Climate Change Adaptation and National Extension Approaches in Malawi:
A Stakeholder Assessment

By

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THESIS

Submitted in partial satisfaction of the requirements for the degree

MASTER OF SCIENCE

in

International Agricultural Development

in the

OFFICE OF GRADUATE STUDIES

of the

UNIVERSITY OF CALIFORNIA

DAVIS

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2021

ABSTRACT

Climate change poses significant challenges to Malawi's ability to grow maize, its staple food crop, due its heavy reliance on rain-fed agriculture and traditional farming practices that largely do not utilize agricultural inputs. According to the Food and Agriculture Organization of the United Nations (FAO), Climate Smart Agriculture (CSA) practices can help to support sustainable food production given changing climate conditions.

The Government of Malawi's (GoM) new pluralistic extension policy calls for the delivery of specialized services to farmers by governmental extension providers, nongovernmental organizations (NGOs), and private industry. These extension services are intended to support farmers to overcome barriers to increasing production and adapting to changing climatic conditions, yet these multiple actors often provide conflicting messages to farmers. The GoM has emphasized the need to improve coordination among extension providers to reduce inefficiency, redundancy, and confusion.

The purpose of this research study was to evaluate the challenges and successes in communicating climate change adaptation information to maize farmers in Malawi to inform the development of content and delivery of information by extension providers. The study included the following objectives:

- Identify the development of content and methods used by extension providers to educate maize farmers about climate adaptation practices in Malawi.
- Evaluate institutional constraints of Malawi's extension system in providing effective information for maize farmers to adapt to climate change.

I conducted a literature review and nineteen in-depth interviews with individuals who provide agricultural extension services to maize farmers in Malawi.

My findings indicate that there are select organizations that develop messages and are considered experts on climate change adaptation. Government departments were referenced as content developers by the greatest number of participants. In terms of knowledge transfer, eighty-five organizations were mentioned in the dissemination of information throughout Malawi's extension network. Several high-level government departments, Malawi NGOs, international NGOs, and farmer groups were identified as crucial to the transfer of information within the extension network.

My findings also suggest that Information Communication Technologies (ICTs), trainings, and written materials are the main advisory methods used to educate farmers about CSA practices. ICT platforms often complement one another by providing increased access to information for farmers who cannot afford technology, are illiterate, or require additional information to address agricultural issues. My findings revealed that organizations address climate change by recommending strategies to farmers including being climate informed, good agriculture practices, water conservation, soil management, improved seeds, crop diversification, agroforestry, and reducing diseases and pests.

This study indicates that there is a need for improved integration of organizations from lower governance levels in order to diversify the types of providers operating in Malawi's core extension network. The increased diversification of organizations within the core network will enhance collaboration and improve the transfer of knowledge among extension providers in Malawi. This study also reaffirms the importance of communicating clear and consistent messages to farmers to address climate change impacts in Malawi.

ACKNOWLEDGEMENTS

I would first like to express my sincerest gratitude to my thesis committee: Dr. Amanda Crump, Dr. Vikram Koundinya, and Dr. Mark Cooper. I am incredibly grateful for your support, guidance, mentorship, and advice throughout this process. You were all instrumental in the design, implementation, and analysis of this research.

Amanda, I feel so lucky to be part of your lab and one of your mentees. This research and my growth in the International Agricultural Development Program would not have been possible without you. Your dedication to your students is truly unparalleled and I am forever grateful.

I would like to extend a special thank you to Mr. Paul Fatch at Lilongwe University of Agriculture and Natural Resources for your support in connecting me to extension professionals in Malawi and invaluable insight to strengthen the development, analysis, and dissemination of this research.

I also express deep gratitude to the Malawian extension professionals who I interviewed for this research for their time and trust.

Thank you to my wonderful team in Amanda Crump's Research Group on Agricultural Equity and Inclusion for your advice, recommendations, and support. I also greatly appreciate the dedication and time of Dr. Kate Scow and Angie Nguyen for your commitment to the International Agricultural Development program.

Thank you to my partner and my family whose encouragement and love makes anything possible.

Finally, I wish to acknowledge the University of California, Davis, Lilongwe University of Natural Resources, and the Government of Malawi for the support that made this research possible.

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LIST OF ABBREVIATIONS

ADD	Agricultural Development Division
AIS	Agricultural Innovation System
ASWAP	Agricultural Sector Wide Approach
CA	Conservation Agriculture
CGIAR	Consultative Group on International Agricultural Research
CSA	Climate-Smart Agriculture
CISANET	Civil Society Agricultural Network
DEAS	Department of Agricultural Extension Services
DARS	Department of Agricultural Research Services
DAHLD	Department of Animal Health and Livestock Development
DCP	Department of Crop Production
DoDMA	Department of Disaster Management Affairs
DOI	Department of Irrigation
DLRC	Department of Land Resources and Conservation
DMCCS	Department of Meteorological and Climate Change Services
DADOs	District Agriculture Development Offices
EAS	Extension and Advisory Services
EPAs	Extension Planning Areas
FAO	Food and Agriculture Organization of the United Nations
GDP	Gross Domestic Product
GFRAAS	Global Forum for Agricultural Advisory Services
GoM	The Government of Malawi
IFPRI	International Food Policy Research Institute
IPCC	The Intergovernmental Panel on Climate Change
LUANAR	Lilongwe University of Agriculture and Natural Resources
MaFAAS	Malawi Forum for Agricultural and Advisory Services
MoAIWD	Ministry of Agriculture, Irrigation, Water, and Development
MoNREM	Ministry of Natural Resources, Energy and Mining
NACDC	National Agriculture Content Development Committee
NGO	Nongovernmental Organization
SANE	Strengthening Agriculture and Nutrition Extension Services Activity (SANE)
USAID	United States Agency for International Development

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CHPATER ONE: INTRODUCTION AND LITERATURE REVIEW

Introduction

Malawi is a landlocked country in Southern Africa with a population of 18.6 million that relies heavily on agriculture (World Bank Group, 2020). In fact, agriculture is the most important sector of the Malawian economy and maize is the most widely grown crop. Changing climate conditions pose significant challenges to Malawi's economic and food security due to a heavy reliance on rain-fed agriculture which will be impacted significantly by droughts and floods. This sector is less resilient to these changes due to a heavy reliance on traditional farming practices that largely do not utilize agricultural inputs and often result in low yields.

In 2000, the Government of Malawi (GoM) adopted a new agricultural extension policy to promote a pluralistic extension system that allows for the delivery of specialized services to farmers by governmental institutions, nongovernmental organizations (NGOs), and private industry. These extension services are intended to support the adoption of new technologies, practices, knowledge, and information that can help farmers increase productivity and adapt to changing climatic conditions. Yet, the adoption of improved agricultural practices amongst farmers remains low.

Challenges exist in implementing effective services for maize farmers. These challenges include a lack of coordination and communication amongst extension providers, conflicting messages disseminated to farmers by various extension providers operating in Malawi, and inadequate engagement among all stakeholders. These challenges will be amplified as farmers will need even more support to adapt to climate change as their ability to grow food using traditional methods will be severely impacted by unpredictable and severe droughts and floods.

There is need to harmonize the efforts of extension providers to enhance the delivery of agricultural services and more effectively support framers to adapt to climate change. This harmonization could be achieved through increased collaboration in agricultural service provision and would support the country's goal of increasing the sustainable intensification of maize even given changing climatic conditions.

Literature Review

Malawi Context

Malawi is a landlocked country in Southeast Africa, comprised of 28 districts across three administrative regions – Northern, Southern, and Central (Cai & Davis, 2017). Forty-two percent of the population lives in the Central Region with a population density of 194 people per square kilometer (Cai & Davis, 2017). According to the World Bank, roughly two-thirds of the population in Malawi lives on less than $1.25 per day and 17% are considered food insecure (World Bank Group, 2020). Thirty-eight percent of the population lives below the poverty line and the country has an extremely high child stunting rate of 47% due to malnutrition (World Bank Group, 2020).

Agricultural Production and Productivity

Agriculture is the most important sector of the Malawian economy, employing 85% of the country's labor force (FAO, 2015). Malawi's main cash crops include tobacco, tea, cotton, groundnut, coffee and sugar. Maize is the largest food crop grown in Malawi, comprising over 70% of the total cultivated land (FAO, 2015). Other important food crops typically grown alongside maize include cassava, ground nut, sweet potato, sorghum, rice, and Irish potato. Maize grown across all regions of Malawi represents 48% of the total caloric intake of Malawi's population and is an important contributor to national food security (Warnatzsch & Reay, 2020).

Eighty percent of the country's maize is grown by smallholder farmers using traditional farming practices, rain-fed systems, and low agricultural inputs (Fatch et al., 2010). There are an estimated two-million smallholder farmers in Malawi who cultivate an average land area of 0.80 hectares (Chirwa et al., 2015).

Low productivity, declining soil fertility, and soil erosion pose significant threats to the agriculture-based economy (Cai & Davis, 2017). Despite efforts to increase agricultural productivity, crop yields remain low. For maize, yields average between 1-2 metric tons per hectare (GoM, 2016). These current maize yields are far below their potential of 5-10 metric tons per hectare (GoM, 2016). This disparity demonstrates a major yield gap in the potential of maize production. GoM attributes low crop productivity to low adoption of agricultural technologies, low access to farming inputs such as fertilizers, low technical skills, and limited available irrigation (GoM, 2016). Additionally, a lack of information to guide farming production decisions has been identified as a key productivity constraint (GoM, 2016). Improving agricultural extension services is therefore critical to increasing production, sustaining economic growth, and feeding the growing population of Malawi.

In 2011, GoM developed an Agricultural Sector Wide Approach (ASWAp) that aimed at increasing agricultural productivity and improving national food security. This approach aimed at supporting farmers to increase crop yields through the development of a subsidy program for agricultural inputs. Additionally, ASWAp called for the widespread implementation of sustainable intensification practices for agriculture including soil conservation, soil fertility management, improved irrigation systems, and efficient water usage. In particular, ASWAp called for increasing maize productivity through sustainable intensification and improved practices for soil and water management.

Maize Production

Maize (*Zea mays* L.) is the most important food crop grown in Malawi. The optimum production of maize requires particular seeds, proper soil management practices, effective fertilizers, effective weed, insect, and disease control, and appropriate harvesting techniques (Du Plessis, 2003). The production of maize typically requires between 450-600 m of water per season to produce optimal yields (Du Plessis, 2003). In fact, it has been estimated that 15 kg of grain are produced for each millimeter of water consumed by the plant (Du Plessis, 2003). By the time the plant reaches maturity, it will have consumed about 250 liters of water. Once the plant reaches maturity, it will also have removed about 8.7 g of nitrogen, 5.1 g of phosphorous and 4 g of potassium from the soil (Du Plessis, 2003).

Under moist conditions, seedlings emerge from the ground 6 – 10 days after initial planting. However, it may take up to three weeks for a seed to germinate under cool, dry conditions (Du Plessis, 2003). The optimal soil moisture content for germination is fairly high at 60% of soil capacity (Du Plessis, 2003). New leaves begin to unfold every third day and both the leaf and stem mass area dramatically increases once sixteen or more leaves have unfolded, the tassel has been visible for a few days, and the lateral shoot bearing the main corn ear is visible. At this stage, the plant has almost reached full maturity. The demand for nutrient inputs and water is very high at this stage and as the plant begins to produce cornels.

Maize thrives in well-drained, moist soils with high nutrient concentrations. Sand, clay, and clay-loam soils are most optimal for high-yielding maize crops. Water availability during the growing season is the most important factor in determining plant growth and yield in Malawi. Therefore, soil tillage practices should increase water infiltration and reduce evaporation (Du Plessis, 2003). In order to reduce soil erosion during floods or extreme wind, it is critical to

maintain a thick layer of topsoil. Different types of plows can be used to coarsely turn the soil and reduce erosion. Alternative strategies such as no-till, mulching, and manure applications can also help to improve soil quality and nutrient concentrations. Applications of nitrogen, phosphorous, potassium, and zinc are also important in ensuring maximum growth potential, but should not exceed maximum recommended applications of 30-70 kg per hectare (Du Plessis, 2003).

Management of weeds, pests, and disease is also critical in reducing production losses and limiting crop damage. Chemical, biological, and physical controls can be implemented to manage these risks depending on their source and severity. Therefore, it is critical for farmers to have adequate inputs and appropriate information to meet the requirements detailed above in order to produce optimal yields and sustain their incomes as farmers.

Climate Change Impacts

Malawi's climate is considered subtropical with two distinct seasons – a cool, dry season lasting from May to October and a warm rainy season from November to April (Fatch et al., 2010). However, recent changes to temperature and precipitation in Malawi have affected the ability of farmers to grow food. According to the Intergovernmental Panel on Climate Change (IPCC) "increased water stress for 75 to 250 million people, reduced yields from rain-fed agriculture by up to 50%, sea level rise, and an increase of 5 to 8% of arid and semi- arid land in Africa," is expected to occur throughout the 21st century; thus Africa remains one of the most vulnerable continents to rapid climate change (Niang et al., 2014, p. 435). GoM's ASWAp found that climate change was a severe threat to increasing the country's agricultural productivity. The ASWAp approach calls for the widespread implementation of innovative agricultural practices to mitigate and adapt to climate changes for vulnerable farmers. The Malawi Growth and

Development Strategy II and the 2016 National Climate Change Management Policy provide strategic direction for climate change priories and call for increased funding and capacity to mitigate and adapt to climate change effects (GoM, 2016).

Changing climate conditions pose significant challenges for Malawi due to a heavy reliance on rain-fed agriculture which comprises 90% of cultivated land (FAO, 2015). According to the World Bank, only 3.3% of rural farming households have access to crop irrigation (Sova et al., 2018). Periods of extreme drought and severe flash flooding events have increased in frequency, intensity, and unpredictability, giving the most vulnerable farming households inadequate time to respond and recover. Malawi has experienced severe natural disasters over the past thirty years including the 1991 drought which affected over six million people and the 2002 drought and flood that resulted in a pronounced food crisis (Warnatzsch & Reay, 2019). The recent floods of 2015 and 2016 have resulted in losses of USD $335 million and USD $365 million respectively (Sova et al., 2018). Changes in the timing and intensity of precipitation, coupled with higher evapotranspiration rates resulting from higher temperatures, pose substantial threats to food security in Malawi (Warnatzsch & Reay, 2019). The increase in variability of rainfall patterns, sudden and severe floods, prolonged droughts, and changing temperatures severely impact Malawi's ability to grow food.

Since 1960, the mean annual temperature has increased by 0.9 ° C (Sova et al., 2018). Recent studies conducted in Malawi show alarming evidence of rapidly warming temperatures with projected temperature increases of between 1.9 to 2.5 °C by 2055 (Warnatzsch & Reay, 2020). See *Figure 1* from Sova et al., 2018 for a country-wide analysis of projected temperature and precipitation changes by 2050.

