed that 87.9% of the respondents had knowledge that co-operative actions had influence on land use and land use changes.

Table 2.5: Perceived land use land-use changes in Moshi and Urambo Districts

Land use/land use change	Percentage
Increase in forest land	66.1
Intensive farming	60.2
Agro forestry	27.6
Decrease in extension of farm lands	48.5
Planting tree for fodder	40.1
Crop rotation	53.5
Planting trees for woodlots	38.4
Expansion of farm lands	52.9
Soil conservation	60.3
Water catchment conservation	57.6
Zero grazing	39.3
Afforestation (tree planting)	57.9

Note: Multiple response variables

2.3.3 Extent of land use, land-use changes

In Moshi District, drastic land use changes occurred between 1995 and 2015 (Fig. 2.3 and Tables 2.6 & 2.7). The major land use change observed in Moshi District between 1995 and 2005 was the replacement of tree crops (agroforestry) with herbaceous crops The area under herbaceous crops expanded by 43 224.6 ha. Also, there was slight percentage increase in dense bush land and bushed grasslands for the same period (1995 to 2005). There was no change in the area under natural forests mostly due to gazetting, but according to in-depth interviews the forest was very much degraded by illegal wood extraction.

Table 2.6: Land use and land-use coverage for 1995, 2005 and 2015 for Moshi District

	1995		2005		2015	
Land Use/Cover Type	**Hectares**	**%**	**Hectares**	**%**	**Hectares**	**%**
Bushed grassland	27.96	0.02	1649.58	1.18	6877.91	4.92
Bushed with scattered crop land	3872.32	2.77	3872.32	2.77	7339.24	5.25
Cultivation with herbaceous crops	27833.18	19.91	71057.80	50.83	29398.89	21.03
Cultivation with tree crops	33774.47	24.16	11001.87	7.87	33033.56	23.63
Dense bush land	4962.72	3.55	5116.50	3.66	4990.68	3.57
Grassland with scattered cropland	5689.66	4.07	5074.56	3.63	2390.49	1.71
Inundated grassland	7632.81	5.46	12385.84	8.86	6598.32	4.72
Mixed cropland	29091.34	20.81	21738.12	15.55	12525.63	8.96
Natural forest	18061.51	12.92	15447.35	11.05	18089.47	12.94
Open woodland	97.86	0.07	4571.30	3.27	2865.80	2.05
Swamp	7674.75	5.49	13.98	0.01	1509.79	1.08
Urban area	391.43	0.28	1202.24	0.86	2082.95	1.49
Water	125.82	0.09	97.86	0.07	307.55	0.22
Woodland with scattered cropland	559.18	0.4	559.18	0.4	11784.72	8.43

Table 2.7: Net Land use, land use Change 2005 – 2015 for Moshi District

	Net Change (Hectares)			% of Initial Area		
	1995-2005	**2005-2015**	**1995-2015**	**1995-2005**	**2005-2015**	**1995-2015**
Bushed grassland	1621.6	5228.3	6850.0	1.2	3.7	4.9
Bushed with scattered crop land	0.0	3466.9	3466.9	0.0	2.5	2.5
Cultivation with herbaceous crops	43224.6	-41658.9	1565.7	30.9	-29.8	1.1
Cultivation with tree crops	-22772.6	22031.7	-740.9	-16.3	15.8	-0.5
Dense bush land	153.8	-125.8	28.0	0.1	-0.1	0.0
Grassland with scattered cropland	-615.1	-2684.1	-3299.2	-0.4	-1.9	-2.4
Inundated grassland	4753.0	-5787.5	-1034.5	3.4	-4.1	-0.7
Mixed cropland	-7353.2	-9212.5	-16565.7	-5.3	-6.6	-11.9
Natural forest	-2614.2	2642.1	28.0	-1.9	1.9	0.0
Open woodland	4473.4	-1705.5	2767.9	3.2	-1.2	2.0
Swamp	-7660.8	1495.8	-6165.0	-5.5	1.1	-4.4
Urban area	810.8	880.7	1691.5	0.6	0.6	1.2
Water	-28.0	209.7	181.7	0.0	0.2	0.1
Woodland with scattered cropland	0.0	11225.5	11225.5	0.0	8.0	8.0

For the 2005 to 2015 period, informative changes occurred in land under cultivation with tree crops. There was a great increment in the 2015 map, and this is concurrent with an enormous decline in the land under herbaceous crops. Land under cultivation with tree crops increased by 22 031.7 ha (Fig. 2.1). This is explained by farmers' extensive efforts to plant new higher-yield coffee plants and an emphasis on the benefits of shade, use of livestock manure and fodder crops.

This is the period in which coffee started to fetch high price after the primary agricultural co-operatives became independent from Kilimanjaro Native Co-operative Union (KNCU) and because of high prices farmers devoted to coffee production, the crop which was largely abandoned due to low prices in the 1990s. In the 2015 map a slight increase was also noted on the proportion of lands with bushed grassland and bush land with scattered cropland. A decrease was noted on mixed cropland and woodland with scattered crops. Further analysis showed that the proportion of areas covered with dense bush land, inundated grassland and swamps decreased between 1995 and 2005 period but increased during the period between 2005 and 2015 by 0.021, 3.63 and 4.9% respectively.

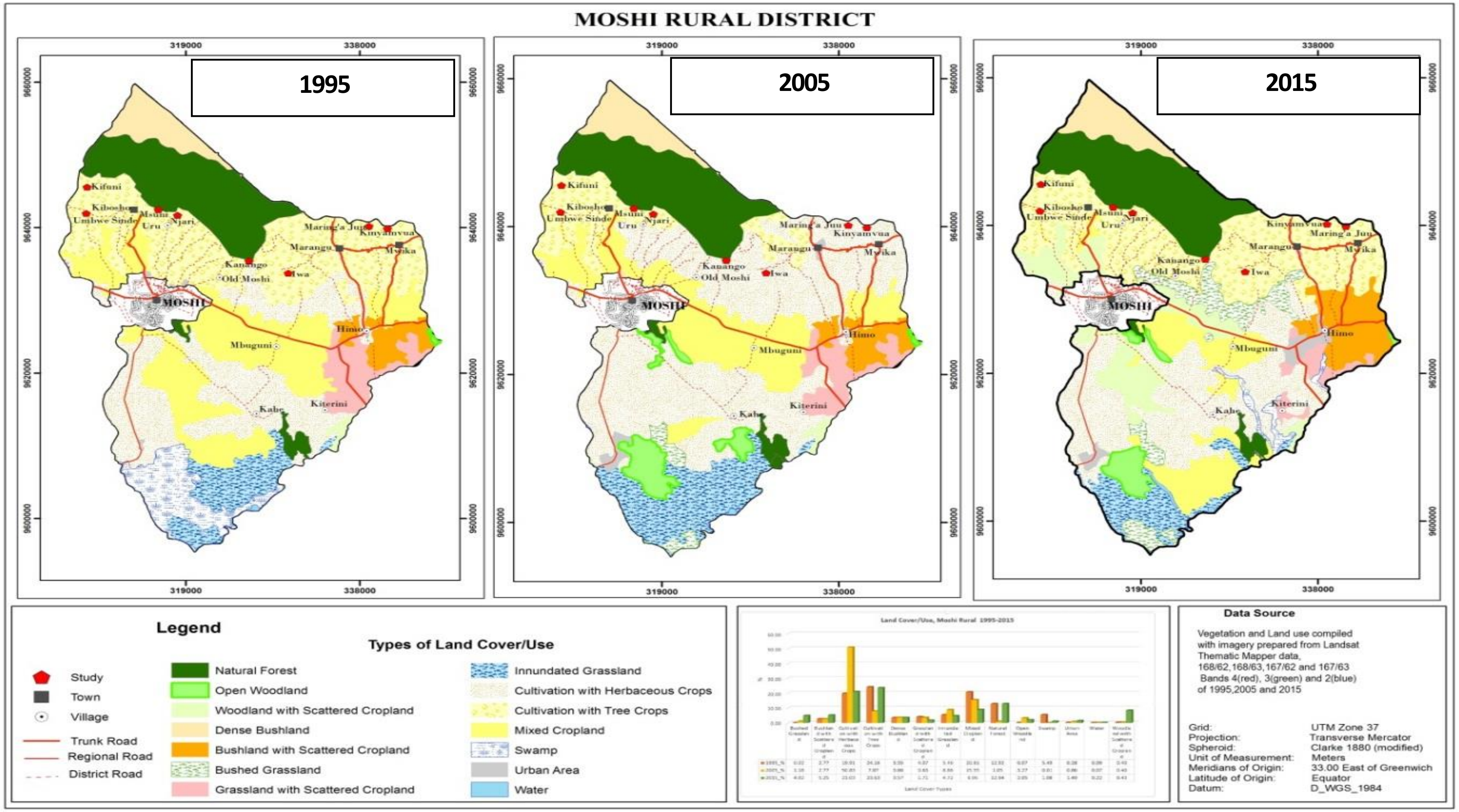

Figure 2.1 : Land use and Land use change maps for Moshi district 1995 - 2015

In Urambo District the results of the land use, land-use change generated for the three periods are presented in Tables 2.8 and Tables 2.9 and Fig. 2.2. From 2005 to 2010 significant land-use changes occurred. In the 2005 and 2010 maps the dominant land use type was woodland with scattered crops covering 50.08 and 36.21% of the total land area in 2005 and 2010 respectively. In 2010, map closed woodland almost doubled from 1644.15 hectares in 2005 to 3245.52 hectares. In 2015, the closed woodland further increased to 4339.58 hectares. A remarkable increase was also noted in the mixed crop land area; it increased by 5.20 and 14.04% in the two periods respectively. This increase is connected to a decrease of woodland with scattered crops.

Table 2.8: Land use and land-use coverage for 2005, 2010 and 2015 for Urambo District

Land Use/Cover Type	2005		2010		2015	
	Hectares	%	Hectares	%	Hectares	%
Closed woodland	1644.2	0.3	3245.5	0.5	4339.6	0.7
Open woodland	73748.5	12.1	50809.8	8.3	46561.9	7.6
Woodland with scattered cropland	306062.9	50.1	221312.7	36.2	149599.5	24.5
Open bushland	1882.5	0.3	984.1	0.2	556.2	0.1
Bushland with scattered cropland	2127.0	0.3	2322.6	0.4	2292.0	0.4
Bushland with emergent trees	67.2	0.0	67.2	0.0	67.2	0.0
Cultivation with herbaceous crops	22565.8	3.7	44746.6	7.3	43481.4	7.1
Mixed cropland	89866.1	14.7	121630.6	19.9	207468.8	33.9
Wooded grassland	641.8	0.1	641.8	0.1	641.8	0.1
Open grassland seasonally inundated	537.9	0.1	11869.7	1.9	11869.7	1.9
Wooded grassland seasonally inundated	95788.7	15.7	125737.9	20.6	78577.0	12.9
Bushed grassland seasonally inundated	14870.7	2.4	24197.8	4.0	55076.0	9.0
Swamp	110.0	0.0	110.0	0.0	110.0	0.0
Urban area	1136.9	0.2	3056.1	0.5	10549.5	1.7

Table 2.9: **Net Land use, land use Change 2005 – 2015 for Urambo District**

Land Use/Cover Type	Net Change			% of Initial Area		
	2005-2010	**2010-2015**	**2005-2015**	**2005-2010**	**2010-2015**	**2005-2015**
Closed woodland	1601.4	1094.1	2695.4	0.3	0.2	0.4
Open woodland	-22938.7	-4247.9	-27186.6	-3.8	-0.7	-4.4
Woodland with scattered cropland	-84750.2	-71713.2	-156463.4	-13.9	-11.7	-25.6
Open bushland	-898.5	-427.9	-1326.3	-0.1	-0.1	-0.2
Bushland with scattered cropland	195.6	-30.6	165.0	0.0	0.0	0.0
Bushland with emergent trees	0.0	0.0	0.0	0.0	0.0	0.0
Cultivation with herbaceous crops	22180.8	-1265.2	20915.6	3.6	-0.2	3.4
Mixed cropland	31764.5	85838.2	117602.7	5.2	14.0	19.2
Wooded grassland	0.0	0.0	0.0	0.0	0.0	0.0
Open grassland seasonally inundated	11331.8	0.0	11331.8	1.9	0.0	1.9
Wooded grassland seasonally inundated	29949.2	-47160.9	-17211.7	4.9	-7.7	-2.8
Bushed grassland seasonally inundated	9327.1	30878.3	40205.3	1.5	5.1	6.6
Swamp	0.0	0.0	0.0	0.0	0.0	0.0
Urban area	1919.2	7493.4	9412.6	0.3	1.2	1.5

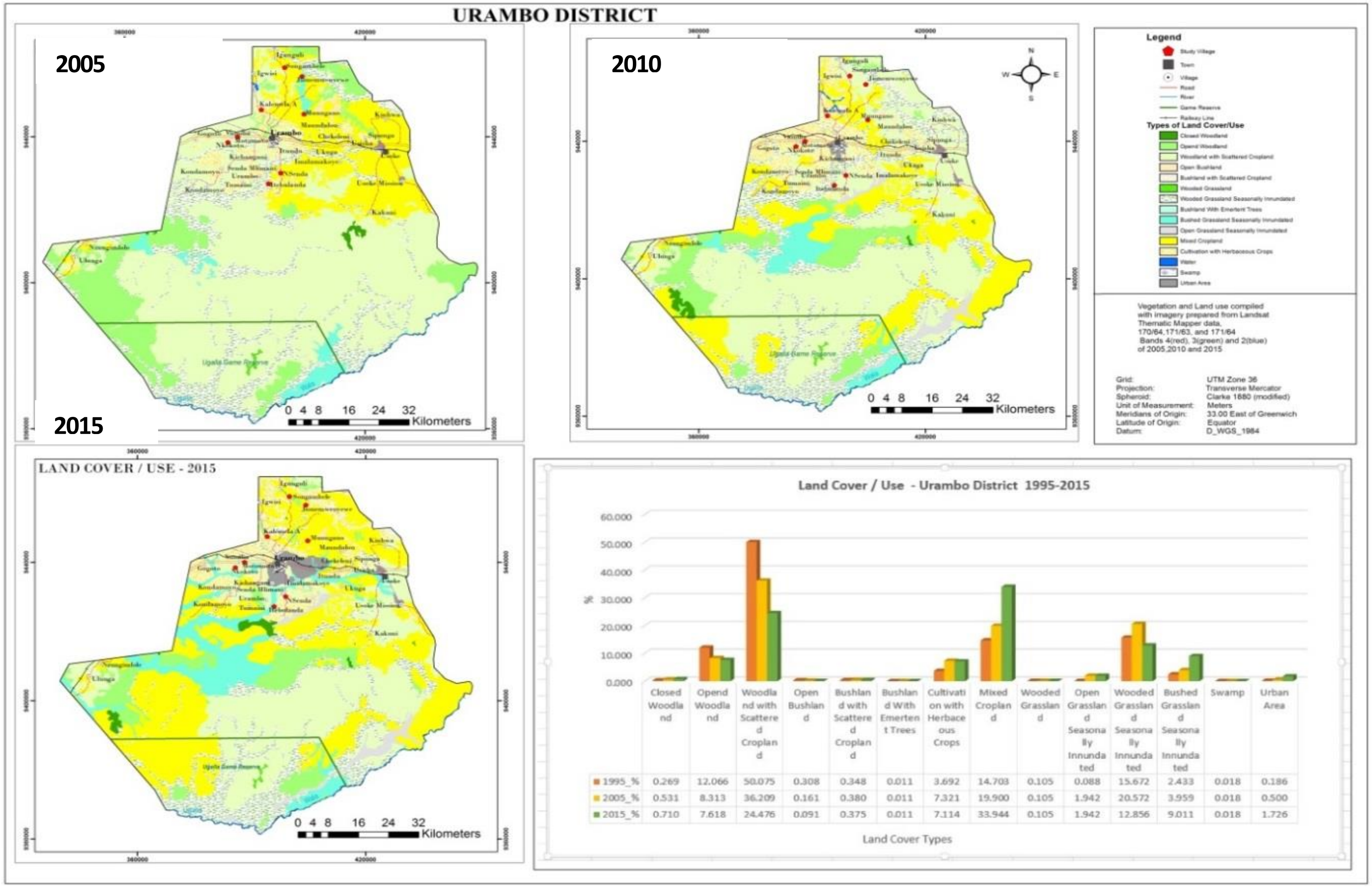

Figure 2.2: Land use and Land-use change maps for Urambo District 2005 – 2015

The 2015 map presents the results of the land cover changes in 2010 – 2015 where closed woodland vegetation increased significantly (26 95.43 hectares). Additionally, fascinating changes occurred in land under mixed cropland where there was a big increment in the 2015 map which is concurrent with an enormous decline in the land under woodland with scattered cropland (Fig. 2.2). According to the results, there was also an eminent decrease of open woodland by 3.75% on the 2010 map and 0.45% on the 2015 map.

Moreover, the proportion of land under cultivation with herbaceous crops increased significantly (22 180.7 hectares) in the period between 2005 and 2010 but decreased by 1265 hectares in the period between 2010 and 2015. As it was detected in the analysis, the bushed grassland seasonally inundated increased in the 2015 map, and this was connected to a decrease inland area under wooded grassland seasonally inundated vegetation. From the above analysis, the changes in land use and land use change varied across the study locations. The biggest change was the increase of agricultural land in proportion to other land use changes in all study areas. Mixed farming increased significantly in Urambo District. Other significant changes are the spreading of cultivation with tree cover crops in Moshi District and increase in closed woodland in Urambo District.

2.3.4 Drivers of land use and land-use change

Outputs from binary regression are summarized in Tables 2.10, 2.11 and 2.12. A good number of the explanatory variables were found to have significant effect on land-use change. In pooled logit model the variables intensive farming ($p < 0.05$), establishment of woodlots ($p < 0.01$), tobacco curing ($p < 0.1$) migration ($p < 0.1$), bylaws and regulations ($p < 0.1$) and population growth ($p < 0.001$) were statistically significant.

Table 2.10: Pooled logistic regression model for drivers of land-use and land use change in Urambo and Moshi Districts

Dependent Variable (1=Use 0=no use)	**Coefficient**	**P-Value**	**Marginal Effects** Coefficient	P-Value
Intensive farming	0 .821	0.021**	0.123	0.017
Extending of farmlands	0 .032	0.935	0.004	0.935
Crop rotation	-0. 676	0.143	-0.101	0.137
Establishment of woodlots	1.740	0.000***	0.260	0.000
Soil conservation	0 .266	0.580	0.039	0.579
Tree planting	-0.188	0.608	-0.028	0.607
Firewood collection	0.519	0.135	0.077	0.130
Timber and poles harvest	0.182	0.607	0.027	0.606
Tobacco curing	0.864	0.052*	0.129	0.048
Immigration	0.635	0.061*	0.095	0.056
Overgrazing	0.422	0.281	0.063	0.278
Conservation of natural forests	-0.097	0.764	-0.014	0.764
Energy saving stoves	-0.056	0.885	-0.008	0.885
Environmental pressure groups	0.418	0.197	0.062	0.193
Bylaws and regulations	0.647	0.096*	0.096	0.091
Population	1.426	0.000***	0.213	0.000
Constant	-2.374	0.000		
Number of observations	297			
Pearson chi2(254)	285.63			
Prob> chi2	0.0003			
Pseudo R2	0.3042			
Log pseudo-likelihood	-136.21448			

*Note: p-value significance level *** refers to 1%, ** refers to 5% and * refers to 10%*

The explanatory variables which showed statistically significant effect on LULUC for Moshi District and Urambo District logit regression models were establishment of woodlots, migration, use of energy efficiency stoves, population growth, tree planting and agroforestry for Moshi District; and intensive farming, establishment of woodlots, firewood collection, use of energy efficiency kilns/stoves, environmental pressure groups, and population growth for Urambo District (Tables 2.11 and 2.12).

