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The feasibility of growing dry-land rice using sustainable agriculture on a commercial basis by smallholder farmers in Zimbabwe, lessons from Magwendere village, Mutasa District, Manicaland Province, Zimbabwe.

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Research submitted in fulfillment of the requirements for the degree: Masters of Science Degree in Natural Resources Management and Environmental Sustainability (MScNME)

Supervisor: Dr Bowora

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Approval form

The undersigned certify that they have read and recommend to the Bindura University of Science Education for acceptance of this dissertation entitled, The feasibility of growing dry-land rice through sustainable agriculture on a commercial basis by smallholder farmers in Zimbabwe, a lesson from Magwendere village, Mutasa District, Manicaland Province, Zimbabwe.

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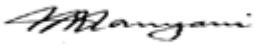
Dr Manyani….  .

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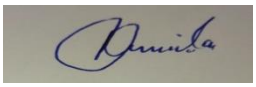
Stanford Marinda  9/10/24

DECLARATION

I, Stanford F Marinda, declare that the dissertation titled "The feasibility of growing dry-land rice through sustainable agriculture on a commercial basis by smallholder farmers in Zimbabwe, a lesson from Magwendere village, Mutasa District, Manicaland, Zimbabwe'' hereby submitted to Bindura University, for the degree of Masters in Natural Resources and Environmental Management has not previously been submitted by me for a degree at Bindura university or any other university. That is my work in plan and accomplishment, and that all the materials contained therein have been thoroughly acknowledged.

Signature…… S Marinda

Date…….20-03-2024

Dedication

This study is dedicated to my wife, Grace Marinda and children; Michael, Amanda, Panashe and Angeline who wished me success in my studies. Special appreciation goes to my parents, Michael and Angeline who encouraged me to persevere at all times, even when the chips were down. I have reached this far because of their love, understanding and full support throughout the study period.

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Acronyms

FAO: Food and Agriculture Organization

Sub-Sahara Africa: SSA

Indigenous knowledge System: IKS

UN: United Nations

Dry-land rice Smallholder farmers: DLRSHFs:

Environmental Education: EE

Dry-land rice: DLR

New rice for Africa: NERICA

United States Dollars: USA $

El Niño–Southern Oscillation ENSO

Mixed Method Research: MMR

Nitrogen: N

Phosphorous: P

Calcium: Ca

Globally Important Agricultural Heritage Systems: GIAHS

National Aeronautics and Space Administration: NASA

United States Agency for International Development: USAID

Sustainable Development Goals: DG

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Abstract

Rice (oryza) has become an important food crop in Zimbabwe and other parts of Africa. The study is to investigate the Feasibility of growing dry-land rice using sustainable means on a commercial basis in Magwendere village and to propose improved strategies. Rice has become an important food item in Zimbabwe and it is paramount that Zimbabwe produces sufficient quantities of this cereal to meet its requirements. The research design adopted in this study was the mixed method, which used quantitative and qualitative methods .to provide reliable and valid results. The research design used the purposive sampling method in selecting the participants and extraneous variability was controlled so that the overall research problem on the feasibility of dry-land rice farming through sustainable methods in Magwendere village are explored. A total of 50 participants were used in this study and these included smallholder farmers, local leadership, agriculture extension officers and community members. Fieldwork surveys, focus group discussions, questionnaires, interviews and secondary sources provided insightful information on the factors that influence the feasibility of growing upland rice in the study area. The study findings identified; presence of forested uplands, rivers and streams and abundance labour as some of the major opportunities in dry-land rice farming in the study area. The major challenges to dry-land rice farming identified in the study included; high cost of fertilizers, poor accessibility, lack of credit and funding, limited extension services, high infestation of weeds and pests, lack of appropriate technology, soil erosion and disorganised markets. Study findings identified Climate change as an existential threat to Dry-land rice farming in the study area including other areas in Zimbabwe, Africa, and the rest of the world. Rainfall variability has increased significantly and this has resulted in the planning of farming activities to be very difficult. Part of the recommendations to propose improved strategies in dry-land rice farming include; use of efficient water management in irrigating rice fields, improved rice cultivars that are tolerant to moisture stress. The government must take a leading role in putting policies and institutions to support dry-land rice smallholder farmers in Zimbabwe so as to grow rice in a sustainable manner on a commercial basis and meet the rice requirements of the country.

