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An Assessment of Hybrid Maize Adoption by Small Scale Farmers in Southern Africa: Some Evidence from Malawi, Zambia and Zimbabwe.

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Abstract

Small scale farmers in Malawi, Zambia and Zimbabwe, defined as farming an area of less than 6 hectares produce 80% of the staple, maize, which is largely for subsistence purposes. Their maize yields are on average less than three metric tonnes per hectare for Malawi and Zambia and less than one tonne in Zimbabwe. These yields are far less compared to their counterparts, commercial farmers, who get yields ranging from four to fifteen metric tonnes per hectare in Malawi, Zambia and Zimbabwe. These commercial farmers' yields vary depending on whether the maize crop is produced on dry or irrigated land.

The yields obtained by small scale farmers are, however, sometimes low in Zambia, Malawi and Zimbabwe for multiple reasons; low hybrid maize adoption, poor farming methods, lack of credit for small scale farmers and perennial droughts. These low productivity problems are worsened by lack of awareness of the derived benefits from hybrid maize adoption by small scale farmers. This slow and low hybrid maize adoption is one of the major causes for low food productivity.

Low productivity, coupled by persistent droughts, forces the governments of Malawi, Zambia and Zimbabwe to occasionally give imported grain hand-outs to small scale farmers to alleviate hunger. The grain hand-outs are usually imported due to local short supply thus diverting foreign currency which could be used for other developmental projects.

The three countries in the study were once under British colonial administration and were referred to jointly as Rhodesia-Nyasaland. This gives Malawi, Zambia and Zimbabwe historical similarities, pre and post-independence. This has led to similar approaches on how the 3 countries administered agriculture. Hence the three countries have carried on with agriculture extension services that were inherited from the past. Extension services influence the adoption of hybrid maize by small scale farmers, but at varying success rates. In addition to the administrative similarities in agriculture Zambia, Zimbabwe and Malawi share similar weather patterns and the performance of hybrid maize across the 3 countries is fairly comparable.

Due to lack of funds by small scale farmers, the three governments assist small scale farmers with subsidised and free inputs using Farmer Input Support Programs (FISP). Even though the

provision of inputs has temporarily improved productivity, budgetary constraints by governments of all three countries have made input support programs unsustainable. This has also been affected by lack of a well monitored mechanism for farmers to pay back to ensure program funds revolved sustainably. This situation is also worsened by perennial droughts that lead to low productivity by small scale farmers. Hence this study explores the impact of sustainable hybrid maize adoption by small scale farmers as a solution to low productivity and hunger, and barriers to this adoption.

Unlike other previous studies on hybrid maize adoption that looked at one or two factors, this study holistically explores various factors that affect hybrid maize adoption by small scale farmers. To analyse this, a pragmatism research philosophy is adopted for this study which has obtained evidence through sampled respondents from Malawi, Zambia and Zimbabwe composed of small scale farmers, farmer organisations, policy makers, fertiliser and agro-chemical companies, non-governmental organisations and grain traders.

Research results from 460 completed questionnaires, analysed by Statistical Package for Social Sciences (SPSS) and 30 in-depth interviews, show that hybrid maize largely achieves higher yields than open pollinated varieties (OPV) in the focus countries. To support the research finding on hybrid maize outperforming OPV, data collected show that farmers planting hybrid maize have a better net income than those farmers growing OPV maize, even though hybrid maize incurrs higher production costs. This study also shows that the adoption of hybrid maize leads to improved social and economic livelihoods of small scale farmers.

Further results gathered from qualitative and quantitative analysis of the data show that policy makers and extension officers have the greatest influence on hybrid maize adoption by small scale farmers. The main handicap for extension officers is low government funding for their mobility, rendering them inefficient as they struggle to reach the farmers in their areas. Ultimately this lack of resources for mobility and lack of credit availability to small scale farmers results in slow hybrid maize adoption.

To resolve the credit availability problem the study recommends sustainable funding by private funders backed by banks and public organisations. The study shows that hybrid maize and OPV production can be affected by other factors like climate change, poor agronomic practice, lack of irrigation infrastructure and pre and post-harvesting losses. These adverse factors like drought can be mitigated by the establishment of irrigation to sustain the production of hybrid maize, and post-harvest losses can be reduced by the improvement of road infrastructure which will facilitate early grain deliveries, otherwise farmers are recommended to store maize using airtight hermetic bags that protect maize grain from storage pests.

List of Acronyms and Special Terms

ADMARC: Agricultural Development Marketing Corporation

Agritex: Agricultural & Technical Extension Services

AQUAMAX: Drought Tolerance Breeding Technology

CA: Conservation Agriculture

CGIAR: Consultative Group for International Agricultural Research

CIMMYT: International Maize and Wheat Improvement Centre

COMESA: Common Markets for Eastern and Southern Africa

DBA: Doctorate in Business Administration

DTMA: Drought Tolerant Maize of Africa

FAO: Food and Agriculture Organisation

FISP: Farmer Input Support Program

FRA: Food Reserve Agency

GMB: Grain Marketing Board

GDP: Gross Domestic Product

Ha: Hectare

IA: Impact Assessment

ICT: Information Computer Technology

Kg: Kilogram

MMR: Mixed Methods Research

Mt: Metric Tonnes

NGO: Non-Governmental Organisation

OPV: Open Pollinated Varieties

SADC: Southern African Development Community

SR: Southern Rhodesia

SPSS: Statistical Package for Social Sciences

SSA: sub-Sahara Africa

WEMA: Water Efficient Maize of Africa

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CHAPTER ONE: INTRODUCTION

1.1 Research Background Context

The United Nations (2019) has projected that the world population will increase from 7.7 billion in 2019 to 9.7 billion by 2050 (Nature, 2010). Similarly, the African population is going to double from the current 1.2 to 2.4 billion by 2050. This increase in population means farmers need to have better skills and resources that will enable them to adopt farming innovations to produce enough food to feed an additional 2.0 billion people globally (Lamontagne-Godwin et al, 2019). Malawi, Zambia and Zimbabwe are the focus countries in this study and are also experiencing population growth with Malawi expected to grow from the current population of 18.6 million to 38.1 million by 2050, Zambia to grow from a current population of 17.8 million to 39.1 million by 2050 and Zimbabwe to grow from a current population of 14.6 million to 23.9 million by 2050 (World Bank, 2019).

In these three countries, small scale farmers produce 80% (Chirwa, 2005) of maize, the staple food that is important for feeding the growing population in these countries. This responsibility puts small scale farmers in a very important and strategic position for food production, but in Malawi, Zambia and Zimbabwe; they all have similar problems of low productivity that contribute to food insecurity and hunger. These three particular countries also share other similarities that include: their colonial federal, political and economic administrative history, similar geography and weather patterns, common official language-English, similar cultures and similar administrative structures organised by provinces, districts and wards.

Although there are large commercial farmers (with lands above 20 hectare up to 1000 hectares) in the three countries their role in producing staple food is smaller than small scale farmers.That said, whilst commercial farmers produce 4 to 15 Mt of maize per hectare small scale farmers persistently produce only 1 to 3 Mt per hectare. This risks food shortages overall in these countries, but it also indicates the potential gains if small scale farmers are able to boost yields. In the meantime, however, low yields translate also into low incomes. In some cases farmers' income is less than $1USD/day (World Bank, 2019) leading to serious poverty because small scale farmers rely on agriculture.

Despite getting much higher yields, unfortunately large commercial farmers are less interested in producing maize grain because they are maize grain price sensitive, unlike small scale farmers who are compelled to produce for subsistence and sell any excess grain. The maize price is controlled by governments in the three countries, and this is set at unfavourably low prices, for the benefit of consumers. This has led to commercial farmers opting only to produce enough maize for their consumption and focus on other crops like soyabeans and tobacco as cash crops. This is the prompt of this study which explores how small scale farmers can sustainably improve grain productivity by adopting hybrid maize whilst mitigating other factors that negatively impact productivity.

The cause of this low productivity has been a combination of factors that include, poor yields, lack of funding for farmers, erratic rains, poor farming methods, high cost of inputs and lack of resources to support government programs on the ground (World Bank, 2019 and Nature, 2010). In addition to these challenges, farmers in Malawi, Zambia and Zimbabwe also face problems of maize pests and diseases, for example the Fall Armyworm (FAW) which is now persistent and devastating for maize in Southern Africa. Since 2017, FAW has been difficult to control because the pest is new to the region and agro-chemical companies are still figuring out how best the pest can be controlled (The Conversation, 2017). In addition to the above factors small scale farmers are facing diminishing land resources due to other competing demands such as mining, new cities and other land demanding projects (World Bank, 2019). Other studies, however, have identified additional factors that affect small scale farmers' productivity and adoption of better farming technology.

Farm size and farmer level of operation influence the adoption of farming technology in east Africa (Feder and Umali, 1993). Small scale farmers with bigger fields of land size of more than 6 hectares adopted new technologies by copying practises from their neighbouring large commercial farmers in Southern province of Zambia (Persson, 1993). In this example the fields of commercial farmers acted as demonstration plots. Again, in this study smaller small scale farmers did not appreciate learning from the big commercial farmers.

In a study carried out in Ethiopia it was revealed that the process of technology adoption has been slow due to ineffective extension and technical information given to small scale farmers (Shiferaw et al, 2011). Further studies carried out on farmer education levels showed that small scale farmers in the three focus countries were low and therefore extension information dissemination needed to be done through more compelling methods that include demonstration plots and training. This is critical for farmers to understand and get trained on how to adopt new technology (Chetsanga, 2000). Demonstration plots and radio adverts are used where literacy levels are low and an example where small scale farmers responded positively to hybrid maize demonstration plots was in the Manica province of Mozambique (Cavane and Donavan, 2011; Davis et al, 2012 and Ransom et al, 2003). Other methods used to transmit technology information to low literacy level small scale farmers included farmer training and farmer field schools (Foster and Rosenzweig, 1995 and Doss et al, 2003). The training offered to small scale farmers included crop spacing, fertiliser application, pest control and minimising pre and post-harvest losses.

More studies revealed that communication behaviour and socio-cultural characteristics of adopters determined the adoption and diffusion of innovations (Havens, 1972). More educated and wealthy small scale farmers were more willing in taking up the hybrid maize technology in Malawi (Chirwa, 2005). In a study carried out in Ethiopia, low literacy level, poor access to road network, lack of credit and lack of extension services caused low technology adoption by small scale farmers (Croppenstedt and Demeke, 1996). Therefore, from these two studies low literacy levels can slow down hybrid maize adoption.

More literature revealed that factors like cash availability and the absence of credit lines to buy maize seed and other inputs had a big bearing on the adoption of maize hybrid by small scale farmers in southern African countries (Matusckke, 2007). This situation of cash constraints hindered progress of technology adoption by small scale farmers in Uganda (Bocquecho and Jacquet, 2010). To evaluate the impact of credit constraints on the adoption of hybrid maize in

Malawi a treatment effect model was used. The results obtained showed that credit constraints limited the amount of land allocated to hybrid maize (Simtowe et al, 2009). The study on cash constraints was also reviewed earlier in Malawi where lack of financial resources and low-priced commodity markets affected the rate of hybrid maize adoption (Zeller et al, 1998). The Malawian example confirmed earlier observations by Persson (1993) in Zambia where farmers with larger land and resources allocated a larger portion of their land to hybrid maize. This phenomenon was also observed in Nigeria where wealthy farmers adapted to maize technology faster than poor farmers (Chianu et al, 2007). The provision of subsidised inputs through the FISP program in Malawi also made it possible for farmers to access affordable maize hybrids and fertiliser (Chirwa, 2005).

The occurrence of prolonged droughts due to climatic change has had a big impact on productivity and to mitigate this devastating problem governments need to work on the provision of irrigation to small scale farmers (Soler et al, 2007). In Zimbabwe, flood irrigation schemes have been established in the lowveld areas of Manicaland and Masvingo provinces (Rukuni et al, 1998). These areas receive below 500 mm of rain annually and few of the communities have always utilised the irrigation facilities to cushion them from the perennial erratic rains.

More studies reviewed showed that improved maize hybrids and the application of fertiliser resulted in successful maize hybrid adoption in Ethiopia (Feleke and Zegeye, 2006; Gbre-Madhin and Haggblade, 2004). This example ties in well with the FISP experience in Malawi where farmers accessed fertiliser through the program. The Ethiopian results were also found in similar studies conducted in Mozambique, Kenya and Zambia where the use of fertiliser enhanced productivity of maize hybrids (Mapila et al, 2012 and Schroeder, 2013).

To minimise the impact of adverse conditions, hybrids offer better tolerance to drought and pests than OPVs. The explanation scientifically is that in the making of a hybrid there are two or more genetically different maize parents that are cross pollinated to make the final hybrid. These different parents contribute attributes like drought, diseases and pest tolerance into the genetic make up of the maize hybrid. Because of this technological capability in hybrids, other technologies like AQUAMAX can be incorporated to enhance drought tolerance (Martin and Shepherd, 2009). This capability in hybrids is not easily incorporated in OPVs because of the genetic makeup of OPVs (Kassie et al, 2017).

To benefit from hybrid maize technology, the importance of agriculture extension to food security and poverty reduction is discussed. Small scale farmers are encouraged to buy high yielding hybrid maize, but for them to realise the best yields they must adopt farming methods that minimise the impact of climatic changes. Therefore, the farmers also need to adopt sustainable farming methods that include conservation agriculture (CA), crop rotation and the construction of contour ridges for soil conservation (Gibbons and Ramsden, 2008). Farmers in the focus countries are familiar with contour ridges and crop rotation as this was a strict requirement under the Federation administration. Extension support is also required so that the small scale farmers are technically supported for better food productivity to avert hunger (Shiferaw et al, 2011 and Abate et al, 2015).

Studies elsewhere have shown the benefits of extension. In Mexico the government supported the adoption of maize hybrid technology through extension services (Sanchez-Toledano, 2018). Field demonstration plots led to full support from small scale farmers. Bellon et al (2011) examined agricultural modernisation among small scale farmers in Mexico and the results showed substantial widespread adoption of hybrid maize. Government programs encouraged farmers to shift from their traditional OPV varieties to maize hybrids and this resulted in improved yields. The Mexican farmers responded positively to the advice and grew hybrids that were more suitable to climate change. This Mexican experience showed that the adoption of hybrid maize and extension work resulted in productivity and improved livelihoods of farmers.

That said, the hybrid maize adoption response in Mexico was more positive compared to the experience in the three focus countries. The study will review reasons why hybrid adoption in Malawi, Zambia and Zimbabwe was not at a comparable rate with the Mexican experience. In the United States successful extension services are offered by the state, where some of the research results are taken to farmers for implementation through well-coordinated field trials. For the trials to be useful to farmers communication is done through various media channels that include audio visuals and print media. This type of extension service has had resounding success over time (Beavers, 1985).

Malaysia and Thailand are other examples of successful extension services. Extension in these countries is responsible for training, information dissemination to farmers, media production and services and setting up demonstration and experimental plots (Beavers, 1985 and Poolsawas and Artachinda, 2011). These extension activities are carried out by both the Ministry of Agriculture and universities. Their main goal is to improve food security and livelihoods. Rivera (2003) analysed the role of agriculture extension and rural development, and showed that agricultural extension has an important role to the eradication of food insecurity. Recommendations from the study highlighted the following key areas: The extension service is better managed through integrated farming projects, the extension officers need to assess the needs for the farmers so that their advice is relevant, extension officers need to be involved from planning all the way to planting and finally farmers need to be informed of potential markets (Beavers, 1985). These successful examples of positive results from Mexico, Malaysia and Thailand, however, need to be reflected on, to see how they can best be transposed to the focus countries.

Maize is an important crop because it provides nutrition and food security. Governments sometimes can feel politically threatened whenever there is food shortage. Most governments can fear food riots because it is difficult to control hungry people. To alleviate hunger and poverty, governments of various countries set goals on food security (The United Nations, 2019 and Dejon, 1980). Hence maize is treated as a political crop in the three focus countries and government policies are set on food production to safeguard food security (Smale et al, 2013). Adoption of technology is influenced by policy makers through their political systems and through a variety of diffusion processes (Walker et al, 2011). Government policies influence the adoption of hybrid maize (Walker et al, 2011) and below are examples of government policies that are aimed at improving farming, marketing grain and adopting hybrid maize in Africa and other parts of the world.

Shifting cultivation (where farmers keep moving from one piece of land to another without following proper conservation methods) in Zambia, practised by small scale farmers has been banned by the Zambian government citing land scarcity, bio-diversity preservation, game parks, conservation of natural forests, maintaining productivity and protecting soil erosion (Reardon et al, 1999 and Ngwari et al, 2009). These sustainable policy reforms protect ecological environments and have been successful in Zambia, but more effort is needed in other countries where soil degradation is a problem.

Positive government involvement is demonstrated in Tanzania where the grain market was liberated to encourage commercial maize grain trading (Putterman, 1995). Duncan and Jones (1993) observed that various reforms, that included private buyers setting market driven pricing encouraged more maize grain trading in Tanzania and more importantly the pricing remaining affordable to consumers. In Ethiopia a study that reviewed the liberalisation of markets by the government in the 1990s alongside the promotion of seed and fertiliser packages resulted in improved yields (Spielman et al, 2010). This reduced the dependency on government food handouts that are mostly imported and costly to governments. Another example of a deliberate policy to enhance production was cited by Duncan and Jones (1993) in Uganda where government and NGOs initiated successful grassroots programmed policies to promote maize grain prices driven by the market for small scale farmers (Reardon et al, 1999). Additionally, the Ugandan government gave imported and locally produced inputs agricultural tax incentives for small scale farmers to access reduced priced inputs, which reduced cost of production for the farmers (Danida, 2005).

To further review how small scale farmers can be institutionally supported in a regionally harmonised seed industry, a study was conducted to understand institutional bottlenecks that affect adoption of maize hybrids in east and southern Africa and caused challenges of food shortages (Langyintuo, 2008). The study examined seed production, proprietary breeding material security, marketing and credit availability as the main bottlenecks. This enabled targeting of remedial strategies involving all stakeholders needing to be put in place to improve hybrid maize adoption.

This takes us to a very important effort on seed laws harmonisation, which has started to get traction in the Southern African Development Community (SADC) and Common Markets for

Eastern and Southern Africa (COMESA) trading countries (Smale et al, 2013). Seed law harmonisation involves the steps required by government seed authorities to register and trade maize hybrids. Fortunately, the seed harmonisation protocol has been finalised and implemented for COMESA benefitting small scale farmers from Malawi, Zambia and Zimbabwe to access maize hybrids from COMESA trading bloc as long as the hybrid maize is registered in two COMESA countries (Kuhlmann, 2015). To date the other seed harmonisation protocol for SADC is now at an advanced stage of being signed by member states. Steps towards harmonised seed trading protocols does help to reduce the cost, to seed companies, for the introduction of new hybrids resulting in reduced hybrid maize prices to small scale farmers in these regional trading blocs. Seed trade harmonisation also helps to reduce the time it takes for hybrid maize registration, allowing for quicker access by the farmers.

The adoption of maize hybrids can be used as an example of a government-set goal for the purpose of food security (FAO, 2015). It is therefore necessary to analyse the impact of government policies on maize hybrid adoption because government policies are a key variable that determines the success or failure of hybrid maize adoption (Sanchez-Toledano et al, 2018). This is important, because although smallscale farmers are the intended beneficiaries, they are often guided by the government extension service. To review the impact on hybrid maize adoption, Malawi can be used as an example. In Malawi the government implemented a Farmer Inputs Support Program (FISP) that was initially supported and funded by the donor community, resulting in a resounding success (Chirwa, 2005). In this program small scale farmers were given subsidised hybrid maize seed and fertiliser, and this resulted in Malawi progressing from a market deficit of 43% to a surplus of 53% (Ellis et al, 2003 and Denning et al, 2009) after implementing the input subsidy program from 2003 (Chirwa, 2005). Another study conducted in Malawi in 2011 confirmed that the adoption of maize hybrid by small scale farmers is directly influenced by government policy, funded and supported by the donor community (Howlett and Walker, 2012).

This particular FISP policy helped the alleviation of hunger in East Africa (Chirwa and Dorward, 2013) leading to countries like Zambia and Zimbabwe following similar policies for their small scale farmers, to improve maize productivity (Chirwa and Dorward, 2013). The FISP program led to Zambia exporting excess grain to neighbouring countries. However, after such a successful FISP story in Malawi the present study will explore reasons why the FISP program has not sustainably continued producing enough food in the three countries in the longer term, compared to its intial success in Malawi.

Regrettably some government policies can negatively affect production. An example is the failed Zimbabwe government policy on cooperatives, intended to benefit small scale farmers (Akwabi-Ameyaw, 1997). This policy's intention was for small scale farmers to work together by combining resources, draught power, sharing of knowledge and labour for better productivity. The cooperatives failed due to lack of farm resources, equipment, lack of coop leadership quality and general strategic direction and lack of follow up by government during the implementation stages. Other factors missing were the development of an effective management team, hard work and a culture that fosters trust, support and productivity. Some government policy interventions, with good intent, have also created a dependency culture. In Malawi some farmers ended up not producing enough food whilst waiting for hand-outs (Sharaunga and Wale, 2013). A similar negative effect resulted from the NAFTA agricultural policy reform in Mexico in 1994.

As revealed in the Malawian example, hybrid maize technology supported by subsidised inputs can improve food productivity amongst small scale farmers. But given the level of poverty amongst these small scale farmers, there is need for initial support via input subsidies before they can sustainably be left alone to produce food by themselves. This study will review how small scale farmers can move from subsidies to levels where they can sustainably buy their own inputs to produce food. The Malawian example resulted in reduced level of poverty and improved food security, with children receiving better education and health care as a result of higher farming incomes (Belion and Risopoulos, 2001 and Becerril, 2010). Similarly, hybrid maize technology adoption by small scale farmers in Ethiopia and Tanzania improved farmers' productivity leading to better lives economically and socially (Asfaw et al, 2012). It is also necessary to note that the impact of hybrid maize adoption does not only benefit the farmers but also has wider benefits for the countries. For example, improved food productivity results in food security at the national level, reducing the need for food imports.

Given the food shortage challenges experienced by small scale farmers this study has been conducted to specifically review the impact of hybrid maize adoption by small scale farmers in Malawi, Zambia and Zimbabwe. Through the study an analysis will be carried out on why low productivity and hunger are still prevalent in the three countries, even after decades of hybrid maize technology being available. The study will propose sustainable solutions so that the three countries will be able to feed the growing population by 2050. In so doing, it will draw on the many years of experience the researcher has in the agriculture field, offering sustainable food security solutions to small scale farmers.

With the expected hybrid maize performance advantage, government officials'role in Malawi, Zambia and Zimbabwe is to encourage small scale farmers to adopt the technology so that they improve productivity and food security. However, from the 1950s, the period when hybrid maize was first introduced to small scale farmers, the rate of adoption has been slow and varies by country. It took Zimbabwe more than 40 years to reach 95% adoption and currently Malawi and Zambia are still at an adoption rate of 50 to 60% (World Bank, 2019). This study is going to analyse reasons behind these statistics. It seeks to understand how different stakeholders influence small scale farmers to adopt hybrid maize technology and other new technologies. This will lead the study to critically review why stakeholders' influence has not yielded good sustainable results to improve small scale farmers' yields and productivity. It will also explore the impact of mitigation measures like CA and irrigation development to combat persistent erratic rains.

Answers will be provided from a detailed analysis of in-depth interviews and surveys conducted with farmers and other stakeholders. The literature reviewed in the study shall help to support the research results. The survey and in-depth interviews gathered from stakeholders such as policy makers, small scale farmers, farmer organisations, NGOs, seed and fertiliser companies who are in the adoption of maize hybrid shall provide evidence-based research results that drive the agenda of hybrid maize adoption (Wambungu, 2014).

Below is a detailed background on the political, economic and historical backgrounds of the study countries. This will lead to the comparison of differences and similarities of the three countries' policies regarding the diffusion and adoption of hybrid maize. This detail starts with Figure 1 below showing the relative locations and size of the three countries.

1.2 Historical, Political and Economic Background of Zimbabwe, Zambia and Malawi

In this section the historical, political and economic contexts of Zimbabwe, Zambia and Malawi are reviewed regarding the status of hybrid maize. The map of Southern Africa shown in Figure 1 provides a guide to the location of the countries.

Figure 1: Map of Southern Africa.

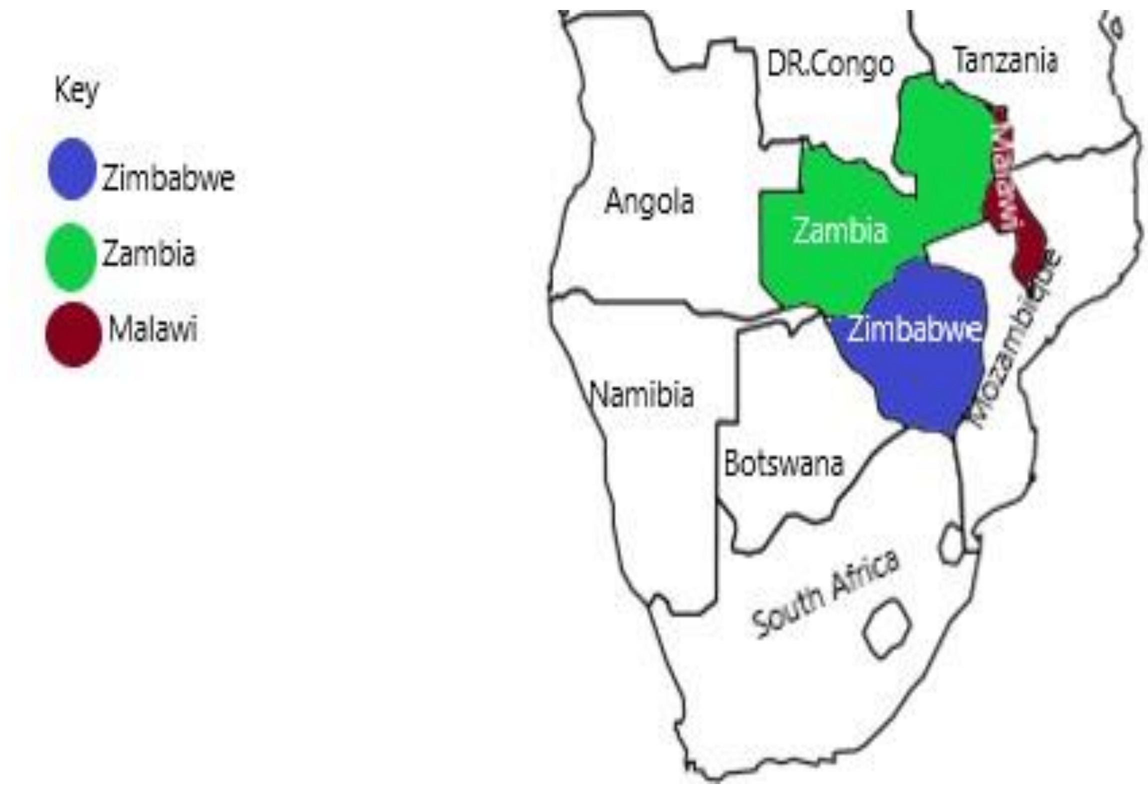


Table 1 below has details of sizes, populations, GDPs, agricultural land sizes, rural populations and percentage of agricultural GDPs of Malawi, Zambia and Zimbabwe.

Table 1: Populations, Land Area and GDP for Malawi, Zambia and Zimbabwe

Country	Area Sq Km	Agric Area Sq Km	Population (Millions)	Rural population %	GDP USD Billions	% GDP Agric	SSF-Farm Sizes Ha
Malawi	119,140	57,900	18.60	83.06	6.30	28.00	1-2
Zambia	752,618	238,360	17.80	56.48	25.81	2.58	5-6
Zimbabwe	390,757	162,000	14.60	67.79	17.85	12.08	5-6
Total	1,262,515	458,260	51.00	69.43	49.96	9.20	1-6

It follows from Table 1 that the size of small scale farms in the three countries are influenced by their population density and size of agricultural land. Although Malawi is the most densely populated (Pachai, 1973) the large portion of their population depending on agriculture is an issue given that it has the smallest agricultural land area compared to Zimbabwe and Zambia. As a result, the Malawian population depends on agriculture the most and suffers the most from hunger when yields are poor.

1.3 Maize Production Status in Malawi, Zambia and Zimbabwe

Maize was first brought to Africa by Portuguese traders who traded with local people in East and Southern Africa from 1500 up to the nineteen century. This led to maize being grown widely from those early years and has been planted alongside other small grains by indigenous people in this region. Over the centuries, the crop has become very popular especially in the South and Eastern parts of Africa (Smale et al, 2013) and became a staple food in Malawi, Zambia, Zimbabwe, Lesotho and South Africa. The varieties grown during the early stages were OPVs with maize hybrid introduced in East and Southern Africa from the 1920s onwards (Blackie, 1987; Chiduza et al, 1994 and Rusike et al, 1995). The adoption rate in the early days was very slow due to limited interest and low research and development interest by the settler governments. Over the years, maize slowly became a major calorie contributor in these countries. In Malawi maize contributes

50% of the calories and it is popularly known as,'' *Chimanga ndi moyo*'' in the local Chewa language which means ''maize is life". In Zambia maizecontributes 58% of the total calories consumed, in Zimbabwe maize contributes 39.5% and in South Africa it contributes 40% of the calories (Smale et al, 2013).

Zimbabwe Maize Perspective

A very productive single cross hybrid maize was developed in Africa, SR 52, bred and registered in Southern Rhodesia in 1960 (Tattersfield, 1982). SR 52 had a 46% yield advantage over improved OPV varieties that were present at that time. The hybrid maize culture in Southern Rhodesia was further forced to improve because of the sanctions imposed on Southern Rhodesia following its unilateral declaration of independence (UDI) from Britain in 1965. The government maize researchers were tasked with breeding early maturity hybrids that included R200, R201 and R215 for food self-sufficiency and food security for the country (Blackie, 1987 and Rukuni et al, 1998). This situation was supported by the best growing climatic conditions in the world: Rhodesia produced the best yields in the world for maize, cotton and groundnuts (Power, 2003), sustained by the then Rhodesian government. This recognised world performance in the 1970s earned Rhodesia the term ''bread basket of Africa'' (Power, 2003).

The adoption of hybrid maize slowly but surely continued in Zimbabwe, during pre- and post-independence eras. Small scale farmers observed hybrid maize performance from their neighbouring commercial farmers who had been adopting and growing hybrid maize. Small scale farmers continued adopting maize hybrids from pre- and post-independence period and by 1985 the hybrid maize adoption rate by small scale farmers was more than 95%. This led to a bumper harvest of more than 3 million tonnes of maize in 1985, of which 80% came from small scale farmers (Mashingaidze et al, 2006). In that year with favourable rainfall conditions, small scale farmers averaged 3 tonnes per hectare.

The provision of credit to small scale farmers by the parastatal Agricultural Finance Corporation (AFC) also made it possible for small scale farmers to fund their inputs for maize production (Chiduza et al, 1994 and Rukuni et al, 1998). Unfortunately, the funding was later stopped by the government in the 1990s due to poor performance of the repayments caused by poor supervision of farmers. This affected the good farmers that had been paying back their loans. Even though small scale farmers continued growing hybrid maize, their productivity was reduced because funding to buy fertiliser had stopped and so maize yields fell below 1Mt/ha over the years.

Despite the current hybrid maize adoption rate (95%) and the presence of a robust seed industry that boasts of multi-national companies like Bayer-Dekalb, Corteva-Pioneer, Seed Co-Lima Grain and Syngenta; Zimbabwe is still experiencing low yields by small scale farmers of less than 1 Mt/Ha. Production has been very low, forcing the Zimbabwean government to import maize to feed its population.

Malawi and Zambia Maize Perspective

Zambia's and Malawi's maize production background is similar to Zimbabwe's because of the three countries' federation history narrated above. Also, they now belong to the SADC and COMESA trading blocs whose roles are enshrined in food security. These two countries, like Zimbabwe, also benefited from hybrid maize research that was done in the 1940s resulting in hybrids that were registered in the 1950s and 1960s. At independence the two countries used similar maize hybrids as were grown in Southern Rhodesia and South Africa. From the 1970s, Zambia had an input subsidy scheme (Smale et al, 2013) that supported the production of maize by small scale farmers to safeguard food security (Xu et al, 2009). This input subsidy program continued through the 1980s until the 1990s when it was stopped. It was later resumed in 2002 as a fertiliser support program (FSP) (Mason and Ricker-Gilbert, 2013; Mason et al, 2013). The program was later named the Farmer Input Support Program (FISP) (Chirwa, 2005).

The FISP program comprised of subsidised 200 kg basal fertiliser, 200 kg top dressing fertiliser and 20 kg seed (McMichael and Schneider, 2011). These inputs were given to all farmers in the selected districts but the inputs only covered one hectare. Even so, as a result of input provision at subsidised prices the production of maize improved significantly and as of 2019, Zambia is maize grain self-sufficient, and it is a net exporter of maize (FAOSTAT, 2019). Yield levels have also improved from below 1.5 metric tonne (Mt) per hectare (Ha) to 3 Mt/Ha due to the subsidised inputs from the FISP program (FAOSTAT, 2019). Based on the researcher's experience on the ground, this level of success with the FISP program meant that farmers did not thinly spread their inputs over additional areas of land, as was the case with Zimbabwe and Malawian farmers, limiting the effectiveness of the inputs provided.

The hybrid maize seed market in Zambia (FAOSTAT, 2019) features mostly the same players in Zimbabwe and is highly competitive, despite hybrid adoption rate currently at only 60%. This is because small scale farmers tend to stick to old OPV maize varieties despite the availability of hybrid maize. Generally, hybrid maize at introduction, perform at about 25% to 30% better than OPV (Magorokosho, 2006) but unfortunately farmers are loyal to stable OPV maize. Based on the researcher's experience it is this that is contributing to the slowness of farmers adopting hybrid maize in general.

Maize in Malawi has been grown widely and maize hybrids have also been adopted since the 1950s, the period of Rhodesia-Nyasaland administration. As mentioned earlier, the 3 countries got their hybrids from the research centres in Southern Rhodesia and from independence onwards Malawi continued using these hybrids until the early 1980s when similar Zimbabwean and Zambian regional seed companies established their seed businesses in Malawi. Similarly like the Zambian situation, hybrid maize adoption has been slow and is currently at 50% (FAOSTAT, 2019). Studies carried out in Malawi show that the small scale farmers always plant flint OPV maize and dent hybrid maize. Flint OPV maize varieties, despite their low yields, are always preferred for consumption because they taste better than dent maize and they are not easily attacked by weevils (Smale et al, 2013). Given this background and low productivity by small scale farmers, the Malawian government introduced the FISP program in 2003. The program led to improved productivity over the years resulting in grain surpluses (Chirwa, 2005) and improved food security by 2012. However, in the last few years the FISP program has not performed as desired and the study will investigate the reasons for this (Ricker-Gilbert et al, 2013).

By way of comparison the study countries can be compared with other parts of sub-Sahara Africa (SSA) regarding hybrid maize adoption. Starting with South Africa (SA); hybrid maize culture came into SA in the 1920s and as happened in Zimbabwe during the 1950s commercial farmers adopted hybrids and yields improved resulting in average yields, to 2-3 Mt/Ha. From the 1970s onwards South Africa was isolated from the rest of world due to Apartheid-related boycotts and multinational seed companies did not invest into SA until the 1990s when Apartheid was abolished. The same seed companies based in Zimbabwe then invested in South Africa and influenced the hybrid maize culture. Currently the hybrid maize adoption rate is more than 95% and the SA maize seed market has even accepted GMO. GMO technology can only be inserted genetically in existing or new hybrid maize to combat diseases, insects and weeds. Seventy five percent of maize hybridsin South Africa are now GMO (World Bank, 2019 and FAOSTAT, 2019). South Africa is self-sufficient in terms of maize grain due to the fact that, unlike the three focus countries, in South Africa most of the maize is produced by commercial farmers who produce 80% of the country's maize. The yields achieved by South African commercial farmers range from 5 to 15 Mt/Ha (Smale et al, 2013).

Secondly it is important to compare hybrid maize adoption in Kenya and other eastern African countries with fellow southern Africa countries because hybrid maize is a staple food in Kenya (Mason et al, 2013) and has been grown for more than 60 years. Kenya's hybrid maize adoption rate is currently at 60%. All the eastern Africa countries like Malawi, Zambia and Zimbabwe have similar land sizes for small scale farmers with more than 80% of grain production by small scale farmers. There are similarities and differences that can be learnt by further comparing with countries like Tanzania, Ethiopia, Uganda and Kenya. Kenya is the biggest maize producer and its adoption rate is 60% whilst Tanzania, Ethiopia and Uganda's adoption rates range between 10 and 40%.

Lastly the western parts of Africa occupied by, for example, Nigeria and Ghana have the lowest area planted to maize compared to all other areas in Africa. This is because the population depends on cassava and other alternative crops than maize. In those countries the hybrid maize adoption rate is between 5 and 30% (Smale et al, 2013). Again, it is important to mention these countries in the west because maize is also produced mainly by small scale farmers and future plans are there to increase production in this part of Africa.

Global Maize Production Status

Maize is a crop that is grown globally. In order to understand the context of maize production in Malawi, Zambia and Zimbabwe discussed above, we reflect on general features of maize and its production. More than 50% of the global tilled maize land is planted to maize hybrids. Yellow maize hybrids constitute 80% of the maize grown globally and the balance is white, a preferred colour in Africa, where it is consumed as a staple food (Shiferaw et al, 2011).

In total, maize, rice and wheat provide 30% of food calories for more than 4.5 billion people in 94 developing countries. This include 900 million people who use maize as a staple, who are poor and are mainly in Africa and South America. Maize is currently grown on 100 million hectares in 125 developing countries (FAOSTAT, 2018) and maize demand is expected to double by 2050 to partly feed a world population that will have grown to 9.7 billion (Rosegrant and Agcaoili, 2010). Although maize yields have improved globally, productivity in the three focus countries has remained stagnant in the past 5 years. In recent years in particular, this could be attributed to droughts although in Zimbabwe the economic recession experienced in the country over the past 20 years will also be a factor (Power, 2003).

Maize also provides 90% of the energy component in animal feed although it is affected by price volatility depending on supply and demand from year to year. Notably demand from China has recently been affected by reduced demand as a result of the outbreak of African swine fever (Vergne et al, 2017). Given these fluctuations farmers need to plan in anticipation of these volatile factors. Also, these players in the maize production industry continue to invest in productivity efforts so that farmers can maintain and increase production of this important cereal. Unless concerted effort is taken to address these challenges and increase productivity, East and Southern Africa in particular may face food shortages leading to starvation and malnutrition. This situation is particularly true in the three study countries where there is current evidence of both low productivity and starvation (CIMMYT, 2018).

Efforts to improve maize productivity have also been increased through hybrid maize breeding technology. The International Maize and Wheat Improvement Centre (CIMMYT), headquartered in Mexico, is one of the leading organisations founded more than fifty years ago mandated to improve livelihoods through maize and wheat science. CIMMYT was initially funded by the Mexican government and Rockefeller Foundation. This development led to improved scientific research that produced improved maize and wheat varieties. Mexico became food sufficient from the 1950s to 1960s because of consistent donor funding unlike the situation in East Africa where donor funding was short lived. Under the scientific leadership of Norman Borlaug, wheat and maize varieties developed by CIMMYT were tolerant to disease and stable in yield. Some of the wheat varieties were adopted during the Green Revolution in Pakistan and India in the 1970s. This success story led to Borlaug winning the Nobel Peace Prize in 1970 (CIMMYT, 2018).

In recent years the work at CIMMYT has been funded by CGIAR (formerly the Consultative Group for International Agricultural Research) through several contributors that include USDA, USAID, CSIRO, EC, DFID, FAO, CAAS, CRS, Syngenta, HAU, MAFF, SDC GR and others. These funding partners made it possible for CIMMYT to achieve their strategic goals that include food security, improved livelihoods, providing stress tolerant varieties, poverty reduction and improved nutrition by 2030, reduced malnutrition and improved female farmers' participation in food production (CIMMYT, 2018). To mitigate climatic change effects CIMMYT and other maize seed producers have introduced AQUAMAX, WEMA and DTMA bred hybrids that are drought and heat tolerant (CYMMIT, 2018). The usage of fertilisers and the adoption of hybrid maize resulted in improved yields from 2003 onwards (Delmer, 2005 and Chirwa, 2005) leading to maize production increasing annually by 6% in Asia, 5% in Latin America and 2.3% in sub-Saharan Africa (SSA) (FAOSTAT, 2018).

Hybrid maize, now important in global maize production started in the early 1900s and was further advanced in Iowa, USA, by Henry Wallace (Brown, 1983). Wallace developed the early maize hybrids between 1922 and 1926 when he formed the Hi-Bred seed company. Through his various experiments he crossed different maize inbred lines that resulted in high performing hybrid maize that out-competed existing OPV maize of that time. The crossing of the different maize lines brought together good maize attributes that led to better yields, improved adaptability and disease tolerance.

The science of maize breeding was later expanded with better genetics and Wallace's Hi-Bred Seed Company grew into the present day, global seed company, Pioneer Hi-Bred. Through Wallace's influence and by the time of his death in 1965, the hybrid maize culture had been widely adopted in the USA (Brown, 1983). Maize yields in the USA currently range between 6 to 15Mt/Ha averaging around 8 Mt/Ha (World Bank, 2019 and FAOSTAT, 2019). This represents an increase in maize yields of 75% over 70 years driven by the adoption of hybrid maize coupled with the establishment of strong grain markets and key institutions like USDA, FAO and CIMMYT (Duvick et al, 2004).

