INSTITUTE FOR GLOBAL PROSPERITY

EXPLORING INNOVATIVE PRACTICES OF SMALLHOLDER FARMERS IN ELGEYO MARAKWET COUNTY, KENYA, AS THE FOUNDATION FOR CO-DESIGNING REGENERATIVE AND INCLUSIVE FOOD SYSTEMS.

Roberta Chapchap

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Abstract

Food insecurity in Sub-Saharan Africa has led corporate agricultural industry to plan for a new African Green Revolution. This focuses innovation on the development of high yielding cereal crops through hybrid technology that require limited resources to grow. Unfortunately, this technological push disregards the complexities of smallholder farming practices thus creating short-term solutions that do not benefit farmers and can exacerbate current issues. This dissertation aims to identify how small holder farmers in Elgeyo Marakwet County, northwest Kenya, are the drivers and producers of innovation for agricultural methods, and how we may harness these processes in collaboration with other institutions to promote sustainable intensification of agriculture. This study will contribute to the argument for increasing agroecological practices in smallholder farms instead of focusing on hybrid technology to mitigate food insecurity in Sub-Saharan Africa. It also presents how smallholder farmers perceive innovation and the how they apply this to their farms. The main Research Question this study aims to answer is 'How can we understand and support processes of smallholder innovation in Elgeyo Marakwet County as the foundation for co-designing regenerative and inclusive food systems?'. The study uses a mixes-method research deign approach to achieve the above aim. Previous data collected by the IGP PROCOL, and other institutions, were used as secondary data to depict the unique practices of smallholder farmers and the results were further explored through semi-structured in-depth interviews with farmers local to the EMC to capture a deeper understanding of their innovation practices.

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List of Abbreviations

AGRA – Alliance for Green Revolution in Africa
AIS – Agricultural Innovation Systems
EMC – Elgeyo-Marakwet County
FAO – Food and Agriculture Organisation of the United Nations
GDP – Gross Domestic Product
GIS – Geographical Information Systems
GM – Genetically Modified
IGP PROCOL – Institute of Global Prosperity, Prosperity Co-Lab
IP – Innovation Platforms
IS – Innovation Systems
ITC – Information and Communication Technology
NGO – Non-Governmental Organisation
OECD – Organisation for Economic Co-operation and Development
PTD – Participatory Technology Development
SSA – Sub-Saharan Africa

List of Illustrations

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Chapter 1 – Introduction

Achieving food security in Sub-Saharan Africa (SSA) falls within the UN's Sustainable Development Goal 2. This aspiration, however, has proven to be an incredibly challenging objective to reach (Giller, 2020). Just under 21% of SSA's population is undernourished and a further 30% struggle with consistent supply of nutritious food (FAO, ECA and AUC. 2020). There is a clear need for a transformation in the agricultural domain so that countries can withstand large scale events that impact food security, such as the COVID-19 pandemic and climate change. There have been efforts to help mitigate the effects of such events and increase food stability in SSA however, doubts about the long-term sustainability of these efforts have recently risen. In order to address this, recent research has focused on the regenerative potential of agroecology in smallholder farming and how this can lead to increased resilience of individual households (Dawson, 2016).

Much of the data that currently represents food security in SSA has temporal and spatial limitations (Fraval et al., 2019). This hinders our understanding of the feasibility of food production schemes that aim at scaling up food per capita as it does not consider the specific conditions of smallholder farmer context. The new African Green Revolution presents a scalable solution to food insecurity based on past success in Asia in the 1960s-1970s (Pingali, 2012). Raising cereal crop yields through increased chemical fertilizers and efficient use of land in SSA is suggested as a way to combat food insecurity (Sasson, 2012), and there is sufficient satellite data that prove the agro-potential of Sub-Saharan countries (Luan et. al., 2019). Unfortunately, yield boosting schemes have proven unsustainable in the long-term creating issues such as farmer displacement (Dawson, 2016), loss of biodiversity (FAO, 2009) and increase control of corporate agribusinesses (Fischer, 2016).

Agroecology has recently been put forward as a sustainable solution for food insecurity in SSA as it increases farmer resilience (Herren and Hilmi, 2011; Badgley et al. 2009; Altieri et al. in 2015; Davies and Moore, 2016), soil conservation, and helps preserve biodiversity (The IPES 2017), among other benefits. Agroecology, however, presents scalability issues where large-scale implementation of the practice is challenging (Lunn-Rockliffe et al. 2020). This is mostly due to the large number of resources needed to advance agroecology so it can help smallholder farmers adapt to fast changing weather patterns and population growth. A fusion between Green Revolution initiatives and agroecological practices is recognised by governments and universities where agricultural technological innovations and local techniques are combined for efficient mitigation of food insecurity (Holt-Giménez and Altieri 2013).

Innovation plays a key role in transforming agricultural systems for increased food sovereignty and security in SSA; the question lies on how this is implemented in an agricultural domain. Technological innovations are assumed as the main path for increasing food supply as it focuses on crop optimization and efficient machines (Hounkonnou et al., 2012; Ouma-Mugabe, 2016). It also incorporates transfer of technology and digital technologies where the latter facilitates other types of innovation to flourish within a smallholder community. This line of innovation, however, does not incorporate the contribution of other institutional and human actors that surround the complex agricultural systems of smallholder farmers (Baumüller, 2016; Otsuka and Larson, 2013). As a response to the lack of contextually appropriate innovation initiatives in SSA, the Agricultural Innovation Systems approach was developed. This approach encompasses diverse types of knowledge through a network of institutions and later applies this to agricultural contexts of smallholder communities to develop specific support mechanisms that fit their local practices (Larsen et al. 2009, Juma, 2015b).

Given the array of information and studies on how to support SSA countries in their battle towards food security, this study focuses on centring the narrative around the people who benefit from this support. This study looks at the extensive pool of knowledge and experience of smallholder farmers in the Elgeyo-Marakwet County in western Kenya that can be used to centre them as co-designers of innovation to reach not only food security but food sovereignty in their community. The findings in this research further contribute to recent literature on agroecological innovation in smallholder communities thus helping develop context specific support mechanisms that capture their unique and dynamic agricultural practices.

The main aim for this research is to identify how smallholder farmers in Elgeyo Marakwet County (EMC) are the drivers and co-designers of innovation for agricultural methods, and how we may harness these processes in collaboration with other institutions to promote sustainable intensification of agriculture, as it is the backbone of the economy of many African countries. Chapter 2 sets the scene for agricultural development and food systems in Africa and reviews the successes and failures of previous agricultural intensification schemes such as the Green Revolution and the role of agroecological practices. Chapter 3 introduces and reviews technological innovation approaches to agricultural change and how innovation practices that centres humans are not fully explored by scholars. Chapter 4 presents the methodology for this study and the analysis of data collected. A mixed-method research design approach was used in this study, where secondary data was used to capture an overview used of the African agricultural domain and current practices in the EMC, and further explore this through focused, in-depth interviews with farmers from the EMC. Finally, Chapter 5 synthesises the findings of this study to what was previously found in previous research. The last chapter concludes this study by providing a general overview of the important contributions of this research, recommendations, and the shortcomings of the overall study.

Chapter 2 – Setting the Scene: Food systems and agricultural development in Africa

2.1 Introduction

In sub-Saharan Africa, around 239 million people are undernourished; a further 347 million people do not have access to a consistent supply of nutritious food (FAO, ECA and AUC. 2020). The situation remains particularly acute in Central and Eastern Africa, where the highest rates of undernourishment and malnourishment are concentrated, leading to significant livelihood vulnerability (FAO, ECA and AUC. 2020). Food security and nutrition in Africa thus remain a top priority (Luan et. al., 2019), and achieving goal 2 of the UN Sustainable Development Goals (ending hunger, achieving food security, and improving nutrition, and promoting sustainable agriculture (UN, 2021) will require a closer analysis of the challenges to food systems and the crafting of new solutions.

African populations have been increasing since the 1950s, with around 60% currently living in rural areas (FAO, 2020). Whilst migration into urban areas is projected to continue, the rural population is expected to reach 1 billion by 2050 (FAO, 2020). Even though the farming population is bound to increase in the next 30 years, farm sizes have been decreasing, for example, the average farm size in Malawi has decreased almost 38% in 7 years (2004-2011) (FAO, 2020). According to the FAO (FAO, ECA and AUC. 2020: xiii) the main factors that negatively impact food security are 'climate change, conflict and economic slowdowns and downturns'. Luan et al. (2019) adds that population growth increases the pressure of achieving the UN's Sustainable Development Goal 2's aim, thus slowing Africa's food insecurity alleviation plans. In 2018, conflict affected 33 million people throughout 10 countries, climate shocks impacted 23 million people and a further 10 million were left struggling for food in light of economic downturns (FAO, ECA and AUC. 2020).

Even though Africa has the largest world average of land availability per capita (FAOSTAT, 2017), the continent's self-sufficiency decreased between 1960 and 2010 (Luan, Cui, Ferrat, 2013). The reasons for this reduction in countries and subregions are evidenced by the fact that almost one third of their cereals are imported (FAO, 2017). There has also been changes in food diets due to economic growth, and trends such as moving towards meat protein, fruit and vegetables have been recorded in more urban areas (FAO, 2020). This demand for different diets is thus linked to the increased food dependency and related loss of control of food production of their population. As well as this, local food production systems have become outperformed by large agri-food companies and subsidized agricultures of the Western countries due to their control of world-wide food prices. This severely affecting small producers from the Global South as they find it hard to compete with the prices set (IPES Food, 2017). Indeed, import prices are often lower than production costs for most smallholder farmers, 'discouraging them from producing more' (Sasson, 2012).

The increasing gap between food production growth rates and consumption rates has exacerbated the self-sufficiency capacity of the continent, with northern and southern countries experiencing particularly low rates. Countries with a lower GDP, even with high self-sufficiency ratios, struggle with the negative impacts of climate change on their food systems due to their limited capacity to offset the lack of production through imports (Luan, Cui, Ferrat, 2013). The effects of climate change include irregular rainfall patterns and increasing temperature that will greatly contribute to a change in agricultural practices in Africa and many other parts of the world (Clay and King, 2019). In addition to water frequency and temperature, controlling pests, weeds, and the quality of crops grown under pressures of a changing climate prove more complex challenges than simply addressing yields when tackling food insecurity in Africa (Ahmed and Stepp, 2016, Altieri et al., 2015). The need for adaptability in their agricultural environments is crucial to combat increased demand and stagnant productivity, as well as prepare for future climate-related disruptions to food security.

To meet current food demands, increasing yields by ‘narrowing gaps between actual farm yields and yield potential’ is suggested by Foley et. al., (2011) as a solution to food insecurity. Model crop simulations were able to assess the potential for yield increase across regions and globally; results show that it is possible to meet demand for food from currently existing agricultural land (Luan et. al., 2019). The studies that calculate yield-gaps through yield experiments and other modelling show potential for increase food production in water-limited areas, for example. However, Luan et. al., (2019) acknowledge that for African countries to meet future food demands there is a need to research, observe and quantify yield divergence in different regions, as these determine maximum production. Perhaps of more importance, and as discussed below, is the need for the reshaping of the socio-economic environment to empower smallholders to increase potential yield (Luan et. al., 2019). Before this is explored, however, it is important to bring to attention solutions for addressing food insecurity and low agricultural productivity, as proposed by policy frameworks of the Green Revolution.

2.2 Green Revolution

The food shortage crisis in the 1960’s called for significant change in yields to reduce hunger and poverty. The result was a Green Revolution where High Yield varieties of wheat and rice were introduced in Asia to address the shortage (Fischer, 2016). The plan for the first Green Revolution (1966-1985) was put in motion through high levels of public and private investment, as well as policy support, to develop research for crop genetics and market infrastructures to increase food productivity (Pingali, 2012). The scientific development was achieved in the Global North and later adapted and applied to the Global South, more specifically in Asia. The investment push for crop productivity growth managed to triple cereal crop production and addressed large food deficits in the area (Pingali, 2012). The success of food production increase, however, also presents downsides as issues surrounding food security continue to surface, such as the food price crisis in 2008.

The world's poorest population suffered the most from the food price crisis in both 2008 and 2010; this hunger was the result of inflation on food prices due to their high volatility (Holt-Giménez and Altieri 2013). Subsequently, a plan was created by the corporate food industry for a 70% increase in food production by 2050 (Holt-Giménez and Altieri, 2013). The food crisis fuelled an initiative from global food institutions for investment in a new Green Revolution. However, the reports were compiled with the aim of justifying the call for investment in biotechnology when based on polemic assumptions, such as the increase of meat consumption in emerging economies and the dependence of increased yields on transgenic technologies and external intervention (Holt-Giménez and Altieri, 2013). The authors argue that the inefficient application of the Green Revolution has further contributed to the food crises; therefore, recreating the Green Revolution by maintaining the assumptions of the past would be inadequate.

There are, however, strong arguments that support boosting yields as it is an efficient way of tackling the issue of providing food for around 9 billion people in 2050 (Sasson, 2012). Fertilisers and pesticides are available for places where there are land and water constraints and even though organic farming growth is important, 'it cannot feed the world' (Sasson, 2012:9). Arguments supporting the potential closing of 'gaps [in agro-climatic homogeneous zones]' by adopting 'best cultivating practices in that same zone' are supported by research looking at satellite data (Luan et. al., 2019). However, best practices are defined in this study as methods that achieve maximum yields mapped by different model simulations (Luan et. al., 2019:709). The satellite data suggested by the study is presented to improve special-yield data that currently focus on country-level agro-ecosystems. The regional satellite data produces results generated from intra-annual and inter-annual vegetation growth ideal for simulating crop yields (Luan et. al., 2019).

Sasson (2012) supports an African Green Revolution but argues that the approach to this method must differ from that applied to rice in Asia. Amidst the planning for a New African Green Revolution, concerns were raised regarding the feasibility of such an endeavour, since many African countries do not have the same water availability as in Asia. Due to African crops and food being different from the ones in Asia, different technologies would have to be applied; however, most Sub-Saharan countries have the potential to tackle the food insecurity independently (Luan et. al., 2019). A practical perspective on the benefits of the Green Revolution suggests that worldwide food production could be concentrated in 50,000 industrial farms (Amin, 2011) however, even though there is enough area for a potential yield increase, there are underlying issues facing each country, such as conflict and poverty levels (Luan et. al., 2019; Dawson, 2016). Scholars call for these socio-economic and institutional factors to be considered when acting. If such factors are not embedded in Green Revolution practices, the context and importance of contemporary smallholder landscapes around the world would be excluded, leaving 2.5 billion farmers displaced and alienated from food production activities.

Methods of monitoring regional crop yield distribution are increasingly accurate (Luan et. al., 2019); however, they do not encompass the qualitative aspects and knowledge of the farmers themselves and therefore cannot put forward the best practices for maximum crop yield and food insecurity mitigation that account for complex cultures of smallholder food production. The development of research and technology regarding agriculture by corporate agribusinesses has been steered away from smallholder farmers (Fischer, 2016). GM (genetically modified) crops and hybrid technologies typical of intensive agricultural practice further increase the corporate control of technology surrounding the African Green Revolution, with such interventions being seen as the 'key drivers in the transformation of African smallholder agriculture' (Fischer 2016:1192).

The neoliberal perspective that surrounds the basic rationale for a new Green Revolution suggests that elements of farming (such as land and labour) are commodified, thus becoming tradable and with an allocated price (Amin, 2011). This path of commodification goes against the principles of food sovereignty, whereby people are granted access to 'healthy and culturally appropriate food' while having the 'right to define their own food and agricultural system', as it prevents farmers from acting individually (Holt-Giménez and Altieri 2013:95). Critiques of the new Green Revolution focus on social, environmental, and agricultural impacts that could arise from insufficient research and understanding undertaken by corporate food institutions about the communities affected (Holt-Giménez and Altieri 2013; Dawson, 2016).

Even though the first Green Revolution focused on maximising yields across all farm sizes and capabilities many smallholder farmers lost their farms and were led towards bankruptcy due to larger farmers with more capital and resources overtaking them. The case study of agricultural modernization in Rwanda by Dawson (2016) supports the argument that the effects of yield raising policies are unequally distributed across the diverse levels of farming by mainly benefiting the wealthier minority. The narrow objective focusing on shifting traditional polyculture to super seeds resulted in the disruption of many smaller household practices such as subsistence cultivation, knowledge networks and land tenure (Dawson, 2016).

The Green Revolution is also seen as one of the main factors that contributed to the loss of more than 70% of agrobiodiversity from farming; smallholder farmers were mostly responsible for the vast agrobiodiversity within their farming ecosystems (FAO, 2009). The combination of the setbacks from the Green Revolution and other crises such as climate change has sparked an interest in the importance of smallholder farmers for ecological and social services (Lunn-Rockliffe et al. 2020). Socio-economic and institutional factors are more influential in increasing food security; 'Strengthening the resilience of individual/household food access is of essential importance for ensuring food security' (Luan et. al., 2019:723; Dawson, 2016)

Environmental impacts and the sustainability of ecological systems should be considered when increasing productivity of land (Luan et. al., 2019). Understanding whether smallholder farmers see the need for increased yields is also key when determining future actions to address food insecurity. Hybrid technologies and other technological developments ignore the interests and needs of smallholder farmers, hence the need for change in the political and economic agenda, so that newly-developed technologies are not depoliticised and can benefit smallholder farming according to their context and practices (Fischer, 2016; Dawson, 2016; Lunn-Rockliffe et al. 2020). In response to the dispossession of their lands by larger, more resourceful farms, the degradation of soil and the loss of agrobiodiversity, smallholder farmers shifted their focus towards agroecology. This allows them to salvage their soils with natural fertilizers, save water and implement other practices that were abandoned in the Green Revolution agenda (Holt-Giménez and Altieri 2013).