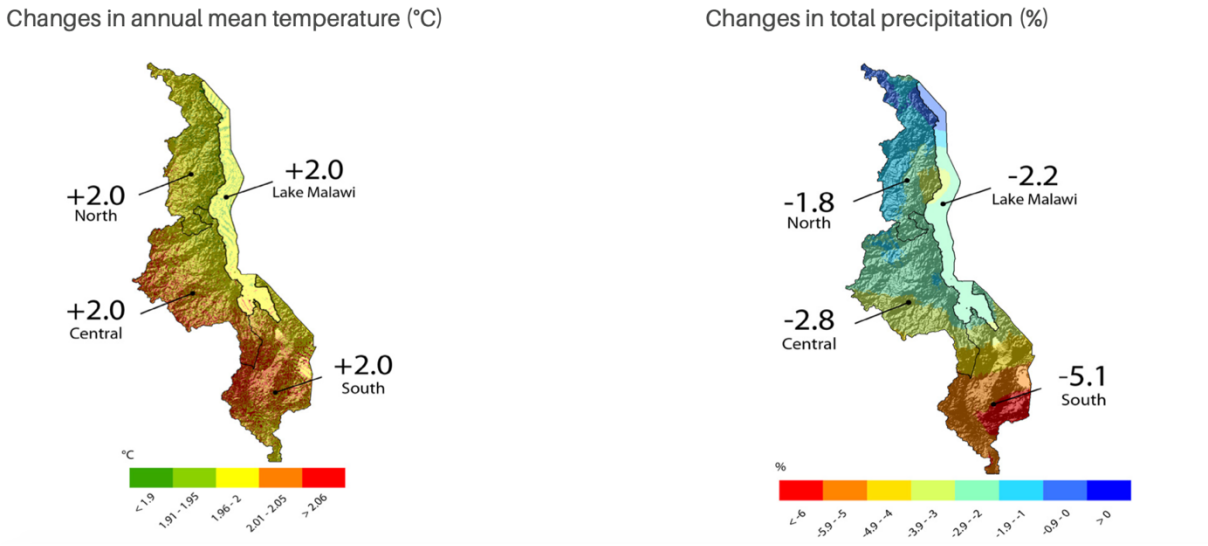


Figure 1. Projected change in temperature and precipitation in Malawi by 2050 (Sova et al., 2018)

Climate change poses addition challenges to maize production in Malawi. Researchers have discovered that warming temperatures in Malawi could lead to reduced planting seasons and significantly reduced maize yields (Warnatzsch & Reay, 2020). Researchers also find that yields decline for all major maize cultivars in Malawi using combined temperature and precipitation projections (Warnatzsch & Reay, 2020).

Climate Smart Agriculture

GoM's National Climate Change Management Policy identifies increased adoption of climate smart agricultural practices as a critical need for farmers in Malawi. According to the FAO, Climate Smart Agriculture (CSA) practices encompass an approach to agriculture that helps to guide actions needed to transform agricultural systems to support sustainable food production given changing climatic conditions (Lipper, 2010). CSA aims to sustainably increasing agricultural productivity, support adaption to climate change, and reduce greenhouse gas emissions through improved agricultural practices (Lipper, 2010).

CSA focuses on the implementation of sustainable interventions including improved soil management, soil and water conservation practices, development of resilient crop varieties, and agroforestry practices. Improving soil management includes practices such as conservation agriculture (CA), soil fertility management, and diversifying farming systems to include multiple crops in order to reduce soil erosion and retain nutrients in the soil (Lipper, 2010). CA encompasses farming practices including minimal soil disturbance through low- or no-tillage planting, maintenance of carbon-rich organic matter to cover and feed soils, and crop rotations (Lipper, 2010).

Soil- and water-conservation practices for agriculture emphasize crop residue management, mulching, terracing, rainwater harvesting, and efficient irrigation management (Lipper, 2010). Planting resilient crop and early maturing varieties also supports the development of high-yielding, heat, drought, and pest-resistant crops.

Agroforestry is another CSA practice that involves integrating trees or shrubs into agricultural production systems. Agroforestry includes practices to improve fallows, grow crops alongside forest plantations, establish home gardens, grow multipurpose trees or shrubs, and integrate trees into animal pastures (Sinclair, 1999). The use of trees in agricultural systems reduces vulnerability to extreme weather events by improving soil fertility and moisture content, reducing erosion and diversifying production for farmers in case of crop failure (Lipper, 2010).

According to the FAO, the CSA interventions described above allow farmers to sustainably increase yields while adapting to impacts of climate change on agricultural systems (FAO, 2015). Adopting CSA practices is critical for developing effective climate change responses and continuing to support sustainable food production in Malawi.

Extension and Advisory Services

Extension and Advisory Services (EAS) support rural development, improve food security, and enhance agricultural production systems across the world. Birner and colleagues (2009) p. 342, define EAS as, "the entire set of organizations that support and facilitate people engaged in agricultural production to solve problems and to obtain information, skills, and technologies to improve their livelihoods and well-being." These services operate within a larger system of agricultural knowledge and information systems with actors that generate and share knowledge about agricultural technologies with farmers and information generators. Rivera and colleagues (2001) have categorized the key actors within agricultural knowledge systems into three types: education, research, and extension (*Figure 2*).

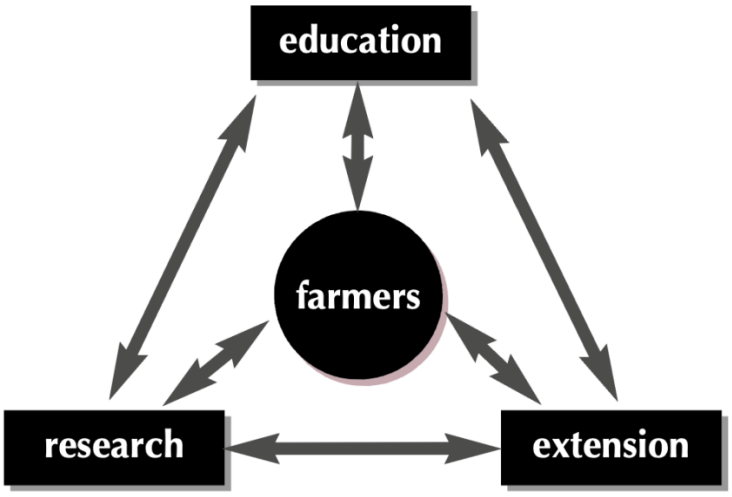


Figure 2. Agricultural extension as part of agricultural knowledge systems (Rivera et al., 2001)

At the center of the Agricultural Knowledge System are the farmers that act as the key clients of agricultural innovations, but also share information with extension institutions, research organizations, and agricultural educators as they field test new technologies and develop new agricultural innovations themselves. According to Lubell and colleagues (2014) p.1093, "agricultural extension enhances adaptive capacity when it manages knowledge systems in ways

that help farmers react to changes in economic, social, and environmental processes." These knowledge systems are strengthened when actors collaborate to develop and deliver relevant information in order to enhance resilience and support sustainable livelihoods for farmers.

There are numerous approaches or methods utilized by actors within agricultural knowledge systems to support farmers with EAS. The advisory methods utilized by extension providers vary depending on actor's paradigms, goals, and resources. EAS providers use a variety of extension methods including the model village approach, demonstrations, field days, lead farmers, farmer field schools, mass media and participatory farmer research. Village meetings or the model village approach, are commonly used to create awareness about important agricultural issues, obtain approval from village leadership for proposed projects, and mobilize farmers to participate in new initiatives (Chowa et al., 2013). Through this approach, community leaders work with extension agents, catalyze community buy-in for new projects, prioritize actions with local leaders, learn about key issues in the community, and design tailored extension plans to improve community management structures (Cai & Davis, 2017).

Demonstrations are widely used by extension officers to disseminate information on new agricultural technologies to farmers. Demonstrations are conducted at research stations, training centers, and on farmer's fields. This method is used by the public sector, NGOs, and the private sector to promote new seeds or agricultural inputs to farmers. Demonstrations show farmers how to implement a technology and the result of that technology on local crop systems (Kimaro et al., 2010).

Field days are also used as an advisory method and are coordinated amongst extension workers and farmers to promote a meaningful learning opportunity between organizations, extension staff, and farmers. These field days allow extension and subject matter experts to

receive feedback on new technologies and agricultural practices. Field days may also, “attract a wide range of stakeholders who include input suppliers, donors, policymakers project staff civil society, and extension service providers” (Kimaro et al., 2010). Within this approach, participatory farmer research programs allow farmers to co-develop new technologies and innovations with researchers in order to increase adoption of those technologies.

The Lead Farmer, or Farmer-to-Farmer approach, is used to help disseminate information and new technologies from fellow farmers who have adopted certain practices or gained new information. Lead Farmers have been shown to substantially increase rates of technology adoption, increase the number of farmers receiving extension services, and reduce the cost of extension services for farmers because they are often viewed as trustworthy and credible sources of information within a community.

Farmer Field Schools are another method used to educate farmers and typically include groups of 20 - 25 farmers who meet regularly to discuss, modify, and experiment with new production practices. During Farmer Field Schools, farmers receive training from experienced facilitators. This method allows farmers to observe and test their own ideas while building agricultural content and skills.

Finally, mass media or Information Communications Technology (ICT) platforms are widely used to provide information to farmers. ICT platforms including radio are widely used by governments and NGOs to disseminate information to large groups of farmers.

Extension Services in Malawi

Agricultural extension and advisory services in Malawi date to 1903 when GoM began advising farmers on improved methods of cotton to be exported to Britain. In 1949, a severe drought led to widespread famine across Malawi. This disaster resulted in the development of a

more centralized approach to advisory services by the government. Then in 1964, the Department of Agricultural Extension and Training (DAET) was established to provide comprehensive training, agriculture, husbandry, home economics, irrigation, and credit services to farmers. The DAET was eventually separated into various departments and nongovernmental organizations became increasingly important dual extension providers.

The Department of Agricultural Extension and Training eventually evolved to become the Department of Agricultural Extension Services (DAES) and operates as one of the six departments within the Ministry of Agriculture, Irrigation, Water, and Development (MoAIWD). DAES is the main provider of extension services to farmers throughout Malawi and coordinates activities with district-level government partners. Additional departments under MoAIWD that support the dissemination of extension information in Malawi include Animal Health, Crop Production, Fisheries, Irrigation, and Land Resources and Conservation Departments. The six departments within MoAIWD including DAES are represented by eight Agricultural Development Divisions (ADDs) (Knorr et al., 2007). These ADDs are further divided into twenty-eight District Agriculture Development Offices (DADOs), one-hundred and eighty-seven Extension Planning Areas (EPAs) under the DADOs, and finally Sections which each comprise 5-15 villages and represent the smallest administrative unit (Chinsinga, 2008). Staff at the EPA level are called Extension Agents and are tasked with, "conveying technical messages to farmers, forming farmer groups to carry out farmer demonstrations, and linking farmers to credit institutions" (Knorr et al., 2007). Technical experts from Malawi's research institutions including Lilongwe University of Agriculture and Natural Resources (LUANAR), the University of Malawi, Mzuzu University, and Malawi University of Science and Technology also support the

development of new technologies and outreach messages to improve Malawi's public extension system (*Figure 3*).

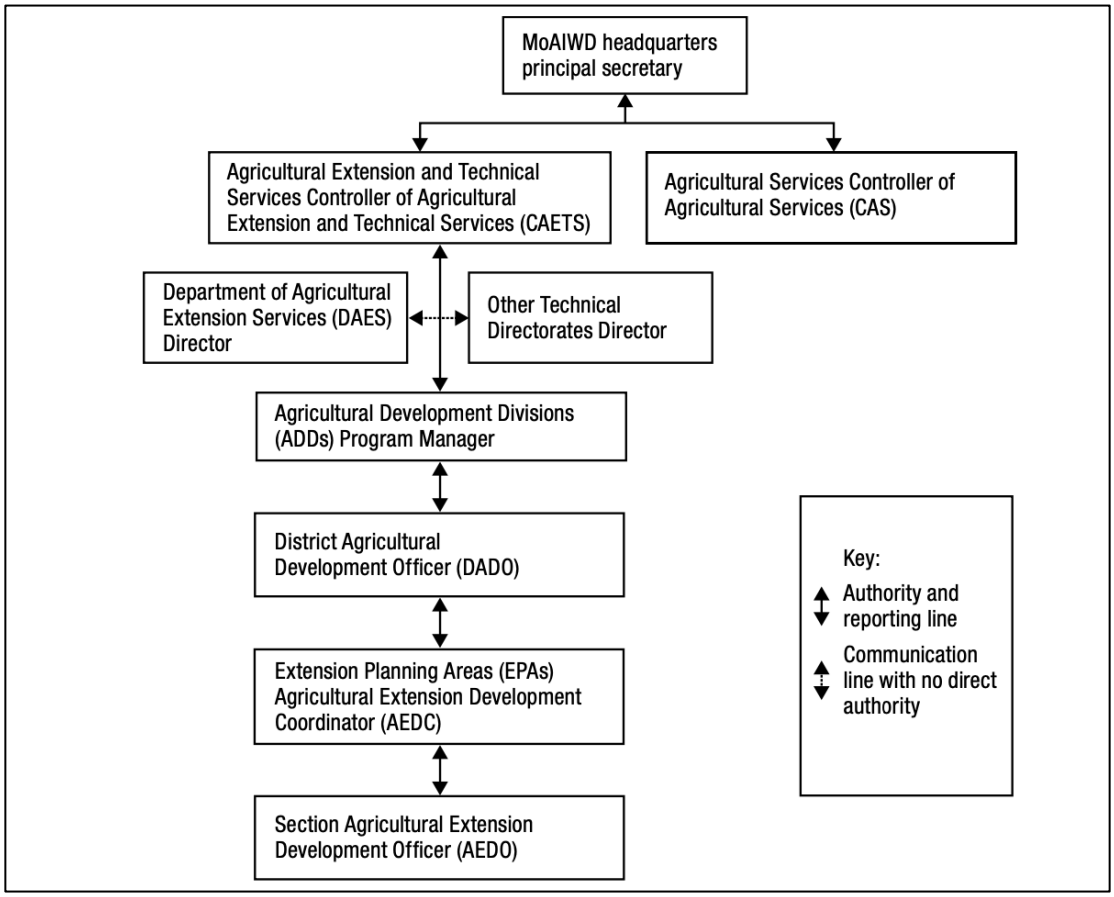


Figure 3. Organizational structure of the MoAIWD (Ragasa and Mthinda, 2020; adapted from Masangano and Mthinda, 2012)

In its effort to decentralize Malawi, in 2000, GoM and DAES introduced a new agricultural extension policy. This new policy termed, "Agricultural Extension in the New Millennium: Towards Pluralistic and Demand-Driven Services in Malawi" promotes a pluralistic extension system that allows for the delivery of specialized services to farmers through multiple extension providers. This policy was introduced to allow for the participation of other extension providers apart from the government to more effectively respond to environmental, social, economic challenges impacting the development of the agriculture sector in Malawi (Masangano & Mthinda, 2012). Through this policy, NGOs, farmer groups, and private industry could operate

extension services to farmers throughout the country to complement government extension activities.

In Malawi, agricultural extension providers also include non-profit organizations, farmer groups, and private companies. Dozens of local and international nongovernmental organizations (NGOs) provide extension services throughout Malawi and many are members of the Civil Society Agricultural Network (CISANET). CISANET has a membership of over one-hundred organizations and provides policy advocacy support in programmatic areas including, "climate-smart agriculture, markets and international trade, livestock and dairy development, governmental budget accountability, and nutrition and social protection" (Simpson et al., 2012). NGOs providing extension services operate across Malawi and often utilize government extension staff to implement their program activities at the local level. The majority of NGO activities are, "funded by external donors through implementation contracts with predetermined targets and centralized control. The relatively small size of NGO efforts and the drive to differentiate themselves technically and operationally from other EAS service providers competing for the same contracts lead to an operational context characterized by a large number of actors employing variations of the same approaches and technical themes, all attempting to work with the DAES to achieve impact" (Simpson et al., 2012). There are also several large donor-funded projects operating within the context of Malawi's extension system. For example, the United States Agency for International Development (USAID) has funded many multi-year, multi-million dollar projects such as Strengthening Agriculture and Nutrition Extension Services Activity (SANE) implemented by the University of Illinois and United in Building and several projects implemented by Catholic Relief Services (CRS) (Cai & Davis, 2017).