Table 2.11: Logistic regression model for drivers of land use change in Moshi District

Dependent Variable (1=Use 0=no use)	**Coefficient**	**P-Value**	**Marginal Effects** Coefficient	P-Value
Intensive farming	0.654	0.229	0 .096	0.221
Crop rotation	-0.242	0.687	-0.035	0.687
Establishment of woodlots	1.825	0.003***	0.268	0.001
Agroforestry	-1.427	0.024**	-0.210	0.017
Farming land	-0.156	0.874	-0.023	0.874
Soil conservation	0.783	0.229	0.115	0.219
Firewood collection	0.118	0.823	0.017	0.823
Timber and poles harvest	0.660	0.162	0.097	0.152
Immigration	1.287	0.012**	0.189	0.007
Conservation of _natural forests	0.472	0.335	0.069	0.329
Energy saving stoves	-0.994	0.080*	-0.146	0.070
Environmental groups	0.189	0.707	0.027	0.707
Bylaws and regulations	0.134	0.830	0.019	0.830
Tree planting	1.548	0.029**	0.227	0.021
Population	1.699	0.002***	0.250	0.000
Constant	-1.921	0.026		
Number of observations	148			
Pearson chi2(124)	131.13			
Prob> chi2	0.0001			
Pseudo R2	0.3389			
Log pseudo-likelihood	-66.925345			

*Note: p-value significance level *** refers to 1%, ** refers to 5% and * refers to 10%*

Table 2.12: Logistic regression model for drivers of land use change in Urambo District

Dependent Variable (1=Use 0=no use)	Coefficient	P-Value	Marginal Effects Coefficient	Marginal Effects P-Value
intensive farming	1.702	0.013**	0.177	0.007
crop rotation	-1.093	0.237	-0.114	0.231
Establishment of woodlots	2.251	0.009***	0.235	0.005
Farming land	0.975	0.227	0.101	0.217
soil conservation	-1.297	0.239	-0.135	0.228
firewood collection	1.617	0.021**	0.168	0.014
Timber and poles harvest	0.747	0.525	0.078	0.524
Tobacco curing	0.832	0.145	0.086	0.134
Immigration	-0.491	0.426	-0.051	0.422
overgrazing	-0.328	0.562	-0.034	0.560
Conservation _natural forests	-0.344	0.556	-0.036	0.553
Energy saving stoves	1.696	0.014**	0.177	0.007
Environmental groups	1.138	0.054*	0.118	0.047
Bylaws and regulations	0.938	0.214	0.097	0.203
Population	2.121	0.002***	0.221	0.000
Constant	-3.346	0.001		
Number of observations	148			
Hosmer-Lemeshow chi2(8)	2.16			
Prob> chi2	0.9755			
Pseudo R2	0.3389			
Log pseudo-likelihood	-49.56965			

*Note: p-value significance level *** refers to 1%, ** refers to 5% and * refers to 10%*

Specifically, all other variables being equal, the odds that intensive farming influences LULUC was 3 times more likely than the perception that intensive farming has no influence on LULUC. Similarly, for Moshi District and Urambo Districts, the odds of the perception that intensive farming influences LULUC were 2.5 and 8 times more than the perceptions that it has no relationship to LULUC respectively. Intensive farming was found to increase the probability of land use change significantly at the 1% level in Moshi District, 0.2% in Urambo District and at 8% in pooled logit regression.

Additionally, key findings were that with all other variables kept constant, the perception that establishment of woodlots induces LULUC was statistically significant at 1%. As it was expected, woodlots had high probability of influencing land-use change at the 0.1% level of significant in Moshi District and 5% in Urambo District. Pooled together, woodlots increased the probability of land-use change significantly at 1% level of significance ($p < 0.01$).

The logistic regression results further showed that there was significant relationship between firewood collection and LULUC for Urambo District. The results were statistically significant at 5% ($p < 0.05$). Furthermore, all other variables held constant, the perception that migration influences LULUC was statistically significant at 1% and 5% levels in pooled and Moshi District regression models respectively. Migration in this context means internal migration from one region to another one or from one district to another one.

With regard to population growth pooled, Rural District and Urambo District logit regression models indicate that, holding all other variables constant, an increase in the number of human populations contributed to LULUC at 1%. Pooled logistic regression analysis showed that population growth increased chanced of land use change at $p < 0.01$ and for Moshi District, and in Urambo District population growth was found to increase the probability of land-use change significantly at $p < 0.01$ in each district. Findings also revealed that tree planting significantly influenced LULUC at 5% ($p < 0.01$) in Moshi District.

The use of energy saving stoves in both districts showed high probability of influencing land use change at 10% ($p < 0.1$) and 5% ($p < 0.05$) significant level for Moshi District and Urambo Districts respectively. The study observed the switch from the use of traditional burns to modern burns in tobacco curing. As explained by the extension officer, the use of modern burns reduces firewood consumption considerably, from 15 tons to as little as 7 tons of firewood for curing one acre of tobacco. Further analysis showed that modern burs, unlike traditional burns, use branches and therefore leave tree stems to regenerate.

As would be expected, agroforestry practices were more likely to influence land use change. Binary logistic regression indicated that, with all other factors kept constant, agroforestry increased chances of land use change at 5% significant level for Moshi District. Land under agroforestry increased by 22 031 hectares between 2005 and 2015. In these agro-ecosystems, trees (some over 50 years old) are grown in mixed banana coffee farms where maize is also grown. The agroforestry ecosystems also include windbreaks and live fences or boundary plantings.

Nevertheless, although not statistically significant, four variables (firewood collection, timber and poles harvest, tobacco curing, environmental pressure groups and by-laws and regulations) were mentioned by most of the respondents as important drivers of LULUC.

2.3 Discussion

2.3.1 Extent of land use, land use changes

The increase of land under cultivation with tree crops in Moshi district for the 2005 – 2015 period is explained by farmers' extensive efforts to plant new higher-yielding coffee plants and an emphasis on the benefits of shade, use of livestock manure and fodder crops. This is the period in which coffee started to fetch high price after the primary agricultural co-operatives became independent from Kilimanjaro Native

Co-operative Union (KNCU) and because of high prices farmers devoted to coffee production, the crop which was largely abandoned due to low prices in the 1990s.

The observed increase in closed woodland in Urambo district is due to introduction of village forest reserves, prohibitions on illegal harvest of poles and timber on forest reserves enforced by local government, use of energy efficiency tobacco curing kilns (modern barns) which, according to interviews with forest extension officer from Tanzania Leaf Tobacco Company Limited (TLTC), reduces wood consumption by half and conservation agriculture, a newly introduced farming system whereby trees, maize and sunflower are grown on the same piece of land at the same time. The big increment of land under mixed cropland in the 2015 map (Fig. 2.2) is mainly due to population growth which leads to more land being converted from indigenous vegetation to cropland and income diversification at household level where a variety of crops are grown for cash mainly maize, sunflower, groundnuts, rice, potatoes and vegetables. Moreover, the decrease of land under cultivation with herbaceous crops in the period between 2010 and 2015 can be explained by the re-growth of vegetation such as grass, herbs or shrubs in land left for fallow.

2.3.2 Intensive farming

An increased practice of intensive farming reduces forest land cleared for agriculture, thereby sparing more forest lands from being converted into crop fields. They also preserve forests and other native land. Intensive farming keeps carbon sequestered in the soils and forests. The study observed intensive farming practices in both study sites. In Moshi the study witnessed use of organic and chemical fertilizer in crop production and raising of cows, pigs and chickens. On the other hand, chemical fertilizer use was observed to be common in tobacco, maize and sunflower farming in Urambo district.

Faced by similar findings by Wu (2013) concluded that land use and land use changes such as agricultural intensification play a significant role in the global carbon cycle; it increases carbon sequestration in agricultural land uses. Thus, intensive farming is a potentially useful mechanism in global efforts to offset expanding greenhouse gas emissions. Similarly, Paustin *et al.* (2000) report that greater cropping intensity, i.e. reducing the frequency of bare fallow in crop rotations and increasing the use of perennial vegetation can increase water and nutrient use efficiency by plants, thereby increasing carbon inputs to the soil and reducing organic matter decomposition rates.

2.3.3 Establishment of woodlots

Apart from satisfying fuel wood demand, woodlots offset carbon emissions through alleviating harvesting pressure on native forests. In Urambo near to two-thirds (65.8%) of the respondents owned woodlots varying between 2 to 10 acres. The woodlots also have immense effect on carbon sequestration; they are said to have a large contribution to carbon sequestration. This observation is in line with those by Barrow and Shah (2012), who found that an estimated 23.2 million tons of carbon were sequestered on woodlots restoration project in Shinyanga Region, Tanzania. Similarly, Ngazi (2011) found out that rotational woodlots and *ngitiri* have the potential for carbon storage and soil fertility improvement. According to Makundi and Okiting'ati (1995), establishing woodlots is one of the options for mitigating climate change.

2.3.4 Migration

Migration in this context means internal migration from one region to another one or from one district to another one. In this study internal migration as a driver of land use, land use change was very pronounced in Urambo District where focus group discussion and in-depth interviews with key informants revealed in-migration into Urambo District which involved herdsmen who went there with their livestock from neighbouring districts of Shinyanga Region. This was reported to exert pressure on the *miombo* woodlands through overgrazing and extensive and unsustainable agricultural practices that led to the encroachment and degradation of the woodlands. These findings are supported by Sunderlin and Pokam (2002) who claim that migrants have shorter planning horizons, which cause them to be more destructive than host populations.

2.3.5 Population growth

While in Moshi District population growth is attributed to natural increase, in Urambo District migration plays an important role in population growth. In Moshi District, population increased from 342 891 in 1988 to 466 737 in 2012, and population density was 358.9 inhabitants per square kilometre. In Urambo District, on the other hand, the population was 192 781 and the population density was 35.6 inhabitants per square kilometre (URT, 2012). Higher population density increases the share of agricultural land, hence, higher demand for agricultural products and thus more pressure on the land and forests as investment in capital-intensive technologies is minimal to reduce the pressure on the land through improved productivity. This is reflected in the increase of land under crop land in both districts.

In Urambo District there was a net increase of 25.6% and 19.3% of land under woodland with scattered crops and mixed cropland respectively (Fig. 2.2). Similarly, in Moshi District there was an increase in land under bushed cropland and woodland with scattered cropland (Fig. 2.2). The relation between demographics and carbon emissions seems to be obvious. As the human population grows so does the demand for agricultural land; as more land is put under cultivation, more carbon pools are reduced. These findings echo Shi's (2001) conclusion in his study on population growth and global carbon dioxide emissions that one per cent of population growth is associated with a 1.28 per cent increase in emissions on average and that the impact of population pressure on emissions has been more pronounced in developing countries than in developed countries.

2.3.6 Tree planting

Although the idea that planting trees could be an easy (and often cheap) way to absorb emissions of carbon dioxide as well as its feasibility, it has however been challenged on the basis that after an initial growth spurt, trees grow more slowly and do not absorb as much excess carbon from the atmosphere as expected (Oren *et al.,* 2001). Many studies consider trees to be a terrestrial carbon sink (Schroeder, 1992; Schroeder; Makundi and Sathaye, 2004); tree planting presents an opportunity to increase the terrestrial carbon sinks and slow increase in atmospheric CO_2 concentration. Carbon is stored in trees (stem, branches, leaves and root), understory, litter and soils (Sharrow and Ismail, 2004). Trees, because of their carbon storage capacity, present an important opportunity for carbon emissions mitigation (van Kooten, *et al*., 1999).

In this study, it was revealed that 96% reported to plant trees to meet fuel wood demand; 33.7% did so for timber and construction poles, 34% for fodder and 35.2% for tobacco curing. In Moshi District tree planting is done to meet timber and fuel wood demand. The study further revealed that bare land in upper belt is planted with trees and also lands left by owners who migrated to towns are planted with trees. In Urambo, tree planting is done in degraded croplands and is a requirement for one to enter into tobacco contract farming. Trees mostly planted in Urambo District are *Albizia* species, *Cassia siamea* (mijohoro) and Eucalyptus species.

2.3.7 Use of energy efficient stoves

The study observed a switch from the use of traditional burns to modern burns in tobacco curing. As explained by the extension officer, the use of modern burns reduced firewood consumption considerably, from up to 15 tons to as little as 7 tons of firewood for curing one acre of tobacco. Further analysis showed that modern burns unlike traditional burns use branches and therefore leave the tree stem to regenerate. This suggests that more use of energy efficiency stoves offsets carbon through relieving pressure on the forests and other woody vegetation. Barnes *et al.* (1993) reported that the use of energy efficiency stoves from the point of view of greenhouse effects contribute to increasing the efficiency of combustion while promoting sustainable biomass harvesting, lessening the pressure on biomass resources and reducing the emissions of carbon dioxide to the atmosphere. Similarly, the benefits of improved cooking stoves, according to García-Frapolli *et al.* (2010), include fuel wood savings, income generation, environmental conservation, and reduction in greenhouse gas emissions.

2.3.8 Agroforestry

Agroforestry has importance as a carbon sequestration strategy because of carbon storage potential in its multiple plant species and soil as well as its applicability in agricultural lands and in reforestation. A variety of environmental benefits found in this study are also similar to those found in other studies, although in this particular study farmers put more emphasis on the benefits of shade, livestock fodders, fruits and wood products. Souza *et al.* (2011) and Singh and Pandey (2011), quoted in Richard *et al.* (2013), argue that the major role of agroforestry in adaptation to changing environmental conditions was through supporting the production of a wide range of products including food, fuel wood, fodder and forage, timber, shade, gardening material, medicine, and ecological services.

Similarly, according to Mutuo *et al.* (2005) in their study on the potential of agroforestry for carbon sequestration and mitigation of GHG emissions from soils in the tropics, agroforestry systems are promising management practices that increase above ground and soil carbon stocks, reduce soil degradation and mitigate GHG emissions. They reported that in the humid tropics, the potential of agroforestry tree-based systems to sequester carbon in vegetation can be over 70 Mg C ha^{-1}, and up to 25 Mg ha^{-1} in the top 20 cm of soil, and that in degraded soils of the sub-humid tropics, improved fallow agroforestry practices have been found to increase top soil carbon stocks up to 1.6 Mg C ha^{-1} y^{-1} above continuous maize cropping.

Some of the common tree species found in the agro-ecosystems in Moshi District are *Albizia schimperiana* and *Albizia maranguens* used for coffee shade, fuel wood and building materials; *Bridelia micrantha* for building poles, fodder, and roots used medicinally; *Cordia africana* for coffee shade, fuel wood, building material, beehive construction; and *Dracena afromontana* for live fence and boundary marker. Boundary plantings contribute to improvement of the soil conditions and indirectly enhance carbon sequestration by improving crop productivity and reducing erosion-induced soil losses (Albrecht, and Kandji, 2003). In Urambo District, trees are grown together with maize and sunflower.

Although agroforestry may involve practices that favour the emission of GHGs including shifting cultivation, pasture maintenance by burning, paddy cultivation (Dixon, 1995; Le Mer and Roger, 2001), inclusion of trees in the agricultural landscapes often improves the productivity of systems while providing opportunities to create carbon sinks (Dixon, 1995; Montagnini and Nair 2004). Integrating trees on farms and landscapes contributes to reducing emissions from deforestation and forests and relieves pressure off the forests arising from demand for fuel-wood, charcoal, and timber and improves soil fertility and boost productivity through nitrogen fixing trees, thus enabling farmers to maximize yields in available plots of land without the pressure to deforest more farmland (Albrecht, and Kandji, 2003; Mutuo *et al.,* 2005; Alfaia *et al.,* 2012; Minang *et al.,* 2014).

2.4 Conclusion and Recommendations

The drivers of LULUC presented here are a generalized interpretation of the farmers' responses as extracted from the field survey. Major changes in land use have occurred on both ecosystems, and they vary overtime. Intensive farming, establishment of woodlots, use of energy efficiency stoves, agroforestry practices, migration, population growth, tree planting, crop rotation and conservation of natural forests were important drivers of land use and land use changes.

Education on agricultural practices that reduce emissions and enhance carbon pools should be enhanced and where possible extension services should be provided. Demographic policies that halt population growth should be enacted.

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CHAPTER THREE

Paper two

Co-operatives' activities linked to carbon emissions and carbon sequestration through land use, land-use change and forestry in Tanzania

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Abstract

Reduction of GHGs and carbon sequestration in terrestrial ecosystems are affected by the actions or inactions of various actors including co-operatives. This study was conducted to explore co-operatives' actions or lack of such actions with respect to GHG emissions and carbon removals through land use, land-use change and forestry (LULUCF). A sample of 297 households was systematically selected from 16 villages for the study.

A questionnaire survey, in-depth interviews and focus group discussions were used to collect primary data on co-operative actions linked to GHG emissions and enhancement of carbon sinks. A Binary logistic regression analysis was used in data analysis. The results showed that majority of the respondents (78.8%) were aware of the land use and land use changes occurring in the areas of study. The prominent changes include increase in forested land resulting from intensive farming, soil conservation, agroforestry and tree planting. The results further revealed that a number of co-operative actions had statistically significant link to carbon emissions reduction and enhancing carbon sinks through LULUCF. Such actions included marketing of agricultural products ($p<0.1$), supply of agricultural inputs ($p<0.05$), provision of agro-credits and agricultural and forestry extension services ($p<0.01$), promotion of agroforestry practices ($p< 0.05$), adoption of organic farming and supply of better and improved seeds ($p<0.01$). The study concludes that there is a strong relationship between co-operatives' actions and GHG emissions and enhancement of carbon stock through LULUCF. Efforts to mitigate climate change through this sector should be built on co-operatives' activities that reduce GHG emissions and/or enhance carbon sinks.

Keywords: *Co-operatives, co-operative actions, Carbon Emissions, Carbon sinks, Land Use, Land-Use Change, Forestry and binary logistic regression*

3.1 Introduction

Land-use changes due to agricultural production contributes significantly (24%) to GHG emissions globally (Pachauri *et al.,* 2014). It is estimated that 50% of all potentially world's vegetated land surface has been converted to croplands, pastures and rangelands (Foley *et al.,* 2005) and these continue to expand to feed the planet's growing population (Elbehri, 2015.) as well as large demands for fuel and fibre. Currently most of this expansion is taking place in the tropics where an estimated 80% of the croplands is replacing forests (Elbehri, 2015). Within this context, there is an increasing global recognition of the need for incentives for agricultural practices that reduce GHG emissions from land use land-use and forestry as well as enhancing carbon sequestration. It is hypothesised that co-operatives' actions linked to LULUCF have the potential to make an important contribution to reducing GHG emissions from agriculture, animal husbandry, deforestation and forest degradation (Birchall, 2003).

Co-operatives as self-help organizations play a significant role in uplifting the socio-economic conditions of their members and that of their local communities. They operate as people centred businesses and also serve as catalysts for social organization and cohesion. The International Co-operative Alliance (ICA) which is apex organization that represents co-operatives worldwide, defined a co-operative as: "An autonomous association of persons united voluntarily to meet their common economic, social and cultural needs and aspirations through a jointly owned and democratically controlled enterprise" (ICA, 2018).

Evidence suggests that co-operatives create opportunities for members not only to reap economic benefits but also facilitate societal development including improvements in environmental health, quality of life and community economic stability

(Blinn *et al.*, 2007). Unfortunately, the co-operative sector has received little attention in climate change mitigation strategies despite having the capability in mobilizing communities to collectively address LULUCF interventions which lead to positive facets of human interaction that include, among others, income generation, risk reduction, social networking, education, information sharing, and public service provision (Wanyama, 2016). By pooling capital, labour, goodwill, and other resources, co-operative members engage in worthwhile activities, which, if undertaken by individuals, would involve greater transaction cost, risk, and efforts.

Co-operatives are obliged to promote sustainable conservation of natural environment for the wellbeing of their members and communities at large and members play a critical role in such endeavours which also go a long way which measures on environmental conservation and activities aimed at reducing GHG emissions from deforestation and forest degradation and/or enhanced carbon sinks.

Works on co-operatives (Sizya, 2001; Majee and Hoyt, 2011 and Bharadwaj, 2012; Wanyama, 2016; Suh, 2015; Herbel*et al.*, 2015) have dwelt more on the critical role played by co-operatives in sustaining socio-economic existence of many communities. However, there is lack of attention on co-operatives' contribution to reducing GHG emissions and enhancing carbon sinks through LULUCF. To better understand the potential of co-operatives in mitigating climate change, it is important to explore what co-operative activities are linked to GHG emissions reduction and enhancing carbon sinks through LULUCF. Therefore, the study on which this paper is based explored and analysed the current and projected co-operatives' actions linked to carbon emissions and carbon sequestration through LULUCF in agroforestry and *miombo* woodland agro-ecosystems.

Specifically, the paper focused on understanding co-operatives members' activities and co-operatives' actions linked to GHG emissions and/or enhancement of carbon terrestrial sinks through land use and land-use change and forestry. The broad argument is that co-operatives have the advantages of identifying economic opportunities for the poor; empowering the disadvantaged to defend their interests; and providing security to the poor by allowing them to convert individual risks into collective risks." However, empirical evidence is necessary to show how co-operatives could play a very crucial role in GHG emissions reduction and/or enhancement of carbon sinks if they operate in accordance to the universally accepted co-operative organizing principles and core values. The main question was is there a link between co-operative actions and GHG emissions and carbon sinks? The findings of this study contribute to the understanding of the role of co-operatives in climate change mitigation, particularly through LULUCF. As such the study provides basic information on the role co-operatives play in GHG emissions and enhancing carbon sinks in their normal co-operative activities, particularly reducing deforestation while playing a part in a global scheme to mitigate climate change. Of germane interest is the ability of co-operatives to assist their members to participate in the global carbon market and increase their income through reducing GHG emissions and/or enhancing carbon sinks.