Summary of Comparisons of Maize Adoption Policies amongst Malawi, Zambia and Zimbabwe

Table 1 above summarises differences amongst the focus countries, including land sizes, GDPs and populations. Generally, prior to the independence era the three countries had very similar policies and practises regarding the diffusion and adoption of hybrid maize amongst small scale farmers. That said, Zimbabwe had an advantage of quicker policy implementation because it had the best natural resources compared to Malawi and Zambia (Mashingaidze, 1996). This advantageous position for Zimbabwe was further strengthened by the fact that the Rhodesia-Nyasaland Federation administration resided in Zimbabwe. Hence Zimbabwe had most of the maize breeding research centers compared to Malawi and Zambia. This situation gave a better platform for farmers in Zimbabwe to adopt hybrid maize faster than Malawi and Zambia despite the three countries' similar extension set up (Magorokosho, 2006).

Following the above analysis, the period after independence saw the creation of various input schemes that supported small scale farmers to produce food to feed themselves through the adoption of hybrid maize. Unlike free input schemes that were prevalent in Malawi and Zambia from the 1970s to the end of the 1990s, as mentioned earlier, Zimbabwe started an AFC loan-based input scheme for small scale farmers in the 1980s, leading to a bumper harvest in 1985 and record hybrid maize adoption of 95% (Mashingaidze, 2006). Unfortunately, the scheme did not last because farmers later failed to pay back the loans. Given the Zimbabwean example Malawi and Zambia established FISP programs in the early 2000 which are still active. As described before the FISP program was initially successful boosting grain yields in both countries but later on government resources to sustain the programs became a challenge. This is reflected by poverty, grain shortage and low adoption rates of hybrid maize by small scale farmers in the two countries. Unlike the FISP program in Malawi and Zambia, Zimbabwe opted for the Presidential Input Scheme (PIS) which issues free inputs to small scale farmers. Besides these input schemes and similar extension staff structures (based on the researcher's professional experience) the three countries are still struggling with food shortages and this study is going to analyse how the adoption of hybrid maize can result in sustainable food production.

1.4 The Research Problem

This study is being carried out by a 'seeds man', a practitioner, a commercial farmer, a provider of advice to small scale farmers, who has worked in the seed industry with policy makers for the past 28 years. The researcher is a senior executive who runs a seed company based in Harare, Zimbabwe and has been working as a managing director for the past 20 years. The researcher, for a number of years, has observed and has been concerned by low food productivity by smallscale farmers in Malawi, Zambia and Zimbabwe. The researcher seeks to analyse the problem and recommend sustainable solutions (Gowing and Palmer, 2008) to the joint problems of low maize productivity and low food security in Zimbabwe, Malawi and Zambia. These problems exist despite the effort put on hybrid maize productivity promotion and inputs provision by the various stakeholders that include policy makers, seed houses, NGOs, fertiliser companies, farmer organisations and agro-chemical companies. The study will evaluate the reasons for the successes and failures of input programs in the focus countries as part of this analysis. Given the support and the challenges small scale farmers face, the research problem is on how the adoption of maize hybrid technology by small scale farmers can sustainably improve food production and reduce hunger and malnutrition in Malawi, Zambia and Zimbabwe.

This is against the backdrop of the Malawian success story after embarking on the FISP program in 2003. Malawi's success story will help to form the context and basis of this research given that the FISP program resulted in small scale farmers producing more than double maize grain leading to Malawi being food sufficient. The FISP program resulted in improved yields due to the availed subsidised hybrid maize seed and fertiliser. Subsidised inputs helped to close the financing gap because inputs financing to the poor farmers had been always a problem due to banks asking for collateral (Chirwa, 2005).

This provision of subsidised inputs gave farmers a big boost, but the farmers also had to follow good agronomic practises, as demanded by extension officers, to achieve good yields (Eadie et al, 2012). Despite the success of the FISP program, it did not offer a full solution to the food deficit because the program only covered part of the small scale farmers' fields due to limited resources, leaving the farmers to look for extra inputs. The program also did not cover other productivity challenges like good crop management, drought and irrigation establishment. Unfortunately, the FISP program is not sustainable because it depends on government and NGOs' heavily subsidised inputs despite various stakeholders engaging small scale farmers through training on how to manage these challenges. It is important for this study to establish what role the different stakeholders play to influence the technological knowledge transfer and the adoption of maize hybrid by small scale farmers. The study will also review how the FISP program can be improved sustainably so as to manage and avoid farmers developing dependency culture and side marketing.

The research, ultimately, seeks to establish how the adoption of hybrid maize technology can sustainably improve small scale farmers' food productivity. Most elements of Rogers' (2003) diffusion and adoption theory shall be used to underpin this study and shall be used in conjunction with stakeholder theories of Mendelow's stakeholder analysis matrix (Johnson et al, 2008) and Kurt Lewin's force field analysis (Johnson et al, 2008) to understand the role of stakeholders' involvement in the issue of hybrid maize adoption and in the study. These will be discussed in detail in Chapter 2.

1.5 Research Objectives and Research Questions

The aim of this research is to provide greater understanding on the impact of hybrid maize adoption by small scale farmers for improved and sustainable food production in Malawi, Zambia and Zimbabwe. Small scale farmers produce most of the maize produced in Malawi, Zambia and Zimbabwe. The research objectives and questions to be used in the study are as follows:

1.5.1 Research Objectives

Before detailing research objectives and questions it is important to mention that in Chapter 3 reserch objectives, questions, questionnaires and interview questions will be linked with themes demonstrating how they are connected to provide research answers.

1. To assess the impact of hybrid maize adoption by small scale farmers with emphasis on economic and sustainable food production that allows the small scale farmers to be food self-sufficient and be able to sell excess to national grain reserves in Malawi, Zambia and Zimbabwe.
2. To assess how best stakeholders can collaboratively work together to influence the knowledge transfer to small scale farmers to adopt hybrid maize for improved food productivity to feed the growingpopulation.
3. To identify the economic and social benefits brought to small scale farmers livelihoods through the adoption of hybrid maize.

In order to achieve the research objectives the following are the research questions:

1 Why has hybrid maize (innovation) adoption been slow (taking long more than 50 years) amongst small scale farmers in Malawi, Zambia and Zimbabwe?

2 How do policy makers and other stakeholders influence the knowledge transfer to small scale farmers on hybrid maize adoption?

3 What are the main causes of low productivity in maize production amongst small scale farmers?

4 What are the social and economic benefits to small scale farmers that are achieved by the adoptionof hybridmaize technology?

1.5.2 Contribution of the Research

This research contributes to the knowledge base through the study on how small scale farmers can sustainably produce enough food to feed themselve, local populations and help to avoid hunger and malnutrition by adopting hybrid maize in Malawi, Zambia and Zimbabwe. The study will also look into present policy interventions and recommend sustainable improvements on how small scale farmers can be assisted in boosting productivity. In addition, the study seeks to establish and improve on how hybrid maize knowledge and new technologies are transferred to small scale farmers in Malawi, Zambia and Zimbabwe.

The study draws on a detailed analysis of data collected during surveys and in-depth interviews conducted during field research data collection. The survey data and in-depth interviews were conducted with small scale farmers, farmer organisations, policy makers and other stakeholders that are involved in hybrid maize adoption. Both survey data collection and in-depth interviews were done from district visits to the southern province of Malawi; Blantyre, Chikwawa and Mwanza and the in the following districts of the southern province of Zambia: Chikankata, Mazabuka, Monze and Choma. In Zimbabwe, data were collected from Mashonaland East province in the following districts: Seke, Goromonzi and Mrewa. The following districts in Manicaland province were also sampled; Chipinge, Chimanimani and Mutare and finally from Mashonaland Central province, the districts of Mazowe and Shamva districts were sampled.

1.6 The DBA Research Journey and Previous Documents

The journey to attain a DBA qualification has been intriguing and it involved experiential learning from one document to another. DBA work required me to be organised so as to meet set deadlines and this changes one’s social life and demanded the family to understand. As I developed organisational skills on handling DBA information, I was helped by Mendeley’s electronic filing tool for organising my research references. The following structure had to be adhered to, starting with Document One an introduction of the research subject on adoption of maize hybrid technology by small scale farmers in Malawi, Zambia and Zimbabwe. The research objectives and questions were defined and the main area covered was to establish how small scale farmers can sustainably produce enough food and improve their livelihoods socially and economically by adopting maize hybrid technology. Secondly, Document Two reviewed literature on the adoption of hybrid maize in Malawi, Zambia and Zimbabwe. The literature review on adoption was drawn from various authors including the use of Mendelow's stakeholder mapping matrix (Johnson et al, 2008) and Kurt Lewis' force field analysis (Johnson et al, 2008). Rogers' theory of diffusion (2003) model, Mendelow and Lewin's models formed the conceptual framework of this study.

In Document 3, in-depth interviews were conducted to collect data for an interpretive qualitative study on the adoption of maize hybrid technology in Malawi, Zambia and Zimbabwe. In addition to the qualitative research a survey was done and findings were quantitatively analysed in Document 4 and findings from the mixed methods research were compared in Document 5. Documents 3, 4 and 5 all involve the analysis of survey data, with different data being analysed in each document.

1.6.1 Structure of the Thesis

The thesis is divided into six chapters. In the introduction, Chapter One, the researcher outlines the study context and background of this research highlighting the research problem, objectives and questions.

Chapter Two critically reviews literature pertaining to the study and establishes an understanding of what is currently known and unknown about hybrid maize technology. It includes examining the theories related to the topic of adoption and diffusion of innovations. The literature review will also look at previous research on the impacts of hybrid maize technology on small scale farmer productivity in Malawi, Zambia and Zimbabwe. Literature review helps the study to develop a conceptual framework that guides the researcher to analyse and evaluate the findings that emerge from the research to come out with conclusions. Findings from the study are then linked to other research findings cited from other studies done in the past.

Chapter Three explains the research design and methodology, covering the research philosophy, research process and data collection. The Chapter covers and explains the methods used to collect data and how the participants were selected. The research process will be guided by the research questions and objectives so that the results will be related and linked to the research objectives.

In Chapter Four research findings are presented and analysed using a mixed quantitative and qualitative research approach. Results from the questionnaire are analysed including farmer production cost information that summaries farmers' financial figures during maize production. In-depth interviews are also analysed to answer the four research questions in Chapter Five research findings are discussed, concluded and areas for future research are discussed. In Chapter Six the researcher will present gaps and recommendations for personal and professional practice.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

This Chapter reviews literature on existing concepts, empirical findings on the adoption of hybrid maize, models, and theoretical frameworks on the adoption and diffusion of hybrid maize. This provides a basis and framework to relate the present study to previous work and ongoing research on the adoption of hybrid maize. Establishing the findings and concepts of previous research helps to advance new research; and understanding of key concepts, theories, debates, issues and how they were developed helps the researcher in becoming an expert in the field (Randolph, 2009 and Hart, 2009). The literature review will help to inform the study's analysis and answer the research questions on the adoption of hybrid maize in Malawi, Zambia and Zimbabwe. The purpose of the literature review is also to identify the strengths and weaknesses of scholarly work on adoption of hybrid maize technology. Conceptually, the literature review will cover Rogers'diffusion theory of innovations, Mendelow's stakeholder analysis and Kurt Lewin's Force Field Analysis models, applied to hybrid maize diffusion and adoption. We begin with these concepts, before moving onto the empirical literature.

Stakeholders play a big role in this study as they impact the diffusion and adoption of hybrid maize by small scale farmers. Before analysing the models of Rogers, Mendelow and Lewin it is important to define the word '*stakeholder*' and how it applies to this study. In this study Freeman's (1984) definition of '*stakehoder*' is used. Stakeholders are any individual, people and groups who are positively or negatively impacted by decisions made during projects and policy initiation by organisations. These individuals, people and organisations are affected differently by these decisions as they impact on stakeholders' interest (Freeman, 1984; Freeman, Banker and Lee, 1981; De Bussy, 2006). As mentioned above there are several stakeholder groups with different interest on value that is created for each and every stakeholder (De Bussy, 2006).

Stakeholders may also conflict, resulting in no value being created (Friedman, 1970 and Ansoff, 1965). Therefore, it is important to analyse the different stakeholders in this study using participatory stakeholder analysis (Aly et al, 2019) to understand how they might engage, interact and potentially come into conflict. This will be done through in-depth interviews that help in the classification of the stakeholders, based on their power, interest and influence. Mendelow's stakeholder analysis matrix and Kurt Lewin's field forces analysis matrix (Mendelow, 1991) will then be used to complete the classification and analysis of the stakeholders. This analysis will help to rank their ability to shape decision making on specific issues (Aly et al, 2019; Friedman and Miles, 2006).

Rogers' theory of diffusion of innovations (Rogers, 2003) is going to be reviewed and analysed in this Chapter and assessed for its applicability to this study. The diffusion concept is important and relevant to this study because it attempts to explain how the new technology of hybrid maize is adopted by small scale farmers. Rogers' model is going to be reviewed later in Chapter Four for the analysis of this study's results. Most parts of Rogers' model are applicable to this study and will be used as part of the Conceptual Framework for the research. This is because hybrid maize is an innovation which is diffused and adopted through various channels. The model covers communication channels, time and social system that are embedded in the hybrid maize adoption process.

Having outlined the main components of Rogers' model it is important to note that the re-invention part of the theory was not included in this study. *Re-invention* as defined by Rogers (1978) is the degree an innovation is changed by adopters in the process of adoption and implementation after its original development. Intended adopters re-invent an innovation as a result of complexity, lack of budget to implement the innovation or lack of detailed knowledge on how to implement the technology. However, in this study based on the researcher's professional experience small scale farmers do not change or modify hybrid maize once released from seed houses because the seed production process ensures that the traits from the genetic make-up of the the seed is expressed fully in the first generation of the hybrid. Any further planting of seed from the first generation results in yield depression of up to 30% and the farmers are aware of this reduced productivity (Chirwa, 2005). Furthermore, the development of new and better hybrids is done by a rigorous breeding process which is undertaken by seed houses therefore the development of new hybrids does not fall under re-invention.

It is important to note that Rogers' theory has been successfully used in agriculture, for example for Iowa farmers (Hammond, 2016), public health, social work and marketing and has been used to accelerate the adoption of important agricultural innovations. The theory will help to explain how critical it is to the adoption of hybrid maize by small scale farmers. Ideally the model will also help in understanding the target population and the factors influencing their rate of adoption (LaMorte, 2019). However, Rogers' theory has been criticised by other authors as follows:

Critique of Rogers' Diffusion of Innovation Theory

Although Rogers' theory is applicable to the adoption and diffusion of the hybrid maize technology, the model has limitations because the diffusion of innovations occurs in a social set up that involves various stakeholders. Rogers does not say much about the power and interest of the various stakeholders which can impact the diffusion process of an innovation. As elaborated later in this Chapter Mendelow's stakeholder matrix will be visited so that it covers this gap in Rogers' model. Secondly Rogers' model does not talk much about the influence and force exerted by the various stakeholders on the diffusion of an innovation. Hence Kurt Lewin's Force Field model will be analysed later in this Chapter for its fit to complement Rogers in this study. Lundblad (2003) critiques Rogers on the communication channels by first acknowledging that Rogers' model is well defined on how diffusion of innovation is spread (including opinion leaders and change agents) through mass media and interpersonal channels, but when it comes to organisations and groups the communication channels are not defined. This would need a different interaction approach for the diffusion of maize hybrid technology to succeeed in organisations.

Lindquist and Mauriel (1989) offered alternative approaches to supplement Rogers' diffusion theory where diffusion of innovation can be better explained using the top to bottom approach in a societal hierachy, externally induced or spread through depth and breadth approaches. This top to bottom approach works in this study where leader farmers are used to disseminate hybrid maize adoption. The breadth approach proved to be most successful (Lindquist and Mauriel, 1989; Van de Ven, 1989; Marcus and Weber, 1986). These authors looked at different aspects which Rogers had not given too much thought, for example whether organisation size or type makes a difference in the diffusion of the innovation. Finally, other authors (Van de Ven, 1989; Marcus and Weber, 1986; Lundblad, 2003) looked at whether organisational leadership, structure, attitude and system openness influence the diffusion and adoption the innovation. Thus in this Chapter and Chapter 4, Rogers' model is supplemented by Mendelow's and Lewin's models and a Conceptual Framework reflecting elements of all three will be incorporated into a Conceptual Framework that covers the diffusion of innovations.

2.2 Theory on Diffusion and Adoption of Innovations

The theory of diffusion of innovation is important to this research given the different levels of hybrid maize technology adoption across southern Africa. Rogers (2003: 11) defined **diffusion** as; ''the process by which an innovation is communicated through certain channels over time among members of a social system''. In addition to Rogers' definition and highlighting social aspect within the diffusion process, Scandizzo and Savastano (2010: 145) defined **diffusion** as, '' the endogenous process by which adoption decisions influence each other and eventually cause the spread of the new technology''. This definition emphasises the fact that diffusion of a technology is influenced through the social set up of the targeted adopters of the technology. Given these two definitions, Rogers' definition might be more applicable to this study because stakeholders communicate with small scale farmers either internally, through those who reside amongst the farmers or externally, through those that come from outside their community. Unlike Rogers' definition which is more encompassing, the other definition by Scandizzo and Savastano is complementary to Rogers' definition as it only speaks of adopters' decisions made mainly when influenced by other adopters.

Although Rogers' model was formulated as far back as 1962, various components of Rogers' diffusion of innovation theory are further elaborated and analysed in context of the present study from Rogers (2003): The first part of the theory covers ***innovation*** which in turn has the following sub-headings; *Relative economic or social advantage, Socio-economic impact assessment, Compatibility, Complexity and Culture, Trialability and Observability, Technology and knowledge* *transfer and Patents and IPR.* The second part of the theory covers ***communication channels, time*** and ***social system*** (that has the following subheadings-*Diffusers, Adopters, Consumers, Regulators and Policy Makers)***.*** The elements of Rogers' theory are discussed in detail below:

2.2.1 Innovation

Innovations introduce a service or a product targeting consumers to accept the new innovation over an old product or a service being offered in a market (Rogers, 2003). For the innovation to be accepted customers or consumers go through a process that starts with trialling followed by adoption. The perception of adopters is important when it comes to the adoption of new ideas or innovation and ultimately determines the success of the adoption. According to Rogers (2003) new innovations tend to diffuse at a slower pace than expected, because adopters may be used to their old technology which they trust better than new. In addition, product knowledge, awareness, advantages and demonstrations would not have been effectively presented to the adopters in the early stages. This leads to slow diffusion of new innovations, as highlighted in the S-shaped curve of Rogers' diffusion of innovations.

This aspect will be analysed in Chapter Four after data analysis to see whether farmers accept change or they remain stuck to their traditional crops. In a study carried out in Kenya farmers took a long time to change to newer products (Olwande and Smale, 2012). The study revealed that maize hybrids that were grown in Kenya, by small scale farmers, had been introduced more than 18 years (Walker et al, 2011). This long time experienced in Kenya is explained by the fact that farmers are more comfortable growing old maize hybrids which they have known for long instead of trying new maize hybrids (Olwande and Smale, 2012). Indeed, some small scale farmers in Malawi, Zambia and Zimbabwe have planted maize hybrids since the 1960s (Chiduza et al, 1994; Zinyama, 1992 and Mashingaidze, 2006) but many farmers have still not adopted the technology- hence this study. We now consider, in turn, the five factors Rogers identifies as being part of innovation.

Relative economic or social advantage

Relative advantage is the degree to which an innovation is perceived as better than the one it is replacing (Rogers, 2003). In the context of this study, farmers invest in new technology if the technology helps in offering solutions to challenges faced during crop production resulting in perceived productivity benefits (Scanndizzo and Savastono, 2010). Farmers usually make choices of what crop to grow based on profitability per unit area of land used for cropping (Mannion and Morse, 2012). Similarly, the choice of which technology to use is determined by relative economic advantage of the technology over alternative technologies. Dharmasiri (2012) defines farm productivity as a measured ratio of farm output against farm inputs. Such economic analysis helps farmers to make informed decisions on what innovations to adopt on farms. That said Chirwa's (2003) finding in Malawi also supports Rogers' theory, because some small scale farmers in Malawi made their choice over maize varieties based on taste irrespective of the maize variety's yield potential. Hence Chirwa's study finds farmers basing their decisions on social gain as opposed to economic gain which also aligns with Rogers' theory.

To review Chirwa's observation, this study seeks to review whether the adoption of hybrid maize compared to OPV maize improves small scale farmers' productivity and ultimately profitability (Abate et al, 2015). The section below critically reviews literature on relative economic and social advantage that is realised by small scale farmers as they adopt hybrid maize. The literature analysis will give some examples of socio-economic impact on small scale farmers' livelihoods after adopting hybrid maize technology.

With the widespread introduction of hybrid maize in the 1930s, in the USA, farmers generally changed from growing OPV maize varieties to hybrids because hybrids outperformed OPV maize in yield terms by nine to forty percent (Duvick et al, 2004). This led maize breeders to focus their breeding and selection effort on hybrid maize (Lonnquist and McGill, 1956). The combination of greater breeding effort on hybrids and less on OPV maize has led to yields of six to fifteen tonnes/Ha for hybrids, compared with OPV yields of two to six tonnes in the USA (Kutka, 2011).

This yield advantage has been found also in studies conducted in developing countries. In the ward of Giwa in the state of Kaduna, Nigeria, maize hybrid yielded 2.2406 Mt/Ha compared to

OPV maize of 1.261Mt/Ha. This study resulted in gross margins of $USD 389.29 and $USD195.31 respectively (Ayinde et al, 2011). Another study in Ethiopia showed that hybrid maize out-performed OPV maize by 17-46% in terms of yield (Abate et al, 2015). This study will review whether a similar yield difference is observed between OPV and hybrid maize in the three focus countries, exploring not only yield but also costs of production.

Socio-economic impact assessment

Impact assessments (IA) are done by assessing and measuring socio-economic benefits and costs to adopters of innovations as with the situation with small scale farmers after a technological intervention like hybrid maize adoption. The impact assessment of hybrid maize adoption is very important for this study since it gives metrics of measure on what the adoption does to small scale farmers' livelihoods (Bezu et al, 2014 and Wossen, 2017). IA can measure three outcomes, namely *direct, indirect and induced* impacts (Lawton, 2004). *Direct* impacts are felt by individuals, organisations and population groups. Small scale farmers directly benefit from revenue received after selling their grain. The adoption of maize hybrids leads to improved yields that bring in more cash for the farmers. The cash improves disposable income leading to improved livelihoods reflected in education for their children, health care and general social welfare improvement (Belion, 2006).

A good example is from an Ethiopian farmer, Tekalgna Abebe from Gunchire area who yielded four tonnes per acre maize after participating in the 2014 Du Pont Pioneer-US Aid Feed the Future Program. His yield from the Pioneer hybrid was four times more than the usual yield from the OPV maize he used to grow. This yield increase led to the farmer sending his four children to school from the excess maize. The farmer was quoted saying, "I am confident that my children's future is bright" (Eller et al, 2014). The present research will analyse livelihood experiences from farmers who adopted hybrid maize. Unfortrunately Rogers' theory does not say much on the impact of costs on the innovation to adopters, so this study will review the impact of costs on the diffusion and adoption of hybrid maize technology.

Indirect impacts are the ripple effects that occur to other businesses that support farmers when their income improves. For example, fertiliser manufacturers get more sales whenever farmers buy inputs to produce. When looking from the farmers' perspective they are *Induced* to spend when income increases from selling their produce. Induced impacts are noticeable whenever farmers get their money from their grain sales. With more disposable income farmers spend their money on goods of their choice including groceries and clothes. This spending by farmers has an indirect impact on businesses supplying the different goods.

To demonstrate the induced impact a study was done in Kenya with 100 farmers. The study measured mean yield from OPV and maize hybrids. Over a three-year period, the latter delivered higher yields, providing those farmers with higher incomes that allowed them to build good houses (Mathenge et al, 2013). In Zambia a similar IA study showed that farmers who grew maize hybrid had better income and their social lives improved (Hamazakaza et al (2013). A similar scenario was observed in Mexico where the socio-economic impact was measured in a study that looked at improved maize yield due to hybrid maize adoption. The findings of the study were shown by the farmers' livelihoods.

The farmers also afforded improved health care, their housing improved, diet and general lifestyle improved. These positive changes in maize yield significantly reduced the Mexican small scale farmers'poverty (Becerril, 2010). In Zimbabwe Bourdilon et al (2007) studied the impact of hybrid maize on resettled farmers. The farmers' livelihoods and income levels improved through improved health provision and more disposal income. Farmers bought more tools, livestock and they paid school fees for their children.

Addressing a different type of socio-econmic impact, a study Ethiopia looked at how adopting maize hybrids can alleviate hunger. The research targeted food availability and productivity and found evidence of improved maize productivity and reduced poverty by 9% annually (Alene and Coulibaly 2009). Studies with similar results include evidence of the FISP programme in Malawi which reversed a food deficit situation (Chirwa, 2005). An important addition to these studies comes from work of Holden and Mangisoni (2013), who found that in Malawi, hybrids outperformed OPVs during drought years. This drought tolerance was also demonstrated in

Kansas, USA where the yield of hybrid maize out-performed OPVs. In this demonstration site hybrid maize showed better resistance to heat stress and drought compared to OPVs (Kassie et al, 2017). Further demonstrations were conducted in Kenya on hybrid maize's drought tolerance compared to OPVs. Again, in this demonstration hybrid maize out yielded OPVs (Marechera et al, 2019).

Additionally, hybrid maize had better tolerance to insects and diseases (Kutka, 2011). In Malaysia and Thailand hybrid maize demonstrations provided opportunities for extension officers to train farmers in agronomy, disseminating information on best farming practices through print media and community radios. During the setting up and execution of demonstration plots, farmers were invited periodically to observe planning, planting and crop management through audio visual aids (Poolsawas and Artachinda, 2011).

Compatibility and Culture

Another attribute associated with an innovation is the degree to which it is consistent and compatible with existing cultural beliefs, past experiences, values and needs of the adopters (Rogers, 2003; Wagner-Weick and Walchli, 2002). Farmers expect new innovations to be always better than old technology and they adopt a new farming method that is compatible with their values and norms of a social system (Rogers, 2003). Based on literature the growing of hybrid maize and cultural farming practise is similar to OPV and the farmers' skills are compatible to growing hybrid maize. Therefore, the switch from OPV maize to hybrid maize is not complicated to small scale farmers. Incompatible innovations may attract the opposite of compatible innovation (Lassie et al, 2017). This situation leads to farmers not getting the intended benefits from the innovation, if they even adopt the new innovation.

It is also possible that farmers may not find any advantages in new products offered to them by suppliers (Wagner-Weick and Walchli, 2002). This brings us to historical maize documentation by Byerlee et al (2006) where 47% to 58% of the agricultural land in East and Southern Africa was planted to hybrid maize by 1990 (Morris, 2001) and the small scale farmers were committed to growing white hybrid maize as their staple food. Although some of the farmers in Malawi preferred their local OPV that is flinty and tasty even though the early maize breeder, Ellis produced a flinty tasty hybrid, LH11 that was compatible with characteristics preferred by the small scale farmers (Smale et al, 2013) his effort did not fully succeed because the farmers continued to prefer their flinty and tasty OPV maize due to lack of effective awareness campaign even though the hybrid had better yield compared to OPV (Smale et al, 2013).

Small scale farmers in East and Southern Africa also require maize that is compatible with their marginal areas that are occasionally exposed to drought, pest outbreaks and poor, acidic, soils (Schroder et al, 2013). Similar demands and experiences were also observed in Mexico and Asia (Duvick et al, 2004). These conditions needed by small scale farmers are satisfied by hybrid maize as demonstrated by the various studies cited above.

Complexity

According to Rogers (2003) complexity relates to what degree the innovation is relatively difficult to understand or use by potential adopters. Out of the five characteristics of innovation, complexity can negatively impact an innovation. This can be assessed by a negative IA result if the adopters do not find benefit in the new innovation. Innovations that require adopters to acquire new skills diffuse slowly (Dibra, 2015; Rogers, 2003; Weick and Walchli, 2002 and Sahin, 2006). Despite Rogers' explanation on complexity and culture on innovations, hybrid maize technology is not complicated for farmers to understand because the agronomic practises (farming practise) for both OPVs and maize hybrids are similar. Furthermore, the types of inputs used are similar and they cost the same. Based on the researcher's field experience, the difference between OPV and hybrid maize is on the yield response to management of the crop especially on fertiliser levels. Hybrid maize responds better to higher level of fertiliser compared to OPV that can only yield to certain levels because of genetic potential. At low management and low fertiliser application rates hybrid maize might still outperform OPV because some hybrids are bred to perform at low input levels (Magorokosho, 2006). Ultimately farmers apply lesser inputs on OPV compared to hybrid maize resulting in lower cash outlay for the former (Magorokosho, 2006) but also lower yields.

Another difference is that seed harvested from OPVs unlike maize hybrids can be replanted, whereas hybrid maize farmers need to buy fresh hybrid seed each time farmers plant (Smale et al, 2013). Replanting seed from hybrid maize may result in yield reduction of up to 30% (Mashingaidze, 2006). Consequently, some small scale farmers who are not certain about hybrid maize productivity continue planting OPVs because they can save money by replanting seed from their previous crop (Rukuni et al, 1998), even though hybrids offer the possibility of higher yields and higher income. The present study shall review this aspect as mentioned earlier so that OPV cost of production can be compared with hybrid maize.

Trialability and observability

Testing (trialling) of new innovations and observing their performance are critical steps, hence innovations which can be tested and verified by potential adopters are adopted quicker. Maize hybrids are tested for two years in different growing areas before registration and commercialisation on the market (Rogers, 2003 and Dibra, 2015). This requirement is mandated and entrenched in the seed laws of Government Seed Services departments in Malawi, Zambia and Zimbabwe. The registration trials are conducted in terms of guidelines provided by the Seed Services departments (Tattersfield, 1982).

However, in conducting registrations trials, the strategic goal of the seed houses is to evaluate the performance of the new maize hybrids against existing hybrids and OPVs as a step towards commercialisation of new maize hybrids (Dibra, 2015). During registration trials, new maize hybrids are planted side by side with existing hybrids and OPVs. Trialability on its own will not enhance adoption of maize hybrids but further work is needed for farmers to observe products first. Farmers take time to gain confidence with new maize hybrids therefore it is imperative for them to see the products being grown, ‘seeing is believing’ (Chirwa, 2005: 120).

In an effort to promote hybrid maize to small scale farmers government extension officers, seed companies and NGOs have crafted ways of demonstrating and reaching out to farmers. Extension officers work with seed companies and farmers are selected based on their ability and influence in the community. These influential farmers are called opinion leader farmers and their role is to plant demonstration plots following instructions given by extension officers and seed companies. As the maize crop gets to maturity farmer field schools and field days are conducted by seed companies in conjunction with extension officers and NGOs to showcase and promote hybrid maize (Abate et al, 2015). This referenced study shall be reviewed against evidence from this present study's findings in Chapter Four.

To enhance farmers' agronomic skills, the literature reviewed in a study carried out in East African countries, showed that during farmer training sessions, farmers are trained on agronomy and hybrid maize attributes so that they can repeat the same practice on their pieces of land (Jayne et al, 2018). These field days are over and above the extension services offered by government extension officers. With the knowledge gained from field days farmers then make choices to adopt the new hybrids being introduced (Kutka, 2011). These farmer trainings proved useful as shown by better adoption rates and yields.

In demonstrations conducted world-wide hybrid maize has performed better than OPV maize even without fertiliser being applied. In nitrogen usage trials conducted in Chiredzi, Zimbabwe, DKC 8031, hybrid maize outperformed all the other hybrids and OPVs in the conducted trials (Magorokosho, 2006). To test the nitrogen usage efficiency no fertiliser was applied to the trial plots. Nitrogen usage efficiency is a selection criterion for hybrids targeted for poor sandy soils that are prevalent in Malawi, Zambia and Zimbabwe where most of the small scale farmers reside (Smale et al, 2013).

Technology, knowledge transfer and Patents and Intellectual Property Rights (*IPR)*

In this study, technology knowledge transfer will be reviewed by understanding how different stakeholders, including seed houses like Dekalb take hybrid maize technology to small scale farmers. It takes more than seven years (Halford, 2012; Phadke and Vyakarnam, 2017) to develop and market a maize hybrid. Seed houses invest millions of dollars in research and development to get hybrid maize products on the market. This done through acquisition and testing of breeding materials. To transfer technologies from developed countries to developing countries such as Malawi, Zambia and Zimbabwe it also takes formal agreements with governments and other seed distributors, that include trade patents and intellectual property rights (IPR) (Kumar, 2015). The ultimate technology transfer occurs through field demonstrations where farmers gain knowledge on how to use the new innovations.

Given research and development (R&D) investment in maize hybrids (Chiwenga, 2010), most hybrid maize developers like Pioneer and Dekalb use patents to protect their IPR (Van Norman and Eisenkot, 2017). These multinational maize hybrid developers also use licensing as a form of technology transfer arrangement (Chiwenga, 2010). For example, Bayer-Dekalb offers its maize hybrids to distributors like Tocek in Zimbabwe, for propagation and onward selling to small scale farmers in return for royalty payments or license fees. The same approach is used by Corteva and Syngenta for their licensing arrangements with Valley Seeds and Intaba Trading respectively in Zimbabwe.

Another aspect of IPR, Patents and Licensing are the efforts made by countries to put in place enforcement mechanisms, which then attract companies' confident that those structures will be respected and enforced (Maskus, 2000). A good example, in Zimbabwe, where IPR laws were gazetted as early as 1967 to protect technology investors resulting in the country achieving more than 95% hybrid maize adoption (Eicher et al, 2006). Sherwood (1990) noted that weak IPR legislation enforcement slows down technology transfer in developing countries. Weak IPR legislation occurs where breeding materials are taken by other players in the industry without consent from the developers of the breeding germplasm and this affect product competition.

In Malawi, Zambia and Zimbabwe hybrid maize knowledge transfer is done by stakeholders who collaborate with seed companies, agro-chemical companies and government extension employees (Magorokosho, 2007). The field visits are used to transfer technology and knowledge from seed houses to farmers who are the adopters. According to Valente and Davis (1999), opinion leaders accelerate the diffusion of innovations. Seed houses in Malawi, Zambia and Zimbabwe use opinion leaders to gain access to farmers (Magorokosho, 2007).

2.2.2 Communication Channels

The second part of diffusion of innovations is communication channels (Rogers, 2003). Rogers' theory speaks of communication of innovations to adopters through mass media and inter-personal channels. Information flow to potential adopters of innovations is very important in the adoption of hybrid maize (Ezezika et al, 2012). Mass media channels include radio, print media, web sites and social media whilst inter-personal channels involve individual interactions with the targeted adopters. According to the literature reviewed hybrid maize developers use communication channels that include side by side plots, one-on-one interpersonal discussions, group discussions at workshops, field days, farmer field schools, print media, TV and radio (see also Halford, 2012; Phadke and Vyakarnam, 2017). In the three focus countries hybrid maize adoption information is disseminated effectively through radio, TV, print media, field days, social media and demonstration plots (see also Smale et al, 2013 and Kutka, 2011).

In Malawi demonstration plots proved very effective because farmers after seeing hybrid maize in demonstration plots were convinced to adopt the new hybrids (see also Chirwa, 2005). The use of demonstrations as means of communicating product performance to small scale farmers was enhanced by the use of farmer opinion leaders (or 'change agents') by seed houses, NGOs and extension officers. They plant and host demonstration plots that are then showcased to their fellow farmers (see also Magorokosho, 2007; Kutka, 2011 and Smale et al, 2013). The effectiveness of this approach to communicating the benefits of hybrids was seen early-on in Iowa (Ryan and Gross, 1943) and continues to be of benefit in Kenya (Wafula, 2015) as well as the other studies reviewed above. In Thailand (Poolsawas et al, 2011) where the internet and social media were important aspects. These communication channels shall be reviewed for this study in Chapter Four during data analysis.

2.2.3 Time

The third element in Rogers' (2003) diffusion of innovations is *time* which measures the rate of adoption of an innovation in communities. As mentioned in Chapter 1 hybrid maize was established in the three focus countries in the early 1950s and the adoption rate improved over the past 65 years (see also Tattersfield, 1982). Zimbabwe had an advantage over Malawi and Zambia because the maize hybrids were firstly bred in Zimbabwe before they got introduced to the other Federation countries (Tattersfield, 1982). Additionally, Zimbabwe had more government research centres for hybrid maize, established as early as 1940 compared to Malawi and Zambia (Blackie, 1987). This early establishment of hybrid maize research and development resulted in Zimbabwe achieving higher adoption rates than both Malawi and Zambia, as cited previously.

Reflecting on other research that has explored adoption rates, a study carried out in Southern Mexico found that the hybrid maize adoption rate was determined by government policy, extension service, availability of credit and markets for the final product (Sanchez-Toledano, 2018). It took up to 10 years for 60% of the farmers surveyed in Southern Mexico to adopt hybrid maize technology – or roughly six times quicker than it took Malawi and Zambia to reach similar adoption levels. However, it is interesting to note that, the 60% adoption rate in South Mexico came from young farmers who had smaller families and were willing to take the risk of the new maize hybrids (Sanchez-Toledano, 2018). In a study of Nepal, multiple factors were found to influence the adoption rate of hybrid maize, notably the cost of hybrid maize seed, access to maize hybrid, yield advantage, type of society, access to credit, special training, seminars, field days, technical support and education of the head of family (Paudel and Matsuoka, 2018). Zimbabwe's early success was built on government policy on extension services, farmer training and credit availability (Blackie, 1987). The present study will review all the factors that affect the rate of hybrid maize adoption in Malawi, Zambia and Zimbabwe.

Policy

Within 'time', Rogers identifies policy as a key factor. Policies are formulated by governments and other bodies who have authority to govern people to achieve set goals (Dejon, 1980). The adoption of maize hybrid can be used as an example of a government set goal for the purpose of food security (World Bank, 2019) which can determine the success or failure of maize hybrid adoption (Sanchez-Toledano, 2018). Adoption of technology is influenced by policy makers through their political systems and a variety of diffusion processes (Berry and Berry, 1991). Government policies influence the adoption of hybrid maize (Berry and Berry, 1991) in multiple ways that we now explore.

A review of the progression of government policies in Malawi, Zambia and Zimbabwe shows three distinct periods. First, during the period 1900 to 1965, maize became the dominant food crop in the study countries. For the second period, after independence, the years are specific for each study country. The third period from 1990 was deemed “uncertain” (Smale and Jayne, 2003). As referenced in Chapter 1, maize research started with the improvement of OPVs, followed by the successful story of hybrid maize in the USA. In 1932 (Chiduza, 1994) Arnold started breeding maize in Southern Rhodesia and in 1949 SR-1 maize hybrid was registered which was followed by the registration of the high performing SR-52 in 1960 (Mashingaidze, 2006). During this period, when the three study countries were governed by one administration the government pushed for policies that encouraged further hybrid development and registrations to suit local needs and the British starch industry requirements (Rukuni et al, 1998 and Tattersfield, 1982). The Rhodesian-Nyasaland government research centres were also well funded to develop hybrid maize to improve food productivity.

In Zimbabwe the second period after independence, 1980 to 1989 was characterised by the government promoting research, supporting farmers with credit (Chimedza, 1994) from the Agriculture Finance Corporation (AFC). Small scale farmers were supported by a well-funded and robust government extension service that continued from the old regime (see also Smale et al, 2013). This not only led to a hybrid maize adoption rate was of more than 95%, but these government policies significantly led to improved productivity. The second period after independence for Malawi and Zambia started from 1965 and saw their governments follow, the Rhodesia-Nyasaland policies of funding hybrid maize research. Unfortunately, the extension service and other government policies that supported small scale farmers’ maize production were not as successfully funded compared to Zimbabwe (Mashingaidze, 2006). Hence the hybrid maize adoption rate in Malawi and Zambia lagged behind the Zimbabwean adoption rate over this period.

As for the third period (from 1990), all the three countries were characterised by a combination of unfavourable weather conditions, declining public investments in agricultural research, input subsidy reduction and erratic policies, which resulted in a decline of maize productivity in the study countries. The fiscal budgets could no longer support the high input costs given to farmers (Smale and Jayne, 2003), whilst farmers resorted to less input per hectare because they could not also afford inputs. Thus, some farmers opted for cheaper OPV seed rather than the more expensive hybrid maize seed (Smale and Jayne, 2003), despite the possibility of higher yields and incomes. These factors contributed to lower productivity.

Other policies in the three focus countries included grain marketing and input subsidies. The grain marketing policy encouraged farmers to produce more grain by offering improved grain prices. These price incentives will be reviewed in Chapter Four to see whether they encouraged farmers to produce more maize grain in the three countries. The pricing and grain buying responsibility in the three countries is managed by government parastatals (Smale et al, 2013). The grain buying policy is also complemented by an input subsidy policy, with the aim of helping farmers meet input costs whilst using hybrid maize and fertilisers. Even though this brings challenges with high input costs it is envisaged that yields would be correspondently higher. In the past farmers used fewer inputs resulting in low yields, which led to food shortage and poverty. This scenario is the one that has prompted the governments of the focus countries to adopt input subsidy programs (Smale et al, 2013 and Chirwa, 2005).