Farmer organizations also provide extension services and represent the interests of farmers at a policy level. The Farmers Union of Malawi (FUM) is the main umbrella organization representing farmer interests and includes 93 member organizations that represent an estimated 350,000 smallholder farmers (Simpson et al., 2012). In addition, the National Smallholder Farmers' Association of Malawi (NASFAM) is a member-owned association of 108,000 farmers organized into approximately 43 farmer associations across Malawi.

Private sector extension providers include actors supporting the production of agricultural commodities as well as, "agricultural input companies (e.g., seeds, fertilizers, pesticides, equipment), and agricultural input retailers" (Cai & Davis, 2017). Private sector extension providers have been categorized by Simpson and colleagues (2012) as utilizing either push or pull business models. Push business models are utilized by agricultural input supplies and, "focus on the provision of additional value-added advisory services, such as advising related to consumers' input purchasing decisions" (Cai & Davis, 2017). In contrast, pull business models are utilized by companies focusing on the production of agricultural commodities such as maize and often provide extension services to farmers in exchange for purchasing the commodities that the farmer grows.

These extension services support the adoption of new technologies, practices, knowledge, and information that can help farmers overcome barriers to increasing crop yields, adapting to changing climatic conditions, and ensuring sustainable livelihoods of farmers. According to GoM, challenges remain in implementing effective services for maize farmers. These include a lack of coordination and communication amongst extension providers, conflicting messages disseminated to farmers by various stakeholders, and inadequate opportunities and support for engagement among stakeholders (GoM, 2016). Inconsistent recommendations provided by the

extension system, particularly regarding climatic viability and best practices for the sustainable intensification of agriculture have remained significant challenges in Malawi. In order to enhance agricultural advisory service delivery, there is need to harmonize the efforts of extension providers to more effectively address the intensification of maize and adapt to climate change.

Theoretical Frameworks

Diffusion of Innovations Theory

The Diffusion of Innovations Theory was developed by Everett M. Rogers to analyze the diffusion and adoption of agricultural innovations among farmers. Considered the theoretical basis for agricultural extension, this theory asserts that the adoption of an agricultural technology communicated through specific channels occurs over time among members of a social network (Rogers, 2003). Under this theory, individuals within the network are categorized according to their ability to adopt the technology. This theory follows the top-down "transfer of technology" model where innovations are developed by researchers, disseminated by extension personnel, and then adopted by farmers. In the context of Malawi, agricultural innovations are developed both by researchers within the hierarchical structure of the public extension system (Knorr et al., 2007) and are co-developed at the grassroots level with input and field testing from farmers (Bezner-Kerr, 2012). Therefore, it is useful to understand the basic elements of the Diffusion of Innovations Theory to evaluate Malawi's public extension system, but also analyze the extension system as a network of actors that all develop, share, and improve agricultural innovations and information.

Conceptual Framework

Best-Fit Framework to Analyze Malawi's Extension System

To effectively analyze Malawi's complex, pluralistic extension system it is useful to develop a conceptual framework that draws from the Diffusion of Innovations Theory as well as Social Network Analysis. Feed the Future's Developing Local Extension Capacity (DLEC) project led by Digital Green in partnership with Care International, the International Food Policy Research Institute (IFPRI) and the Global Forum for Rural Advisory Services (GFRAS)

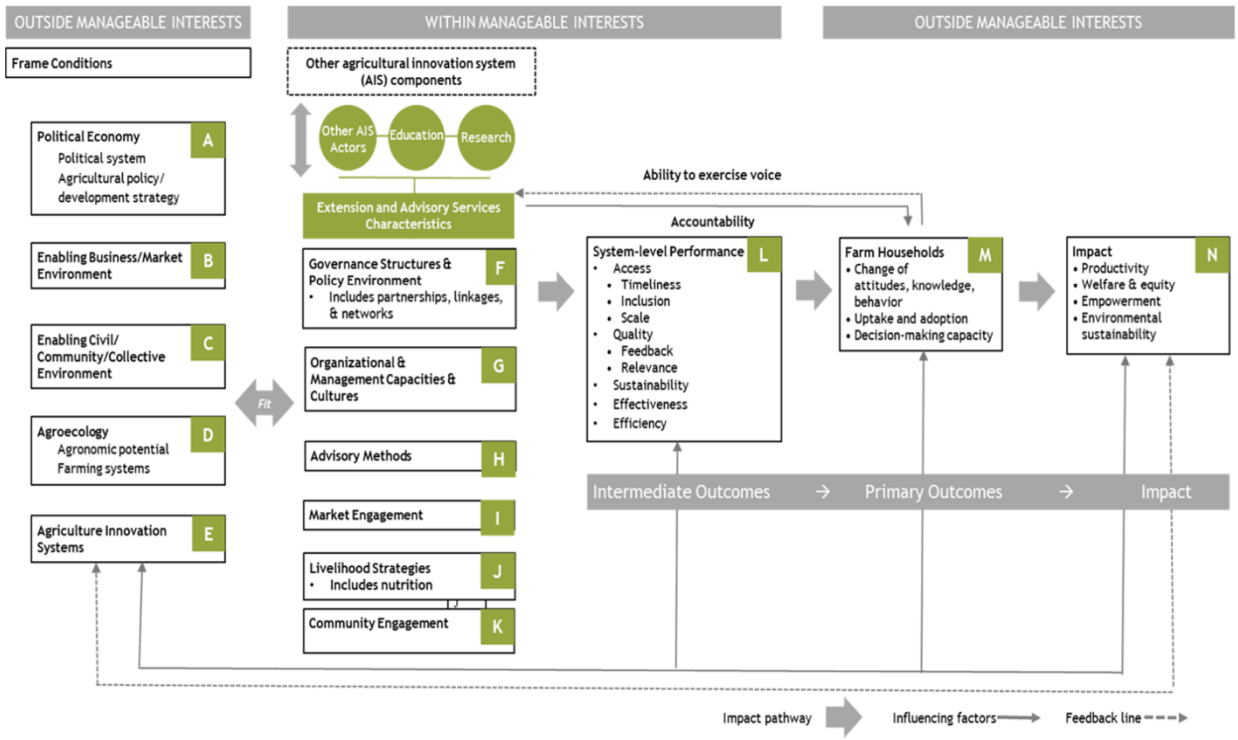


Figure 4. Conceptual framework for Malawi's extension system (Cai and Davis, 2017; adapted from Birner et al. 2009)

developed a "best fit" framework for analyzing Malawi's extension and advisory services that target key activities for improving the system (Cai & Davis, 2017). This framework outlines extension parameters and characteristics allowing stakeholders to understand the state of Malawi's extension system and where critical levers for change exist (*Figure 4*).

Within this framework, the frame conditions outside the manageable interests are meant to show factors that influence extension services in Malawi, but are not the focal area for change within the efforts of this study. The critical factors for change within the manageable interests of this study are the characteristics of AIS including 1) the governance structures which I will analyze using Social Network Analysis to understand the development of content, transfer of information, and engagement between stakeholders; 2) the organizational and management capacities which I will analyze as the capacity for organizations to provide EAS and ways in which organizations are structured; 3) the advisory methods used by providers to deliver EAS; 4) the connection to local and international markets; 5) the livelihood strategies integrated into the provision of EAS; 6) the engagement of community members, villages, and farmers in the process of EAS information development and dissemination; and 7) the performance of EAS with respect to climate change adaptation based on the messages communicated to farmers and the effectiveness of information delivery.

Problem Statement and Justification

GoM has developed a pluralistic extension policy that calls for the delivery of specialized services to farmers by governmental institutions, nongovernmental organizations, and private industry. These extension services support farmers to overcome barriers to increasing crop yields and adapting to changing climatic conditions. Yet, inconsistent recommendations provided by different extension providers regarding best practices to adapt to climate change have remained significant challenges in Malawi.

GoM has emphasized the need to improve coordination among extension providers in order to reduce inefficiency, redundancy, and confusion due to conflicting messages to farmers. In fact, few nongovernmental organizations or private companies coordinate their extension

activities with DAES under MoAIWD. In order to improve stakeholder engagement amongst extension providers, communicate clear messages to farmers, and improve the adoption climate adaptation practices, there is a critical need to identify what climate change information is currently being communicated to farmers across the extension system.

Purpose, Objectives, and Research Questions

The purpose of this study was to assess the challenges and successes in communicating climate change adaption information to maize farmers in Malawi in order to improve the development of content and delivery of information by extension providers. The following were specific objectives of the study:

- Identify the development of content and methods used by extension providers to educate maize farmers about climate adaptation practices in Malawi.
- Evaluate institutional constraints of Malawi's extension system in providing effective information for maize farmers to adapt to climate change.

To address the research objectives, I posed the following questions:

1. How is information generated in Malawi's extension system to address climate change?
2. How do extension providers engage and share information with other organizations to address climate change?
3. What advisory methods do extension providers use to educate maize farmers about climate smart agricultural practices?
4. How are extension providers addressing climate change in their recommendations to maize farmers?
5. What challenges exist in providing effective information for maize farmers to adapt to climate change?

CHAPTER TWO: METHODS

Introduction

This chapter describes the research methodology that was developed to achieve my objectives. This methodology included a literature review used to inform the development of interview questions and in-depth interviews with individuals that provide agricultural extension services to maize farmers in Malawi.

Participant Selection

To meet the objectives of the study, I contacted key informants using the snowball sampling method to identify affiliate organizations and individuals who provide extension services to maize farmers in Malawi. The location for this study was chosen based on the projected severity of climate change impacts to Malawi's maize production across all regions and high concentration of extension providers that operate throughout the country.

I developed a professional network in Malawi that connected me to key organizations and individuals who work on extension. This network included staff from IFPRI where I interned, GFRAAS, MaFAAS, USAID, and faculty specializing in extension from LUANAR in Malawi. My researcher team at the University of California, Davis included my advisor and the Co-Principal Investigator, Dr. Amanda Crump who has worked on agricultural extension issues in Malawi and an experienced thesis committee who provided additional contacts for this research. In total, 130 individuals were contacted through email and phone calls and 19 agreed to participate in virtual interviews through online platforms for this research study. All interview participants were adults and consented to being recorded during phone interviews. Interviews were conducted in English over the phone from October 1, 2020 to January 1, 2021 with

individuals from organizations who provide extension services to farmers. It should be noted that English if the official language of Malawi and is widely spoken among extension providers.

The table below shows how many individuals from each type of organization participated in the research study through in-depth interviews.

Table 1. Organizations participating in in-depth interviews

Organization Type	**Interview Participants**
Private	3
International NGO	4
Farmer Organization	4
Malawi NGO	3
Governmental	5
TOTAL	**19**

Research Design and Data Collection

Through this research, I sought to assess the challenges and successes in communicating climate change adaption information to maize farmers in Malawi in order to improve the development of content and delivery of information by extension providers. Therefore, I focused on understanding the development and dissemination of information throughout the extension system, messaging around climate risk and variability, curriculum and learning tools extension providers use to educate farmers, and engagement with other organizations that support farmers across the extension system in Malawi. I employed qualitative methods to develop a deeper understanding of the participants' experiences, perspectives, and relationships which are essential to better understand Malawi's extension system and the stakeholders involved (Ary et al., 2010).

The research began with a literature review to understand climate change impacts to agriculture in Malawi, climate change adaptation practices for farmers, and the agricultural

extension system in Malawi. This was followed by key informant interviews with a sample of identified organizations using an interview questionnaire.

A detailed Interview Questionnaire was developed to administer in-depth interviews with all participants. The Interview Questionnaire introduced participants to the intention, goal, and dissemination of the research. This document also informed all participants that their participation was voluntary and asked if they consented to participating in the research. Participants who opted not to participate were thanked and no further communication was made. All participants were asked if they consented to being recorded on the my phone and all who participated consented to being recorded.

In addition, a script was developed to introduce participants to questions and a question route was developed to ensure consistency across all interviews. A semi-structured questionnaire was used because I recognized that a detailed explanation of certain topics might be required, and certain responses could not be anticipated prior to the interview.

The questions asked during interviews focused on climate smart agricultural practices shared with farmers, extension approaches, and key constraints in delivering effective climate change information to maize farmers. Specifically, the interviews gathered information about the following themes: organizational activities and partnership, information development and dissemination, educational tools, extension methods, climate smart agricultural practices, and communication successes and challenges (Appendix 1).

In order to evaluate the validity of the content obtained during interviews, I tested the instruments developed for this study prior to use with several members of my research team at UC Davis and at MaFAAS by phone. This allowed me to understand if the questions were clear and could be answered in the time allotted for the interview. After testing, I made several format

and phrasing changes to the Interview Questionnaire to improve the quality of the guide and ensure that participants could understand the questions being asked. Each interview lasted between 60-90 minutes depending on the participant's responses and elaborations.

Research Approval

In preparation for this study, I sought approval from the Institutional Review Board and Committee on the Use of Human Research Subjects (IRB) at UC Davis and the Malawi Government through the National Commission for Science and Technology's Framework for Guidelines for Research in the Social Sciences and Humanities. This process required the submission of a research proposal to be reviewed and approved by the National Commission for Science and Technology in Malawi. In order to comply with Malawi's requirements, this research was first affiliated with a local research institution; LUANAR. This affiliation was initiated with an extension faculty member of LUANAR, Mr. Paul Fatch, on July 28, 2020. All appropriate forms and documents were provided to UC Davis and the Malawi Government. The UC Davis IRB deemed this study to meet the criteria of exemption on August 24, 2020. I obtained a permit from the Malawi Government on September 29th, 2020 was approved to proceed with all interviews.

Data Analysis

Qualitative data analysis used for these interviews involved analyzing the relationships between themes in my data in order to understand the phenomena and derive a theory about information generated during the interviews. The data for this research were collected through in-depth interviews with 19 participants who provide extension services to farmers in Malawi. All phone interviews were recorded using my mobile device or computer and were transcribed using Word. After all interviews had been transcribed, each interview was coded to identify

common patterns and themes using NVivo. NVivo is a Qualitative Data Analysis (QDA) computer software package that helps a researcher analyze qualitative data produced during interviews. Using NVivo significantly improves the quality of qualitative research analysis by reducing the number of manual tasks and allowing the researchers to easily discover themes in the data (Hilal & Alabri, 2013).

The data analysis process began by developing a project database in NVivo. The unit of analysis for the study was the "organization." Therefore, I analyzed patterns, themes, and relationships between organizations instead of the individuals representing those groups. A unique "case" was created for each organization to ensure that the organization's associated information such as type of organization (NGO, government, private, or farmer group) was linked to them and stored in the NVivo Classification Sheet in order to compare information between organizations.

After building the NVivo project structure, coding took place in order to sort the data into meaningful segments. I used both inductive and deductive methods to develop theme codes that were generated both from the theoretical framework used and those that reflected emerging themes present in the data. The words and phrases directly mentioned by the participants were then combined to formulate a connection and relationship between related words or phrases in order to develop broader themes. The model explorer tool in NVivo was then used to visually map the ways in which different themes related to one another in order to derive greater meaning from the data. This analysis was then connected to existing concepts and the theoretical framework used and existing concepts discovered through the literature review.

In addition to theme codes, relationship codes were also developed to record the relationships between stakeholders and the transfer of information between organizations. Relationship coding

occurred any time an interview participant mentioned information sharing or a partnership between two organizations. Organizational relationships were categorized in three district ways. First, if an interview participant mentioned one organization receiving information from another the relationship was coded as "Organization X receives information from Organization Y." Second, if an interview participant mentioned information sharing between two organizations, but did not specify which organization developed the information, the relationship was coded as "Organization X shares information with Organization Y." Finally, if one organization was associated with another, such as the Department of Agricultural Extension Services is part of the Ministry of Agriculture, the relationship was coded as "Organization X is associated with Organization Y." Relationship coding allowed me to visualize the stakeholder network and the dissemination of information through a Network Sociogram that was exported from NVivo into a data visualization software, Gephi. The Network Sociogram produced through Gephi allowed for the visualization of the complex network of relationships and organizations that are central to information sharing within Malawi's extension network, and organizations that are not as closely connected to others.