The paper on the co-operative's activities linked to carbon emissions and carbon sequestration through land use, land-use change and forestry provides some new empirical evidences that may help us to understand the conditions under which co-operatives are involved in climate change mitigation through LULUCF and improvement of rural welfare. The paper was guided by economic theory of co-operatives by Helmberger and Hoos (1962). The theory explores possible roles of agricultural co-operatives in dealing with the fundamental problems of coordinating economic activities including climate change services by improvement of members' livelihood objectives than profit maximization members benefits. The researcher also hopes that this paper provides new insight for policymakers, researchers, and development practitioners.

3.2 Materials and Methods this Section is also Found in Chapter Two

3.2.1 Study area

The study was conducted in two rural areas of Moshi and Urambo Districts, Tanzania. In both districts co-operatives had been dominant drivers of economic activities for a long time: Kilimanjaro Native Co-operative Union (KNCU) for Moshi District and Western zone Tobacco Growers Co-operative Union (WETCU) for Urambo District. The dominant vegetation in Urambo District is *miombo* woodlands, which play an important role as carbon sinks and which are under threats by anthropogenic activities, particularly tobacco farming which is coordinated by primary co-operatives. In Moshi District the dominant farming system is a multi-storied agro-forestry cropping system which involves the integration of several multi-purpose trees and shrubs with food and cash crops and livestock on the same unit of land. The dominant tree species include *Albizia schimperiana* (*mruka*), *Grevillea robusta* (*mwerezi*), *Albizia gummifera* (*mfuruanji*), *Croton macrostachyus* (*mfurufuru*), *Cordia africana* (*mringaringa*), and *Persea americana* (*mparachichi*). There is an intimate relationship between the farmers and the surrounding forests which have an emissions/sinks component. The farmers in the two districts are mostly integrated in co-operatives, making them relevant for this study.

3.2.2 Research design, sampling and data collection methods

The study adopted a cross-sectional design in examining co-operative actions linked to carbon emissions reduction and enhancing carbon sinks. Data were collected in the study areas in a specified period. The target population of the study included all farmers in the study areas, and a sample of respondents was drawn from the selected villages. Both probability and non-probability techniques were used for sampling. Purposive sampling was employed to get 16 co-operative societies from the four wards in each district; then systematic sampling was applied to obtain the households in each village where respondents were obtained. A list of households from village offices was used to obtain the population of household heads who had stayed in the villages for not less than five years. For villages where such lists were not available the lists that were used were generated by the help of village and hamlets leaders. A sample size of 384 farmers was predetermined using the formula by Fisher *et al*. (1991) for population greater than 10 000. It was considered adequate at 95% confidence level, 5% margin of error and 50% skew level.

From the predetermined sample size, a total of 297 respondents were covered, 149 respondents from Moshi District and 148 from Urambo District. This sample size represented 77.3% response rate. The response rate conforms to a stipulation by Mugenda and Mugenda (2003) that a response rate of 50% is adequate for analysis and reporting; a rate of 60% is good and a response rate of 70% and above is excellent.

3.2.3 Data collection

Both qualitative and quantitative approaches for data collection and analysis were done using a questionnaire survey, enriched by focus group discussions (FGDs), key informant interviews and direct observation. The survey was undertaken using a structured questionnaire that included both open-ended and close-ended questions. In the survey questionnaire respondents were asked to select actions/services provided by co-operatives to members.

3.2.4 Data analysis: Theoretical and empirical model

Qualitative data were analysed by coding arguments given by the interviewees, determining similarities and differences in the arguments. Quantitative data were analysed by computing descriptive statistics, multiple response analysis and by binary logistic regression analysis. To determine key co-operative activities linked to GHG emission and carbon sinks through LULUCF, a binary logistic model was used. Factors crucial to the selection of the independent variables (predictors) arises from results of previous studies. A study by Tollefson (2010) titled, "Intensive farming may ease climate change" indicates that investments in agricultural yields reduce carbon emission. Burney *et al.* (2010), in their article captioned "Greenhouse gas mitigation by agricultural intensification", concluded that the carbon savings from land use outweighs the increased agricultural emissions". Intensive farming on the other hand contributes directly to emissions of GHGs through a variety of processes, including enteric fermentation in domestic livestock, animal manure management systems, agricultural fertilization and soil management (IPCC, 2007, Johnson *et al.*, 2007; Smith, 2014).

The literature further indicates that planting trees, agroforestry and organic agriculture are strongly correlated with GHG emissions and carbon sinks (Cacho *et al.,* 2003; Schoeneberger, 2009; Soto-Pinto *et al.,* 2010; Jose and Bardhan, 2012). Also growing trees sequesters large amounts of carbon dioxide from the atmosphere through photosynthesis; an increase in biomass from the growth of forests (both above ground and below ground) provides a carbon sink (Takle and Hofstrand (2015). Carbon sequestration through the implementation of agroforestry practices is identified as one of the major strategies in the reduction of carbon emissions from the agricultural sector (Takle and Hofstrand, 2015; Dixon, 1995); and organic agriculture plays a significant role both for reducing GHG emissions and to sequester carbon (Jarecki and Lal 2003; Kotschi and Müller-Sämann 2004, (Jezeer *et al.*, 2017).

It was also found that agricultural loans and credit programmes, access to markets were generally associated with higher deforestation rates (Zwane, 2007). Other studies also show that alternative income generating activities ((Lupala *et al.*, 2015); Certification of crops (Silas, 2014; Tscharntke *et al.*, 2015), supply of improved seeds (Thapa, 2008) and provision of agricultural extension services were significantly related to decrease in deforestation rate.

Considering the review of the previous studies, thirteen predictors (independent variables) were selected for this study in developing the probability equation. Co-operatives' activities linked to GHG emissions and carbon sequestration was captured as a dummy (dependent variable) and denoted as Y, and the actions/services provided by co-operatives to members (independent variables) were denoted by X. The model was specified as follows:

$$Y_c = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \cdots \beta_{13} X_{13} + \varepsilon \quad \text{......................................} (1)$$

Where:

Y_c = carbon emissions reduction and enhancement of carbon sinks; Yes = 1 if co-operative action/service provided to members, No = 0 otherwise

$X_1 - X_{13}$= explanatory variables

β_1- β_{13} = parameter coefficients to be estimated

α = constant

ε = error term

The explanatory variables (X_1) and their *a priori* expectations are presented in Table 3.1.

Table 3.1: A priori expectation of variables in the logistic model on Co-operative activities linked to carbon emissions in Urambo and Moshi Districts

Label	Variable Name	Description	Hypothesized effect
X_1 =	Marketing of agricultural produce	Dummy; Yes=1, No=0	+/-
X_2 =	Provision of loan	Dummy; Yes=1, No=0	-
X_3 =	Supply of agricultural inputs	Dummy; Yes=1, No=0	+
X_4 =	Provision of agricultural extension services	Dummy; Yes=1, No=0	+
X_5 =	Provision of agro-credits	Dummy; Yes=1, No=0	-
X_6 =	Promotion of intensive farming	Dummy; Yes=1, No=0	+/-
X_7 =	Promotion of alternative IGAs	Dummy; Yes=1, No=0	+/-
X_8 =	Provision of improved seeds	Dummy; Yes=1, No=0	+
X_9 =	Promotion of agroforestry practices	Dummy; Yes=1, No=0	+
X_{10} =	Involvement in environmental conservation	Dummy; Yes=1, No=0	+
X_{11} =	Provision of dividends	Dummy; Yes=1, No=0	+
X_{12} =	Promotion/support of organic farming	Dummy; Yes=1, No=0	+
X_{13} =	Involvement in tree planting	Dummy; Yes=1, No=0	+

3.3 Results

3.3.1 Socio-demographic characteristics of the respondents

The analysis of respondents' socioeconomic characteristics in Table 3.2 shows that the majority (81.8%) were male, while the remaining 18.2 % were female. The per cent of males in Urambo District (89.3%) was significantly higher than that for Moshi District (74.3%). There was no significant difference between the age distributions of the respondents from the two districts although those from Moshi appeared to be older than their counterparts in Urambo District. The mean age was 52.7 years (minimum 22, maximum 94, range 72, SD 14.67).

With regard to education, primary education was the typical education level for most of the respondents from the two districts (70.1% for Moshi District and 76.7% for Urambo District). The major income generating activity was crop production, followed by animal husbandry and trade. Regarding membership to co-operatives, 80.8% were members of co-operative societies disaggregated into Agricultural Marketing Co-operative Societies (78.9%); Savings and Credit Co-operative societies (10.2%) and Village Community Banks or VICOBA (11%).

Table 3.2: Respondents' socio-demographic characteristics

S/N	Socio-demographic Characteristics	Moshi	Urambo	Overall
1.	Gender (%)			
	Male	74.3	89.3	81.8
	Female	25.7	10.7	18.2
2.	Marital status of respondent (%)			
	Single	2.7	16.1	9.4
	Married	79.1	77.2	78.1
	Separated/ Divorced	3.4	2	2.7
	Widow/er	14.9	4.7	9.8
3.	Age of respondent (mean)	59.3	46.1	52.7
4.	Household size (count) mean	4.9	7.3	6.2
5.	Awareness on Land use and land-use changes (%)	75.7	81.9	78.8
6.	Main income generating activity (%)			
	Crop production	84.5	97.3	90.9
	Animal husbandry	11.5	1.3	6.4
	Trade	3.4	1.3	2.4
	salaried employment	0.7	-	0.3
7.	Level of education (%)			
	No formal education	3.4	7.4	5.4
	Primary	71.0	82.6	76.7
	Secondary	19.6	8.7	14.1
	Middle-level college	4.1	1.3	2.7
	University	2	-	1
8.	Annual household income (Tshs) (mean)	2,011,832	2,626,627	2,320,264

3.3.2 Distribution of respondents based on types of co-operatives

The distribution of co-operative members (co-operators) based on type of co-operative societies is presented in Table 3.3. As expected, the results show that the majority (96.8%) of co-operators were members of agricultural marketing co-operative societies (AMCOS). The results showed no appreciable variation in membership among SACCOS (17.7%) and VICOBA (19.1%). With regard to specific districts, however, Moshi District had more membership in SACCOS (26.1%) and VICOBA (27.6%) compared to Urambo District where membership in SACCOS and VICOBA was 4.7% and 5.8% respectively.

Table 3.3: Co-operative Types and Membership

District	Co-operative Types	No.	Per cent
Moshi	Agricultural Marketing Co-operatives (AMCOS)	145	97.0
	Savings and Credit Co-operative Societies	39	26.1
	Village Community Banks (VICOBA)	41	27.6
	Total	**225**	**150.7**
Urambo	Agricultural Marketing Co-operatives	143	96.5
	Savings and Credit Co-operative Societies	7	4.7
	Village Community Banks	9	5.8
	Total	**159**	**107.0**
Overall	Agricultural Marketing Co-operatives	287	96.8
	Savings and Credit Co-operative Societies	53	17.7
	Village Community Banks	57	19.1
	Total	**397**	**133.6**

3.3.3 Land Use and Land-use Changes

Land use and land-use changes detected varied across the study locations. In Moshi District, drastic land-use changes occurred between 1995 and 2015. The major change observed between 1995 and 2005 was the replacement of tree crops (agroforestry) with herbaceous crops. It was evident that land under herbaceous crops had expanded at the expense of growing tree crops. In the same period (1995 to 2005) the percentage of dense bush land and bushed grasslands increased slightly. Notable increase in land under open woodlands, urban area and inundated grassland is also evident. Between 2005 and 2015 informative changes occurred. There was a substantial increment in land under cultivation with tree crops. This is explained by farmers' extensive effort to uproot the old coffee trees and planting new higher-yield coffee plants and an emphasis on the benefits of shade, use of livestock manure and fodder crops. This is the period in which coffee started to fetch high prices following some primary agricultural co-operatives becoming independent from Kilimanjaro Native Co-operative Union (KNCU). Because of higher coffee prices, farmers devoted time and efforts to coffee production, the crop which was largely abandoned due to low prices in the preceding decades. In the same period the area under mixed cropland and woodland with scattered crops decreased.

In Urambo District on the other hand, significant land-use changes occurred between 2005 and 2010 whereby woodlands with scattered crops decreased from 50.08% to 36.21% of the total land area whereas closed woodlands almost doubled from 1 644.15 hectares to 3 245.52 hectares. In 2015, the closed woodlands further increased to 4, 339.58 hectares. A remarkable increase was also noted in the mixed crop land area, which increased by 5.20 and 14.04 per cent in the two periods respectively. This increase is linked to a decrease in the area of woodlands with scattered crops. The observed increase in closed woodland is due to introduction of village forest reserves, prohibitions on illegal poles and timber harvesting in gazetted forest reserves, enforced by local government, use of energy efficient tobacco curing kilns (modern barns) which, according to interviews with forest extension officer from Tanzania Leaf Tobacco Company (TLTC), reduce wood consumption by half and conservation agriculture, a newly introduced farming system whereby trees, maize and sunflower are simultaneously grown on the same piece of land. Additionally, substantial changes occurred in land under mixed cropland where there was a big increment in 2015, concurrent with an enormous decline in the land under woodland with scattered cropland.

Moreover, the proportion of land under cultivation with herbaceous crops increased significantly (22, 1 80.7 hectares) in the period between 2005 and 2010 but decreased by 1265 hectares in the period between 2010 and 2015. This can be explained by the re-growth of natural vegetation such as grass, herbs or shrubs in land left for fallow.

3.3.4 Co-operatives' actions linked to GHG emissions and carbon sinks through land use and land use change and forestry

This part presents the findings relating to co-operative actions linked to GHG emissions and carbon sinks through land use and land-use change and forestry. Binary Logistic regression analysis was done in both districts. The findings are presented in Tables 3.4, 3.5 and 3.6.

Table 3.4: Pooled Logistic regression model for co-operative actions that reduce GHG emissions and enhance carbon sinks through land use and land-use change in Moshi and Urambo Districts

Dependent Variable	Coefficient	P-Value	Marginal Effects Coefficient	Marginal Effects P-Value
Marketing agricultural produce	-2.719	0.063*	-0.078	0.025
Provision of loans	-0.009	0.993	-0.002	0.993
Supply of agricultural inputs	2.892	0.035**	0.083	0.001
Provision of extension services	3.923	0.005***	0.113	0.000
Provision of agro-credits	1.754	0.090*	0.051	0.105
Promoting intensive farming	2.232	0.055*	0.064	0.004
Promoting _alternative IGAs	4.335	0.000***	0.124	0.000
Supply of seeds	3.729	0.000***	0.107	0.000
Promotion of agroforestry	4.608	0.017**	0.132	0.606
Environmental conservation	5.705	0.000***	0.164	0.000
Distribution of dividends	2.259	0.089*	0.065	0.176
Promotion of organic farming	5.100	0.000***	0.146	0.001
Crop certification	1.559	0.081*	0.045	0.033
Planting trees	3.235	0.002***	0.093	0.000
Promotion of savings	1.374	0.091*	0.039	0.047
Constant	-18.848	0.000		
Number of observations	297			
number of groups	10			
Hosmer-Lemeshow chi-square (8)	2.02			
Prob> chi-square2	0.9803			
Pseudo R2	0.8602			
Log pseudo-likelihood	-27.843111			

Note: p-value significance level *** refers to 1%, ** refers to 5% and *refers to 10%

(Dependent variable is Reduction of Carbon Emissions: Yes = 1 if co-operative action/service provided to members the stated variable, no = 0 otherwise)

Table 3.5: Logistic regression model for co-operatives' actions that reduce GHG emissions and enhance carbon sinks through land use and land-use for Moshi District

			Marginal Effects	
Dependent Variable	**Coefficient**	**P-Value**	**Coefficient**	**P-Value**
Marketing agricultural produce	-6.626	0.001***	-0.213	0.000
Providing loans	-1.171	0.386	-0.037	0.391
Supplying agricultural inputs	2.667	0.155	0.086	0.064
Providing extension services	2.394	0.026**	0.077	0.008
Providing agro-credits	-0.075	0.949	-0.002	0.949
Promoting intensive farming	3.001	0.044**	0.096	0.005
Promoting _alternative IGAs	3.737	0.021**	0.120	0.001
Supplying seeds	6.443	0.006***	0.207	0.000
Environmental conservation	5.977	0.006 ***	0.192	0.001
Promoting organic farming	2.721	0.009***	0.087	0.008
Promoting savings	2.685	0.035**	0.086	0.012
Constant	-7.717	0.021**		
Number of observations	148			
Hosmer-Lemeshow chi-square (8)	12.19			
Prob> chi-square2	0.1430			
Pseudo R2	0.8287			
Log pseudo-likelihood	-15.971994			

Note: p-value significance level *** refers to 1%, ** refers to 5% and * refers to 10% (Dependent variable is Reduction of Carbon Emissions: yes = 1 if co-operative action/service provided to members the stated variable, no = 0 otherwise)

Table 3.6: Logistic regression model for co-operatives' actions that reduce GHG emissions and enhance carbon sinks through land use and land-use changes for Urambo District

			Marginal Effects	
Dependent Variable	**Coefficient**	**P-Value**	**Coefficient**	**P-Value**
Marketing agricultural produce	-2.328	0.145	-0.064	0.190
Providing loans	4.898	0.004***	0.136	0.000
Supplying agricultural inputs	1.719	0.193	0.047	0.204
Providing extension services	7.026	0.000***	0.195	0.000
Providing agro-credit	1.547	0.325	0.043	0.264
Promoting intensive farming	2.270	0.081*	0.063	0.045
Promoting alternative IGAs	5.710	0.000***	0.158	0.000
Supplying seeds	5.962	0.000***	0.165	0.000
Environmental conservation	7.329	0.000***	0.203	0.000
Promoting organic farming	1.841	0.154	0.051	0.186
Promoting savings	-1.613	0.109	-0.044	0.151
Constant	-20.916	0.000		
Number of observations	149			
Hosmer-Lemeshow chi-square (8)	2.02			
Prob> chi-square	0.9804			
Pseudo R2	0.8646			
Log pseudo-likelihood	-13.929285			

Note: p-value significance level *** refers to 1%, ** refers to 5% and * refers to 10%

(Dependent variable is reduction of Carbon emissions: yes = 1 if co-operative action/service provided to members, no = 0 otherwise)

Marketing of agricultural produce was found to be statistically significant in influencing land use and land-use change for pooled and Moshi District regression models at $p < 0.1$ and $p < 0.001$ respectively. The negative and significant involvement of co-operatives in marketing farmers' produce implied that a 10% increase in marketing of agricultural produce increased GHG emissions and was linked to reduction of carbon sinks. Supply of agricultural inputs, other variables being constant, was positive and significantly ($p < 0.05$) linked to LULUCF that reduced emissions and increased carbon removals for pooled regression model. By contrast, supply of agricultural inputs was not significant in increasing emissions and enhancing carbon sinks when districts were analysed independently.

Provision of agro-credit on the other hand was also found to have a statistically significant influence on GHG emissions reduction and enhancement of carbon sinks through LULUCF at 10% ($p < 0.1$). Similarly, agricultural and forestry extension services had a statistically significant link to GHG emissions reduction and enhancement of carbon removals through land use and land-use change and forestry for pooled and Moshi District models at 1% and 5% respectively. In Urambo District extension services had statistically significant link to GHG emissions reduction and carbon sequestration at 1% ($p < 0.01$).

Intensive farming, as expected, was significantly linked to GHG emissions reduction and enhancement of carbon sinks through LULUCF in all regression models. It was found to be statistically significant at 10% ($p < 0.1$) for pooled regression model and at 5% ($p < 0.05$) and 0.1% ($p < 0.001$) for Moshi and Urambo Districts respectively. Promotion of alternative income generation activities (IGAs), other variables remaining constant, showed to have a statistically significant link to GHG emissions reduction and carbon sinks enhancement through LULUCF at 1% for both pooled regression ($p < 0.01$) and Urambo District models ($p < 0.001$) and 5% for Moshi District regression model.

Promotion of agroforestry systems by co-operatives was found to have statistically significant link to GHG emissions reduction and carbon sequestration through LULUCF at 5% ($p < 0.05$). The study observed two different agroforestry schemes: intercropping short tree species and corn (maize) in Urambo District and longer rotation agroforestry schemes in Moshi District. In addition, co-operative involvement in environmental conservation initiatives had a statistically significant link to GHG emission reduction and enhancement of carbon sinks through LULUCF at 1% for all logistic regression models. As expected, tree planting had also a statistically significant link to GHG emissions reduction and carbon sequestration at 1% ($p < 0.01$).