2.3 Agroecology

The development of agroecology stems from traditional agriculture where cultural and ecological practices are rooted in the ways of the smallholder farming agroecosystem (Holt-Giménez and Altieri 2013). NGOs have worked with both practices to promote activities surrounding agroecology but have also been caught in the 'follow the money' cycle, where funding for their projects and research is directed towards activities that lead to the appropriation of agroecology within the Green Revolution agenda (Holt-Giménez and Altieri 2013:97). Recently, there have been calls by members of organic farming communities and ecologists for NGOs to shift their focus and start to help farm-led political organisations.

The potential of agroecology has been recognised by some governments and universities; ecologists argue for a fusion between Green Revolution practices and the technical aspects of agroecology (Holt-Giménez and Altieri 2013). However, the funding allocated to agroecology practices is not enough to mobilize and scale up this movement, as has been done for the New Green Revolution. Practices such as agroecology and organic techniques 'are options that address the main constraints to food and nutrition security as well as food sovereignty issues' (Herren and Hilmi, 2011). For these options to be explored successfully and efficiently, information and resources within agricultural knowledge, science and technology need to be directed towards advancing the aforementioned practices. Political actors are major players in the effort of scaling up agroecology development. Holt-Giménez and Altieri (2013:95) not only emphasise the need for 'extensive on-the-ground agroecological practice', but also the involvement of political will to resist any undermining of the power of agroecology when parts of it are incorporated into the new African Green Revolution agenda.

A political shift can help fuel research and development towards a model of agriculture that will encourage 'diversifying farms and farming landscapes, replacing chemical inputs, optimizing biodiversity, and stimulating interactions between different species' (The IPES 2017:3); all of these practices will help to create long-term solutions in the fight for food sovereignty and a sustainable way of diversifying agroecological systems. In addition to this, significant evidence suggests that agroecological practices can be as productive as industrial agriculture, all whilst building greater resiliency to the harsh effects of climate change, helping to diversify diets and combat malnutrition (Altieri et al. 2015; IPES 2016, 2017).

The first Green Revolution required resources to be mobilised from several institutions across both private and public sectors; agroecology requires similar interventions and efforts, but it is argued that scaling up this practice presents many challenges (Holt-Giménez and Altieri 2013;

Lunn-Rockliffe et al. 2020). This argument goes against the evidence that shows smallholder farming to be increasingly resilient and productive when investment is provided (Badgley et al. 2009). Arguments made for the exploration of agroecology have been supported if they do not interfere with the Green Revolution.

Nevertheless, the enhancement of agroecological practices has been highlighted as the ideal alternative to help transform agricultural systems where they can help to sustain global food supplies through climate change and pandemics, such as COVID-19 (Altieri and Nicholls, 2020). The transformation towards sustainable agriculture depends on a new body of knowledge that can be found through informal smallholder farmer knowledge systems (Šūmane et al. 2018). These local, context-based knowledge systems attempt to fill the gap of generalised agricultural knowledge used to boost global food production. Three key ways of knowledge generation in smallholder farmer community found by Šūmane et al. (2018) were combining experiences and information from different sources, networking between them and institutions, and co-generating knowledge with experts.

However, there are numerous benefits to advancing agroecology practices for increased smallholder resilience in relation to climate change (Altieri et al. in 2015). The practices and measures that the authors emphasise as providing the most 'durable benefits' are 'diversification of agroecosystems in the form of polycultures, agroforestry systems, and crop-livestock mixed systems accompanied by organic soil management, water conservation and harvesting, and general enhancement of agrobiodiversity' (Altieri et al., 2015:869). This study presents these methods as signs of the resilience of smallholder farmers when faced with crisis; radical agroecological change is suggested as a key player when developing strategies to resist the impact of climatic extremes. For agroecological strategies to be effective, they need to be identified and understood by the dominant agroecological systems and other global agriculture institutions, thus providing long-term solutions for farming adaptation (Altieri et al., 2015).

2.4 Conclusion

This chapter has outlined the serious challenges within agriculture in Africa and described attempts to mitigate these challenges. In addition to the undernourished population, Sub-Saharan African countries have been facing issues within agriculture due to climate change, conflict, and economic uncertainties. Whilst these issues exacerbate the current situation, there is evidence that the agricultural community shows resilience when faced with these challenges and works towards adapting to them (Davies and Moore, 2016; Badgley et al. 2009). Responses to challenges are, however, highly complex and diverse. As seen above, the Green Revolution was developed in Asia to mitigate food insecurity issues and is seen as a next step for African smallholder farmers. The Green Revolution succeeded in increasing yields and lifting many communities out of poverty in Asia. However, the critiques that follow the efforts of such a movement shadow argument that claim its unsustainability, alongside a lack of granulated knowledge and understanding of how smallholder farmers were affected in the long run.

There were also suggestions regarding the creation of a more sustainable green revolution where preserving the environment would be a priority. Still, some critics believe that green revolution technologies are not on par with agroecological practices. Agroecology is brought forward as an alternative solution where indigenous knowledge and traditional practices are harnessed to create diversity and resilience, so that smallholder farmers can adapt in their unique way. Either way, there is an overwhelming consensus that urgent change is needed, be it through green revolution technologies and policies or through promotion of agroecology and harnessing of indigenous knowledge. As the next chapter goes on to explore, the need for change is often framed through the prism of innovation.

Chapter 3 – Innovation and Agriculture

3.1 What is Innovation

Innovation is difficult to define given its wide range of applications. Still, many authors have attempted to lay out a concrete definition, for example, Blake and Hanson (2005:681) defines it as 'the novel application of economically valuable knowledge, the creation and exploitation of new ideas'. The word itself originates form the Latin *innovare,* meaning to make something new (Lin, 2006) and within the business world it was initially regarded as a tool for changing a business or service and as a practice that can be learnt (Drucker, 1985). The application of innovation was later developed by scholars who regarded it rather as a process of change that harnesses opportunity for new ideas and transformation (Tidd et al., 1998). Hence, the consensus surrounding innovation is that it relates to the development of new ideas applied in practice, such as technological and administrative knowledge, while also encompassing the innovative potential of processes where new ideas are applied to transform it.

Innovation is widely separated into different categories, usually product, process, organisational and marketing innovation. These surround the technological sphere of what is considered an innovation (Edwards-Schachter, 2018) and are seen as the most common categories for innovation. According to Mohd Zawawi et al. (2016), most authors and scholars tend to focus on technological and administrative innovation as the two main dimensions. The concept of well-established innovation types, however, is challenged by global issues that require more complex application of innovative practices not defined by their technological aspect, raising the need for diverse types of innovation (Edwards-Schachter, 2018).

3.2 Innovation as technology

High levels of research and development around crop genetics and technologies that help to increase productivity of smallholder farmers are seen as the best route for tackling global food insecurity (Hounkonnou et al., 2012; Ouma-Mugabe, 2016). Advances in this area are commonly identified as technological innovation and regarded as the solution for intensifying food production (Hounkonnou et al., 2012; Otsuka and Larson, 2013; Dawson et al., 2016; Francis and van Huis, 2016).

The technology supply push in Sub-Saharan Africa is an example of technological innovation. This approach was based on the success of the Green Revolution in Asia and the increased productivity in many parts of the OECD; it saw the free-flowing transition of information and knowledge between subject specialists, smallholder farmers, and other villagers across most countries in the area (Hounkonnou et al., 2012). The implementation of this approach, however, was too expensive. Technology supply push requires investment that facilitates this transfer of knowledge and technologies to farmers as well as ensuring that they can use this efficiently. Technological scientific knowledge, transferred to farmers within agricultural research, is seen as the necessary innovation for growth in productivity growth, alongside the high return on investment of agricultural development within technological innovation (Hounkonnou et al., 2012; Otsuka and Larson, 2013; Francis and van Huis, 2016). Investors believed that improvements in agricultural production systems, coupled with national and international demand, would benefit both them and farmers. Moreover, Sub-Saharan African population are set on staple crops and not so focused on high-value products. Therefore, improving yields of staple crops will help feed farming and other populations (Otsuka and Larson, 2013).

Participatory technology development (PTD) help engage smallholder farmers, to ensure that technologies are 'appropriate to the context and desired by smallholders, given their circumstances and needs' (Hounkonnou et al., 2012:76). A case study in Kenya found that the knowledge and skills of farmer are advantageous in developing appropriate technologies for their context; however, these technologies need an opportunity to be efficient (Hounkonnou et al., 2012). Additionally, technological changes and advances were not applied in combination with management practices, such as soil and water management, focusing only on the technologies surrounding seeds and chemical fertilizer, therefore, leading to the failure of an attempted Green Revolution in Sub-Saharan Africa. (Francis and van Huis, 2016; Otsuka and Muraoka, 2017). Transferring technologies from other countries, such as South Africa and Asia, proved difficult as these models were more suited to larger commercial farmers and consequently brought complications regarding different location specificities. Therefore, research into the specific context where there is need of food productivity increase is fundamental for the implementation of maize technologies with high yields and low management costs. Context and geographies are important within innovation thus, in neglecting a region's context and focusing predominantly on the technological aspect, the concept of innovation is lost because it is not seen and understood as influential and innovative under current characterisation of innovation (Blake and Hanson, 2005; Hounkonnou et al., 2012; Otsuka and Muraoka, 2017).

It is claimed that farmers will make use of profitable technologies if they are made available to them (Otsuka and Muraoka, 2017). However, this argument is based on a study made in 1964 (Schultz, 1964) with outdated results. The study continues to argue that theories of technological innovation from 1985 (Hayami and Ruttan, 1985) help institutions to adapt to innovations and aid by developing and disseminating them further. In the highlands in Kenya, farmers use their own ideas and techniques to improve yields. Whilst this can be harnessed to boost green revolution, it is management intensive (Otsuka and Muraoka, 2017). Still, it is argued that even with technology that 'is adjusted to the specific agro-ecological conditions', return on investments are restricted by low adaptation to these technologies by the farmers (Iskandar and Gatzweiler, 2016:94). A pathway to ensure this is suggested by Iskandar and Gatzweiler (2016:94): 'Improving the institutional infrastructure and reducing transaction costs by improving education and information and securing property rights would decrease societal depreciation, improve absorption capacities and make investments in technological innovations economically worthwhile.'

Technological innovation can also be considered as the combination of knowledge passed on by older generations with newer ideas and knowledge. This breaks down the conflict between technological advances and traditional knowledge. (Juma, C., 2015a; Lunn-Rockliffe et al. 2020). Other institutions also benefit from ICT in Africa when information on actions in the Global South can reach other parts of the world. This knowledge dispersal greatly impacts research that will in turn help to build collaborations between countries (Juma, C., 2015a). Agricultural productivity is positively correlated with sustained research and development investments in Africa. Data on the specific agricultural challenges in Sub-Saharan Africa is currently not at the level it should be given its agricultural potential; advancements in quantitative data collection and accessibility would help provide location and context-specific solutions (Juma, C., 2015a; Šūmane et al. 2018). Gro Intelligence, a company from Kenya, attempts to address this challenge by developing a platform for data on agriculture, which includes analysis, socio-political and regulatory information (Juma, C., 2015a). This form of technological innovation increases understanding of the agricultural sector in Africa which can lead to substantial economic development due to Sub-Saharan countries' economies' high reliance on farming. An interesting question, however, is to what extent these technologies stretch towards smallholder farmers, rather than focussing solely on larger, wealthier farmers with higher accessibility to the data collecting technology?

Technology innovation in the Sub-Saharan African agricultural also includes communication and digital farmers as well as how they interact with each other. In addition to government support, private companies such as IBM and Google have recently been investing in information and communication technology in Kenya (Baumüller, 2016). Scholars argue Sub-Saharan African countries have great potential for growth within innovation platforms such as ICT and geographic information systems (GIS) (Juma, C., 2015a); Kenya is at the forefront of innovation growth, and this is benefiting all levels of the population. Within agriculture, the technological benefits lie in facilitating communication amongst the rural community - between farmers and by connecting their services to other third-party stakeholders through platform such as M-Farm and iCow (Baumüller, 2016). This easier access to information and knowledge is incredibly beneficial for farmers as they can get immediate answers to questions relating to food process and market inputs and outputs (Baumüller, 2016).

Despite over 80% of Sub-Saharan African population having access to mobile phones with reception, technological developments such as mobile phone services in farming have limited practical application and most are in trial/pilot phase. Additionally, many farmers prefer more traditional channels for information, such as the radio (Baumüller, 2016). Thus, mobile technology effectiveness and extent to which it can provide solution to smallholder farming have not yet been confirmed.

3.3 Innovation as a process

As mentioned earlier in this chapter, innovation can take the form of process where it focusses on the approaches taken to integrate new ideas and services into an environment (Najafi-Tavani et al., 2018). Process innovation surrounds collaborative capabilities of all levels of a network where they are innovated and this subsequently leads to improved performance of a given product or service (Najafi-Tavani et al., 2018). Innovation process in agriculture involves the actors that contribute to tackling issues such as climate change and population growth, but without the focus on actual product innovation, such as hybrid seeds. Rather, the collaborative network and systems that can help increase productivity and soil fertility sustainably and in the long-term are developed (Francis and van Huis, 2016). Francis and van Huis (2016) describes this focus shift as Innovation Systems (IS).

Innovation Systems originated in Japan in a 1987 study and embraced African agriculture in the early 2000s (Ouma-Mugabe, 2016). The impacts of IS remain unclear as it has only recently been explored by scholars, specially within the smallholder agricultural domain. The shift from a technology focus during the first Green Revolution in Asia to one of process and system innovation is gaining momentum and bring notable changes to research and development for agriculture (Francis and van Huis, 2016; Ouma-Mugabe, 2016) The increasingly 'interactive innovation model' (Francis and van Huis, 2016:9) presents valuable tools when exploring knowledge and information in agriculture, creating a clearer picture of the possible impacts of this type of innovation. Smallholder farmers are 'essentially entrepreneurs, operating a 'business' in a competitive environment' (Francis and van Huis, 2016:10) and therefore the application of Innovation Systems in analysing competitive advantage and economic growth is relevant. IS are now becoming widely regarded as the 'main source of knowledge or drivers of technological change' within agriculture. Therefore, there is the need for further empirical explorations of its effects on smallholder farming innovations (Francis and van Huis, 2016:10).

Due to interest in IS being relatively recent and with limited application, attempts from different disciplines have been made to understand the implications of such an innovation model (Francis and van Huis, 2016; Ouma-Mugabe, 2016). The Convergence of Sciences: Strengthening Innovation Systems (CoS-SIS) Program, for example, is put forward as an Innovation Platform (IP) to help with institutional change (Hounkonnou et al., 2012). Innovation Platforms 'takes as its point of departure the SI insight that innovation takes place in networks of actors' (Jacob, 2016:15). Through this approach, Hounkonnou et al., (2012) was able to identify the failures of direct science-based technological changes introduced in smallholder farming. The Cocoa Research Institute Ghana (CRIG) case study showed farmers had only made use of 3% of technology offered. The result of the technological change in providing food to schools were issues such as 'insecurity of land tenure; lack of infrastructure; uncertain markets and variable prices; corruption; lack of farmer organizations that can defend farmers' interests; probability that other people (including state officials) will cream off profits' (Hounkonnou et al., 2012:79). These challenges surpass the reach of solutions proposed by technological innovation, calling for deeper institutional change.

Innovation Platforms embrace institutional innovation as the system 'implies a whole that is more than the sum of its parts, i.e., the system emerges through synergy' (Francis and van Huis (2016:12). Thus, Innovation Systems will not reach its full innovative capacity if there is no movement for institutional change. Focusing on changing institutions relates to the importance of contextual understanding and the role of informal institutions, which are largely present within smallholder farming (Hounkonnou et al., 2012). Emphasising the importance of context within institutional innovation in research for development will greatly improve the opportunities for smallholder farmers, as it will help to identify the key actors within their innovation systems and platforms (Hounkonnou et al., 2012; Iskandar and Gatzweiler, 2016; Hounkonnou et al., 2018; Šūmane et al. 2018; Lunn-Rockliffe et al. 2020). This allows for not only efficient decision-making and problem-solving aimed at tackling the most pressing issues for smallholder farmers, but also all facilitate interaction and collaboration with other stakeholders, such as private companies and governments (Hounkonnou et al., 2012; Ouma-Mugabe, 2016; Hounkonnou et al. 2018).

Stemming from Innovation Systems, Agricultural Innovation Systems (AIS) is a recent approach to agricultural growth innovation that encompasses a network of universities, private companies, governments, and NGOs, as well as other institutions, that focus on capturing global knowledge and later applying this to the needs of local farming communities by developing support mechanisms specific to them (Larsen et al. 2009, Juma, 2015b). AIS does not apply to one type of innovation, but rather incorporates the many forms innovation can take, such as product, technology, partnerships, and marketing, thus capturing the true essence of smallholder farming and the needs of these communities (Larsen et al 2009; Šūmane et al. 2018).

Juma (2015b) emphasises the need for a coalition between institutions that are linked to other areas which contribute to the economy, so that innovation systems can provide dynamic interaction between diverse institutional actors who focus on capturing knowledge and developing learning activities. These can offer more useful support systems to targeted communities, as their level of systemic innovation differs from other communities (Juma, 2015b:86). A case study on innovation in the maize, tomato, and dairy subsectors in Kenya by Šūmane et al. (2018) is evidence that, by using the AIS framework, much can be discovered about the importance of incorporating the participation of other institutions such as the legal and political spheres in innovation. This study focuses on how value chains in the agricultural sector can be targeted by innovation. Value chains for each subsector are different from each other and involve different actors. Therefore, the author concludes that the 'influence of policy on the innovation thus varies over the value chains' (Šūmane et al:131).