In Malawi the government implemented the FISP program, supported by donor community and which was a resounding success (Chirwa, 2005). Malawi became food self-sufficient, switching from a deficit of 43% to a surplus of 53% (Ellis et al, 2003 and Denning et al, 2009) when they implemented the input subsidy program from 2003 to 2005 (Chirwa, 2005). Countries like Zambia followed the same policy for their small scale farmers and they have improved their maize productivity by 40% (Chirwa, 2005). The FISP program has been a success in Zambia where excess grain is being exported to neighbouring countries and has helped the alleviation of hunger in East Africa (Chirwa, 2005). Government subsidies as confirmed in the study by Bosch (1985) showed their importance in helping vulnerable farmers. A further example of markets inputs assistance by the government, was in Ethiopia in the 1990s, found that the distribution of seed and fertiliser packages to small scale farmers resulted in improved yields (Spielman et al, 2010). This measure reduced the financial burden to buy food handouts by government. However, after these subsidies are established, they are not easily removed. This study will review why after subsidies are removed farmers' productivity is negatively affected.

Another example of a deliberate policy to enhance production was cited by Duncan and Jones (1993) in Uganda, where the government and NGOs initiated grassroots programmed policies to promote competitive pricing in maize markets for small scale farmers (Reardon et al, 1999). Government involvement is again demonstrated in Tanzania where the grain market was liberalised to encourage commercial maize grain trading (Putterman, 1995) a finding also reached by Duncan and Jones (1995).

Another policy challenge that governments must address relates to changing cultivation practices. As mentioned earlier in Chapter 1, shifting cultivation in Africa that used to be pursued by small scale farmers has been banned by most governments citing land scarcity, bio-diversity preservation, game parks, and conservation of natural forests and protecting soil erosion (Reardon et al, 1999), although it still occurs in some parts of Kenya, Somalia and Ethiopia. Whilst the vegetation regenerates after the farmers vacate the land the resultant vegetation would not have the same ecological purpose and benefits compared to original undisturbed vegetation. Undisturbed vegetation influences rainfall and protects soil from erosion. By remaining on the same piece of land and practising crop rotation, farmers can avoid upsetting the ecosystem compared with shifting cultivation practises. Therefore, it is important for governments to introduce sustainable policy reforms to protect ecological environments. Besides increasing crop productivity, these policies have been successful in some countries but more effort is needed in other countries to stop land degradation. Another example of a positive policy to decongest rural areas in South Africa benefited small scale farmers' livelihoods because the farmers had more land for their crops and livestock (Hart, 2009). Small scale farmers were relocated to bigger and more spread-out grazing lands to avoid overgrazing and soil degradation.

As mentioned in Chapter 1 there are institutional bottlenecks that affect adoption of maize hybrids in Eastern and Southern Africa, including seed production, proprietary breeding material security, marketing and credit availability. Remedial strategies involving all stakeholders need to be put in place to improve on maize hybrid adoption. This includes the seed trade harmonisation efforts by SADC and COMESA that will help small scale farmers in Malawi, Zambia and Zimbabwe who will be able to access more maize hybrids across these two trading blocks in Africa (Smale, et al, 2013).

Unfortunately, potentially beneficial government policies that are badly implemented can negatively affect production because of a lack of follow up and implementation flaws. Also, some government policy interventions, can create a dependency culture. This was found, for example, in Malawi where farmers ended up not producing enough food whilst waiting for handouts (Sharaunga and Wale, 2013). Again, the intention of government was not to create dependency but due to a lack of proper implementation strategies, this was the result. Again, the present study will review and analyse the impact of the various factors on hybrid maize adoption by small scale farmers.

2.2.4 The Social System and Hybrid Maize Diffusion

This section is going to cover Rogers' fourth element in his diffusion theory, covering how innovations are diffused through a social set up. The section will cover stakeholders that are involved in the diffusion process. Rogers (2003: 11) defines the social system as ''A set of interrelated units that are engaged in joint problem solving to accomplish a common goal''. This study adopts Rogers' (2003) definition and takes note that stakeholders involved in the diffusion and adoption of hybrid maize in Malawi, Zambia and Zimbabwe, within social systems comprise of diffusers, adopters, regulators and disseminators of information about maize hybrids. Furthermore, this study notes that stakeholders' interests and power impact diffusion and adoption of maize hybrids. Therefore, it is important to identify and analyse not only the diffusers, adopters, regulators and disseminators of maize hybrids but also their interest and power. These social players make up the social system of maize hybrids in Malawi, Zambia and Zimbabwe (Aerni, 2005). This present study will identify members of the social system involved in maize hybrid adoption in the three countries (Aerni, 2005 and Ezezika et al, 2012). The potential stakeholders identified by Rogers, all relevant to this study, are explored in turn.

Diffusers

According to Rogers (2003) diffusers of an innovation are individuals, opinion leaders or change agents responsible for the spread and adoption of an innovation in a social set up. In other studies carried out in the focus countries, the diffusers for farm innovations, like the usage of hybrid seed maize, were seed companies and government extension officers (Duvick et al, 2004). Extension officers played an important role in diffusing hybrid maize technology. Based on my professional experience, the extension structure started from grassroots where an extension officer manages three hundred to one thousand families at ward level. The extension officers in the wards were then managed by three district-based supervisors who report to the district extension head. The district extension head reports to the provincial extension head who in turn reports to the national extension head. This structure that is present in all the 3 study countries was inherited from the Rhodesia-Nyasaland era and it is well structured for the extension service to small scale farmers.

To elaborate more on the extension structure, a district is comprised of twenty-five to thirty wards and each province has a range of eight to ten districts (Smale and Jayne, 2003). With an average of eight to ten provinces in each of the focus countries the extension arm is well coordinated to have an impact on small scale farmers' agricultural activities (FAOSTAT, 2015). With this structural analysis of the extension service in the three countries it is very important to have a motorised extension team that can reach out all the farmers and give technical advice. A strong and well-resourced extension arm is critical to the diffusion of any new innovation targeted at small scale farmers (Shiferaw, et al, 2011 and Abate et al, 2015). Extension officers are also diffusers because they are guided by policy to support the adoption of maize hybrids for the sake of food security and productivity (Smale and Jayne, 2003). They give technical training to small scale farmers on the benefits of maize hybrids (Blackie, 1987). This study shall review the role and impact of extension officers on the adoption of hybrid maize by small scale farmers.

Seed companies are involved in research and development (R&D) of maize hybrids (Duvick et al, 2004). Most of the hybrids that are distributed in Africa are bred by Pioneer, Seed Co, Dekalb, Syngenta and government run institutions (Hallauer, 1999). Based on my experience in the focus countries, seed houses plant observation plots to showcase their maize hybrids and these have been helpful in Malawi to spread the advantage of hybrid yield over OPV maize (Chirwa, 2005). Seed houses and government research institutions collaboratively bring new technology to the market (Smale et al, 2013). A good example is exhibited when technology collaboration is done through the donation of maize breeding material by CIMMYT to private seed companies and government breeding institutes in Malawi, Zambia and Zimbabwe (Smale et al, 2013). Breeding seed houses also collaborate with government extension officers in promoting the use of hybrid maize in the three study countries. These collaborations have led to certain brands of seed to be visible in the three countries. Joint field days and demonstration plots have been collaboratively held with some level of success (Chirwa, 2005). This success level of the collaboration will be reviewed in the study.

Adopters

Adopters are targeted recipients of an innovation. Small scale farmers are the key decision makers as far as hybrid maize adoption is concerned (Johnson et al, 2008). Indeed, the adoption of hybrid maize generally relies heavily on small scale farmers in these three study countries because they produce 80% of the staple food planted from hybrid maize seed sold on the market (Magorokosho, 2006). In this, a key factor they need to understand is the economic benefits of hybrid maize as a cash crop (Mannion and Morse, 2012)

Based on the researcher's experience small scale farmers are organised in groups and are represented by opinion leader farmers who are the leading performing farmers in the community and lead by example amongst their fellow farmers. They play a key role in the spreading of new ideas and the successful adoption of agricultural technologies (Valente and Davis, 1999; Rogers, 2003; Feder and Savastano, 2006). Rogers (2003) described opinion leader farmers characteristics as cosmopolitan, higher socio-economic status and more innovative. Romero-Rodríguez et al (2020) see opinion leader farmers as convincing, experts and having a large network of social ties.

Consumers

Consumers are the end users of products produced within the value chain of an innovation. In relation to the adoption of maize hybrids small scale farmers, grain traders, millers and shop floor customers are the targeted consumers. Millers and shop floor customers have interest to choose maize grain that has good milling qualities and taste. This because the millers are influenced by the shopfloor customers who buy milled maize and their choice is driven by the taste of the milled maize. Small scale farmers are part of the consumers of maize meal which is a staple, therefore the taste and storability of the maize grain also matters to them (Wambungu, 2014). Breeding of maize hybrids takes into consideration required traits by the consumers.

As discussed previously In Malawi small scale farmers prefer hybrids or OPVs with hard and flint grain for better storability, taste and poundability (Smale et al, 2013 and Chirwa, 2005). This influences the farmers' purchasing decisions because of the preferences for those further down the supply chain as mentioned in my previuos comment. Therefore, grain traders who buy for various millers may demand certain attributes from the maize grain they buy to satisfy their customers. Similarly, stock feed processors may have different nutritional needs for their livestock and may demand maize of particular nutritional value (Chirwa, 2005). Therefore, to meet those buyers' different needs seed houses provide different varieties (Chirwa, 2005). The present study will seek to understand consumers' needs and review how these needs influence the adoption of hybrid maize.

Regulators and policy makers

The seed act governs the registrations of maize hybrids to protect farmers from underperforming maize hybrids. For a seed company to gain registration of hybrid maize the variety is trialled for over two seasons under different localities (CIMMYT, 2018). During registration, data for yield, drought tolerance, disease tolerance and adaptability are recorded and only varieties that meet certain criteria will be registered by seed authorities in the three countries (see also Halford, 2012; Phadke and Vyakarnam, 2017). Governments in Malawi, Zambia and Zimbabwe all have similar regulations that are followed by any seed company before registering maize hybrids. (Rusike and Eicher 1995), and they therefore play a prominent role in the development, diffusion and adoption of maize hybrid (Sanchez-Toledano, 2018). As explained earlier this requirement is now simplified as a result of the harmonised seed trading agreements in COMESA and SADC trading blocs.

For this study, the key regulators in the three countries are senior government officials who are policy makers in the ministry of agriculture. The Ministry of agriculture also supervises the extension department that promotes the adoption of new technologies on the ground. The adoption of hybrid maize is driven by policies that are set up and monitored by policy makers. Extension officers play a great role in making sure small scale farmers are trained and taught about technical aspects of hybrid maize adoption. This collaborative effort helps all stakeholders to offer the best service to the farmers (see also CIMMYT, 2018; Shiferaw et al, 2015; Duvik et al, 2004; Sanchez-Toledano, 2018; Abate et al, 2013 and Magorokosho, 2007).

Disseminators

Dissemination of information in this study is through interpersonal, NGOs and media channels, each of which is now analysed in turn:

The Media

The media assists the diffusion process of an innovation communicated through members of a social system over time (Rogers, 2003). The media plays a critical role in helping adopters to go through the stages of adopting a technology, which are: awareness, interest, evaluation, trial and adoption (Rogers, 2003). Adopters are then, in turn, classified as: innovators, early adopters, early majority, late majority and laggards (Rogers, 2003). It is then critical for the change agents to target their potential adopters through mass or interpersonal media. The interpersonal channel was very effective in the adoption of the drug tetracycline (Rogers, 2003). Mass media brings critical mass because more targeted customers are made aware of the technology through websites and messages send to large number of people using emails and phone text messages (Markus, 1987). This channel pushes innovations into quicker adoptions rates. Both mass media and interpersonal channels have now been enhanced by internet that provides many different social media platforms (Rice and Webster, 2002).

Change agents use the media to disseminate information on diffusion and adoption of hybrid maize technology. The easier the technology design, the easier it becomes for media use (Rice and Webster, 2002). Rogers (2003) linked the involvement of mass media and interpersonal media to Ryan and Gross' (1943) study of the adoption of hybrid maize in Iowa, USA. At that time this was done through interpersonal interactions with farmers, print media, radio and field demonstration plots. Seed houses in all of Malawi, Zambia and Zimbabwe have used print media and radios to advertise their maize hybrids to farmers, an approach that has been very successful. Similarly Pioneer Seeds using print media launched a very successful hybrid maize, 30G19 that had good traits that included a good yield per hectare, drought and disease tolerance got advertised through the media, in conjunction with field demonstrations, resulting in more farmers buying this hybrid.

Although print media works for farmers who can access it from towns in the three focus countries, radio is the most preferred means of getting hybrid maize information to small scale farmers. The use of radio adverts is most appropriate because 90% of the small scale farmers in the three countries have a radio set, on which they listen to adverts and agriculture news bulletins. That said, language is also very important here. Such broadcasts must be in languages appropriate to the target audiences. Different media can also be used to disseminate 'good news' stories. The example cited earlier, about the farmer, in Ethiopia, who grew Pioneer hybrids, earned a higher income and supported his children in graduating with degrees for the first time, was published in the print media spreading the news in the whole of Ethiopia (Fortune, 2017). The present study will review the role of radio as a means of disseminating hybrid maize information to farmers.

However, some media stories can be counter-productive, especially when a product's poor performance is published. An example occurred in Zimbabwe when a sorghum product failed to produce any grain but only grew very tall. The pictures were published and the responsible seed company had to do a lot of damage control replacing the sorghum variety and compensating farmers for the losses made.

Non-governmental organisations (NGOs)

There are two categories of NGOs in this area*,* those that support hybrid maize and those that oppose it because they believe small scale farmers can save money by planting OPVs (such as CARE-International). With OPVs the same seed harvested from the previous crop can be re-cycled as planting material, unlike hybrids which drop in yield when re-cycled as seed (Gerhart, 1975). NGOs that support OPVs further argue that the yield achieved by small scale farmers is affected by fertiliser and weather conditions and therefore planting maize hybrids will not give any significant yield difference compared to hybrid maize grown under the same conditions. That said, the NGOs that do not support hybrid maize have not yet started lobbying against big international hybrid maize seed companies in contrast to, for example, anti-GMO campaigns.

The NGOs that support hybrids, for example PLAN International, HarvestPlus and Lead disseminate information on hybrid maize diffusion and adoption through the use of strong promotional language, adjectives and rhetoric that are not used by agronomists and scientists (Gerhart, 1975). The interest of other NGOs and international organisations such as FAO, is in the diffusion and adoption of maize hybrids because their objective is to feed the future growing population. The present study will review and compare the yields achieved and input costs incurred when farmers grow OPVs or hybrid maize. It will be interesting to see whether more inputs applied to hybrid maize will result in corresponding higher yields that will off-set the higher cost of inputs. Likewise, this study will review whether the yields achieved by planting OPV will be relative to the low inputs applied by small scale farmers. This analysis will guide farmers and other stakeholders on how OPV and hybrid maize respond to inputs quantities applied in relationship to cost and yield achieved.

NGOs'stakeholder power in Mendelow's stakeholder model (Johnson et al, 2008), is relatively low because NGOs do not administer statutes and they have no legal authority. NGOs interest is however, high. They are members of the Social System involved in the diffusion and adoption of maize hybrids in Malawi, Zambia and Zimbabwe. So, for NGOs to influence the diffusion of hybrid maize, they collaborate with extension officers and seed houses so that they can have an impact on the adoption of hybrid maize by small scale farmers (Chirwa, 2005; Shiferaw et al, 2015; Bekele et al, 2015 and Duvick et al, 2004). The hybrid maize adoption is done collaboratively with NGOs support through field days, farmer field schools and demonstrations.

Having discussed the stakeholders I now bring them into Mendelow's stakeholder matrix and then incorporate the other relevant ideas into Lewin's model. The two models of Mendelow and Lewin are also used in this study as they complement Rogers' diffusion of innovation theory. The two models as detailed below will assist to unpack the role and influence of stakeholders on the adoption of hybrid maize adoption (Johnson et al, 2008). Mendelow's stakeholder matrix will be adopted in this study as it will assist to classify the various stakeholders using the matrix shown in Figure 2. The same matrix will be used in Chapter 4 to classify the various stakeholders including, small scale farmers, farmer organisations, agro-chemical companies, seed companies, policy makers and grain traders. The classification will be done using research data collected in this study. These stakeholders play various roles as diffusers, adopters, regulators and disseminators of innovations.

As mentioned earlier Rogers' model does not give details on the influence of stakeholders driving forces on the diffusion of an innovation therefore Kurt Lewin's field forces model (Johnson et al, 2008) will fill in the gap by analysing how various stakeholders will influence or slow the diffusion of innovations process in this study. Stakeholders exert different levels of influence to the diffusion and adoption of hybrid maize resulting in enhancing or retarding the adoption rate as shown in Figure 3 below. The researcher will further use Lewin'smodel to analyse research findings in Chapter Four. Below the two models are explained in detail:

Figure 2: Mendelow's Stakeholder Analysis Matrix:

Stakeholder mapping: the power/interest matrixStakeholder mapping: the power/interest matrix

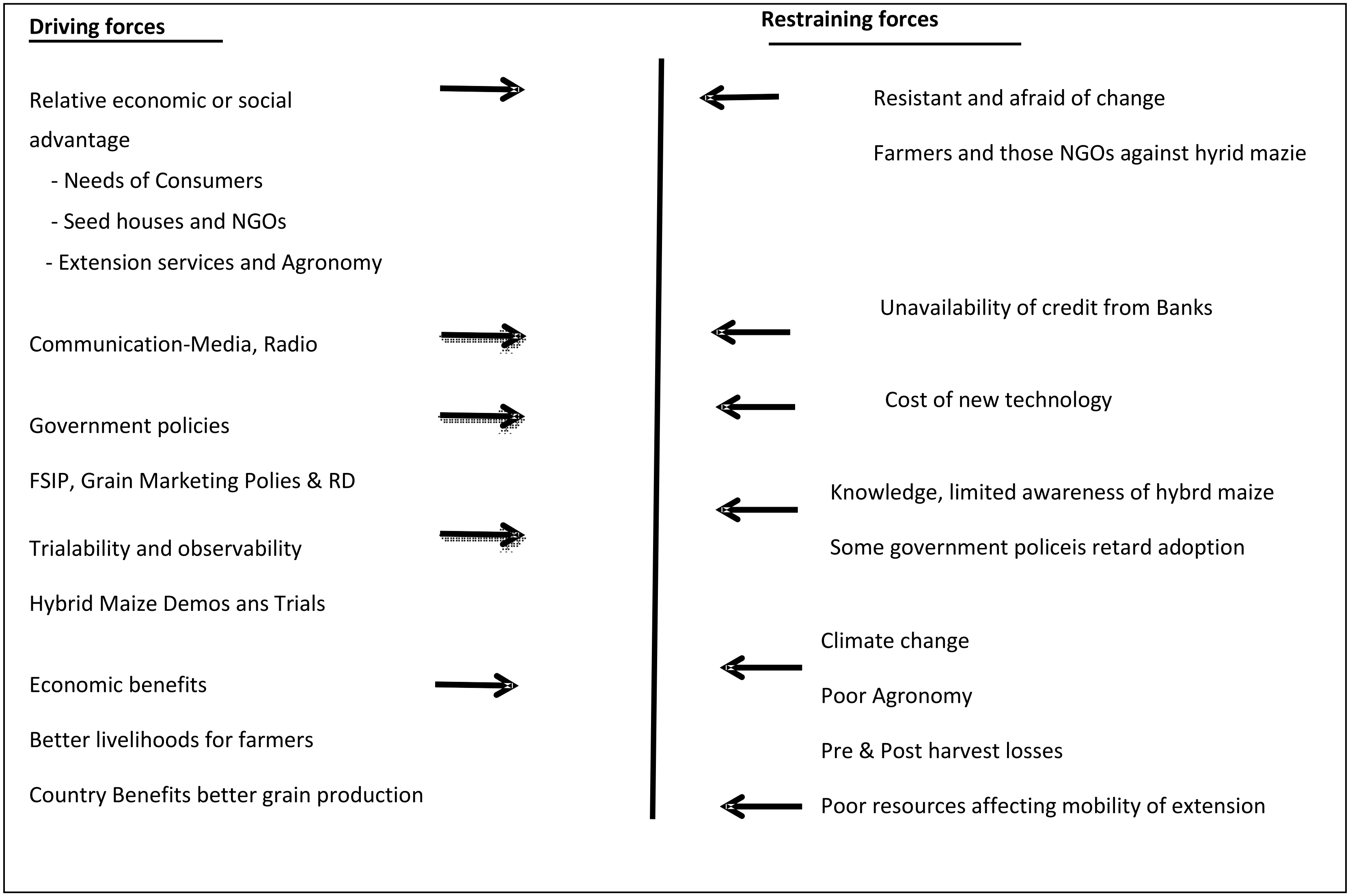
Level of InterestLevel of Interest

	LowLow	HighHigh
LowLow	A **Minimal effort** 1. Print Media 2. Electronic media 3. Radio	B **Keep informed** 1. Agro Input Suppliers 2. NGOS 3. Seed Companies
HighHigh	C **Keep satisfied** 1. Grain Processors 2. Consumers	D **Key players** 1. Policy Makers 2. Farmers 3. Farmer organisations

PowerPower

Proceedings of the Second International Conference **Source: Adapted from Mendelow, A. (1991)**

Figure 3: Kurt Lewin's Model: Driving Forces in Favour and Restraining Forces against hybrid maize adoption: Johnson 2008



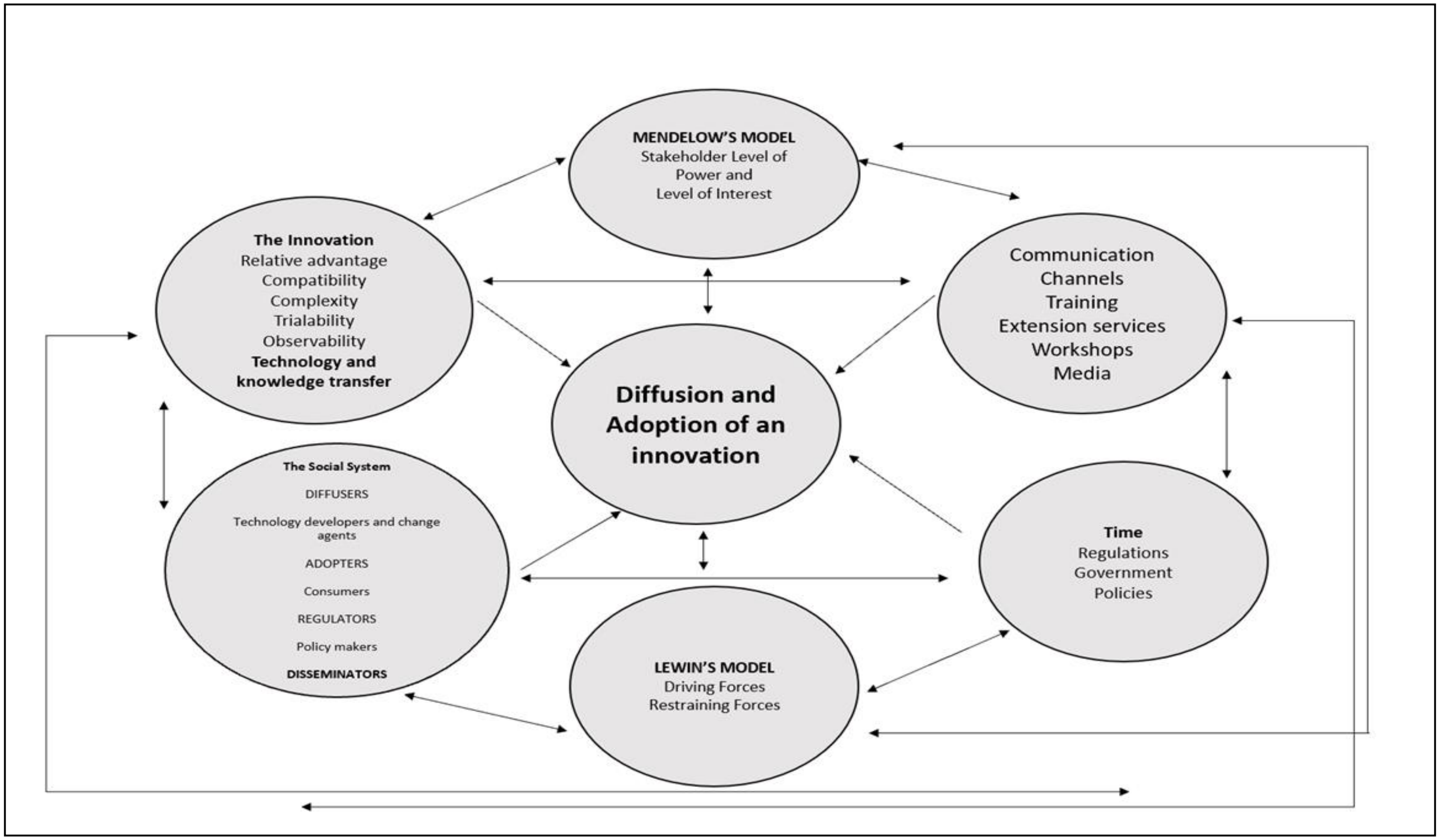
Mendelow's Stakeholder Analysis Matrix as shown in Figure 2 is based on stakeholders' level of power and interest to influence a process. In this study's context the power and interest are measured against the adoption of hybrid maize technology. Stakeholders have different levels of power and interest. Hence in Figure 2, the four quadrants designated the following categories: Stakeholders classified in Quadrant A have low power and interest and this can be occupied by the media and cannot be completely ignored but need to be monitored in case articles from the media can be damaging or promotional. Quadrant B has low power and high interest stakeholders and they need to be kept informed. Quadrant C has stakeholders that have high power and less interest and they need to be kept satisfied and lastly Quadrant D is occupied by stakeholders who have high power and interest and they need to be managed closely (Johnson et al, 2008). For example, a government policy maker has high power to regulate but may have low interest in the project. Therefore, in Chapter Four after the analysis of study findings the various stakeholders will be classified based on their power and interest as regards the adoption of hybrid maize as it arises from this research.

Lewin's force field analysis model (Johnson et al, 2008) in Figure 3 covers the influence of opposing and supporting forces generated by stakeholders or the environment in which the innovation is occuring. Factors that support the innovation change are usually shapped by stakeholders who drive for the change. Other stakeholders may apply forces that oppose the change and they may hinder progress on the change. Therefore, in the context of hybrid maize adoption some stakeholders may push for hybrid maize adoption that others may oppose. The two models of Mendelow and Lewin complement each other in analysing stakeholder influence on the adoption of hybrid maize technology and shall be revisited in Chapter Four as explained above.

In the study, the focus of the impact other factors like agronomy, drought, and pre and post-harvest losses, will be on the productivity of hybrid maize in the focus countries and other countries in Africa, but also in the Americas and Asia. This will help to draw lessons learned from other countries in different continents. These lessons will include what is known about hybrid maize adoption and the policies adopted as well as how farmers benefitted socially and economically as a result of adopting hybrid maize. The analysis will include the challenges faced by the farmers during the adoption process and the time it took for the farmers to adopt the technology. Lastly the study will review the impacts on small scale farmers' livelihoods, socially and economically in the focus countries and other countries. Drawing lessons that include the identification of practical strategies used by other countries will help to figure out similarities and differences that can help to close the research gap for this particular study.

2.3 Key Theories that Emerged in Literature Review and Conceptual Framework

Figure 4: Rogers' Diffusion of Innovations Model, Mendelow's stakeholder matrix and Lewin's force field –used in a Conceptual Framework to Show factors that drive or restrain the adoption of Maize Hybrids in Malawi, Zambia and Zimbabwe:



Before getting into detail on how the Conceptual Framework (which is anchored by Rogers' model and supported by both Mendelow and Lewin's models) above will be applied in this study, it is important to revisit the topic of the study. The problem that triggered this study is that of food shortages, hunger and malnutrition that recurs in Malawi, Zambia and Zimbabwe, whilst greater adoption of maize hybrids could achieve higher crop yields. Therefore, the main objective of this study is to establish factors that drive or constrain diffusion and adoption of maize hybrids in Malawi, Zambia and Zimbabwe. Rogers' (2003) four main elements supported by Mendelow and Lewin's models in Figure 4, are applied in this study's Conceptual Framework to critically analyse the factors that affect diffusion and adoption of maize hybrid innovation in Malawi, Zambia and Malawi. The analysis of the four elements in Rogers' model complemented by Mendelow and Lewin's models will help to answer the research questions in this study.This will be supported by literature drawn from examples of studies conducted in other countries.

Figure 4 summarises Conceptual Framework of this study derived from theories and concepts that emerged from the literature review. The Conceptual Framework is presented in seven circles, with the seventh circle representing the diffusion and adoption of an innovation and the outer six circles representing the four main elements of Rogers' theory; and Mendelow and Lewin's models supporting, Rogers' diffusion theory. The elements in the conceptual framework diagram are linked by arrows which represent their inter-dependence and relationship (Fisher, 2010 and Punch, 2014). Most arrows point in both directions linking the outer interrelated six circles. This is because the diffusion of an innovation is a seamless process that does not start or end at a specific point (Rogers, 2003). This is also demonstrating the integration and relationship in the seven circles. The unidirectional arrows show the relationship of elements of diffusion of innovations and factors within the elements that drive or constrain the adoption of a technology. The models of Mendelow and Lewin represent the interest, power and the driving forces behind the stakeholders in the diffusion and adoption of hybrid maize. Next is a summary of how Rodgers, Mendelow and Lewin's models apply to this study.

Rogers' model talks about the adoption of an **innovation** and in the present study hybrid maize adoption is the innovation targeted at small scale farmers. According to the model the product or innovation is supposed to bring economic and social advantage (Rogers, 2003). Therefore, in this study hybrid maize performance is being compared with OPV maize and the study will seek to provide evidence of economic and social advantage to small scale farmers. In addition, the innovation has to be compatible with the norms, values, beliefs and past experience of the small scale farmers. This is reviewed through farmers' past experiences and their expectations as they adopt hybrid maize in comparison to their usual OPV maize.

Furthermore, Rogers' model talks about complexity and in this study hybrid maize adoption should be easily understandable to the farmer s. Helping farmers by running trials and demonstration plots aligns well with Rogers' model (triallability and observability). In this way, knowledge transfer occurs in the process equipping the farmers to make informed decisions on adoption. Another aspect that will be brought out by the study is how the different stakeholders will influence small scale farmers to adopt hybrid maize for improved food availability and productivity. Mendelow's stakeholder matrix and Kurt Lewin's Force Field models contribute to the overall Conceptual Framework and help in explaining the different roles and influences of stakeholders on small scale farmers. All the explained points and applicability of Rogers, Mendelow and Lewin's models will be demonstrated by the analysis of results in Chapter Four of this study.

The model has a section on **communication channels** where print media, radio and electronic media are used and in this study, communication will be reviewed as to whether it will be done through, print media, radio, farmer field schools, demonstrations and/or field days. According to Rogers these communication channels are used to disseminate information about innovation adoption to adopters. Therefore, in Chapter Four research findings will be reviewed and analysed on how the study communication channels fit to Rogers' model and ultimately in the conceptual framework.

Further review of the model looks at **time** which measures the rate of adoption of an innovation. The adoption of hybrid maize by small scale farmers is measured as a percentage of volume of hybrid maize usage against the total maize planted in each of the study countries. The adoption rate will be reviewed in Chapter Four to see who amongst the stakeholders mostly influenced the adoption of hybrid maize by small scale farmers. Several policy examples, like FISP, grain prices and extension services, have been highlighted earlier in this Chapter that support or discourage the adoption of hybrid maize. These policies that cover marketing and pricing of grain will be analysed and their impact on measured on hybrid maize adoption assessed.

The model also has a section on **social system** for an innovation to be adopted and diffused. In this study diffusers and disseminators are extension officers, media, NGOs and seed companies who promote the use of hybrid maize and the adopters are small scale farmers. As mentioned earlier, extension officers, NGOs and seed companies through demonstration plots, media, demonstrations, field days and farmer field schools influence the agenda of hybrid maize adoption. Mendelow and Lewin's models will help us to explain, the influence of the various stakeholders involved in the adoption of hybrid maize.

Small scale farmers, besides being adopters of hybrid maizeare also consumers and they share this position with grain traders and millers. If consumers are not happy with the product the adoption rate may be affected. Finally, in the model, regulators and policy makers play an important role in the model because they regulate conditions of product registration before it gets to market. In the case of hybrid maize registration, the seed act guides seed companies on how to register hybrid maize before they can be sold on to the market.

2.4 Conclusion

The literature review in this Chapter covered work on applicable themes and examples that will be referenced again after data analysis in Chapter Four. The author has reviewed studies related to hybrid maize adoption directly or indirectly mainly from sub-Sahara Africa (SSA) and in particular from the three focus countries. To have a better understanding of the subject matter literature review also analysed global historical information on hybrid maize adoption.

Of key relevance are Mendelow's and Lewin's models that are included in the final Conceptual Framework. The two models covered stakeholders' interest, power, supporting and restraining forces. The models are applicable to the study as they allow us to analyse explicitly key aspects of stakeholder influence, notably power and interest on hybrid maize adoption at different levels.

The themes, in this study are going to use the Conceptual Framework to analyse findings from this study. They have been, highlighted in the literature review summarised below, located within the structure of the conceptual framework. The impact of stakeholder influence is topical to the study. The literature reviewed showed that the **social system,** following Rogers, will include policy makers, extension officers, seed houses and NGOs that play a big role influencing the adoption of hybrid maize by small scale farmers. Amongst this group policy makers set up policies that guide other stakeholders on hybrid adoption. Policy makers set input subsidy policies like FISP and they set maize grain market prices in the three focus countries. They are also responsible for managing and deploying extension officers who have a big role of training and advising farmers on technical agricultural matters. Finally, policy makers are regulators that control the registration of hybrid maize in the three focus countries.

The next stakeholders are extension officers, NGOs and seed houses who lead dissemination and diffusion of hybrid maize to small scale farmers. These stakeholders collaborate and importantly combine their energy in driving the adoption of hybrid maize. From the literature review and using Rogers' theory of diffusion, these stakeholders form the **Social System** in the model. Their power is summarised by Mendelow's and Lewin's models. The social system in the model is closely linked to **communication channels** that are used to disseminate technology information to adopters through mass media, interpersonal, demonstrations, training and field days.

The third theme covers **time** measuring the hybrid maize adoption rate and the reasons why the adoption rate has been slow in the study countries. Several reasons have been raised in the literature reviewed that include, lack of mobility by extension officers to effectively reach out to small scale farmers and explain the benefits of hybrid maize and a lack of funding for small scale farmers to buy inputs to effectively grow hybrid maize. Other factors that affect hybrid maize adoption include climatic change, lack of irrigation facilities, poor management of pre- and post-harvest losses and poor agronomic practises.

Finally, the fourth theme covered in the literature review is on the relative advantage and socio-economic impact caused by the adoption of the **innovation** on the livelihoods of farmers when they adopt hybrid maize technology. Several examples were cited in the literature that showed that with better productivity farmers' income improve leading to better livelihoods after adopting hybrid maize. Examples cited were better housing, better health provision for families and better educational provision to children. All these themes highlighted above helped to formulate the Conceptual Framework. Further, the literature reviewed will then be analysed and compared with the research results in Chapter Four of this thesis. Having covered all these themes, the study will reveal the gap that continuously causes food shortage in the three countries. The next chapter covers details on research philosophy, methodologies and research methods adopted in this study.

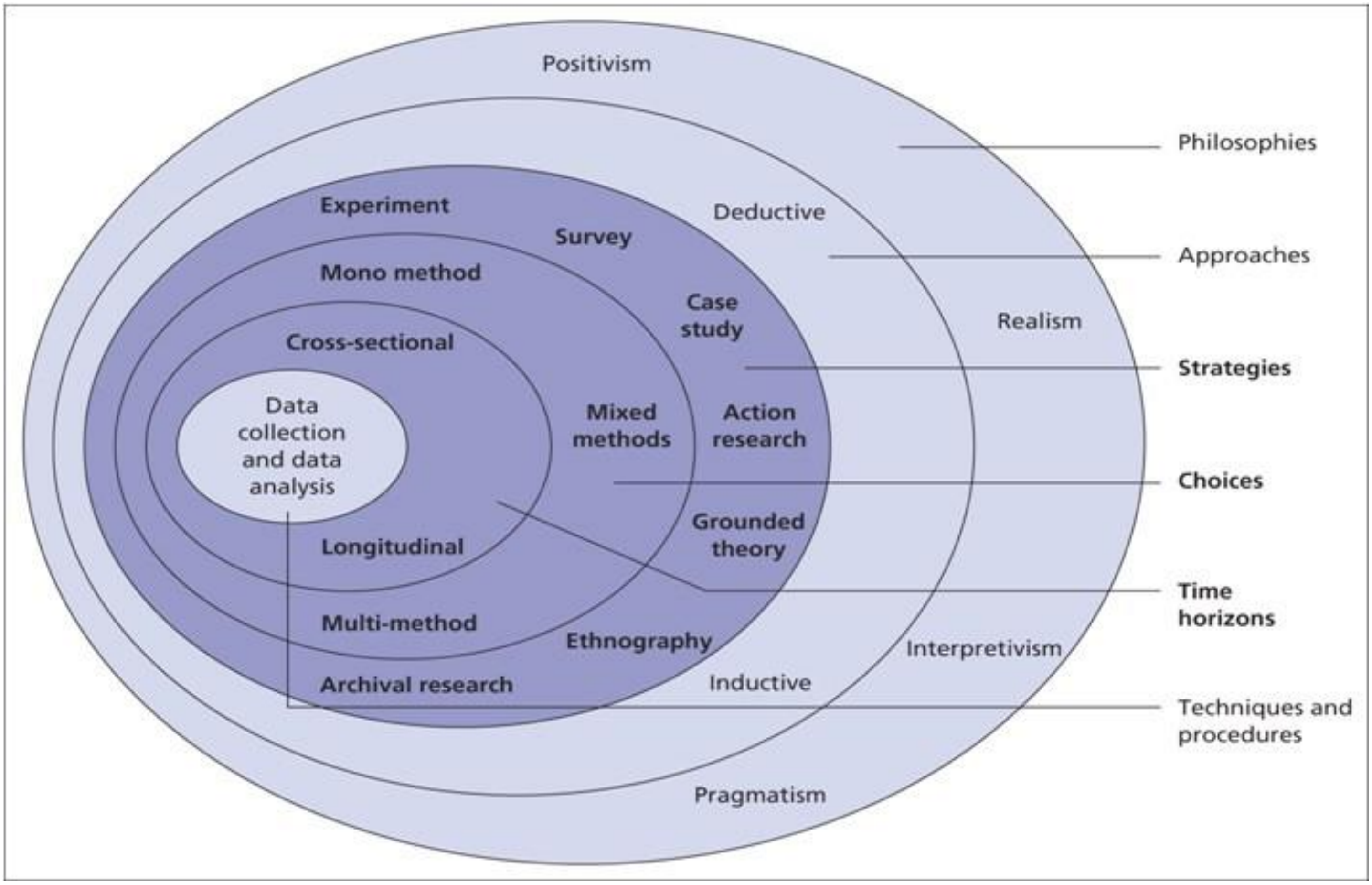
CHAPTER THREE: RESEARCH METHODOLOGY AND METHODS

3.1 Introduction

This Chapter discusses the research process, research philosophies and research design adopted to collect and analyse empirical data for the study. Interpretivist and positivist are the research philosophies to be discussed further in this Chapter followed by highlights, discussions and comparisons of the two research philosophies. The Chapter will also cover details on research methodologies and methods used in the study.

Creswell (2003) and Cameron (2011) state that the researcher must take a paradigm stance and adopt a research framework which allows them to lodge their plans in a scope grounded in literature and identifiable with the intended audience. This is because methodological choices in research work are driven by philosophical assumptions and theoretical perspectives about reality (Cameron, 2011; Crotty, 1998). To illustrate the research process below is a diagrammatic representation of the research processes using onion shells (Saunders et al, 2003). Figure 5 below shows the research process being similar to the peeling process of ‘’onion’’ shells (Saunders et al, 2003). This Chapter shall be structured like the onion shells, giving an outline of the research overview highlighting research philosophies, research process and research strategy. These highlighted topics are going to be covered in turn in the sections below.

Figure 5: The Research Process ''Onion''



Saunders, Lewis and Thornhill, 2003:83

The primary objective of this study focuses on the impact of maize hybrid adoption by small scale farmers for sustainable food production in Malawi, Zambia and Zimbabwe. Secondly the study looks at how new knowledge is transferred to small scale farmers by stakeholders and third, how the livelihoods are changed by adopting maize hybrids. In this regard the study attempts to answer the following four research questions:

1. **Why is hybrid maize adoption currently slow amongst small scale farmers in Zimbabwe, Malawi and Zambia?**

   Research Question One (RQ1) is seeking to find out the reasons why the full adoption of hybrid maize has been limited, in Malawi, Zambia and Zimbabwe. The focus of the research question is on facts affecting the farmers' limited adoption. The study will also look at factors that promoted or hindered maize hybrid adoption in Malawi, Zambia and Zimbabwe in relation to the existing research literature. RQ1 will be primarily answered by responses from questionnaire variables: Q22 and Q23 (Annex 1) and interview questions: Q4, Q9, Q10 and Q11 (Annex 2). Factor analysis from similar variables (factors) on the questionnaire will be analysed to provide a quantitative response to RQ1.