Additionally, key findings were that, with all other variables kept constant, tree planting had a statistically significant link to carbon emissions reduction and carbon sinks enhancement through LULUCF at 1% ($p < 0.002$) for pooled regression model. Similarly, promotion of organic farming and certification of crops showed to be statistically significantly related to GHG emissions reduction through LULIUCF at 1% ($p < 0.001$) and 10% ($p < 0.1$) respectively. Provision of dividends also revealed to be linked to GHG emissions reductions and enhancement of carbon sinks through LULUCF at 10% ($p < 0.1$). In the same way promotion of savings was considered to have a statistically significant link to GHG emissions reduction through LULUCF at 10% ($p < 0.1$) for pooled regression model and at 5% ($p < 0.05$) for Moshi District regression model. The results also showed that supply of better and improved seeds had a statistically significant link to GHG emissions reduction and carbon sinks enhancement through LULUCF at 1% percent in all logistic regression models.

3.4 Discussion

The findings of this study have demonstrated that a number of co-operatives' actions are linked to GHG emissions reduction and carbon sinks enhancement through LULUCF. Marketing of agricultural produce by co-operatives was significantly related to increase of GHG emissions and decrease of carbon sinks through LULUCF. This suggests that the more agricultural marketing co-operatives collect and sell agricultural commodities the more farmers directly plough up more forestland or grassland, which releases to the atmosphere much of the carbon previously stored in plants and in soils through decomposition or fire. The results are consistent with observations by Searchinger *et al.* (2008) that the loss of maturing forests and grasslands foregoes carbon sequestration as plants grow each year, and this foregone sequestration is the equivalent of additional emissions.

Similarly, as revealed by the study, the collection and marketing of coffee in Moshi District and tobacco in Urambo District increases farmers' income, some of which has been reinvested in expansion of farmlands at the expense of the forested land. Furthermore, FGD and key informant interviews revealed that some income from selling coffee and tobacco was reinvested in animal husbandry, the result of which is direct contribution to GHG emissions, particularly methane (CH_4) through enteric fermentation in domestic livestock and animal manure management systems.

Supply of agricultural inputs, provision of extension services and promotion of intensive farming by co-operatives was found to have a statistically significant link with land use and land-use changes that have influence on GHG emissions reduction and carbon removals. Key informant interviews and focus group discussions revealed that co-operatives supply inputs to farmers specifically fertilizers and pesticides. While co-operatives in Moshi Districts promote the use of organic fertilizer in coffee farming, in Urambo District the application of nitrogen-based fertilizer in tobacco farming is on the increase, thus contributing to the rise of N_2O levels in the atmosphere. This is consistent with Sanders (2012) whose study showed empirically that the nitrogen isotope ratio in the atmosphere and how it has changed over time is a fingerprint of fertilizer use.

Furthermore, farmers get extension services from co-operatives or through co-operatives. Several studies have shown that agricultural co-operatives improve farm productivity through their influence on the adoption of productivity-enhancing technologies (Spielman *et al.*, 2010; Francesconi and Heerink, 2011) and by improving farm productivity (Abate *et al.*, 2014; Francesconi and Ruben, 2012). The result of this is increase in yields which causes decrease in land used for crop production; hence decrease in emissions and accumulation of carbon in the atmosphere. This finding is also consistent with West and Marland's (2003) analysis on yield as a factor of land-use change who indicated that if yields increased while crop demand remained unchanged, land used for cultivating the crop would be expected to decrease and vice versa. Yield gains alone, however, do not necessarily preclude expansion of cropland, thus the intensification must be coupled with conservation and development efforts (Balmford *et al.*, 2005; Ewers *et al.*, 2009).

As expected, the involvement of co-operatives in advocating agroforestry practices determines the probability of co-operatives' activities to influence GHG emissions reductions and carbon removals significantly. Agroforestry, in which trees are included in a cropping system, improves nutrient availability and land-use efficiency, reduces erosion, provides firewood and stores carbon (Wang *et al.*, 2015). This was supported by FGDs in Moshi district which revealed that perennial crops planted under the trees have good yields compared to those planted on open land. The effectiveness of agroforestry practices to mitigate climate change was also observed by Makundi and Okiting'at (1995) that long rotation of agroforestry regimes has significantly more carbon sequestered compared to short rotation tree species. Similar observations were reported by Kim *et al.* (2016) that the agroforestry farming system in Moshi District where trees and agricultural crops are grown together sequester 7.2 ±2.8 t C ha^{-1} y^{-1}, consisting of an above-ground biomass carbon sequestration rate of 3.8 ±1.3 t C ha^{-1} y^{-1} (53%), a below-ground biomass carbon sequestration rate of 1.2±0.4 t C $ha^{-1}y^{-1}$ (17%), and a soil C sequestration rate of 2.2±1.2 t C ha^{-1} y^{-1} (31%). Tree-crop rotation agroforestry farming system where trees and crops are grown alternately on the same piece of land, on average sequesters 8.4± 2.9 t C ha^{-1} y^{-1} consisting of a biomass carbon sequestration rate of 4.8 1.4 t C ha^{-1} y^{-1} (74%) and a soil carbon sequestration rate of 2.2± 1.1 t C ha^{-1} y^{-1} (26%) (Kim *et al.*, 2016). Furthermore, interviews with co-operative board members in Moshi District revealed that farmers were encouraged to manage trees so as to provide shade to coffee trees, the most important cash crop produced by the co-operatives' members, usually inter-cropped with bananas and trees. Considering CH_4 and N_2O emissions, Kim *et al.* (2016) reported inconsistent changes in net CH_4 and N_2O emissions with conversion from agricultural lands to agroforestry. They reported differences in emissions between agroforestry and agriculture to be -0.1± 1.4 kg CH_4 ha^{-1} y^{-1} and 2.7±10.6 kg N_2O ha^{-1} y^{-1}.

Combining carbon sequestration in biomass and the soil with changes in net emissions of CH_4 and N_2O emissions, it is estimated that a shift to agroforestry can mitigate 27.2±13.5 t CO_2eq ha^{-1} y^{-1} (Kim *et al.,* 2006). These values are substantially higher than the value of 11.4 t CO_2 ha^{-1} y^{-1} estimated by Watson *et al.* (2000).

Many studies consider trees to be a terrestrial carbon sink (Schroeder, 1992; Schroeder; Makundi and Sathaye, 2004). Tree planting presents an opportunity to increase the terrestrial carbon sink, and slows the increase in atmospheric CO_2 concentration. Carbon is stored in trees (stem, branches, leaves and root), understory, litter and soils (Sharrow and Ismail, 2004). Trees, because of their carbon storage capacity, present an important opportunity for carbon emissions mitigation (van Kooten, *et al.*, 1999). In this study, it was revealed that 96% of the respondents reported to plant trees to meet fuel wood demands while 33.7% did so for timber and construction poles, 34% for fodder and 35.2% for tobacco curing. In Moshi District tree planting is done apart from providing shade to coffee trees, to meet timber and fuel wood demands. The study further revealed that bare land in the upper belt is planted with trees and also land left by owners who migrated to towns is planted with trees. In Urambo District, tree planting is done in degraded croplands and is a requirement for a afrmer to enter into tobacco contract farming. Trees mostly planted in Urambo district are *Albizia* species, *Cassia siamea* (*mijohoro*) and Eucalyptus species.

The study further demonstrates that advocating organic farming, certification of crops and provision of dividends were co-operatives' actions linked to GHG emissions and carbon sinks through LULUCF. The study showed that agricultural marketing co-operatives advocate organic coffee, and certification of organic coffee is done by primary co-operatives. FGDs and key informant interviews showed that crop certification is done by some AMCOS in Moshi District, whereby organic coffee has been certified in Uru North Msuni, Uru North Njari, Mwika North East, Kirua Vunjo North and Kirua Vunjo West Agricultural Marketing Co-operative Societies. In organic coffee production, the agro-ecological balance is restored. The soils are protected; fertility and structure are enhanced; shade trees are maintained and good yields are observed.

According to key informant interviews in Moshi District reduced expenses and good prices paid for organic coffee, farmers are able to increase their income and improve their livelihoods. Organic agriculture is one of the land use practices that mitigate GHG gases through farming practices that build soil fertility, avoid use of synthetic fertilizer and improve carbon sequestration. These findings are in line with the findings reported by Ramírez (2014), that a co-operative can help farmers to get necessary resources that they need to be more competitive and to get more produce at reduced costs. On the other hand Méndez *et al.* (2010) put forward that certified coffee marketing is one of the co-operative actions/initiatives that could still contribute to broad-based sustainable livelihoods, rural development and conservation processes in coffee growing regions.

Finally, supply of improved and better seeds by co-operatives had a statistically significant link to GHG emissions reduction and carbon removals. Seed is the critical determinant of agricultural production on which performance and efficacy of other inputs depend. Seed itself can potentially raise total production by about 15 to 20%, depending upon the crop and further up to 45% with efficient management of other inputs. Quality seeds appropriate to different agro-climatic conditions and in sufficient quantity at affordable prices are required to raise productivity. Sustained increase in agricultural production and productivity necessarily require continuous development of new and improved varieties of crops befitting the needs of the farmers and an efficient system of production and supply of seeds to farmers (Neate, 2013). Interviews with co-operative managers in both districts revealed that timely supply of quality seeds to the farmers even in the remote areas is being ensured by co-operatives. In Urambo District tobacco seeds are supplied to farmers by companies through primary agricultural co-operatives. Similarly, in Moshi District, coffee seedlings are supplied by co-operatives, and some primary co-operatives have coffee tree nurseries. Application of improved and better seeds results in good yields from a small piece of land, sparing forestland that sequesters carbon dioxide and increase soil organic carbon.

3.5 Conclusion and Recommendations

Co-operatives contribute to carbon emissions reduction and enhance carbon sinks by getting involved in land use and use changes. Marketing of agricultural products, supply of agricultural inputs, provision of extension services, promotion of intensive farming and advocating agroforestry practices are linked to GHG emissions and carbon removals. As such, collective efforts occupy a key position in climate change mitigation initiatives through LULUCF. Efforts to mitigate climate change through LULUCF should build on co-operatives' activities that wean GHG emissions and enhance carbon sinks. This is particularly important because the realization of climate change mitigation through LULUCF will most likely require active collective participation.

The study further recommends that climate change mitigation efforts should integrate relevant models of collective action into programmes designed to address climate change mitigation through LULUCF. Central, local governments and other stakeholders should encourage and patronize community groups as important focal points for propelling activities linked to GHG emissions reduction and enhancing carbon emissions removals.

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CHAPTER FOUR

Paper three

Contribution of co-operatives in maintaining carbon stocks in agroforestry cropping systems and miombo woodland agro-ecosystems in Tanzania

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Abstract

The paper aims to quantitatively estimate the contribution of co-operatives operating in two varied Tanzanian agroecosystems: agroforestry and *miombo* woodlands with regard to carbon emission mitigation through conservation of existing carbon stocks. Specific area and/or species allometric models were used to estimate above ground biomass (AGB) and associated carbon stocks in the tree component of the systems. The contribution of co-operatives in maintaining carbon stocks was determined by comparing the proportion of carbon stocks in the land use systems in relation to co-operatives' activities to total carbon stocks in land use systems without co-operative activities in the respective districts. The results indicate that, in Moshi District, the estimated aboveground carbon stocks ranged from 7.67 to 96.52 t C ha^{-1}. Specifically, coffee plantations had more total carbon stocks (96.52 t C ha^{-1}) followed by a coffee-banana dominated agroforestry system (29.94t C ha^{-1}). In land use systems with no co-operative action the carbon stocks were 7.67 t Cha^{-1}and 27.35 t C ha^{-1} in mixed cropland with scattered trees and natural forests respectively. In the case of Urambo District, aboveground carbon stocks were estimated to range from 0.82 to 32.87 t C ha^{-1}. The average carbon stock in areas with co-operative actions was 13.5 t C ha^{-1} while in areas with no co-operative action it was 17.86 t ha^{-1} showing no substantial difference. The analyses reveal that co-operatives' actions contributed as much as 76% (126.91 t C ha^{-1}) of the existing carbon stock per hectare in agroforestry systems and 31% (35.35 t C ha^{-1}) of the total carbon stocks per hectare in the *miombo* woodlands. The paper concludes that majority of co-operatives' activities related to land use land use change and forestry (LULUCF) improve carbon sequestration. Hence, co-operatives' activities linked to land use systems that enhance carbon stocks have a significant contribution to climate change mitigation. It is recommended that activities related to land use systems that enhance carbon stock should be given the highest priority in climate change mitigation efforts through actions by concerned co-operatives.

Key words: co-operative actions, land use systems, agroforestry, miombo woodlands, carbon stocks, and biomass

4.1 Introduction

The climate is changing. It is increasing climate risks and altering the patterns and impacts of these risks, affecting particularly agriculture, one of the sectors most sensitive to climate. Reducing greenhouse gas emissions and developing strategies to adapt to and counterbalance future impacts of climate change sustainably are among the most pressing needs of the world today. Co-operatives are considered one of the main actors driving land use and land use changes. There are 11,330 co-operatives in Tanzania with a total membership of nearly 3,998,193 individual members. About 32% of the co-operatives are agriculture marketing co-operatives (TCDC, 2017). Each and every village in the country is linked to co-operatives. A majority of the farmers obtain credit, input supply and marketing services from their co-operatives. Co-operatives in Tanzania are broad based and thus can influence agriculture production system. According to Acharya (2017), there is a strong relationship between co-operatives' actions and carbon emissions through LULUCF, because most of activities lead to extensive deforestation.

However, co-operatives may very well contribute to enhancing carbon stocks by getting involved in land use and land-use changes aimed at conserving existing forests and restoring forests and biodiversity in degraded forest ecosystems. Co-operatives and self-help farmers' organizations stand as one of the main actors that best meet the economic, social and environmental sustainability agenda because their ethos and structure seek to meet the requirements for social, cultural and ensuring environment protection (ILO, 2016).

At the same time, co-operatives and self-help organizations are participatory platforms in finding local environmental solutions to their concerns, promoting the responsible use of agro-inputs and helping in the diffusion of technical innovations that improve the production efficiency (Abate *et al.*, 2014). Agricultural co-operatives not only have the potential to lead the sustainable management of natural resources but also their governance model is endowed with positive impacts in sustainable development through transparency, participation and cooperation with communities, enterprises and local and international governments (ILO, 2016; Cato, 2009). This scenario creates the needed efforts and imperatives of co-operatives both as self-help organizations and business organizations that have to balance the social, economic and environmental objectives and solve several social dilemmas in the communities they serve.

Overall, land management approaches used by farmer co-operatives differentially affect soil nutrient content and properties. Co-operatives may be involved in environmentally friendly activities such as agricultural practices that support shade grown farming and composting farming, which increase soil carbon stocks (Fitzgerald, 2012). A study by Jose (2009) has shown that working with farmers in co-operatives, rather than with individual farmers, facilitates improved ecosystem services at the landscape scale. It is therefore, important to understanding the complex social and ecological context in which co-operative systems such as those in tropical shade coffee agro-ecosystems operate to sustain the environment.

Farmers in Moshi District have, for many decades, practised a unique agroforestry cropping system which entails the growing of coffee interplanted with bananas, horticultural crops and trees such as *Grevillea Robusta* (*mwerezi*) and *Persea Americana* (*mparachichi*), a system which has earned the name of “Chagga home-gardens” which have won special praise on account of their characteristic storey-wise cultivation of banana-plants below high shading trees, coffee-bushes below the banana-plants, pulses below the coffee-bushes, and vegetables and root-crops below the pulses (Winter, 2009).

This land-use system increases carbon stock through increased tree biomass from the shade trees, coffee trees and other farm trees. As such, agroforestry has a huge potential as a mitigation strategy to the changing climate because of its ability to sequester carbon in its multiple plant species and maintaining soil organic carbon (Montagnini and Nair, 2004; Albrecht and Kandji, 2003). Previous studies show that the average carbon sequestered by maintaining the agroforestry practices are estimated to be 9, 21, 50, and 63 t Cha^{-1} in semi-arid, sub-humid, humid, and temperate regions respectively (Montagnini and Nair, 2004). For small agroforestry systems in the tropics, carbon sequestration ranges from 1.5 to 3.5 t $Cha^{-1}yr^{-1}$, and therefore it is a viable strategy for climate change mitigation (Roshetko *et al.*, 2007; Montagnini and Nair, 2004). In the case of Urambo district co-operatives in have pioneered in strengthening and supporting their members to conserve traditional woodlots, through a system popularly known as *ngitiri*. Co-operatives also encourage afforestation programmes, use of energy efficient stoves/kilns and promote land fallow practices to restore the degraded *miombo* woodlands that have been degraded by tobacco farming.

These co-operatives' activities have a significant contribution to carbon stock and therefore to climate change mitigation. Some initiatives have been taken nationally to mitigate or reduce the impact of climate change. Though at government level there are initiatives but at the community level they are not visible. No studies have been carried out to estimate the amount of carbon stock linked to co-operatives activities in various land uses including in privately-owned agroforestry and miombo woodlands agroecosystems at community level. It was, therefore, imperative to establish the quantitative contribution of co-operatives' actions to carbon stock through land use and land-use changes. The objective of the paper was to estimate quantitatively the existing carbon stock in land use systems linked to co-operatives' actions. Specifically, the study sought to identify land use systems in the two districts and estimate tree biomass and carbon stock in the identified land uses. An improved understanding this context would help policy makers and farmers in their efforts to adopt land use practices and institutional systems that adequately manage and conserve a variety of ecosystem services.

4.2 Materials and Methods

4.2.1 Study areas

The study was conducted from July 2016 to February 2017 in agroforestry cropping systems in Moshi District and Miombo woodlands agro-ecosystems in Urambo District. In both districts co-operatives have been the main drivers of economic activities for a long time: Kilimanjaro Native Co-operative Union (KNCU) for Moshi District and Western Zone Tobacco Growers Co-operative Union (WETCU) for Urambo District. The dominant farming system in Moshi District is a multi-storied agro-forestry cropping system which involves integration of several multi-purpose trees and shrubs with food and cash crops and livestock on the same unit of land. In Urambo District tobacco farming dominates the farming scene. This, for decades, has exerted pressure on *miombo* woodlands; the vegetation which plays an important role as a carbon sink. The two areas of study have a significant and historical co-operative activity tied to LULUCF.

The study population was land use systems; four different land use systems in Moshi District and five in Urambo Districts were identified and investigated. These are natural forest (forest reserve), coffee banana agroforestry (Chagga gardens), coffee plantations with scattered trees and mixed crop land with scattered trees (often non-native trees) in Moshi District and closed woodlands, open woodlands, village protected forest, forest restoration (*ngitiri)*, woodlots and fallow fields in Urambo District.

4.2.2 Sampling design

A nested sampling strategy, organized by plot and sub-plot was employed to inventory live tree biomass data. Nested plots of 5 m × 40 m sizes) were used for measuring tree diameter at breast height (DBH) for all trees with DBH ≥ 5 cm. Complete enumeration of all trees' with DBH ≥ 5 cm was conducted in each land use system. For each plot, the following data were obtained: (a) tree species name and (b) DBH. The circumference of trees was measured at 1.32 m above ground surface except for coffee which was measured at 0.15 m (13 cm) above ground surface (Bohre *et al.*, 2012). A total of 28 plots in Moshi District and 62 in Urambo district were measured.

4.2.3 Carbon stock estimation

The aboveground biomass (AGB) from each land use system was estimated by first measuring the DBH of each tree. Tree biomass was computed using different allometric equations based on habitat type and tree species (Table 4.1). Biomass was calculated for individual trees and aggregated into total AGB density per plot and finally average AGB per land use system (Williams *et al.*, 2008; Danarto and Hapsari, 2016; Chave and Dubois, 2001; Eggleston *et al.*, 2006). Default root shoot ratio of 0.26 was applied to get below ground biomass (Mokany *et al.*, 2006). Total tree biomass was then converted into total carbon by applying a factor of 48% adopted from Condit (2008). Others have suggested a factor of 50% (Pearson *et al.*, 2005), 46.5% (Djomo *et al.,* 2011), respectively.

4.2.4 Contribution of co-operatives in maintaining carbon stock

The contribution of co-operatives in maintaining carbon stock was calculated by comparing the proportion of carbon stock in the land use systems linked to co-operatives' actions to total carbon stock in all land use systems in the respective district.

$$\text{Coops' to C stock} = \frac{\text{Total C in LU system linked to Coops' actions}}{\text{Total C in all LU systems}} * 100$$

Table 4.1: List of allometric equations used to estimate biomass of various vegetations

Biomass Category	Allometric Equation	Source
Banana plantations	$AGB = 0.0303 * D^{2.1345}$	Hairiah *et al.* (2010)
Coffee	$AGB = 0.281*D^{2.06}$	Van Noordwijk, (2002)
Miombo woodland	$AGB = 0.1054*D^{2.4809}$	Mugasha *et al.* (2013); Malimbwi *et al.* (2016)
Acacia	$AGB=0.139*D^{2.32}$	Elamin *et al.* (2015)
Humid montane forest	$AGB = 0.9635*D^{1.9440}$	Masota *et al.* (2016).
Tropical forest	$AGB = 0.2035*D^{2.3196}$	Pearson *et al.* (2005).