Rural communities in Sub-Saharan Africa are diverse and most have shown 'desire for autonomy and food sovereignty' as well as incredibly adaptability to the changing environment due to centuries of development. (Dawson, 2016:215; Davies et al. 2016). Policies that focus on facilitating innovation in the agricultural domain should focus on the numerous ways in which innovation can affect smallholder communities as well as the overall macro-economic benefits of agricultural growth. The case study of imposed innovation in Rwanda presents the scheme as a failure as they ignore the traditional practices of the farmers; 'The identified solutions of crop specialization and application of chemical fertilizers are a polar opposite to the traditional polyculture system prevalent in this region and disrupts local social practice, trade, and labour patterns in addition to farming methods' (Dawson, 2016:215). This is yet another example where knowledge about specific contexts is central when designing policies that aim at promoting innovation, as well as the interlinking of institutions at various levels when following the Agricultural Innovation Systems approach.

3.4 Conclusion

Technological innovations alone are not enough to provide a solution to food insecurity in Africa; innovations must be implemented within other changes such as the institutional advances which surround infrastructure and support programs (Baumüller, 2016; Otsuka and Larson, 2013). Embedding technological innovation within the overall movement for farming change in Sub-Saharan Africa has been widely emphasised by many scholars who conclude that, without the effort from other actors, NGOs, governments and policy, the results to boost technological advances will fall short of what is expected of them. (Hounkonnou et al., 2012; Otsuka, K. and Larson, D., 2013; Baumüller, 2016; Gatzweiler, F.W., 2016; Lunn-Rockliffe et al. 2020).

Process innovation allows for more synthesised efforts between innovation systems where it emphasises how all actors of innovation present their contribution to the solutions. Centring smallholder farmers as key actors in Agricultural Innovation Systems captures specific contextual intricacies of their farming practices suggesting more appropriate development of innovation, benefiting smallholder communities' overall prosperity. Focusing on the human aspect of innovation and how the experience and knowledge of farmers should be present throughout the decision-making process of innovative advances helps to drive further understanding of smallholder ways of living, thus suggesting meaningful impact on farming practices from inclusive innovation mechanisms.

Chapter 4 – Methodology and Data Analysis

4.1 Introduction

The purpose of this chapter is to introduce the research design, empirical case, present and analyse of the data for this study. The aim for this research is to identify how small holder farmers in Elgeyo Marakwet County, northwest Kenya, are the drivers and producers of innovation for agricultural methods, and how we may harness these processes in collaboration with other institutions to promote sustainable intensification of agriculture.

The research for this dissertation is twofold; a compilation of data and identification of common themes from secondary data sets and a follow up through qualitative interviews. The use of a mixed-method approach is to create well-rounded and comprehensive results where most aspects of the complexities of farming practices, found in secondary data, are captured, and later further explored to understand the reasons behind the decisions made by the farmers. Therefore, this study follows an inductive research approach where the collection of empirical data is used to generate a theory.

A constructivist approach is adopted for this dissertation where human knowledge is believed to be constructed though external influences relative to specific contexts such as society and culture (Bryman and Bell, 2018). Thus, assuming practices of smallholder farming communities adapt, and change given the external environment and their interactions with others and not based on phenomena beyond their reach. In this study, the ontological consideration is applied to an explanatory mixed- method research design where quantitative data results present a need for further clarification that are then acquired through primary qualitative data collection. (Bryman and Bell, 2018). An interpretivist epistemological perspective is followed as this research focuses on understanding farming innovation practices on a deeper level where it has been overlooked due to lack of in-depth research and limited interpretive scope by other institutions.

4.2 Empirical case for farming innovation in Marakwet

Population growth and current undernourishment issues worsen SSA countries' vulnerability to climate change thus the need to enhance and secure food production (Carabine et al. 2014). External technological advances such as genetically modified innovations have pushed for unsustainable industrial production process and ignore the complexities of local smallholder farming and politics of the areas (Rhodes 2017). Smallholder farming accounts for most of the food production in Kenya (75% (AGRA 2018) therefore, exploring the capabilities of these farmers as actors within innovation systems is essential when working towards tackling the negative impacts from climate change (Dolinska and d'Aquino, 2016).

The main rationale for this study stems from the notion that African smallholder farmers have inherent capacities to innovate through the combination of old and new practices and ideas, including technologies, and can explore these skills to address issues of food insecurity and the effects of climate change within the community of smallholder farming and beyond (Davies et al. 2016). As seen in the chapters above, previous exploration of smallholder practices through methods such as ethnographic research, present the long-term benefits and sustainability of traditional agroecological practices as well as emphasise their productivity when met with challenges (Davies, 2015; Davies et al. 2016). The gap in the literature surrounding research towards understanding traditional smallholder farming practice is the lack of exploration and understanding of the diversity of these cropping practices and how the farmers perceive innovation based on their own capacities as innovators to maintain their practices sustainable.

This study aims to reveal the many complexities of smallholder farming practices in the Elgeyo-Marakwet county in Kenya and present these unique methods and changes to explore the extent in which smallholder farmer use these changes as innovation and further identify what can be done to support these actions. Additionally, we aim to explore the knowledge gaps on the complex and sophisticated dynamics of smallholder farming in Elgeyo-Marakwet county and their capacity to be key actors in agroecological innovation.

The main research question developed for this study is:

- How can we understand and support processes of smallholder innovation in Elgeyo Marakwet County as the foundation for co-designing regenerative and inclusive food systems?

Following this, sub questions were developed to help answer the above RQ:

- What are the impacts of a potential new African Green Revolution on small holder farmers in Elgeyo Marakwet?
- How is innovation conventionally understood within the agricultural sector (i.e., Agricultural Innovation Systems) and what is the role of the smallholder in this?
- How is innovation perceived and performed by small holder farmers?

4.3 Data Collection

4.3.1 Secondary Data

A collection of five data sets from previous research led by UCL's Institute for Global Prosperity's PROCOL (Prosperity Co-Lab) Kenya team is used as secondary data, most of which is currently unpublished, along with data from institutions such as the FAO (Food and Agriculture Organization of the United Nations) and the Kenyan Government (Kenya Agri Census Data). PROCOL Kenya is a collaborative research programme that explores pathways to prosperity in Africa (PROCOL Kenya, 2020). Table 1 below contains a summary of each data set used.

Data Set	***Time, Place***	***Method***	***Aim***
Notebook (NTBK)	2011/2012, Tot, EMC	GPS mapping and interviews	Focuses on farmer resiliency, irrigation schemes and mapping of agricultural landscapes to capture diversity and fluidity of irrigation systems
Canadian Red Cross Notebook (RC NTBK)	2014/2015, Tot-Sibou, EMC	GPS mapping, digital photography, and interviews	Document impacts of RC irrigation scheme and how farmers responded to the initiative
IAPS	2019, Tot and Iten, EMC	Sapelli smartphone data collection application	Harness small-holder farmer's capacities through a Citizen Scientist Approach; looking at cultivation, challenges, and diversity within an annual cultivation cycle
IGP MSc Global Prosperity Dissertation	2019, Iten, EMC	Interviews and Mapping of farms	Explores how smallholder farmers adapt their practices to change, their climate change perception, and how innovation in farming is applied
Prosperity and Innovation in the Past and Future of Agriculture in Eastern Africa (PIPFA)	2020, Embobut Forest, Iten, and Tot, EMC	Interviews	Explore and capture farming practices across different locations and farmers from a variety of backgrounds
Plant Biodiversity	Elgeyo-Marakwet County	Focus Group Discussions	Record diversity of flora in the valley and its various uses
FAO Kenya Agriculture Statistics	2018, Kenya	Questionnaires	Systematically collect data and report it the international community
Kenya Agri Census Data	2019, Kenya	-	Collect data on agricultural activities and "provide basic structural data and sampling frames for agricultural surveys" (Tradingeconomics.com, 2021)

Table 1: Summary of each data set

The complied data sets include quantified interview responses and previous quantitative results. Patterns were identified across the data sets where they were defined into themes for detailed analysis. Other secondary data from the FAO and the Kenya Agri Census were used to portray the different scales of information and data found on food production and farming practices across Africa. The final themes are presented below, Table 2, along with what data sets in which they are present in.

	Themes	*Data sets*
1	Scales	FAO, KAC 2019, Diss 2019 (Maps), Plant Biodiversity
2	Crop diveristy and on-farm biodiversity	Diss 2019, IAPS 2019, PIPFA 2020, NTBK 2012, RC NTBK 2015.
3	Issues/Challenges	Diss 2019, RC NTBK 2015, IAPS 2019, PIPFA 2020.
4	Practices and innovations	Diss 2019, RC NTBK 2015, PIPFA 2020
5	Knowledge networks	Diss 2019, PIPFA 2020

Table 2: Data sets separated into themes

Theme 1 presents data that depicts a general scenario of agricultural issues and crop diversity, and a more focused look illustrating the intricacies of the reality of smallholder farming communities in the EMC. Theme 2 focuses on the diversity of crops and on farm biodiversity where it was present in all PROCOL Kenya data sets. Theme 3 brings forward the issues and challenges smallholder farmers face both due to climate change and external interventions. Theme 4 looks at farmer's responses to these challenges and practice changes implemented to maintain a good level of production. Finally, theme 5 looks at the knowledge networks farmers access and trust for information on what new practices and trends they should be up to date with.

4.3.2 Primary Data

Primary data was collected through a qualitative approach where semi-structured in-depth interviews were conducted with farmers to gain a deeper understanding of their changes in farming activities and innovation practices based on what is observed in the quantitative results. The aim of this method is to explore in more detail the 'how's and 'why's of the decision-making process given the many environmental changes that smallholder farmers are currently facing. To access these farmers, PROCOL Kenya Citizen Scientists Mr Timothy Kipkeu Kipruto and Mr Andrew Kibet Yano were asked to participate in the data collection, sampling method, and logistical aspects of the study, consistent with previous projects by the research programme.

<u>4.3.2.1 Sampling</u>

After consulting with the Citizen Scientists, a group of 7 farmers were chosen to participate in this study. Mr Kipruto used purposive sampling method by choosing participants they believed were more involved in innovative practices, which is interesting in itself as their own perception of innovation was the main reason for selecting the candidates, that varied in experience and age so that there was good rage of ideas and reasoning throughout the responses. The diversity in candidates' experiences and knowledge acquisition allows for well-rounded answers with limited skewing of results.

4.3.2.2 Data Collection and Coding

The interviews were conducted through WhatsApp Facetime Call and recorded through Voice Memos on a laptop. Oral consent for recording was obtained for each candidate and anonymity of names was guaranteed. A sample of the interview questions and an example of a cleaned transcribed interview (not verbatim) can be found in Appendix A and B respectively. Results were coded according to themes established for the secondary data. New themes were also identified and later explored in theme 6 in the Data Analysis section. The participants are farmers from the farmlands surrounding the town of Iten, in the Elgeyo-Marakwet county, seen in Figure 1 below. Table 3 presents basic demographics and information of the participants.

Participant No.	***Age***	***How long they have been farming***	***Where they learnt how to farm***	***How they acquired land***	***Code***
1	43	26 years	Learnt by assisting parents and learnt in school	He bought his land and farms in communal lands	P1_43
2	40	21 years	School, is an agronomist	Bought from parents	P2_40
3	34	12 years	Learnt from parents, started farming from a young boy	Parent's land	P3_34
4	30	5 years	Learnt from agriculture college	Inherited and occasionally hires from friends	P4_30
5	25	6 years	Learnt from parents	Parent's land	P5_25
6	65	42 years	Trained in agriculture institute	Bought it	P6_65
7	54	Over 25 years	Went to farming training centre, vocational training centre	Inherited	P7_54

Table 3: Participant demographic and further information

Map of Area of Study

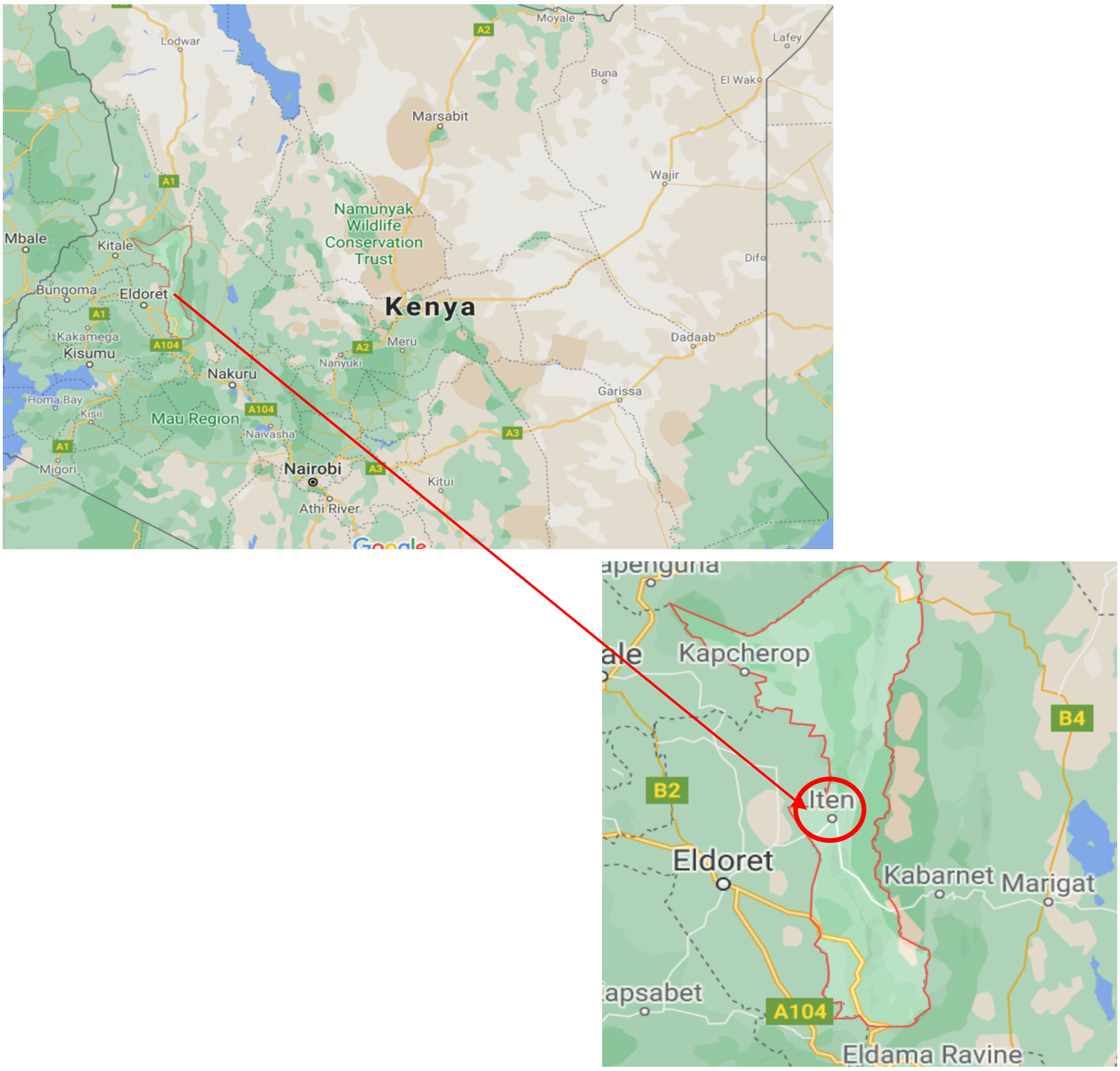


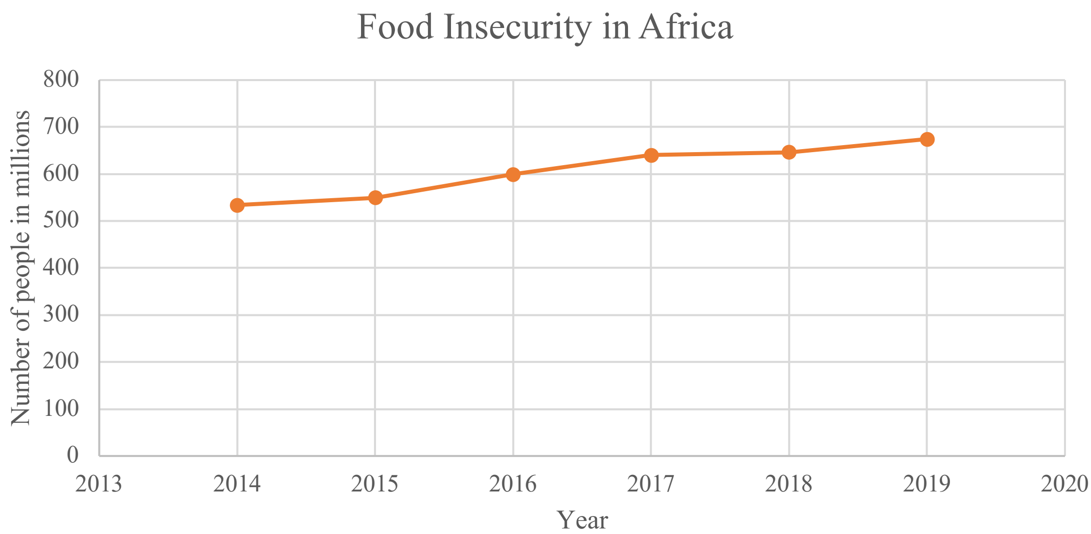
Figure 1: Elgeyo-Marakwet county's location in Kenya and Iten

4.4 Data Analysis

The following section will present the findings from secondary quantitative and primary qualitative data collected. Starting with quantitative data, each theme will be explored in detail and later expanded upon by the qualitative findings apart from the Scales theme as the data for this was all secondary. Findings from the qualitative interviews that do not fit within the set themes are analysed in theme 6 and later discussed in the Chapter 5.