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Chapter One

The problem and its setting

1.0 Introduction

Food security is an important requisite for prosperity in any country. According to Masipa (2017), food security occurs when all people at all times have access to sufficient nutritious food, which meet their dietary requirements for them to be active and have a healthy life. In order to meet Food security through agriculture emphasis should be placed on countries aiming for sustainable agriculture. Food and Agriculture Organization of the United Nations (FAO) proclaims that Sustainable agriculture should involve the successful management of resources for agriculture to satisfy changing human needs while maintaining or enhancing the quality of the environment and conserving natural resources for present and future generations (FAO, 1995). According to USAID (2022) Zimbabwe's food security situation in recent years has been fragile as a result of a failing economy and poor weather conditions, and this has contributed to increased humanitarian needs in the country. Zimbabwe is a net importer of rice, with data showing that imports have been growing sharply from around 50,000 tons in 2010 to 154, 833 tonnes in 2022 (Zimstats, 2022). In 2020, alone, nearly US$100 million was spent on bulk rice imports and in 2021, Zimbabwe imported $120M in rice mainly from Asian countries, becoming the 62nd largest importer of Rice in the world (Economic Complexity of Zimbabwe, rice in Zimbabwe, 2022). Zimbabwe does not grow rice commercially; the country only produces a tonne of rice annually, (Faostat 2017). Rice production in some parts of Zimbabwe is mainly through the cultivation of wetlands, and such a practice has far reaching negative consequences such as production of greenhouse gases, and disruption of the ecosystem services associated with wetlands (Chirinda et al, 2013). Studies of the cultivation of rice under dry-land farming in Zimbabwe are limited, and this research study will explore the feasibility of growing it in an environmentally sustainable manner without damaging the environment, drawing experiences from Magwendere village, Chavhanga, Mutasa, Zimbabwe where smallholder farmers are growing dry-land rice in uplands. As Zimbabwe faces severe food shortages, this threatens food security and livelihoods, making people less resilient and vulnerable. The importation of cheap

rice from the Asian countries that has been used as one of the stop gap measures to avert food shortages in Zimbabwe is not a sustainable effort, and the country must aim to be self-sufficient in meeting its food and rice requirements. Establishing food security is important to people of Zimbabwe and Africa, and is crucial for sustainable development and long-term prosperity of the continent. Sustainable agriculture encompasses three aims which must be accomplished simultaneously and these are; environmental quality, economic prosperity and social equity (Brundtland, 1972). Zimbabwe has to focus and redirect both human and financial resources toward increasing local food production in a sustainable manner in order to achieve adequate food security status.

1.1 Contextual background of the study

Food and nutrition is an important critical entry point to alleviate various development challenges. The 2017 Global Nutrition Report argues that a better nourished world play a catalytic role in achieving the SDGs (Development Initiatives 2017: 9). In order for food and nutrition security to play this catalytic role, policies and programs must put in place and this will reduce nutrition insecurity amongst rural smallholder farmers and the general population of Zimbabwean citizens.

Zimbabwe is an agrarian economy, where the agriculture sector accounts for 52% of the Gross Domestic Product (GDP) (Srivastava et al, 2016). The downturn in food security conditions in Zimbabwe needs to be addressed to end chronic food insecurity. Food security activities that are sustainable should be designed to help people transition from humanitarian assistance to food and nutrition security and self-reliance must be promoted. Activities that focus on increasing food production and productivity must take centre stage as a matter of urgency if Zimbabwe is to escape from the jaws of food insecurity. Zimbabwe has received financial assistance for years to address the underlying causes of chronic food insecurity and malnutrition and to strengthen agriculture and livelihoods for millions of vulnerable Zimbabweans from organisations such as USAID (Masasi, B, & Ng'ombe, J. N. (2019).

The importation of cheap rice as a measure to meet local food demands has offered a temporary reprieve, and has been met with mixed feelings, on one hand it has helped to improve food security as many families has opted for rice as a cheap alternative to wheat. Products such as bread have become astronomically expensive and beyond the reach of many households in Zimbabwe. Zimbabweans have shifted from being maize centric to other starches such as rice, (Shayanewako and Vhera, Herald 2022). This change in preference has greatly influenced the balance between production and consumption of rice in many African countries (Olembo et al., 2010). However, the importation of rice is not sustainable for Zimbabwe's economy, with so many pressing demands and competing priorities that needs foreign currency, Zimbabwe is grappling with foreign currency shortages and this has negatively affected the balance of trade (Hlupo et al, 2022). It is important for Zimbabwe to be food sufficient, and cut the food import bill and improve food security matters. Zimbabwe must desist from relying heavily on rice imports given price fluctuations on the world market and presented with the fact that the major rice producing countries are also threatened with the vagaries of climate change, and solely relying from rice from such major rice producing countries could be disastrous (Elahi et al, 2022). Zimbabwe as a country has also experienced a fair share of climate induced challenges that have affected livelihoods, food production and this has had the effect of making the general populous of the Zimbabwean citizens more vulnerable and less resilient to adapt to the climate perturbations (Mwadzingeni et al, 2022).