AGB = Above Ground Biomass; D = Diameter at Breast Height

4.3 Results and Discussion

4.3.1 Estimated carbon stock in the land use systems

The results showed that the dominant tree species integrated with coffee in the agroforestry cropping system in Moshi included *Albizia schimperiana* (*mruka*), *Grevillea robusta* (*mwerezi*), *Albizia gummifera* (*mfuruanji*), *Croton macrostachyus* (*mfurufuru*), *Cordia africana* (*mringaringa*), and *Persea americana* (*mparachichi*). According to smallholder farmers, these species are preferred because they have positive effect on communities' daily life including amelioration of microclimate, soil fertility improvement, fuel wood, fodder and fruits. The estimated total carbon stocks of agroforestry systems ranged from 9.66 to 122.10 t C ha^{-1} (Fig. 4.1). Coffee growing areas exhibited more total carbon stocks (122.10tC ha^{-1}) than other land uses. The existence of trees with DBH more than 30 cm (mean DBH 78.66 +9.7 cm) in coffee planted areas makes large contribution to the total carbon stocks. Coffee-banana dominated agroforestry system was the second in storing more carbon (37.73tCha^{-1}). Also, this is explained by the existence of trees with high DBH, particularly *Albizia gummifera* (mean DBH 69.7$\pm$7.3 cm) and *Grevillea robusta* (mean DBH 37.77$\pm$3.3 cm). Further analysis showed that banana plants contributed around 8.47 kg C/plant.

For coffee plantations and coffee-banana dominated agroforestry, the contributions of carbon stocks from trees with diameter > 30 cm was 78.44% and 89.84% respectively. The results further showed that agroforestry systems had the highest carbon stock compared to natural forests. The values for natural forests were lower compared to those reported by Imani *et al.* (2017) in tropical montane forests (80.64- 139.2t C ha-1). This might be one of the long-time effects of selective logging subjected to these forests in the past three decades (Rutten *et al.,* 2015). This implies that land use systems with co-operatives' actions are better management for carbon storage compared to systems with no co-operative actions. The carbon stocks of the two agroforestry farming systems studied (coffee plantations and coffee banana agroforestry) were within the range of 12 to 228 t ha−1 for agroforestry systems as estimated by Albrecht and Kandji (2003) and Nair *et al.* (2009).

In Urambo District, the findings from the study revealed that the dominant *miombo* tree species were *Brachystegia spiciformis* (*mtundu*), *Terminalia sericea* (*mzima*), *Combretum zeyheri* (*msana*), *Burkea africana* (*mgando*), *Albizia gummifera* (*myenze*), *Annona senegalensis* (*mtopetope*) *Julbernardia globiflora* (*mpimati*), and *Dichrostachys cinerea* (*mtundulu*). *Acasia* sp. was the dominant species in woodlots, followed by *Albizia* sp. The average stem per plot was 50 (625 stems ha^{-2}) for *Albizia* sp. and 53 (663 stems ha^{-2}) for *Acacia* sp. The estimated total carbon stock ranged from 1.04 to 32.37 t C ha^{-1} for land uses with co-operative actions namely village forests, household managed woodlands, fallow fields and woodlots (Fig. 4.2). Carbon stock was higher in land use systems with no co-operative actions such as forest reserves ((41.42 t C ha^{-1}). In land use systems with cooperatives actions such as household managed woodlands and village forests (*ngitiri)* the carbon stock was 32.37 and 31.39 t C ha^{-1} of carbon respectively; which is lower than in the forest reserve.

Further analysis showed that carbon stock was within the range of carbon stock estimates in *miombo* woodlands as per previous studies which showed that carbon stock was 33.3 t C ha^{-1} (Williams *et al.*, 2008); 19.2 t C ha^{-1} (Munishi *et al.*, 2010), 20.8 to 34.2 t C ha^{-1} (Munishi *et al.*, 2016) and 32.1 t C ha^{-1} (Ryan *et al.*, 2011). Planted woodlots had lower carbon of 3.64 t C ha^{-1}. This is due to age and poor survival rate of the trees. These findings are more or less similar to findings by Maikhuri *et al.* (2000) who estimated species wise carbon storage potential of planted tree species on abandoned agricultural land to be 3.9 t C ha^{-1} while degraded forest land stored 1.79 t C ha^{-1}.

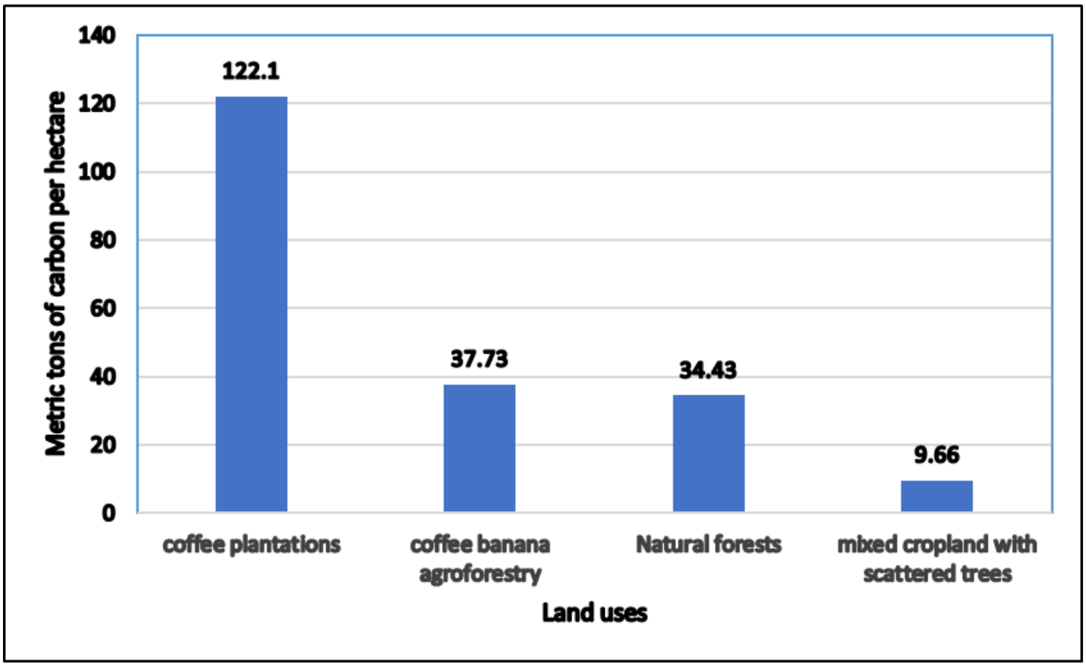

Figure 4.1 Carbon stock in different land uses in Moshi District

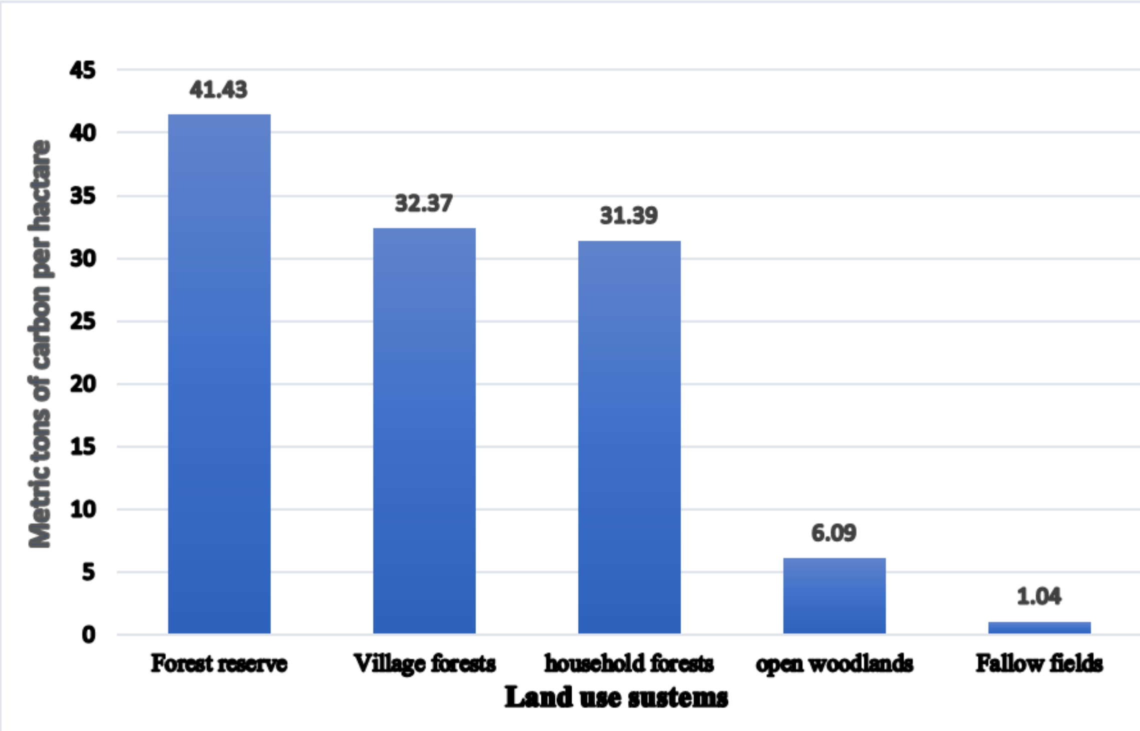

Figure 4.2 : Carbon stock in different land uses in Urambo District

4.3.2 The contribution of co-operatives in maintaining carbon stock

The carbon stocks in coffee planted areas and banana coffee agroforestry land use systems in Moshi District and household conserved natural forests, village forests, woodlots and fallow land in Urambo district are the points of reference for this study. It is in these land use systems that co-operatives' actions are evident. In Moshi District coffee banana agroforestry is promoted by co-operative societies, which encourage their members to plant and maintain trees for the purpose of providing shade to coffee and improving soil fertility. Tree species like *Albizia schimperiana* existed for decades, and coffee trees are said to grow better under the shade of these trees. Coffee plants which are credited to store high amounts of carbon (122.1 t C ha^{-1}) are under primary co-operative societies.

The study showed that coffee plantations alone contain more carbon per hectare compared to forest reserves and mixed crop land with scattered trees land use systems combined. With regard to quantitative contribution to carbon stock in the land use systems studied, land use system with cooperative actions contributed significant proportion (78.4%) of the existing carbon stock per hectare.

Figure 4.3 summarizes the distribution of carbon stock components for each land use system in Urambo District. Farmers' conservation of natural forests, village forests, afforestation programmes (woodlots) and land fallow fields are promoted and supported by co-operatives. These land use systems contributed 59% of the total carbon stock. Reforestation programme in Urambo District is done by individual farmers who are members of primary co-operatives also known as associations (Katundu and Mwaseba, 2009). The fuel wood grown under these programmes replaces wood which was otherwise being unsustainably harvested from natural woodlands/forests. Tobacco buying companies support reforestation programmes, a measure intended to reduce pressure on woodlands through primary farmer co-operatives. The study showed that primary farmer co-operatives in Urambo District perform several functions linked to carbon emissions reduction and enhancing carbon stocks. The most prominent ones include propagation of tree seedlings, supplying inputs, provision of technical education, running demonstration farms, promotion of the use of energy efficient kilns for tobacco curing and provision of education to members and awareness creation. In terms of tree seedlings, some primary farmer co-operatives own and manage tree nurseries. Fallow fields systems are also promoted by co-operative societies and contribute 1% of the total carbon stock per hectare in the *miombo* woodlands ecosystem. The role of reforestation programmes in storing and maintaining carbon stocks on the other hand is lower than that of natural forests (forest reserves and village forests). This system however, proves to increase carbon stocks on degraded lands without which it could have been lost. Quantitatively, land use systems with co-operatives' actions contribute 64.28% (70 (17.11 t C ha^{-1}).

In the absence of co-operatives' actions this carbon could have been lost.

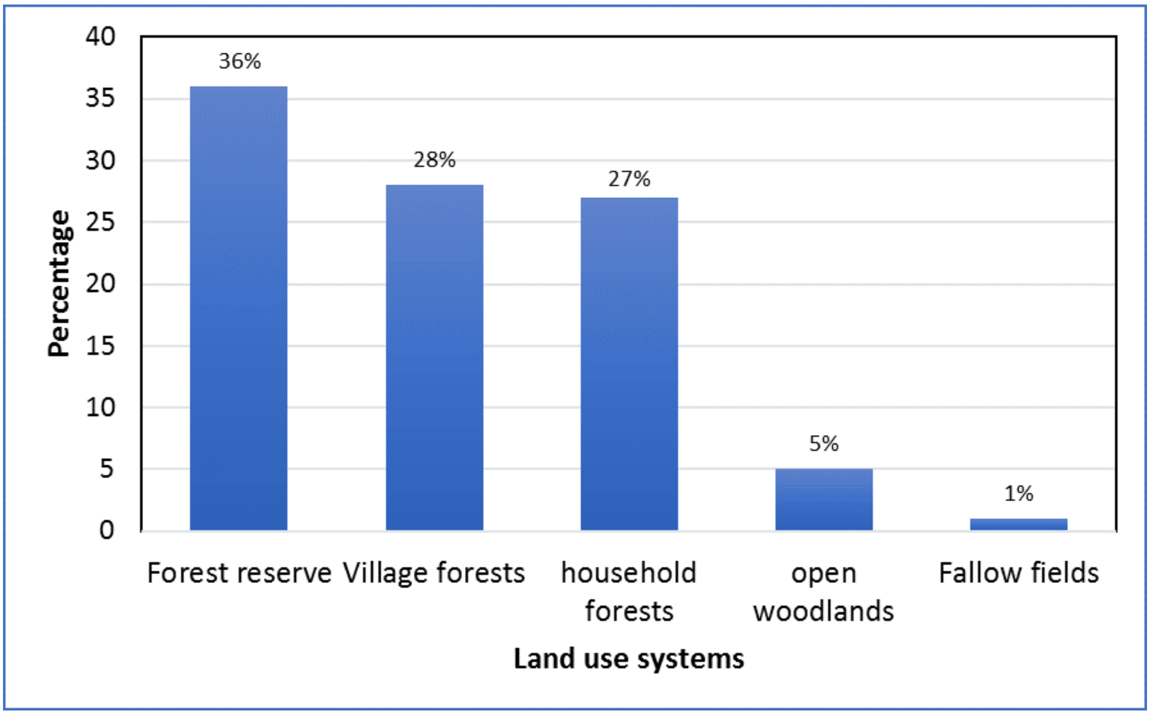

Figure 4.3: Carbon stock components for each land use system in Urambo District by percentage

4.3.3 Conclusion and recommendations

Land use systems with co-operatives' actions illustrate an effective approach in climate change mitigation initiatives. This study clearly demonstrated that majority of co-operatives' activities linked to LULUCF improve carbon sequestration. Thus, farming systems promoted by co-operatives have a significant contribution to climate change mitigation through carbon storage in the above and belowground plant biomass.

The results further suggest that well-managed forms of land use systems under cooperatives' actions that avoid forest degradation provide the best opportunity for maintaining high carbon stocks in both districts.

The study recommends that management of land use systems that enhance carbon stock, agroforestry, restoration of degraded forests, afforestation and land fallow should be given the highest priority in efforts to reduce loss of carbon stocks through co-operative actions. These land use forms can provide a partial mitigating effect on the overall rate of carbon loss through unsustainable land use systems. Deliberate international efforts are essential to propagate an agenda in which co-operatives' activities linked to LULUCF that enhance carbon stock become a major part of climate change mitigation strategies.

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CHAPTER FIVE

Paper four

The role of co-operatives in carbon trading under community managed carbon enhancement activities in Tanzania

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Abstract

The thesis looks into how the agricultural marketing business model may apply to carbon trading with special emphasis on community carbon enhancement activities.. Data were generated from semi-structured interviews, focus group discussions and key informant interviews. Sixteen primary co-operatives were purposely selected and a sample of 297 smallholder farmers were systematically selected for questionnaire survey. The results indicated that co-operatives are important for integrating production and marketing of agricultural produce, extension services, supply of better agricultural inputs to warehousing, grading, and market information. Farmers, through co-operatives' activities, mainly agroforestry practices, land fallow, afforestation programmes and conservation of degraded natural forests generate tradable carbon credits that become a commodity for farmers. The analysis reveals that the general characteristic of the co-operative marketing model fits aptly in trading the carbon offset credits generated by smallholder farmers. The study concludes that co-operatives business model offers a framework for smallholder famers to come together as a strong entity for collectively bargain to achieve benefits in terms of creating avenues for marketing carbon credits generated through community carbon enhancement actions. The study recommends that co-operatives need additional support to effectively engage in carbon trading in terms of technical expertise and awareness creation for smallholder farmers to recognize opportunities offered by a new commodity, of carbon credits.

Key words: *co-operatives, co-operative business model, carbon enhancement activities, carbon credits, carbon trading.*

5.1 Introduction

Growing international concerns about climate change have led companies across the globe to reduce their GHG emissions. Among the popular ways to reduce GHG emissions is by purchasing carbon offsets (Adams and Jones, 2009). Carbon trading allows farmers and investors to generate tradable carbon offsets from farmlands and forestry projects through carbon trading. It involves implementing practices that are known to improve the rate at which CO_2 is removed from the atmosphere and converted into biomass or soil organic matter (Spash and Theine, 2016). Carbon trading is successful when carbon gains resulting from enhanced land use and land use change practices exceed carbon losses (IPCC, 2007; Smith *et al.*, 2014). Carbon trading, as described in the Kyoto Protocol, is a voluntary and mandatory emission trading markets for GHGs (Smith *et al.*, 2014). Among the land use practices; agroforestry, conservation of natural forests, afforestation programmes and restoration of cultivated and degraded lands have been given priority for carbon trading based on the efficiency of reducing emissions or capturing carbon by storing it (IPCC, 2007).

To-date, co-operatives' activities linked to LULUCF that reduce GHG emissions and enhancing carbon stock have been recognized (reference). Certain co-operatives' practices remove carbon from the atmosphere and store it in vegetation and soil organic matter (Nadeau and Nadeau, 2016). Farmer co-operatives' carbon enhancement activities include agroforestry practices, restoration of degraded natural forests, afforestation programmes, land fallow and promotion of the use of energy saving stoves/kilns. Carbon captured from co-operatives' carbon enhancement activities may be qualified to receive carbon credits. Agroforestry cropping systems are said to have a higher potential to sequester carbon than single-species crop or pasture systems because of their perceived ability for greater capture and utilization of growth resources (light, nutrients, and water)

(Murthy *et al.*, 2013; Tiwari *et al.*, 2017). The estimates of carbon stored in agroforestry cropping systems range from 0.29 to 15.21 Mg ha^{-1} yr^{-1} aboveground, and 30 to 300 Mg C ha^{-1} up to 1-m depth in the soil (Nair *et al.*, 2010).

Furthermore, co-operatives are known for high productivity (Hunter and Wu, 2002), which has created an increasing interest of scientific communities in studying the role of co-operatives activities in carbon storage and ecosystem services (Innocent and Adefila, 2014). Co-operatives are local institutions that address local needs, employing local talents, and led by local leaders (Majee, and Hoyt, 2011; Dubey *et al.*, 2016). They are considered to have enormous potential to deliver goods and services in areas where the public and private sectors have failed (Das *et al.*, 2006). Co-operatives, agricultural marketing co-operatives in particular, occupy a key position in agricultural development with support in resource and input use, harvesting, marketing channels, storage facilities, distribution channels, value addition, market information and a regular monitoring network system (Kumar *et al.*, 2015). In Tanzania, since 1925 when some of the early co-operative societies such as the Kilimanjaro Native Planters Association were formed, the co-operative movement has grown to be one of the formidable sectors of Tanzania's economy. As a rural based economy with agriculture significantly contributing to GDP, any strategy to promote rural development has not and cannot succeed without the co-operative movement (Sizya, 2001).

The primary objective of forming agricultural marketing co-operatives is to increase agricultural outputs and marketing of agricultural produce and farmers are the single largest group of users and managers of land, water, and other ecological resources throughout the world. However, the influence of agricultural marketing co-operatives on ecosystems services, specifically on how co-operative business model may apply to carbon trading is less known. This is the gap in knowledge that this paper intends to fill. Hence the objective of this paper was to specifically examine how the co-operative business model may apply to carbon trading with special emphasis on community carbon enhancement activities. The principal research questions examined in this study is whether the co-operative marketing approach applies to the carbon trading and what are the managerial implications of this.

5.2 Theoretical Framework

A co-operative is an organization or business owned and operated for the benefit of its members. It is a business enterprise where earnings and profits are distributed among its members (Kenkel, 2015). Co-operative enterprises are a unique form of business model based on the principles of collective ownership, voluntary membership, democratic governance, independence and the benefit of its members as the primary purpose (Birchall, 2004). As a business model, the co-operative enterprise has a different strategic purpose to that of an investor owned enterprise; the focus being on the maximization of member benefits rather than the maximization of shareholder returns (Mazzarol, 2009). The co-operative model is a longstanding method by which independent business owners who would otherwise be competitors join forces for their mutual benefit (Goldstein, 2012). The members of these associations believe in the dethical ideals of honesty, openness, social responsibility and caring for others (Wanyama, 2016).