Social Network Analysis

Social network analysis was used as the analytical method for understanding and evaluating Malawi's extension network. Networks are defined as "nodes of individuals, groups, organizations, and related systems that tie in one or more types of interdependencies" (Serrat, 2009). Interdependencies might include shared values, ideas, and information exchanges that are critical to the success of individual actors as well as the network as a whole. Within a social network exists a knowledge network with, "heterogeneously distributed repositories of knowledge and agents that search for, transmit, and create knowledge" (Phelps et al., 2012). In

the context of Malawi's extension system, a difference in worldviews, lack of coordination, and diversity of messages have remained challenges in providing effective information to farmers (Masangano et al., 2017). The disconnect of stakeholders cited by Masangano, Kambewa, Bosscher, and Fatch (2017) promotes misconceptions and misinformation to farmers by extension providers and affects the quality of extension services throughout the extension system. Therefore, it was necessary to evaluate the structure of organizations providing extension services, engagement amongst stakeholders operating within the network, and transfer of knowledge within the extension system.

In fact, an understanding of contemporary agricultural knowledge networks, "highlights the importance of networks of actors who cooperatively work together to deliver relevant knowledge to the right people at the right time and place" (Lubell et al., 2014). The ability of extension providers in Malawi to communicate consistent messages to farmers was not only dependent on their access to resources, but also the strength of social ties within the network itself. Using social network analysis allowed these networks, social ties, and information transfer to be analyzed. Relationships or ties within the network were be evaluated by understanding the direction of ties and measures of centrality which represent the importance of actors relative to one another. Several types of centrality measures have been identified by Wasserman and Faust (1994) and are essential in evaluating the importance of different actors within the network. The first type of centrality measure is *degree centrality* and concerns the number of ties directly related to an actor or organization of interest. This measure is also differentiated by the number of ties coming to an actor (in-degree) and the number of ties leaving an actor (out-degree). The second type of centrality measure is *betweenness centrality* and refers to the number of times an actor is situated between two other actors. This measure captures which actors hold the network

together, where key paths of communication exist, and where network breaks could occur. The third type of centrality measure is *closeness centrality* and relates to the shortest distance between actors relative to a certain starting point. An actor with low closeness centrality must pass through many intermediaries to reach other actors within the network.

Bodin and Prell (2011) also describe the importance of evaluating the cohesion of the whole network through a measure of network density. Network density is the proportion of ties that exit throughout the whole network and reveals the level of connectedness or cohesion present in the network. Cohesion within the network describes the extent to which the network is interlinked and united. Thus, this information was important in understanding the stakeholder connections within Malawi's extension system.

CHAPTER THREE: FINDINGS

Introduction, Purpose, Objectives, and Research Questions

This chapter provides the outcomes of the research study based on the data collected and analyzed through the methodology described in Chapter 2. As stated in Chapter 1, the purpose of this study was to assess the challenges and successes in communicating climate change adaption information to maize farmers in Malawi in order to improve the development of content and delivery of information by extension providers. The following were specific objectives of the study:

- Identify the development of content and methods used by extension providers to educate maize farmers about climate adaptation practices in Malawi.
- Evaluate institutional constraints of Malawi's extension system in providing effective information for maize farmers to adapt to climate change.

To address the research objectives, this research study posed the following questions:

1. How is information generated in Malawi's extension system to address climate change?
2. How do extension providers engage and share information with other organizations to address climate change?
3. What advisory methods do extension providers use to educate maize farmers about climate smart agricultural practices?
4. How are extension providers addressing climate change in their recommendations to maize farmers?
5. What challenges exist in providing effective information for maize farmers to adapt to climate change?

Results

Descriptive Characteristics of Extension Providers

This study included 19 participants from organizations that provide extension services to farmers in Malawi. Study participants included three actors from the private sector, four actors from international NGOs, four actors from farmer organizations, three actors from Malawi NGOs, and five governmental actors (Table 1).

The key activities, clientele, and structure of extension providers participating in this study are described in this section. A summary of key activities and clientele from each type of organization are included in Table 2.

Table 2. Activities and clientele of participant organizations

Organization Type	Key Activities	Clients Served	Annual Number of Clients
Private	• Market linkages • Farming inputs • Farmer training	• Smallholder farmers • Public sector	350 – 5,000
International NGO	• Food security • Emergency response • Health and nutrition	• Smallholder farmers	5,0000 - 148,000

	• Capacity-building • Sustainable food production • Improvement of rural livelihoods	• Public sector • Research institutions	
Farmer Organization	• Agribusiness and marketing • Agricultural development • Improvement of farmer livelihoods • Advocate for farmer well-being	• Farmers	7,000 - 1,000,000
Malawi NGO	• Disseminate information on development and agriculture • Customize messages for farmers	• Smallholder farmers	8,000 - 2,000,000
Governmental	• Extension services in livestock, crop production, environmental affairs, fisheries, and irrigation • Disseminate agriculture messages • Capacity-building • Improvement of rural livelihoods	• Smallholder farmers	24,000 - 4,200,000

Private Sector Organizations

The private sector organizations are involved in activities to develop structured markets for farmer's products, provide inputs for crop production processes such as fertilizers and pesticides, and facilitate farmer trainings focused on specific value chains and commodities. The main clientele for private sector participants includes smallholder farmers and public sector actors whose employers pay private companies to learn about specific topics. One private sector participant explained, "we focus on closing the finance gap affecting most small-scale farmers who are forced to sell their produce at harvest because they need money to re-pay the cost of inputs and prepare for the next season." The annual number of farmers reached by private sector actors ranges from 350 for a small farmer training company to 5,000 for a large private input supplier. The organizational structure of the larger company is fairly hierarchical with field staff, subject matter experts, and company heads. The organizational structure of the two smaller companies is similar to a cooperative where each employee holds multiple positions and is also a farmer themselves. Although not directly asked during interviews, five participants mentioned

having advanced degrees and the majority of participants hold high-level positions within their organizations as Directors, Managers, Subject Matter Experts, Specialists or Team Leaders.

International NGOs

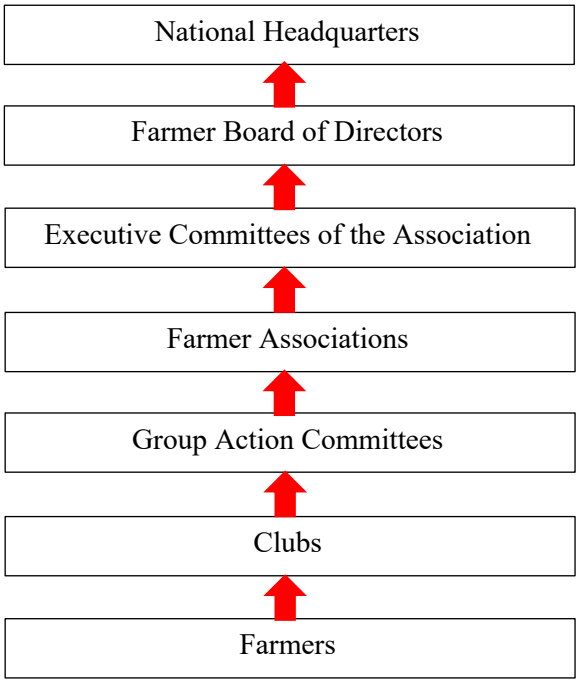
Participants from international NGOs are involved in a wide range of activities focused around improving food security, providing emergency response during disasters, supporting national health and nutrition outcomes, and building capacity of local communities to sustainably grow food and improve rural livelihoods. A common word used by international NGO participants to describe their organization's activities was "resilience." One participant noted, "we're trying to build resilience with these farmers. We identify farmers, and then come up with interventions that will build their resilience." The main clients for international NGO participants are smallholder farmers who participate in agricultural interventions, public sector actors who receive funding for extension activities, and research institutions who receive support for technological innovations. According to interview participants, the annual number of clients served by international NGOs ranged from 5,0000 - 148,000 depending on the number of projects implemented in Malawi. The organizational structure of all participating international NGOs is fairly similar and includes Extension Staff with specific expertise, Project Managers in Malawi, Program Managers located internationally, and international Program Directors overseeing programs in multiple countries.

Farmer Organizations

Participants from farmer organizations are involved in activities including agribusiness and marketing, agricultural development and crop production, and the improvement of farmer livelihoods. As one participant noted, "we try to assist these farmers and make their farming a business." Participants also explained how they advocate for farmers on a local and national

level through proposed policy changes in the National Assembly (Malawi's national legislature). Organizations that support farmers serve between 7,000 - 1,000,000 farmers each year. The largest of the farmer organizations operates with a clearly defined organizational structure that begins with individual farmers. Around 10-15 farmers come together to form a Club, several Clubs form Group Action Committees, Group Action Committees come together to form Farmer Associations, and select farmers from the Associations for the Executive Committees of the Association. A Board of Directors manages each Association and the National Farmer Organization headquarters provides support and management of each of the 54 associations in Malawi (Figure 5).

Figure 1. Organizational and management structure of a national farmer organization in Malawi



According to one participant, "each Association has Field Officers who are trained by crop officers, gender specialists, business or market specialists, or policy specialists." Field Officers select and train Lead Farmers who will then provide trainings for several clubs in their locality.

Malawi NGOs

Malawi NGOs engage in activities geared towards customizing and disseminating agricultural messages from the public sector or international NGOs to farmers throughout the country. One participant described their organization as "knowledge brokers," noting that they did not develop content, but customized and tailored messages to fit the needs of specific farmers. The NGOs explained their ability to reach large numbers of farming households through ICTs such as radio and served between 8,000 - 2,000,000 farmers annually. Participants from the local NGOs noted the multitude of positions they and their colleagues hold within their organizations. One participant commented, "I'm the manager of the organization, but I'm also doubling as the Field Officer, which means I have a big job to do. Sometimes it becomes a big challenge for me to fulfill all my duties at once."

Governmental

Finally, government representatives engage in a wide variety of activities including supporting extension services in livestock, crop production, environmental affairs, fisheries, and irrigation, disseminating agricultural messages to farmers, and supporting rural livelihoods through capacity-building efforts. Two common phrases mentioned by government participants in their explanation of program activities were "climate advisory services" and "nutrition-sensitive agriculture." These participants noted how their organizations strive to incorporate both cross-cutting themes into the interventions they implement with farmers. The number of farmers served by the governmental organizations ranged from 24,000 in a single section to 4,200,000 at DAES. The hierarchical structure of the government extension system was articulated by one participant who noted:

> The country is divided into what we call agriculture development divisions (ADDs). We have eight ADDs and those areas are divided based on the agro-ecological zone. One ADD covers multiple districts with similar agricultural practices that are done there. Below the ADDs we have twenty-eight districts, but we have actually 31 District Agricultural Development Offices (DADOs) because some districts are large and split in two or three offices. Below the DADOs, we have what we called Extension Planning Areas (EPAs) and we have 204 EPA's. Below the Extension Planning Areas, we have sections. This is the smallest unit. The sections are where we have the agricultural extension officers on the front lines who interface with farmers.

Messages are developed by the MoAIWD and then disseminated to the DAES through the extension system described above.

Process of Information Generation

One of the most important research questions posed in this study was, "how is information generated in Malawi's extension system to address climate change?" In order to answer this question, I sought to understand which organizations develop content and what is the process for generating and improving messages that are disseminated throughout the extension system to address climate change.

A total of 85 organizations from international NGOs, Malawi NGOs, private industries, farmer groups, government agencies, and research institutions were referenced by participants. The number and types of organizations that were referenced by participants during interviews is shown in Table 3.

Table 3. Extension providers mentioned during interviews by type of organization

Type of Organization	Number of Organizations
International NGO	23
Malawi NGO	20
Private	12
Farmer Organization	3
Government	24
Research Institution	3
TOTAL	**85**

Participants described who they receive climate change adaptation information from within the extension network. The figure below shows one direction relationships between those receiving and those developing climate change adaptation content in Malawi's extension network. Organizations that did not receive or develop climate change adaption content for others were included, but do not have any arrows coming to or leaving that organization.

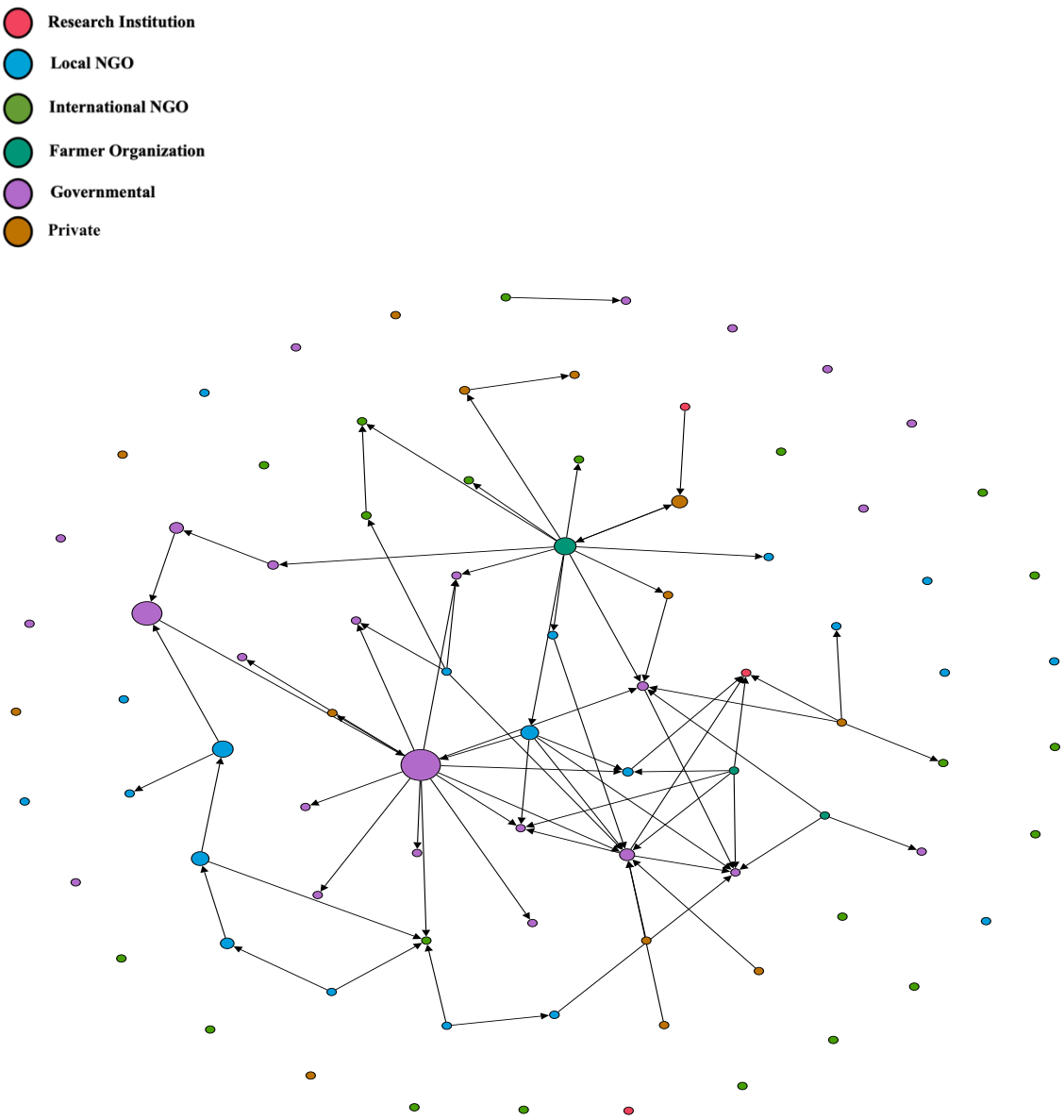


Figure 2. Climate change adaptation content developers in Malawi's extension network

One direction relationships were described by participants with the size of the node (circle) indicating the level of betweenness with other organizations in the network and are shown in Figure 6. The hierarchical development of content from a few organizations operating within Malawi's extension network is also illustrated in Figure 6. Seven out of the top ten content developers referenced by participants are government organizations, one is from the U.S. government, one is an international research institution, and one is a Malawi NGO. It is also

evident that the majority of Malawi's extension providers (52.9%) were not referenced by participants as content developers and therefore do not have any directional arrows present. Measures of centrality for the top ten organizations developing content to address climate change in Malawi's extension system are seen in Table 4.