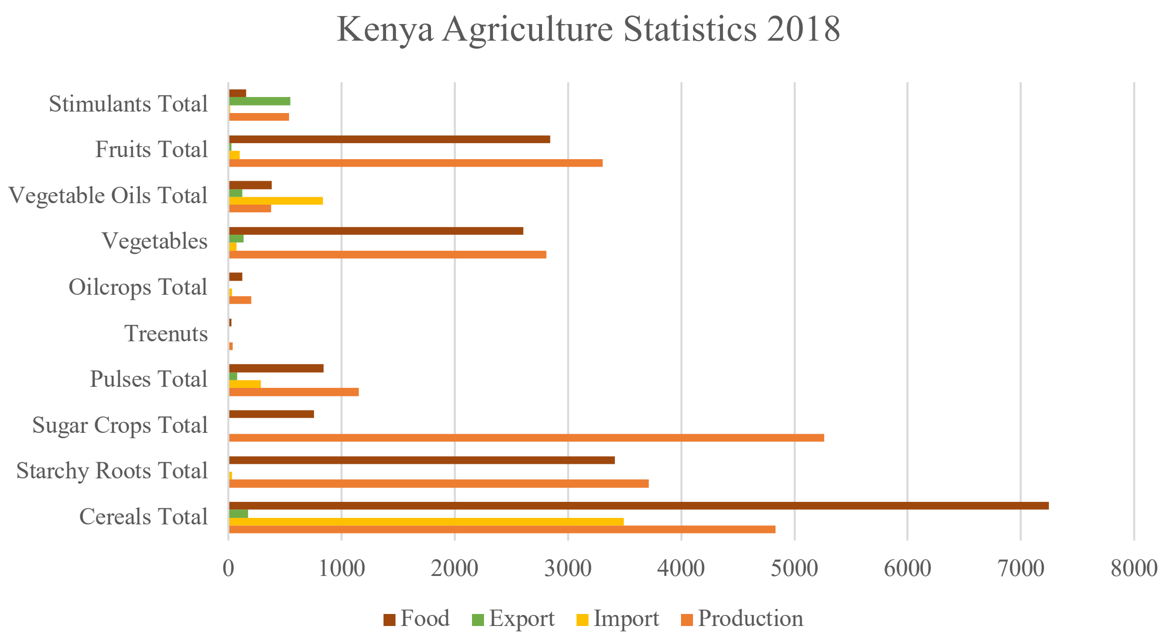
4.4.1 Theme 1 - Scales

The scales of data available on African agricultural domain was chosen as the first theme as it sets the scene to the following themes presented below. The different scales depicting how SSA agriculture is represented to the international community say much about how the continent is perceived regarding its agricultural capabilities.



Graph 1: Food insecurity in Africa between 2015 and 2019

Graph 1 shows just over a 25% increase in the food insecurity in Africa within 5 years. This suggests 674.5 million people do not have access to sufficient nutritious food. Graph 2 below shows a closer look at the categories of food in Kenya and the amounts that serve different purposes. The original data set is much larger but for the purpose of this analysis, there is an emphasis on production, imports, exports, and how much of it is consumed as food.



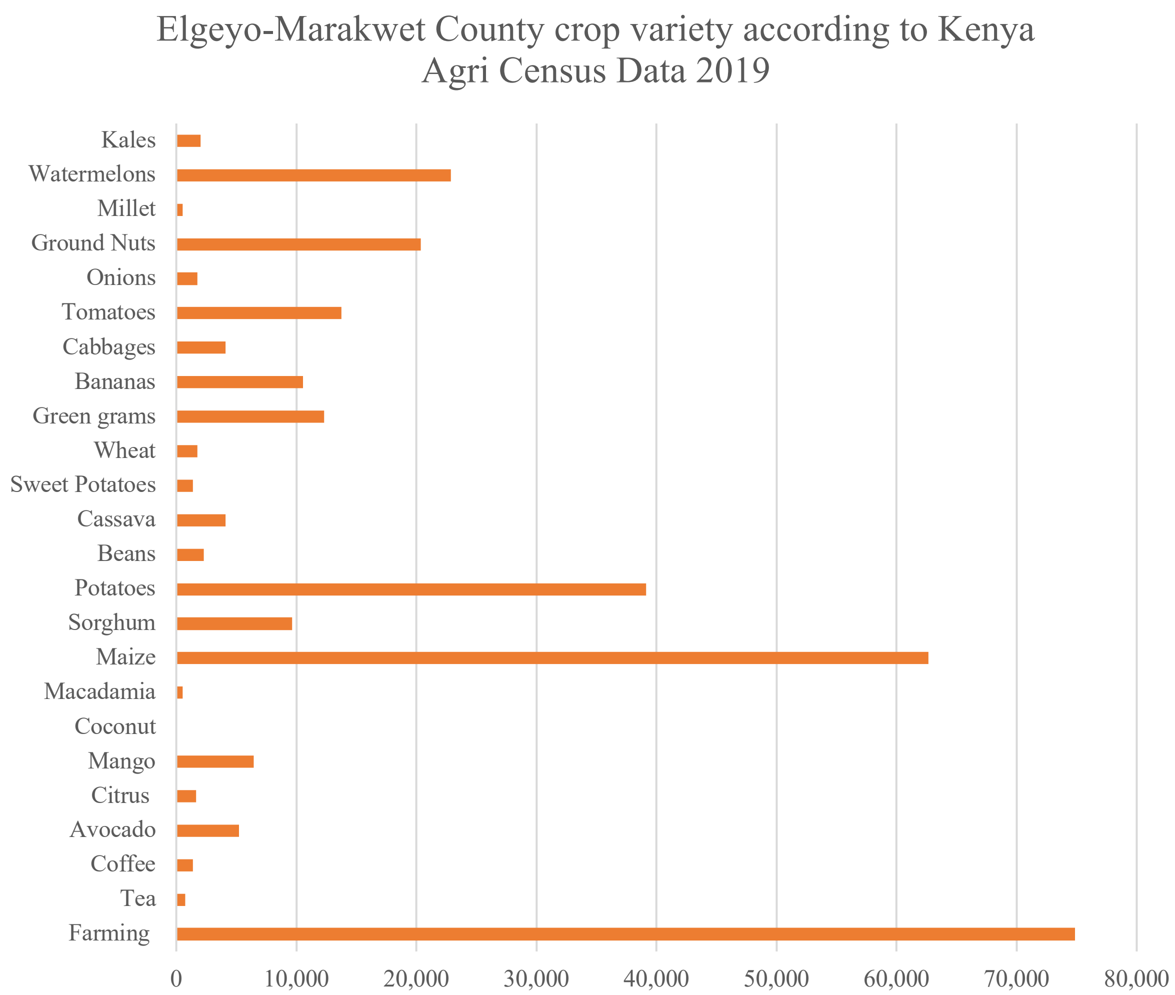
Graph 2: Production, imports, exports, and food amounts, FAO Kenya Agricultural Statistics 2018

It is clear that a small amount of food products is exported from Kenya, and are mostly produced domestically, with the exception of cereals, pulses, and vegetable oils being partly imported (3495 thousand tonnes, 228 thousand tonnes, 836 thousand tonnes, respectively). Overall, the highest production rates are from cereals, starchy roots, sugar crops, fruits, and vegetables. This suggests that there is not a primary focus on cereal crops in Kenya, fruits and vegetables are also produced in high quantities (3306 thousand tonnes and 2807 thousand tonnes, respectively). However, even though there are high levels of domestic production of cereal foods, there is also a high rate of cereal import where 4833 thousand tonnes are produced, and an extra 3495 thousand tonnes are bought in from outside Kenya. In relation to food consumption, most of what is produced is then consumed by the Kenyan population suggesting a healthy market flow of produce.

Table 4 below hones further into the reality of agriculture within Kenya showing the practices of individual households in EMC. The numbers suggest that most households practice some form of agriculture but a small number of them irrigate their productive land.

	Total	***Farming***	***Crop production***	***Livestock***	***Aquaculture***	***Fishing***	***Irrigation***
EMC	99,861	74,881	71,084	54,322	280	340	8,383
Keiyo North	21,947	15,190	14,339	10,582	29	58	809
Keiyo South	27,029	21,518	20,441	16,550	113	115	1,074
Marakwet East	21,362	15,779	14,723	11,044	36	69	4,250
Marakwet West	29,523	22,394	21,581	16,146	102	98	2,250

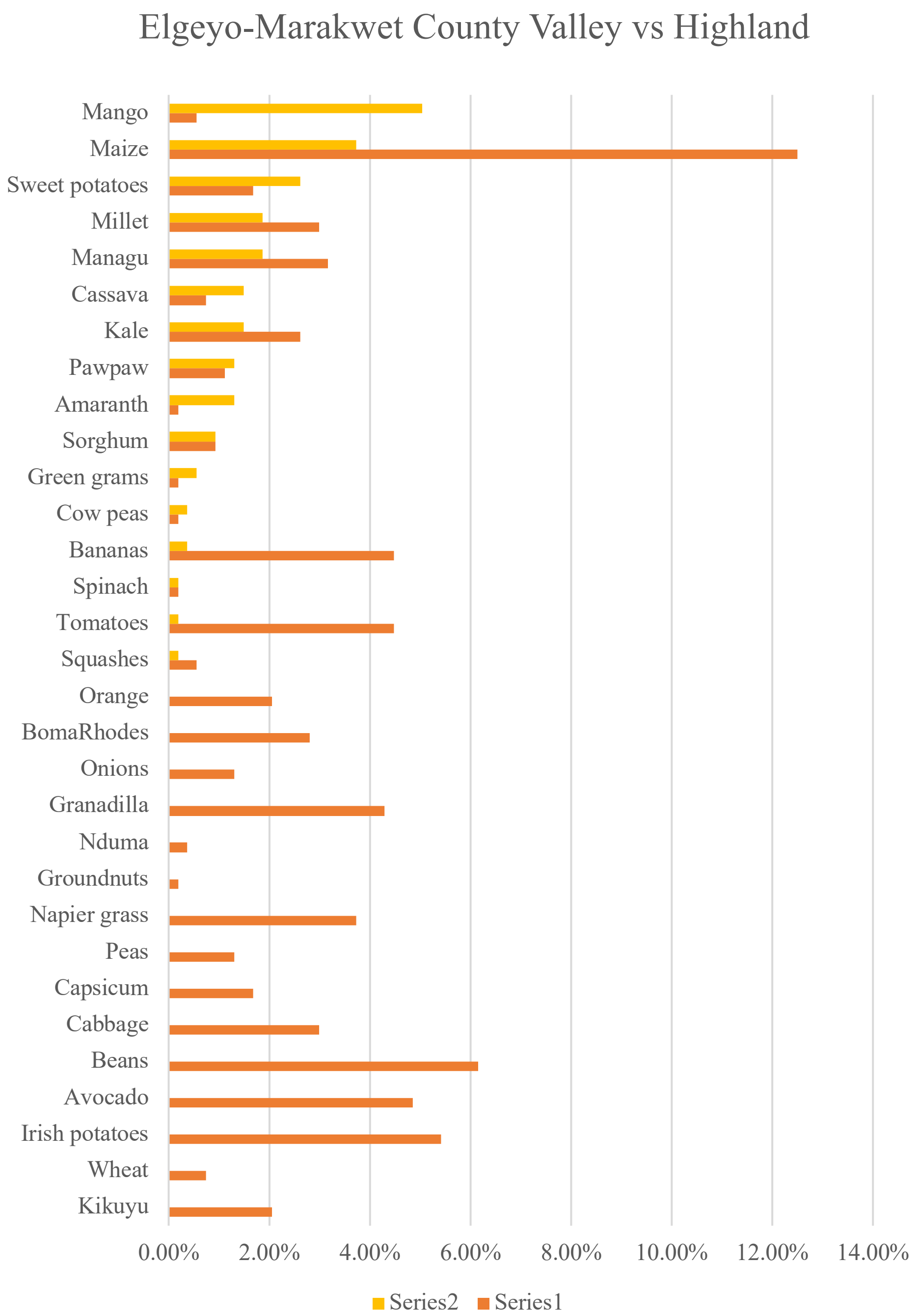
Table 4: Practices of individual households in the Elgeyo-Marakwet County (EMC), Kenya Agri Census data 2019



Graph 3: Elgeyo-Marakwet County crop variety, Kenya Agri Census Data 2019

On a larger scale compared to Graph 2, the Graph 3 sets out the variety of crops planted by farmers and households in the EMC. As expected, maize and starchy roots such as potatoes are seen as the most predominant crop types in the farms (62,633 recordings of maize and 39,126 of potatoes). Other crops such as watermelon and green grams (type of bean) are also widely planted. The key information observed on this graph is the diverse variety of main crops recorded in one county in Kenya reflecting the diversity of food production in the area.

Graph 4 demonstrates how the variety of crops differs within EMC due to the different weather patterns and soil in the highlands compared to the valley area. Crops that do well in the highland areas, such as mango, are not as prominent in the valley (5% in highland and 0.6% valley). Kale and Pawpaw are part of the minority of crops that are farmed at similar amounts in both environments. These results show that there is no one crop that is suitable for both areas.



Graph 4: Elgeyo-Marakwet County valley vs highland crop variety

Finally, Figures 2 and 3 represent the layout of crops in two farms in Iten. These show how each individual farmer has their unique way of farming and decide on what crops to plant given their shamba size and crop preference. Both farms have grass and trees spread across which also shows that not all the land is used for food crops.

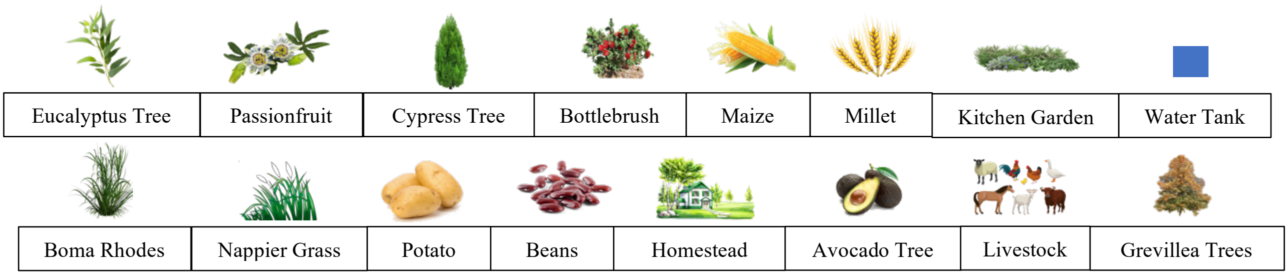


Figure 2: Key

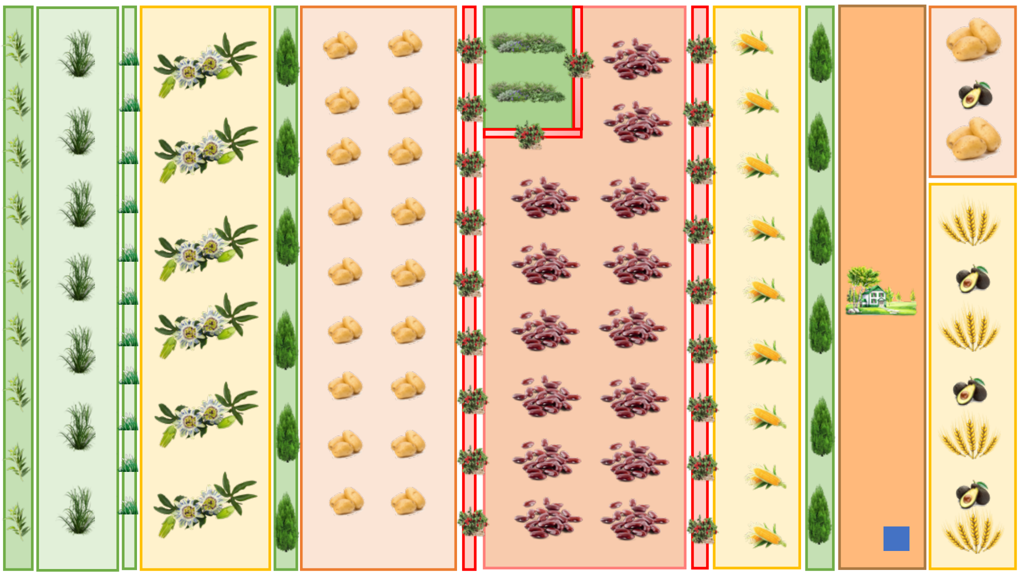


Figure 3: Farm 1 in Iten, IGP MSc Global Prosperity Dissertation

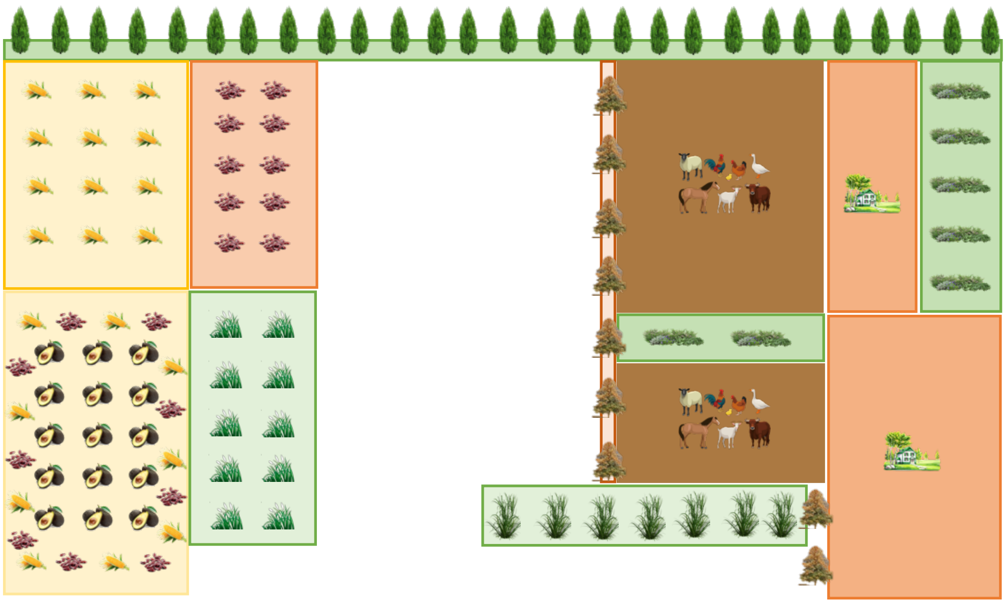


Figure 4: Farm 2 in Iten, IGP MSc Global Prosperity Dissertation

4.4.1.1 Conclusion

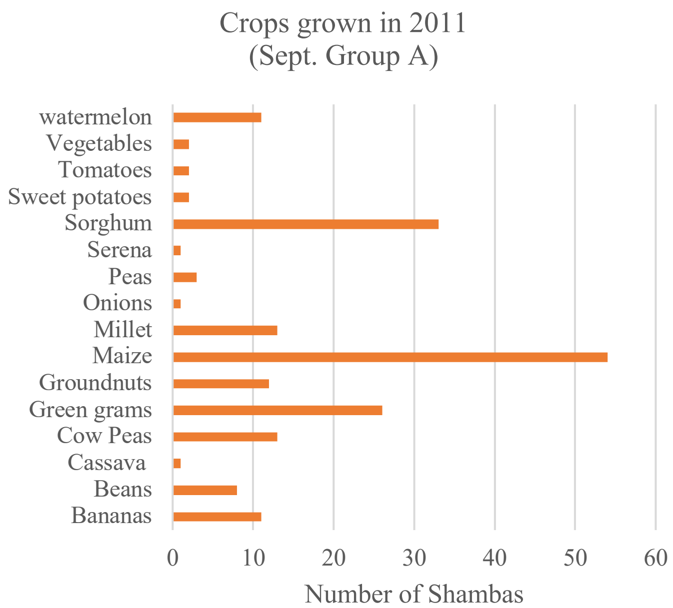
Overall, the scales depict different snapshots of the agricultural scene in Kenya and show that a more focused research scope and area allow for more information on the diversity of crops. Suggesting that conclusions about what should be done to mitigate food insecurity in Africa should not be generalised as different areas require distinct action plans. An overview is ideal as a starting point however, it does not present a realistic picture of the farming practices.