Co-operatives play an important role in linking farmers to markets; markets that farmers could not access individually (Nembhard, 2014). A market-oriented co-operative is characterized by a group of individuals who organize themselves into joint undertaking with the aim of delivering benefits for themselves as members (Beucheltzeller, 2012).

The study on which this paper is based was guided by the Marxist classic theory of co-operation by Jossa (2005) and human development theory advanced by Amartya Sen (1997). The Marxist classic theory of co-operation addresses how farmers' cooperatives can enhance their sustainability under pressure from large-scale production organizations and private traders, who, in most cases, are more organized than the small-scale farmers when they are on their own. Furthermore, it operates on the assumption that cooperatives are formed by groups of individual farmers or small agricultural cooperatives for the purpose of large-scale marketing, purchasing agricultural inputs, acquiring credit, and so on. The human development theory on the other hand emphasizes that human development should, among other things, be measured by the enhancement of human capabilities through education and training in order to avail themselves with existing opportunities to remove impediments to their own development. Entering the carbon industry with small farmers, through co-operative marketing, is a process of competence building and raising the stock of knowledge for small farmers' enhanced capabilities and searching for opportunities to enter competitive markets and address environmental threats no logical link. The emphasis here is the fact that going into carbon trading may not be easy and automatic, rather preparedness of members is needed as they enter into a new commodity trade shrouded in competitive environment. These theories of co-operation go in line with two important principles of co-operation; principle number five putting emphasis on enhancing the stock of knowledge for raising their business capacity through education, training and experimentation and principle number seven, namely concern for the community.

The co-operatively-owned business strategy is, an approach to entrepreneurial development to foster growth and vitality in communities. It is a viable model that capitalizes on the power of people to create their own futures (Crandall, 2014).

Co-operative ownership of a business helps to provide essential business services to the community. Furthermore, it serves as a vehicle for community development that can add income to producers who want to access a value-added market. The shared business ownership gives the users control of the business, the benefits that the business provides to their community, and a share of ownership in a business which they find important to themselves and their families (Crandall, 2014).

5.3 Materials and Methods

5.3.1 Study area description

The study was conducted from July 2016 to February 2017 in agroforestry cropping systems in Moshi District and *miombo* woodland agro-ecosystems in Urambo District. In both districts co-operatives are dominant drivers of economic activities for a long time: Kilimanjaro Native Co-operative Union (KNCU) for Moshi District and Western Zone Tobacco Growers Co-operative Union (WETCU) for Urambo District. The dominant farming system in Moshi District is a multi-storeyed agro-forestry cropping system which involves the integration of several multi-purpose trees and shrubs with food and cash crops and livestock on the same unit of land. Because of the high quantities of biomass, it produces and its capacity to recycle organic matter on farms, the agroforestry system contributes significantly to carbon storage. In Urambo District tobacco farming is the dominant farming system which for decades, has exerted pressure on *miombo* woodlands, the vegetation which plays an important role as a carbon sink. The two areas of study have significant and historical co-operative activities related to LULUCF.

5.3.2 Data collection

As the study sought to explore the ability of co-operative marketing approach to carbon trading, a qualitative research design was chosen. This enabled the study to gain a holistic perspective on cooperative business model and capture all of the potentially rich and meaningful characteristics of co-operatives marketing approach. Designed to obtain a quick overview of the co-operative business model, the study relied heavily on qualitative techniques to collect primary data. Consequently, the bulk of the data was generated from semi-structured interviews and focus group discussions (FGDs) with key informants that were purposively sampled on the basis of their leadership positions in co-operative societies. Sixteen (16) FGDs were conducted, one from each co-operative society. Accordingly, twelve interviews were held with key informants. These were from the co-operative Unions (KNCU and WETCU), district agricultural and co-operative extension officers and retired co-operatives' leaders. A questionnaire for smallholders was administered to 297 farmers which the qualitative techniques, mainly to capture the nature of farming and smallholder farmers' perceptions on co-operatives services to farmers.

The sampling technique was purposive. Co-operatives were selected based on the likelihood that they would provide useful information. Given the focus of the study, 16 primary agricultural marketing co-operatives were sampled, eight from each district.

In order to enhance validity and reliability, a standard set of questions were used for each interview. The topics for discussion centred around five key categories: carbon enhancement activities, co-operative services, market environment, networks and general performance. This interview protocol only formed a guide for each interview, as new issues emerged in each case that required further investigation. The interviews were supplemented with focus group discussions and review of literature.

5.4 Results

The findings are presented around two key themes. First, the study identified the co-operative model and explored their characteristics and services offered to members. Second, building on this first section, the study explored the replication of co-operative marketing approach to carbon trading.

5.4.1 Farmers' Socio-demographic characteristics

Of the 297 respondents involved in the study, 148 were from Moshi District and 149 were from Urambo District. The respondents from the two districts were predominantly males. The number of males from Urambo district (133) was significantly higher than that for Moshi District (110). There was no significant difference between the age distributions of the respondents from the two districts although those from Moshi appeared to be older than their counterparts in Urambo District. The mean age for all of them (297) was 52.7 years (minimum 22, maximum 94, range 72, sd 14.67). With regard to education, standard VII (primary education) was the highest education level for majority of the respondents from the two districts 50.7% for Moshi district and 63.8% for Urambo District. The major income generating activity is farming, followed by animal husbandry and petty business. Again, these were stated in previous chapters.

5.4.2 Size and structure of smallholders farms

With regard to land size, there was a great variation between the two ecosystems. In the agroforestry cropping system, the mean total land size was 3.05 ha (minimum 0.5 ha, maximum 7.0 ha, range 6.5 and standard deviation 1.07). The mean land size for land under coffee banana agroforestry was 0.8 ha (min 0.5 and max 2 ha). The land under agroforestry system covers 62 432.45 hectares which is 44.66% of the total land area of Moshi District (Chapter 2 of this thesis).

In the *miombo* woodland agro-ecosystem the mean total land size for smallholders' farmers was 8.25 ha (min 2.5 and max 22 ha, range 6.5 and standard deviation1.07). The mean land size for land under restored forests was 1.7 ha (min 1.0 and max 8 ha); woodlots 1.6 ha (min 0.5 and max 4 ha), fallow land 1.3 ha (min 0.5 and max 3 ha). Land under woodlots, fallow fields and restored forests roughly covers 196,161.41 (32.09%) of the total land area in Urambo district.

5.4.3 Carbon enhancement activities

The study revealed that smallholder farmers were involved in some activities that ostensibly enhance carbon stock in both districts. When ranked from most to least farmers' carbon enhancement activities, tree planting (88.6%), soil management (76.4%), watershed management (74.1%), agroforestry (66.4%), protecting trees from fires (60.6%) and use of energy saving stoves (59.6%) scored as shown in the bracketed parentages (Table 5.1). A sizeable number of farmers reported to be practicing organic farming (22.1%), zero grazing (23.1%) while planting fodder accounted for 42.0%. Observations revealed that in Urambo District where tobacco farming poses a threat to continued existence of *miombo* woodlands, tree planting was set as condition for tobacco farmers to enter into contract with tobacco buying companies. Other conditions were switching from traditional kilns used for tobacco curing to modern kilns which use fewer firewood and restoration of degraded natural forests. Furthermore, the study observed some farmers practising organic farming and zero grazing in Moshi District no logical link with the previous sentence. Interviews with primary co-operative leaders showed that these practices are promoted and/or coordinated by farmers' primary co-operatives.

Table 5.1: Carbon enhancement activities by smallholder farmers under co-operative action

Activity	Percent
Tree planting	88.6
Soil conservation	76.4
Water shed management	74.1
Use of energy saving stoves	59.6
Protecting trees from fires	60.6
Restoration of degraded natural forests	44.7
Planting fodder	42.0
Crop rotation	53.5
Zero grazing	23.0
Agroforestry practices	66.4
Organic farming	22.1

Percentage do not total 100 because of multiple responses

5.4.4 Services provided by primary co-operatives

It was observed that farmers' primary co-operatives are central for integrating production and marketing of produce. Farmers were asked to list services they get from co-operatives; as illustrated in Figure 5.1, the overwhelming majority (87.9%) listed collection and selling of agricultural produce, 72.4% extension services, 68.7% and supply of better seeds, 70.7% of the respondents reported that they got education, training or information provided by their co-operatives, 49.5% the supply of agricultural inputs, 32.7% agro credit and 27.9% certification of crops. Interviews with co-operative leaders indicated that agricultural marketing co-operatives provide other post-harvest services to their members, which include warehousing, grading, packaging, transport and market information.

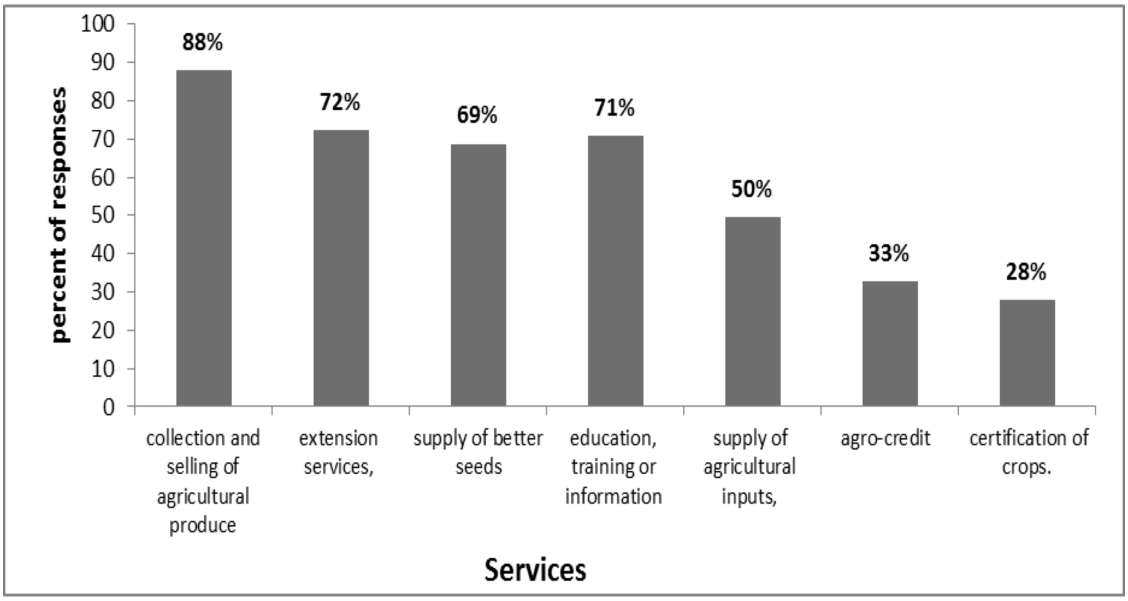

Figure 5.1: Services provided by primary co-operatives to members

Members who got education, training or information from co-operatives reported that education focused on better farm management, mainly production skills (88%), post-harvest management and storage (78%), tree planting (78%), soil conservation (76.1%), water shed management (74.1%), use of energy saving stoves (59.6%) and protecting trees from fires (60.6%).

5.4.5 Participation of co-operatives in environmental services

The study also sought to ascertain the participation of co-operative societies in ecosystem services. Figure 5.2 summarises the respondents' responses on the participation of co-operatives in environmental services. As shown, the majority of the respondents agreed that co-operatives were highly involved in environmental services.

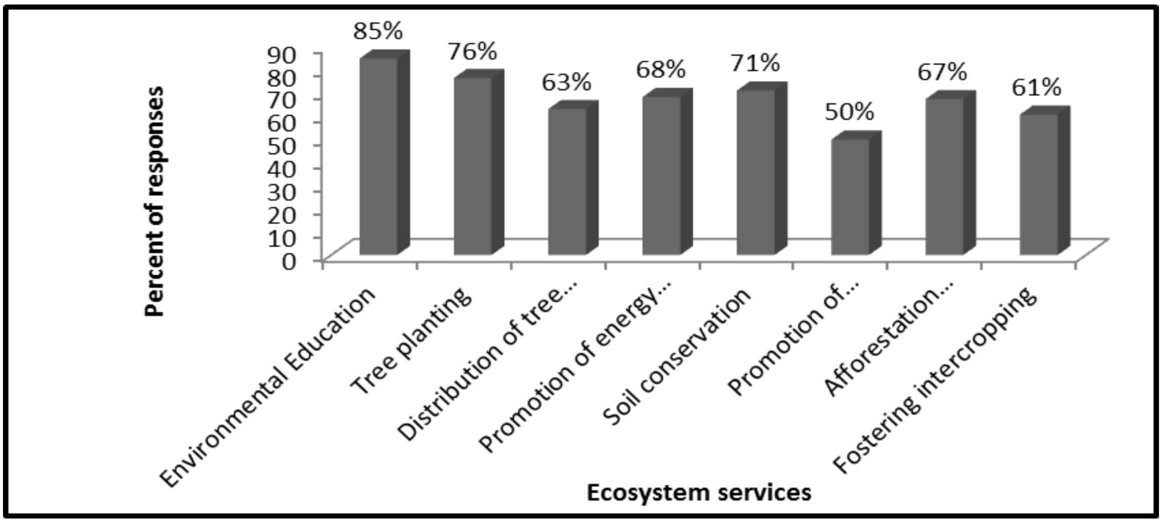

Figure 5.2: Participation of co-operatives in environmental services

Information gathered from farmers through focus group discussions revealed that agroforestry cropping system involves the integration of several multi-purpose trees and shrubs with food and cash crops and livestock on the same unit of land. Furthermore, the results showed that the agroforestry practices apart from providing shade to coffee, fodder and mulch, they also exhibited considerable capacity to accumulate biomass and nutrients. The results in chapter four showed that in the agroforestry cropping systems the amount of carbon was higher compared to other cropping systems. Carbon stock ranged from 29.94 t C ha^{-1} in coffee banana dominated agroforestry to 96.52 t C ha^{-1} in coffee agroforestry plantations.

In Urambo District, the study revealed that co-operatives in addition to coordinating marketing and storage of agricultural produce (tobacco) they were also involved in carbon enhancement activities. These activities according to FGDs and Key Informant Interviews include tree planting, conservation of natural forests, land fallow and promotion of the use of energy efficient kilns (modern kilns). Key informant interviews with farmers and co-operative leaders revealed that tree planting and/or restoration of degraded natural forest was mandatory for all tobacco farmers. These practices reduce GHG emissions resulting from forest loss and enhance carbon stock through conservation of forests and afforestation programmes. The FGDs results further showed that, for every one bag of fertilizer, a farmer was supplied with 50 tree seedlings for afforestation programme. Interviews with co-operative leaders showed that modern kilns for tobacco curing cut fuel wood use by 50% compared to conventional kilns. With conventional kilns, a farmer used 14 tons of wood for an acre of tobacco compared to modern ones where only 7 tons of fuel woods for curing tobacco from an acre were burned. Moreover, the interviews - confirmed that the modern kilns used tree branches and not logs as did traditional ones. FGDs associated these practices with reduced pressure on *miombo* woodlands and therefore enhanced carbon stock.

5.4.6 Business Model of the sampled co-operative societies

The analysis describes the basic co-operative business models of 16 primary agricultural marketing co-operatives (8 coffee farming and 8 tobacco farming). An overview of the co-operatives' business models, their characteristics and services offered is presented in Figure 5.3. Farmers' primary co-operatives in the two districts coordinate farming of the two main cash crops, namely, coffee in Moshi District and tobacco in Urambo District. The findings showed that co-operatives offer several well-known technical, managerial and marketing services to smallholder farmers. Technical services include processing, grading, certification and classification. Managerial services include organizing, networking. Training, input supply and agro-credit collection and selling of agricultural produces. With regard to marketing approaches, the study noted two different marketing channels: farmers' primary co-operatives selling agricultural produce through the co-operative union (2nd tier) and direct selling to the open market without passing through the co-operative union.

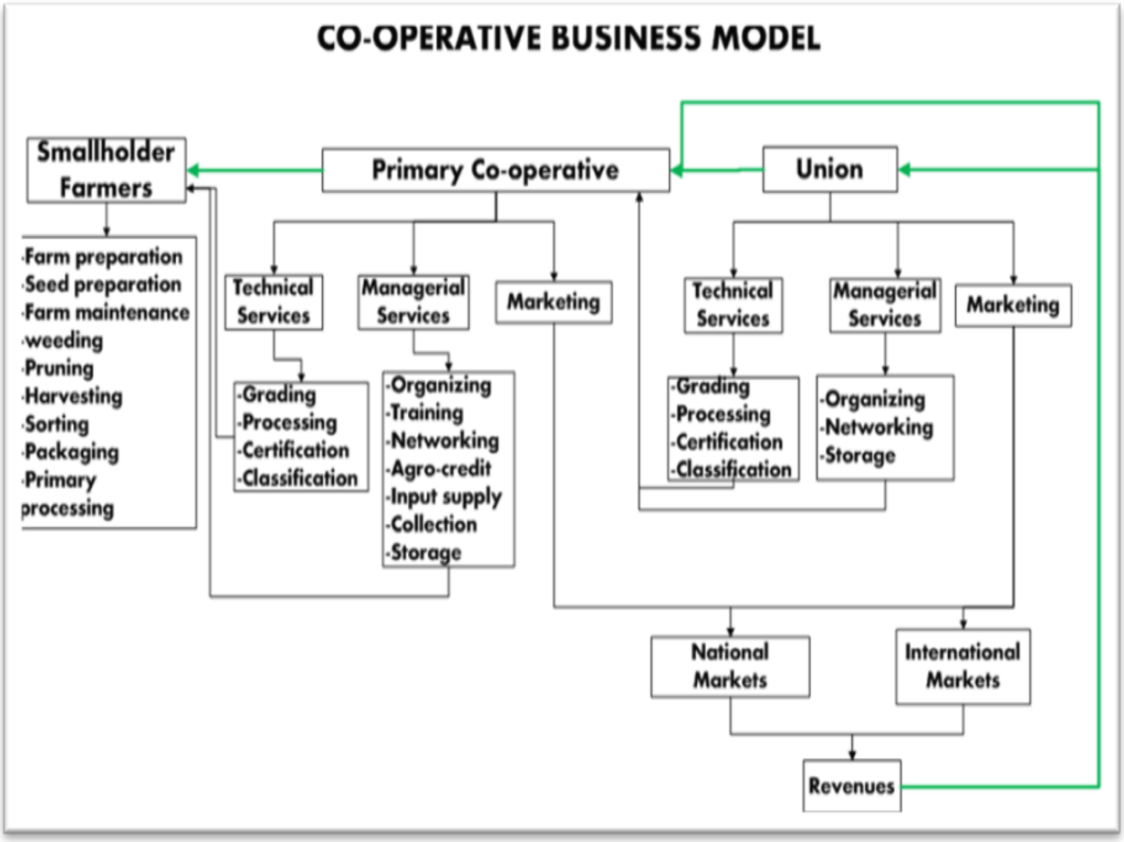

Figure 5.3: Business Model of the sampled Co-operative societies

The former is the traditional/conventional marketing channel. Under this model the role of primary co-operatives is the collection and processing and then handing the crop/produce to the union, whereas the union sets the market on behalf of the members. The union then looks for the buyer offering the best price. With respect to the latter approach some primary co-operatives in Moshi District declined selling coffee through the union and instead formed a network through which they marketed or auctioned their produce. According to interviews with primary co-operative leaders, the motive to withdraw from the union was to seek an alternative marketing system free from bureaucracy and high coordination costs inherent in the union structure that further reduced prices to members. Under this marketing channel primary co-operative societies do the collection, bulk storage and handling, grading, transport and marketing directly at the coffee auction.

The latter marketing approach was also observed in tobacco marketing in Urambo District, where tobacco farmers sell their produce directly in the open market through their primary co-operatives. Interviews with co-operative leaders showed that the second marketing model reduces operation costs compared to the conventional one; as a result, the farmers enjoy financial benefits arising from economies of scale, thus achieving higher prices for equal or better-quality services.