2. **How do policy makers and other stakeholders influence or hinder hybrid maize adoption?**
   Research Question Two (RQ2) assesses the influence or hindrance of various stakeholders on hybrid maize adoption by small scale farmers. The research question focuses on whether established policies and policy makers are promoting or slowing the adoption of hybrid maize by small scale farmers. The question also measures the success or failure of the implemented policies. RQ2 will be answered by the analysis of questionnaire variables: Q10, Q11, Q12, Q13, Q14, Q15, Q16 Q17, Q19, Q20, Q21, Q24, Q25 and Q26 (Annex 1) and interview questions: Q1, Q3, Q7, Q8 and Q12 (Annex 2).
3. **What are the main factors that cause low maize productivity amongst small scale farmers?**
   This Research Question explores the causal factors for low productivity and seeks to find solutions for these. The study through literature reviewed, interviews and responses from the questionnaire will assess the factors that cause low productivity in the focus countries. To answer Research Question Three (RQ3), quantitative survey responses from questionnaire variables: Q1, Q2, Q4, Q6, Q8 and Q9 and interview question Q6, are analysed.
4. **What are the social and economic benefits to small scale farmers that are realised when they adopt hybrid maize?**
   This Research Question explores the benefits of hybrid maize adoption not only to small scale farmers but also to the countries, given that commercial farmers are not significantly involved in maize production in the three countries. Based on the literature reviewed, both the interviews and survey of small scale farmers are assessed to see how small scale farmers benefit socially and economically by growing hybrid maize. To answer RQ4 survey questions, Q3, Q5 and Q7 and interview questions, Q2, Q5, Q13 and Q14 are analysed. Analysis of

Section B of the questionnaire with both costs of production from OPV and hybrid maize will assist to answer RQ4.

It is important to note that the answers for the RQs above are therefore derived from interview data, the qualitative survey responses, and the quantitative survey responses.

3.2 Research Paradigms and Pragmatism Philosophy

A paradigm is defined as a set of beliefs on how problems should be understood and resolved, and is largely determined by ontological and epistemological perspectives taken by the researcher (Anderson, 2013). Ontology is concerned with the reality of things and how reality is constructed (Holden and Lynch, 2004; Anderson, 2013). Epistemology looks at how we come to know about that knowledge and nature of the relationship between the enquirer and enquired (Krauss, 2005; Anderson, 2013).

Pragmatism is adopted as the research paradigm for this study, embracing interpretivist and positivist research philosophies. Pragmatist philosophy is a paradigm that accommodates practically both qualitative and quantitative research methods (Morgan, 2014, Van Griensven et al, 2014; Krivokapic-Skoko and O'Neill, 2011). Given the researcher's field experience this approach goes well with the researcher's values and is in line with the research objectives and questions. Fisher (2010) asserts that a researcher, subconsciously, at the beginning of a research process chooses a philosophical stance that resonates with their values. Further based on the researcher's experience the four research questions are crafted in such a way they will bring out the required research data.

Pragmatist philosophy brings together apparently opposing philosophies, that is, positivism and interpretivism (Agerfalk, 2010). The epistemological assumption of positivism takes the objective view of conducting research with minimum interaction with participants and for the researcher in this case there is the claim that the author is free from personal bias (Wilson, 2014). Positivist research philosophy is further described using objectivism that assumes that there is an objective reality that should be studied with hard facts, which have the status of truth (Anderson, 2013). Proponents of positivism argue that speculation and subjectivity should be cleansed from research, and the world can be viewed through one mirror and the data analysis does not change regardless of the researcher (Krauss, 2005). This means the results on hybrid maize adoption regardless of the researcher or context, can be reproduced using the positivist research approach. Proponents argue that positivism brings reliability, accuracy and objectivity to the research; the research can be repeated at different times with different researchers but with the same results each time (Anderson, 2013). After gathering data from the questionnaire, which was used to collect quantitative data and qualitative texts from respondents, the quantitative data was analysed using the SPSS statistical package to develop statistical inferences as part of the answers to each of the research questions.

However, in this study, the perceptions of stakeholders who are involved in diffusion and adoption of maize hybrids play an important role. Therefore, it is also important to hear the voices and opinions of these stakeholders through the interpretivist approach, which includes the use of in-depth interviews. This is further supported by critics of positivist philosophy, by arguing that research is more complex when it involves human beings, and positivism does not provide ways to study human behaviour in a thorough way (Ayer, 1973). Therefore, the exploration of human behaviour such as, feelings, attitudes and beliefs is beyond the comprehension of positivism.

This brings in the interpretivist philosophy which is based on the ontological assumption that reality is not rigid, but it is context and time dependent (Hoepfl, 1997 and Krauss, 2005). The epistemological assumption for this paradigm is that knowledge is subjectively acquired and exists in many versions of reality depending on context, and there is greater opportunity to gain knowledge by placing and engaging with people in their social context and seeing the world in their perspective (Anderson, 2013; Holden and Lynch, 2004; Kelliher, 2005). Therefore, applying an interpretivist approach to qualitative data offers advantages of gaining insights that promote or inhibit the diffusion and adoption of maize hybrids through personal observation and conversations with informants. Interpretive analysis described in detail below, will contribute to answering all four research questions through analysis of in-depth interview responses and texts from the questionnaire. All four research questions are going to be subjected to qualitative analysis.

Later on in this Chapter, positivist and interpretivist epistemologies will be discussed in detail as to how they will be used to help analyse findings in this study through quantitative and qualitative analysis of the questionnaire responses, texts and in-depth interviews, in order to answer the research questions. In answering them the researcher will compare the findings of both the qualitative and quantitative analysis to check results obtained from the two methodologies.

Given this stance the combined Conceptional Framework developed from Rogers', Mendelow's and Lewin's models will assist in analysing research data derived from both the posivist and interpretivist philosophies. Therefore the Conceptual Framework will guide the analysis of the research data qualitatively and quantitatively. Having introduced the positivist and interpretivist research philosophies above, the next sections will discuss details of quantitative and qualitative steps taken to analyse this study, starting with the survey piloting below:

3.3 Survey Piloting and Training of Field Assistance

Before going into field work it was necessary to do a pilot test run with the questionnaire. To statisfy this pilot excercise, with the assistance of extension officers, six farmers were randomly chosen from Zimbabwe's Seke district in Mashonaland East province, testing the questionnaire's effectiveness and ease of use. This district was chosen because of its closeness to Harare where the researcher resides, making logistics easier.

The process of piloting the survey ensured nothing goes wrong when one starts the survey in the field (Andrews et al, 2003). This will give confidence to the researcher because any problems that may arise during the research process would have been dealt with prior to the onset of data collection. Before piloting the survey, Agriculture Extension Officers (AEO) and Dekalb Field Officers (DFO) were trained on how to distribute questionnaires randomly amongst the stakeholders that included mainly small scale farmers. The AEOs and DFOs were trained in such a way that they guided the farmers in filling in the questionnaire only, without any due influence in leading the farmers into giving certain answers.

These selected farmers were purposefully selected by the researcher and his assistants (AEOs and DFOs). This process helped also in training research assistants on how to distribute and collect the questionnaires. No farmer had difficulties in understanding the questionnaire although the vernacular language was used to explain the details of questions when needed. This was done to accommodate those farmers who might have difficulties in understanding English. The same strategy of translating the questionnaire into the vernacular was used in the main surveys conducted in the 3 focus countries. The actual survey did not include the farmers that participated in the pilot survey. After going through the pilot process the section below details the quantitative research approach of this study:

3.4 Quantitative Research Strategy

The quantitative data collected for this study were primarily from data collected from small scale farmers located in Malawi, Zambia and Zimbabwe shown in Table 2 below. Research strategies of conducting surveys are done through the use of questionnaires aiming at getting information from a sample of the population (Cresswell, 2003 andGroenewald, 2004). This survey strategy allows collected data comparison from various groups in the population (Sukamolson, 2007). This strategy was appropriate for the data being collected and the questionnaires could fit descriptive research questions (Sukamolson, 2007). A survey strategy was important for this study because the questionnaire can be filled in by more farmers without necessarily meeting the respondents physically and this allowed data collection to reach more participants. Below Table 2 shows sampled participants across all stakeholder groups in the study.

Table 2: Profile of the Sample and Participants in the Focus Countries as administered by the Questionnaire

Stakeholders Category	Zimbabwe	Malawi	Zambia	Total
Government Extension Officers	10	5	5	20
Policy Makers	11	5	5	21
Farmers no experience of Planting Hybrids	8	38	30	76
Farmers with experience of Planting Hybrids	147	57	70	274
Total Small Scale Farmers Sampled	155	95	100	350
Grain Traders	15	5	9	29
NGOs	10	4	5	19
Seed Companies	6	4	4	14
Regional Fertiliser and Chemical Companies	3	2	2	7
Total	**210**	**120**	**130**	**460**

Sampling Approach

This study used purposeful snowball sampling (Noy, 2008; Gray, 2009 and Petty et al, 2012). The researcher got the first few respondents by approaching government extension officers who led the researcher to them. This was followed by other respondents who were selected through referrals by other participants who were selected based on key characteristics and the objectives of the study (Bryman and Bell, 2011). By following this methodology the research managed to sample relevant respondents whose answers could help to address the research questions.

Participants only referred others within the same category for example, NGOs only referred other NGOs and farmers only referred other farmers. This helped to build critical mass in terms of a sufficient number of appropriate interviewees for the study (Bryman and Bell, 2011). This strategy helped the researcher to get to more respondents, especially in Malawi and Zambia, given that these two countries are not so familiar to the researcher. This resulted in the numbers of respondents surveyed below:

Survey Results

Table 3: Number of small scale farmers surveyed

Country and location	**Number of small scale farmers**
Malawi: Blantyre (55), Chikwawa (25) and Mwanza (15)	95
Zambia: Lusaka (20), Chikankata (25), Mazabuka (16), Monze (19) and Choma (20)	100
Zimbabwe: Harare (25), Mazowe (15), Shamva (13), Mutare (20), Chipinge (14), Chimanimani (15), Goromonzi (12), Seke (11), Mrewa (10)	155
Total	350

The participants of the survey were 350 small scale farmers who were unfortunately not categorised by their gender and 110 other stakeholders as shown in Tables 1 and 2 above. The farmers, who are the adopters of hybrid maize, were drawn from districts in Malawi, Zambia and Zimbabwe. Small scale farmers were the most important stakeholders in the study because they are the target of the adoption of hybrid maize and it is they who decide whether or not to adopt hybrid maize.

The other stakeholders who completed the questionnaire are shown in Table 2. These stakeholders are as identified in the literature review, promoted and regulated hybrid maize adoption.

3.4.1 Data Collection Using Questionnaire -Annex1 and Interview Questions (IQs)-Annex 2

The research itself, as well as the questionnaire and interview questions, were approved by the appropriate NTU ethics review process. In line with Rowley (2014), the questionnaire was developed such that it collected sufficient data that answered the research objectives and questions and achieved the required response rate. Table 4 below shows the relationship of the questionnaire and interview questions in line with research objectives (ROs), research questions (RQs), research themes and questionnaire variables (QVs). The table is also supported by detailed questionnaire and IQs in Annex 1 & 2 for the quantitative and qualitative analysis respectively.

Table 4: Research Objectives, Questions and Themes Linked with Questionnaire Variables and Interview Questions (IQs)

Objectives		Research Questions		Themes (Factors)	Qs and IQs
1	To assess the impact of hybrid maize adoption by small scale farmers with emphasis on economic and sustainable food production that allows the small scale farmers to be food self-sufficient and be able to sell excess to national grain reserves in Malawi, Zambia and Zimbabwe.	RQ1	Why has hybrid maize (innovation) adoption been slow (taking long more than 50 years) amongst small scale farmers in Malawi, Zambia and Zimbabwe?	Factors causing slow hybrid maize adoption rate by small scale farmers	Qs 22-23 IQs4, 9-11
	To assess the impact of hybrid maize adoption by small scale farmers with emphasis on economic and sustainable food production that allows the small scale farmers to be food self-sufficient and be able to sell excess to national grain reserves in Malawi, Zambia and Zimbabwe.	RQ3	What are the main causes of low productivity in maize production amongst small scale farmers?	Other factors causing low productivity of hybrid maize by small scale farmers	Qs 1-2, 4, 6, 8-9 IQ6
2	To assess how best stakeholders can collaboratively work together to influence the knowledge transfer to small scale farmers to adopt hybrid maize for improved food productivity to feed the growing population.	RQ2	How do policy makers and other stakeholders influence knowledge transfer to small scale farmers on hybrid maize adoption?	Factors that influence or retard the diffusion and adoption of hybrid maize by small scale farmers	Qs 10-17,19-21, 24-26 IQs-Qs 1,3, 7-8, 12
3	To identify the economic and social benefits brought to small scale farmers (land holding for the farmers range from 1-6 hectares) livelihoods through the adoption of hybrid maize.	RQ4	What are the social and economic benefits to small scale farmers that are achieved by the adoption of hybrid maize technology?		Qs 3, 5, 7 IQs 2, 5, 13-14

The questionnaire and IQs as summarised in Table 4 above and presented in full in Annex 1 and 2 were distributed and interviews were conducted respectively from April to June 2018 using the district and ward structures in the countries. The researcher was helped by Dekalb and extension officers in the focus countries. Once the questionnaires were filled in, the researcher coordinated the collection process.

Likert scale ratings of 1-5 were used because they were easily understood by the farmers. Responses generated from questionnaire variables were factor analysed using SPSS statistical package. The variables in the questionnaire were constructed in a semi-structured way so that the respondents could pause and reflect for detailed answers (Saunders et al, 2007). In addition, by using farmers' field records including, costs of production, yields and incomes the questionnaire brought out useful economic and production data.

3.4.2 Quantitative Data Analysis

Section A of the questionnaire (Annex 1) had twenty six variables that generated data using a Likert scale. The data were analysed using factor loading with a cut-off value point of 0.4 for easy analysis of social data analysis. Any variables with a value below 0.4 were dropped remaining with those variables with more effect on hybrid maize adoption (Schonrock-Adema et al, 2009). The variables with commonalties on a specific factor were loaded on that particular factor only (Schonrock-Adema et al, 2009). To reduce over factoring (Schonrock-Adema et al, 2009) from the different variables in the questionnaire, eigenvalues were tightened starting with a cut-off of 1.1 for the Zambian and Zimbabwean data. For Malawian analysis eigenvalues were tightened to a minimum value of 1.5. Scree plot diagrams were then constructed from these eigenvalues of the factors resulting in graphs reflecting inflexion points where the cut off values were set. After generating the scree plot diagrams the factor variables were then analysed using SPSS regression analysis (Schonrock-Adema et al, 2009). This analysis of the data brought out factor variables that were checked for statistical significance regarding answering the four research questions. Table 4 above shows how different questions on the questionnaire informed the analysis for each of the RQs. In addition, any information added in text by the respondents, on the questionnaire, was intended to further inform qualitative analysis derived from in-depth interviews.

Unfortuanately most of the respondents, did not fill in the text as required due to their literacy levels hence there was no additional text data collected.

Data gathered from Section B (Annex 2) of the questionnaire were analysed by SPSS using costs and yield gathered from both OPV and hybrid maize farmers' responses. Factor analysis was used to measure the statistical significance of the variables in the costing model. This analysis helped to evaluate the profitability and establish the relative economic advantage of maize hybrid adoption compared to OPV maize (Schonrock-Adema et al, 2009). Financial ratios and net profit margin were calculated for ease of interpreting the data. This format and approach is widely used to assess financial performances of various business sizes (Horrigan, 1965). Small scale farmers usually operated at subsistence levels for feeding their families and coming up with financial records was difficult. However, some of the farmers kept farming records which made it possible to prepare useful and reliable analysis from the data collected. The analysis of profitability ratios and profit margins calculated from net profit against sales was a good tool with which to measure farming enterprise performance (Delen et al, 2013).

3.4.3 Qualitative Research Strategy

Turning now to the qualitative data collected, this came from stakeholders' in-depth interviews, this was best suited to this study for purposeful sampling which sought to maximize the depth and richness of the data to address the research questions (Grix, 2010). In-depth interviews unpacked the factors that affected the adoption of hybrid maize by small scale farmers. Answers from the in-depth interviews will be compared amongst the three countries so that we can identify similarities and differences in answering the RQs.

3.4.4 Qualitative Data Collection.

The interviewing of stakeholders needed special skills and attention hence it was done by the researcher alone with work mates and extension officers assisting with translations. It was important that the researcher took the responsibility of interviewing informants because research ethics as required by the NTU ethics protocol needed to be followed. Additionally the researcher has gained enough skills to conduct interviews which requires listening skills, probing and use of open ended questions. Field data collection was conducted between April and June of 2018.

3.4.5 Choosing Qualitative Research Participants

The participants in this study included, policy makers, extension officers, seed houses, fertiliser and agro-chemical companies, small scale farmers, farmer organisations and NGOs. Based on Rogers' (2003) theory of Social System, this study then categorised participants as diffusers, adopters, regulators and disseminators.

The qualitative research included thirty participants interviewed, as shown in Table 5. Before embarking on the purposeful snowball sampling to access informants, the intial interviewees were chosen through referrals from extension officers who knew the farmers well (Noy, 2008). As with the questionnaire, small scale farmers were the most numerous category of stakeholders interviewed. The researcher attended several field days in the three study countries, where most small scale farmers and respondents were met and sampled for in-depth interviews.

Representatives from two agro-chemical companies were met and sampled at field days and were also interviewed.

Table 5: Profile of the Sample and Participants in the Focus Countries

Stakeholders Category	**Zimbabwe**	**Malawi**	**Zambia**	**Total**
Government Policy Makers	1	2	2	5
Farmers not Planting Hybrids	1	1	1	3
Farmers with Experience of Planting Hybrids	3	3	2	8
Total Farmers Interviewed	4	4	3	11
Farmer Unions	1	1	1	3
Grain Traders	1	2	1	4
NGOs	1	1	1	3
Seed Companies	1	1	1	3
Regional Fertilizer and Chemical Companies	1			1
Total	**10**	**11**	**9**	**30**

3.4.6 In-depth Interviews

Participants in the interviews were referred to by coded numbers because some of them did not want their names published as shown in Annex 6; this was to safeguard those informants who asked for anonymity. In preparation for the interviews, interview guide questions that were aligned with the research questions were prepared ahead of the in-depth interviews (Annex 2). These interview guides were prepared for each stakeholder group and this helped the flow of the interviews.

The researcher followed Denscombe's (2010) suggestion that before closing the interview, participants should be allowed to point out any issues that they consider important but were not asked.

A voice recorder was used to capture the interviews and transcriptions were done by the researcher. The process required the researcher to repeatedly listen to the recordings during the transcription. In some cases the researcher had to seek further clarification from participants to ensure rigor of the transcripts. Before interviewing the informants, the voice recorder was placed where it was visible and the researcher asked the participants for their consent before recording the discussion.

The comparison of yield between OPV maize and hybrid maize was important to the respondents. They were eager to know whether the researcher was for OPV maize or maize hybrid. The researcher did not evade the question and advised the participants that on completion of the interview, an answer will be provided. The delay in answering the question is a tactic supported by Goodell et al (2016), who point out that if a researcher presents their own perspective during an interview, it may result in participants changing their answers to fit what they think the interviewer wants to hear, resulting in biased responses. In such situations, at the end of the interview, the researcher gave participants an honest account of previous findings from top researchers on maize hybrid technology that emerged from the literature reviewed, presenting points from both proponents and critics of hybrid maize adoption.

The interviews were conducted at venues (homes, farmer hall or a business centre) selected by the participants. This allowed the researcher to connect with the participants where they were comfortable and relaxed. In-depth interviews that were recorded had an advantage in the sense that the researcher does not only collect data first-hand as the participants speak but can watch body language of the informants. The researcher could interpret meaning in ways that might not have been possible with a self-administered questionnaire. Furthermore, follow up questions were asked that might not have been anticipated at the time of formulating the interview research questions.

3.4.7 Qualitative Data Analysis

Based on the pragmatism research philosophy and focusing on research methods that best answer the research questions, the qualitative research involves in-depth interviews. Qualitative data analysis can be defined as range of methods used to sort, organise, index and interpret qualitative data (Rambaree, 2007). Qualitative data analysis is a complex process which requires the researcher to develop skills in data interpretation and coding (Rambaree, 2007). There are several qualitative data analysis methods available that include content analysis, discourse analysis and conversational analysis (Gray, 2009; Fisher, 2010). Content analysis was used for this study and following Hsieh and Shannon (2005) was used to interpret subjective data through systematic classification process of identifying themes and patterns. In qualitative analysis, a code can be defined as "a word or short phrase that symbolically assigns a summative, silent, essence-capturing, and or evocative attribute for a portion of data" (Saldana, 2009). Annex 5 shows the transcriptions and summary of key points and themes raised from the in-depth interviews.

To begin data analysis, the researcher had to put together manually typed interview transcripts. This processing was a time consuming and laborious exercise. The researcher read the transcripts repeatedly, ''immersing within the data to gain detailed insights'' into the phenomena on stakeholders' perceptions about maize hybrids (Hsieh and Shannon, 2005 and Noble and Smith, 2014). To maintain the quality of the research, contributions of all participants were considered and the researcher used quotations from the transcripts to capture accurate responses from participants.

The researcher used narrative analysis based on the various themes of the study so as to gain insights into participants' experiences of maize hybrids using direct quotations from informants. The findings from participants were linked to research questions and themes whilst comparing them with the literature reviewed. This approach used quotations from interviews during the presentation of findings and comparing them against the literature reviewed, established differences or similarities to what was known already.

To establish interpretive evidence that were transferrable to quantitative results, in-depth interviews with experts and informants from the stakeholders' groups (that include policy makers, small scale farmers, farmer organizations, grain traders, agro-chemical companies and NGOs) were also conducted (Annex 5). Using a two-column format, the left column was filled with interview texts and on the right column comments were inserted (Annex 5). Information transcribed from the interviews were analysed and used to answer research questions. The study will have sections in Chapters Four and Five to cover on reliability, validity and generalisation of the qualitative and quantitative research methods.

Having completed describing the two research approaches of interpretivist and positivist and how they are going to be applied in this study, the next section summarises the research approach adopted for this study.

3.5 Research Approach

This study is using a mixed methods research (MMR), pragmatist strategy, to address the four research questions stated in earlier sections. As described above both qualitative and quantitative research methods have pros and cons and this study used both methods. In addition, the two methods complemented each other such that mixed methods are appropriate for this study. The two research methods brought different insights that gave a better interpretation of the research findings, giving more insight into results and reduced bias by checking on the similarities and differences of the analysed results (Grix, 2010 and Lynch, 2013). As stated above the quantitative research approach analysed responses from the questionnaire seeking to answer all four research questions. This was followed by an interpretive qualitative research method example that gathered data on the views and opinions of participants to answer the four research questions. Relative socio-economic advantage was one of the factors that promoted the diffusion and adoption of maize hybrids. On their own, the quantitative results did not explain finer details of what pushed or slowed the diffusion of maize hybrid (Berg, 2001 and Boahene et al, 1999). The qualitative analysis explored what the quantitative could not analyse, whilst the quantitative analysis explored what the qualitative could not explore explicitly.

Whilst qualitative research can provide an in-depth understanding of a phenomenon, critics have questioned its research legitimisation in terms of reality, validity and lack of generalisation (MacLeod and Pennell, 1993; Kelliher, 2005). It is crucial to remember that qualitative research is quite different in its approach and purpose to quantitative research, and therefore the validation of research legitimisation for qualitative research cannot be done using the same measures as quantitative research. This means that the established criteria for scientific rigour for quantitative research cannot be applied to qualitative research (Malterud, 2001). Therefore, qualitative research can be more focused on transferability as opposed to generalisation (Bitsch, 2005; Malterund, 2001).

An example where MMR was used in a study of GM cotton adoption study in South Africa, where quantitative and qualitative research methods were applied (Bennett et al, 2006) However, the Bennett et al (2006) study was more skewed on quantitative research and the qualitative part only touched on a group discussion with farmers. The findings in this study showed farmers preferred GM cotton because of less chemical sprays required on GM cotton compared to conventional cotton. The researchers acknowledged more insight would have been recorded from the farmers if in-depth interviews were conducted with a bigger sample of the farmers interviewed one-on-one. That is the approach adopted in the present study.

3.6 Conflict of Interest Management

The researcher is a Managing Director at Dekalb, a licensed seed company called Zadzamatura based in Harare. Zadzamatura is in the business of producing and selling seed in Zimbabwe. This study was on the adoption of maize hybrids and there was a possibility of conflict interest because the researcher works for a seed company that develops and sells maize hybrids. However, the researcher started working for Zadzamatura after commencing the DBA program. There was no undue influence by the employer on the research findings and academic work.

The researcher is well known in the farming community in Zimbabwe and to reduce bias of respondents the questionnaire distribution was done with the help of assistants, who were given strict guidance of how they were to conduct themselves when confronted by situations which they would end up influencing bias to responses. Wherever the researcher had to distribute the questionnaire he made sure that the respondents filled in the questionnaire without any influence or bias. In Zambia and Malawi 3 different assistants (work mates and extension officers) were engaged respectively and again respondents filled in the questionnaire independently.

3.7 Conclusion

Adopting the framework of the research onion, this Chapter has discussed the research process, approach and design used to collect and analyse research data for this study. This in turn covered the philosophical research paradigm stance of pragmatism philosophy that was chosen for this study and has been discussed in detail. So different elements of the study follow either positivist or interpretivist epistemological philosophies. The positivist approach used quantitative methodology and the data was gathered through a questionnaire with two sections administered in the survey. Section A of the questionnaire had twenty-six variables and section B of the questionnaire had a production model that collected production cost data for purposes of calculating gross margin figures from farmers who grew hybrid maize in comparison with gross margin data from farmers who grew OPV maize.

Before conducting the main survey, a pilot survey was done to test the questionnaire's applicability to the targeted respondents. The pilot survey was done successfully but translation was necessary for those farmers who had low English understanding. Having tested the questionnaire and trained AEOs and DFOs it was then distributed to stakeholders with the help of fellow employees and extension officers. This resulted in the collection of 460 completed questionnaires from respondents. As discussed, earlier bias on completing the questionnaires, was managed by letting the participants fill in the questionnaire independently without the influence of fellow employees, AEOs or myself. Data collected from questionnaire was analysed by SPSS statistical package.

Data collection for the interpretive research approach was done through purposeful snowball sampling strategy of the respondents. In-depth interview questions were formulated for the various stakeholders. Thirty participants from the various stakeholders were sampled for in-depth interviews from Malawi, Zambia and Zimbabwe. During interviews voice recordings were taken and transcribed for content analysis. The data analysed was categorised into themes or factors that answered the research questions. The next chapter will present the research findings from the study and analysis of results, in accordance with the conceptual framework presented in Chapter 2 and the research design presented here in Chapter 3.

CHAPTER FOUR: RESEARCH FINDINGS, ANALYSIS AND DISCUSSIONS

4.1. Introduction

This Chapter presents the research findings and analysis of this study of the main factors influencing the adoption of hybrid maize by small scale farmers in Malawi, Zambia and Zimbabwe. Having adopted a mixed methods strategy, we draw together the findings from different parts of the research. The results will then be compared to the theories and empirical findings that emerged from the literature reviewed in Chapter 2. To aid the reader, we reproduce below in Table 4 the structure of the research that links the Research Objectives to the Research Questions, then through the Themes (Factors); and which Questionnaire and Interview Questions are drawn on in presenting the analysis and answers to the Research Questions. The questionnaire is reproduced in Annex 1 and interview questions in Annex 2.

Table 4: Research Objectives, Questions and Themes Linked with Questionnaire Variables (Qs) and Interview Questions (IQs)

Objectives		Research Questions		Themes (Factors)	Qs and IQs
1	To assess the impact of hybrid maize adoption by small scale farmers with emphasis on economic and sustainable food production that allows the small scale farmers to be food self-sufficient and be able to sell excess to national grain reserves in Malawi, Zambia and Zimbabwe.	RQ1	Why has hybrid maize (innovation) adoption been slow (taking long more than 50 years) amongst small scale farmers in Malawi, Zambia and Zimbabwe?	Factors causing slow hybrid maize adoption rate by small scale farmers	Qs 22-23 IQs4, 9-11
	To assess the impact of hybrid maize adoption by small scale farmers with emphasis on economic and sustainable food production that allows the small scale farmers to be food self-sufficient and be able to sell excess to national grain reserves in Malawi, Zambia and Zimbabwe.	RQ3	What are the main causes of low productivity in maize production amongst small scale farmers?	Other factors causing low productivity of hybrid maize by small scale farmers	Qs 1-2, 4, 6, 8-9 IQ6
2	To assess how best stakeholders can collaboratively work together to influence the knowledge transfer to small scale farmers to adopt hybrid maize for improved food productivity to feed the growing population.	RQ2	How do policy makers and other stakeholders influence knowledge transfer to small scale farmers on hybrid maize adoption?	Factors that influence or retard the diffusion and adoption of hybrid maize by small scale farmers	Qs 10-17,19-21, 24-26 IQs-Qs 1,3, 7-8, 12
3	To identify the economic and social benefits brought to small scale farmers (land holding for the farmers range from 1-6 hectares) livelihoods through the adoption of hybrid maize.	RQ4	What are the social and economic benefits to small scale farmers that are achieved by the adoption of hybrid maize technology?		Qs 3, 5, 7 IQs 2, 5, 13-14

4.2 Qualitative Data Collection and Pre-Testing

As discussed in Chapter 3, this study adopts a pragmatist research philosophy using qualitative (interview) and quantitative (questionnaire) data collecting methods. Before we utilise the quantitative data in the analysis below, for each of the three countries in turn, we must first test the data for its robustness followed by a summary of the main findings. In Section 4.3 we can utilise the information in the analysis confident in its validity and robustness.

4.2.1 Questionnaire Quantitative Data Analysis - Zimbabwe

We first check whether the sample size of respondents is adequate to perform statistical analysis otherwise the analysis will not produce valid results. With reference from Tables 2 and 3 in Chapter 3, there were 260 stakeholders who responded to the questionnaire in Zimbabwe consisting mostly of small scale farmers. Using the Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO) and Bartlett's Test of Sphericity (Schonrock-Adema et al, 2009; Buglear, 2005) the sample size is found to be significant, as at 0.786 above, the rule of thumb of 0.5 or more representing stastical adequacy (Table 6).

Table 6: KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.786
	Approx. Chi-Square	957.145
Bartlett's Test of Sphericity	Df	300
	Sig.	.000 ***

Due to the large number (26) of variables in the questionnaire, a dimension reduction was performed to reduce manifest variables into fewer factors called latent variables (Schonrock-Adema et al, 2009; Bryman and Bell, 2011). In this respect Principal Axis Factoring was performed and a minimum factor loading cut off value of 0.4 was used as described in Chapter 3. Table 7 below shows the variables selected through factor analysis and loaded on to a single factor. The selected factors are a result of the relationship between the research questions and questionnaire variable responses. After factor analysis, four factors were identified as follows: Factor 1 as shown in Table 7 had the highest (9) variables that are highly loaded on a single factor. Based on commonalities (Schonrock-Adema et al, 2009) of the questionnaire variables, Factor 1 related to RQ2. This means that nine closely related variables are assembled into a factor attempting to answer RQ2. RQ2 seeks to analyse responses from the questionnaire variables on policy makers and other stakeholders' influence on small scale farmers' hybrid maize adoption (as shown in Table 4).

The next factor to be defined is Factor 2, which was loaded by variable responses (Table 7) and related to RQ3. The following factors that included agronomy, climatic change and pre- and post-harvest losses affected small scale farmers' productivity.

Factor 3 reviewed variable responses (Table 7) that are related to RQ1. This question seeks to address the causes (lack of funding and resources for extension officers) of slow hybrid adoption by small scale farmers. Finally factor 4 had one variable (Table 7) which analysed the socio-economic impact of hybrid maize adoption on small scale farmers' livelihoods.

Table 7: Factor Extraction for Hybrid Maize Adoption

Extraction Method: Principal Axis factoring. Rotation: Varima

	Rotated Factors			
	1.- Ans. RQ2	***2.- Ans. RQ3***	***3- Ans. RQ1***	***4- Ans. RQ4***
Questionnaire Variables				
V10	0.692			
V24	0.618			
V12	0.592			
V13	0.577			
V26	0.573			
V17	0.564			
V25	0.562			
V16	0.536			
V21	0.533			
V8		0.675		
V9		0.631		
V2		0.57		
V1		0.542		
V4		0.462		
V6		0.4		
V22			0.571	
V23			0.437	
V7				0.451

Details of the Data Analysis Approach

In an effort to answer all research questions in this research, the next step in the analysis provided another opportunity to interpret the results according to a technique advocated by Sharma and Sharma (1996) using the scree plot diagram derived from eigenvalues. A scree plot is a diagrammatic representation of reduced variables. The reduced variables were in turn represented by factors ranked by their weighting importance.

The weighting is by percentage of importance of the factor in causing variation and the factor values are called eigenvalues. This whole process of deriving eigenvalues is called factor analysis. The factors are then plotted and ranked statistically in accordance with their importance. The most important factors which caused most of the variability are found before the breaking point or the elbow on the scree plot diagram. Having extracted the factors from the Zimbabwe data, 44.691% of the variability observed in the variables is explained by four factors where each variable was highly loaded on one factor only. As depicted in **Table 8** below, the results of total variation fell below the expected rule of thumb of 50-60% for social sciences research. However, increasing the number of factors to six increases total variation to 55.2% and in this instance, it resulted in cross loading of variables on a number of factors leading to a masking of underlying constructs (Schonrock-Adema, 2009). As a result, the cut-off point of the loading factor is tightened to value 0.4 and that of the lowest eigenvalue was tightened to 1.1 instead of 1.

Quantitative Research Results Analysis

Table 8, below, shows and explains the scree plot diagram, where Factor 1 contributes 24.13% of the variance. This percentage variance is reflected in the sharp scree suggesting that most of the variables are loaded highly on **stakeholder influence**. Figure 6 below presented the scree plot clearly showing the inflexion on the graph caused by the high eigenvalues for Factor 1. This shows in practice that stakeholder influence had a high degree of impact on the process of hybrid maize adoption by small scale farmers. Further the same result was shown in Figure 7 where a three-dimensional factor rotation showed variable maximisation around **stakeholder influence**. This analysis confirmed that stakeholders had a significant influence on hybrid maize adoption.

Table 8: Total Variance Explained by the Factors

Factor	Eigenvalue	% of Variance	Cumulative %
1	6.032	24.127	24.127
2	1.901	7.605	31.732
3	1.746	6.984	38.716
4	1.494	5.975	44.691
5	1.323	5.293	49.984
6	1.303	5.211	55.195

Figure 6: Hybrid maize adoption dimension reduction Scree Plot - Zimbabwe

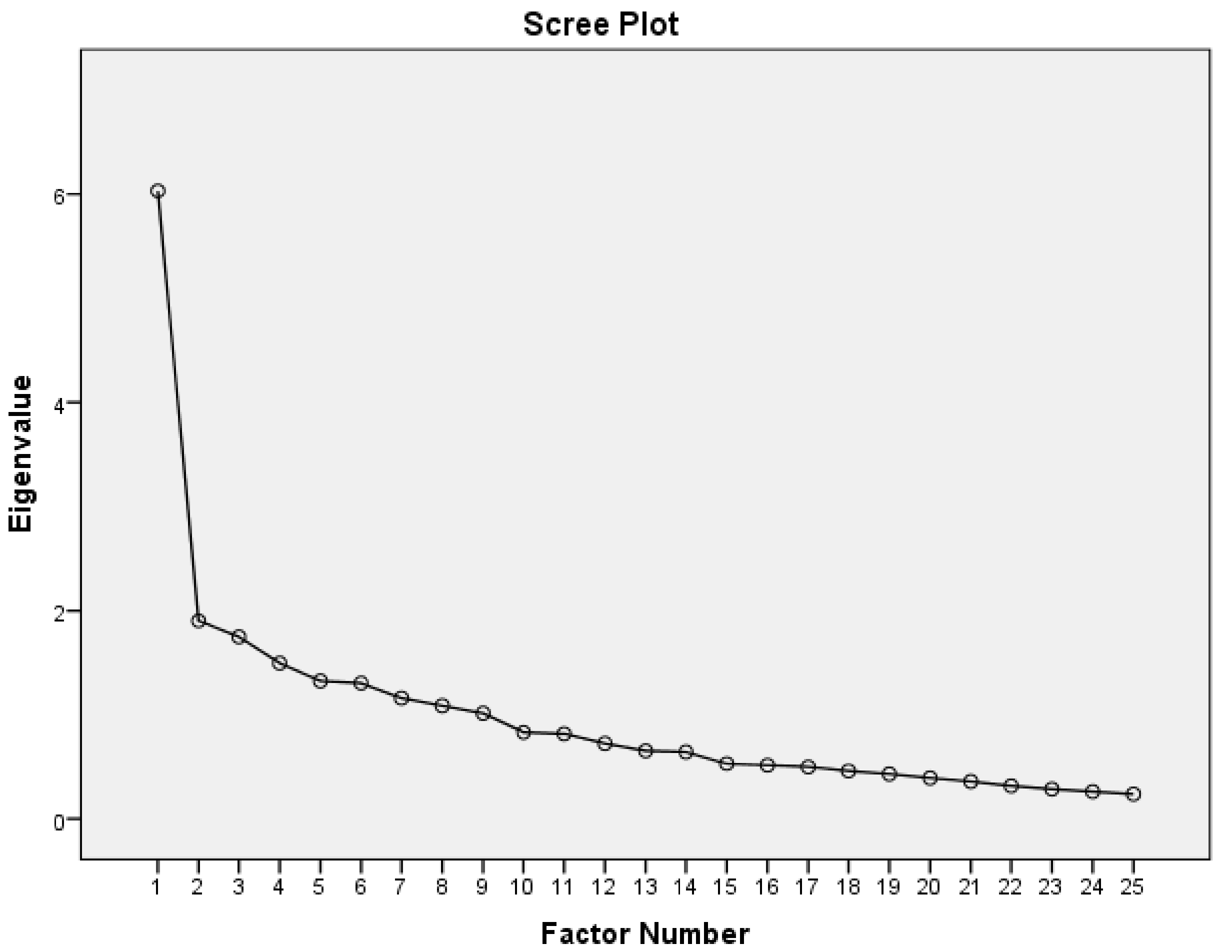
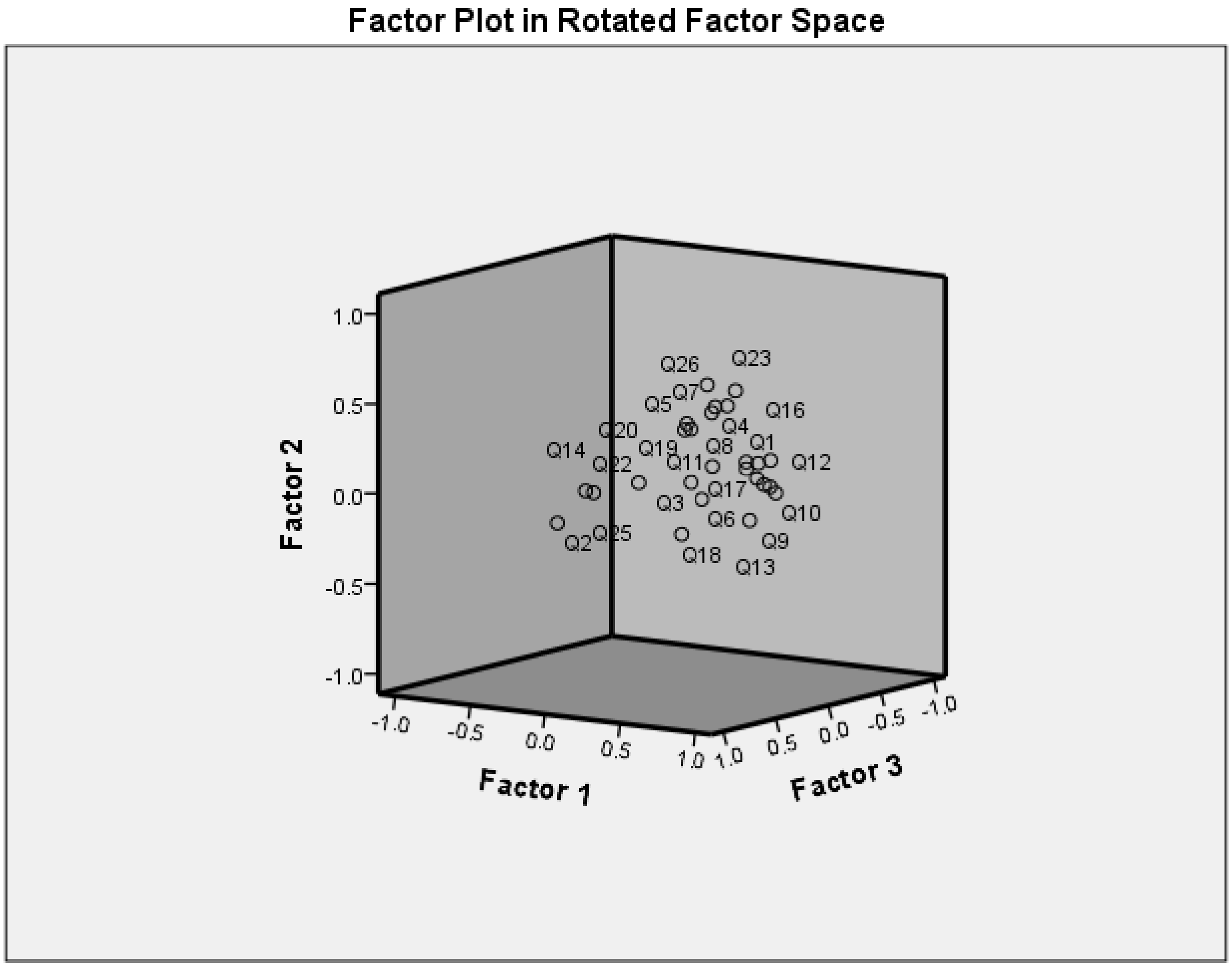


Figure 7: Maize adoption 3-D variable plot



After performing factor extraction, the factors were saved as variables and their respective factor scores were used in further analysis. To determine which factors were statistically significant, a logistic regression was performed in table 9 below:

Table 9: Logistic regression results on maize adoption factors from Zimbabwe data

Factors	B	S.E.	Wald	Df	Sig.	Exp(B)	95% C.I.for EXP(B)	
							Lower	Upper
1. Stakeholder Influence	0.822	0.322	6.504	1	0.01***	2.275	1.210	4.279
2. Causes of Low productivity	-0.175	0.341	0.262	1	0.61	.840	0.430	1.638
3. Slow Hybrid adoption rate	-0.774	0.425	3.319	1	0.07*	.461	.201	1.060
4. Economic and social benefit	-0.593	0.392	2.288	1	0.13	.553	.256	1.192
5. Constant	2.502	0.448	31.17 0	1	0.00	12.204		

a. Variable(s)
   1.Stakeholder Influence
   2. Causes of Low yields
   3. Slow Hybrid adoption rate
   4. Economic and social benefit
b. P<0.01***<0.05**, P<0.1*

Table 9 above shows the regression analysis of the four factors as listed in this present study. The statistical significance test was conducted at p values <0.01, <0.05 and <0.1. Any factor that was below the set p values mentioned above had no statistical significance in influencing hybrid adoption by small scale farmers. To help us to answer RQ1 below, the logistic regression results in Tables 7 and 9 show that lack of credit support to small scale farmers and lack of resources to support extension officers have a statistically significant impact at p<0.1. This showed that farmers in general when they lack funding and awareness were 46.1% less likely to adopt hybrids but even if they lack knowledge and funding, 54% of the farmers were still likely to adopt hybrids (also see Cavane and Donavan, 2011 and Davis et al, 2012).