4.4.2 Theme 2 - Crop Diversity and In-Farm Biodiversity

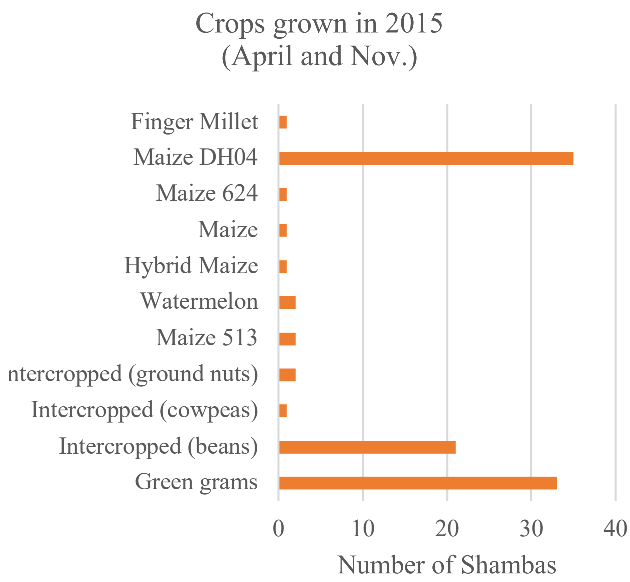
4.4.2.1 Secondary Quantitative Data

Theme 2 explores crop diversity in the EMC farms in more detail and shows the incredible biodiversity within the farms. The data presented in this section was collected between 2011 and 2020, by the IGP PROCOL Kenya Team. The data sets followed varying data collection methods however, the aim remained consistent throughout the years.

Graphs 5 and 6 below show crop variety in the town of Tot in 2011 and 2015. This data represents crops cultivated in different seasons therefore, there variation in crops is expected. For both seasons maize, green grams (bean), and sorghum (cereal crop) are presented as the most abundant food crop farmed. Data from the 2015 RC NTBK goes on to show the different types of maize that farmers use suggesting Maize DH04 as the most popular choice.



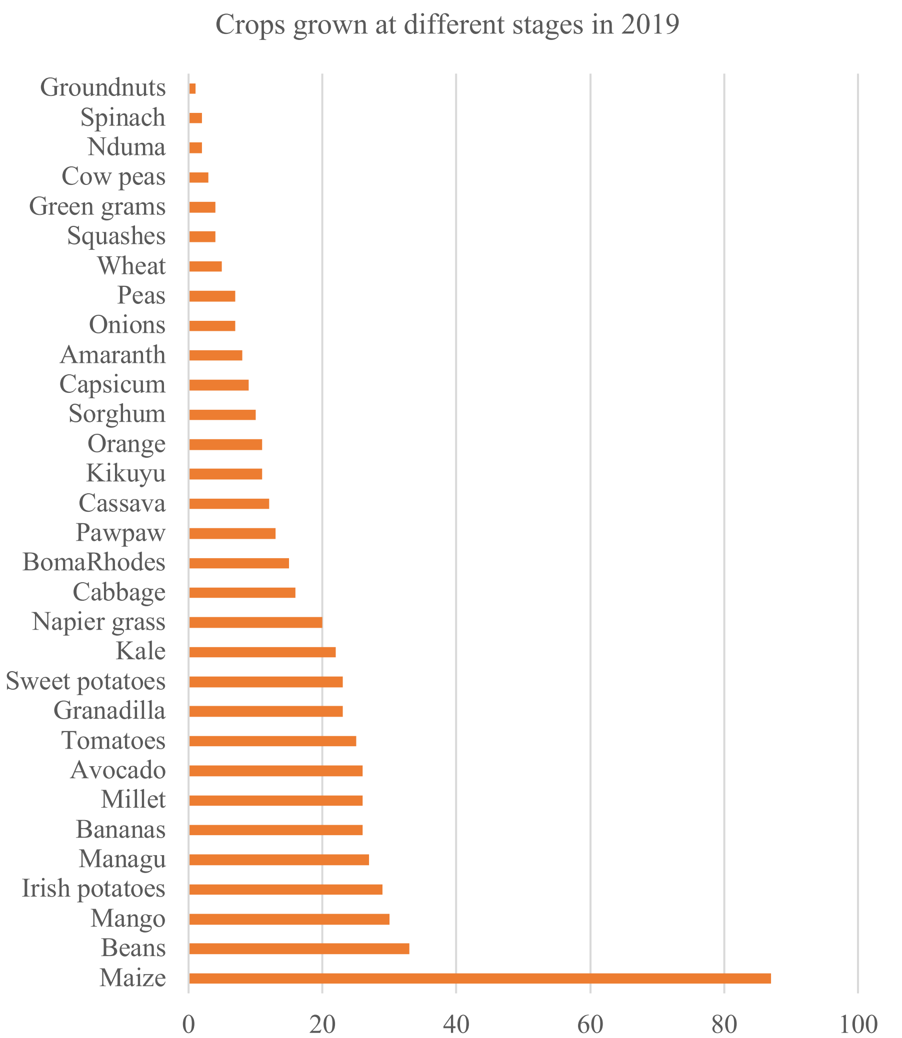
Graph 5: Crops grown in 2011 in EMC, NTBK 2012



Graph 6: Crops grown in 2015 in EMC, RC NTBK 2015

Similar patterns were found in the data from the IAPS 2019 research, presented in Graph 7, where maize and beans continue to be found in most farms surrounding Tot however, sorghum appears to be less present in the shambas. The high number of shambas that maize (87 shambas) and beans (33 shambas) are farmed in, however, does not represent a high quantity of crop produced, it simply reflects that most farmers and households include these foods in their practice. This is further explored through primary research further into this chapter.

Additionally, Graph 7 shows an increase in fruits and vegetables such as mango (30), banana (26), avocado (26), tomatoes (25) and kale (22). Green grams are significantly lower however, the graph below includes beans as a crop and green grams fall into the category of beans thus indicating that farmers continue cultivating beans, however, might use different variations. This result leads onto the last Table (5) of this section that shows the incredible biodiversity within the farms.



Graph 7: Crops grown in 2019 in EMC, IAPS 2019

	Crop					
	Maize	***Finger millet***	***Sorghum***	***Cassava***	***Banana***	***Bean***
Varieties	Kisimi	Montrich	Kipkanin	Kipsakaram	Black Banana	Wahirimu
	Chebolos	Witwit	Kipkemei	Chebolachurya	Chebareria	Rose coco
	Katumani	Kipkanin	Chepkunur (bending head)	Chebokalomit	Kampala	Nyayo
	DH04	Katau	Serena (red)	Ka glara	Cheborusio	Yellow bean
	5/3	Chepkorit (long finger)	Serena (white)	Kapkirkacha	Mamsab	Black bean
	5/1	Kimuino	Chepkos		Tissue Banana	KAT 56
	5/8	Kiptukonis	Kipokitis (Queen)			
	6/3	Kuluu	Seredo			
	6/2	Kiptukani	Gadam			
		Cherongo	**Mosong**			
		Kiptot				
		Kaptaun				
		Kaprokacha (P224)				

Table 5: Crop diversity in EMC, Plant Biodiversity data set

Table 5 shows that for each type of crop, there are many sub-varieties representing their diversity. From this data, maize has 9 varieties, and types of finger millet go up to 13. Further information on crop diversity across different towns from the PIPFA 2020 data set can be found in Appendix C.

4.4.2.2 Primary Qualitative Data

All 7 participants answered that they cultivate maize in their shambas however, they all also focus on other types of crops. Most of them plant avocados (5) and passionfruit (4) and have stated that these are both high cash crops that are highly valued in the market.

When asked about the reason behind the choice of crops, most (5) farmers made it clear that they prioritized diversification of crops that have good market value. Consumption of nutritious foods was also mentioned by P2_40 where they highlighted it as one the priorities for their family. More specifically, when asked about maize production, 6 participants said they want to reduce maize production. The reasons for this varied but the most common among them was the increasing market price fluctuation and high production cost for low returns. P3_34 and P5_25 stated only planting maize for consumption. The following quote by P7_54 suggests farmers are not concerned with maize yields as much as they are interested in diversifying crops in their shambas as this means increase profits due to higher market value and higher nutritional benefits.

> "I want to reduce maize so I can increase acreage for other crops like potato and avocado. Maize is slow and costly to produce, slow returns. Fluctuating prices. Prices of wheat are like maize too. I want to focus on diversifying".

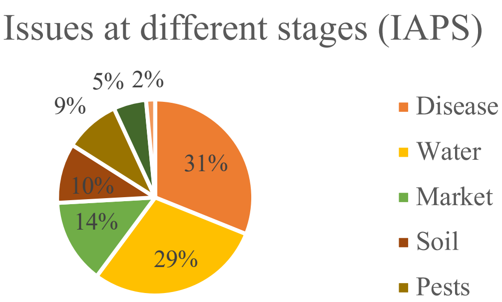
4.4.2.3 Conclusion

The data presented above, although not being from the same data set and research, all show the abundant number of crops and their varieties in the EMC. While most farmers plant similar crops such as maize and beans, there are several different varieties of maize and beans they can choose to plant from. The immense diversity within one county shows the local agronomic knowledge and information these farmers hold, and the detailed understanding of each variety needed for successful cultivation. Through primary data it was found that farmers in fact would like to reduce maize production and focus on diversifying their shambas for increase production of high value products; market was found to me the main driver for crop choice.

4.4.3 Theme 3 - Issues/Challenges

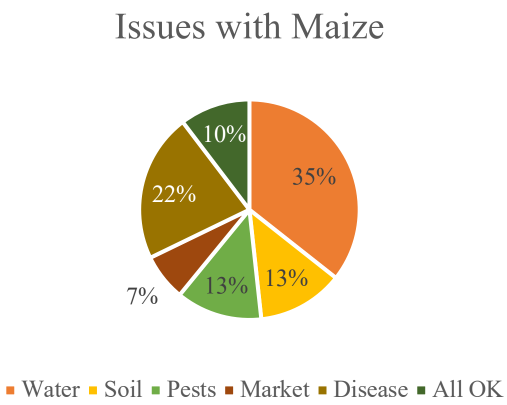
4.4.3.1 Secondary Quantitative Data

The third theme identified are challenges farmers face on their farms and market issues. Presented below are challenges found in the IAPS 2019 and IGP MSc Global Prosperity Dissertation. Additionally, challenges brought to the community by the Red Cross Irrigation Scheme are also explored. The graphs below present challenges for crops at different cultivation stages as well as some examples as to how each crop suffers from distinct issues.

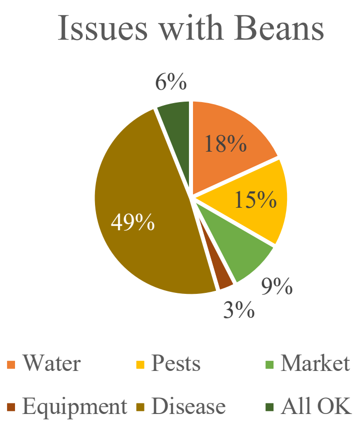


Graph 8: Issues at different stages, IAPS 2019

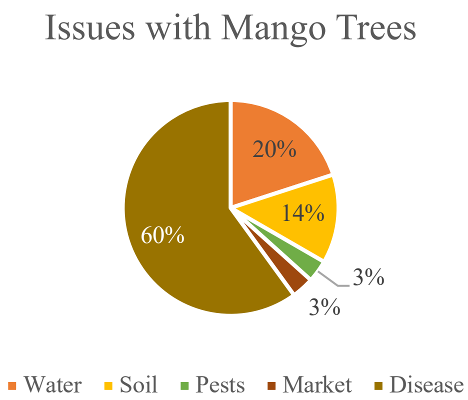
Graph 8 shows that diseases and water scarcity are the two main challenges that farmers face for most of their crop types (affecting 167 (31%) and 156 (29%) crop types respectively). Market issues prove to be relatively significant, affecting 14% of the crops farmed.



Graph 9: Issues with maize in EMC, IAPS 2019



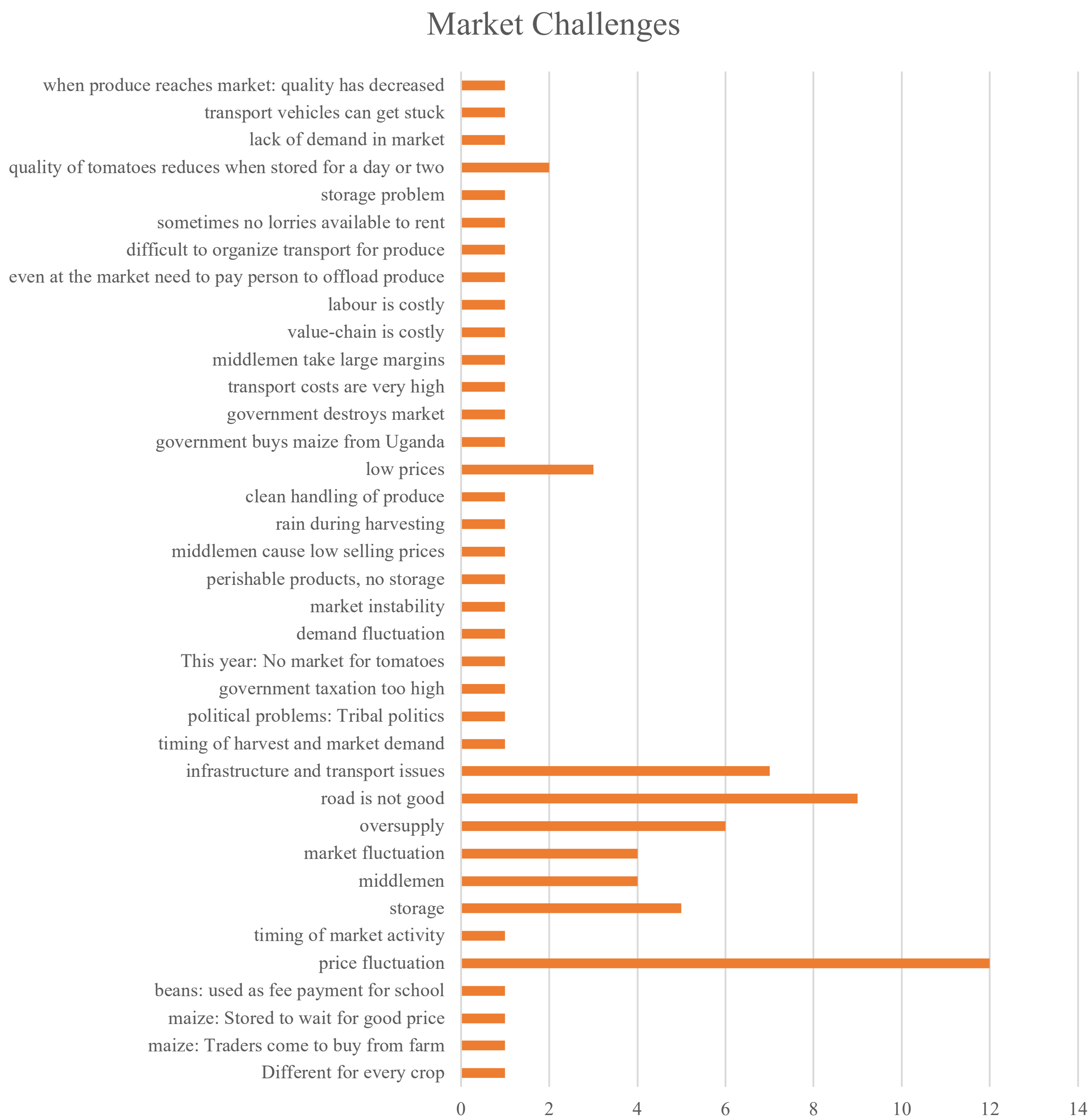
Graph 10: Issues with beans in EMC, IAPS 2019



Graph 11: Issues with mango trees in EMC, IAPS 2019

The three Graphs (9,10,11) above show how different crops are affected by different issues. In the examples presented, disease appears to be a predominant for all (affecting 35% of maize, 49% of beans and 60% of mango trees). Water, however, does not seem to be as much of an issue for most mango trees and bean crops compared to maize.