Zimbabwe is evidently experiencing the effects of climate of extreme weather events, making it face chronic food insecurity. It is important that since rice has become a household product of choice in many homes in Zimbabwe, its availability must be guaranteed through such measures as promoting its production and value chain in the country. Without such strategies of home-grown solutions on food production, Zimbabwe will experience food shortages that will be beyond its control if it ignores and delays measures to avert the food crisis through developments in its own food production. The on-going war between Ukraine and Russia has exposed many countries including Zimbabwe to shortages of wheat and this has been a clarion call to find sustainable ways of self-sustenance on food productions. Russia and Ukraine produce nearly 30% of the world's traded wheat, and the current Russia–Ukraine war has created new food insecurity and highlighted existing systemic weaknesses in international food security such as an

increase in food prices on local and international markets with negative effects for food-importing, low-income countries (Behnassi, M., & El Haiba, M. (2022).

We will focus our study in Magwendere Village, in Mutasa District. Magwendere village has been growing dry-land rice on the slopes of the mountains in the past. Paddy rice fields were also common in some of the vleis in the area and this was important in food security at the household level, but the practice was threatening wetland ecosystems. Zimbabwe ratified the Ramsar convection on wetlands and this calls for all land users to desist from cultivation or developing on wetlands. According to Mandishora and Knight (2022), wetlands are important since they provide us with important ecosystem services. The promotion of the cultivation of dry-land rice production in an environmentally sustainable manner will certainly cut Zimbabwe's import bill and reduce heavy reliance on food imports. The economy of Zimbabwe and the citizens can benefit significantly from introducing another grain crop such as rice since this will not only benefit the smallholder farmers but it will contribute significantly to the whole value chain and downstream industries providing the much needed employment. The new rice for Africa (NERICA) varieties that were bred and released in West Africa have high yields and offer high adaptability to harsh environments found in Africa (Mazarire et al 2013). At present, Malawi is producing 150 000 tonnes of rice per annum (FAO) and Zimbabwe can tap on its vast agricultural expertise and extension network to promote the growing of this staple. The new NERICA cultivars offer opportunities for smallholder farmers in Zimbabwe to grow dry-land rice sustainably on a commercial basis.

In SSA, 30% of its population suffers from extreme poverty and food insecurity as more than 70% of the population lives off farming and related activities, agricultural development will have to play a major role in improving this situation (Balasubramanian et al, 2007). Africa has an abundant supply of natural resources that can support a huge expansion in food, specifically rice production. SSA currently accounts for 25% of global rice imports, at a cost of more than US$1.5 billion per year (Sie et al, 2007). African governments must accord high priority to developing their local rice sector as an important component of national food security, economic growth, and poverty alleviation (Tanaka et al, 2017), and the abundant supply of agro-climatically suitable areas, and the labour-intensive nature of rice cultivation will provide

additional sources of work and income to the rural poor, especially women. According to Balasubramanian et al (2007), rice is cultivated in four ecosystems of SSA which include dry (38% of the cultivated rice area), rain fed wetland (33%), deep-water and mangrove swamps (9%), and irrigated wetland (20%). In 2004, rice was declared a strategic crop by the government of Zimbabwe; the Ministry of Agriculture introduced seven upland NERICA varieties from West African Rice Development Association (WARDA) (Kareda, 2007; Jones et al).

Zimbabwe also needs to be self-sufficient in food supply because food imports from other countries rely heavily on the transport industry which burn fossil fuels, thus contributing to global warming. According to the international energy agency report, the world transportation industry carbon emissions accounts for over 23.96% of the total global carbon emission and it is one of the major global warming drivers (Zhu, C., & Gao, D. (2019). A further downside of the importation of rice from outside is that it contributes to the underutilization of the excess labour that is ubiquitous throughout the rural communities of Chavhanga and Zimbabwe. If sufficient dry-land rice is cultivated in an environmentally sustainable manner, livelihoods will be uplifted and the people will become more resilient to the stresses and shocks associated with climate change that is affecting Chavhanga community and the rest of the country. When rice is produced in significant quantities it will also add value to the whole supply chain including upstream and downstream economies, and resultantly contributing to the development of the country. The author hopes to unmask the significant opportunities and constraints to rice farming and propose improved feasible environmentally sustainable measures that can be adopted in order to make Chavhanga and the rest of the country attain self-sufficiency in the production of rice.

1.2 Justification

The justification of the study is premised on the fact that food security is of paramount importance to any nation, and this prompted the need to research. Rice has become a common household food item on the menu of many homes in Zimbabwe, and it is important that its

availability be guaranteed through the contribution of local farmers in growing the crop in an environmentally sustainable manner that does not harm the environment. Though maize remains a staple diet in Zimbabwe, other grains such as rice has become equally important judging from the food preference pattern observed in Zimbabwe (Kareda, 2007; Jones et al).