Further data review showed that total responses from Q22 recorded higher value responses than Q23 which meant lack of hybrid maize awareness (caused by lack of resources by extension officers) by small scale farmers had higher responses than lack of credit availability therefore slowing down hybrid maize adoption by small scale farmers. Turning to quantitative data related to answering RQ3, the results from Table 7 and 9 showed that agronomy, climatic change, irrigation and pre- and post-harvest losses affect low productivity. This Factor had no statistically significant impact on the adoption of hybrid maize by small scale farmers.

Similarly, the results, relating to RQ4 on relative economic and social impact, did not have a statistically significant impact on the adoption of hybrid maize by small scale farmers. However, to further help answer RQ4 a comparison of productivity and returns of hybrid maize against OPV maize was undertaken by analysing production model data from Section B of the questionnaire. The results of the Zimbabwe data presented in **Table 10** below, showed that yield and production costs per hectare were statistically significant at p value of <0.01 when measuring small scale farmers' profitability. The size of land planted and product adopted (hybrid or OPV) were not statistically significant. The results showed that the production cost and the yield were more important in determining farmers' income and profitability (see Smale et al, 2013). The analysis performed was targeting the key drivers for the farmer's bottom line (profitability) and it is not surprising that yield and cost were the two variables that had significant influence on profitability (see also Mannion and Morse, 2009 and Kutka et al, 2011). Based on the consolidated cost-based analysis in Table 20 hybrid maize had a better statistically significant return compared to OPV.

Table10: Factor Analysis on the Profitability of Maize Production in Zimbabwe

Model	Unstandardised Coefficients		Standardised Coefficients	T	Sig.	95% Confidence Interval for B		Collinearity Statistics	
	B	Std. Error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
(Constant)	-85.962	46.999		-1.829	0.070	-178.874	6.951		
HYB/OPV	56.927	49.308	0.006	1.155	0.250	-40.553	154.406	0.970	1.031
Area	5.856	11.999	0.004	0.488	0.626	-17.864	29.576	0.341	2.937
Yield/Ha	388.661	3.114	1.300	124.799	0.000***	382.504	394.818	0.207	4.842
Prod Cost/Ha	-0.996	.013	-0.565	-79.613	0.000***	-1.021	-0.972	0.444	2.251

a. Dependent Variable: Income, P<0.1*, P<0.05** , P<0.01***

Further regression data analysis from Table 9, in attempting to answer RQ2, showed that at p <0.01, only stakeholder influence was highly statistically significant in influencing hybrid maize adoption. This meant that, once small scale farmers were exposed to strong stakeholder influence, they were 2.275 times more likely to adopt hybrids than their counterparts (see also Wambungu, 2014). Further descriptive statistical data reviewed from the questionnaire and Table 9 show that policy makers and extension officers had the most influence on the adoption of hybrid maize by small scale farmers, compared to other stakeholders in Zimbabwe.

4.2.2 Questionnaire Quantitative Data Analysis- Zambia

The Zambian data passed the KMO and Bartlett Tests for sample size adequacy, as shown in **Table 11**. Factor analysis was again performed and the factors converted to variables.

As before, the analysis had to be tightened to fewer explainable constructs. Table 12 below shows the four factors that were extracted using the principal component extraction method. Although in Table 12 there are 6 components, Factors 5 and 6 were dropped to remain with four factors for reasons explained above. With these adjustments the scree plot and the rotated component (factor) diagram in Figures 8 and 9 respectively explained the impact of the four factors, described above, on hybrid maize adoption. From the scree plot in Figure 8 below, **stakeholder influence** had the **greatest impact on hybrid adoption** by small scale farmers. The other three factors had lesser impact compared to stakeholder influence.

Table 11: KMO and Bartlett's Test - Zambia

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.620
Bartlett's Test of Sphericity	Approx. Chi-Square	1163.511
	Df	300
	Sig.	0.000

The table above showed that the sample size was adequate (0.62>0.5) and the model is fit for factor analysis (p=0.000<0.05).

Table 12: Total Variance Explained by the Components

Factor	Eigenvalue	% of Variance	Cumulative %
1	5.351	21.403	21.403
2	2.996	11.982	33.385
3	2.38	9.518	42.903
4	1.435	7.112	50.015
5	1.327	5.739	55.754
6	1.215	5.309	61.063

Figure 8: Scree Plot - Zambia

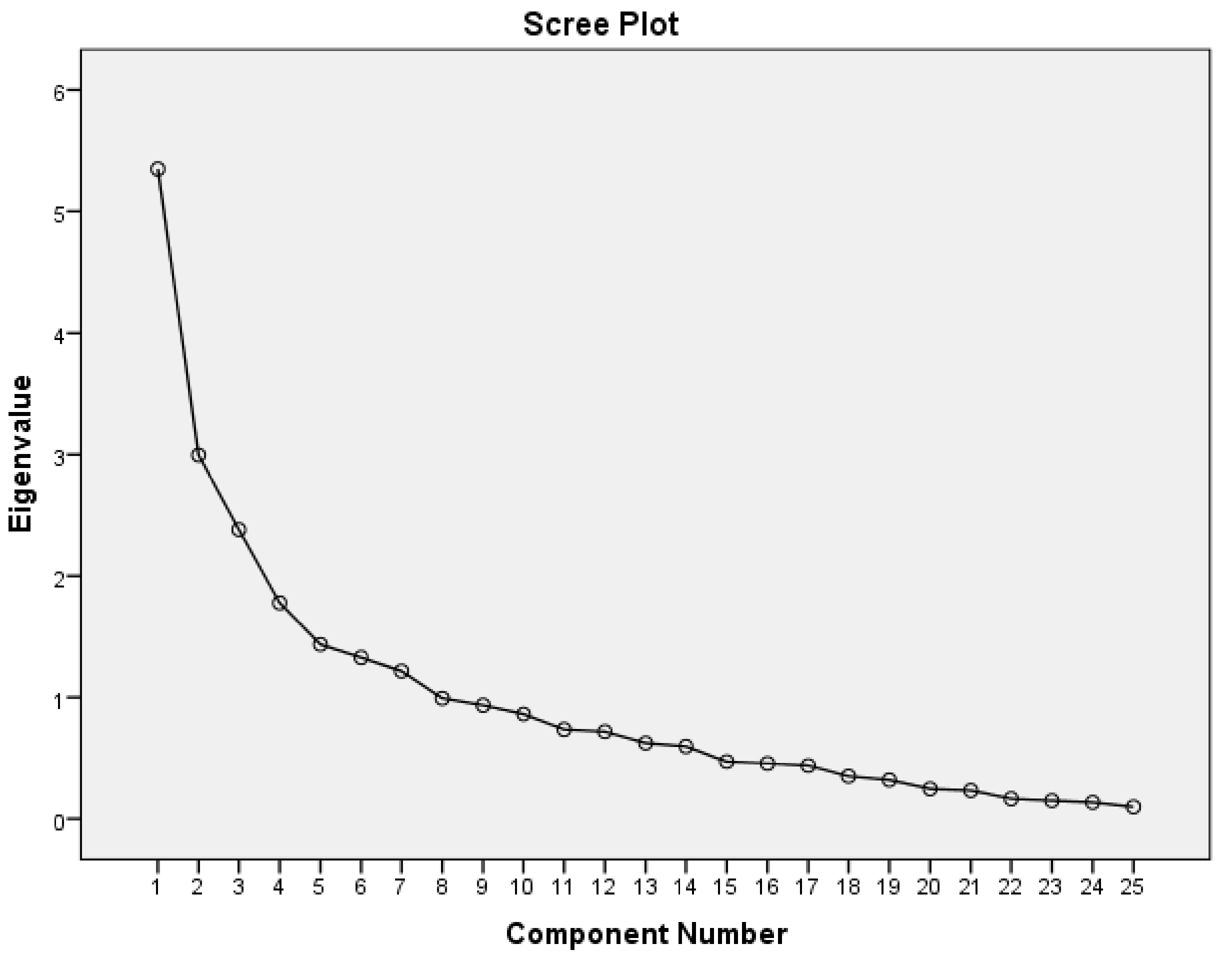
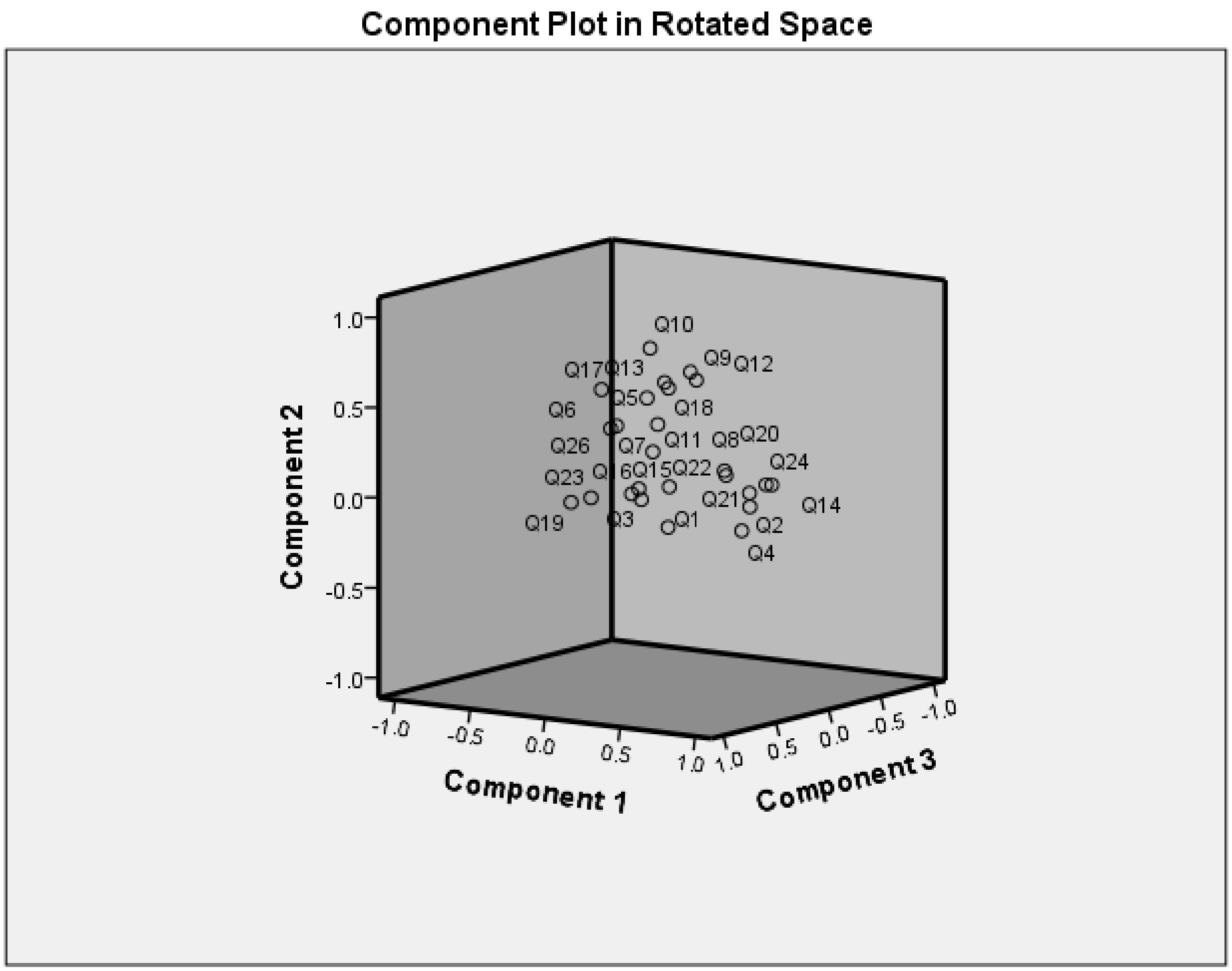


Figure 9: Component Plot in Rotated Space- Zambia



The variables denoted by the questionnaire in Figure 9 above were densely populated on component 1 and 3 showing that stakeholder influence and had the greatest impact on hybrid maize adoption.

Table 13: Factor Extraction for Hybrid Maize Adoption in Zambia

	Rotated Factor			
	1	*2*	*3*	*4*
Variable				
V10	0.762			
V24	0.747			
V12	0.746			
V13	0.71			
V26	0.696			
V17	0.696			
V25	0.639			
V16	0.638			
V21	0.596			
V8		0.588		
V9		-0.339		
V2		0.531		
V1		0.703		
V4		0.62		
V6		0.548		
V22			0.364	
V23			0.381	
V7				0.459

Table 14: Logistic Regression for Hybrid Maize Adoption in Zambia

Logistic regression for hybrid adoption in Zambia						
	B	**S.E.**	**Wald**	**Df**	**Sig.**	**Exp(B)**
Stakeholder influence	0.712	0.273	6.816	1	.009***	2.037
Causes of low productivity	-0.724	0.309	5.482	1	.019**	0.485
Slow rate of adoption	0.610	0.320	3.645	1	.056*	1.841
Economic and social stability	1.035	0.419	6.099	1	.014**	2.815
Constant	-0.830	0.302	7.575	1	.006	0.436

a. Variable(s)
   1. Stakeholder Influence
   2. Causes of low productivity
   3. Slow rate of adoption
   4. Economic and social stability.

b. P<0.01***, P<0.05**, P<0.1*

Tables 13 and 14 highlight factors that will be used in analysing RQ1 as they apply in Zambia. As there was a strong connection in the constructs, the variable (Factor 3) of slow adoption rate was statistically significant at $p<0.1$, this indicates that lack of funding and poor awareness of hybrid maize performance still had a statistically significant impact on hybrid maize adoption rate (see Poolsawas et al, 2011; and Simtowe, 2009). From the values in Tables 13 and 14, farmers that lacked awareness and funding were 1.841 times less likely to adopt hybrids than their counterparts. Lack of credit availability to small scale farmers had a greater impact than hybrid maize awareness as regards to slow adoption of hybrid maize.
In answering RQ3, Factor 2 from the factorial analysis represented causes of low productivity and had a $p<0.05$. This means, a lack of irrigation, poor agronomy and climatic change had a statistically significant impact on hybrid maize adoption (see also Mapila et al, 2012 and Schroeder, 2013). Results from Tables 13 and 14 also showed that causes of low productivity had a statistically significant impact on adoption.

Turning to answer RQ2 and after performing binary logistic regression analysis, the four factors showed varying significant p values interpreted as follows: The results in Table 14 showed that stakeholder influence was highly statistically significant at $p<0.01$. Stakeholders' influence had a significant impact on hybrid maize adoption by small scale farmers (also see Kutka, 2011; Howlett and Walker, 2012). As shown in Table 14 above, farmers that were exposed to stakeholder influence were 2.037 times more likely to adopt hybrids than their counterparts. Most of the selected variables from the questionnaire scored high on the responses for the various stakeholders, with policy makers and extension officers registering the highest response values.

Lastly regarding responses relevant to RQ4, small scale farmers' livelihoods (Factor 4) were statistically and significantly impacted economically and socially by hybrid maize adoption. This was shown by a significant $p<0.05$. Farmers who perceived hybrid adoption as an economically and socially stabilising enterprise were 2.815 more likely to adopt hybrid maize compared to those that are yet to realise the significance of hybrid maize productivity (see also Ali et al, 2020 and Mathenge et al, 2013). Further logistic regression was performed on the data collected from

Section B of the questionnaire. Based on the analysis in Table 15 below, only, yield had a statistically significant ($p<0.01$) impact on the small scale farmers' profitability.

Table 15: Zambia Data - Factors Affecting Farmers' Profitability

Model	Unstandardised Coefficients		Standardized Coefficients	T	Sig.	95.0% Confidence Interval for B	
	B	Std. Error	Beta			Lower Bound	Upper Bound
Constant	115.416	2442.400		.047	0.962	-4770.110	5000.943
Area	74.893	478.098	.001	.157	0.876	-881.445	1031.231
Yield	900.444	7.277	.999	123.740	0.000***	885.888	915.000
Price	0.969	0.879	.009	1.103	0.275	-0.789	2.727
ProdnCost	0.002	0.056	.000	.032	0.974	-0.110	0.113
Hyb/OPV	-1515.523	1879.414	-.007	-.806	0.423	-5274.911	2243.865

4.2.3 Questionnaire Quantitative Data Analysis- Malawi

Analysis of the Malawian results are presented below. First, the KMO and Bartlett tests were conducted done for sample size adequacy and as shown in Table 16, KMO (0.712) is greater than 0.5.

Table 16: KMO and Bartlett's Test – Malawi

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.712
Bartlett's Test of Sphericity	Approx. Chi-Square	1238.799
	Df	325
	Sig.	0.000

Once again, the large number of variables were reduced once more, in this instance resulting in four factors as shown in Tables 16 and 17 followed by a scree plot in Figure 10. After extracting the factor constructs a logistic regression analysis was performed as presented in Table 17.

Table 17: Total variation explained by Four Latent Factors of maize Adoption

Factor	Eigenvalue	% of Variance	Cumulative %
1	6.317	24.295	24.295
2	3.717	14.297	38.592
3	2.989	11.495	50.087
4	1.651	6.349	56.436

Figure 10: **Scree Plot - Malawi**

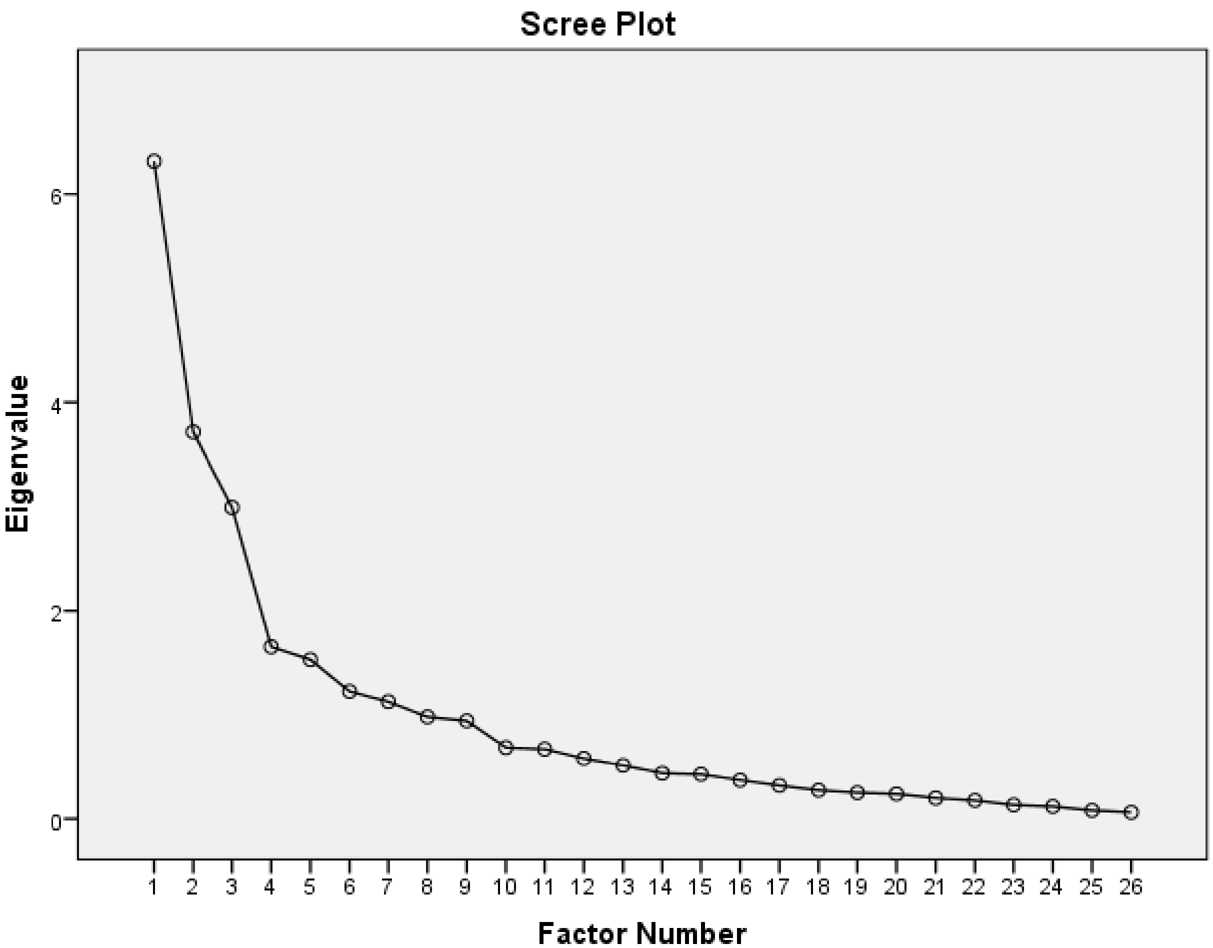


Table 18: Factor Extraction for Hybrid Maize Adoption in Malawi

Rotated Factor Matrix

	Factor			
	1	2	3	4
V10	-.847			
V24	.781			
V12	-.665			
V13	.654			
V26	.627			
V17	.782			
V25	.696			
V16	.641			
V21	.587			
V8		.567		
V9		-.748		
V2		.602		
V1		.580		
V4		.520		
V6		.520		
V22			.520	
V23			.440	
V7				.424

Table 19: Logistic Regression for Hybrid Maize Adoption in Malawi

Logistic regression for Maize hybrid adoption in Malawi						
	B	**S.E.**	**Wald**	**Df**	**Sig.**	**Exp(B)**
Stakeholder Influence	3.497	1.383	6.391	1	0.011**	33.011
Economic and social stability	0.202	0.496	.166	1	0.683	1.224
Causes of low yields	-0.004	0.406	.000	1	0.991	.996
Slow adoption rate	-2.114	0.995	4.517	1	0.034**	.121
Constant	3.624	1.020	12.623	1	0.000	37.477

a. Variable(s)
   1. Stakeholder Influence
   2. Economic and social stability
   3. Causes of low yields
   4. Slow adoption rate.

b. $P<0.01^{***}$, $P<0.05^{**}$, $P<0.1^{*}$

Relevant to our later analysis of RQ1, Tables 18 and 19 show that lack of credit support to small scale farmers and lack of resources to support extension officers had a statistically significant impact at p<0.05. Further, a lack of hybrid maize awareness by small scale farmers had higher responses than lack of credit availability regarding causes of slow adoption of hybrid maize. Regarding the factors relevant to our analysis of RQ3 and RQ4 Tables 18 and 19 show no statistical significance on all the factors relating to the productivity of hybrid maize. Also results on the relative economic and social impact had no statistically significant impact on the adoption of hybrid maize by small scale farmers.

Finally in determining the factors relevant to answering RQ2, covariates in Table 19 indicate that stakeholder influence was statistically significant this time at $p<0.05$. Again, like the Zambian results, high value responses were recorded mostly from policy makers and extension officers, showing these two stakeholders were the most influential.

4.2.4 An Overview of Main Themes (Factors) from the Countries

Consolidated Data Comparing Hybrid Maize vs. OPV Maize

Table 20: Farmers' Average Summary of Production Model Records from Section B for Hybrid Maize Vs OPV Costing and Income for all Focus Countries

B1	**Farming activity**	Hybrid	OPV
B2	Crop Planted:		
B3	Total hectares planted (Ha)	1,050	386
B4	Total Harvest (MT)	2,625	618
B5	Total Sales @USD250/Mt	656,250.00	154,500.00
B6	Yield achieved /Ha	2.5	1.6
B7	Price of Maize/Mt (USD)	250.00	250.00
	Income/Ha	625.00	400.00
	Production Costs/Ha	USD	USD
B8	Land Preparation	60.00	50.00
B9	Seed	50.00	35.00
B10	Insecticides	25.00	5.00
B11	Fertiliser	250.00	100.00
B12	Labour	170.00	100.00
B13	Transport	50.00	45.00
B14	Other costs- Bags	10.00	10.00
B15	Other costs- Thread	5.00	5.00
B16	Other costs- Security	6.00	6.00
B17	Other costs- Storage	5.00	5.00
B18	Total production cost	531.00	361.00
B19	Net Income	94.00	39.00

Although Zimbabwe and Zambia had adequate data to compare OPV versus hybrid maize performance, Malawi had inadequate data because the sampled farmers did not record their production data. This study then took the inadequate data and consolidated it with other two countries for the aggregate analysis. Table 20 above shows consolidated averages on income and costs per hectare for the three countries. From the analysis, hybrid maize had more costs per hectare than OPV but had a better return because of a superior yield per hectare compared to OPV. Similar comparisons could be drawn from studies done in Malawi, Nigeria and Pakistan where hybrid maize outperformed OPV (Chirwa and Dorward, 2013 and Ali et al, 2020). After analysing each Section B of the questionnaire in relation to answer RQ4, yield and cost of production mattered most for the farmer's profitability, and this was supported by a better productivity by hybrid maize compared to OPV maize. This improved productivity supported the farmers socially and economically.

Firstly, related to answer RQ2, the quantitative results showed that stakeholder influence had the greatest impact on the adoption of hybrid maize in all the three countries, supported by high statistically significant values. These results from the focus countries were not surprising given the successful push for hybrid maize by stakeholders especially during establishment of the FISP and PIS programmes. Based on descriptive statistics, policy makers and extension officers had the most powerful influence on the adoption of hybrid maize by small scale farmers.

Secondly, relating to RQ1 lack of credit and resources for extension officers had a statistically significant effect on the adoption of hybrid maize adoption by small scale farmers in the three countries. However, factors relevant to RQ3 and RQ4 had no statistically significant impact on adoption in Malawi and Zimbabwe, although they recorded a statistically significant impact on hybrid maize adoption in Zambia. Therefore agronomy, climatic change, irrigation, pre- and post-harvest losses and socio-economic impact had no statistical significance impact on hybrid maize adoption in Malawi and Zimbabwe. Therefore, this quantitaive analysis overall, showed that stakeholder influence had the highest impact on the adoption of hybrid maize by small scale farmers, followed by credit availability and lack of resources for extension officers across the three focus countries.

In the next four sections, 4.3-4.6, we analyse our data addressing each research question in turn, drawing together the interview data with the findings from the questionnaire data identified above. The factorial analysis and descriptive statistics allow us to identify key factors, but it is difficult to get finer details on these factors and how they impact on the rate of hybrid maize adoption. This comes from the in-depth interviews also conducted in the three countries. This illustrates the importance of using MMR and how the two parts complement each other in identifying and analysing the key factors affecting small scale farmers to adopt hybrid maize.

4.3. Factors Causing Slow Hybrid Maize Adoption

In this section, we focus on the two variables identified in Section 4.2 above, across all three countries: credit availability and lack of hybrid maize awareness as key factors that impact and slow down the diffusion and adoption of hybrid maize by small scale farmers.

Credit Availability and Funding

The quantitative analysis above identified two key reasons for slow hybrid maize adoption, a lack of credit facilities, for small scale farmers and poorly resourced extension officers. We now reflect further on these factors, bringing in the data from qualitative research activities which allows us to offer a much more detailed and nuanced analysis of these issues. In general, credit for small scale farmers in all three countries was difficult to get due to lack of title deeds for land and property in the communal areas (see Musembi, 2007). Recently micro-finance facilities were being offered in the three countries, but they were of short term and only offered to cash crops other than maize, because the price of maize was controlled by each government. Related to this small scale farmers face high risk due to perennial droughts and indiscipline to pay back loans. With few irrigation schemes dotted around the countryside, most of the farmers relied on rains and each time there was drought the harvest is much reduced to the point that farmers even failed to feed their own families. The few farmers on irrigation schemes get more reliable yields but their numbers are too small to feed the nations. Hence banks are shy to extend credit to most small scale farmers because persistent droughts created uncertainty around farmers having crops as valuable collateral.

To mitigate the problem of lack of funding, the FISP program (discussed in Chapter 2) brought relief to farmers because they could afford inputs when they were subsidised by the government, allowing the farmers to produce better yields to meet their production costs. The interviews highlighted the importance of such policies to small scale farmers.

An official, from the Zambian government, Participant 1 (Annex 6), commented that:

> "*Funding from banks for small scale farmers in Zambia has been a problem and the government embarked on the FISP program that has been helpful."*

This claim was supported by Participant, 2, a small scale farmer, from Zambia:

> *"We do appreciate government policy on subsidised inputs in the FISP program because banks require collateral which we do not have".*

That said, follow up questions showed that the FISP input package did not cover all that the farmers required for their fields. Inputs given on the program can only cover an acre or hectare depending on the allocations for that season, whereas small scale farmers had arable land of 3 to 6 hectares. However, the concept and focus of FISP program was for food security for a standard household, so for anything above the program's target the farmer had to fend for themselves (Jayne et al, 2018). So, the program partially funded the farmer and some interviewed farmers confessed that they ended up stretching the inputs to cover a bigger area, rendering the inputs ineffective. Comments from one FISP input recipient showed that the FISP program lacked consistency in planning, monitoring and supervision by government extension officers.

Monitoring could ensure that the farmers only used FISP inputs on the targeted FISP area rather than spreading thinly the inputs on a much bigger area of land. From this analysis, it is shown that even though FISP inputs were provided, there had always been a funding and input gap for the extra land (Matusckke, 2007 and Chirwa and Dorward, 2013).

In Zambia, the FISP program was successful because farmers' yield improved shown by the excess grain produced since the inception of the program. The only shortcoming recorded by this study was that the fertilisers and hybrid maize seed (inputs) required by farmers were not adequate for their additional land. What can be done to help farmers who have inadequate collateral is discussed on Chapter 6.

Data collection also established that, even if farmers were able to participate in the FISP scheme, supply chain problems that included inadequate budgets and poor road networks resulted in late delivery of inputs, compromising the yield potential. Supply chain effectiveness was also affected by corruption. Corruption by officials manifests itself when they ask for monetary favours from small scale farmers when they distribute the limited and scarce inputs. At times they create artificial shortages to create an environment where farmers are forced to pay bribes. Interviews revealed that some farmers failed to access inputs due to the corruption of FISP officials.

Government Policy on Agricultural Input Subsidies

During field work for this research, input subsidy programs featured in most of the interviews in all three countries, so it was crucial to understand more of the intrinsic details of this important program. The reasons behind governments embarking on FISP were mainly due to the fact that small scale farmers in the three countries were vulnerable to tough growing conditions as a result of droughts, coupled with a lack of funding to buy inputs, which has led to poor yields. As an expert in this field I have seen how important input subsidy programs are to enable these vulnerable small scale farmers to afford inputs required to boost maize productivity. Interviews with policy makers in all three countries confirmed that year in year out, most farmers failed to produce enough food due to the lack of money to buy adequate inputs, a situation exacerbated by erratic rainfall (Chirwa, 2005). Unfortunately global warming and climate change in the years ahead brings no sign of hope for change. Hence the need seen by governments for these input subsidy programs. One Zambian government official (Participant 3) confirmed that from as early as the 1970s there has been a form of an input subsidy or free inputs given to small scale farmers. These input programmes have been improved over the years, although further potential improvements and recommendations are discussed in Chapter 6.

The policy maker, Participant 3, further added that, from the late 1990s, FISP had safeguarded food security for the country (see Xu et al, 2009) and since its inception Zambia had been a net exporter of maize (see also Mason, et al, 2013). He added that small scale farmers used to get yields below 2 tonnes per hectare but with the introduction of FISP average yields have improved to more than 3 tonnes per hectare. **This is crucial new information that we obtained from the interviews, that shows the potential value from such a policy.**

The policy maker was asked to comment on the sustainability of the FISP program and his reply was two pronged. Firstly, he said that the program needed to be treated as a revolving fund where farmers paid back their inputs, but unfortunately some farmers failed to pay back and this research did not find any form of punishment to those who failed to pay back. He gave the following reasons for this: inputs were distributed late, leading to late planting resulting in low yields; low prices given by government grain agents forced farmers to side-market and this was worsened by devastating droughts in some years, resulting in low yield. Secondly, he said that the program depended on government funding and at times there were budgetary constraints leading to inadequate funding for the inputs and resulting in farmers getting inadequate inputs, again leading to unsustainable low yields. Unfortunately the farmers develop a dependency culture and they do not treat farming as a business, making the input programs unsustainable. With further probing the policy maker did not comment on the allegations of corruption at input distribution centres, citing inadequate knowledge of the allegations.

Asked whether he thought farmers would be able to continue producing adequate food after withdrawing the FISP program his thought was that, without a funding alternative, small scale farmers would struggle to produce enough food because of the difficulties in accessing finance, made worse by droughts. In Chapter 6 we offer FISP sustainable financial recommendations.

The Malawian government, too, has championed a similar FISP program, which policy makers deemed to have been very successful. Indeed, it is used as a case study by other countries (see Chirwa, 2005). But for reasons mentioned in the Zambian example above, the success of the FISP programmes faced challenges leading to inconsistent results. Initially, however, the scheme worked well. As one policy maker, Participant 4, from Malawi said:

> "*Our government in collaboration with NGOs implemented a very successful FISP program that gave out subsidised hybrid maize seed and fertilisers. This program*

resulted in surplus production of maize grain during the first five years of its inception".

Interviews conducted with policy makers, established that the success of FISP resulted from timely distribution of affordable and accessible inputs. Further probing confirmed that hybrid maize and fertiliser were the key inputs given to farmers in the FISP program. However, policy makers said that despite the FISP program being successful in the early days in Malawi, droughts (again) and withdrawal of funding (this time by NGOs) brought some funding challenges to the program. Even though the program was continuing farmers were now getting their inputs very late, resulting in late planting and poor yields. This was a crucial problem given that, as shown with Zambia above, early planting and timely use of inputs were known to deliver higher yields. Another problem, also seen in Zambia, was corruption by some officials at input distribution points that resulted in some genuine recipients failing to get their inputs at all. The officials distribute fewer inputs and the rest are used for corrupt activities resulting in reduced productivity.

A similar picture was found through interviews in Zimbabwe, Participant 5, from the Ministry of Agriculture, who gave a historical and current perspective of small scale farmers' funding:

> *"When Zimbabwe attained independence in 1980 the government through the parastatal bank, Agricultural Finance Corporation (AFC) provided credit to small scale farmers."*

This credit availability credit availability to small scale farmers in Zimbabwe enhanced the adoption of hybrid maize (see also Chimedza, 1994 and Chiduza et al, 1994). On the other hand, currently farmers interviewed needed credit lines for capital projects and working capital but this was not possible due to tight collateral requirements by banks.

In addition to the withdrawal of the AFC credit, droughts affecting Zimbabwe, have also well also reduced maize production. In Zimbabwe this has been made worse by a severe economic recession. To alleviate this problem, from 2004 the government of Zimbabwe brought in the Presidential Input Scheme (PIS) targeted initially at vulnerable families in society and later extended to 1.8 million out of 2.5 million small scale farmers. This program brought relief to farmers because the inputs were given for free. Positive results of the PIS program were mainly realised in 2017 when the country produced 3 million tonnes of grain, surpassing the 1.8 million tonnes required by the country annually (Jayne et al, 2018). The success took a long time to be realised, due to droughts and financial crisis that affected the country. However, although the PIS program brought some relief to farmers, like the FISP program, farmers tend to develop dependency culture.

Lack of Resources for Government Extension Officers

Extension officers are discussed extensively in this section in the context of limited resources and are further analysed in Section 4.5 highlighting their role in implementing government policy. As stated in Chapter One and based on the researcher's field experience, Malawi, Zambia and Zimbabwe have very similar government agricultural extension structures. These structures are administered from ward level to national level resulting in a very broad coverage of all functional levels that assists small scale farmers in all the three countries. Through the interviews with farmers, government extension service and seed houses were found to be the main channel that disseminated technical information to small scale farmers, as analysed below.

The second factor relating to RQ1 and partly to RQ2 identified in Section 4.2 is the limited resources allocated to extension officers, since they can influence through direct engagement with small scale farmers the adoption of hybrid maize. Extension officers in all three countries are given resources to execute their duties, which is a mandate to implement government policies in agriculture. As mentioned in Chapter 2, for extension officers to effectively deliver their mandate they needtransport to cover villagers in the ward where they reside. Although working for the government their influence was felt through collaboration with other stakeholders, mainly seed houses, agro-chemical companies and NGOs.

Even though the effectiveness of extension officers was compromised by poor resources for mobility, a policy maker from Zimbabwe also appreciated the importance and existence of extension service. Extension officers' role cover training, monitoring and the dissemination of technical information including, agronomic recommendations, such as contour ridges construction and conservation agriculture (CA) practises. The dissemination and diffusion of information is done through field days, farmer field schools and demonstrations which are used as effective communication channels to promote the adoption of hybrid maize. In addition, extension officers conduct bi-seasonal training sessions in agronomy, at farmers' halls (community halls) where farmers joined training classes (see also Abate et al, 2015; Shiferaw et al, 2011 and Bekele, 2015). This form of training is different from the field environment where farmers are trained practically which gives them a hands experience rather than the class room set up. The farmers attend the training in groups (50 farmers at a time) in accordance with their existing farmer groups. Whilst in attendance they are trained in various technical aspects mentioned above, all with the aim of promoting the successful adoption of hybrid maize. These workshops are to prepare farmers and farmer leaders on their roles, to practically plant and manage field demonstration plots.

Based on the researcher's field experience and what the study has found, once the crop in the farmers' home-based demonstration plots reaches maturity, farmers are taken through them to learn the various attributes of the products before they fully adopted them. This was then followed by field days that were organised and sponsored by seed houses and NGOs. Again, the purposes of the field days on demonstration plots were to showcase product attributes to bigger groups of invited farmers who benefitted from learning hybrid maize performance leading to a more informed adoption process. Seed houses also sponsor and benefit from field days because they use them for marketing their products. This brings some relief to financial resources required for these field days. That said, interviews conducted below confirmed the important role played by extension officers during these events, hence the need for them to be properly resourced.

Reflecting on how these issues came through the interviews, Participant 6, a small scale farmer from Zambia confirmed the main influencers of hybrid maize adoption:

> *"Government Extension officers play an important role in supporting seed houses by giving technical advice on the adoption of hybrid maize".*

When asked further to explain how government extension officers assisted small scale farmers, the farmer said that government extension officers were village based and their locality made them readily available to the farmers. The farmer elaborated by explaining that the locality of extension officers made it easy for them to monitor farmers' activities, offering practical and technical advice through training. The farmer went on to say that extension officers were very influential and respected by farmers. To further confirm this effort of promoting hybrid maize adoption, Participant 8, a policy maker from Malawi was interviewed on the same subject matter and he had the following to say:

> *"Our government extension arm plays a critical role in making sure small scale farmers are well informed and trained on new technology."*

Based on the researcher's experience and as this quote shows, their strategic collaboration with seed houses, NGOs and agro-chemical companies is very important to transfer new knowledge and technology to farmers (see Lamontagne-Godwin et al, 2019). Informants interviewed from Malawi, Zambia and Zimbabwe confirmed the partnership of extension officers working in collaboration with seed houses (see Ahuja, 2000). These demonstration plots have been given a phrase in Malawi by Chirwa (2005: 54) "seeing is believing". More evidence from the small scale farmers interviewed in all three countries, supported the role of extension officers (for example a small scale farmer, from Zimbabwe Participant 7).

That is to say, governments as well as farmers understand and value the role that extension officers play. Going deeper into another specific aspect of their work although many farmers after viewing demonstration plots, preferred to adopt hybrid maize, we also found evidence, in all three countries, that government extension officers did not condemn OPV maize and those farmers who chose to stick with it. This is because, basing on the researcher's experience the extension officers offer training to both hybrid and OPV maize farmers and they respect farmers' choices even after showing the farmers beneficial attributes from hybrid maize.

Turning to the support given to extension officers, the three focus countries had similar problems of poor mobility and high farmer to extension officer ratio. This analysis provided additional detail to the results presented in Section 4.2. An important role for extension officers and other stakeholders is reassuring farmers when faced with the decision of whether or not to switch totally to new ways of growing maize. This role puts them in a position where they are required to effectively monitor small scale farmers on how they execute their farming including helping the farmers to adopt hybrid maize and giving them agronomic support after adoption. Each extension officer is expected to cover more than 300 farmers and mobility is crucial for the officer to go round all the farmers. Given the large numbers of farmers to be looked after, the extension officers report to supervisors who in turn make sure that the farmers are monitored and supervised. Farmers are organised in groups making it easier for monitoring and supervising their agronomic practises. It is therefore essential for them to be mobile, to get around meeting other stakeholders and small scale farmers. Most of the small scale farmers, across all the countries lamented the mobility challenges facing extension officers (see also Bekele, 2015).