Table 4. Centrality measures for top climate adaption content developers in Malawi's extension network

Organization	Organization Type	In-Degree	Out-Degree	Degree	Betweenness
DAES	Government	8	3	11	25.5
DMCCS	Government	6	0	6	0
MoAIWD	Government	5	1	6	7.5
U.S. Government	International	4	0	4	0
DARS	Government	4	0	4	0
CGIARs	Research Institution	4	0	4	0
NACDC	Malawi NGO	3	1	4	5.5
DCP	Government	3	0	3	0
ADDs	Government	2	13	15	136
DoI	Government	2	0	2	0
MEAN		**0.9**	**0.9**	**1.7**	**6.2**

The average information in-degree (number of ties coming to an organization) is 0.9 and average information out-degree (number of ties leaving an organization) is 0.9. In Table 4, in-degree represents the number of organizations referencing another as a content developer. ADDs (government) have the highest information betweenness scores of 136 which shows organizations that hold the network together and a collaboration degree of 15 which shows the total number of ties of the organization. Therefore, although ADDs have a low in-degree score and are commonly referenced by participants as content developers, they are integral in disseminating information developed by other organizations.

The two organizations with the highest in-degree scores are DAES (a department of MoAIWD) and DMCCS (a department of MoNREM). Participants noted that they rely on these

organization to develop messages that are then customized before the information is disseminated to farmers. Participants explained that DAES provides technical agricultural messages to extension providers, while DMCCS develops and shares information regarding national and local weather conditions. Several participants noted that agricultural content originates from partnerships and information sharing between DAES and other organization such as DARS, CGIARs, and other MoAIWD departments. A representative from DAES explained, "the technologies that come to us normally come from the research institutions like the CGIARS with leadership from the Department of Agricultural Research in Malawi. Our function is then to take the different technologies generated by research and improve them." Although DAES has the highest in-degree score, DAES staff noted that the technologies they share throughout the extension system originate from research organizations outside Malawi and research departments within the country. Instead of developing the technologies, the role of DAES is to customize and tailor messages about agricultural technologies to meet the needs of specific audiences and communities. Additionally, although MoAIWD has a high in-degree score of 5, several participants noted that technical messages are typically developed through MoAWID's technical departments before being presented to top officials within the ministry. Additionally, it should be noted that several participants indicated that they did not know which departments within MoAIWD develop climate adaptation messages for farmers.

DMCCS has the second highest in-degree score and was commonly referenced as a content developer by participants. One participant shared the type of information provided by DMCCS commenting:

> Climate information is provided to farmers at the beginning of each growing season. The Department of Climate Change and Meteorological releases a forecast for that season.

This forecast says that it is a normal year, below normal, or above normal year for rain and temperature.

Participants explained that DMCCS staff analyze seasonal, monthly, weekly, and daily weather forecasts and share that information with farmers and extension providers. Information about weather conditions is either disseminated directly to farmers through mass media like ICTs or by extension providers who deliver messages to a specific locality and offer support to farmers to prepare for the growing conditions of a particular season. Although not as commonly referenced, several participants also mentioned weather content being developed and disseminated by DoDMA.

The U.S government funded project, SANE also has a high in-degree score of 4. Participants mentioned that specific technologies or technical messages were often provided to farmers through interaction with the SANE representatives tackle agricultural and climate adaptation challenges with a focus on nutrition-sensitive agriculture. SANE representatives are also members of the NACDC.

CGIARs and NACDC have in-degree scores of 4 and 3, respectively. Several participants noted that CGIARs work closely with Malawi's technical agriculture departments to develop technologies that can be scaled up. A government representative from DAES noted that in some cases CGIARs will bring a new technology to Malawi that has yet to be tested locally. In those cases, the technology will first be analyzed by the appropriate MoAIWD department before it is disseminated throughout the extension system. Several participants noted that new technologies developed by international institutions like the CGIARs will be presented to extension stakeholders during a meeting of the NACDC. A Malawi NGO participant noted that it could take up to three years for the NACDC to analyze and disseminate a new technology because of

the thorough process undertaken by stakeholders on the NACDC. Another participant noted that the NACDC is spearheaded by representatives of MoAIWD and allows extension providers in the public sector, NGOs, farmer organizations, and the private sector to harmonize the messages that are disseminated to farmers. A Malawi NGO participant commented, "we always want to make sure that that the thematic areas that have been developed by the National Agriculture Content Development Committee are things that can be put in place at district level and demystified to fit the conditions that are prevailing on the ground for each district." It is also worth noting that several participants had never heard of the NACDC and two others had only heard of the committee by name but did not know its function or membership.

DCP (a department of MoAIWD) was also common content developer referenced by participants and has an in-degree score of 3. Participants explained that DCP develops new crop technologies for farmers to use stating, "the crops department along with the agriculture researchers are responsible for developing technologies which we disseminate to farmers for their interventions." In order to increase the production of crops like maize, DCP will partner with research institutions to develop new seeds and methods from increasing yields. Similarly, several participants mentioned that agricultural technologies are developed by MoAIWD's technical departments and then disseminated to farmers through the public extension system.

Stakeholder Engagement

This section provides an analysis of the relationships within Malawi's extension network that were described by participants in order to answer the research question, "how do extension providers engage and share information with other organizations to address climate change?"

The network analyzed through this research contains 85 organizations and 170 unique relationships or ties between those organizations. The average degree of collaboration between

organizations within the network is 6.2 or 7.3% of total organizations in the network. Therefore, most extension providers operating in Malawi are only connected to a few organizations in the network. The network density (proportion of actual connections to possible connections within the network) is .037 and reveals that organizations within the network are not as closely connected as they could be. The relational ties and node connectivity within Malawi's extension network ties as described by participants through a sociogram are shown in Figure 7.

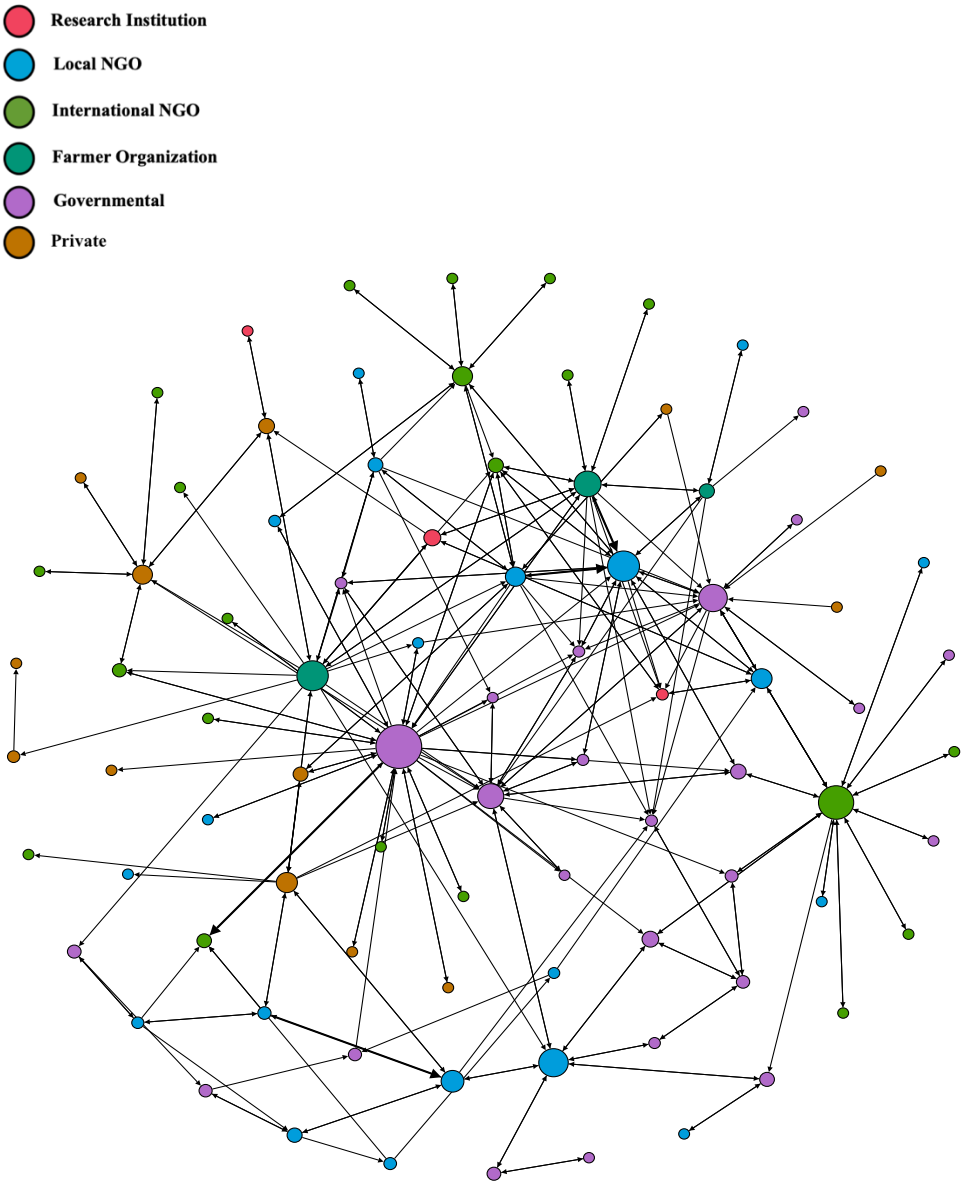


Figure 3. Malawi's information sharing extension network described by participant organizations

Both one direction and two direction relationships that were described by participants with the size of node (circle) indicating the level of betweenness with other organizations in the network are illustrated in Figure 7. Thirty-eight out of the 85 organizations in the network, or 45%, are only connected to one other organization and are therefore operate within the periphery of the network. These 38 organizations are also seen on the edges of the network and therefore less connected to the greater extension community. It is also clear that certain organizations are central to the transfer of information within the network. Centrality measures for the 10 core organizations with the highest degrees of collaboration and information sharing within the extension network are shown in Table 5 (a list of centrality measures for all organizations is included in Appendix 2).

Table 5. Centrality measures for information sharing among core extension providers in Malawi

Organization	**Organization Type**	**In-Degree**	**Out-Degree**	**Degree**	**Betweenness**
ADDs	Government	16	26	42	1935.9
DAES	Government	14	9	23	982.4
MoAIWD	Government	13	9	22	843.3
NACDC	Malawi NGO	12	12	24	1167.3
Catholic Relief Services	International NGO	12	13	25	1350.4
NASFAM	Farmer Organization	8	12	20	890.6
Self Help Africa	International NGO	7	7	14	509.8
Farm Radio Trust	Malawi NGO	7	10	17	513.7
United Nations	International NGO	7	5	12	240.2
Environment Malawi	Malawi NGO	7	6	13	1033.3
MEAN		**3.1**	**3.1**	**6.2**	**201.4**

The average information in-degree (number of ties coming to an organization) is 3.1 and average information out-degree (number of ties leaving an organization) is 3.1. ADDs

(government) have the great number of ties coming to and leaving the organization. ADDs also have the highest information betweenness of 1936 which shows organizations that hold the network together and collaboration degree of 42 which shows the total number of ties of the organization. The top three organizations identified are government and include ADDs, DAES, and MoAIWD. Other top organizations include those from Malawi NGOs, international NGOs, and farmer organizations. NACDC, Catholic Relief Services, and NASFAM also have high collaboration degrees indicating their importance in sharing information and connecting organizations within the network. Catholic Relief Services has the second highest betweenness score of 1350 indicating that this organization is situated between a large number of organizations (many who are faith-based) and provides a connection between a high number of organizations that otherwise might not be able to share information as easily. Farmers have one of the highest out-degree (16) collaboration degree (21), and betweenness score (1138.0) (Appendix 2). This shows that farmers are critical links of information sharing between organizations in extension network.

Advisory Methods

The third research question posed in this study and addressed in this section was, "what advisory methods do extension providers use to educate maize farmers about climate smart agricultural practices?" The advisory methods used by extension providers to communicate messages to farmers about climate smart agricultural practices are categorized into three distinct themes: ICTs, trainings, and written materials. The percentage of participants by organization type using each advisory method is shown in Table 6.

Table 6. Advisory methods used by participants by percentage

	ICTs	Trainings	Written Materials
Private [3]	66.7% [2]	100.0% [3]	66.7% [2]

International NGO [4]	50.0% [2]	100.0% [4]	50.0% [2]
Farmer Organization [4]	75.0% [3]	100.0% [4]	75.0% [3]
Malawi NGO [3]	100.0% [3]	66.7% [2]	33.3% [1]
Governmental [5]	80.0% [4]	80.0% [4]	80.0% [4]
TOTAL [19]	**73.7% [14]**	**89.5% [17]**	**63.2% [12]**

The most common advisory method used by participants is trainings (90%), followed by ICTs (74%), and then written materials (63%). Use of trainings is the most common advisory method used by the private sector, international NGOs, and farmer organization participants. ICTs are the most common advisory method used by Malawi NGOs and participants from the Malawi Government reported using all advisory methods equally.

ICT Platforms

Among the 19 interview participants, 14 reported that their organizations used ICTs to communicate messages to farmers. The use of ICTs varied slightly by organization type from 50% of the international NGO actors to 100% of the Malawi NGO actors (Table 7).

Table 7. ICT communication channels used by participants

ICTs	Percentage	Description
Radio	57.9% [11]	• Community Radio Stations • National Radio Station • Radio Listening Clubs
SMS	52.6% [10]	• Text messages • Interactive Voice Response (IVR)
Internet	31.6% [6]	• WhatsApp Groups • Social Media • Videos
TV	15.8% [3]	• TV Programs • Documentaries
Call Center	10.5% [2]	• Farmers receive production information from Call Centers
Mobile Van	10.5% [2]	• Mobile vans are used to communicate broad messages

Of the ICTs used by participants, radio was the most commonly referenced communication channel. Almost 58% of participants reported using radio platforms to disseminate messages to farmers including community radio and national radio stations often

utilizing radio listening clubs comprising small groups of farmers with radio access within a village. According to a participant from the Malawi government, “when programs are aired on the radio, we encourage our farmers to go to their radio listening groups. So, if one farmer has a radio in a village, then that radio is used by a group of farmers to listen to the messages that are on the radio.” Organizations also utilize radio platforms to share weather forecasts and provide other timely messages to farmers. According to a participant from an international NGO, “we're disseminating messages on climate change and weather forecasts through radio. They learn about the things that they need to know before the disaster comes.”

The use of mobile phones was the second most common ICT referenced by participants. Short Message Service (SMS) messages are sent directly to farmers by extension providers and are used by 53% of participants. Participants noted that SMS allows farmers to receive both text messages and Interactive Voice Response (IVR) messages. A representative of the Malawi government noted, “We send messages using phones and we reach about 24,000 Lead Farmers across all the districts.” Once Lead Farmers receive text messages, they will then share the information with fellow farmers in their locality. Participants also commented that SMS platforms often complement one another and increase access to information. A representative of a Malawi NGO noted:

> We have seen that the platforms we use like SMS platforms and IVR Interactive Voice Response promote each other because each one of them has got its own challenges. For SMS, they can keep the SMS as long as they like. But SMS is limited in characters and those that are not literate have challenges. So, use of IVR Interactive Voice Response helps the illiterate access the information as well.