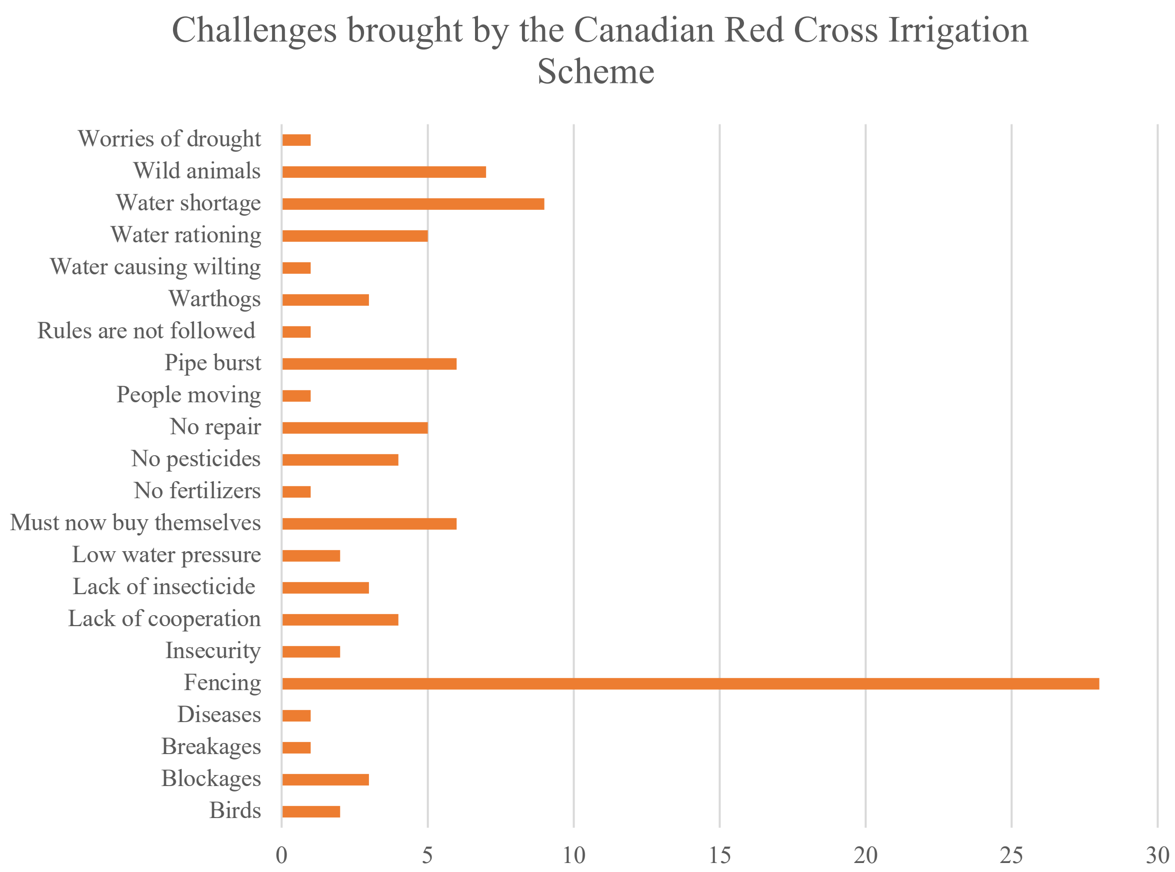
Taking a closer look at the specific market issues, it is clear from Graph 12 below that there are numerous issues when taking produce to market. Price fluctuation of produce and infrastructure issues are common amongst most farmers (over 50% mentioned price fluctuation and 41% mentioned road issues).



Graph 12: Market challenges in EMC, IAPS 2019

Finally, Graph 13 below shows the challenges farmers faced after the irrigation scheme intervention. The irrigation scheme by the Canadian Red Cross in partnership with Kenyan Red Cross aimed to improve water systems in two counties and provide a maize hybrid crop along with fertilizers and pesticides to be used on freshly ploughed land by new tractors provided by the institutions. This was initially welcomed by the Tot-Kolowa population however, the scheme failed to fulfil its expected potential; it exacerbated existing conflicts and created issues within the carefully balanced water irrigation system that has been used for centuries (Davies et al. *in prep)*.

Graph 13 shows that the biggest issue was the need for fencing due to the increase numbers of wild animals feeding on the crops and land that was cleared for the scheme. Infrastructure issues also surfaced such as water shortage due to the faulty pipes (Davies et al. *in prep)*. Farmers mentioned having to buy their own fertilizers and pesticides after the ones provided by the scheme ran out.



Graph 13: Challenges brought by the Canadian Red Cross Irrigation Scheme

4.4.3.2 Primary Qualitative Data

When asked about the challenges they face, half of the participants mentioned increased price of inputs and 4 of them said market issues. The main issues for market barriers are price fluctuation and being unable to trust that they will be able to sell their produce. Another main issue has been the change of rain patterns; this has massively affected crop production as "most of the farms are rain fed" P7_54. Two participants mentioned that maize yields suffered most from changes in rain fall patterns while other crops remained relatively stable. Finally, nutrition of soil was brought up twice as an issue including the fact that the acidity has increased.

Based on past research, the farmers were asked about the issue of yields and its importance compared to profits. Most (5) mentioned directly that yields are not a main challenge for them, especially "if the weather holds" P1_43. The issue they connected to yields is the number of inputs. However, when asked what is more important between yields and profit, all except for one participant said yield. The reasons behind this were that they can store the produce if prices are low and sell later when demands increases, however this can be inconsistent as seen above with market fluctuations, and that yields can still feed their family "and even feed neighbourhood" P7_54.

The final question relating to challenges focused on their efforts to address them. Unsurprisingly, each farmer had their own methods for mitigating the issues in their farms. No response was the same except for 2 participants mentioned the need for faster responses to some issues. One seeks knowledge through 'Digital Farmers' platform and the second pursues the advice of experts since "… government response can be slow and might not have expertise needed" P5_25. Crop rotation was P4_30's main approach to help with "fertility" of the soil however they also mentioned the application of chemicals to help prepare the soil. On the other hand, P6_65 preferers organic manure for his farm as it is "cheaper and better for soil". They also mentioned adding lime to the soil to help with acidity. P6_65 was the eldest and most experienced of the participants suggesting their techniques have been perfected through years of experience.

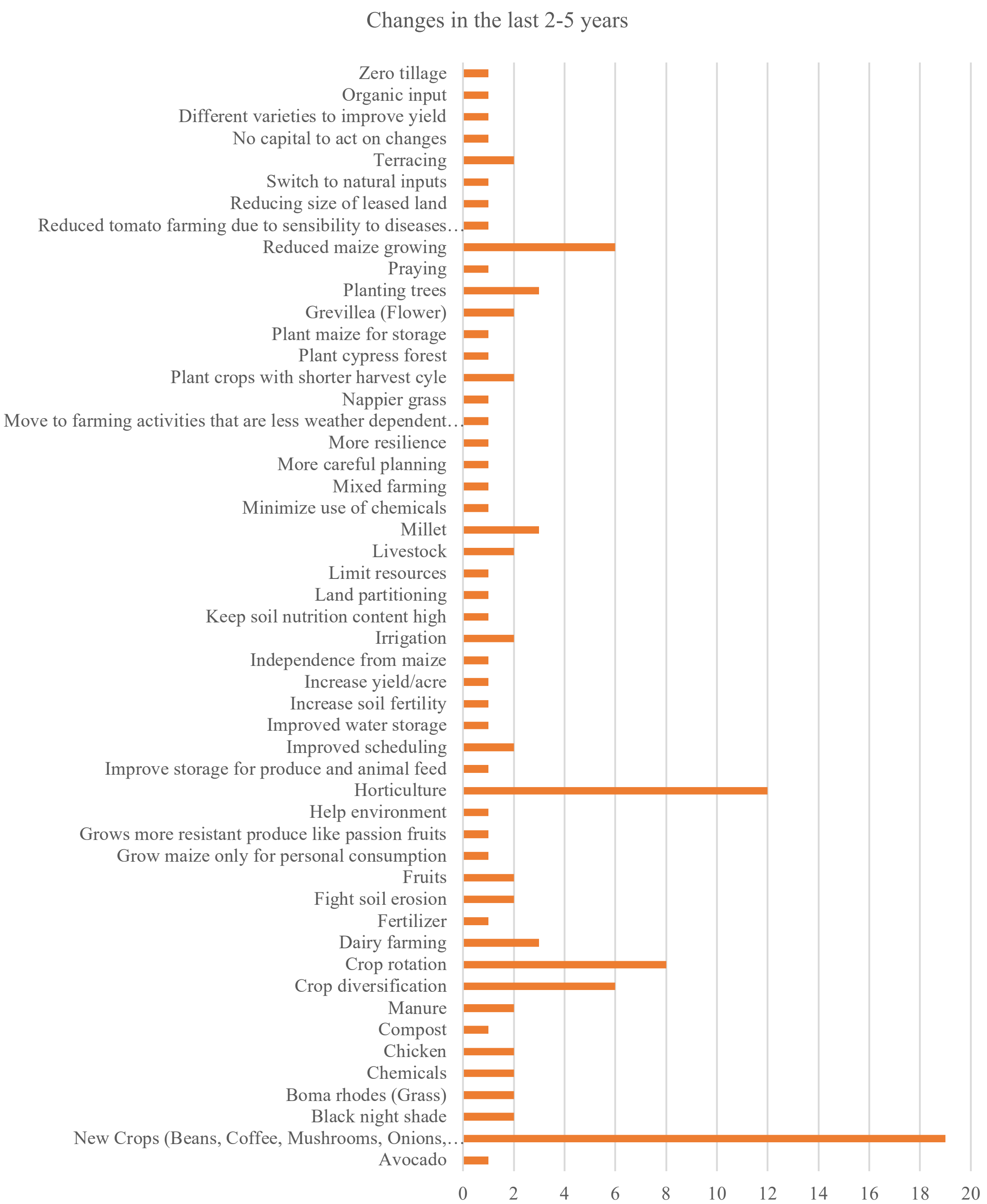
4.4.3.3 Conclusion

There are ample problems in all stages of crop cultivation. However, market issues appear to be just as significant, slowing and sometimes preventing the selling of produce. Farmers have more control over how they adapt their farms to increase yields however, issues of infrastructure and prices are unfortunately out of their reach. External intervention such as the irrigation scheme may offer benefits however, when not implemented according to specific context of land it can exacerbate issues. The variation in practice change and methods presented through the interviews suggests each farmer has their unique way of improving their farms and have a good grasp of what would work best for them compared to their neighbour.

4.4.4 Theme 4 - Practice and Innovation

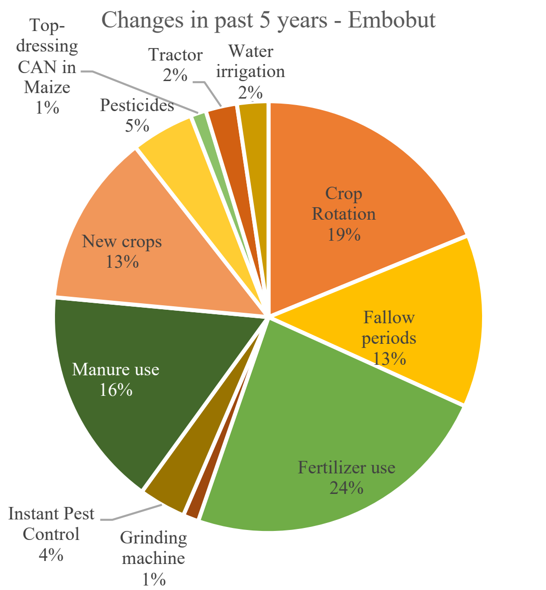
4.4.4.1 Secondary Quantitative Data

The following theme addresses the changes and innovative practices that farmers implement in their shambas to tackle many of the issues presented above. In this section, farmers' distinct ideas to improve their practices are analysed as well as how they benefited from the Canadian Red Cross Irrigation Scheme's resources and by using their creativity.

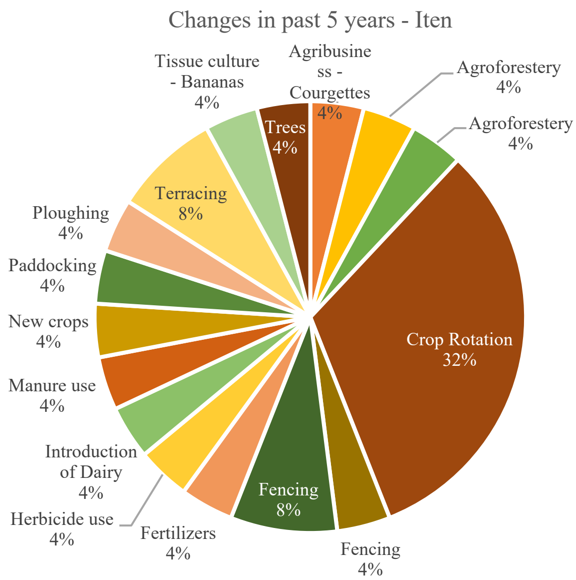


Graph 14: Changes in the last 2 to 5 years, 2019 IGP MSc Global Prosperity Dissertation

The data from Graph 14 presents results from 22 interviews based on farming practices. Similar to Graph 12, the size of the Graph 14 is interesting in itself as it suggests a diverse number of techniques. This also suggests that each farmer has their own preferences based on their knowledge and experience and what their land needs. The 4 main implementations are introducing new or different crops (86%), crop rotation (36%), starting horticulture (55%) and the reduction of maize (27%).



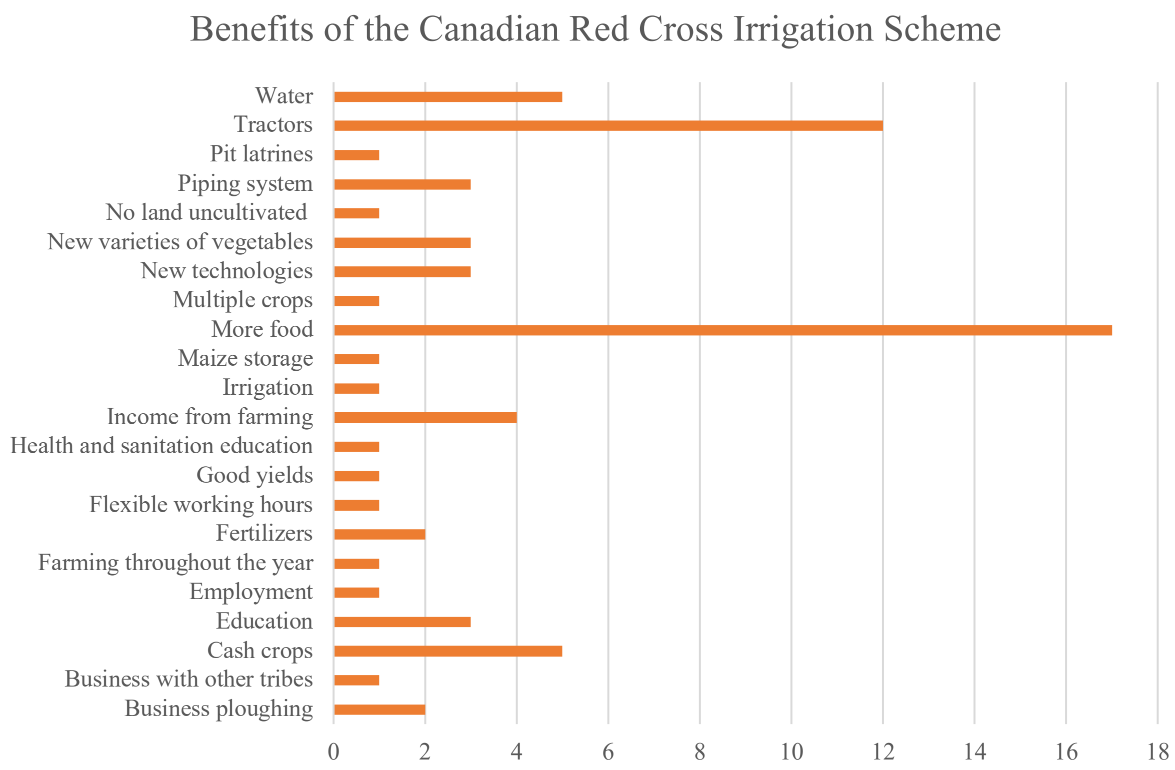
Graph 15: Changes in the past 5 years in Embobut, PIPFA 2020



Graph 16: Changes in the past 5 years in Iten, PIPFA 2020

Graphs 15 and 16 present data from PIPFA 2020 showing the different changes applied by farmers from two areas in the EMC. The similarity between them lies on the introduction of crop rotation in both areas by most of the farmers interviewed (19% in Embobut and 32% in Iten). The use of fertilizers and organic manure are widely implemented in Embobut (24%). These results are consistent with the ones in Graph 14 where both show the wide range of possible techniques and changes to improve productivity in the farms.

Graph 17 presents the benefits brought in by the Red Cross scheme related by 41 farmers. In addition to the benefits, the local farmers adapted to these changes and acted innovatively to solve the problems they faced (Davies et al. *in prep*). The main advantages appear to be the increase in food production and the introduction of tractors (41% and 29% respectively). Increase in water supply and cash crops were also significant for the farmers (12% for both).