Interviewed farmers said that most of the motor bikes were broken down and the government had not been able to repair or replace them. This then left the extension officers with no choice but to walk or cycle long distances, perhaps up to ten kilometres to see a single farmer. This was made worse, farmers saw, (for example Participant 9, a small scale farmer in Zimbabwe) because of a big ratio of farmers to extension officer, resulting in the officers being thinly spread. Based on interviewed farmers and my field experience, extension officers become ineffective due to poor resources. The officers fail to cover most of the farmers in their area due to unavailability of motorbikes or bicycles (see also Smale et al, 2013). This lack of coverage for all farmers result in reduced awareness of new technology hence slowing down the adoption rate.

Interviewed government officials acknowledged this crisis citing shortage of resources and budgetary constraints for additional head count. This reduced expenditure by government affected the morale and energy of extension officers (see Lamontagne-Godwin et al, 2019). Suggestions for possible solutions to these constraints on resources are offered in Chapter 6.

Generally, farmers take a long time to adopt new hybrid maize because they prefer not to take any chances with new products because of fear for product failure. Small scale famers look for stability from well adapted products that have drought and disease tolerance. Therefore, awareness campaigns on and off farms and are crucial for farmers to adopt new technology.

Another challenge faced by extension officers in their attempts to train farmers is a basic lack of training materials, during classroom training, for example flip charts and fliers. Based on the researcher's experience, this can now be resolved through social media groups which are being used for training and as communication channels. That said, although seed houses try to market their hybrid maize through print media, social media, radio, field days and demonstration plots, their effort need also face to face support from extension officers because of the impact it had in addressing community based small scale farmers (see Rice and Webster, 2020).

Based on data from all three countries, we have been able to offer analysis to answer RQ1. Credit availability to small scale was limited for a variety of reasons. This then led to the intervention of the FISP and PIS programmes by governments with the support of NGOs. The programs brought some relief leading to grain self-sufficiency in Zambia and Malawi, with the former continuing to produce a grain surplus. In Malawi, FISP was successful in the first five years but as the program progressed, it faced challenges of NGOs' funding withdrawal and government budget constraints. Other challenges faced were linked to supply chain issues and corruption, leading to late farmer input delivery (or a failure or refusal to deliver) which resulted in late planting and reduced yields. In addition, small scale farmers in both countries having to make their own plan for inputs for the balance of the land. Furthermore, some farmers failed to pay back for their inputs resulting in funds failing to revolve and ultimately affecting the sustainability of the program.

The Zimbabwean, Presidential Input Scheme, (PIS) was different from the FISP program, mainly because small scale farmers were given the inputs for free. Based on the successful AFC farmer support program in the 1980s, Zimbabwean policy makers felt it was necessary to give input support to small scale farmers for food security reasons. The Zimbabwean government recently improved the PIS program by encouraging farmers to embark on **CA** practises, which paid off in the 2020-21 season. Like the Malawian and Zambian situations, the PIS program initially only provided inputs sufficient for household food security but with successful roll out of the

Pfumvudza (spring) **CA** practice, the government doubled the PIS program support in 2021-22 summer season.

In summary the quantitative results in Section 4.2 show that factors causing slow hybrid maize adoption rate are statistically significant in all three countries, Malawi ($p<0.05$), Zambia ($p<0.1$) and Zimbabwe ($p<0.1$). This is also true for the role of extension officers and policy makers in significantly influencing the adoption of hybrid maize by small scale farmers. Hence similarly from the qualitative analysis, one can draw conclusion from the interviews, that lack of hybrid maize awareness campaign is a result of mobility problems faced by extension officers. Finally, a lack of private credit availability to small scale farmers caused slow hybrid maize adoption by small scale farmers leading to a number of government (public) input schemes.

4.4. Other Factors Affecting Hybrid Maize Productivity and Diffusion by Small Scale Farmers

We now turn our attention to analysis that can provide answers to RQ3 which, along with RQ1, also addresses Objective 1 of the research study. We note first that whilst the Zambian data showed statistically significant impacts ($p<0.05$) on hybrid maize adoption by small scale farmers caused by agronomic practises, irrigation, CA, climatic change and pre- and post-harvest factors, the same factors were not found to have a statistically significant impact in Malawi and Zimbabwe. However, we can still reflect on the qualitative data obtained from the latter two countries on these themes.

Climatic Change and Irrigation

Southern Africa has been devastated by droughts for the past ten years due to low rainfall caused by climatic change. For maize to effectively grow it requires more than 600 mm of well distributed rainfall (see Magorokosho, 2006 and Cairns et al, 2013). Low and poorly distributed rainfall results in low maize productivity and it is evident from interviwees that climatic change has a big impact on productivity, with devastating droughts in Malawi and Zambia but with Zimbabwe hit the worst (see Jayne et al, 2018). Interviews with farmers from Zimbabwe showed that for the past ten years, they experienced only one good rainfall season in every 5 years. Although from interviews conducted, droughts affected both hybrid maize and OPV farmers for example, Participant 24 an OPV farmer from Malawi was quoted saying:

> "*This past season we experienced a major dry spell that went for more than four weeks without rain. Because of this drought I am harvesting less than half a tonne instead of my usual five tonnes per hectare*".

According to the farmers such weather patterns require drought tolerant, short maturing maize varieties. Despite the current effort by seed houses providing short season hybrids, more research effort, is needed to produce products that survive these harsh conditions. In addition to the need for breeding techniques to avert climatic change challenges, the establishment of water harvesting techniques through practising CA has been recommended to small scale farmers by extension officers (also see Reardon et al, 1999 and Ramsden, 2019).

Unfortunately, from extension officers interviewed, some of the farmers failed to follow CA recommendations, leading to soil erosion and poor water retention (see Holden and Mangison, 2013). The study also revealed that some farmers failed to implement mechanised CA in their fields due to shortage of draught power and machinery. The shortage of cattle, caused by droughts, forced governments of the three countries to consider assisting farmers with tillage tractor units so that farmers could improve their land preparation and CA practises to conserve water. On the positive side, implementation of CA programs in Malawi reduced soil erosion and land degradation, positively impacting productivity (Gardner et al, 2019 and Mortimore, 2012).

Further interviews with Malawian farmers highlighted their continuous suffering from droughts and their wish to engage the government to help them with irrigation facilities. Their plea was for the government to establish irrigation schemes for farmers who were close to water bodies. Again taking from the Malawian interview, small scale farmers close to Shire River, had approached the government to consider them for irrigation establishment. Their hope was once irrigation got established, their hybrid maize adoption and productivity would improve. Similarly Participant, 25, a small scale farmer from Zambia had approached their government, noting:

"The use of irrigation will go a long way especially with my lands that are less than five hundred metres away from Kafue River."

In Zimbabwe, farmers experienced droughts in 2018 and 2019 and the government ended up importing grain to feed its population. To mitigate the impact of droughts the Zimbabwe government started to rehabilitate and expand several irrigation schemes (see Magorokosho, 2006). Overall, the research found that most farmers in the three countries wished for irrigation schemes, either to establish or rehabilitate and expand the small scale irrigation schemes that were dotted over the countryside. By revamping these irrigation schemes the governments would help to safeguard food security and reduce hunger and malnutrition.

Agronomy

Good agronomic practisesare a critical in component of crop production. For farmers to get reasonable yields the crops need to be protected from weeds, have effective fertiliser application, as well as plants getting the moisture until the crop matures. Technology alone can not get the farmer the desired yield without good agronomic practises. The interviews found that some small scale farmers did not use adequate fertiliser, despite being advised by extension officers, resulting in poor yields consistent with earlier studies, for example Mapila et al, 2012; Chirwa and Dorward, 2013; Feleke and Zegeye, 2006 and Blackie and Jones, 1993. Weed control is an important agronomic factor in maintaining yields. Participant, 26, a small scale farmer from Zimbabwe revealed how after being coached by extension officers, had been successful by practising good crop husbandry:

"We have also been taught how to control weeds so that our yields are not affected by weed competition".

Despite the benefits from following agronomic advice, there is no disciplinary action taken against farmers who do not follow the advice given, even though it is a government funded project. Most small scale farmers were found not to use herbicides to control weeds, but instead hand weeded their fields. Another agronomic practice that harmed yields was mono-cropping, where farmers repeatedly planted the same crop on a given area of land without rotation.

Interviewed extension officers pointed out that they recommended rotations citing nutrition, diseases and pest management advantages but farmers tend to repeat their preferred crops, leading to reduced yields. Finally, interviewed extension officers also mentioned that despite their recommendation for soil pH testing most small scale farmers could not afford it leading to low pH levels negatively affecting crop yields. Low soil pH leads to soil acidity, although this can be reversed using lime.

Pre- and Post-Harvest Losses

A good crop that stood until harvesting time was always appreciated by farmers, because of minimum pre-harvesting losses. Farmers interviewed spoke highly of maize hybrids that had good standability. This attribute resulted in reduced pre-harvest losses. Root and stem lodging problems were mentioned and observed in some OPV maize by some respondents, resulting in pre-harvest losses. This observation encouraged some farmers to switch to hybrid maize. Meanwhile, post-harvest losses were mainly caused by large grain borers and weevils. Farmers usually avoided planting maize OPV and hybrid maize varieties that were easily attacked by weevils and large grain borers (see Abass et al, 2014). Similarly, OPV maize that lodged forced small scale farmers to switch to hybrid maize varieties that stood well. This factor which led to farmers switching from OPV to hybrid maize, was also mentioned by Participant 27, an extension officer from Zambia who had these comments to add:

> "*Some of the OPV maize varieties that are tall in stature get affected by stem and root lodging just before harvesting, leading to termite damages and grain rots from late rains.*"

Interviewed farmers confirmed that their granaries had poor ventilation, resulting in grain rotting or again getting attacked by large grain borers and weevils. These post-harvest losses had a huge impact on the farmer's income because the combination of less grain and reduced grain quality led to lower prices being received.

Reflecting on all the data analysed in this this section. CA and irrigation support helped all the three countries. Practising CA on hybrid maize production helped to improve productivity, it also helped to conserve moisture, reduce land degradation and soil erosion, especially in Malawi, the most densely populated of the three countries. In addition, restoring delapidated irrigation schemes in the three countries can prove very useful in mitigating climatic changes being experienced. Irrigation restorations face budgetary limitations in the three countries, hence they are happening at a slow pace.

Good agronomy practises, including weed control and the use of fertiliser boosted, productivity, especially for the farmers who adopted hybrid maize. That said, it was also found that a lot of farmers were not utilising the best agronomic practises. Positive experiences were observed when pre and post-harvest losses were managed through adopting maize hybrids with better standability.

4.5 Stakeholder Influence on Adoption of Hybrid Maize

As a first step in answering RQ2, which addresses research objective 2, the quantitative results reported in Section 4.2 showed high statistical significance on the influence of stakeholders on hybrid maize adoption by small scale farmers, in all three countries. Policy makers and extension officers were identified as the most dominant and powerful stakeholders influencing small scale farmers. To explore this in more detail, we reflect further on stakeholder influence bringing in qualitative data to complement the analysis from Section 4.2.

The stakeholders to be covered in this section are policy makers, small scale farmers, farmer organisations, NGOs, extension officers, seed houses, grain traders and agro-chemical companies. Policy makers are responsible for setting up policies that impact hybrid maize adoption. These government policies are implemented by government extension officers, who are diffusers and implementers of hybrid maize policy and are deployed by governments to go out to work with farmers. The deployment of extension officers seek to make sure farmers are trained in the new technology in conjunction with seed houses and NGOs. In turn seed houses and NGOs sponsor farmer training workshops, field days and farmer field workshops. With the defined stakeholders' roles above, the following sub-sections outline details on how these stakeholders have influenced small scale farmers in the research to adopt hybrid maize.

Policy Makers

Policy makers formulate and implement government policies that influence hybrid maize adoption by small scale farmers. In this section the analysis covers government policies that were identified in the field whilst conducting the study. The key policies identified through the fieldwork interviews involved deployment of extension services, policy on hybrid maize adoption, policy on inputs subsidies and policy on grain marketing. This control of extension services, pricing policy and regulation of the seed industry give government policy makers a lot of power and influence as confirmed by interviewees in all three countries. It was also confirmed that policy makers sought to use their influence to strengthen food security.

Interviews with policy makers in all three countries showed this, such as Participant 10 from Zimbabwe:

> *"Government promotes hybrid maize as part of alleviating hunger and as a safe net for food security amongst small scale farmers."*

Unfortunately when they set low prices to safe guard the population this can be counter-productive.

It must also be remembered that government policy on extension and hybrid maize adoption are, crucially, implemented through the activities of extension officers- also a point made by interviews (including Participant 10, quoted above).

Government Extension Officers- Role and Importance as Detailed in the Previous Section 4.3

The role of extension officers has been detailed in Section 4.3 where government policy on extension in the three countries has been pivotal in supporting small scale farmers adopting hybrid maize seed since the time of Federation. This commitment by governments make extension officers the most powerful stakeholder, in the diffusion and adoption of hybrid maize by small scale farmers. To avoid repetition the analysis on resource challenges faced by extension officers covered in interviews contained in Section 4.3 shows the importance of extension officers. As discussed there, extension officers' activities included training, monitoring and mobilisation of resources from different stakeholders to support knowledge transfer to small scale farmers. This role by extension officers led to improved technology adoption and productivity by small scale farmers.

Grain Marketing Policy and Pricing

The study in the three focus countries confirms that maize is a staple food and it is therefore a political commodity. Governments in power try to remain popular and control food availability and prices, so that they retain power at election time. Hence the selling and marketing of grain in the three countries is done through quasi government organisations, namely the Grain Marketing Board (GMB) in Zimbabwe, Agricultural Development and Marketing Corporation (ADMARC) in Malawi and Food Reserve Agent (FRA) in Zambia. These organisations are responsible for controlling grain movement and have the mandate for grain pricing. That said, whilst such policies like low grain prices may benefit food consumers, the interviews with farmers told a very different story. Participant, 11, a small scale farmer from Malawi, put it starkly:

> "*I won't be bothered to grow maize for commercial purposes because it does not pay.*"

Crucially, farmers and farmers' representatives' groups, have no input to the pricing of grain. As a result and confirming the views of Participant 11 many farmers interviewed continue producing enough for their consumption, because maize was a staple, but several planted more legumes for commercial sale, because they had better market returns. To avoid the imposition of inadequate grain prices, farmers, farmer organisations and governments need to discuss and agree on prices that strike a better balance between consumers and producers.

Another aspect of maize marketing was the choice between hybrid maize and OPV in terms of buyers' and consumers' preferences. In Malawi in particular, a strong preference was stated by several participants for flint OPV grain than dent hybrid maize, a factor that will also affect farmers' decision over whether or not to grow hybrid maize at all (see also Wambungu, 2014). In Blantyre, District, Malawi, Participant 16, a private grain buyer was quite clear, *“My customers prefer the tasty flint maize grain from the local OPV and I only buy flint OPV grain for reselling for mealie-meal.”*

This triangulated with the observations made in interviews with Malawian small scale farmers. As is clear throughout this research project, however, decisions around whether or not to adopt hybrid maize are shaped by many influences. In this instance, the attraction of the taste and flintiness of OPV maize to many buyers and consumers was reinforced by the fact that many farmers were also put off by the higher price of hybrid seed than OPV seed. The flintiness provided grain hardness, reducing weevil attack, hence farmers were also attracted to OPVs with such characteristics. Participant 17, a small scale farmer, from Malawi provided helpful insights:

“I have always grown local maize (OPV) because I save my seed from the previous crop and instead of buying hybrid maize seed I add the money for top dressing fertiliser.”

That is to say not only is hybrid maize more expensive, seed from one year cannot be saved for planting in the following year, unlike OPV maize. It also highlights the issues of concern to many farmers and buyers, that the seed houses and other stakeholders would need to put into context through field days, demonstration plots, etc. For example, they might need to emphasise the benefits of higher revenues outweighing the benefits from retaining some OPV seed for subsequent replanting, grain hardness (reduced weevil damage) and taste.

With grain marketing, evidence from Zambia shows the involvement and power of government grain agents. This was confirmed by Participant 12, a small scale farmer, who said that the FRA is not a reliable buyer, because in some years when there was abundance of grain, maize was left to rot because they did not come out early enough to open satellite buying points. During the years of abundance grain prices are usually depressed and farmers get a raw deal. The farmer added that the FRA also struggles with storage and grain ends up rotting during years of abundance. The interviewee also mentioned that road infrastructure is very poor therefore accessibility to collect grain is always a problem. To address the road infrastructure problem policy recommendations on infrastructure development are highlighted in Chapter 6. When probed further, Participant 12 acknowledged that the FRA was sometimes responsive in a year when the harvest was poor, especially in a year following a drought. They also added that, "*Although FRA cannot be relied upon they come handy when they come to buy grain at reasonable prices and we appreciate them coming close to our villages saving us a fortune on transport cost"*.

Because maize is a political crop, private grain buyers also face challenges. As mentioned earlier, rulling governments are faced with a dilemma when it comes to staple food. They therefore maintain popularity by keeping maize prices low but in the process hurt farmers' prices. Participant 15 from Zambia observed that their hands were tied because they followed the FRA pricing structure and at times they can not export due to low yields during a drought year. He further mentioned the earlier problem, of farmers shifting away from maize when government-set prices were too low to be viable for farmers. However, the buyer acknowledged that, despite these challenges they always had some grain to trade on, but they prefer an open and unrestricted maize grain market. An open market meant the FRA will not dictate the price, allowing buyers to export to other countries during years of abundance. This encourages the market to follow demand and supply principles stabilising prices and supply of grain.

In contrast to Malawi and Zambia evidence from Zimbabwe suggested a very different approach, Participant 13, a small scale farmer from Zimbabwe, noted that:

> "*Our country is experiencing grain shortages mainly due to climatic change that is causing droughts. To avoid too much grain imports our government has been giving high grain prices so that more maize is grown locally so as to save foreign currency for other needs".*

Other farmers interviewed in Zimbabwe also said they welcomed government price incentives and early payments, although they acknowledged that farmers used to get low prices and late payments in the past. Early payments to both hybrid and OPV farmers allowed them to make timely inputs purchases for the next farming season. The farmers also acknowledged their farmer organisation leaders lobbied the government continuously for better and more viable grain prices (Ton et al, 2014). The farmers lamented climate change that brought droughts resulting in low yields. Otherwise in good years the farmers confirmed that farming paid them well. To support the opinion of Participant 13, Participant 14 an official from the government buying agent in Zimbabwe had this to say:

> *"My organisation is mandated to buy maize for strategic grain reserves at reasonable prices and stabilise the grain market in the country".*

Participant 14 also felt that the GMB had a very good relationship with most farmers. Based on the researcher's experience, farmers usually brought in quality grain and Participant 14 also mentioned satellite depots that were located in all districts countrywide, making it easier and closer for farmers to bring their maize to these buying points. He added that as the farmers delivered their produce, they were either issued with inputs for the next government farming program or they were paid their money within the shortest possible time. This assurance of good grain prices incentivised farmers to produce more maize.

Opinion Leader Farmers

In the communal setting, farmers amongst themselves respected those farmers who led by example. These farmers usually had leadership qualities and they influenced their fellow small scale farmers. They play a key role in the adoption of new technologies, working with seed companies and extension officers to introduce new technologies to small scale farmers. Participant 18 was one such opinion leader farmer, from Zambia:

> "*I am one of the farmer leaders and I lead by example by working closely with government extension officers, NGOs and seed houses to promote new technologies to my colleagues."*

The research found that opinion leader farmers were of good social standing and their influence to fellow farmers had proven useful in driving the agenda of hybrid maize adoption (Savastano and Feder, 2006). The selection and usage of opinion leader farmers, who plant demonstration plots for their colleagues to observe new technology, proved a useful strategy which improved the hybrid maize adoption rate.

NGOs

It is regrettable for the scope of the research that the NGOs interviewed were all pro-hybrid maize, so we can only analyse NGOs from this viewpoint. As shown in the application of the stakeholder models of Mendelow and Lewin, NGOs in this research did not have much power by themselves to influence hybrid maize adoption but had interest and funding that was expressed through collaboration (see also Ahuja, 2000) with other influential stakeholders like extension officers. NGOs played an important role in funding and promoting new technologies to small scale farmers and their effort in conjunction with extension officers was supported by seed houses through field days that showcased product performance (see Fowler, 1991). Participant 19, from an NGO (Harvest Plus) in Zimbabwe highlighted this collaboration, saying:

> *"Our NGO in partnership with seed houses, extension officers and small scale farmers are promoting and advertising recently introduced bio-fortified hybrid maize called Quality Protein Maize (QPM)."*

Governments in the three countries had fully opened up and allowed NGO participation to help on various programs that supported farmers' nutrition, training and supply of inputs to farmers. As Participant 19 confirmed, new bio-fortified hybrid maize with important nutritional value was jointly introduced to farmers through field demonstrations by NGOs, extension officers, and seed houses working together. Asked how nutrition was added into hybrid maize, the NGO representative said that unlike OPV maize, these nutritionally beneficial attributes were easily incorporated into the hybrid maize through breeding and nutrient fortification processes: "By their genetic makeup, hybrid maize breeding handles the nutritional fortification process."

A complementary approach was also taken in Zimbabwe, as Participant 19 highlighted. His NGO supported farmers in practicing conservation agriculture, promoting the use of planting hybrid maize and leguminous trees. Importantly, using hybrid maize, Participant 19 confirmed, meant maximising yield potential alongside protecting the environment and soil productivity. These two aspects complemented each other. A similar approach is taken by NGOs in Malawi, where an NGO representative, Participant 20, confirmed the same CA approach was being promoted.

The NGO (PLAN) in conjunction with extension officers is therefore focussing attention on maximising output from existing hybrids, supporting sustainable intensification in agriculture whilst looking after land degradation and other environmental problems (Townsend et al, 2016 and Maatman, 2007). Reduced tillage intensity thus enhances sustainable intensification. It is important to practise good CA so that small scale farmers grow their crops on soil conserved fields so that they get maximum return from their small area of land.

NGOs (MUSIKA and SNV) also work with agro-input suppliers. The distribution of inputs to small scale farmers by agro-input suppliers is important so that farmers access the inputs close to their homes without incurring huge transport costs. In most cases, agro-input suppliers are based in major towns where farmers are expected to travel to purchase their inputs. In an interview with one of the NGOs that had sourced a grant to support the downstream distribution of inputs, Participant 21, from Zambia, had this to say:

> "*Our role is to support the agro-input suppliers so that they serve the small scale farmers by facilitating marketing and sales linkages for agr-inputs in the value chain for sustainable food production."*

The study reviewed collaboration between an NGO and agro-input suppliers to assess the impact of input distribution in relationship to hybrid maize adoption. The interview revealed that small scale farmers used to walk long distances to access inputs and were often discouraged because of this. Hence with the NGO's intervention, farmers accessed inputs closer to their homes. This was done by setting up aggregation access points, in the form of containers, where inputs were then sold to the farmers. The NGO also facilitated SMEs loans to the farmers and they encouraged farmers to buy hybrid maize seed.

When probed, the NGO representative said the intervention resulted in improved productivity. His comment was that farmers experienced better yields because they accessed hybrid maize and fertilisers in a timely way and closer to their homes. The farmers managed to plant early, leading to better yields. That said, we draw a comparison between the well supported NGO input supplychain against the problems experienced of delayed input supply by the government FISP programme. So this analysis brings a valid point of availing distribution points after the introduction of technologies. It is not good to talk about hybrid maize adoption without establishing a well coordinated supply chain with distribution points where farmers can easily access the new technology. Furthermore, in the analysis in this section, a key point is that NGOs work in collaboration with other stakeholders to achieve their aims and as such solve problems with government reliant supply chains as noted above.

Seed Houses

As stated in the literature review, seed houses invest huge amounts in research to come up with hybrid maize and it will take 5 to 7 years before a new hybrid can be released onto the market. Once the product is about to be released on to the market, promotional activities start on the ground where the product is showcased to small scale farmers (see Halford, 2012). An interview conducted with Participant 22, from a Zimbabwean seed company, gave an account of how their company then market their hybrid maize to small scale farmers:

> *"We do a lot of product trialling and plant more than one thousand demonstration plots per year to promote hybrid maize culture."*

This was supported by another seed house representative from Zambia who confirmed that his company was involved in the adoption of hybrid maize:

> *"Our company believes in supporting farmers' enterprises without misrepresenting product performance. To achieve this philosophy farmers are exposed to hybrid maize demonstration plots planted with a number of different maize hybrids under farmers' own management."*

These two interviews with seed house representatives clearly show that seed houses invest money and time on promoting hybrid maize to small scale farmers who are ultimately their customers. This analysis leads to the question whether the seed companies are doing enough campaigning and promotion effort. From the interviews it is clear that there is heavy reliance on extension officers. One aspect of this was seen in an interview with Participant 22, a small scale farmer from Zambia:

> *"Some of the seed houses are very visible on the ground promoting their products unfortunately some are doing themselves disfavour by not frequently visiting, supporting their product and collaborating with extension officers."*

After further probing, one of the seed houses admitted being in a dilemma because they found themselves in a position where they sold both OPVs and hybrid maize. In this case, they confirmed that they campaign vigorously for hybrid maize in most of their sales areas and they do not campaign for OPVs which they mostly sell through NGO programs. This point is interesting given that all of the NGOs we interviewed were pro-hybrid, but it is important to note that the research found out that pro-OPV NGOs continue offering OPVs to those farmers who wanted them.

This review on seed houses' influence on the adoption of hybrid maize by small scale farmers finds out an over reliance on extension officers. From further analysis and interviews seed houses focus their energy on converting OPV markets to hybrid maize. This is done through side-by-side demonstration plots. Seed houses were found to push more sales of hybrid maize than OPV because hybrid maize seed had better and more traits to offer farmers compared to OPV. Lastly, one question asked is how seed houses managed price sensitive farmers who opt for cheaper OPV maize seed. The answer given is that they sell value in hybrid maize attributes that consist of yield, drought and disease tolerance which may out-weigh the offerings by OPVs. It is then up to the farmers to choose products that give them value for money.

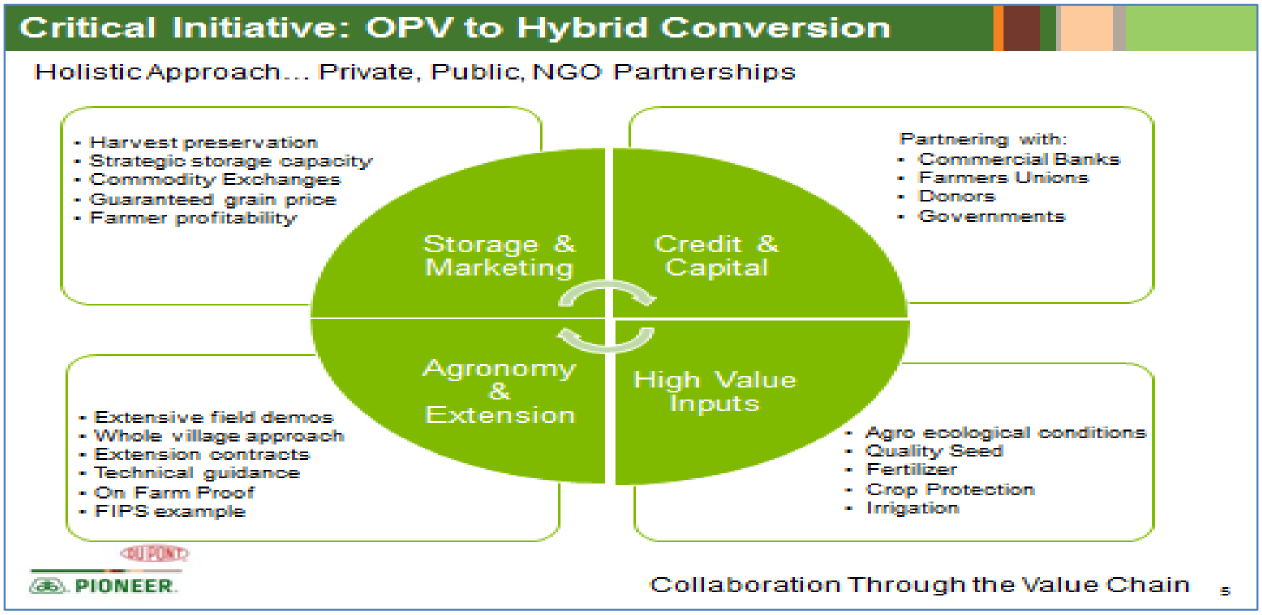
Stakeholder Collaboration Effort

As the previous discussion shows, a key feature of efforts to boost the adoption of hybrid maize relies on stakeholder collaborations. Each stakeholder group has a vital role to play, but the implementation of policies requires them to work together. As shown in Figure 11 below, proponents of hybrid maize pushed small scale farmers to convert from OPV to hybrid maize. Although most of the stakeholders try to work collaboratively with extension officers, there is need for even more partnership amongst stakeholders, so that resources are amalgamated for a resounding hybrid maize adoption success story. Collaboration between NGOs, seed houses, agro-chemical companies and governments, being the main sponsors of hybrid maize adoption, is very important as they provide essential enablers through their value chain. The value chain brought about by the collaboration in Figure 11 below, provides for marketing, storage of grain, credit availability, extension services and high value inputs. Disjointed efforts by stakeholders who try to help small scale farmers to adopt hybrid maize can render their efforts ineffective (see also Smale, 2013 and Ahuja, 2000). A senior policy maker in Zambia, Participant, 23 lamented over one particular problem:

"We get a lot of support for small scale farmers from various stakeholders but I wish their effort could be combined and coordinated."

From the research highlighted above, governments try to bring stakeholders like NGOs, seed companies etc, together so that farmers can eventually benefit from the consolidated resources. For example, the farmer field schools (where farmers gather to get training for specific agronomic lectures) are coordinated by government extension staff in collaboration with NGOs, agro-chemical companies and seed houses. Each of the stakeholders can bring in resources that enhance the quality of farmer training. Overall, there was some evidence shown from the interviews, here and earlier, that collaboration between stakeholders took place, in particular through demonstration plots and field days. The quote from Participant 23 also showed that more collaboration is needed to increase hybrid maize uptake and get the most out of hybrid maize for small scale farmers.

Figure 11: **An Example of Collaboration of stakeholders Through the Value Chain**



Borrowed from DuPont Pioneer 2014 Strategy Document

Based on the quantitative results in Section 4.2, stakeholder influence had a highly statistically significant influence ($p<0.01$ for Zambia and Zimbabwe and $p<0.05$ for Malawi) on hybrid adoption by small scale farmers, compared to the other factors, for all three focus countries. This has now also been shown in the qualitative analysis that showed a robust and strong extension service inherited from the Rhodesia-Nyasaland government which has master farmer training programs (see also Chimedza, 1994; Leiman and Behar, 2011 and Tattersfield, 1982). The extension service still has, mandatory requirements for farmers to follow proper soil conservations measures, including the establishment of contour ridges (see Mashingaidze, 2006). The reason why Zimbabwe has a higher hybrid maize adoption could be that Rhodesia-Nyasaland Federation was one of the earliest countries in Africa to register its own hybrid maize, with these activities located mostly in what is now Zimbabwe. This led to a very strong collaboration between the seed industry and the government extension service that promoted vigorously the use of hybrids.

In addition, the three governments made policies that controlled the maize grain market and pricing, providing a much-needed market, although in Malawi and Zambia the farmers complained of low prices. However, the Zimbabwean farmers had a more positive experience, with higher prices being offered. Examples of policies that supported subsidised or free inputs like FISP, PIS and AFC helped farmers in accessing hybrid maize seed in the three countries, also resulting in improved hybrid maize adoption rates.

Maize grain buyers in Zambia and Zimbabwe focus on grain quality but they do not have power to impact the grain market because FRA and GMB, respectively, had been mandated to control the grain market and pricing. So as stakeholders they do not have influence on what the small scale farmers can grow, unlike the Malawian grain buyers who trade based on the customer demand for tasty OPV maize.

Turning to opinion leader farmers who play a key role in hybrid maize knowledge transfer to fellow farmers by taking the lead in planting demonstration plots, they collaborate with seed houses, NGOS and extension officers in the three focus countries resulting in improved hybrid maize adoption. Within this group of collaborators, NGOs in the three countries participate in promoting hybrid maize, including the adoption of quality protein maize (QPM) playing a pivotal role in nutrition and training. In Zambia, Zimbabwe and Malawi, NGOs also promote the distribution of inputs and adoption of CA practices, resulting in improved adoption of hybrid maize. Lastly, seed houses in the three countries campaign vigorously using field demonstration plots enhancing the uptake of hybrid maize.

Building on the quantitative results, the qualitative analysis allows for the identification of prominent influencers amongst the stakeholders. This was done through probing, follow up questions and reading the body language of interviewees, which also allowed for stakeholders to be identified in terms of power and interest.

4.6. The Relative Advantage of Social and Economic Benefits Derived from Hybrid Maize Adoption

In answering RQ4, from the quantitative analysis in Section 4.2 only the Zambian results recorded statistical significance ($p<0.05$), showing that small scale farmers benefitted socially and economically when they adopted hybrid maize. The Malawian and Zimbabwean quantitative results showed no statistical significance as regards RQ4. When small scale farmers adopted hybrid maize they expected the performance and productivity to be better than OPVs. Farmers have a tendency of taking on new technology after checking on whether the technology is compatible with their values and norms of a social system (see Rogers, 2003; Wagner-Weick and Wachli, 2002). In addition, the new technology needs to be affordable to small scale farmers. Even though some of the inputs are provided by government, most of the small scale farmers struggle to afford adequate inputs, whether for hybrid maize or OPV production. Therefore, this study reviews the introduction of hybrid maize in regard of cost of inputs and ultimate productivity. The study also assesses farmers' expectations and actual experiences with OPV and hybrid maize performance.

Most farmers expect hybrid maize adoption to bring improved social and economic benefits, leading to improved livelihoods. Most farmers that participated in the interviews said that they were motivated to adopt hybrid maize against OPV maize in anticipation of better yields and returns per unit area of land. That said, achieving these gains was not simple Participant 28, a small scale farmer from Zimbabwe observed that:

> *"When I switched from growing OPV to hybrid maize I realised the yield could not just be achieved without adequate fertiliser and weed control".*

With further probing Participant 28 revealed that increased yield came from a combination of good agronomy, adequate inputs and improved maize seed. Therefore, small scale farmers required support from NGOs and governments for them to afford inputs for hybrid maize, as well as having to implement better agronomic practices. Without incurring costs for adequate fertilisers and proper weed control, the yield gain will not be realised when a farmer adopts hybrid maize. This farmer further confirmed that indeed after following proper agronomic practises he indeed gained a yield advantage from hybrid maize, of about 25% (see also Chirwa, 2005) compared to OPV maize that he got in the past. More than this, he said that the extra yield helped to improve food security at his household level, and he also helped the elderly in community with grain whilst the school fees burden was reduced by the income earned from the additional grain sold. Several farmers interviewed indicated that better productivity achieved from hybrid maize resulted in improved incomes that were used by families to buy clothes, food and other essential needs like medicine (see Bellon and Hellin, 2011).

A farmer interviewed in Zambia, Participant, 22, confirmed that hybrid maize outperformed OPV maize but he was quick to mention that at low levels inputs hybrid maize was less responsive in yield performance compared to when high input levels were applied. Unlike the situation mentioned earlier, where FISP inputs are sometimes delivered late, the farmer pointed out the importance of early planting to help differentiate hybrid maize from OPV. The crop takes advantage of better heat units and early rains for improved yield. Further probing revealed that hybrid maize treated similarly (in inputs applied) to OPV and planted early responded better in yield compared to OPV. Interviews with farmers in all three countries also confirmed that it was difficult to differentiate hybrid maize performance from OPV when the crop was planted late in the season. Based on the researcher's experience, temperatures drop after the 15th of November in the focus countries leading to reduced heat units, ultimately affecting potential yield. Maize performs better in high temperatures and such conditions are mostly experienced in October and November in all three countries.

With climate change and rains also being so important, Participant, 29, a farmer from Malawi, gave testimony as to how hybrid maize outperformed OPV maize during a drought year (see Holden and Mangison, 2013). The farmer said that the OPV crop kept on growing tall and some maize plants produced barren cobs, unlike the hybrid maize that produced well filled cobs, delivering a reasonable yield that provided food security for the farmer's family.

In summary, interviews with farmers in all three countries showed that the farmers benefitted from improved yields from hybrid maize, giving them capacity to do more for their families' needs. These included school fees, clothing, housing and food. However, the analysis also showed that yields could not be achieved only by only adopting hybrid maize, but the farmers had to practise good agronomy and apply adequate inputs (see Chirwa, 2005). Socially, some Malawian small scale farmers preferred OPV to hybrid maize because of taste and flintiness and this slowed down the hybrid maize adoption rate. The flintiness is associated with grain hardness protecting it from weevil damage. These results supported by Zambian quantitative analysis, reflect of benefits seen in all three countries from the adoption of hybrid maize by small scale farmers.

4.7 Reliability and Validity

In this study the findings were centred on the stakeholder's perceptions and how they viewed the world around them. The issue of validity and reliability gains in importance as the readers of this thesis would judge the credibility of the results. Denscombe (2010) argued that the validity hinges around the extent to which research methods to collect data, used were deemed transparent. According to Bannigan and Watson (2009) validity is the degree which a scale measures what it is intended to measure.

The questionnaire went through a piloting process to ensure that it was properly designed to collect the intended data. This also gave an opportunity to train research assistants in Zimbabwe. Although the researcher was well known in Zimbabwe, the questionnaire distribution for both the pilot and the main survey, was done with the help of 3 assistants in each country and wherever the researcher had to distribute the questionnaire, he made sure that the respondents filled in the questionnaire without any influence so that they would answer questions independently. In Zambia and Malawi, 3 assistants were used and again respondents filled in the questionnaire independently. This approach helped the respondents to answer the questionnaire earnestly without just pleasing the researcher and his team.

Reliability in accordance quantitative analysis means that there is stability in measurement and the same results can be achieved under different settings (Bannigan and Watson, 2009). This is different with qualitative analysis because results are based on interviews from informants' opinions, unlike quantitative analysis which is based on data collected from surveys. The results achieved as presented above showed that out of the 26 variables in the questionnaire, the results achieved were consistently in agreement with the aggregated variables, derived from the factor analysis. For example, the variables on drought and lack of irrigation, poor agronomy and pre- and post-harvest losses, when aggregated, showed that poor yields were caused by these variables. This trend of consistent results was also true with the questions on how policy makers and other stakeholders influenced hybrid maize adoption. To support the reliability of the researcher's findings, hybrid maize yield in comparison to OPV had a 25-30% advantage. This compares with the findings of other writers (see Chirwa 2005) who reported a 30% better yield than OPV maize. This productivity was also shown by Denning et al (2009) when they cited the Malawian government input scheme that used hybrid maize and the country moved from a 43% deficit in 2005 to a 53% surplus in 2007. Schroeder et al (2013), Feleke and Zegeye (2006) in separate studies also found that the use of hybrid maize improved farmers' yields.

Borrowing from Yin (2013), qualitative data for this research is obtained from several sources and key informants were given their voice recorded transcript to review the accuracy of the recorded data. All the key respondents got back the details of their contributions to check for mistakes. All the recordings were manually transcribed into MS Word and accuracy was checked by listening repeatedly to the voice recordings. For the study results to be reliable, Yin (2013) argued that the research should have minimum errors and that if any other researcher conducts the same study the results will not be too different.

Finally, this research adopted an MMR approach because the two approaches provide different, but complementary, data to analyse.

4.8 Summary and Conclusions

A summary of findings and conclusions from both the above analysis on the study of the adoption of hybrid maize by small scale farmers is presented in this section. The section will also include contrasts and comparisons of study results amongst the three study countries and how the research findings also compared with literature reviewed from similar work done in the past. This will highlight new contribution by this study. The study analysis included the chosen conceptual framework composed of Rogers' diffusion and adoption of innovations model complemented by Mendelow's stakeholder analysis model and Kurt Lewin's Force Field model, that were presented earlier in Figures 2, 3 and 4, to assist with the analysis of the research findings.

Causes for Slow Hybrid Maize Adoption Rate

The analysis of the theme on the slowness of the hybrid maize adoption rate in this study answers RQ1. Lack of awareness for hybrid maize benefits, and lack of funding for small scale farmers contributed to the slow adoption of hybrid maize in all three study countries. Malawi and Zambia are still at 50% and 60% hybrid maize adoption rate respectively. In all three countries campaigns alone by extension officers, seed houses, agro-chemical companies and NGOs for hybrid maize adoption by small scale farmers are not effective. This is because extension officers who have the greatest influence and authority to implement hybrid maize adoption are poorly resourced. Findings revealed a lack of mobility and a high farmer to extension officer ratio, which made it difficult for extension officers to cover their allocated small scale farmers effectively. This evidence was prevalent in all the three study countries. Governments' budget constraints made it difficult for motorbikes repairs and replacement. However, the donation of 5000 motorbikes in Zimbabwe has greatly improved mobility lately and the improved economy in Zambia enabled mobility to be assisted more effectively than in Malawi.