Internet platforms are used by 32% of participants and included social media, WhatsApp groups, and videos. A participant from the Malawi government commented, “Some content is now being accessed online. We partner with Access Agriculture. Access Agriculture has a lot of videos that have been translated into Chichewa, the local language.” Increasingly, organizations are leveraging internet content to disseminate information to farmers and increase knowledge about new agricultural technologies. According to a representative from an international NGO, “we have WhatsApp groups where farmers are able to share videos of the technologies that they're learning. I'm also able to post some videos on nutrition or soil fertility management. These technologies are being promoted in order for them to increase production.” The use of these internet platforms broadens the source of content and allows for the rapid transfer of knowledge with those who have access.

Almost 16% of participants mentioned using television programs to communicate messages to farmers. Participants commonly noted that farmers receive information about weather conditions from television weather forecasts. In other cases, documentaries are produced and then aired on television to disseminate information about agricultural technologies and innovations. One government representative noted that his department is responsible for the development and dissemination of content through electronic media including television.

Call Centers and Mobile Vans are used by 11% of participants. Call Centers allow farmers to ask questions and receive quick feedback from extension experts. A participant from a Malawi NGO commented, “with the Call Centers, farmers can call for free to ask any question relating to their farming activities. That provides near real-time feedback to farmers for whatever inquiries they have.” Several participants from the Malawi government also noted using Mobile Audio Vans to disseminate various messages to farmers in the field. One stated, “if we want to

reach out to the masses with some awareness messages that are very simple and not technical, we could use Mobile Vans. A Mobile Van is effective just to communicate simple issues on awareness." Yet a Mobile Van might be less effective at communicating highly technical messages that require training and real-time feedback from farmers.

Trainings

About 90% of participants mentioned using some form of trainings to communicate information to farmers and this was the most common advisory method used among extension providers. Common training methods utilized by participants included Lead Farmers, Farmer Field Schools, site visits, demonstrations, and the Model Village Approach.

Trainings facilitated by Lead Farmers are common among NGOs, the government, farmer organizations, and private sector participants. Participants mentioned that Lead Farmers train up to fifty farmers at one time depending on their own skills, experience, and the community's needs. One private sector participant noted that Lead Farmers are regarded as "knowledgeable individuals who can lead their fellow farmers." Other participants vocalized additional benefits of Lead Farmers including high rates of technology adoption and trust among community members. A government representative stated:

> There are also some methods that we use like the Lead Farmer approach and the Lead Farmer approach in my view is more effective in terms of facilitating adoption of technologies among farmers. Why? It is because there is that farmer to farmer interaction and the farmers understand each other better and they also respect each other since they are coming from the same locality.

Several representatives from the farmer's organizations described hierarchical structures used by their organizations to implement the Lead Farmer Approach. One representative noted:

> Farmers are part of Group Action Committees in a village center. In each Group Action Committee, we have three lead Farmer-to-Farmer trainers. The Lead Farmers do small trainings with other village farmers. Lead Farmers from one Group Action Committee come together with other Group Action Committees to form an Association within different parts of an EPA. A few Associations come together to form Executive Committees of the Association. These Executive Committee have powers like finances and employ someone to do record-keeping or an account officer.

Lead Farmers within this structure have different responsibilities to their villages, EPAs, and Districts. Lead Farmers involved in the Executive Committees of the Association may also hold substantial decision-making power and influence.

Another participant noted that Farmer Field Schools are often used, "when we have specific issues that we want to deal with or when you have a particular problem that farmers face and it requires a lot of time to study that problem, look at the causes, and look at various ways of overcoming that issue." The length of farmer trainings mentioned by participants varied from a single, one-hour to several, week-long trainings and the number of training participants ranged from ten to thirty. One participant from a farmer's organization described the detail and intentionality of planning and facilitating a Farmer Field School Training. This participant explained the steps their organization takes including 1) determining the focal audience and their needs; 2) identifying the training's objectives; 3) creating a workshop outline including proposed activities; 4) developing training support materials; 5) facilitating the training; and 6) implementing monitoring and evaluation components for future training improvement.

The use of site visits and demonstrations were also mentioned by some of the participants as a way to train farmers. Participants explained that farm or site visits allow individual or small

groups of farmers to receive feedback or learn about a new technology to adopt on their farms. Demonstrations allow farmers to observe the results of a new technology that they can choose to implement on their own farms. One private sector representative noted:

> For demonstrations, we show farmers how our varieties form. So, when they make a decision of what to plant for next season, they can follow what they saw in the demonstration and what variety is doing ok, which they can then feel good about planting in their field.

Several government participants also mentioned using the Model Village Approach to promote new agricultural technologies and innovations within a certain village. One government representative noted, "we conduct training on participatory rural appraisal or PRA with farmers in the Model Village. We also mount demonstration in the village depending on the technologies we are promoting in that particular village." After observing a demonstration from another Model Village, Lead Farmers are often instructed to establish a model village back in their own villages. Participants noted that this process can help to facilitate widespread adoption of a particular technology among members of a village who are closely connected.

Written Materials

Written materials are also common and were mentioned by 63% of participants. Written materials used to communicate messages to farmers included leaflets, extension manuals, and newspapers.

A private sector participant noted, "it is the extension workers who use the government extension manual for promotion of modern agriculture production technologies including the right farm inputs. The curriculum covers cross section of production/agronomic technologies of various crops in Malawi." In total, four participants noted using written lessons to educate farmer

about a topic. Leaflets were the most commonly used written materials and include information and images about a particular technology or production process. Participants noted that leaflets, pamphlets, and posters were often placed in community meeting spots or supply warehouses to increase the visibility of messages among farmers. Two participants noted communicating messages through print media including newspaper. A representative from a farmer's organization mentioned disseminating messages through a quarterly newsletter stating, "we have a printed newsletter that comes out quarterly where we write a lot of training materials, capturing success stories, and also taking some profiles of farmers. This motivates other farmers to follow those things that have changed the lives of their fellow farmers." This newsletter is distributed to farmers during Group Action Committee meetings and is sometimes accompanied by oral anecdotes from the farmers profiled in that quarter. It is also worth noting that several participants mentioned developing written materials to use during in-person farmer trainings. Therefore, written materials complement trainings in some instances.

Climate Smart Agriculture Practices

This section serves to answer the research question, "how are extension providers addressing climate change in their recommendations to maize farmers?" Participants described the messages their organizations provide to farmers that address the impacts of climate change (Figure 8).

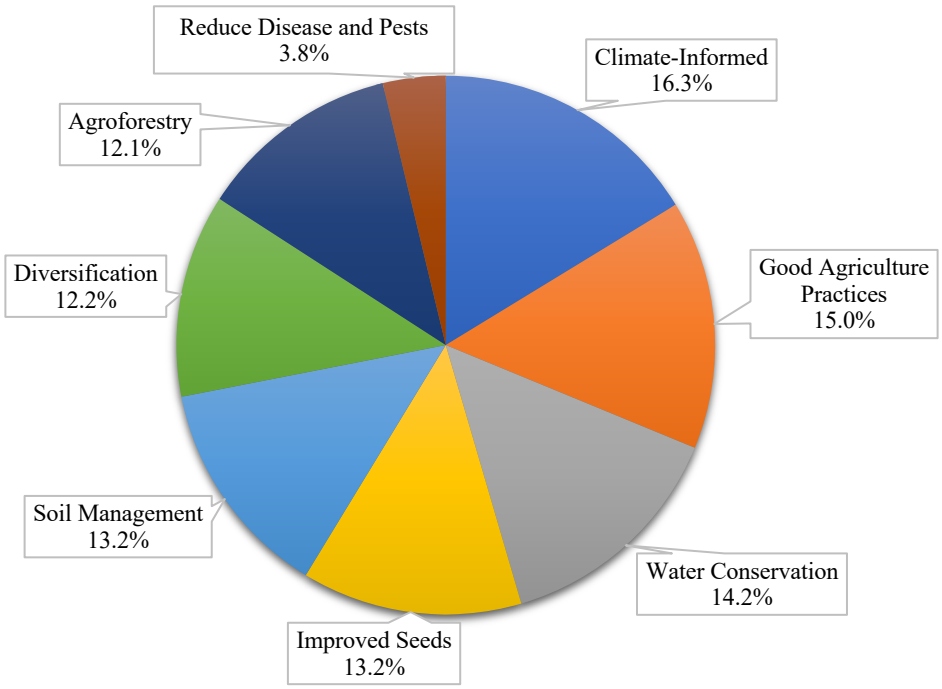


Figure 4. Percentage of participants recommending strategies to farmers to address climate change

The most common strategies recommended to farmers include being climate-informed (16%) and good agriculture practices (15%). Being climate-informed was the most common strategy recommended to farmers by participant organizations. While some participants explained that their organizations would share climate and weather information with farmers as part of their delivery of EAS, others mentioned developing specific program content to inform farmers about climate changes. Several participants noted that they receive frequent weather forecasts from DMCCS and then are able to share information about expected temperature and precipitation conditions with the farmers they serve. One approach mentioned by an international NGO participant was related to climate-informed programming for farmers. This participant explained:

> There is a specific approach that has emerged called PICSA or Participatory Integrated Climate Services for Agriculture. There are several steps which are meant to make the

> farmers recognize that the climate is really changing. Once they [farmers] have accepted that the climate is changing, they will look at the impacts of climate change of which floods is one of those impacts. After they have looked at impacts, they are now convinced through the steps in this approach that they should change their ways of farming. Now they select options like crop options to implement and overcome those challenges. They also select livestock options to implement to overcome the challenges. They also select livelihood options to overcome the challenges with climate change.

Through this approach, farmers will analyze historic weather patterns and make their conclusions from the data.

When referencing good agriculture practices participants described providing information about agronomic practices, specific characteristics of certain maize varieties, proper land preparation methods, appropriate fertilizer applications given soil types and crop requirements, and increasing crop productivity through sustainable intensification.

Water conservation practices were also common and encompassed activities including watershed management, water harvesting, constructing dams, swales, and gullies, pit planting, contouring, and winter irrigation farming to supplement rainfed agricultural production systems. Participants explained that focusing on an entire watershed allows farmers to understand downstream impacts to waterways and promotes the conservation of an entire waterway with a focus on reducing sources of pollution and limiting water withdrawals during times of drought. Similarly, a Malawi NGO participant explained that dams, swales, and gullies allow farmers to raise water levels in times of drought to prevent widespread crop loss due to a lack of water. In some cases, farmers are encouraged to plow their fields along contours and are encouraged to practice ‘continuous contouring’ where they dig various holes along the contour to harvest water.

Another participant from the government explained the strategies that their organization recommends to farmers stating, “we want them to do water harvesting methodologies like pit planting, mulching to cover the ground, and conserving the land by constructing contour ridges so that the soil moisture is maintained.” Several participants also mentioned the connection between water and soil conservation explaining how the two practices often complement one another.

Soil management practices were commonly referenced by participants in addition to water conservation strategies and included themes relating to conservation agriculture, minimum or no-till agriculture, cover crops, mulching, manure from livestock waste, and composting. Participants explained that the goal of these strategies was to reduce topsoil erosion and improve soil fertility and moisture content in order to increase production and become less reliant on chemical fertilizers. Conservation agriculture included a variety of strategies including mulching fields to conserve soil and water, practicing minimum tillage agriculture, implementing cover crops, leaving crop residues on a field after harvest, and doing crop rotations. One participant from a farmer organization noted, “for conservation agriculture, we have observed that there are different players in the implementation of conservation agriculture and these players have different information and the approaches are also different.” The participant added that the difference in approaches for conservation agriculture sometimes confused farmers and ultimately led to the lack of adoption of any of the specified methods. A common soil management approach mentioned by participants was manure and compost making. A government representative stated, “we also conduct demonstrations on different types of manure making or we demonstrate how to make compost manure using different methods. After the demonstration activity, farmers also do it in their homes. That’s how we disseminate the information.” Several

participants also mentioned teaching farmers to use animal waste from their livestock as manure and produce scraps from home gardens as compost for their fields.

Use of improved maize varieties was also recommended as a climate adaptation strategy. Improved seed varieties described by most participants included those that were hybrid, drought-tolerant, early maturing or short-duration, and fortified. A noticeable difference in opinion was expressed by one Malawi NGO participant who commented that the local, traditional maize varieties performed better than new hybrid maize varieties and did not view new varieties as improved. This participant stated:

> There are these local seeds that are drought resistant. We are encouraging people to use the local seeds. Most people normally depend on maize and that maize usually a hybrid seed, but, these hybrids are not good at all. But these local seeds; they're just very simple, and they can grow naturally.

The participant further elaborated on their aversion to hybrid maize varieties noting that they were too expensive and labor intensive for farmers to afford and properly manage.

The promotion of diversified farming as a climate adaptation strategy was also commonly referenced by participants. Diversification including planting crops such as legumes, peas, groundnuts, soy, beans, cassava, sweet potato, and rice as well as raising livestock. A Malawi NGO participant commented:

> We look at what alternatives are there for farmers to still salvage something even during a drought. They should diversify, so that if one crop fails, they can rely on the other crops that they planted. As part of diversification, we do encourage them to raise small livestock. That way, they can easily eat that small livestock or sell it without problem.

Some participants encouraged farmers to create separate plots or zones for diversified production systems while others recommended growing maize alongside other vegetables in a single plot. Several participants noted that diversification was also seen as a nutrition strategy because growing multiple crops and raising livestock could help to increase the consumption of a variety of vegetables. Similarly, four participants noted that diversification could help to increase the income of a farmer in case of extreme weather events or other crop failure.

Tree planting or agroforestry was another recommended practice for farmers. Agroforestry practices described by participants included tree regeneration, growing fruit trees, maintaining old and new growth forests, establishing village forests, and not clearing or burning the land. Several participants mentioned that their organizations encourage farmers to grow trees or establish village forests as a group in order to share the responsibility of taking care of the trees and sharing the rewards of trees that bear fruit.

The final category of strategies recommended to farmers was related to reducing instances of crop pests. However, this strategy was not commonly referenced and was only mentioned by four participants. Participants who mentioned this strategy referenced fall army worm which has devastated maize crops throughout the country and root rot. A variety of strategies to reduce pests and disease were recommended including pesticides or "crop protection products" as chemical controls, physical controls, biological controls, and understanding the lifecycle of pests and diseases in order to tailor strategies to the appropriate stage.

There was a noticeable difference in the strategies recommended by different types of organizations to address climate change as seen in the table below.