5.4.7 Linking carbon trading to co-operative business models: application of the co-operative business model to carbon trading

With regard to the application of co-operative business model to carbon trading, the study focused on two actors in the value chain; the smallholder farmers and the primary co-operative societies. The analysis based on the second co-operative marketing channel described in section 4.4 above is presented from two points of view: the farmers are in charge of implementing activities that result in generating carbon credits and primary co-operatives are involved in coordinating the generation and selling of the resultant carbon credits. In the case of the co-operatives studied, carbon trading widens the number of commodities to two commodities (coffee and carbon for coffee farming communities or tobacco and carbon for tobacco farming communities) instead of a single commodity demanded by external markets. In the widened commodity perspective, co-operatives are able to deal with other types of commodities including carbon credits. Based on the carbon production chain the following applies to the Co-operative Business Model as regards carbon trading

***Smallholder farmers*:** Farmers in both districts through their co-operatives-based activities linked to carbon emissions reduction and carbon enhancement activities generate carbon credits. These activities include improved soil management techniques, agroforestry practices, and management of perennial shade trees in coffee agroforestry cropping systems, land fallow practices, afforestation programmes and conservation of natural forests/restoration of degraded natural forests in miombo woodland agro-ecosystems. These activities by cooperatives generate carbon credits. Carbon credits generated become a commodity for farmers and can be traded as the carbon a second commodity

***Primary Co-operatives*:** The primary co-operatives farmers' organizations are supposed to promote sustainable forest management by capitalizing on activities that reduce pressure from harvesting forests products. Carbon is a stock commodity**,** because it is a stock, primary co-operatives must be active to look for assessment, measurement, evaluation and markets. Key activities by primary co-operatives for carbon enhancement activities include organizing and documenting the progress of participating farmers, administrating contracts and monitoring, communicating with farmers about tasks, obligations and rights along with buyers, attending the third-party verification, and paying visits to all participating farmers. In terms of carbon credits marketing, although credits are created at the farm level, the commodification and trading process are supposed to take place off the farm through primary co-operatives. The primary societies bundle/stack and channel carbon credits created and act as focal contact points for buyers or international carbon markets. Once sales of credits take off, primary co-operatives sell credits in the name of the farmers and also be responsible for fund management and equitable sharing of the benefits. Figure 5.4 illustrated how the co-operative business model applies to carbon trading.

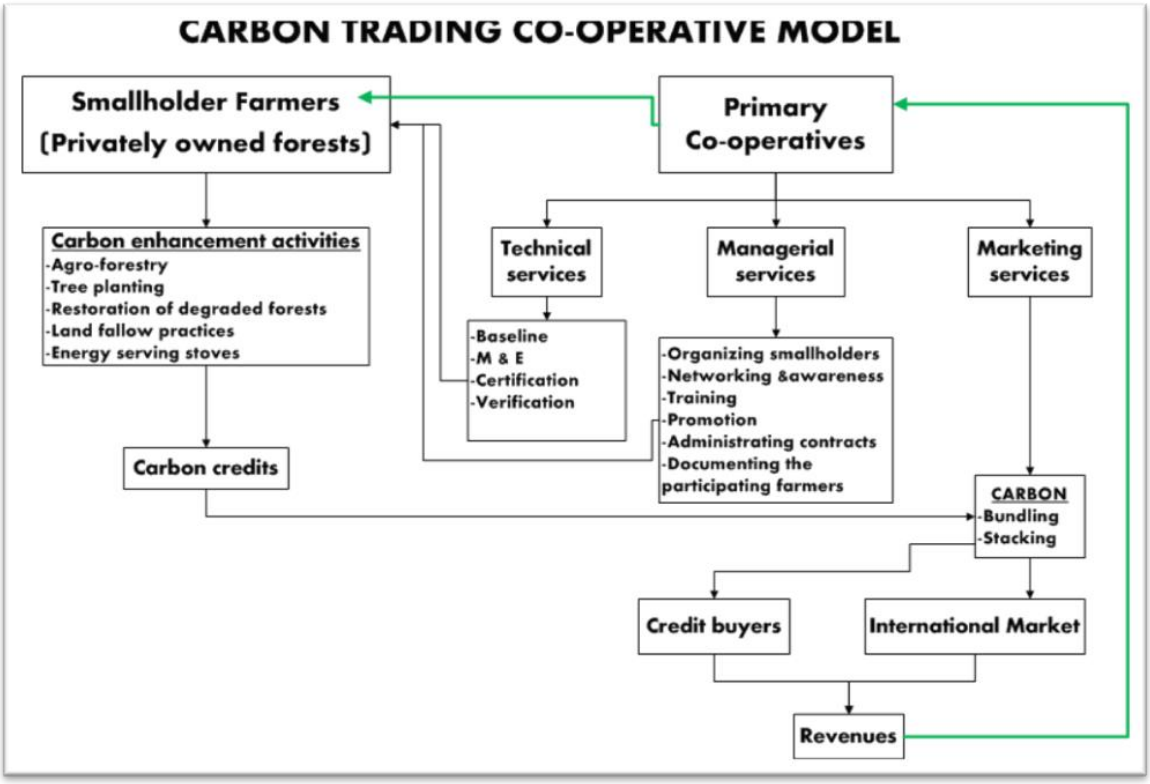

Figure 5.4:Co-operative carbon credit trading model

The key resources needed are the internal control systems and project technicians that provide technical assistance on how to implement mitigation activities. The primary co-operatives will recruit or hire extension personnel for baseline, monitoring and reporting, land use planning, verification and measurements as they do for crop production and marketing.

5.5 Discussion

The underlying contention of the study is that co-operatives have a unique ability or potential to efficiently aggregate and mobilize large numbers of people and resources at the community level in order to increase crop productivity and overall income by generating support in various activities related to agriculture. Suitable farming systems to generate income through crops marketing have been achieved by members of the co-operatives. Focusing on ecosystem services, a comprehensive set of activities related to LULUCF have been integrated in order to develop resilience towards climate change. The activities as mentioned earlier include agroforestry, restoration of degraded forests, tree planting, land fallow and intensive farming. These activities increase net forest carbon sequestration, thereby generating carbon credits, another commodity that can be traded through the co-operative approach.

The importance of engaging in meaningful action to reduce GHG emissions and enhance carbon stock is recognized in the United Nations Framework Convention on Climate Change (UNFCCC) through various mitigation options mainly the Clean Development Mechanism(CDM) and reducing emissions from deforestation and forest degradation, and enhancing forest carbon stocks in developing countries (REDD+) (Rahman *et al.*, 2015). These are intended to engage multi-scale stakeholders in conservation and sustainable management of forest resources for enhancing carbon sequestration in developing countries with incentives as a reward for mitigating global climate change (Gardner *et al.*, 2012).

The results suggest that the general characteristic of the co-operative marketing model fits in carbon trading. Co-operatives have the potential to chip in to organize the smallholder farmers to take advantage of the carbon market, both voluntarily and/or in compliance to markets. Smallholder farmers do not know how to access carbon markets because of small scale production. The study showed potentials of co-operative societies bundling or stacking carbon credits into bigger volumes that meets the requirement of the market. Thus, co-operatives act as aggregators who collect carbon credits from smallholders before selling at the international markets or private buyers through the voluntary market.

Organizing communities into groups (co-operatives) addresses the long-lasting challenges of rewarding climate services by smallholders without which they could not meet the minimum volume/quantity required by the international markets (Deal *et al.*, 2012). Carbon credits are traded only in large bundles (more than 10 000 metric tons per year), so "aggregators" bundle together the offsets from numerous smallholders to sell them at the carbon market (Adams and Jones, 2009). On their own, individual smallholder farmers may not be generating sufficient carbon credits in a cost effective manner but their co-operatives by bundling and/or stacking climate services can enable individual smallholders not only to effectively participate in carbon trading but also provide an improved method for integrating markets Deal *et al.* (2012). Bundling or stacking of climate services for payments could both increase forestland value and encourage farmers to consider their land as natural assets that provide a set of different ecosystem services (Collins and Larry, 2008; Farley and Costanza, 2010; LaRocco and Deal, 2011).

The results show that agricultural co-operatives hire or recruit extension officers to assist the farmers in better crop production. carbon trading on the other hand, needs accurate information on carbon stocks, biodiversity and the socioeconomic status of the communities (van der Gaast *et al.*, 2018). Therefore, carbon trading through co-operatives may engage extension personnel for baseline, monitoring, verification and measurements to carry out these functions. Furthermore, co-operatives may organize training and awareness campaign on carbon trade benefits (Liebrand and Ling, 2009)·

As verification of the land use practices impact on greenhouse gas reduction is usually required, a co-operative may engage verifiers, or have verifiers on its field service staff to carry out the function. Thus, a co-operative could help its members maximize the benefit available from the sale of carbon credits by negotiating the highest prices possible for the credits and minimizing the costs associated with selling carbon credits. Combined with other revenue streams associated with sales of coffee/tobacco, carbon credits could contribute additional cash flow to enhance the economic welfare of the members.

It is undisputable that LULUCF has the potential to contribute considerably to reducing net emissions by sequestering carbon dioxide from the atmosphere (Rose *et al.*, 2012). The uptake of these opportunities, however, has been slow, particularly in regulating carbon markets (Cacho *et al.*, 2005); because of high carbon transaction costs, the property right to be exchanged is fragmented, difficult to measure and its exact size is subject to uncertainty. Stacking of carbon credits by co-operatives could reduce transaction costs, specifically costs related to organizational aspects of the bundle and running costs related to verification and certification of credits generated (LaRocco and Deal, 2011; Deal *et al.*, 2012). Collective selling provides co-operative members with an opportunity to access multiple sources of revenue (LaRocco and Deal, 2011).

With regard to marketing, a co-operative does bargain for lower marketing fees and/or higher returns. Similarly, co-operatives may play these roles in carbon trading; a co-operative may engage a broker(s) to negotiate with carbon credit purchasers on prices and terms of trade or may act as a broker to negotiate with carbon credit purchasers, may engage an aggregator(s) to trade carbon credits for members and/or may act as an aggregator if there is enough volume of carbon credits generated by members (Liebrand and Ling, 2009). In essence, the function of a carbon credit aggregator is similar to that of primary co-operative society. It is as if you are going back to literature review arther than discussion of findings.

Thus, a co-operative could help its members maximize the benefit available from the sale of carbon credits by negotiating the highest prices possible for the credits and minimizing the costs associated with selling carbon credits. Co-operatives can work to ensure monitoring, benefit transfer and reporting. There is potential to reap additional dividends if conservation of one ecosystem service leads to the conservation of other services including biodiversity (Venter *et al.*, 2009).

Two key limiting factors in collective carbon trading are shared knowledge of how the business works and political will. Both of these can be overcome with targeted educational campaigns, clear dissemination of success and failures directed at both the co-operatives members and the general public.

5.6 Conclusion and Recommendations

The study examined how the co-operative business approach may apply to carbon trading with special emphasis on community carbon enhancement activities. Co-operatives play a major role in uniting their members to address common purpose. The study effectively demonstrated the potential and efficacy of co-operatives in mobilizing their members to undertake carbon enhancement activities, generate carbon credits and participate in carbon trading. Thus, co-operatives apply not only to crop production, but can be used in a wide range of other commodities. The co-operative marketing approach, through stacking carbon credits, makes smallholder farmers eligible for carbon projects and therefore smallholder farmers can earn revenue from both carbon credits and agricultural produce. The concept of co-operatives business model as a tool for carbon trading leaves much to be desired in the area of climate change services. It offers a framework for small-holder famers to come together as a strong entity to gain collective bargaining power and by so doing, the groups can achieve considerable benefits in terms of creating avenues for the marketing of carbon credits generated through activities with co-operative actions.

However, co-operatives need additional support to effectively engage in carbon trading in terms of technical experts in carbon trading. There is also a need to look at the rules and regulations of carbon trading to facilitate flexibility to suit the carbon trading requirements and promote various activities required for enhancing carbon stock which can be done by cooperatives through the cooperative business model.

This study has stressed the role of co-operatives and similar organizations as the best means to carry out local carbon projects. As such, co-operatives need to be given much more attention by researchers and policy makers as a delivery mechanism for carbon-related services in local communities especially small holder farmers. Meaningful change often takes place based on learning from pilot projects. The community of co-operative researchers and developers can play a very important role in propagating an agenda in which co-operatives can become a major part of climate change mitigation. They can do this through identifying examples of co-operatives that are carrying out carbon enhancement activities, to broaden their activities into the area of climate services, including carbon trading.

Carbon is a new commodity smallholder farmers need to be introduced to. Therefore, awareness creation for members to recognize new opportunities for another commodity (carbon credits) is required. Finally, participation of co-operatives in climate services is an opportunity for training institutions, Moshi Co-operative University in particular can organize seminars and workshops on climate services and/or develop climate change related courses for co-operative extension officers and co-operatives stakeholders.

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CHAPTER SIX

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

6.1 Introduction

The study was carried out with the main objective to explore the role of co-operatives in reducing GHG emissions and enhancing sinks through land use, land use-change and forestry in Moshi and Urambo Districts. Given the potential for co-operatives to strengthen and build capacities that enhance communities' economic and social conditions it was imperative to consider the model of economic enterprise that co-operatives offer to foster community participation in LULUCF activities in an endeavour to reduce pressure on forests thereby enhancing the prospects to sequester carbon emissions.

Co-operatives, as economic enterprises and as self-help organizations, play a meaningful role in uplifting the socio-economic conditions of their members and their local communities. Over the years, co-operatives have successfully operated locally owned people-centred businesses while also serving as catalysts for social organization and cohesion. With their concern for their members and communities, they represent a business model that places high regard for democratic and human values and respect for the environment. As the world today faces rapid climate change and increased environmental degradation, co-operatives become relevant in addressing the problems arising from climate change through enhancing carbon stock by getting involved in land use and land use changes aimed at conserving existing forests and restoring forests and biodiversity. The focus of the study was mainly on the following specific objectives: (1) to assess the drivers of land use and land use changes associated with agricultural co-operatives' actions linked to carbon emissions reduction and enhancing carbon sinks (2) to study the extent to which agricultural co-operatives' activities have contributed to mitigating (weaning) carbon emissions from land use and land-use changes, (3) to determine the contribution of co-operatives in maintaining carbon stocks in agroforestry cropping systems and *miombo* woodland agro-ecosystems, and (4) to assess the potential of co-operative marketing approach in enhancing carbon trading in community managed carbon enhancement activities.

6.2 Summary of Major Results and Conclusions

This section presents a summary of the major findings and conclusions in accordance with the study objectives. The study has made an attempt to gain a better understanding of the role of co-operatives in GHG emissions and carbon sinks enhancement through land use, land-use change and forestry.

6.2.1 Drivers of land use and land-use changes and their influence on carbon sinks in agroforestry and miombo woodland agro-ecosystems

Chapter two examined the drivers of LULUC that influence GHG emissions and carbon sinks in Moshi and Urambo Districts of Tanzania. It studied the nature and extent of land-use changes in these differing districts. The focus was on drivers of land use and land-use changes and their implications on GHG emissions and enhancing carbon sinks. Binary logistic regression analysis was undertaken to assess drivers having higher chances of influencing land use and land-use change; the land use changes being analysed basing on the interpretation of satellite images. Specifically, the study sought to understand the nature and extent of land use changes as well as examining their drivers and implications on reducing GHG emissions and increasing carbon stocks in different pools.

The results showed that over three quarters of the respondents (78.8%) were aware of land use and land-use changes occurring in the districts. The prominent changes, according to their perception, were increase in forestland (66.1%), soil conservation (60.3%), intensive farming (60.2%), tree planting (57.9%), water catchment conservation (57.6%), crop rotation (53.5%) and expansion of farm lands (52.9%). The study further demonstrated that 87.9% of the respondents had knowledge that co-operative actions had influence on land use and land use changes.

Furthermore, based on image analysis and change detection it was demonstrated that there were drastic land use and land-use changes in both districts. The major land use change for Moshi district occurred in land under cultivation with tree crops. This was concurrent with an enormous decline in the land under herbaceous crops. For Urambo district the thesis showed significant land-use changes with remarkable increase in closed woodlands, and mixed crop land area where there was a big increment in 2015 connected to the decrease in land under woodlands with scattered cropland. The thesis concludes that the changes in land use and land-use change varied across the study locations.

By analyzing drivers of land use and land use change in the period from 1995 to 2015 in Moshi District and the period between 2005 and 2015 for Urambo District, the study has provided a more detailed picture of the drivers propelling GHG emissions and those associated with enhancing carbon sinks through LULUCF. Binary logistic regression showed that pooled together intensive farming, population increase, establishment of woodlots and bye-laws and regulations are statistically significant in influencing land use and land use-change at $p<0.021$, $p<0.000$, $p<0.000$ and 0.096 respectively. On the other hand, the findings showed that whereas establishment of woodlots and population increase were statistically significant for both Moshi and Urambo districts, agroforestry (p<0.024), tree planting (p<0.029) and migration (p<0.012) were significant for Moshi district and intensive farming (p<0.013), firewood collection (p<0.021), environmental pressure groups (p<0.054) and intensive farming (p<0.0.3) for Urambo district. The findings demonstrated that tree planting increased biomass and reduced pressure on forest lands. Intensive farming specifically organic farming, use of organic and chemical fertilisers in crop production increased productivity per unit land area thus sparing more forest lands from being converted into crop fields and therefore keeping carbon sequestered in the soils and forests. Use of energy efficiency kilns reduces pressure on forests, thus it has potential for carbon storage and sequestration. Meanwhile, population growth and migration are the major land use and land-use change drivers that propel GHG emissions and reduce carbon sinks. The findings further showed that timber and poles harvest, conservation of natural forests, farmland expansion, timber and poles harvest and conservation natural forests, although not statistically significant, were identified by most of the respondents as important drivers of LULUCF.

Based on results, this study concludes that major changes in land use occurred on both ecosystems, and they vary overtime. Intensive farming, establishment of woodlots, use of energy efficiency stoves, agroforestry practices, migration, population growth, tree planting, crop rotation and conservation of natural forests were important drivers of land use and land use changes.

6.2.2 Co-operatives' activities linked to carbon emissions and carbon sequestration through land use, land-use change and forestry

Chapter three presented and discussed findings concerning co-operatives' actions linked to GHG emissions and carbon removals through land use, land-use change and forestry. Co-operatives' actions or lack thereof linked to increased or reduced GHG emissions as well as increasing carbon sequestration in terrestrial ecosystems have been successfully described. The prominent land use and land-use changes identified by the study are increase in forestland, intensive farming, soil conservation, agroforestry, and tree planting. Pooled binary logistic regression showed co-operatives' actions influencing GHG emissions and carbon sinks as supply of agricultural inputs ($p<0.035$), provision of extension services at $p< 0.005$, Promoting alternative income generating activities at $p<0.000$, supply of improved seeds at $p<0.000$, environmental conservation $p<0.000$, promotion of organic farming $p<0.000$, agroforestry $p<0.017$ and tree planting $p<0.002$.

With regard to individual district the study demonstrated that marketing agricultural produce ($p<0.001$), providing extension services ($p<0.026$), promoting intensive farming ($p<0.044$), promoting alternative income generating activities (($p<0.021$), supplying seeds ($p<0.006$), environmental conservation ($p<0.006$), promoting organic farming (($p<0.009$) and promoting savings ($p<0.035$) were statistically significant in influencing GHG emissions and carbon sinks for Moshi District. For Urambo district the study showed that other factors remaining constant providing loans ($p<0.004$), providing extension services ($p<0.000$), promoting intensive farming (($p<0.081$), promoting alternative income generating activities ($p<0.000$), supplying seeds ($p<0.000$) and environmental conservation ($p<0.000$) were statistically significant in influencing GHG emissions and carbon sinks through LULUCF.

The positive conclusions which can be drawn from the chapter are that co-operatives contribute to carbon emissions reduction and enhance carbon sinks by getting involved in land use and land-use changes. Marketing of agricultural products, supply of agricultural inputs, provision of extension services, promotion of intensive farming and advocating agroforestry practices have a significant contribution to climate change mitigation.

6.2.3 Contribution of Co-operatives in maintaining carbon stocks in agroforestry cropping systems and miombo woodland agro-ecosystems

Quantitative contribution of co-operatives in carbon emission mitigation through conservation of existing carbon stocks in agroforestry and *miombo* woodland agro-ecosystems was discussed in chapter four. The study has clearly demonstrated that some co-operatives' activities linked to LULUCF improve carbon sequestration and enhance carbon stock. It has been revealed that carbon stock varied greatly from one land use type to another one. The estimated total carbon stocks of agroforestry systems ranged from 9.66 to 122.10 t C ha^{-1}. Coffee plantations exhibited more total carbon stocks (122.10 t C ha^{-1}) compared to coffee, banana agroforestry (37.73 t C ha^{-1}), Mixed crop land with scattered trees (9.66) and natural forests (forest reserves) (34.46 t C ha^{-1}). This is due to the existence of trees with higher DBH (mean DBH 78.66 +9.7 cm) in coffee plantations. The study further showed that banana plants contributed around 8.47 kg C/plant. The results further showed that agroforestry systems had the highest carbon stock compared to natural forests. The study concludes that agroforestry systems had the highest carbon stock compared to natural forests.

In the miombo woodlands agroecosystems the estimated total carbon stock ranged from 1.04 to 32.37 t C ha^{-1} for land uses with co-operative actions namely village forests (32.37), household managed woodlands (31.39 t C ha^{-1}), fallow fields (1.04 t C ha^{-1}) and woodlots (3.64 t C ha^{-1}). Carbon stock was higher in forest reserves (land use with no co-operative actions) where carbon stock was estimated to be 41.42 t C ha^{-1}.