As for the other stakeholder groups, seed companies and NGOs seemed to rely more on extension officers without putting more of their own efforts into spreading the advantages of adopting hybrid maize. Thus weak campaign drives, by stakeholders partly slows down hybrid maize adoption. However, the Zimbabwean situation showed reasonable results when hybrid maize adoption accelerated between 1980 and 1985 because of a robust extension system that was supported by funding for small scale farmers from the AFC. The country reached more than 95% hybrid maize adoption due to solid extension staff support and funding availability (see Mashingaidze, 2006 and Chimedza, 1994). This situation improved productivity and the country had abundant grain during that time. Further analysis of this positive result showed that the rainfall situation was also very good to support bumper harvests during those years. The withdrawal of funding later on by the AFC resulted in lower yields, worsened by climatic change and a failing economy. Despite the hybrid adoption rate at 95% Zimbabwe has been experiencing yields of below 1 Mt/Ha for the past 20 years for the reasons mentioned above. The introduction of the PIS program by the government is an attempt to redeem the situation which has been worsened by droughts and an economic meltdown. The PIS uses CA to counter drought problems and the free inputs goes a long supporting small scale farmers who do not have credit to buy inputs for themselves.

Similarly, funding availability for small scale farmers brought relief and positive results to productivity when funding was introduced in the form of inputs in the Malawian and Zambian FISP programs. The productivity resulted in excess grain that was exported to neighbouring countries. The subsidised inputs provided a rare opportunity to support small scale farmers who usually failed to pay for inputs. Again, like the Zimbabwean example, when the funding became inadequate due to government, budgetary constraints, productivity dropped significantly, especially in Malawi. In this situation the volume of hybrid maize grown by small scale farmers was negatively affected.

Hence in answering RQ1, hybrid awareness campaigns and funding has an impact on the rate of hybrid maize adoption by small scale farmers. The two factors were interchangeable in terms of which one had a greater impact depending on country.

Factors that Affect Hybrid Maize Productivity

In answering RQ3, the study has looked at various factors that affected hybrid maize productivity, which included CA, climatic change, agronomic practices and pre- and post-harvest losses. Quantitative results showed statistically significant results ($p<0.05$) only in Zambia for the factors that affect hybrid adoption as listed above. This showed that overall, the variables linked to RQ3 had less impact on the adoption of hybrid maize compared to RQ1 and RQ2.

Qualitative results from the three countries showed that although hybrid maize outperformed most OPV maize during droughts, it was important to note that other respondents mentioned maize hybrids succumbing to severe drought conditions. This calls for seed houses to continue their efforts to breed more drought tolerant hybrid maize. However, as drought conditions continued to prevail, irrigation and CA practises become important parts of the solutions for farmers. Even with the adoption of hybrid maize, study results in the three countries also showed that, good agronomic practices contributed to productivity. The application of fertilisers, weeding, time of planting, plant population, moisture availability and pest control are very important for one to realise the full potential of hybrid maize.

For farmers to conserve their yield, pre- and post-harvest losses must be minimised by adopting maize that stands well until harvesting time. During the study respondents confirmed that hybrid maize stands well compared to OPV reducing pre-harvest losses caused by cob rot and termite damage. However post-harvest losses are determined by grain flintiness and hardness and in the Malawian situation small scale farmers preferred their local OPVs that were flinty and hard dented giving them protection from weevils and large grain borers. Further evidence showed that post-harvest losses were also caused by poor storage facilities, made worse by poor road networks that resulted in government buying agents failing to timely access and buy the maize grain from small scale farmers in a timely manner. Air-tight hermetic bags are being recommended by stakeholders for small scale farmers to improve grain storage capability, allowing farmers to keep the grain safe for longer, therefore helping to overcome the factors contributing to the current need for urgent post-harvest collection.

Stakeholders' Influence on the Adoption of Hybrid Maize by Small Scale Farmers

The quantitative analysis showed that, policy makers and other stakeholders (extension officers, NGOs, seed houses and agro-chemical companies) had a statistically significant ($p<0.01$ or $p<0.05$) influence on small scale farmers adopting hybrid maize in all the three countries. These quantitative findings helped to answer RQ2. This was supported by descriptive statistics which had higher ‘’p’’ values and scores for policy makers and extension officers.

This was the case in Malawi, Zambia and Zimbabwe, which showed policy makers and government extension officers having the biggest influence on hybrid maize adoption, because they had the authority to set policies on hybrid maize adoption. Further, extension officers, implementers of policies on the ground, had an impact on hybrid adoption by small scale farmers through face to face engagement. Although policy makers and extension officers can influence productivity, they have limited resources because of government budgetary constraints. The three study countries have a similar government administered network of extension officers who are mandated to train and demonstrate to small scale farmers how to adopt hybrid maize.

Although extension officers are the most influential stakeholders because they **work with farmers on both demonstration plots and field days,** and they are also resident within the community, they need to work collaboratively with other stakeholder groups to be most effective. That said, extension officers have problems of mobility which is worsened by the fact that one extension officer has to serve more than 300 families, limiting their effectiveness. When extension officers are poorly resourced, their influence is less effective hence their impact on hybrid maize adoption is compromised leading to a slower rate of hybrid maize adoption. This is especially the case when lack of resources are sequezed from both directions, with government’s limited financial resources and seed houses being over-reliant on extension officers, meaning they too did not give the service sufficient resources, even for their own commercial benefit.

The study also showed that one effective type of policy in the three countries was an input subsidy policy, such as the FISP programme in Malawi and Zambia. The intention of the policy is for food security, but it also helped to secure the ruling government future votes. Small scale farmers are amongst the majority of the voters, but usually they do not get funding from banks. This policy proved successful as it increased productivity during the early days of implementation in Zimbabwe, Malawi and Zambia. But lately the subsidised input policy has been affected by budgetary constraints and the withdrawal of funding by NGOs who participated during the inception periods. In addition to budgetary limitations the study also revealed elements of corruption and late distribution of inputs impacting negatively on the FISP program. Despite these shortfalls, FISP still managed to distribute fertiliser and hybrid maize leading to more farmers adopting hybrid maize in Malawi and Zambia. This led to improved productivity and both countries were able to export surplus grain to neighbouring countries. The challenge is the long-term financial viability of such schemes, with shortcomings here, resulting in reduced exports over time.

Zimbabwe's version of FISP is different in the sense that farmers are given inputs for free, unlike the Malawian and Zambian versions where the cost of inputs is subsidised. In Zimbabwe, farmers saw improved production in 2017 and 2021 when the country received adequate rainfall and there were bumper harvests. The other limitation noticed by the study is that the input subsidy programs can only cater for inputs for less than 50% of the farmers' land, leading to some of the farmers spreading the inputs too thinly to be effective over the remainder of their land. This reduction in input application rates per hectare results in farmers not getting the intended yields. Another problem also lamented by policy makers in Malawi and Zambia was that some farmers failed to pay back their subsidised inputs, resulting in retardation of the FISP program. Unfortunately, the study showed that there was no punishment for those farmers who failed to pay back for their inputs. This negative effect slows down hybrid maize adoption by more potential adopters because the money does not revolve to allow the scheme to reach out to more farmers. Hence hybrid maize adoption overall is negatively impacted and the long-term viability of the schemes undermined.

Another policy reviewed by the study is on grain marketing, which had an impact on prices in Malawi and Zambia. During interviews in Malawi the farmers complained of low prices offered by government, forcing farmers to opt for other crops and reducing maize production. This situation does not encourage more farmers to adopt hybrid maize because they are restricted to sell to the government grain agent. In Zambia the study showed that the FRA offered low prices when there is a good harvest and the road infrastructure hindered farmers from delivering their produce to the designated FRA buying points. Unlike the Zambian and Malawian situations, lately

Zimbabwean small scale farmers are happy with the prices offered by the GMB, hence they strived to grow hybrid maize despite the droughts that are a hindrance to productivity.

Other important stakeholders are NGOs and seed houses that influence the diffusion of hybrid maize amongst small scale farmers in the focus countries. In Malawi, CA based projects on leguminous trees and hybrid maize promotes the use of hybrid maize. Following successful NGO led CA projects from other SADC countries, the Ministry of Agriculture in Zimbabwe embarked on a huge and successful CA project (Pfumvudza) in 2020 that involved 1.8 million small scale farmers.

The present study found NGOs that promote agro-input distribution through communal inputs aggregation points. This effort has been successful in Zambia and Zimbabwe where rural agro-dealers were trained to distribute inputs to their fellow farmers saving their fellow farmers from transport costs. These rural agro-dealers distribute hybrid maize and this move has promoted the use of hybrid maize by more farmers.

To make the distribution effort a success, NGOs also sponsore field demonstrations that showcase hybrid maize performance and this effort results in more farmers adopting hybrid maize. Seed houses in the three countries also confirmed their heavy involvement in demonstration plots that have consistently yielded good results. Indeed, the seed houses confirmed that they influence small scale farmers through collaboration with extension officers who have more power than seed houses.

This analysis ties in well with Mendelow's stakeholder matrix. Grain traders are classified as having low power and interest (in Mendelow's stakeholder matrix-Figure 11), meaning they do not influence much the adoption of hybrid maize by small scale farmers. Grain traders in Zambia and Malawi are restricted and only participated once the government agents allow them to trade. This was because government buying agents in the three countries dictate prices and they control exports and general grain movement, making private grain traders weak. Lastly policy makers encourage stakeholder collaboration (see Figure 11) to enhance the adoption of hybrid maize. By combining resources, stakeholders jointly influence hybrid maize adoption a lot better than individual efforts.

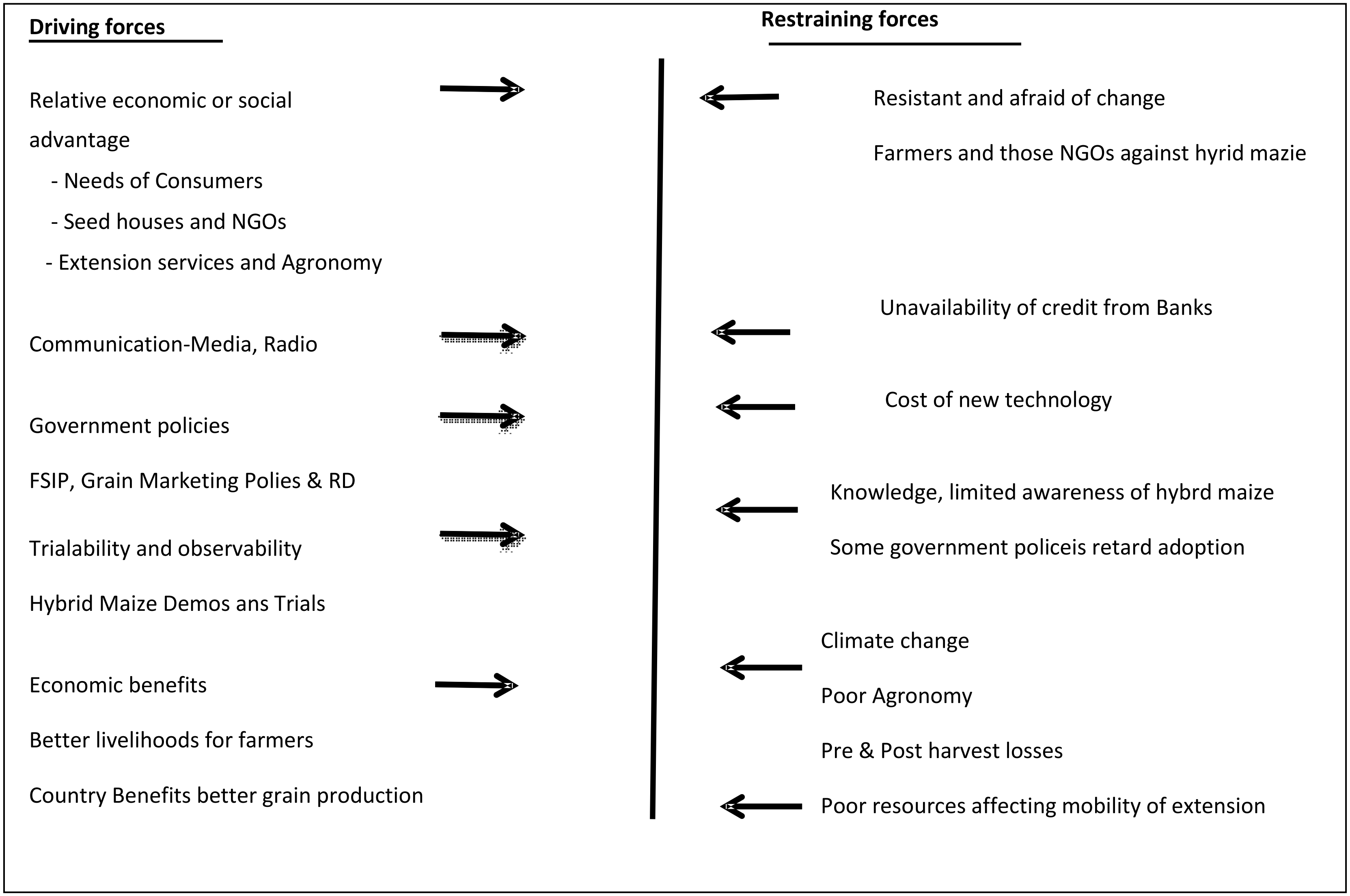
Socio-economic Impact of Hybrid Maize Adoption

In a bid to answer RQ4, the study revealed that small scale farmers' livelihoods improved after adopting hybrid maize, as reflected during interviews and from statistical production data analysis from the three countries. Farmers constructed decent houses for their families, sending children to better schools including tertiary education, good health provision for families and providing food to families. But the adoption of hybrid maize alone, without proper crop husbandry, did not deliver the desired productivity results. Respondents confirmed that crops needed to be tended for high yields to be achieved. Once hybrid maize is nurtured properly, more economically viable yields are more likely to be achieved. These economic yields cover costs and the surplus are used for the socio-economic benefits listed above.

This variable of socio-economic impact on hybrid maize adoption only recorded as being statistically significance ($p<0.05$) in Zambia, but overall, the socioe-conomic variable was well supported by the qualitative analysis. That said, the Malawian results showed that some small scale farmers choose OPV over hybrid maize due to better taste and flintiness. Therefore, one can conclude that the socio-economic variable is important as a motivation for small scale farmers to adopt hybrid maize. For Zimbabwe's quantitative results for the production model, yield and cost had statistically significant values ($p<0.01$) that impacted the profitability for the farmer irrespective of product type grown. This was followed by the Zambian quantitative results that showed statistically significant value of $p<0.01$ on yield only. Unfortunately, the sampled Malawian farmers did not complete adequate responses on Section B of the survey, leaving the study to use the data in a consolidated analysis for OPV against hybrid maize. In this analysis hybrid maize had higher costs but had better yield compared to OPV. These results are consistent with other studies found in the literature reviewed in Chapter 2.

We conclude this discussion by taking the findings in this Chapter and analysing them with the help of the Conceptual Framework which combines Rogers', Mendelow's and Lewin's models, Figures 12, 13 and 14. The analysis of the research results is categorised into factors and themes that promote or restrain the diffusion and adoption of hybrid maize in Malawi, Zambia and Zimbabwe.

FFigure 12: Kurt Lewin’s Model: Driving Forces in Favour and Restraining Forces against hybrid maize adoption



Kurt Lewin's Force Field model as shown in Figure 12 above shows the factors that promote, hybrid maize adoption on the left side of the model. Factors listed on the right side retard the adoption of hybrid maize and promote OPV maize.

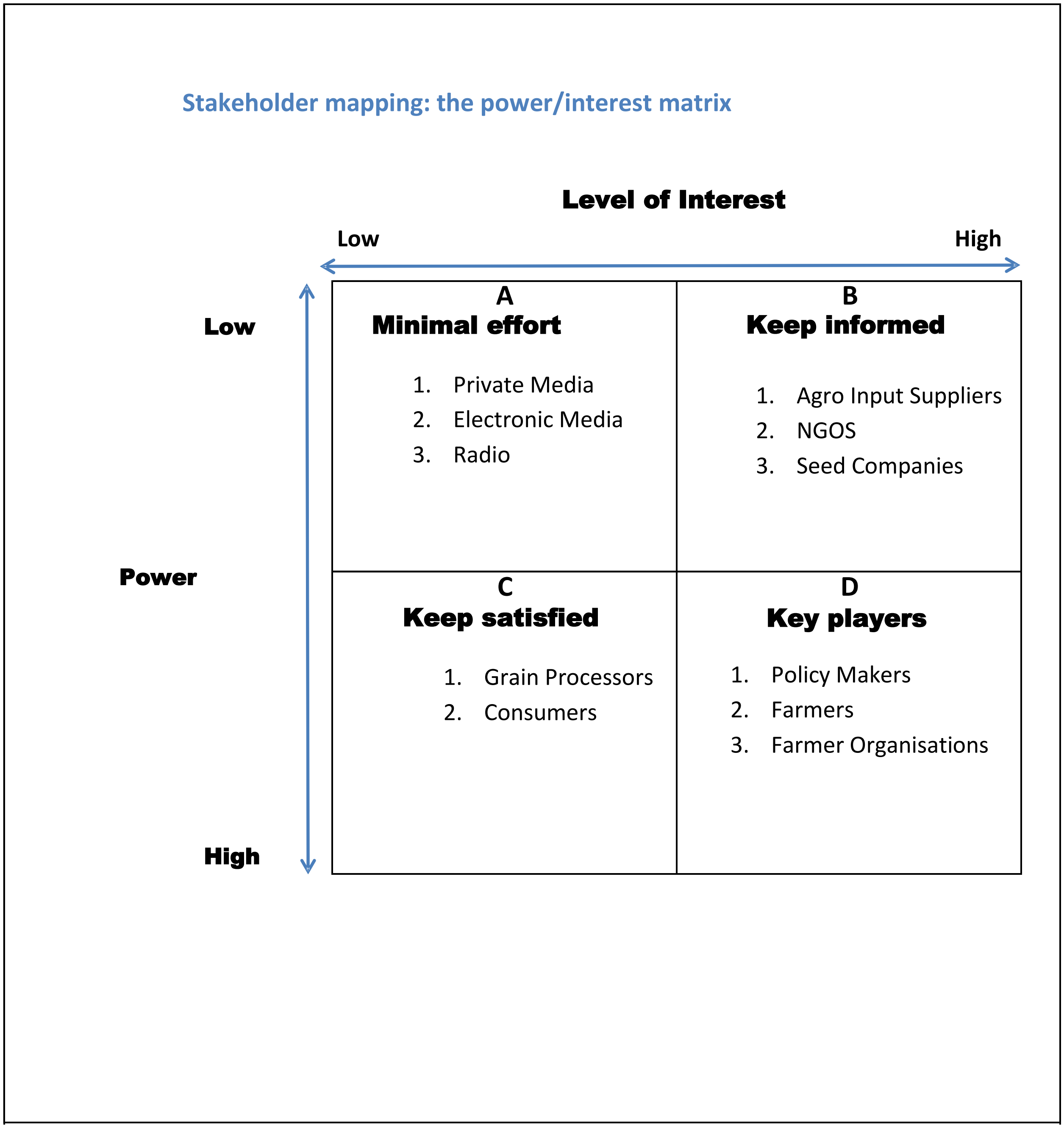
Factors like relative economic benefits and better yield from hybrid maize motivated farmers to adopt hybrid maize. These findings from the study are shown in Lewin's model as positive forces for hybrid maize adoption. Other collaborative promotional efforts for hybrid maize adoption included demonstrations, trials, field days and farmer field schools by extension officers, NGOs, seed houses and agro-chemical companies. These promotional activities were also reflected in Lewin's model as propellers of hybrid maize adoption. In addition, extension services and hybrid maize awareness campaigns helped to push the agenda of hybrid maize adoption by small scale farmers. Finally, the improved yields from hybrid maize seed encouraged farmers to adopt this technology because they were able to send children to school, buy food and improve on health provision from the proceeds derived from growing hybrid maize.

The right side of Lewin's model shows restraining forces against the adoption of hybrid maize. Some NGOs did not support hybrid but instead promoted OPV for reasons explained earlier. This restraining force is worsened by the unavailability of credit lines for small scale farmers and lack of hybrid maize awareness by small scale farmers resulting in a slower hybrid maize hybrid adoption rate.

Mendelow's Stakeholder Analysis Model – Figure 13

The other model adopted in this study is Mendelow's Stakeholder Analysis Matrix shown in Figure 13 below. The stakeholders' power and interest determined the level of influence they had on the adoption of hybrid maize by small scale farmers. Based on this study's findings, the various stakeholders have been placed in their respective quadrants. Policy makers, extension officers and small scale farmers have the greatest power and interest in hybrid maize adoption. This is because government policies related to food security are administered through extension officers and the farmers are powerful because they decide to adopt hybrid maize technology with help of extension officers. Other stakeholders are placed in the other quadrants in relation to their power and interest.

Figure 13: Mendelow's Stakeholder Analysis Matrix Mendelow



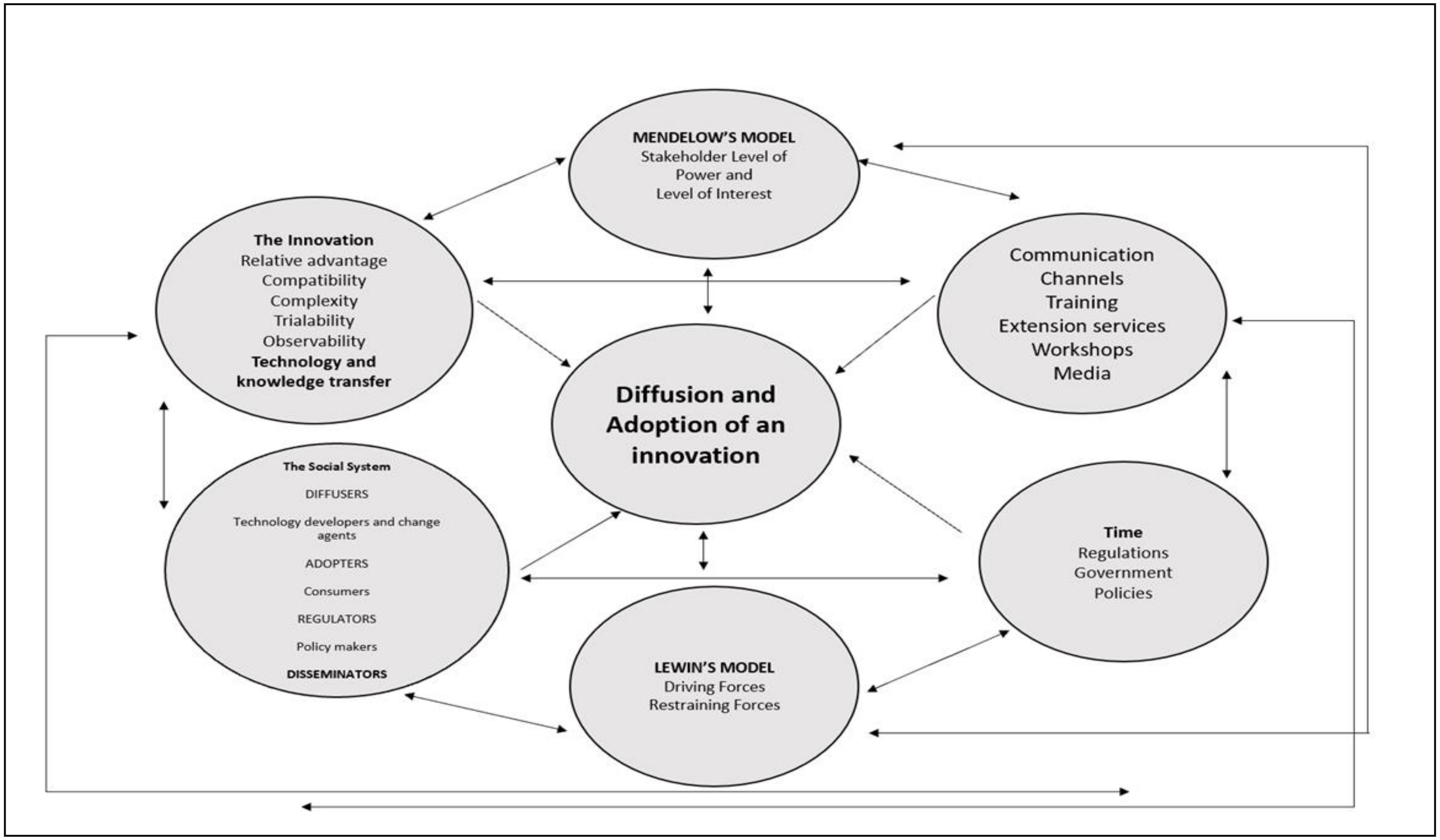
Rogers' Model Combined with Mendelow's and Lewin's Models' Application as the Conceptual Framework to this Study- Figure 14

Rogers' model combined with Mendelow's and Lewin's models creates the main Conceptual Framework (CF) for this study. The elements of the CF that included innovation, communication channels, social system, time, stakeholder power and interest, supporting and restraining forces were used to analyse the findings of this study. The model shows linkages, overlaps and interdependence of the seven elements, highlighted by the arrows in Figure 14. The diffusion and adoption of hybrid maize depends on the innovation and other elements shown in the CF below. Therefore, the adoption of hybrid maize by small scale farmers was influenced by the compatibility of the technology with the norms and values of small scale farmers.

Indeed, hybrid maize adoption is not complicated and the technological benefits are communicated through demonstrations by stakeholders as shown in this study. The demonstrations and field days were conducted collaboratively by extension officers, seed houses, NGOs and agro-chemical companies. During these technical sessions, knowledge and awareness of hybrid maize were further transferred to farmers using communication channels that included interpersonal contact, radio and print media.

Diffusers, disseminators and adopters of hybrid maize technology forming the Social System, are shown in Figure 14 below. These social system players including extension officers, small scale farmers, NGOs and agro-chemical companies, influenced the rate of hybrid maize adoption which is time bound. In addition, policies by policy makers promoted or slowed hybrid maize adoption rates. All these elements supported by stakeholder power and interest resulted in promoting or restraining forces for the adoption of the innovation hence combining the Rogers, Mendelow and Lewin models in the CF.

Figure 14: Rogers' Diffusion of Innovations Model, Mendelow's stakeholder matrix and Lewin's force field –used in a Conceptual Framework to Show factors that drive or restrain the adoption of Maize Hybrids in Malawi, Zambia and Zimbabwe:



CHAPTER FIVE: CONCLUSIONS

The purpose of this study has been to undertake an impact assessment of hybrid maize adoption by small scale farmers for sustainable food production in Malawi, Zambia and Zimbabwe. Using pragmatist mixed-methods research (MMR), the study seeks to establish factors that drive or slow the adoption of hybrid maize in Malawi, Zambia and Zimbabwe. This analysis has been undertaken using interviews and a survey conducted in Malawi, Zambia and Zimbabwe. Rogers (2003) theory of diffusion of innovations, in combination with Mendelow's stakeholder analysis model and Kurt Lewin's Force Field model, formed the conceptual framework to underpin this study. Highlights from the research findings are explained and discussed below. The discussions focus on implications, conclusions and limitations of the study.

Utilising the unified conceptual framework the study looked at how policy makers and other stakeholders influenced knowledge transfer of hybrid maize adoption to small scale farmers, given that the diffusion and adoption of hybrid maize face factors that can either promote or slow adoption. The study also investigated the reasons for slow hybrid maize adoption in the focus countries and how the technology impacted on the livelihoods of small scale farmers socially and economically. Finally, the study reviewed the impact of factors like climatic change, agronomic practises, CA and pre- and post-harvest losses, on the adoption of hybrid maize by small scale farmers. The context of this study is that the current hybrid adoption rate varied in the three focus countries, from Zimbabwe at over 95%, to Zambia at 60% and Malawi at 50% (FAOSTAT, 2018) but with low productivity, low food production and hunger in all three countries. The study therefore reviews how the factors and their recommendations impact on hybrid maize adoption by small scale farmers as a possible solution to boost production.

The major research findings are that a lack of resources for extension officers and lack of credit for small scale farmers slowed the rate of hybrid adoption. In addition the availability of resources to extension officers improve awareness of hybrid maize because of improved mobility, resulting in accessibility of more farmers by extension officers. Lastly the provision of inputs to farmers bridges the funding gap resulting in more farmers being productive.

Policy makers and other stakeholders influenced the rate of hybrid adoption; pre- and post-, harvest losses, agronomy and drought influenced the rate of hybrid maize adoption; and the adoption of hybrid maize generated socio-economic benefits for the livelihoods of small scale farmers. These findings from the study are discussed in relationship to their implications, limitations and conclusions. This chapter also critically addresses the various propositions derived from the study findings in relation to the objectives of the study, research questions and the theories referenced in the study.

Factors that promoted hybrid maize adoption result in higher productivity and more income to farmers, as shown in Section 4.2, where hybrid maize achieved a 15% margin compared to OPV that had a 10% margin (see Asfaw et al, 2012; Becerril, 2010 and Belion et al, 2006). On the other hand, critics of hybrid maize adoption argue that hybrid maize seed is expensive compared to OPV seed. Their argument is buttressed by the fact that; OPV maize seed can also be recycled for planting the next season. The critics further argue that with the level of inputs applied by small scale farmers, hybrid maize potential is not fully realised to make any yield difference when compared to OPV maize (see Kutka,2011). However, even if the yields achieved by small scale farmers are still low, the research showed that, farmers who used hybrid maize seed achieved higher yields in comparison to those that used OPV varieties, even at low input levels (see Marechera et al, 2019; Holden and Mangison, 2013; Ayinde et al, 2011; Byerlee and Eicher, 1997; Gerhart, 1975 and Lonnquist, 1956). Additionally even if the price of hybrid maize seed is taken as a barrier to the adoption of hybrid maize, the research found out that seed is the cheapest input compared to other inputs like fertiliser and tillage. Therefore farmers should worry more about getting better yields when they use hybrid seed instead of reverting to OPVs that are not as productive, just because of a lower purchase price. Overall and confirmed by the researcher's experience, the study also showed that hybrid maize production incurred more production cost per hectare but gave a better net return overall compared to OPV production.

Proponents of hybrid maize further added that, behind the yield advantage, hybrid maize offers attributes like drought and disease tolerance and better usage of nitrogen in the soil than OPV maize (see Magorokosho, 2006). Given these arguments, hybrid maize is seen to improve food productivity. Such technologies are needed by farmers to be able to produce more food for the growing global population forecast to reach nine billion by 2050 (The United Nations, 2019).

In summarising and discussing the results below, we refer to other studies that this research relates to. The most important point to make here is that none of these studies has asked the range of questions as this research has, nor for these three countries. This makes the present research especially important in its contribution to the literature and to the practical challenges of boosting the adoption of hybrid maize by small scale farmers.

5.1 Factors that Influence Diffusion and Adoption of Hybrid Maize

In this section we summarise the main findings, structured to follow the four research questions, discussing and reviewing each in turn to examine whether they promote or retard the diffusion and adoption of hybrid maize in Malawi, Zambia and Zimbabwe. Each will incorporate aspects of Rogers' diffusion and adoption theory as summarised in the sub-headings below (Rogers, 2003 and Wagner and Walchli, 2002).

5.1.1 Factors Causing Slow Hybrid Maize Adoption Rate

RQ1 explored factors that caused slow hybrid maize adoption by small scale farmers. This study showed that the key factors, in all three countries, were a lack of resources for extension officers and lack of credit for small scale farmers. This is especially important as the study showed that extension officers play two critical roles as they are at the centre of collaboration with other stakeholders, and they are responsible for continuous monitoring and training of small scale farmers on their farming operations leading to hybrid maize adoption.

Information flow is critical in the dissemination of innovations to small scale farmers (see Ezezika et al, 2012 and Shiferaw et al, 2015). Poorly managed information flow leads to lack of awareness by small scale farmers. As discussed above, in Subsection 4.5 extension officers together with seed houses, agro-chemical companies and NGOs play a crucial role in taking hybrid maize technology to small scale farmers. In an effort to persuade small scale farmers to adopt hybrid maize, extension officers collaboratively take the lead in demonstrations, field days and farmer field schools.

The study found that extension officers are not as effective as they could be in their collaborative role, because they lacked resources from government for them to be mobile and to partner other stakeholders in driving the adoption of hybrid maize by small scale farmers. This same handicap affected the extension officers from discharging their duties in monitoring and training of farmers. With a lack of working motorbikes, extension officers are not able effectively to cover the more than 300 farmers attached to each of them. This mobility aspect is very important if the extension officers are to reach out to those farmers who fail to attend field days and farmer field schools, where farmers are taught on productivity issues and agronomy. Based on my professional experience, extension officers play an indispensable role in advising farmers leading to improved productivity, but these challenges limit just how much they can achieve.

The study also showed that the lack of resources extends to lack of training materials to enhance the farming skills of small scale farmers. Therefore, all these described factors slow down the rate of hybrid adoption by small scale farmers. In Chapter 6 this study will recommend mitigation measures that improve mobility of extension officers and training materials they require.

The study also revealed that extension officers' numbers per district need to be increased by employing more officers to reduce the high ratio of farmers to extension officer. Besides hiring more headcount, other alternative ways of monitoring and disseminating information to farmers should be explored. For example cell phones can be used in getting to farmers with technical information and geophysics technology can be used to monitor crops. Once extension officers are resourced as discussed above, their effectiveness will improve the hybrid maize adoption rate by small scale farmers (see Huang, 2016; Shiferaw and Abebe, 2015; Wafula, 2015; Poolsawas et al, 2011; Chetsanga, 2000; Croppenstedt and Demeke, 1996).

Similarly, a lack of access to financing for small scale farmers slows the adoption rate (supporting the earlier findings of Simtowe et al, 2009 and Matusckke, 2007). The study showed that in Zimbabwe in 1985, the hybrid maize adoption rate increased greatly because of funding provided by the AFC to small scale farmers. This funding was supported by a strong extension department resulting in an adoption rate of 95%. This analysis showed that funding and robust extension backing can significantly increase the rate of hybrid adoption by small scale farmers. However, farmers failed to continue servicing their loans, in the AFC scenario, for various reasons including discipline and a dependency syndrome, thus farmers could not farm without funding. This led to governments of the three focus countries adopting FISP and PIS input subsidy programs that had some success, albeit limited due to budgetary constraints that later failed to sustainably fund the input subsidy programs (see Chirwa, 2005). Therefore, lack of awareness and funding had a bearing on the rate and ability of small scale farmers to adopt hybrid maize. In Chapter 6 recommendations on alternative funding structures are suggested.

5.1.2 The Influence of Policy Makers and other Stakeholders

In answering RQ2, the study has shown the significant importance of the role played by policy makers and other stakeholders in the process of hybrid maize adoption by small scale farmers (see also Smale et al, 2013; Howlett and Walker, 2012; Berry and Berry, 1991; Dejon, 1980). Detailed analysis of the interviews with policy makers and other stakeholders revealed how these stakeholders influenced hybrid adoption. The finding of stakeholder influence was further supported by quantitative analysis results that showed a highly statistically significant impact in persuading small scale farmers to adopt hybrid maize in all three study countries.

Government policy makers are responsible for making sure hybrid maize gets adopted for purposes of food security (see Jayne et al, 2018 and M. Xu et al, 2009). It is the government's duty to set up food production goals and policies that enhance food productivity. It is in their interest to make sure technologies like hybrid maize adoption succeed (see World Bank, 2019). This is the reason why the Malawian, Zambian and Zimbabwean (2017, PIS boosted production) governments were successful when they funded and implemented the FISP and PIS programs (see Chirwa, 2005 and Jayne, 2018). The Malawi and Zambia ended being net exporters of grain whilst solving lack of funding that was prevalent amongst small scale farmers in the past (supporting Mason et al, 2013; Simtowe et al, 2009; Matusckke, 2007). Unfortunately, because of inconsistent follow up by governments of the three countries, budgetary constraints and poor management of the FISP and PIS programs, all have faced the following problems: Interviewed farmers in both countries reported rampant corruption by input distributing officers leading to some intended beneficiaries not getting their inputs (see Smale et al, 2013 and Ricker-Gilbert et al, 2013). These corrupt activities led to some of the farmers getting inadequate inputs resulting in poor yields. Therefore, corruption interferes with the hybrid maize adoption process. Another problem facing the program in Zambia, Zimbabwe and Malawi is of inadequate funding and late funding from government leading to late input distribution and farmers end up planting late, also leading to poor yields (see Smale et al, 2013).

Finally, the government buying agents offered low grain prices and they came late to the few buying points (see Jayne et al, 2018). This problem discouraged farmers from adopting hybrid maize and opting for other cash crops, where prices were higher and markets less controlled by government. The three governments deliberately established these grain buying agents because they have a mandate to keep food affordable to the populace. Hence, they deliberately keep grain price low in order to sell to consumers at a lower price. All these issues negatively impact productivity of the farmers leading to hunger and poverty (see Ricker-Gilbert, 2013).

The PIS and FISP programs have been implemented on a similar basis and the inputs provided are less than needed for the size of landholding for the farmers. This situation forced the farmer to look for their own inputs or spread them thinly over a larger area of land rendering the inputs ineffective. However, even if the inputs were inadequate to cover the farmers' needs, the programs brought some relief to poor farmers who could not afford inputs in the absence of funding from banks (see Chimedza, 1994). Examples of successful hybrid maize adoption from Zimbabwe, during the 1980s and the early success rate of FISP program in Zambia and Malawi showed that sustainable funding and extension services are critical for successful hybrid maize adoption by small scale farmers.

The study brought out an influential stakeholder group in the name of opinion leader farmers. These opinion leader farmers are outstanding skilled farmers that lead other community farmers on planting demonstrations and holding field days. These opinion leader farmers are chosen by extension officers based on their leadership capability, supported by their past productivity records. Instead of relying mostly on extension officers to disseminate technological information to farmers, opinion leader farmers play a critical role in mobilising and bridging the gap between technology disseminators and small scale farmers (see Valente and Davis, 1999; Kutka, 2011). This strategy of using opinion leader farmers has worked for hybrid maize adoption (see Valente and Davis, 1999).

Farmers are organised in groups and coordinated by extension officers so that training, field days and farmer field schools by seed houses and NGOs are easily managed (see Makorokosho, 2007; Valente and Davis, 1999 and Kutka, 2011).

The study also revealed that seed houses and NGOs are important stakeholders who support field demonstrations, farmer field schools and field days (see Poolsawas et al, 2011). Some of the NGOs spearheaded conservation agriculture programs, leading to better soil conservation (Townsend et al, 2016) whilst others also promoted input dealers' training resulting in inputs being brought closer to small scale farmers. Instead of farmers travelling long distances they now saved on transport, leading to reduced overall production costs. Even so, the study found that some of these stakeholders did not collaborate enough, but instead they took their programs to farmers in a disjointed manner making their efforts less than fully impactful (see Frey, 2006; Gajda, 2004).

5.1.3 Other Factors that Cause Low Productivity of Maize Production

In seeking answers to RQ3 the study showed that climatic change has been a big problem, resulting in perennial droughts in the three countries, with Zimbabwe hit the worst (Soler et al, 2007). These droughts have had a big impact on productivity, affecting the hybrid maize adoption rate. This study has revealed that farmers who adopted hybrids had a better chance of escaping droughts compared to those that planted OPV maize (see Schroeder et al, 2013). The scientific reason given for this trend is based on the fact that hybrids are produced by a combination of two to three unrelated parental lines of maize which give rise to more desirable attributes compared to OPV maize that is derived from a single parental line. These desired traits bred into the hybrid maize include drought and disease tolerance in the final product (see Martin and Shepherd, 2009; Schroeder, 2013 and Mapila et al, 2012). The study through field research showed that, in the three countries, besides breeding for drought tolerance, the establishment of irrigation schemes and CA practises for small scale farmers brought relief from devastating droughts experienced lately by famers in the three countries.

Extension officers should be responsible to monitor farmers so that they keep weed-free and well fertilised fields. Unfortunately, poor agronomic practises by small scale farmers go unnoticed at times because the extension officers are not well enough resourced to discharge their duties. This impacts on hybrid maize adoption because of poor weed control and fertiliser application can impact on yields achieved by farmers (see Eadie and Stone, 2012; Feleke and Zegeye, 2006; Gbre-Madhin and Haggblade, 2004). The study showed that those farmers who looked after their crop by controlling weeds and applying fertiliser achieved better yields compared to farmers who neglected their crops (see Eadie and Stone, 2012; Schroeder, 2013 and Mapila et al, 2012).

A good potential harvest should be protected from pre and post harvest losses. Results showed that hybrid maize stood better and did not fall over in the field compared to some OPV, resulting in reduced field losses by small scale farmers. Farmers also need to be watchful of post-harvest losses due to large grain bores and weevils. To avoid these losses, hermetic airtight bags proved to be a reliable storage solution for small scale farmers before they take their maize to the market (Ndegwa et al, 2016). This study showed that these bags are being introduced in the three study countries and are proving to be useful.

5.1.4 Relative Social and Economic Advantage

To answer RQ4, which seeks to review the socio-economic impact on small scale farmers' livelihoods when they adopt hybrid maize, the study showed that relative advantage is a significant factor that propels diffusion and adoption of hybrid maize. Relative advantage is determined by economic and social factors, as viewed by adopters and it determines how fast an innovation can be diffused (see Rogers, 2003). For farmers to adopt hybrid maize they are attracted by returns per unit area of land and the yield potential of hybrid maize compared to OPV maize (Rogers, 2003). In this study, farmers that grew hybrid maize in the three focus countries achieved a profit margin of 15%, as compared to 10% achieved by their counterparts that grew OPV maize. From the analysis of data collected, yield achieved per unit area and cost of production drove profitability for the farmers. Despite the study showing this positive outcome, some of the farmers based on my professional experience still needed to be funded and monitored for a period of five years until they could make the adoption of higher-cost hybrid economically self-sustaining. The literature reviewed and cross referenced below, gives examples of studies that supported this stance.