Table 8. Agricultural strategies recommended by extension providers to adapt to climate change

Organiz-ation Type	Climate-Informed	Good Agricul-ture Practices	Water Conser-vation	Improved Seeds	Soil Manag-ement	Divers-ification	Agro-forestry	Reduce Crop Pests
Private [3]	66.7% [2]	66.7% [2]	100.0% [3]	100.0% [3]	100.0% [3]	33.3% [1]	66.7% [2]	66.7% [2]
International NGO [4]	100.0% [4]	75.0% [3]	100.0% [4]	75.0% [3]	100.0% [4]	75.0% [3]	75.0% [3]	50.0% [2]
Farmer Organization [4]	100.0% [4]	100.0% [4]	75.0% [3]	75.0% [3]	50.0% [2]	75.0% [3]	75.0% [3]	0.0% [3]
Malawi NGO [3]	100.0% [3]	100.0% [3]	100.0% [3]	66.7% [2]	66.7% [2]	100.0% [3]	100.0% [3]	0.0% [0]
Governmental [5]	80.0% [4]	80.0% [4]	60.0% [3]	60.0% [3]	60.0% [3]	60.0% [3]	40.0% [2]	0.0% [0]
TOTAL [19]	**89.5% [17]**	**84.2% [16]**	**78.9% [15]**	**73.6% [14]**	**73.6% [14]**	**68.4% [13]**	**68.4% [13]**	**21.1% [4]**

While all private sector participants referenced improved seeds, soil management, and water conservation strategies to address climate change, all international NGO participants soil management, water conservation, and climate-informed strategies. Farmer organizations all referenced good agriculture practices and climate-informed strategies while 100% of Malawi NGO participants referenced all strategies except reducing pests, soil management practices, and improved seeds. Finally, the percent of government participants referencing strategies ranged from 80% for good agriculture practices and being climate informed to 0% for reducing instances of pests.

Information Challenges

This section addresses the final research question, "what challenges exist in providing effective information for maize farmers to adapt to climate change?" A summary of challenges referenced by participants are shown in Table 9 and were organized into the following themes: disaster, poverty, education, messages, and resources.

Table 9. Challenges in supporting farmers to adapt to climate change

Organization Type	Resources	Messages	Disaster	Poverty	Education
Private [3]	66.7% [2]	66.7% [2]	33.3% [1]	33.3% [1]	33.3% [1]
International NGO [4]	100.0% [4]	75.0% [3]	50.0% [2]	50.0% [2]	0.0% [0]

Malawi NGO [3]	66.7% [2]	66.7% [2]	66.7% [2]	33.3% [1]	0.0% [0]
Farmer Organization [4]	100.0% [4]	50.0% [2]	50.0% [2]	50.0% [2]	50.0% [2]
Government [5]	80.0% [4]	20.0% [1]	20.0% [1]	40.0% [2]	20.0% [1]
TOTAL [19]	**84.2% [16]**	**52.6% [10]**	**42.1% [8]**	**42.1% [8]**	**21.1% [4]**

The most commonly refenced challenges included a lack of resources and was mentioned by 84% of participants. Participants described a lack of resources including funding, staff personnel, and equipment. A lack of funding included finances to sustain agricultural extension programs as well as the tensions that exist between farmers who receive allowances from extension providers and those who do not. One private sector partner described this tension by explaining:

> The challenge that I consider very big is the approach of using incentives. There are some organizations which are giving allowances to farmers or Lead Farmers. When they meet farmers, they give them allowances in Malawian money. Now when another institution comes which doesn't offer such allowance, farmers do not go or participate. So, it is a big problem because afterwards, if there are no allowances, farmers won't participate. Other times, institutions might train Lead Farmers and give them transport and an allowance. But when the Lead Farmers go back to the village, the other farmers are angry that the Lead Farmers went alone and enjoyed nice places and nice food without providing anything for the village.

A lack of staff included the total number of personnel operating within an organization, but also the expertise, skillset, and training of an organization's staff. One international NGO participant commented:

> The issue of staff capacity is more prominent in government. Government at the moment has got very low staffing levels and that makes it even harder for some of the communities to be reached with extension messages or services. When you look at

> capacity on the other side, it also has to do with capacity in terms of hired expertise. Some people may not have the necessary technical capacity to deliver agricultural extension services, but this problem is not manifested in government because the government extension workers are well trained. But some NGOs that are not very serious with their interventions will sometimes hire someone who is not highly trained in technical areas.

Additional resource challenges mentioned by participants included a lack of equipment such as mobile phones, radios, printers, and motorbikes to access rural farmers.

The lack of clear and consistent messages communicated to farmers was the second most common challenge referenced by 53% of participants. A Malawi NGO participant noted, "some of the challenges have to do with messaging. You find that government extension workers they have their own messages that they are pushing to farmers. You also see that NGO's extension workers might provide information that might be conflicting, so that is still a challenge." Between 50 – 75% of participants from farmer organizations, Malawi NGOs, international NGOs, and private sector participants referenced a lack of clear and consistent messages. Yet, only 20% of government participants referenced messages as a challenge. Specifically, several participants noted that the messages communicated to farmers regarding conservation agriculture and tillage practices conflicted with one another.

Another common challenge relating to messages was the duplication of information provided to farmers from different types of organizations. One NGO participant highlighted this challenge by commenting:

> There is still a need for coordination of activities. You find that institutions are often doing the same thing. Like NGO A comes to farmers and says something and then NGO

B comes to the same famers and says the same thing. If these institutions were able to sit down, share what they are doing, and synergize their activities, and then come up with different areas to concentrate on, that would be good.

To address some of these challenges, several participants mentioned a need for policyholders to continue coordinating messages and farmers served to ensure all regions are effectively reached and information is not duplicated.

Disaster was an additional challenge mentioned by 42% of participants. Participants mentioned both short- and long-term program addressing disaster depending on the frequency, intensity, and duration of events including both extreme weather events and public health crises such as Covid-19. Several participants noted that Covid-19 has limited profits from agricultural commodities and severely impacted market operations throughout the country.

Issues related to farmer poverty were referenced by 42% of participants. Several participants explained that farmers sometimes cut down trees in order to sell firewood or provide fuel for their homes because it is a free resource that they can readily access. Additionally, poverty was referenced in relation to other issues relating to a lack of farmer equipment and gadgets like radio to receive information from extension providers.

Finally, a lack of education among farmer populations was referenced as a challenge in providing effective information to address climate change. Several participants noted that the farmers they work with are often illiterate and are not able to read information that is written down or distributed through SMS. While this challenge was referenced by representatives from the government, farmer organizations, and the private sector, this challenge was not referenced by any NGOs.

Other Messages

Other messages shared with farmers by participant organizations that were not explained as climate adaption strategies were categorized into the following themes: economic strategies, nutrition, public health and sanitation, and gender. Economic strategies referenced by participants included transforming value chains, building infrastructure for crop value addition, supporting market linkages, training farmers to develop business, marketing, and financial literacy skills, implementing villages savings, loan programs, cash transfers, mobile banking, and improving household livelihoods. One government participant noted, "when we train farmers on market-oriented agriculture and there are varies modules that are used, so that the farmers should be trained systematically on things like farming as a business or maybe creating their gross profit margins." Agribusiness support was commonly referenced by participants as an economic strategy.

Providing information about nutrition was another theme commonly referenced by participants when describing the activities and goals of their organizations. Nutrition was commonly referenced by participants in addition to other strategies such as diversified farming, post-harvest management, food safety, and nutrition sensitive agriculture which involves growing crops to maximize nutrition benefits. One participant noted that their organization encourages farmers to develop home gardens in order to build resilience to weather shocks through diversified production systems and increase the nutrition among members of a household.

Public health and sanitation practices were referenced by one participant from each organization type. These strategies were aimed at supporting human and environmental health, addressing HIV/AIDS, building health and sanitation facilities to avoid disease outbreaks,

providing emergency response during natural disasters, and delivering information about the ways to reduce the spread of Covid-19.

Addressing gender issues was the final theme referenced by participants. As part of the household approach to address agriculture issues at the family level, organizations also address gender relations and gender inequity to ensure that women are also able to benefit from agricultural interventions that are implemented by extension providers.

Summary of Findings

Nineteen participants from organizations providing extension services to farmers in Malawi participated in this research including three actors from the private sector, four actors from international NGOs, four actors from farmer organizations, three actors from Malawi NGOs, and five governmental actors. Participant organizations were involved in a wide range of activities focused around providing inputs to farmers, improving market linkages, farmer training, supporting food security outcomes, sustainable agricultural production, improving rural livelihoods, and capacity-building. According to interview participants, the annual number of clients served by each organization ranges from 350 - 4,200,000. The organizational structure of governmental organizations, international NGOs, and farmer organizations is very hierarchical while the structure of small private sector partners and Malawi NGOs is more cooperative and participatory. Five participants mentioned having advanced degrees and the majority of participants are the directors or managers of their organizations.

Although 85 organizations were identified by participants as stakeholders in Malawi's extension system, there appear to be a select number of organizations that develop messages and are considered experts on climate change adaptation practices. The organizations referenced as content developers by the greatest number of participants were DAES for agricultural messages

and DMCCS for information related to climate and weather. Staff from DAES explained that they often receive agricultural messages and information about new technologies from CGIARS and DARS; both of whom were also referenced by several participants as content developers. Other common content developers include MoAIWD, the U.S. Government, NACDC. Several participants noted that new agricultural technologies are often first presented to Malawi's extension providers during NACDC meetings and then customized to fit farmer needs by the committee's members including representatives from government, NGOs, farmer organizations, research institutions, and the private sector.

The 85 organizations identified by participants are involved in the transfer of knowledge throughout Malawi's extension and this network contains 170 unique relationships. Although the average degree of collaboration between organizations is low at 6.2, several organizations and actors were identified as central to network connectedness and the transfer of knowledge within the extension system. Organizations with the highest degrees of collaboration include ADDs, DAES, MoAIWD, farmers, NACDC, Catholic Relief Services, and NASFAM.

There are a variety of advisory methods used to educate farmers about CSA practices which include ICTs, trainings, and written materials. The use of ICTs includes radio, SMS, internet, TV, Call Centers, and Mobile Vans. The majority of organizations use radio to disseminate messages to farmers through national and community stations. SMS was also used by over 50% of organizations to disseminate information directly to farmers through text messages and IVR. Participants noted that ICT platforms complement one another by providing increased access to information for farmers who cannot afford technology, are illiterate, or require specific recommendations to address agricultural issues. 90% of organizations used trainings to communicate information to farmers including Lead Farmer Approaches, Farmer

Field Schools, site visits, demonstrations, and the Model Village approach. Written materials were also commonly mentioned by organizations, but varied in format and length from short leaflets or posters describing a particular technology or production process to longer manuals or lesson plans used by government extension providers during trainings or newspapers used by farmer organizations highlighting farmers success stories.

Organizations address climate change by recommending strategies to farmers including being climate informed, good agriculture practices, water conservation, soil management, improved seeds, diversification, agroforestry, and reducing disease and pests. The most common strategy recommended to farmers was to be climate-informed and have information about the near-term weather conditions of a particular locality.

The most common challenges in providing effective information for maize farmers to adapt to climate change included a lack of resources and a lack of clear and consistent messages. Resource challenges encompassed a lack of funding, staff expertise, skillset, and training, and equipment. Participants explained that challenges surrounding messages often resulted in the duplication of information provided to farmers by multiple organizations.

CHAPTER FOUR: DISCUSSION AND CONCLUSIONS

Discussion

This chapter elaborates on key research findings, offers contributions to current theoretical perspectives, and provides recommendations and implications for future research.

Within Malawi's extension network, the direction of information exchanges both in the development of content and sharing of information within the network is notably asymmetric. Certain organizations hold substantial power within this network because more information comes to them, then is shared by them. The government departments included in the core of both

networks are also not representative of all types of organizations within Malawi's extension system. Ingold and colleagues (2010) argue that the vertical integration of actors from different types of organizations is essential for knowledge transfer and adaptation to climate change. Moreover, the integration of actors from lower governance levels is crucial for information acceptance from all stakeholders and increases the strength of relationships within the network.

The content development network shows an imbalance of power between high-level government departments and other organizations operating in the extension system. The most commonly referenced content developers were government departments operating within MoAIWD and MoREM structures, CGIARs, the U.S Government and NACDC. While these organizations have high in-degree scores, their out-degree scores are low. This reveals that other organizations rely on these actors as content developers, but the content development process is not reciprocal. The NACDC which includes a diversity of stakeholders is spearheaded and led by representatives from DAES and MoAIWD suggesting that power lies with those government representatives when decisions are made in the committee. It is noteworthy that the majority of extension providers were not referenced as content developers and remain in the periphery of this network. Within the government sector, only ministry departments and district personnel were referenced as content developers. This indicates a lack of vertical integration among organizations involved in content development and reveals a top-down, hierarchical structure of content development among government departments and research institutions perceived to be experts in climate change adaptation and agricultural technologies. These findings are consistent with analyses conducted by research organizations who have found that the public sector remains the central technology generator for agricultural research and development in Malawi (Phiri et al., 2012; Knorr et al., 2007; Masangano & Mthinda, 2012).

It is also important to recognize that farmers are the main clientele for EAS in Malawi, but are not commonly referenced as content developers. Bezner Kerr and colleagues (2018) note that low farmer adoption of agricultural technologies in Malawi may be due to a lack of farmer involvement in the co-creation of knowledge. Several studies have also found that participatory approaches that involve Malawian farmers in the creation of knowledge can increase farmer confidence in experimenting with new agricultural technologies, support knowledge sharing among farming communities, and strengthen farmer networks to build adaptative capacity (Bezner Kerr et al., 2018; Chowa et al., 2013).

However, there is a clear integration of multi-sectorial actors within Malawi's extension system and the composition of organizations within the core of the information sharing network is heterogenous. Additionally, the types of organizations present within the core of the network are fairly diverse with the exclusion of private sector actors. In fact, farmers have one of the highest degrees of collaboration within the network and are critical actors that link other organizations together. Therefore, farmers are not only receivers of information, but also are important transfers of knowledge between organizations addressing climate change impacts in Malawi. However, a significant number of organizations are not as well connected to the core of the network and operate within the periphery. These organizations are not only reliant on actors to receive information, but also may experience difficulty in communicating their messages to core actors within the network.

In terms of information communication platforms, trainings, ICTs, and written materials are the advisory methods most used to communicate climate smart agricultural practices to farmers. Trainings are the most common way organizations disseminate this information to farmers and participants utilize Lead Farmers, Farmer Field Schools, site visits, demonstrations,

and the Model Village Approach. Trainings facilitated by Lead Farmers were commonly referenced by participants who noted that this approach increase access to and the adoption of agricultural technologies because local farmers trust and value information from their peers. This is consistent with a 2012 survey that found that 78% of extension providers used the Farmer-to-Farmer approach (Masangano & Mthinda, 2012). Lead Farmers often hold leadership positions in a community, provide education and training to peer farmers, and organize meetings and discussions. Some Lead Farmers receive compensation or accreditation for their services, although most do not.

For ICTs, radio is overwhelmingly the most common medium used followed by SMS, internet, TV, Call Centers, and Mobile Vans. For example, an NGO called Farm Radio Trust "provides farmer advisory services through radio programming, trains and builds capacity of broadcasters and radio stations, and promotes participatory radio campaigns facilitated using ICTs" (Kimaro et al., 2010). Farmer groups allow for the greater dissemination of ICTs for those who do not have access to technologies or are illiterate. Written materials are commonly distributed to farmers as leaflets, posters, and magazines or are utilized by extension during trainings and can help to strengthen information delivery for those who are literate. However, written materials were not commonly referenced by Malawi NGOs who noted that their organizations do not have the resources to print and distribute written materials.

The most notable finding from an analysis of the practices recommended by extension providers to address climate change is that farmers are commonly informed about climate and weather conditions, but are slightly less informed about specific strategies to deal with the impacts of climate change. Participant organizations frequently receive weather forecasts from DMCCS and then share information about expected temperature and precipitation conditions

with the farmers they serve. However, only one participant mentioned the delivery of climate-informed programming for farmers to address local climate impacts. Additional strategies recommended by some participant organizations to address climate change include good agriculture practices, water conservation, soil management, improved seeds, diversification, and agroforestry. However, many of these strategies hold different meanings for participants and encompass a variety of different activities. For example, "good agriculture practices" seems to be a generic phrase which includes general agronomic practices, understanding the characteristics of certain crop varieties, land preparation methods, fertilizer applications, and other approaches designed to increase crop productivity. It's also unclear if these strategies directly address climate change impacts. Other strategies like conservation agriculture which fall into the category of soil management also appear to hold different meanings for participant organizations. For instance, conservation agriculture might include crop rotations, minimum-tillage agriculture, crop residue, manure and compost additions to a field. Yet participants noted that farmers tend to disregard agricultural practices if they do not receive consistent information from extension providers. Therefore, while extension providers might prefer certain conservation agriculture practices over others; messages communicated to farmers must be clear and consistent otherwise they are less likely to be adopted.