Graph 17: Benefits of the Canadian Red Cross Irrigation Scheme

4.4.4.2 Primary Qualitative Data

To understand why farmers chose these specific changes to improve their farms, questions about their perception of innovation and how innovative practices could benefit them were asked in the qualitative interviews. When asked what they understood of innovation, the concept of improvement was mentioned by 4 farmers while newness was only mentioned by 2 participants. Technology was brought up by 3 participants. P7_54 suggested that innovation is about:

> "… adopting new ideas for a profitable purpose. Embracing new ideas. Something new that can change. But also, old ideas that can be applied now to help farming. Ideas that can help us adapt to issues of climate change. You do not remain ridged, have to accommodate".

These findings show that the farmers agree innovation means change for the better and that it can come from diverse sources.

When asked if they had come up with innovative ideas, 4 participants said the introduction of new/different crops such as fruit trees and vegetables help soil health, and they use these crops as substitutes for maize and low growth seasons. P5_25 went into more detail and described and ideas he had to improve maize and passionfruit growth:

Maize: “I planted maize without ploughing the shamba. Did this to conserve moisture in soil. Engage in traditional ways of farming due to small portions of land. I found that when the plant sprouts, there is water in it, so moisture is not lost in the soil from the plant and from ploughing.”

Passionfruit: “I planted grass and did selective herbicide spraying. Then dug holes for the vines and put in wires to hold them. For the lower part of crop, I didn’t spray the plant to kill weeds; planted grass instead to get rid of weeds, along with organic manure and sheep that eat the weeds and not the vines. This lowers production cost because I use less chemicals and didn’t need to hire someone to weed his farm”.

Box 1: Example of innovative practice change to help regenerate land

Other participants mentioned the use of machinery and chemicals as innovations in their farms as they have been recently introduced. All participants agree that innovation and technology are linked. Most (4) believe that technology helps drive innovation and that it does not only mean machines, but also digital technology such as communication and Digital Farmers. P6_65 mentions the efficiency technology can bring to solving problems at their farms, he believes “knowledge can come from technology”. However, all participants believe that collaboration between them is also innovation because they learn from each other and can come up with innovative ideas based on what their neighbours are doing. P5_25 “Innovation can be getting idea from someone else and apply to my own shamba in my own way”. The community feeling and drive to help other is strong amongst the participants for example, P7_54 was told by neighbour to plant different type avocado, so they exchanged ideas and techniques about how to do it.

The final question asked the participants if they have had to change traditional practices to fit their needs and 4 replied it changed completely while P7_54 said they have not changed as much. This suggests that the decision to change practices is personal to the farmers and their needs. Four participants mentioned crop rotation as a major change from past practices as well as the use of more chemicals; P7_54 said that “people coming from other places in the world have impacted the way [they] farm. The farmers are eager to learn and hear from people and institutions and learn from them.”

4.4.4.3 Conclusion

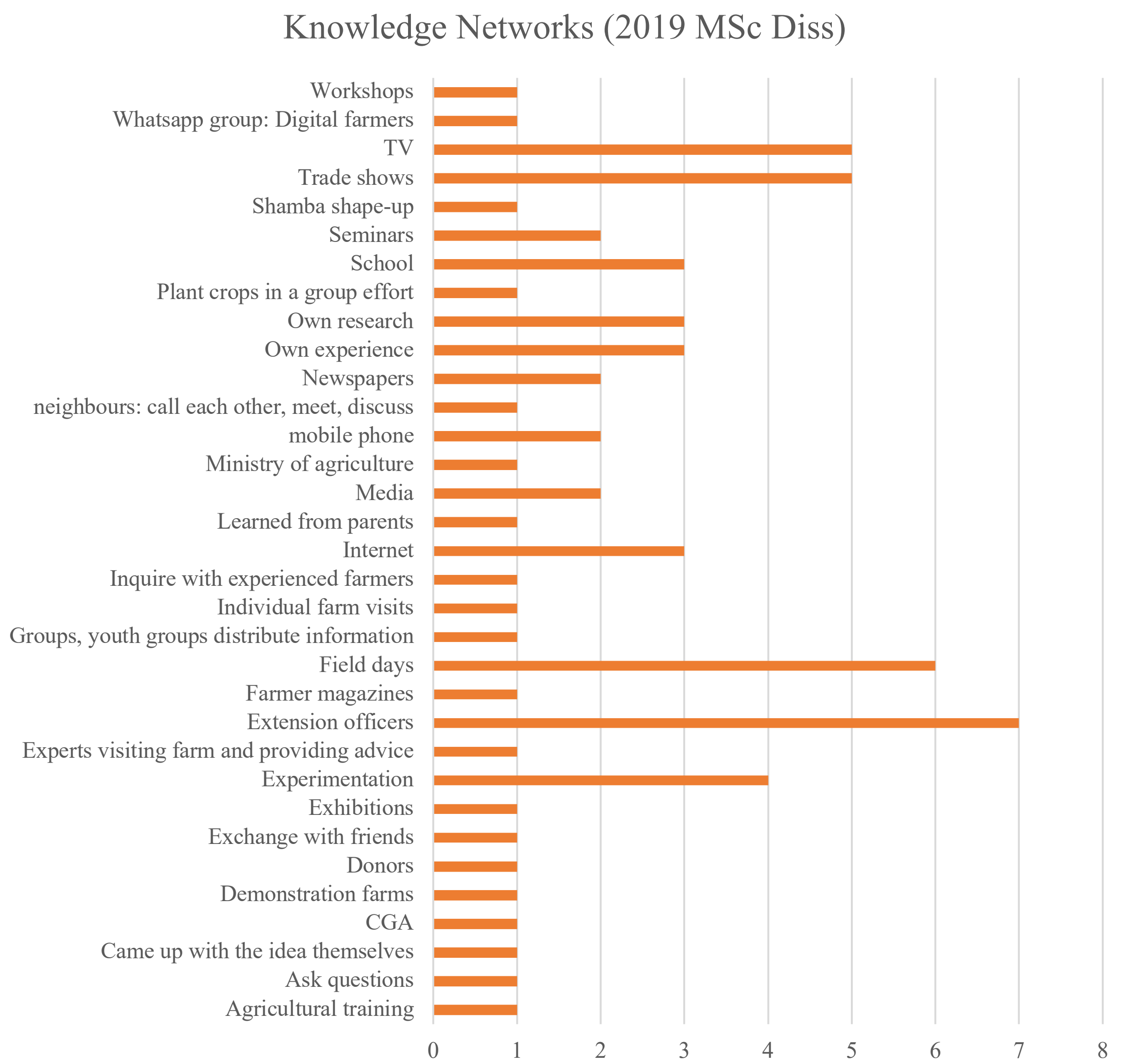
Most farmers are interested in diversifying their farms. The large number of changes to some farming practices suggest the range of possible modifications that can be applied to farms as well as the varying effects on different crops. Increased use of fertilizer and organic manure also suggest the need for more nutrition for the soil and through primary data, farmers agree that organic manure is cheaper and more effective than chemical fertilizers. It was found that climate change forced the farmers to use more inputs in their farms and focus on moisture of the soil therefore some turned to older practise of holding moisture on the ground.

4.4.5 Theme 5 - Knowledge Networks

4.4.5.1 Secondary Quantitative Data

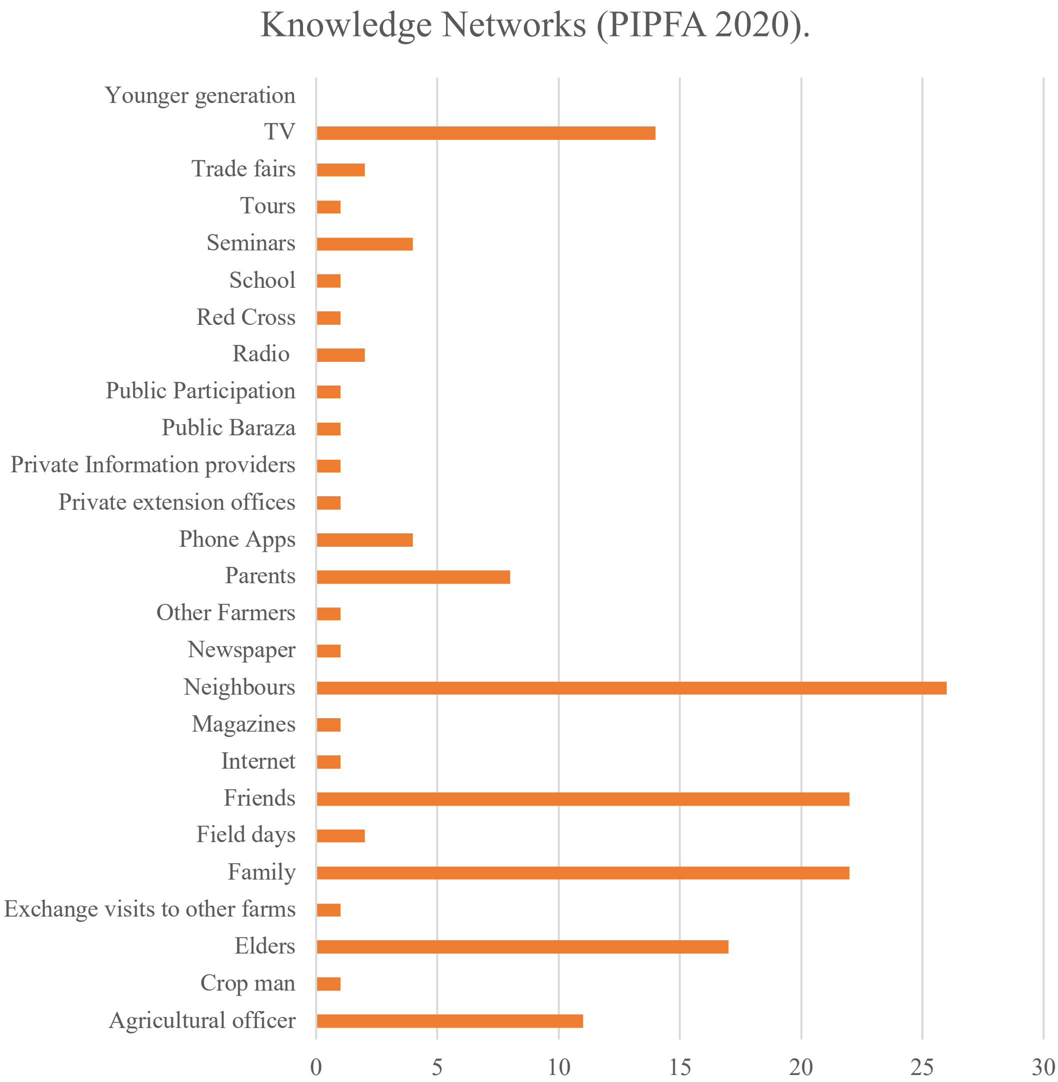
The fifth and final theme relates to where and how farmers access knowledge for their farming practices. The data is present in two previous research used in this study: 2019 MSc Global Prosperity Dissertation and PIPFA 2020.

The information in Graph 18 is based on the responses of 22 farmers therefore it can be observed that no knowledge network has popularity rates above 50% since the most sought-after method (Extension Officers) was mentioned by 7 farmers. Field days are also considered a trustworthy source of information given 6 farmers mentioned it. Some knowledge sources overlap, such as media and internet and WhatsApp and mobile phone. The diversity of answers also suggest that farmers seek advice and information from varying sources thus suggesting no main one would satisfy their needs.



Graph 18: Knowledge Networks, IGP MSc Global Prosperity Dissertation

The PIPFA data set has a larger number of responses (62) and therefore may offer a better representation of the preferred knowledge networks amongst the farmers. Graph 19 below shows that farmers trust word of mouth and knowledge from others in their community. This is seen through many of them responding neighbours (42%), friends (35%), family (35%) and elders (27%). Acquiring knowledge from TV is consistent across both data sets and suggests farmers trust TV shows as a faster and more updated source of information.



Graph 19: Knowledge Networks, PIPFA 2020

<u>4.4.5.3 Primary Qualitative Data</u>

Further exploration through interviews shows that all farmers seek information and advice from experts in the field and from people whose jobs are to help them as farmers, similar to the quantitative findings. All farmers mention looking for knowledge that comes from within Kenya, the source of this varies from government help, extension officers, and technical assistance as well as NGOs. Turning towards their neighbours and farmers groups (WhatsApp mentioned specifically) where they can learn from someone who's successfully applied changes is a popular approach by the farmers as they can trust the advice.

Field days and research is also presented as a trustworthy means for acquiring new techniques as they introduce new technologies, advice on soil from experts and extension officers that offer up to date information for the farmers; P4_30 said he "can get advice from [technicians] on soil". Finally, 4 participants highlighted their use of governmental events to gain new knowledge and technological updates. P2_40 mentioned that "… trade fairs organised by the government with machine demonstration" are useful as they introduce machines that can help with the processing of maize such as shelling and processing animal feed. This speeds up some stages and suggests less effort in farming maize.

P7_54 "Knowledge is power".

4.4.5.3 Conclusion

When seeking information and knowledge to improve their farming practices, farmers in EMC prefer accessing these from sources close to home such as neighbours and from farmers' groups (WhatsApp was consistent in primary and secondary results), as well as extension officers, experts such as technical assistants and technician from the government. This suggests farmers are concerned with being up to date with current modern practices and information however, they trust the expertise of the local farmers.

4.4.6 Theme 6 – Future Considerations

4.4.6.1 Primary Qualitative Data

The participants were asked if they benefited from external interventions and 3 participants replied saying they've not benefited much from external assistance, P7_54 said they've not been offered any help from external institutions. 2 farmers mentioned benefiting from institutions from Japan and the United States of America. The US organisation taught the farmers about energy conservation regarding the use of firewood. The Japanese organisation brought in knowledge about soil conservation; P6_65 mentioned that the farmers already knew some of the information brough it by the Japanese organisation, but the NGO helped them upgrade that knowledge. P7_54 emphasised that he "[does] not mind where the knowledge comes from, but [they] need it to improve [their] lively hoods".

The farmers were then asked what they want from the government and other institutions to help them with their farms. Unsurprisingly, the two main support mechanisms all farmers agreed on are stabilizing markets and providing more knowledge. Government subsidising inputs was also brought up by 3 participants as an essential component of successful farming. 2 participants mentioned that the introduction of new technologies is not a priority as "farmers can work well without technology" P2_40; they would rather have knowledge inputs and technicians to come assess their soils and advise them. P5_25 emphasised the need for organisations "to be on the ground, at the farms, to understand their challenges and they can help the area. The government could facilitate this and help solve the problems".

Finally, based on past efforts to help smallholder farmers improve their farm productivity, the participants were asked if one super crop with high yields would provide a solution to their challenges. The concept of higher yields appealed to some farmers due to less inputs and higher production in a small piece of land however, the main concern is the market and how that would change with increased production. P5_25 emphasised the need for support for farmers that choose to use hybrids. P3_34 said that he'd welcome high yielding crops however, they "must come in many varieties. Not only one main type".

4.4.6.2 Conclusion

Farmers are generally interested in higher yields; however, this is not they main priority as they can manage higher growths in their shambas without needing a super crop. They are more worried about market stability and if the new crops introduced have higher market value as well as nutrition.

4.5 Limitations

The limitations of this study begin with the secondary data sets from previous IGP PROCOL research. PIPFA 2020 and IAPS 2019 are pilot projects where the data collection was not consistent throughout different towns, mainly due to the COVID-19 pandemic, and the variables were not controlled. This prevents the study from establishing concrete conclusions thus the use of a variety of data sets to strengthen the validity of the arguments presented in the next chapter. Additionally, the pandemic prevented the researcher from conducting in-person interviews therefore restricting the rapport created with the interviewees and issues such as language barriers were exacerbated. Finally, the sampling method, as mentioned earlier in the chapter, was convenient sampling where the Citizen Scientist followed his interpretation of innovation and chose participants, he believed were most involved in it, narrowing the results and prevents higher variety of perceptions.

4.6 Ethics

A 'Research Ethics Application Form for IGP Student Dissertations' was approved for this by the IGP at UCL, and the completion of the form was discussed with the primary supervisor of this study. The participants were ensured their identities would remain anonymous and any of the information they provided would be linked back to them. An oral consent was acquired for the recording of the interviews for each participant. They are referred as P'n'_(age).

Chapter 5 – Discussion

The purpose of this chapter is to demonstrate how the findings in this study answer the main Research Question and later synthesise them with the studies presented in Chapters 2 and 3. The aim of this study was to uncover the complex smallholder farming practises and through these understand how the farmers perceive and make use of innovation to mitigate issues in their farms. The main research question that guides this research is 'How can we understand and support processes of smallholder innovation in Elgeyo Marakwet County as the foundation for co-designing regenerative and inclusive food systems?'. Three sub-questions were developed to help answer the main question, and these are 'What are the impacts of a potential new African Green Revolution on small holder farmers in Elgeyo Marakwet?', 'How is innovation conventionally understood within the agricultural sector and what is the role of the smallholder in this?', and 'How is innovation perceived and performed by smallholder farmers?'

Answering the questions above, this study found that smallholder farmers are innovative in their practices when facing challenges such as climate change. When adapting to changes and developing innovative techniques, farmers look towards experts and other farmers in their community for advice and help; these support systems help them understand the changes in the soil as well as in other parts of farming and drives them to adapt old ideas and practices to their farms. The farmers make use of communication and farming technologies to upgrade any practice they find useful. The study also found that market challenges are one of the main drivers for change given the instability of food prices and poor infrastructure. Farmers made it clear that improvements in market infrastructure and input subsidization would help them better plan crop cultivation in their shambas. Thus, the findings show that we can understand smallholder practices by engaging with them and their techniques and learn where their innovative drive and ideas come from; this allows policy makers and other institutions to develop the appropriate support for these communities. This support needs to stem from knowledge networks and technical assistance for farmer as this was found as the main ways in which innovation is co-designed by smallholders.