The study further demonstrated that there are social and economic benefits that accrue to farmers who adopted hybrid maize. Hybrid maize adoption resulted in better yields compared to OPV maize that farmers grew in the past (see Marechera et al, 2019; Holden and Mangison, 2013; Ayinde et al, 2011; Byerlee and Eicher, 1997; Gerhart, 1975 and Lonnquist, 1956). Farmers invested in this technology because it reduced uncertainty on perceived benefits (see Rogers, 2003; Scanndizo and Savastono, 2010). Ultimately because of the improved productivity, farmers' livelihoods improved, as reflected in better health provision, improved housing and better education provision for children (see Eller, 2014; Mathenge et al, 2013; Becerril, 2010; Alene and Coulibaly, 2009). Most of the adopting farmers interviewed stated that they will continue planting hybrid maize because of these added benefits (see Kutka, 2011).

The cost of hybrid maize seed is usually less than 10% of the total cost per hectare and most farmers interviewed did not complain about the price. However, the few that complained did not only complain about seed price but that they needed support for all the other inputs. However, in the Malawian situation those farmers who opted for OPV local maize attributed their choice to the taste, flintiness and grain hardness of the maize rather than the return per unit area or productivity.

Thus, the results from the study showed that small scale farmers are motivated by adopting hybrid maize because of the associated underlying benefits, resulting in improving productivity and food security. However, the Malawian needs to be continuously considered by maize breeders, to incorporate these other attributes in their hybrid maize. As mentioned earlier, flintness and grain hardness protected maize grain from weevil damage, providing economic benefits as well as delivering on customer preferences.

5.1.5 Compatibility, Trialability and Observability

According to Rogers (2003) innovations that are compatible with norms and values of a social system have a faster diffusion and adoption rate, and those that are complicated do not diffuse as fast. The success stories associated with hybrid maize disseminated through radio, social and print media motivate farmers to adopt the technology. There are several examples reported in the literature where hybrid maize improved farmers' yield bringing about economic and social gains resulting in increased hybrid maize usage globally (see Holden and Mangison, 2013; Ayinde et al, 2011 and Lonnquist, 1956). In addition, the hybrid maize technical requirements at farmer level are not complicated and similar to local farm saved seed or OPV maize (see Rukuni et al, 1998 and Smale et al, 2013).

The Literature reviewed stated that innovations that can be experimented, can diffuse faster (see Rogers, 2003). The process of registering hybrid maize in Malawi, Zambia and Zimbabwe requires testing the products for two years and thereafter registration can be granted by the authorities in the respective country (see CIMMYT, 2018; Halford, 2012 and Rusike and Eicher, 1995). Recently the COMESA trading bloc has completed the seed harmonisation protocol and SADC is waiting for a signed agreement by member states. In this agreement any seed product that is registered in any two regional member states can be registered in any other COMESA or SADC country for the first time without further trials. This development is advantageous to small scale farmers in SADC and COMESA because they can access new products registered in any two regional countries faster, without having to wait for the two year trialling requirement (see Halford, 2012).

With all these registration requirements, governments make sure their farmers are protected from substandard products and, in turn, they also protect the seed companies by observing protocols for intellectual property rights (IPR) (see Phadke and Vyakarman, 2017; Van Norman and Eisenkot, 2017; Kumar et al, 2015 and Halford, 2012). As the seed companies follow the registration requirements, they simultaneously also test their products widely, so that when they release the hybrids commercially, they are placed in the correct ecological environments (see Marechera et al, 2019).

Guided by this trialling data, seed houses in conjunction with extension officers plant demonstration plots that showcase the products for farmers to observe before adopting the hybrids (Kutka, 2011). This process is very important because for farmers to have an appreciation of the new hybrids' performance, they need to see the maize hybrids planted side by side with the farmers' usual OPV maize (see Chirwa, 2005). During workshops and field days, farmers choose products with desired traits or characteristics (see Duvick et al, 2004). The study has established that trialability and observability are important factors that drive the adoption of hybrid maize because farmers are able to evaluate themselves the performance of the new hybrid maize in comparison with their old varieties (see Chirwa, 2005).

5.2 Contribution of the Study

This study holistically (involving the analysis of several causal factors) has consolidated information on productivity challenges faced by small scale in the three countries. The holistic approach has put new consolidated knowledge on challenges faced by small scale farmers when they try to adopt hybrid maize for sustainable food production. Unlike previous studies that looked only at climate change and funding as factors that affected the adoption of hybrid, this study looked at multiple factors, across three countries that had an impact on hybrid maize adoption by small scale farmers. These important factors in this study included stakeholder influence, agronomy, irrigation, CA, funding, resources for extension officers and livelihood impacts.

We now set out contributions to each audience in turn, starting with academic audiences where new knowledge has been added on factors affecting hybrid maize adoption by small scale farmers. The study follows the set research standards that incorporates of a novel Conceptual Framework for analysing research data. This helps to analyse data that draws on conclusions that are comparable with other authors in the field. The research brings new knowledge that can be referenced to by future authors.

The research brings valid information to policy makers in the three countries regarding the adoption of hybrid maize. Governments are able to learn best practices on how to manage FISP programs sustainably and successfully based recommended solutions offered in Chapter 6. These recommendations will lead to improved food security by small scale farmers.

The study determined that slow hybrid maize adoption is also caused by ineffective hybrid maize awareness campaign by extension officers and seed houses. This inefficiency was attributed to lack of resources by government and limited numbers of extension officers. This factor caused ineffectiveness of extension officers, resulting in slow adoption of hybrid maize by small scale farmers. The recent donation of 5000 motor bikes by well-wishers in Zimbabwe is a good example of how practically the extension officers can be helped to reach more farmers.

Extension officers are extensively discussed in the study and issues regarding mobility explored for effective farmer coverage. Extension officers are identified as the most influential stakeholder for hybrid maize adoption because they are mandated to train and monitor technology transfer to small scale farmers. This study reveals that the FISP program is not as sustainable because of the involvement of governments alone who face periodic budgetary constraints. Based on my professional experience, the FISP program is necessary in the first five years, but it must be then be adapted by sustainable collaborative institutional set ups that involve private and public partners (Figure 11). These institutions unlike governments who have constrained budgets, need to be sustainably funded using private and public partners continued support of food productivity by small scale farmers. The study also advocated for small scale farmers to be allowed to use their non-movable assets (houses, land) and movable assets (farm implements, vehicles, harvested grain, livestock) to unlock value to get funding for their farming operations.

This study revealed that input subsidies programs encouraged a dependency culture among farmers and as such farmers are not paying back for their inputs. We encourage them to pay back for inputs received. Eventually farmers should fully pay for their inputs through improved institutionalised structures. Once funds are revolving productivity will improve because the funding of such programs will be much easier. These institutions will be accessible to small scale farmers, and they will have an organisational set up that is funded by institutions like agricultural land banks. They must represent small scale farmers' interests and should provide monitoring and training to the farmers.

This study also covered the adoption of hybrid maize by small scale farmers in Malawi, Zambia and Zimbabwe, resulting in the analysis of similarities and differences amongst the three countries. The FISP program applied to Malawi and Zambia had some experiences that could be adopted and improved in the different countries. Whilst Zimbabwe had a similar program to FISP with the inputs distributed freely, one can learn how FISP was being run in Zambia and Malawi for future consideration. Each country had its own uniqueness that could be compared with the other countries for learning and understanding of the problems and challenges of food productivity by small scale farmers, notably with input support and subsidy programs: farmers access inputs without paying upfront, the inputs are available at reduced prices and payable after harvest and the inputs are brought closer to the farmers. The study also showed that government input subsidy programs may not sustainably support small scale farmers' productivity unless, as highlighted above, institutes like agricultural land banks and private sector are involved to provide sustainable funding.

The study has brought out the fact that hybrid maize adoption on its own without good crop husbandry, like weeding and application of fertiliser, does not bring out the desired productivity results. Weed control, irrigation and fertiliser application are also required to get the enhanced productivity. It also showed that yield per unit area drive profitability and productivity. Finally, the study also highlighted the need for the establishment of conservation agriculture and irrigation to mitigate the effects of climatic change and maximise yield potential.

The study has also showed that seed houses rely too much on extension officers and have to consider other strategies, like engaging opinion leader farmers, to influence more hybrid adoption for their own benefit.

5.3 Limitations

The methodology used for sampling in this study is purposeful snowball sampling and it had limitations. During sampling there is a chance that participants would refer the researcher to their colleagues that share the same beliefs about hybrid maize adoption. This will lead to some bias in the sense that the findings may miss critical information from respondents with different opinions. The DBA course required the candidate to conduct their own research without assistance and when it came to conducting the interviews the researcher conducted them single-handedly, that needed covering a huge geography consisting of varying economic environments. This situation limited the number of informants covered in the three countries.

The distribution of the questionnaire demanded going on the ground with local people to assist with translations, especially in Zambia and Malawi where the researcher could not speak the same language as small scale farmer participants. The visits in the three countries, to these remote areas, needed travelling money, fuel and travelling time, leading to thirty interviews being conducted in the three countries under these circumstances. The researcher paid for the above-mentioned costs to conduct the research.

The study was conducted in a difficult setting with poorly resourced small scale farmers. The farmers lacked financial resources to pay for inputs such as fertilisers, chemicals and labour. Persistent droughts made it even more difficult for the farmers because at times their crops wilt before maturity leading to no measurable yield. Therefore, getting reliable yield data was not easy in such environments. The study observed that the resilience showed by the farmers was similar across all three countries because farmers did not have any options to feed their families, because agriculture is their mainstay.

Even so, the quantitative data were generally very consistent with qualitative interview data. More so, small scale farmers do not have farm machinery that could improve productivity on the farms and moreover most small scale farmers lacked education and agronomic knowledge making adoption of new technology difficult.

The researcher could also have organised focus groups, but these were not included because of the time needed to get these groups mobilised in the three countries. However, focus groups might have brought in one disadvantage in a situation where one comes across a powerful individual who might dominate discussion, resulting in the other participants being overshadowed.

5.4 Considerations for Further Research

After reviewing the results of the study there are areas that can be considered for further research. In this regard, the study's questionnaire did not take into consideration the aspects of age, education, gender, size of land and wealth of the participants, because it was based on a broad stakeholder analysis. That said, adoption could be correlated to the different demographics. This additional information may bring valid information to see if the adoption may follow a certain pattern linked to the factors listed above. In addition, the questionnaire had spaces for respondents to fill out, but this was largely left blank by participants. In future respondents need to be encouraged to fill in all spaces on the questionnaire, or new questions added. This was the same case with the costing questions that were mostly left unanswered in Malawi. Further research can be done to explore effective ways of disseminating technology information to small scale farmers. This will assist in knowledge transfer to small scale leading to faster adoption rates of technologies by small scale farmers. These additional research aspects may lead to improved hybrid maize adoption by small scale farmers.

CHAPTER 6: RECOMMENDATIONS

This Chapter brings the curtain down on this study by offering a range of appropriate industry recommendations reflecting the results of the study. Government policy makers play a critical role in the adoption of hybrid maize to enhance productivity and ensure food security. The FISP program brings a partial solution to the funding gap and therefore there is a need to improve on its deliverables. This can be done by introducing an inclusive electronic voucher system that takes out corruption issues and distribution inefficiencies. In this regard farmers are encouraged to use electronic swipe cards for their chosen inputs thereby removing manual processing of papers which was the source of corruption by distributing officers (Sitko et al, 2012).

Governments should tighten the repayments of the subsidised inputs so that their limited subsidy budget would see them affording to provide viable grain market prices that balances the affordability of the staple grain to consumers. Alternatively further subsidies to the millers can be introduced, as the case with GMB in Zimbabwe. This allows better prices to farmers whilst the governments make sure the staple food is bought at reasonable prices. This move need to be supported by more buying points by government grain buying agents, this will also help farmers not to travel long distances to sell their product, resulting in reducing the temptation of side marketing by the farmers (Onumah, 2012). It is also important for farmers to appreciate government effort by paying back their inputs costs leading to a more sustainable subsidy programs.

To reduce post-harvest losses maize hybrids that do not lodge are recommended and to prevent insect damage, NGO funded hermatic airtight bags are recommended. To facilitate early and quick grain deliveries road infrastructure needs to be improved so that trucks can access farmers. This helps to reduce the use of expensive airtight hermetic (Ndegwa et al, 2016) bags and, by not having to travel to sell their crops, reduces the incentives for side marketing. The bags could only be used when grain deliveries are delayed and then farmers are forced to use the bags to avoid grain rots and weevil damage. But once grain deliveries are made early there will be no need to store the grain after harvest.

The awareness campaign lacked resources to support extension officers and the governments need to equip the extension officers with motorbikes for farm visits to facilitate monitoring, support and supervision of farmers. These visits are key in the awareness campaign for hybrid maize adoption by small scale farmers. Secondly for classroom training extension officers lack training materials, which include overhead projectors, flyers and flip charts. These materials could be spornsored by stakeholder groups that include NGOs and seed houses. As demonstrated recently in Zimbabwe a well-wisher, motivated by self-interest (because they are a seed company) donated 5000 motor bikes to extension officers to improve mobility which was crucial for follow ups especially when some farmers failed to attend field days and workshops. This donation from Valley Seeds went a long way in providing the much-needed mobility. Based on my field experience and observation extension officers become more visible when they are mobile, resulting in better monitoring of the successful CA (Pfumvudza program) in Zimbabwe in 2021, for example. In addition, the ratio of extension officer to supervised farmers should also be increased by employing more extension officers. This would represent an important indirect investment in improving food security.

Seed houses are key players in this whole equation for sustainable food production, as they breed maize hybrids that are tolerant to drought and diseases reducing the impact of these adverse conditions. In the wake of climatic change, more of their effort should focus on short season maize hybrids and small grains that are resilient to drought and diseases. The CIMMYT Drought Tolerant Maize for Africa (DTMA) is targeting hybrid maize with drought tolerance and seed houses are encouraged to take up these products to enhance their product offerings regarding drought tolerance. Trialled DTMA products have been very effective in the three countries. Given limited government resources allocated to extension officers, seed houses, like what Valley Seeds did by donating motorbikes, should adopt strategies to deploy more resources to extension officers, add more manpower, including recruiting their own opinion leader farmers, who will help to plant more hybrid maize demonstrations to raise awareness among small scale farmers.

Seed houses need to continue to use social media, radio and print media as a form of communication to raise hybrid maize awareness. Finally seed houses, agro-chemical companies and NGOs' awareness campaigns are better when leveraged via collaboration with policy makers and extension officers. The campaign for hybrid maize adoption should be done collaboratively with extension officers, agro-chemical companies and NGOs.

The role of NGOs has always been commendable especially when they fund responses to natural disasters like Cyclone IDAI (in Zimbabwe) and the drilling of boreholes to access water and counter the effects of climate change. However, their effort should also focus on sustainable projects that make small scale farmers independent of donations beyond the very short term. Examples are awareness campaigns of technologies that make sure the farmer is upskilled to meet climatic change challenges.

Funding of irrigation schemes is another project that makes the farmers more sustainable in the face of climatic changes. In all the projects assisted by NGOs, there is a need for the farmers to pay for their inputs and focus should be on how the farmers can improve on productivity, so that they can make these payments as a result of higher net profits. An example could be a seed multiplication scheme where farmers are given inputs but with the seed house buying back the produced seed crop. The seed house will deduct the costs of inputs at delivery by the farmers. This scenario brings a win-win situation to both the farmers and the seed houses. The farmers will benefit from the input support while the seed houses benefit from the delivered seed.

With the climatic change, irrigation infrastructure needs to be revamped and expanded by government as a mitigation measure for the perennial droughts affecting the focus countries. Priority of setting up new irrigation schemes should start with farmers that are close to water bodies. Irrigation is initially costly to establish, but once it is set up it will sustain local food production, saving foreign currency for food imports. In some situations, governments may need to provide borehole water which goes a long way to providing both drinking water and irrigation. That said, with prolonged droughts the underground water may dwindle forcing farmers to reserve the water for drinking only. Seed houses therefore still need to keep developing more drought tolerant varieties.

As discussed further in Document 6, after completion of the DBA, the researcher will be involved in agriculture consultancy, especially in areas related to this study in the SSA, SADC and COMESA regions. The researcher will consult governments regarding management of input subsidy programs, knowledge transfer to farmers, stakeholder awareness and technology transfer to farmers. The researcher will also offer training and consultancy on capabilities of solving productivity issues using known tools like six sigma and warehouse receipting as an option for providing funding to small scale farmers (Coulter and Onumah, 2002 and Onumah, 2012).

The researcher is seriously thinking of setting up an institution that is funded by banks, like the AFC and the Indian Grameen bank which have funding models that support farmers only. In this case the institution with the support of public and private partners will run credible warehouse receipting structures. This institution will offer farmers subsidised inputs and contract small scale farmers to grow small grains and hybrid maize that will be value added and exported, allowing farmers, higher prices which incentivises them improved productivity. This warehouse receipting works in situations where farmers are contracted and as they deliver to grain buyers, the buyers will in turn deduct funds for inputs, advanced to the farmers at planting time. These funds for inputs will then be managed as a revolving funding scheme driven by farmers paying back for their inputs through delivery of their produce. This set up will generate enough money to sustain productivity without involving government funds. This arrangement can also be supported by small scale farmers using their non-movable and movable assets to guarantee their advanced inputs in these programs. This will force the farmers to be serious with their productivity for fear of losing their assets. This funding option is described in detail below:

Lack of funding can be explored differently by approaching banks and other funders for a possibility of accepting small scale farmers' collateral from non-movable and movable property, that include land, houses, furniture, livestock, grain and farm implements. This option was supported by work done in Kenya, by Musembi (2007: 45) using De Soto's argument, which stated that, "formal property rights hold the key to poverty reduction by unlocking the capital potential of assets held informally by poor people". The issuance of credit to small scale farmers using their communal assets would help them to access finance for their cropping program. This development unlocks potential in small scale farmers, enabling them to adopt hybrid maize, boost their incomes and help to address food supply locally.

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Annexes

Annex1- Research Questionnaire

Research Title: "**An Impact Assessment of Hybrid Maize Technology Adoption for Sustainable Food Production by Small Scale Farmers in East and Southern Africa": Evidence from Zimbabwe, Zambia and Malawi.**

Section A

Please tick the appropriate box in accordance with your opinion and fill in the space provided for suggested comments.

Q1. Farmers' choice of maize hybrids is mainly based on yield.

Strongly agree	Agree	No Opinion	Disagree	Strongly disagree
5	4	3	2	1

Comments and Suggestions

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Q2. The reason why small scale farmers choose a certain maize hybrids is based how the hybrid is able to perform across different ecological conditions.

Strongly agree	Agree	No opinion	Disagree	Strongly disagree
5	4	3	2	1

Comments and Suggestions

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Q3. Farmers that grow maize hybrids achieve yields that are generally higher than Open Pollinated Varieties (OPV).

Strongly agree	Agree	No opinion	Disagree	Strongly disagree
5	4	3	2	1

Comments and Suggestions

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Q4. In this country maize is grown in different climatic regions and the success rate is dependent on the rains received and the adaptability of the maize hybrid grown.

Strongly agree	Agree	No opinion	Disagree	Strongly disagree
5	4	3	2	1

Comments and Suggestions

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Q5. The use of fertilisers or manure and weed control directly affect the performance of maize hybrid grown.

Strongly agree	Agree	No opinion	Disagree	Strongly disagree
5	4	3	2	1

Comments and Suggestions

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Q6. Hybrid maize responses better when farmers put adequate fertilizers, weed their fields and take control of pests compared to OPV maize.

Strongly agree	Agree	No opinion	Disagree	Strongly disagree
5	4	3	2	1

Comments and Suggestions

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Q7. Farmers choose to grow crops that give them higher cash returns per unit area.

Strongly agree	Agree	No Opinion	Disagree	Strongly disagree
5	4	3	2	1

Comments and Suggestions

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Q8. The use of hybrid maize by small scale farmers enhances sustainable food production.

Strongly agree	Agree	No Opinion	Disagree	Strongly disagree
5	4	3	2	1

Comments and Suggestions

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Q9. Irrigation provision is required to reduce the risk associated with droughts during maize production.

Strongly agree	Agree	No opinion	Disagree	Strongly disagree
5	4	3	2	1

Comments and Suggestions

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Q10. Inadequate on farm storage facility is a big problem for small scale farmers.

Strongly agree	Agree	No opinion	Disagree	Strongly disagree
5	4	3	2	1

Comments and Suggestions

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Q11. Extension service provided by government officers is important to the small scale farmers because the extension officers are used a conduit for disseminating technical information to farmers.

Strongly agree	Agree	No Opinion	Disagree	Strongly disagree
5	4	3	2	1

Comments and Suggestions

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Q12. Most small scale farmers rely on the technical information they receive from government extension officers

Strongly agree	Agree	Not certain	Disagree	Strongly disagree
5	4	3	2	1

Comments and Suggestions

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Q13. Most of the other stakeholders access small scale farmers through the government extension arm.

Strongly agree	Agree	No Opinion	Disagree	Strongly disagree
5	4	3	2	1

Comments and Suggestions

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Q14. The current collaboration amongst stakeholders is not effective to influence improved uptake of hybrid maize.

Strongly agree	Agree	No Opinion	Disagree	Strongly disagree
5	4	3	2	1

Comments and Suggestions

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Q15. The decisions by government to promote hybrid maize is based on scientific research

Strongly agree	Agree	No Opinion	Disagree	Strongly disagree
5	4	3	2	1

Comments and Suggestions

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Q16. Field days and demonstration plots are the best way of influencing farmers to adopt hybrid maize

Strongly agree	Agree	No Opinion	Disagree	Strongly disagree
5	4	3	2	1

Comments and Suggestions

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Q17. Joint field days amongst the different stakeholders enhances hybrid maize adoption

Strongly agree	Agree	No Opinion	Disagree	Strongly disagree
5	4	3	2	1

Comments and Suggestions

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Q18. In this country there is no justification for the commercialisation of hybrid maize.

Strongly agree	Agree	No Opinion	Disagree	Strongly disagree
5	4	3	2	1

Comments and Suggestions

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Q19. Hybrid maize adoption needs the support from other stakeholders like fertilizer, seed companies, agro-chemical companies for higher yields to be achieved.

Strongly agree	Agree	No Opinion	Disagree	Strongly disagree
5	4	3	2	1

Comments and Suggestions

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Q20. Stakeholders should work with the Farmers in the decision making on the adoption of hybrid maize. What are your suggestions regarding this statement? Use the space provided below.

Strongly agree	Agree	No Opinion	Disagree	Strongly disagree
5	4	3	2	1

Comments and Suggestions

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Q21. The governments believe in hybrid maize adoption and have facilitated investment to confirm its interest. What are your comments and suggestions on the statement? Use the space provided below.

Strongly agree	Agree	No Opinion	Disagree	Strongly disagree
5	4	3	2	1

Comments and Suggestions

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Q22. Lack of awareness of the benefits of hybrid maize is the reason for the slow uptake of hybrid maize. What are your comments regarding this statement? Use the space provided below.

Strongly agree	Agree	No Opinion	Disagree	Strongly disagree
5	4	3	2	1

Comments and Suggestions

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Q23. Lack of access to funding by small scale farmers is a stumbling block for accelerated hybrid maize adoption in this country. What are comments regarding this statement? Please use the space provided below.

Strongly agree	Agree	No Opinion	Disagree	Strongly disagree
5	4	3	2	1

Comments and Suggestions

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Q24. Policy makers play a pivotal role to the adoption on hybrid maize. What is your comment? Please use the space provided below.

Strongly agree	Agree	No Opinion	Disagree	Strongly disagree
5	4	3	2	1

Comments and Suggestions

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Q25. It is important to follow other success stories from neighbouring countries to make sound policies for hybrid maize adoption. Do you have any comments regarding this statement? Please use the space below.

Strongly agree	Agree	No Opinion	Disagree	Strongly disagree
5	4	3	2	1

Comments and Suggestions

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Q26. Market development for grain produced by farmers is critical for the successful hybrid maize adoption. What is your comment regarding this statement? Please use the space below.

Strongly agree	Agree	No Opinion	Disagree	Strongly disagree
5	4	3	2	1

Comments and Suggestions

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Section B of the Questionnaire

Farmer's records, please complete in the appropriate box, the actual achieved in 2017/18 season.

B1	**Farming activity**	
B2	Crop Planted: Indicate hybrid or OPV maize	
B3	Total hectares planted	
B4	Total Harvest (MT)	
B5	Total Sales	
B6	Yield achieved /Ha	
B7	Price of Maize/Mt	
	Production Costs/Ha	
B8	Land Preparation	
B9	Seed	
B10	Insecticides	
B11	Fertiliser	
B12	Labour	
B13	Transport	
B14	Other costs	

B15	Other costs	
B16	Other costs	
B17	Other costs	
B18	Total production cost	
B19	Net Income	

Annex 2

Interview Guide – Farmer- Hybrid

1. How do you choose the crop to grow on your farm?
2. Do you grow open pollinated varieties (OPV) or hybrid maize?
3. How do you decide which type of maize to grow?
4. Who influences your choice of product you grow on your farm?
5. What yield level is economic and sustainable on your farm?
6. What do you think are causes for the low yields
7. What are the constraints you face to achieve high yields?
8. What is your comment regarding Government extension services?
9. Does government offer input support to farmers?
10. What is your comment regarding the support?
11. Are you able to borrow money from banks and on what terms?
12. In your opinion who else besides government can support productivity on your farms?
13. In your opinion what are the disadvantages and advantages on the adoption of hybrid maize?
14. What are the economic and social concerns that affect hybrid productivity in your country?

Interview Guide – Farmer- OPV

1. Do you grow maize open pollinated varieties (OPV) or hybrid maize?
2. How do you choose the type of maize crop to grow on your farm?
3. How do you decide which type of maize to grow?
4. Who influences your choice of product you grow on your farm?
5. Have you ever grown hybrid maize?
6. Why did you stop growing hybrid maize?
7. Why do choose OPV over hybrid maize?
8. In your opinion what are the disadvantages and advantages on the adoption of hybrid maize?
9. What yield level is economic and sustainable on your farm?

10. What do you think are causes for the low yields?
11. What are the constraints you face to achieve high yields?
12. What is your comment regarding Government extension services?
13. Comment on the government input support to farmers?
14. What is your comment regarding the support?
15. In your opinion who else besides government can support productivity on your farms?
16. Are you able to borrow money from banks and on what terms?
17. What are the economic and social concerns that affect maize productivity in your country?
18. Is there anything that we did not discuss that you feel should be included in this study?
19. Is there anything that we did not discuss that you feel should be included in this study?

Interview Guide – Fertiliser and Agrochemical Company

1. What is the impact of fertilizer and pests control in producing hybrid maize in the region?
2. How is your Company influencing the adoption of maize hybrid in this region?
3. What is the impact of your effort?
4. What are the constraints your face to convince farmers to use your products?
5. What is your organisation's strategy in promoting your products?
6. Who are the key stakeholders who influence hybrid maize adoption?
7. What is your company doing together with other stakeholders to promote hybrid maize and usage of fertilizers and pesticides?
8. To what level do you engage government extension service on the adoption of your products?
9. What are the major constraints faced by small scale farmers to achieve economically sustainable yields?
10. What are the social and economic benefits for adopting hybrid maize technology in conjunction with the use of your products?
11. How does the debate on OPV versus Hybrid maize affect your organization?
12. Is there anything that we did not discuss that you feel should be included in this study?

Interview Guide – Maize Grain Buyer

1. What is your organisation’s role in the maize sector?
2. What are the benefits of maize hybrid adoption to your organization?
3. As a Grain Buyer how do you make sure you get the right grain quality into your company?
4. What attributes do you look for in the maize grain you buy?
5. What are the benefits of hybrid maize to the grain buyers?
6. Would you recommend hybrid maize to other farmers?
7. What are the responsibilities of grain buyers in the adoption of hybrid maize?
8. Would you consider contract farming to assist the farmers with productivity and what would you do to avoid side marketing?
9. What are your future plans to help maize grain farmers?
10. What can be done to increase awareness for hybrid maize?
11. What areas of collaboration would you consider to work with other stakeholders so as to improve maize grain production?
12. What are the economic and social benefits to the farmers when they adopt hybrid maize?
13. Is there anything that we did not discuss that you feel should be included

Interview Guide – Policy Makers - Zimbabwe

1. What is the Government policy on hybrid maize utilisation in your country?
2. What quantities of maize do you require for the country?
3. Does your country produce enough maize for meet the national requirement?
4. What causes the deficit?
5. What is your national average yield for maize?
6. What is an economically sustainable yield for small scale farmers?
7. How does your OPV maize national yield compare with hybrid maize yield?
8. What is the Government policy on Open Pollinated Varieties (OPV)?
9. What is your hybrid maize adoption level in your country?
10. What attributes would you say make hybrid adoption process succeed or fail?
11. What level of hybrid adoption would you call a success?
12. Is your hybrid adoption rate in line with farmer productivity and if it is not aligned what could be the reason?

13. What efforts were done to improve hybrid adoption?
14. How does government support maize productivity?
15. What is Government policy regarding extension services?
16. What are the constraints that hinder an efficient extension service?
17. In the effort to support the farmers what are government constraints?
18. What are the constraints that the farmers face to improve maize productivity?
19. What are your suggestions and solutions to improve small scale farmers' yields?
20. Has there been research on hybrid maize adoption in your country?
21. How does the research results influence government policy?
22. What is the government policy on inputs support schemes?
23. What impact has the input scheme done to the small scale farmers?
24. How does the Government make sure that all stakeholders that are involved with small scale farmers are focused on improving productivity issues?
25. How has the government facilitated the farmers be able to borrow for their maize production?
26. What is the government policy on maize grain marketing?
27. How has the government supported small scale farmers in terms of marketing maize grain?
28. What are the economic and social benefits to the farmer on the adoption of hybrid maize?
29. Is there anything that we did not discuss that you feel should be included in this study?

Interview Guide – Policy Makers (Zambia and Malawi)

1. What is the Government policy on hybrid maize adoption in your country?
2. What is the Government policy on Open Pollinated Varieties (OPV)?

3. What is your national average yield for maize?
4. How does the Government make sure that productivity issues are tackled in your country?
5. What are the factors that hinder farmers to achieve economically sustainable yields?
6. Who enforces the adoption of hybrid maize technology?
7. How does government make sure hybrid maize is adopted in your country?
8. What are the economic and social benefits to the farmer on the adoption of hybrid maize?
9. What is Government policy regarding extension services?
10. What are the constraints faced by government on efficiently administering extension services to small scale farmers?
11. What are the economic and social concerns that affect hybrid adoption in your country?
12. Has the government embarked on input schemes and what has been the success rate?
13. How are the stakeholders who work with small scale organized to ensure they focus on productivity issues?
14. What is the government policy on grain marketing in your country?
15. What is government policy regarding funding for small scale farmers?
16. Has government done a research on how hybrid maize adoption can be best implemented?
17. Is there anything that we did not discuss that you feel should be included in this study?

Interview Guide – NGO

1. What is your organisation's role regarding small scale farmers?
2. What is the view of your organization on the adoption of hybrid maize?
3. Does your organisation support OPV maize production by small scale farmers?
4. What are the economic and social benefits or disadvantages to the farmers on hybrid or OPV usage?
5. Has your organisation done any research on hybrid maize adoption?
6. In your opinion what are the obstacles to small scale farmers on maize productivity?
7. Does your NGO communicate with policy makers on issues of hybrid maize adoption?
8. Does your NGO collaborate with other stakeholders in maize productivity issues?
9. In your opinion what are the farmers' perception on hybrid maize?
10. Who funds your NGO?

11. What is the opinion of your as regards hybrid maize?
12. What future plans do you have for maize grain farmers?
13. What can be done to increase awareness for hybrid maize?
14. Is there anything that we did not discuss that you feel should be included in this study?

Interview Guide – Seed Company

1. What do you think about hybrid maize adoption in Zimbabwe, Zambia and Malawi?
2. How is your Seed Company commercialising maize hybrid in these countries?
3. What is your success rate by country?
4. What are the constraints your company faces to convince farmers to adopt hybrid maize in the 3 countries?
5. What is your organisation's strategy in promoting hybrid maize in the 3 countries?
6. Who are the key stakeholders who influence hybrid maize adoption in the 3 countries?
7. What is your company doing together with other stakeholders to promote hybrid maize in the 3 countries?
8. To what level do you engage government extension service on hybrid adoption in the 3 countries?
9. What are the major constraints faced by small scale farmers to achieve economically sustainable yields?
10. What are the social and economic benefits for adopting hybrid maize technology?
11. How does the debate on OPV versus Hybrid maize affect your organization?
12. Is there anything that we did not discuss that you feel should be included in this study?

Annex3- Letter of Introduction

Letter of Introduction

Daniel Myers

54 Selous Road

Colne Valley

Harare, Zimbabwe

26 April 2018

Dear Sir/Madam

Re: Letter of Introduction

I am studying towards a doctorate of business administration (DBA) with Nottingham Trent University (NTU), United Kingdom (UK). My research topic is "**An Impact Assessment of Hybrid Maize Technology Adoption on Sustainable Food Production by Small Scale Farmers in East and Southern Africa".** I have been working in the seed industry for the past 24 years and my responsibility and experience covered several countries in Africa. Recently I joined a small seed company that has intentions to grow regionally in Africa and I am also a commercial farmer that grows maize and soyabean. My working experience exposed me to small and large commercial farmers

The project that I am studying seeks to determine how best small scale farmers can adopt the hybrid maize with the assistance of other stakeholders who operate in their environment. The adoption of hybrid maize technology varies depending on country. Zimbabwe and South Africa have adoption rates of above 90% and other east and southern countries are still below 60%. Given the different adoption rates and the problems associated with the maximum utilisation of maize hybrids, the study will help to understand how the adoption rate can be improved in the various countries. Improved maize production will enhance sustainable food production of the staple food in the region. The research will contribute to the understanding of the subject mainly to benefit policy makers, small scale farmers, seed companies, NGOs, farmer organizations and other agro-input suppliers. The study will focus on Zimbabwe, Malawi and Zambia.

I would appreciate your participation by responding to questionnaire attached that will take 30 minutes to an hour. The questionnaire shall be collected from you as soon as you complete filling it in. Your responses shall be kept anonymous and therefore I am encouraging you to offer your honest and frank opinion regarding maize hybrid adoption. This research project makes part of the requirement of the DBA program with NTU and has been approved by the university.

Your assistance will be greatly appreciated.

Yours Sincerely

Daniel Myers. (+263772568329). dmyers@mweb.co.zw

Annex 4- Consent Form

Informed Consent Form

This form will provide you with information about the research. Please read through all the details carefully.

As mentioned in the introduction letter the purpose of this research is to understand the problems associated with the adoption and the maximum utilisation of maize hybrids by small scale farmers.

You are being asked to participate by responding to the questionnaire that will take you approximately 30 minutes to an hour. The questionnaire has a series of questions about your own experience and opinion on the adoption of hybrid maize by small scale farmers. Your responses will be recorded on the issued structured form. After completion of the questionnaire, please let the researcher know if you would rather not submit your form. You have the right to withdraw your participation without giving a reason to do so. If you wish to withdraw you should contact the researcher and ask your data to be withdrawn from the study. Data collected from your responses will be confidential and anonymous and will be used in the final report. All the responses will be destroyed after completion of the doctorate.

Participation is voluntary and greatly appreciated. If you are happy to take part in this research please sign and date below. If you have any questions or concerns before, during or after your participation in this research my contact details are on the bottom of this form.

Participant Information Sheet

Participant Statement

In relation to the study titled, "**An Impact Assessment of Hybrid Maize Technology Adoption on Sustainable Food Production by Small Scale Farmers in East and Southern Africa",** I have been fully informed about the purpose of the study and exactly what is required in order to participate. I have been given, read, and understood, written information about the project and have been given opportunity to ask questions. My participation is voluntary and that I can withdraw at any stage without having to give any reasons. I understand the consent to the methods of data collection and that will take place, and I know how long my data will be retained. I know my limits regarding the confidentiality of sharing data with people outside the project. I have the right to withdraw my data at any point and all materials will be destroyed. I have read and fully understood the letter of introduction and I agree to participate in this survey voluntarily.

Appending my signature below I hereby confirm my consent and agree to take part in the research.

Signature	
Full Name (Print)	
Date	

Researcher

Daniel Myers

Doctorate Candidate

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Annex 5: Word Transcriptions

Informant	Details	Comments
Policy Maker A Zimbabwe	OPV the early crops planted but research then brought in hybrids starting as early 1952. The hybrids brought added advantages like yield, disease and drought tolerance. OPV still have a place because when there is shortage of hybrid seed OPV can be planted. Some of the OPVs are adaptable. But where there are inputs the government promotes hybrid maize. The farmers found benefits themselves. The Seed Suppliers made all effort to promote hybrids. SR52 stood out and farmers noticed the good yields under ideal conditions. As government pricing has been increased and this improved adoption rate. Yield, income, drought, heat tolerance and disease. Socially you can family and more income and safety net for the community. Hybrid brings more biomass and they helped with manure. Policy on extension service gives technical advice. Skills development, information dissemination. Constraints are on mobility, no motorbikes and vehicles, equipment and tools on the job, ph meters, and livestock kits. Operational resources fiscus is now small. Digital phase and they do not have computers ICT lacking for information to	1. SR 52 2. OPV 3. Hybrid benefits 4. Price Incentives 5. Biomass 6. Constraints 7. Mobility 8. Manure 9. Hybrid promotion 10. Drought tolerance 11. Seed Houses promotions 12. Tools 13. ICT 14. Digital phase 15. Yields 16. 0.9 Mt/ha 17. Price Incentive 18. Agronomic practices 19. Fees 20. Health 21. Yield 22. Income 23. Drought and heat 24. Food availability 25. Weeds

	farmers. Not fully taken on board. In Zimbabwe Government extension services pluralistic approach with other players like seed houses CIAT ICRISAT and CIMMYT. Governments coordinate activities through the government services. We want continuity. Yield sustainable economical depending on inputs and there is variability. National average is very low why range of producers low side large scale has achieved 11-12Mt/ha. Area planted together and the weighted average brings the average down. A good yield the farmers should get at list 4-5 Mt/ha. Reasons for low yields agronomic practises soils, poor soils very sandy soils. pH soil fertility levels. Presidential input scheme, weeds are a challenge. Its mainly agronomic practise plus timeliness of operations. Availability of draught power. Without cattle they have low yields and those with cattle yields. Can do better. Inputs costs. Labour migration into towns. Suggestion affordable inputs, subsidy, promote CA and smart climate, soil improvement amelioration. Soil testing and increasing organic matter. Issues of rotations including cowpeas and ground nuts. Input support scheme. Presidential and Command Agriculture. Household food	26. Rainfall 27. Agronomic practice 28. Draught power 29. No manure 30. Input costs 31. Lack of labour 32. CA 33. Soil testing 34. Organic matter 35. Presidential input scheme 36. Crop rotations 37. Command Agric 38. Tillage units 39. Household food sufficiency 40. Dependency syndrome 41. Vulnerable groups 42. Group landing 43. Collaboration 44. Coordinated approach 45. Farmers 'field 46. Loans 47. Small groups landing 48. Clusters

	requirement. Free inputs. Current politics. Presidential scheme for those who follow but some do not follow the yields have been low. Technical result in dependency syndrome and inputs do not come in time. This is complementary only. Can we sustain this and for how long there vulnerable groups. The inputs are not enough. Household food security and those who add on to and buy their own inputs. Productivity issues number of player's extension officers plays their part. We invite other players to provide information the farmers. Innovation platforms bring in all the players in maize, fertiliser, agro, tillage and marketing including GMB. Who coordinates the ministry aertex for every value chain approach and each one is selling the best. Farmer field school is good in the sense that you are looking at the whole value chain farmer's field and meet every 2 weeks throughout the season. Do it at the farmer's field. Funding influence by the government. Pose a challenge and they have small fields. Cluster approach is clustered together and buys in groups and negotiates discounts. Group landing scheme with assumption of policing done by the farmers themselves. Tobacco contract farming and cotton. Food	49. Market liberal 50. Food side marketing 51. Group buying 52. GMB

	crops suffer from side marketing. Command Agric extended to farmers with record of production over the years. It is the selected on the basis. Policy on grain marketing is liberalised. The price is quite high parity is high to incentivise farmers. Command through GMB. Has there been any research but there have been research farm systems surveys. Good adoption positively various agro ecological zones to satisfy different niches. GMO no in Zimbabwe	

Annex 6: Interview Participants

Participants Numbers	Country	Name code
1	Zambia	Policy Maker
2	Zambia	Small Scale Farmer
3	Zambia	Policy Maker
4	Malawi	Policy Maker
5	Zimbabwe	Policy Maker
6	Zambia	Small Scale Farmer
7	Zimbabwe	Small Scale Farmers
8	Malawi	Policy Maker
9	Zimbabwe	Small Scale Farmers
10	Zimbabwe	Policy Maker
11	Malawi	Small Scale Farmer
12	Zambia	Small Scale Farmers
13	Zimbabwe	Small Scale Farmer
14	Zimbabwe	Policy Maker-GMB
15	Zambia	Grain Buyer
16	Malawi	Private Grain Buyer
17	Zambia	Small Scale Farmer
18	Zambia	Opinion Leader Farmer
19	Zimbabwe	NGO Representative
20	Malawi	NGO Representative
21	Zambia	NGO Representative
22	Zimbabwe & Zambia	Seed House Representatives
23	Zambia	Policy Maker
24	Malawi	Small Scale Farmer – OPV
25	Zambia	Small Scale Farmer
26	Zimbabwe	Small Scale Farmer
27	Zambia	Policy Maker – Extension Officer
28	Zimbabwe	Small Scale Farmer
29	Malawi	Small Scale Farmer