Nutrition and economic strategies were referenced by participants as cross-cutting themes when describing organizational activities, goals, and climate adaptation practices. Diversification, improved seeds, and agroforestry were climate adaptation practices that participants also mentioned as nutrition and economic strategies. Crop diversification allows households to consume a greater diversity of nutrients while providing the option for farmers to receive an income from different crops sold to markets, cushioning the potential impacts from

the loss of a single crop. Some participants also recommended that famers use fortified maize in order to address nutritional deficiencies. Finally, agroforestry serves environmental, economic, and nutrition purposes by improving soil fertility, acting as a buffer between rivers and farmer's fields, and allowing farm households to diversify their diets by growing fruit trees for consumption.

Gender was also referenced by extension providers as a cross-cutting theme in the delivery of EAS to farmers. In fact, several participants echoed statistics shared by the GoM noting that 70% of farmers in Malawi are women and produce 80% of food for household consumption (GoM, 2009). Although this study did not evaluate differences between men and women's involvement in content development, gender inequality has been cited as a significant barrier to women's participation in knowledge production and access to EAS in Malawi (Bezner Kerr, 2017). Furthermore, 56% of Malawian women are illiterate and this has been associated with additional difficulty in accessing agricultural information (GoM, 2009).

In terms of extension challenges, a lack of clear and consistent messages was refenced by the majority of participants in addition to a lack of resources. While participants from farmer organizations, Malawi NGOs, international NGOs, and the private sector referenced a lack of clear and consistent messages as substantial challenges, only 20% of government participants referenced messages as a challenge. One reason for this difference could be the high degree of connectedness of government departments within the extension network compared to other organization types. Government organizations that were referenced both as content developers and as central transfers of knowledge within the extension network might not view messages as a challenge because they operate as core actors within the network. Therefore, government personnel may believe that their messages are effectively communicated throughout the

extension system while this might not be the case for organizations that are not as closely linked to government departments.

A lack of resources was the most common challenge referenced by participants, but within this category; staffing challenges were the most commonly cited. Organizations often lack the proper number of individuals to fill extension positions, staff are not effectively trained, or staff lack certain experiences or skills in the extension field. A lack of technology and equipment compounds resource challenges for staff disseminating messages to farmers.

Contributions to Theoretical Perspective

The theoretical perspective employed in this research utilize elements from the diffusion of innovation theory, social network analysis, and DLEC's conceptual framework for analyzing Malawi's extension system. These perspectives were useful in understanding the development and dissemination of climate adaption information as well as key characteristics of EAS in Malawi.

This study indicated that the development of content in Malawi's extension system appears to follow one of the core assumptions of the diffusion of innovation theory in which agricultural innovations are developed by researchers and high-level government departments, disseminated by extension personnel, and then communicated to farmers who adopt technologies at different rates based on a variety of factors. Although this model appears to be prevalent in the development of climate change adaptation content in Malawi as evident by the select few organizations that were referenced as content developers, it is not evident that this strategy leads to higher rates of adoption than more participatory approaches. In fact, several recent studies have affirmed that the innovation diffusion model used to disseminate new technologies to farmers does not necessarily lead to adoption in Malawi. Hermans et al. 2021 and Engler et al.

2016 found that the adoption of climate smart agricultural practices in Malawi is a dynamic, multidimensional, and complex process. Additionally, this hierarchical process does not appear to allow for effective feedback from farmers who receive and interact with new technologies.

My analysis also revealed that social network analysis is a useful tool to understand which extension providers in Malawi are central to the development of content and transfer of information and which organizations are on the edge or periphery of the network. The majority of organizations referenced in this study do not generate climate adaptation information, but are involved in the transfer of this information. It also appears as though clusters of organizations exist within the information sharing network. These clusters include government departments and select international and local NGOs, private sector partners involved in providing inputs to farmers, and religious-affiliated organizations. Social network analysis is a promising tool for evaluating the relationships and clusters present within extension networks in order to evaluate the strengths, weaknesses, and power imbalances between organizations operating within a network. Future social network analyses should seek to incorporate an analysis of the ways in which hierarchies between organizations impact power imbalances as well as the transfer of information within an extension network.

Within DLEC's conceptual framework for analyzing Malawi's extension system, governance structures, partnerships, linkages, and networks are recognized as crucial characteristics that impact the performance and effectiveness of EAS. This study has reaffirmed the importance of strong relationships and ties among different types of organizations operating within Malawi's extension network. This study has also revealed that these linkages are not only essential among high-level actors such as government departments and international NGOs, but also among farmers and farmer associations. In DLEC's conceptual framework, the knowledge,

behaviors, and adoption of agricultural technologies among farming households are seen as outcomes of Malawi's EAS. Yet, strong relationships and networks formed by farmers may be just as important, if not more, in impacting the uptake of technologies. In order to strengthen DLEC's EAS framework for Malawi, farmer networks should be included as a key component of the agricultural innovation system in addition to the existing components which include governance structures, organizational capacities, advisory methods, market engagement, livelihood strategies, and community engagement.

Recommendations and Implications for Future Research

I propose the following recommendations and areas of emphasis for future agricultural extension research to address climate change impacts in Malawi.

First, there is a need for improved integration of organizations from lower governance levels in order to diversify the types of organizations operating in Malawi's core extension network. Government representatives should also continue to facilitate platforms like the NACDC that involve diverse extension providers and allow for the vertical integration of information sharing among actors within different levels of government and farmers themselves. The increased diversification of organizations within the core network and facilitation of collaborative platforms will help to increase access to information, facilitate the transfer of knowledge, improve collaboration among extension providers, and increase the communication of consistent climate adaptation messages to farmers.

In addition, extension providers should also focus on supporting farmers with specific and consistent agricultural technologies that will address climate change risks. The delivery of consistent climate adaptation practices such as conservation agriculture and good agriculture practices should be a top priority for extension providers. Future studies should also seek to

analyze the efficacy of different advisory methods in disseminating information to farmers and rates of adoption of specific CSA practices.

In terms of content development, increased engagement of farmers in the co-production of agricultural knowledge can help to facilitate greater adoption of climate adaptation practices. Co-production processes allow for a participatory approach to content development through a combination of collaborative scientific review, dialogue, input from farmers, and joint decision-making by researchers and participating farmers (Bezner Kerr et al., 2017). Participatory research approaches can support collaborative farmer learning and innovative problem-solving. Participatory methods also value the institutional knowledge of local farming communities and can help to better understand the social interactions at play that influence the information available to farmers. This approach can be used to collaboratively develop agricultural improvements that allow farmers to effectively adapt to climate change. Additionally, women's contributions to Malawi's agriculture sector are vitally important to the success of the industry and the ability of farmers to adapt to climate change. Therefore, future studies should also incorporate an analysis of the gendered nature of EAS delivery and the role of women farmers in the co-production of agricultural content.

Finally, organizations should continue to address resource challenges by providing tailored trainings for their staff and leveraging partnerships within the extension network to fill gaps in staffing capacity. New partnerships with donors and within the private sector could also help to increase funding for the delivery of EAS in Malawi.

Limitations

This research has several limitations that readers should be aware of as they interpret study findings and conclusions. First, due to the qualitative nature of this research and limited number

of study participants, findings cannot be generalized the full population of extension providers operating in Malawi. This study included 19 participants who consented to participate in virtual interviews and is therefore not representative of all individuals or organizations providing EAS in Malawi. Once travel is permitted, this study should be replicated with in-person interviews with extension providers operating in Malawi and farmers that receive EAS.

Second, due to travel restrictions imposed from the Covid-19 pandemic, in-person travel to Malawi was not possible during this research process. Due to the virtual nature of these interviews, only participants with access to internet were able to participate.

A third limitation was the study protocol and questionnaire I developed. Although I prompted participants to elaborate on their answers, the responses shared by participants were framed by my questionnaire. I strove to maintain an unbiased perspective of the responses provided by participants and the analysis of data by receiving input from local partners in Malawi. However, this study reflects my Western worldviews and positionality as a 27-year-old, Caucasian woman from the United States.

A final limitation was the lack of scholarly research on social network analysis and climate change adaptation content development and dissemination in Malawi. This knowledge gap limited the my ability to draw comparisons between other researcher's findings and form recommendations.

Conclusions

Results from this study can help to improve the development and dissemination of agricultural content to address climate change in four ways. First, this study identified key content developers and information sharing pathways for those generating and disseminating agricultural knowledge within Malawi's extension system. These organizational ties can be used

to inform agricultural extension policy decisions in order to strengthen stakeholder collaboration and coordination. Second, this study revealed that farmers are the receivers of agricultural information and transfer knowledge to other organizations, but are not commonly involved in the content development process. Future research should seek to involve farmers in the co-production of agricultural knowledge and evaluate the impact of co-creation on adaptation to climate change. Third, this study begins to evaluate how the type of advisory methods used by extension providers impacts the delivery of content and the adoption of CSA practices. Future studies should build upon this research protocol to better understand if the advisory method used by extension providers impacts the rate of adoption of different technologies. Finally, this study reaffirms the importance of communicating clear and consistent messages to farmers to address climate change. Increased stakeholder collaboration and coordination can improve the delivery of these messages and ultimately, better support Malawian farmers to adapt to climate change.

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APPENDICES

Appendix 1: Interview Questionnaire: Key Informant Interviews

Title of study: Climate Change Adaptation and Extension Approaches in Malawi: A Stakeholder Assessment

Investigator: Ms. Hope Zabronsky, MSc Candidate, International Agricultural Development

Preamble:

Thank you for sending a signed consent form to participate in this research through an interview. My name is Hope Zabronsky and I am a graduate student studying international agricultural development in the United States. I am conducting a research study to evaluate the ways in which extension providers gather information and teach maize farmers. Specifically, I want to understand how information is communicated to maize farmers regarding extreme weather events and changing climate conditions.

I will use the information gathered from today's interview to help identify practices could strengthen the extension system's ability to support climate change adaption for maize farmers in Malawi.

All of your responses will remain confidential, and the information will be protected by several layers of data security. If you do not want to answer a specific question for any reason, that is okay, and we can skip the question and if you want to stop the interview at any point, that too is okay.

There is no time limit for the answers you provide. If there is any confusion about the question, or a term or word in the question, please feel free to ask for clarification. I may follow up a response with a brief question to help my own clarity.

Do you have any questions or concerns before we begin?

Interview Questions:

Organization Background:

1. What is your affiliate organization?
2. What are the main activities of your organization?
3. Who are the main clients that your organization works with?
4. Which EPA/section does your organization offer services in?
5. What partners does your organization work with?

Information Collection and Dissemination:

1. Where does your organization receive its information from?
2. What information does your organization provide to clients?
3. How does your organization share information with clients (trainings, farm visits, website, pamphlets, calls, etc.)
4. Does your organization use a curriculum (or lesson plans) in order to educate clients?
5. If so, what is included in this curriculum?
6. Could you share this curriculum with me after the interview?

Climate Change:

1. What kind of work does your organization do related to drought?
2. Where does your organization get its information about drought?
3. How are clients educated about drought?
4. What practices does your organization recommend its clients use to reduce the impacts of drought?
5. What kind of work does your organization do related to floods?
6. Where does your organization get its information about floods?
7. How are clients educated about floods?
8. What practices are recommended to clients to reduce the impacts of floods?
9. Are there certain practices that clients have adopted more than others?
10. Is this information shared with partner organizations?

Questions for the Researcher:

1. Do you have any questions for me?

Appendix 2: Centrality Measures for all Malawian Extension Providers

Organization	In-Degree	Out-Degree	Degree	Betweenness
Department of Agricultural Extension Services	8	3	11	25.5
Department of Meteorological and Climate Change Services	6	0	6	0
Ministry of Agriculture, Irrigation, and Water Development	5	1	6	7.5
U.S. Government	4	0	4	0
Department of Agricultural Research Services	4	0	4	0
CGIARs	4	0	4	0

Department of Crop Production	3	0	3	0
National Agriculture Content Development Committee	3	1	4	5.5
Agricultural Development Division	2	13	15	136
Department of Irrigation	2	0	2	0
United Nations	2	0	2	0
District Agriculture Office	2	1	3	93
Private Farmer Training Company	2	1	3	29
Access Agriculture	1	0	1	0
Self Help Africa	1	1	2	1
Africa Development Foundation	1	0	1	0
Agricultural Commodity Exchange	1	1	2	3
Marketplace	1	0	1	0
Farmers	1	12	13	56
Department of Environmental Affairs	1	0	1	0
Department of Forestry	1	0	1	0
Zodiak Radio	1	1	2	2.5
Department of Fisheries	1	0	1	0
World Vision International	1	0	1	0
Farm Radio Trust	1	5	6	38
Department of Animal Health and Livestock Development	1	0	1	0
Department of Land Resources and Conservation	1	0	1	0
Bayer	1	1	2	0
Area Development Committees	1	1	2	1
Environment Malawi	1	0	1	0
Area Stakeholder Panel	1	1	2	19
District Stakeholder Panel	1	2	3	37
Extension Planning Area	1	1	2	20
Department of Disaster Management Affairs	1	0	1	0
MaFAAS	1	0	1	0
Mewa Development Trust	1	0	1	0
DAECC	1	2	3	51
Section AEDO	1	1	2	6
Total Land Care	1	0	1	0
Ministry of Industry and Trade	1	0	1	0
Action Aid	0	0	0	0
Adventist Development and Relief Agency	0	0	0	0
Cooperative	0	4	4	0
Project Concern International	0	0	0	0
United Purpose	0	0	0	0

NASFAM	0	5	5	0
Malawi Input Suppliers	0	0	0	0
Malawi Enterprise Development Fund	0	0	0	0
NBS Bank	0	0	0	0
Luntha TV	0	0	0	0
Evangelical Association of Malawi	0	0	0	0
Path Project	0	0	0	0
Save the Children	0	0	0	0
Alliance One	0	0	0	0
Village Development Committees	0	2	2	0
Village Agriculture Committees	0	2	2	0
Association of Women in Religious Institutions	0	0	0	0
Catholic Relief Services	0	1	1	0
One Acre Fund	0	0	0	0
Crop Life International	0	0	0	0
Catholic Dioceses	0	0	0	0
Catholic Health Commissions	0	0	0	0
Ministry of Health	0	0	0	0
Ministry of Education, Science and Technology	0	0	0	0
Churches Action in Relief and Development	0	0	0	0
Lusubilo Community Care Project	0	0	0	0
Civil Society Agriculture Network	0	0	0	0
Farmers Union of Malawi	0	3	3	0
Community Radio Stations	0	4	4	0
Farm Voice Radio	0	0	0	0
Village Civil Protection Committees	0	0	0	0
Department of National Parks and Wildlife	0	0	0	0
Department of Community Development	0	0	0	0
Malawi Broadcasting Corporation	0	1	1	0
LUANAR	0	1	1	0
Georgetown University	0	0	0	0
Irish Aid	0	0	0	0
Kusamala Institute of Agriculture and Ecology	0	0	0	0
Times Radio Malawi	0	1	1	0
Ministry of Information	0	0	0	0
Ministry of Civic Education and National Unity	0	0	0	0
NBC	0	1	1	0

Ministry of Gender, Children, and Community Development	0	0	0	0
Ministry of Natural Resources, Energy, and Mining	0	0	0	0
Plan International	0	0	0	0