The first significant finding of this study was that crop variety and diversification are incredibly important in smallholder farming as this allows farmers to have a wide range of crops for consumption as well as for selling in the markets. Diversification of high value crops was highlighted as a priority for farmers as they offer a secure inflow of financial capital. These include passionfruit and avocado, which most participants in this study cultivate and value due to their nutritional content and higher market prices. The expectation for this study was that indeed, diversification is preferred by smallholder farmers as this prevents overreliance on one crop for consumption and market. This finding supports Luan et. al.'s (2019) and Dawson's (2016) claim that individual household and farmer resilience is central for food security. Farmers have expressed the desire to have control over their food production, when one participant claimed farmers in the EMC are able to support themselves and their families.

The first finding is linked to the second major finding that suggests yields are not a main issue for farmers in the EMC but rather challenges related to the market. Due to price instability and unreliable market infrastructures, farmers favour improving soil fertility and cash crop production. Most participants actively choose to reduce maize production due to low market price and high cost of production thus prioritizing diversification. This is not reflected in the secondary data as the main crop for famers around EMC is maize however, most maize production is for consumption therefore suggesting increase in production proposed by African Green Revolution (Sasson, 2012) would not be suitable for smallholder farmers. On the other hand, when having to pick between higher yields and higher profit, most farmers would prioritize yields as they can use it to feed their families even if there is no income and store the produce for selling at the market when prices are up. This agrees with Luan et. al.'s (2019) argument for yield increase in Africa however, this claim does not encompass the fact that farmers prefer improving their soil fertility through organic manure and technical assistance rather than a super crop or chemicals.

Another interesting finding, that was expected based on quantitative results, was the choice of crop rotation as a main way to mitigate challenges in farms. This falls in line with arguments proposed by Holt-Giménez and Altieri (2013) and Herren and Hilmi (2011) on the benefits of agroecology for food security and sovereignty in smallholder communities. Crop rotation was, however, mentioned as a change in practice compared to traditional ways of farming which contradicts the argument that old practices can help with regenerating land and bring back agroecological practices (Dawson, 2016). Yet, this study found that farmers recognise older practices as beneficial forms of innovative practices such as retaining moisture in the soil, planting maize without ploughing the land and increased use of organic manure, where traditional practices help with farming on smaller pieces of land (Holt-Giménez and Altieri 2013).

The fifth key finding in this study was that diversity in sources of knowledge is valued by farmers as they trust advice from past experiences and local experts. Both qualitative and quantitative results show farmers' decision to explore many knowledge networks and the effectiveness of these when implementing innovative ideas. This finding agrees with Šūmane et al.'s (2018) argument claiming the efficacy of Agricultural Innovation Systems in supporting smallholder farming productivity as it focuses on the combination of actors in innovation rather than one focal factor. The result also furthers Juma's (2015b) case on the benefit of coalitions between institutions to advance innovation driven by farmers knowledge along with the knowledge and expertise they can acquire from institutions like governments and NGOs. This allows for effective humanization of innovation where ideas that stem from experience and practice are combined with technical support for these to flourish. Ultimately, this finding, and its relevance to previous research, rejects ideas that a Green Revolution can provide solution by focusing on crop growth enhancement rather that knowledge enhancement and application (Sasson, 2012). Finally, a strong community feeling of wanting to help neighbours and other farmers was found through qualitative research which suggests the farmers themselves are key actors and sources of knowledge for when generating innovation.

The final result from this study suggests the main external support sought after by smallholder farmers is in the form of knowledge and technical assistance from the government and other institutions, the stabilization of market prices, and access to buyers for their produce. The farmers made it clear that the main assistance they need is for institutions to help them help themselves; these include improvement in communication platforms where they could get information faster, subsidised input for increased soil fertility and crop protection, knowledge transfer from experts and technicians that and help them identify what is wrong with the soil. This finding contradicts the results from secondary data analysis where large-scale data sets suggested a healthy market structure due to much of cereal food produced in Kenya being imported. However, qualitative interviews reject this because farmers highlighted market challenges as a main barrier to their farming practices; they prefer support from the government. This further suggests that innovation should encompass the human aspect as drivers for decision-making given the farmers preference towards market solutions rather than technical innovations.

The main implications of this study for policy makers lie on the capture of information and knowledge on smallholder farmers to place them as co-designers of innovation. This study suggests that decision-makers working on support systems for farming innovation must focus on the ways of knowing of farmers as they use this to act on changes that challenge their traditional practice. Moreover, this study emphasises the need to conduct on the ground research that will aid, not only policy and law makers, but also universities and NGOs, in understanding the intricacies of smallholder practice and combine them with modern technologies that can enhance the intrinsic cultural knowledge of these communities. This approach to research and development of mechanisms to support smallholder farming is in line with Agricultural Innovation Systems and how it provides a framework for agroecological innovation. The in-depth understanding of the complexities of smallholder farming and their capacities as co-producers of innovation can lead policy makers and other institutions to develop the appropriate support for these communities to work towards mitigating the effects of climate change. This study has helped further the understanding of smallholder practices and innovation mindset therefore paving the way towards building effective support systems.

A possible area for future research includes investigating the innovative potential of female farmers as all the participants in this study were male. Pollard et al. (2015) suggests that exploring women's roles in small holder farmer communities could present insightful information on their influence when it comes to change and what they can do as community members to address futures issues brought by climate change. Additionally, future studies would benefit from a larger research sample as more in-depth information can be collected and quantified for a more accurate representation of farmers' perspectives on innovation and a clearer path to including them as co-designers within their communities. Finally, given the limited literature on specific governmental and institutional activity aimed at driving innovation where it is co-designed by smallholder farmers, future research could aim at investigating specific support systems by these institutions that are effective towards innovative practices in Africa.

Chapter 6 – Conclusion

This research aimed to identify the power of smallholder farmers in western Kenya as co-designers of innovative agricultural practices and how these can be harnessed in collaboration with other institutions to mitigate the effects of climate change and population growth. To achieve this, this research analysed data previously collected by the IGP PROCOL Team in Kenya and expanded on the results through in-depth interviews with local smallholder farmers. This chapter provides a summary of the findings and their resulting conclusions, an overview of important contributions, recommendations and finally the shortcomings of this study.

The findings in this research answered the main research question that guided this study: 'How can we understand and support processes of smallholder innovation in Elgeyo Marakwet County as the foundation for co-designing regenerative and inclusive food systems?'. The study found that smallholder farmers are incredibly capable of developing innovative solutions for their farms when facing negative impacts from climate change; these innovations, however, would benefit from governmental and institutional support that allow farmers to explore and advance their full potential as innovators. There is a wide range in the way farmers innovate extending from adapting old practices into new contexts to collaborating with other members of the community through the sharing of new successful practices. The key findings showed the main challenge farmers face is market instability where price fluctuations and improper infrastructure prevent them from accessing the market and selling their produce at a fair price. These issues can be mitigated by the government, based on the farmers experience, providing substantial help to the EMC. The effects of weather challenges such as irregular rain patterns, found as the main cause of the issues in their farms, were addressed by the farmers by incorporating crop rotation and diversification of crops to help with soil fertility and yields. Finally, the acquisition and sharing of knowledge is seen as the main driver of innovation development as most farmers search for this from other community members based on their experience and from trained technicians and government officials that provide technical assistance such as testing soils for acidity levels.

In order to address the main question, three sub-questions were designed. The answer to the first sub-question, 'What are the impacts of a potential new African Green Revolution on smallholder farmers in Elgeyo Marakwet?', found that farmers value higher yields as this helps smaller pieces of land become more efficient however, they look for higher diversity in crops and favour high value crops that are sought after in markets. Therefore, the introduction of one or two high yielding cereal crops would not solve the farmers main challenges concerning market and price fluctuations, opposing the argument for a new African Green Revolution (Sasson, 2012; Luan et. al., 2019). In fact, if most farmers begin planting the same crops throughout the community, market prices will drop and further exacerbate the issue of maize price instability.

In answering the second sub-question, 'How is innovation conventionally understood within the agricultural sector (i.e., AIS) and what is the role of the smallholder in this?', this research found that technological innovations usually are at the centre of the agricultural domain however, recent applications of AIS have emphasised the need for more inclusive innovation designs and development so that benefits from these are not one sided and end up worsening the situations smallholder farmers encounter in the face of climate change. This provides wight to Šūmane et al. (2018) and Juma's (2015b) argument for the use of AIS in smallholder communities. Centring smallholder in innovation design allows for all-encompassing, long-term solutions when tackling food insecurity.

Finally, sub-question three, 'How is innovation perceived and performed by small holder farmers?', found that innovation is mostly understood by the farmers as the introduction of new and improved ideas and technology that can help facilitate their work and provide a more prosperous life. Technological innovations encompass communication with outside institutions and between the farmers themselves and they believe that increased access to information and knowledge from technology can help them develop innovative ideas (Dawson, 2016). Combining new with traditional knowledge acquired through experience and past generations have shown to help farmers adapt agroecological practices furthering Holt-Giménez and Altieri (2013) and Herren and Hilmi's (2011) claims on the benefits of agroecology.

This study contributes to the recent body of knowledge that aspires to provide clarity on the benefits of agroecological practices in smallholder communities (Holt-Giménez and Altieri, 2013; Herren and Hilmi, 2011) by providing an in-depth exploration of the complexities of smallholder farming. It also furthers the notion that farmers can be centred as co-designer of innovation to promote agroecological practices to address forthcoming challenges of climate change and population growth (Šūmane et al., 2018; Juma, 2015b). This dissertation contributes to the overall literature that aims to help policy makers and institutions understand smallholder farming practices, their challenges and how they innovate so that support systems and mechanisms can be advanced to aid these farmers in combating these challenges (Hounkonnou et al., 2012; Iskandar and Gatzweiler, 2016; Hounkonnou et al., 2018; Šūmane et al. 2018; Lunn-Rockliffe et al. 2020). Subsequently, this study recommends that for the purpose of further developing inclusive support systems for smallholders across the globe to help them incorporate innovative agroecology into their practices, a coalition of institutions is required to facilitate the transfer if knowledge to these communities. For this to be effective and inclusive, extensive on-the-ground research needs to be conducted where smallholder farmers are centred in the decision-making and are able to participate in the design of innovations target to help them tackle global issues. (Larsen et al. 2009; Juma, 2015b).

Two significant shortcomings of this research are that the researcher has limited farming experience and was not able to go to the EMC to conduct the interviews in person. This prevented capturing the true essence of the farmers and led the researcher to assume things such as the reality of the difficulties and challenges that come with owning land and managing a farm, thus hindering the overall analysis of data. In the findings of this research, one farmer emphasised the need for research to be done on-the-ground at the farms so that the institutions responsible for providing support can fully comprehend the day-to-day of the farmers and their community dynamic. Future research should focus on acquiring data from within the smallholder communities and create relationships with the locals to fully engage with them to capture their challenges.

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Appendices

Appendix A

Primary Research Instrument

Section 1: Introduction, background and creating rapport with interviewee.

a) Ask for their name and how they are. Introduce myself (consider asking about their wellbeing during the pandemic)
b) Age
c) How long have you've been a farmer?
d) Where did you learn how to farm?
e) How did you acquire your land?

Section 2: Crop diversity

a) What are the main farming enterprises undertaken at your farm?
b) Are there any specific reasons as to why you chose to cultivate these crops? Ex, some farmers have said that they plant DH04 maize and local maize, what's the difference between them? How do you determine that?
c) In other interviews some farmers have said they want to reduce or even stop cultivating maize, is this true for you?
    a. Follow up, why? Please expand.

Section 3: Challenges

a) What are the main challenges you currently face in your farms?
    a. Do these challenges differ from the ones in the past? How so?
    b. Why do you think you are having these issues?
b) Are low yields a main issue at your farms?
c) What's more of a problem, low yields or low profits? (More important, profit or yield)
d) What have you done to address these challenges?

Section 4: Innovation and Technology

a) What does innovation mean to you? (Check translation with Kip)
b) Do you think you have come up with innovative ideas?
    a. Follow up, tell me more.
c) Do you believe more technology is linked to innovation?
    a. Follow-up, why?
d) Do you consider collaborating with other farmers and institutions innovation?
    a. Follow up, what has worked best for you?
e) Have you changed traditional and older practices to fit your current needs?

f) In previous interview people have said they get their knowledge form sources such as family and elders in the community; how do you select where you get your knowledge from and how to you decided what source to trust and follow. Why did you pick a specific seed? Focus on how and why.

Section 5: Future

a) Have you benefited from external interventions?
    a. How and why?
b) If the government were to offer more help/new schemes, what would you like to be included?
    a. Why?
c) Would the introduction of a crop that had high yields and needed little resources to grow provide a solution?

Appendix B

<u>Section 1: Introduction, background and creating rapport with interviewee.</u>

a) Ask for their name and how they are. Introduce myself (consider asking about their wellbeing during the pandemic)

Richard

f) Age

25

g) How long have you've been a farmer?

After college, in 2015 (bachelor's in arts)

h) Where did you learn how to farm?

Learnt from parents

i) How did you acquire your land?

Parent's land

<u>Section 2: Crop diversity</u>

d) What are the main farming enterprises undertaken at your farm?

Maize, vegetables, (some local some exotic), avocado, passionfruit, tree, dairy.

e) Are there any specific reasons as to why you chose to cultivate these crops? Ex, some farmers have said that they plant DH04 maize and local maize, what's the difference between them? How do you determine that?

Plant whatever can be sold in the market, a major driver.
Hybrid maize, from Kenya Seed Company.

f) In other interviews some farmers have said they want to reduce or even stop cultivating maize, is this true for you?
    a. Follow up, why? Please expand.

He started reducing maize since 2017. ½ an acre of maize. Mainly for consumption.

Small land doesn't allow for machine farming. Maize has high production costs for small yields. Too much effort and time for low returns.

<u>Section 3: Challenges</u>

e) What are the main challenges you currently face in your farms?

Inconsistent rain patterns and weather patterns.
Maize suffers from rain reduction. Used to rain a lot but now it has become an issue.
Issues with selling produce through middlemen, brokers, therefore inconsistent pricing in market.
Diseases in his passionfruit. Not Breaking even with passionfruit production.

a. Do these challenges differ from the ones in the past? How so?

Similar problems

b. Why do you think you are having these issues?

Change in weather and rain patterns.

f) Are low yields a main issue at your farms?

Passionfruit example: different pests affect different parts of the crop (roots, flower, leaf, stem) meaning production will go down. They need to use more chemicals and fertilisers therefore driving the costs up.

g) What's more of a problem, low yields, or low profits? (More important, profit or yield)

Both. Higher yields help but more money would be very useful. He worries about yield first and then worries about market prices later because it depends on demand and supply of the area.

h) What have you done to address these challenges?

Government response can be slow and might not have expertise needed, so they go to experts and consult with them.

<u>Section 4: Innovation and Technology</u>

g) What does innovation mean to you?

Someone being creative and bringing something new and smart to help productivity in the farms. Touches on technology.

h) Do you think you have come up with innovative ideas?
    a. Follow up, tell me more.

Yes, but can also mean new ideas and be creative on the farm.

i) Do you believe more technology is linked to innovation?
    a. Follow-up, why?

Planted maize without ploughing shamba. Did this to conserve moisture in soils. Engage in traditional ways of farming due to small portions of land. He found that when the plant sprouts, there is water in it, so moisture is not lost in the soil from the plant and from ploughing.

Passionfruit farm: planted grass and did selective herbicide spraying. Then dug holes for the vines and put in wires to hold them. Lower part of crop: he opted out of spraying plant to kill weeds and planted grass instead to get rid of weeds, along with organic manure and sheep that eat the weeds and not the vines.
This lower production cost because he used less chemicals and didn't need to hire someone to weed his farm.

j) Do you consider collaborating with other farmers and institutions innovation?
    a. Follow up, what has worked best for you?

Yes. With farming you can visit other farms and learn something new each time and bring idea to his farm, he thinks this is innovation too.
Innovation can be getting idea from someone else and apply to his own shamba in his own way.

k) Have you changed traditional and older practices to fit your current needs?

Yes

l) In previous interview people have said they get their knowledge form sources such as family and elders in the community; how do you select where you get your knowledge from and how to you decided what source to trust and follow. Why did you pick a specific seed? Focus on how and why.

Neighbour who is working on addressing the challenges on his farm, such as irrigation.
Look for people who have the knowledge, but also look online and WhatsApp groups.

<u>Section 5: Future</u>

b) Have you benefited from external interventions?
    a. How and why?

Not really.

c) If the government were to offer more help/new schemes, what would you like to be included?
    a. Why?

Everyone is a farmer in the area, so government need to help them with market so that they are able to have reliable prices and selling of produce. Help the farmers sell their produce.

Most organisations need to be on the ground, at the farms, to understand their challenges and they can help the area. The government could facilitate this and help solve the problems.

He participated in data collection scheme with the governments inquiring about: what kind of farming, input in shamba, how do they maintain crop, costs of production, output level, market they sell products to.

- Out of this the government can learn what support they need to provide to help the farmers
- They introduced goat dairy farming and seeds for tomato farming

The groups involved in the project benefited from government support. Project will go on.

d) Would the introduction of a crop that had high yields and needed little resources to grow provide a solution?

Major issue is market. Output level is not a problem, what to do with it is the issue. They sell a lot of avocados when the global north is in winter.

Bringing something new to the market would be good, but main focus should be on market and how the farmers that are using the new hybrids are being supported.

Extra:

- **Politics in Kenya:**

Kenya can produce maize to feed country. This maize can be/is stored because prices are down.
Top gov. officials keep saying there is food scarcity and that they. Need to import it from somewhere else. So, they import the maize even though there is much of stored by local farmers.
Local farmers cannot sell maize to governments because prices are down, so they store it to wait for prices to go up.

Appendix C

PIPFA 2020