Quantitatively, land use systems with co-operatives' actions contribute 78.4% (159.83 t C ha^{-1}) of the existing carbon stock per hectare in the agroforestry ecosystems and 64.28% of carbon stock to the total carbon in the miombo woodland agro-ecosystems, an average of 17.11 t C ha^{-1}. In the absence of co-operatives' actions this carbon could have been lost. The study concludes that farming systems with co-operatives' actions have a significant contribution to climate change mitigation through carbon storage in the above and below ground plant biomass.

6.2.4 The Role of Co-operatives in carbon trading in community managed carbon enhancement activities

The results in Chapter five are about how the co-operative business model can be applied to carbon trading with special emphasis on community carbon enhancement activities. The results showed that co-operatives are central for integrating production and marketing of agricultural produce, and the services provided range from extension services, collection, processing, to warehousing, grading, market information and selling of produce. The study demonstrated the potential and efficacy of co-operatives in mobilizing their members to undertake carbon enhancement activities, generate carbon credits and participate in carbon trading. The principle research questions examined was whether the co-operative marketing approach applies to the carbon trading.

The study findings indicated that smallholder farmers were involved in some activities that enhance carbon stock in both districts. When ranked from most carbon enhancement activities observed by this study were tree planting (88.6%), soil management (76.4%), watershed management (74.1%), agroforestry (66.4%), protecting trees from fires (60.6%) and use of energy efficient stoves (59.6%). The study further showed that in Urambo District where tobacco farming poses threat to *miombo* woodlands, tree planting was one condition for tobacco farmers to enter into contract with tobacco buying companies.

The study has revealed that primary co-operatives are central for integrating production and marketing and provide a range of services to farmers. The most services listed by farmers include collection and selling of agricultural produce (72.4%), supply of better and improved seeds (70.7%), extension services (68.7%) education and training (49.5%) and supply of agricultural inputs (32.7%). Other services included post-harvest services mainly warehousing, grading, packaging, transport and market information. The findings showed that under the co-operative model co-operatives offer several well-known technical, managerial and marketing services to small farmers. Technical services include processing, grading, certification and classification. Managerial services include organizing, networking, training, input supply and agro-credit collection and selling of agricultural produces. With regard to marketing services co-operative societies do the collection, bulk storage and handling, grading, transport and marketing directly the farmers' crops at the coffee auction.

Farmers in both districts through co-operatives' activities linked to carbon emissions reduction and carbon enhancement activities generate carbon credits. Carbon credits that can be traded. The study has showed that Co-operatives have the potential to chip in to organize the smallholder farmers to take advantage of the carbon market, both voluntary and/or compliance markets. Once sales of credits take off, primary co-operatives will be selling credits in the name of the farmers and also be responsible for fund management and equitable sharing of the benefits.

The study concludes that the general characteristic of the co-operative marketing model fits nicely in carbon trading. Smallholder farmers do not know how to access carbon markets because of small scale production. Co-operative societies fit the requirement of the market by bundling or stacking carbon credits into bigger volumes eligible for trading. Therefore, the co-operative marketing approach through stacking carbon credits makes smallholder farmers eligible for carbon projects and therefore can earn revenue from both carbon credits and agricultural produce.

6.3 Recommendations

6.3.1 Drivers of land use and land-use changes and their influence on carbon sinks

The study calls upon national and international communities to enhance knowledge on agricultural practices that reduce GHG emissions and enhance carbon pools and where possible to provide extension services. Furthermore, governments should promote demographic policies that reduce population growth.

The study further recommends that the international and national communities' strategies to mitigate climate change should give highest priority to co-operatives' activities related to land use systems that reduce GHG emissions and/or enhance carbon sinks.

It is further recommended that co-operative approach be incorporated into National REDD+ planning as one strategy to address the drivers of LULUCF linked to emissions reduction and enhancement of carbon stock.

6.3.2 Co-operatives' activities linked to carbon emissions and carbon sequestration

The realization of climate change mitigation through LULUCF mostly requires active collective participation. Therefore, central and local governments, development partners, and nongovernmental organisations' efforts to mitigate climate change through LULUCF should be built on co-operatives' activities that reduce GHG emissions and/or enhance carbon sinks.

Expansion and exploitation of agricultural land threatens trade-offs in the form of deforestation and loss of biodiversity. The study calls for action to reduce human pressure on forests through involvement of co-operatives in development and implementation of national strategies or action plans for reducing emissions from deforestation and forest degradation plus conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries' (REDD+). This can be done by all stakeholders including central and local governments, Non-Governmental Organizations as well as through established co-operative societies.

6.3.3 Contribution of Co-operatives in maintaining carbon stocks

The chapter has demonstrated land use forms that provide a partial mitigating effect on the overall rate of carbon loss through unsustainable land use forms. The study recommends that management of land use systems that enhance carbon stock, agroforestry, restoration of degraded forests, afforestation and land fallow should be given the highest priority in efforts to increase carbon stock through co-operatives' actions.

The chapter suggests that well-managed forms of land use systems that avoid forest degradation may provide the best opportunity for maintaining high carbon stocks. The study recommends deliberate national and international efforts to propagate an agenda in which co-operatives' activities linked to LULUCF that enhance carbon stock become a major part of climate change mitigation strategies.

6.3.4 The role of Co-operatives in carbon trading

The study further recommends that climate change mitigation efforts should integrate relevant models of collective action into programmes designed to address climate change through LULUCF. Both central and local governments and development partners, NGOs in particular should encourage and patronize community groups as important focal points for propelling activities linked to GHG emissions reduction and enhancing carbon emissions removals.

The study recommends that co-operatives need additional support to effectively engage in carbon trading in terms of technical experts in carbon trade and calls for awareness creation for smallholder farmers to recognize new opportunities for carbon trading.

6.4 Contribution to New Knowledge

The study findings contribute to the body of knowledge. The study widens the historical co-operative business model from the traditions of dealing with agricultural export commodities and services to a naturally developed and conceived business, dealing with carbon trading. Secondly, the research is making a departure from the *flow* concept of conveyance of goods and services such as the production and transfer of coffee and tobacco or audit delivery services, to the *stock* concept of co-operative business, primarily dealing with the invisible carbon stock. It is also centred on the ecosystem absorption capacity of carbon dioxide emitted by industry at a global level. The study also provides a new mechanism for commodity diversification for co-operatives and enhances the income of members to fight against income poverty.

With respect to theoretical contribution, the findings of this thesis are in line with human development theory. The human development theory echoes two important principles of co-operation, namely principle number five putting emphasis on enhancing the stock of knowledge for raising business capacity through education, training and experimentation and principle number seven concern for the community. Thus, it puts emphasis on sustainable development encouraging members of co-operatives to do business which sustains current and future environment. The findings suggest that entering the carbon industry with small farmers, through co-operative marketing approach, is a process of competence building and raising the stock of knowledge for small farmers' enhanced capabilities and searching for opportunities to enter competitive markets and address environmental threats

With regard to methodological contribution, the main methodological contribution of the research has been the integration and application of research methods of the natural and social science disciplines to study the contribution of co-operatives in climate change services and how it has been done in a scientifically rigorous way. This enables more scientists to engage in interdisciplinary research, and to facilitate communication of the results through the publishing of interdisciplinary research papers.

6.5 Recommendations for Future Research

The findings of this study provide an insight on the areas that require further research in the future. The study concentrated on justifying that co-operatives have a great role to play in climate change mitigation through LULUCF. This study was confined to farmer agricultural marketing co-operatives. Therefore, a similar study needs to be carried out in other types of co-operatives like the role of financial co-operatives in carbon trade financing. It is suggested that further study should be carried out in this area. The interlinkages between agricultural cooperatives and financial cooperatives in advancing carbon trading among small holder farmers is pertinent.

Since *Miombo* woodlands are under severe threat because of tobacco farming, a cost benefit analysis study on substituting carbon trade for tobacco is suggested. This would provide a wider scope of information for policy decision on *miombo* woodland conservation.

APPENDICES

Appendix 1: Survey Questionnaire

Introduction

My name is Justinian Bamanyisa. This questionnaire is designed to explore the role of co-operatives in reducing carbon emissions and enhancing sinks through land use, land use change and forestry. It is the part of my PhD study requirement at Sokoine University of Agriculture in collaboration with Moshi Co-operative University. Please be honest and sincere in answering the questions in this questionnaire. All of your answers will be kept strictly confidential. You have the right to stop the interview at any time or to skip any questions that you don't want to answer.

Questionnaire No. ---------------------------------

Date of interview: --

District: ---

Ward: --

Village: ---

Name of the interviewee ---

1. Are you the household head? 1. Yes 2. No.
2. If no, what is your relationship to the household head?

   (1) Spouse (2) Son/daughter (3) Parent

   (4) In-law (5) Sibling (6) other relation (specify) -------------

3. What is the sex of the household head? (***Circle one***) 1. Male 2. Female
4. What is the age of the household head? ---------- years.

5. Which of the following best describes the present marital status of the household head

6.

   1. Never Married/Single 2. Married 3.Divorced/Separated 4. Widow/Widower

7. If polygamous, how many wives are in the household? ------------

8. Highest education level of the household head

   1. None 2. Primary STD IV 3. Primary STD VII

   4. Ordinary level 5. Advanced level 6. Vocational college

   7. University

9. Highest education level of the household head spouse

   1. None 2. Primary STD IV 3. Primary STD VII

   4. Ordinary level 5. Advanced level 6. Vocational college

   7. University

10. How many members are currently living in this household in the following age categories?

    a. Child under five years -----------

    b. Children between 5 and 17 years -----------

    c. Adult aged between 18 – 59 years -----------

    d. Elders aged above 59 years -----------

11. What are the main income generating activities of the household head? (tick where appropriate)

occupation	1st	2nd	3rd
Farming			
livestock keeping			
Self-employed off-farm			
Business			
Salaried employment			
Farm worker			
Off-farm work			
Casual labour			
House keeping			
Others (mention)			

12. What is the second income generating activity of the household head? (***Circle one***)

    1. Farming
    2. livestock keeping
    3. Self-employed off-farm
    4. Business
    5. Salaried employment
    6. Farm worker
    7. Off-farm worker
    8. Casual labour
    9. Housekeeping
    10. Other (Specify) -------------

13. What is the third income generating activity of the household head? (***Circle one***)

    1. Farming
    2. livestock keeping
    3. Self-employed off-farm
    4. Business
    5. Salaried employment

6. Farm worker
7. Off-farm worker
8. Casual labour
9. Housekeeping
10. Other (Specify) -------------

14. What is the approximate level of net household income per year? This means the total income ……………………………………………...

Housing

15. What kind of material the main housing does the household have?

(a) Type of walls:

1. Brick walls plastered
2. Brick walls unplastered
3. Mud poles plastered
4. Mud poles unplastered

(b) Type of roof:

1. Iron sheet roof
2. Grass thatched roof

(c) Type of floor:

1. Cement floor
2. Earth floor

16. Where does your household mainly collect wood building materials?

1. From the forest reserve
2. From the nearest forest

3. From household plot
4. Buy from suppliers at the village
5. Buy from suppliers at the nearby village
6. Buy from another district

17. If from suppliers, from where do you think they get the materials? ……………..

1. From the forest reserve
2. From the nearest forest
3. From the forest in the neighbouring village
4. Other places (mention)……………………..

Participation in Co-Ops (Membership in Any Association or Group Etc)

18. Do you and/or any other adult in this household *belong to a co-op*?

    1. Yes 2. No.

19. If yes, which household member and which co-operative?

    a. Who? ______________Name of Co-op_________ Since when? ______

    b. Who? _____________ Name of Co-op___________Since when? ______

20. What services do you get as a result of being a member of a co-operative?

Service	**Yes = 1**	**No = 2**
Selling of produce with support of the coop		
Getting dividends		
Member education and training		
Attending meetings		
Accessing agricultural inputs		
Getting Agro credits		
Loan		
Savings		
Insurance		
Others		

21. Have you made any changes in farming or running your business as a result of being a member of a co-op? (***Circle one***) 1. Yes 2. No.

22. If yes, what are these changes? --

    ----

23. As a result of any change(s) that you have made in farming or in your household as a member a co-op, do you have *more* people you consider as '*close friends*' now?

    1. Yes 2. No.

24. Has the cooperative helped you in maximizing agricultural yields?
25. If not a member of cooperative, have you eve enjoyed services offered by the cooperative?

    1. Yes 2. No.

26. If yes, what are the services you enjoyed?

Service	Yes = 1	No = 2
Selling of produce with support of the coop		
Getting dividends		
Member education and training		
Attending AMCOS meetings		
Accessing agricultural inputs		
Accessing credit for my business		
Getting Agro credits		
Others		

27. If you experience a major problem (for example, failure or loss of your most important crop), do you first turn to cooperative for help? ----------------------------
28. Is the co-operative in your area involved in environmental management?

    1. Yes 2. No.

29. If yes how?
    1. promoting tree planting
    2. distributing trees for planting
    3. promoting soil management
    4. protecting water sheds
    5. promoting of protection of the existing forests
    6. promoting use of energy saving stoves
    7. others (mention)…………

30. Has being a member of a cooperative helped you to have the following? Tick whatever applies

1. good modern house	
2. afford to get enough food for your household	
3. pay for your children's education	
4. make savings	
5. get improved seed varieties	
6. get high yields from a small piece of land	
7. get credit	
8. start a business/income generating activity	
9. plant more trees in my plot	
10. start animal husbandry	
11. get transport facility	
12. afford agricultural in puts (fertilizer)	
13. use energy saving stoves for cooking	
14. open bank account for savings	
15. others (mention)	

16. Are there any institutions other than co-operatives that are involved in environmental management?

    1. Yes 2. No

    If yes what are they?..

    ....

Access to Land

17. In total, how much land (in acres) does this household (*all members*) own? ------ acres
18. Of the above land, how much is currently under use? --------acres.
19. If you needed more land to farm, could you get access to more?

    1. Yes 2. No

20. If yes, how? --

    ----

21. Is your household farming more land than it did 5 years ago?

1. Yes 2. No

a. If yes, how much more? --------------------acres

b. Who is the owner of the land? ---

c. How did you get this land? --

22. Did belonging to a co-op group help you in better management of your land?

1. Yes 2. No

23. If yes, how? (tick any that applies)

1. Helped to produce more on existing land
2. Assisted in tree planting
3. Supply of better seeds
4. Soil conservation
5. Supply of pesticides
6. Supply of agricultural inputs
7. Others (mention)---
------

24. Is belonging to a co-op group in any way responsible for having less land than you would have?

1. Yes 2. No

If yes, how? --

Section C: Crop Production

25. Name, in order of importance, ***four*** major crops grown in your household last year (2015)

Crop	Acreage	Average output (kg)	Main purpose
1.			
2.			
3.			
4.			

Main purpose- ***Codes***: (1) Food, (2) Cash, (3) Both food and cash, (4) Others

26. Of the major crops mentioned above, are there any crops that you grow because of the influence or support of the co-op society where you or member of your household belongs?

    1. Yes 2. No.

27. If yes, what type of influence or support?

___

28. Did you experience any severe constraints in producing crops in the last year?

    1 Yes 2 No. (*If no, go to Q 41*)

29. If yes, what were the main production constraints your household faced?

Constraint	Did the cooperative society where you or member of your household belongs assist in coping with production constraints	
	1. Yes 2. No	If yes, how?
1. Low soil fertility		
2. Pests		
3. Diseases		
4. Weeds		
5. Vermin/rodents		
6. Lack of improved varieties		
7. Lack of access to inputs		
8. Lack of good markets		
9. Extreme weather changes		
10. Small land holding		
11. Lack of labour		

30. What are the major types of livestock kept in this household?

Livestock	**Type**	**Number**
Chickens	Local	
	Crossbreed/Exotic	
Pigs	Local	
Goats	Local	
Cows	Local	
	Dairy	
Sheep	Local	
Bees		

31. Where do you graze your animals? (***Circle all that apply***)

1. zero grazing
2. Own land
3. Land belonging to fellow farmers
4. Communal land
5. neighbouring forest
6. Land belonging to my co-operative society
7. Other (Specify) --

Land and Forest Management

32. For the pas five to ten years, has there been changes in land use?

1. Yes 2. No

33. If yes in question 32 above what do you think are the drivers of those changes (tick whatever applies)

Land-use change drivers	Response
Intensive farming	
Crop rotation	
Woodlots	
Expanding farmlands	
Soil conservation	
Firewood collection	
Timber and poles harvest	
Migration	

Conservation of natural forests	
Use of energy efficient stoves	
Environmental pressure groups	
Bylaws and regulations	
Population growth	
Tree Planting	
Planting fodder	
Agroforestry	
Tobacco curing	
overgrazing	

34. How is the status of the nearby forest(s)?

35. Were forests ever more widespread in your village than they are today?

    1. Yes 2. No.

36. Do you feel that forests currently occupy land which should be used for agricultural purposes?

    1. Yes 2. No.

37. In general, would you prefer to see land which could be used for agriculture being farmed rather than being developed for forestry?

    1. Yes, prefer agricultural uses
    2. No, I'm happy to see forests on otherwise agricultural land

38. If a tree is cut down in a forest, how many are generally replaced and why? --------

----

39. Is your co-operative society involved in protecting the forest?

    1. Yes 1
    2. No 2

40. If yes, how?

……………………………………………………………………………………………

Agroforestry

41. Do you grow trees in your farm land/home garden?

42. list the major trees/shrub species found in your farm land

	Name of tree	**No. of trees**
1		
2		
3		
4		

43. Salient uses of trees in your farm (if more than one rank them in order of importance: **1** the most important and **5** the least important)

Uses	**Rank**				
	1	2	3	4	5
Firewood					
Fodder					
Timber					
Construction poles					
Fruits					
Conservation of biodiversity					
Shade					

44. How regularly do you plant trees in your farm land?

1.…Whenever I cut a tree   2. Every year   3. After 2 to 4 years

4.…after 5 years   5. after ten years   6. Other specify ………

45. Has the cooperative helped you in anyway to plant trees?

1. Yes   2. No

46. If yes how? ………………………………..

Energy Use

47. Main type of fuel used currently and their uses

Type	**Uses**			
	Cooking	**Brewing**	**Bricks making**	**Tobacco currying**
Firewood				
Charcoal				
Kerosene				
Electricity				
Gas				
Others………				

48. Main type of fuel used in the past and their uses

Type	**Uses**			
	Cooking	**Brewing**	**Bricks making**	**Tobacco currying**
Firewood				
Charcoal				
Kerosene				
Electricity				
Gas				
Others……… …				

49. Preferred cooking fuel type and reasons

Reason for preference	**Firewoo d**	**Charcoa l**	**Kerosen e**	**Electricit y**	**Ga s**	**Solar**
Easy to use						
Available						
Habit						
Does not smoke						
Quick						
Clean						

50. If firewood, how do you get your firewood?

1. collect it myself,
2. rely on others to collect it,
3. purchase it or

4. given to me

51. Where exactly do you go to find the wood? ………………………

52. Why do you go to that location? ………………………………

53. Do you collect firewood to sell? …………………………………

1. Yes 2. No

54. If yes, about what percentage of the wood that you collect are you selling?

……………………………………………………………..………………

55. If purchases. What do you purchase? (i.e., firewood or charcoal)

56. Roughly how much do you spend per week on cooking fuel?

57. Do you feel you have enough fuel to cook the number/amount of meals you would like to, thoroughly?

1. Yes
2. No

58. If not, what do you do to cope?

1. skip meals;
2. undercook meals;
3. purchase
4. trade for remainder

THANK YOU FOR YOUR TIME AND COOPERATION

Appendix 2: Interview guide for key informant interviews and Focus group discussions

1. What are the main services that the cooperative society offers to the farmers?
2. What are the main crops grown by members of this cooperative?
3. Does the cooperative society serve even non-members?
4. Is the cooperative society a member of the cooperative union
5. Which services are offered by the cooperative union?
6. Does your cooperative society support any income generating activity?
7. Is your cooperative a member of the union?
8. If yes above, what services does your cooperatives get from union?
9. Has the cooperative society supported/participated in any environmental management activity?
10. What strategies does the cooperative society have on protecting the environment?
11. What are the major changes in land use (area + quality) and management you noted in your locality over the last 10 years?
12. What are the drivers for the land use and land use changes you have mentioned?
13. What are the major factors that affect your decision related to land use or management in order of importance (+explain)?
14. Describe land lost or additional land gained in your locality during the last 10 to 20 years and associated factors?
15. What are the environmental challenges in the locality where the cooperative works?
16. Are the stakeholders and interest groups aware of and satisfied with the cooperative involvement in land management?
17. If your cooperative is involved in forest management; what are the key management objectives of the forests that you manage?

THANK YOU FOR YOUR TIME AND COOPERATION