Magwendere village has been traditionally a dry-land rice growing community since the seventies, and it used to contribute significantly to the local demand of rice which was largely consumed during special occasions such as weddings and festival holidays as Christmas. With the change of food preference it has become important that rice production be scaled up in Magwendere village and other places so as to meet the local demand and the possibility of supplying rice to other regions in the country, and even to export to other countries. Smallholder farmers in Magwendere village have cultivated crops such as bananas, yams, and sugarcane, maize and avocado pears to meet the local demand and have been supplying urban markets as far as Harare, Mutare and Bulawayo. If the opportunities and challenges experienced by smallholder farmers in dry-land rice production are identified, it becomes feasible to craft environmentally sustainable measures that can be used to improve dry-land rice production in Magwendere and other potential rice growing regions in Zimbabwe. Hence, it becomes justifiable to carry out a research to come up with a robust plan to grow dry-land rice sustainably on a commercial basis, to promote food security, and build resilience of the smallholder farmers and spur rural development and raise the standard of living of the generality of Zimbabwe. The results will be used as a sound mechanism to alert relevant stakeholders and policy makers on the conditions, challenges and opportunities that will result in sustainable agriculture of DLR. This study will improve and extend knowledge on impact of climate change on DLRF in Magwendere village. Findings from this study will bring about improved strategies that are sustainable on DLRF in Zimbabwe and this has the potential of meeting local rice requirements, thus reducing the food import bill.

1.3 Problem statement

Studies on dry-land rice production done in many parts of the world have found that challenges and opportunities exist in the growing of rice. The studies have highlighted feasibility issues

regarding constraints for increasing and maintaining the productivity of rice-based systems, the use of water, labor, fertilizers, and the effect of climate change. Studies in India have shown nitrogen, phosphorus, and zinc use efficiencies, for various rice production systems (Mohapatra et al. 2013). Other studies done in Kenya have identified the challenges and opportunities in rice production in Kenya. In Zimbabwe, studies on dry-land rice production has only focused on rice production in experimental plots in Harare, and no studies have been done on the feasibility of growing dry-land rice in Magwendere village. Thus, since no study has been undertaken before on rice growing in Magwendere village, this study becomes paramount in order to investigate the factors that impact rice growing in the study area.

1.4 Aim of the study

The aim of the study is to investigate the extent to which dry-land rice is grown sustainably on profitable basis rice by smallholder farmers in Magwendere village, Mutasa District, Manicaland, Zimbabwe.

1.5 Specific objectives of the study

1. To examine the feasibility of growing dry-land rice in an environmentally sustainable manner by smallholder farmers in Magwendere village, Mutasa District, Zimbabwe.
2. To assess the impact of climate change on the growing of dry-land rice by smallholder farmers in Magwendere village, Mutasa District, Zimbabwe.
3. To examine the challenges and opportunities that exists in the production of dry-land rice in an environmentally sustainable manner by smallholder farmers in Magwendere village, Mutasa District Zimbabwe.
4. To proposes improved strategies that has the potential of growing dry-land rice in an environmentally sustainable manner on a commercial basis in Zimbabwe.

1.6 Research Questions of the study

1. What is the feasibility of growing dry-land rice by smallholder farmers in an environmentally sustainable manner in Magwendere Village, Mutasa District, Zimbabwe?
2. What are the effects of climate change when growing dry-land rice by smallholder farmers in Magwendere Village, Mutasa District, Zimbabwe?

3. What are the challenges and opportunities that exist in the growing of dry-land rice in an environmentally sustainable manner by smallholder farmers in Magwendere, village, Mutasa, Zimbabwe?
4. What are the improved strategies that can be employed to grow dry-land rice in an environmentally sustainable manner Zimbabwe?

1.7 **Assumption**

That feasibility of growing dry-land rice by smallholder farmers in a sustainable manner in Magwendere Village, Mutasa District, Zimbabwe, exists.

That feasibility of growing dry-land rice by smallholder farmers in a sustainable manner in Magwendere Village, Mutasa District, Zimbabwe, does not exist.

1.8 Location of the study area

The study will take place in Magwendere village in Mutasa District, Manicaland Province, Zimbabwe (fig 1). This area falls under ecological region 1. Average annual rainfall totals are above 1000mm, and temperature annual temperature averages 24 degrees Celsius. Chavhanga is located between 18°15’72.7’’ S, 33°07’81 E and 18°15’97’’5 S, 33°04’88’’ E at an altitude of between 703m and 765m. Chavhanga is in Ward 28, shares a border with Mozambique on the east, Nyanga District on the north, Ward 2 on the west, and Ward 1 on the south west (Figure 1). It is 160 km from the nearest town, Mutare. The study area has a total population of 4,572 of which, 2,081 were male and 2,491 were female. The total households in the area were 1,172 and the average household size was 3, 9 during the 2022 census data (Zimstat 2022).

1.11 Mapping Magwendere Village, Ward 28, Chavhanga, Mutasa, Manicland province Zimbabwe

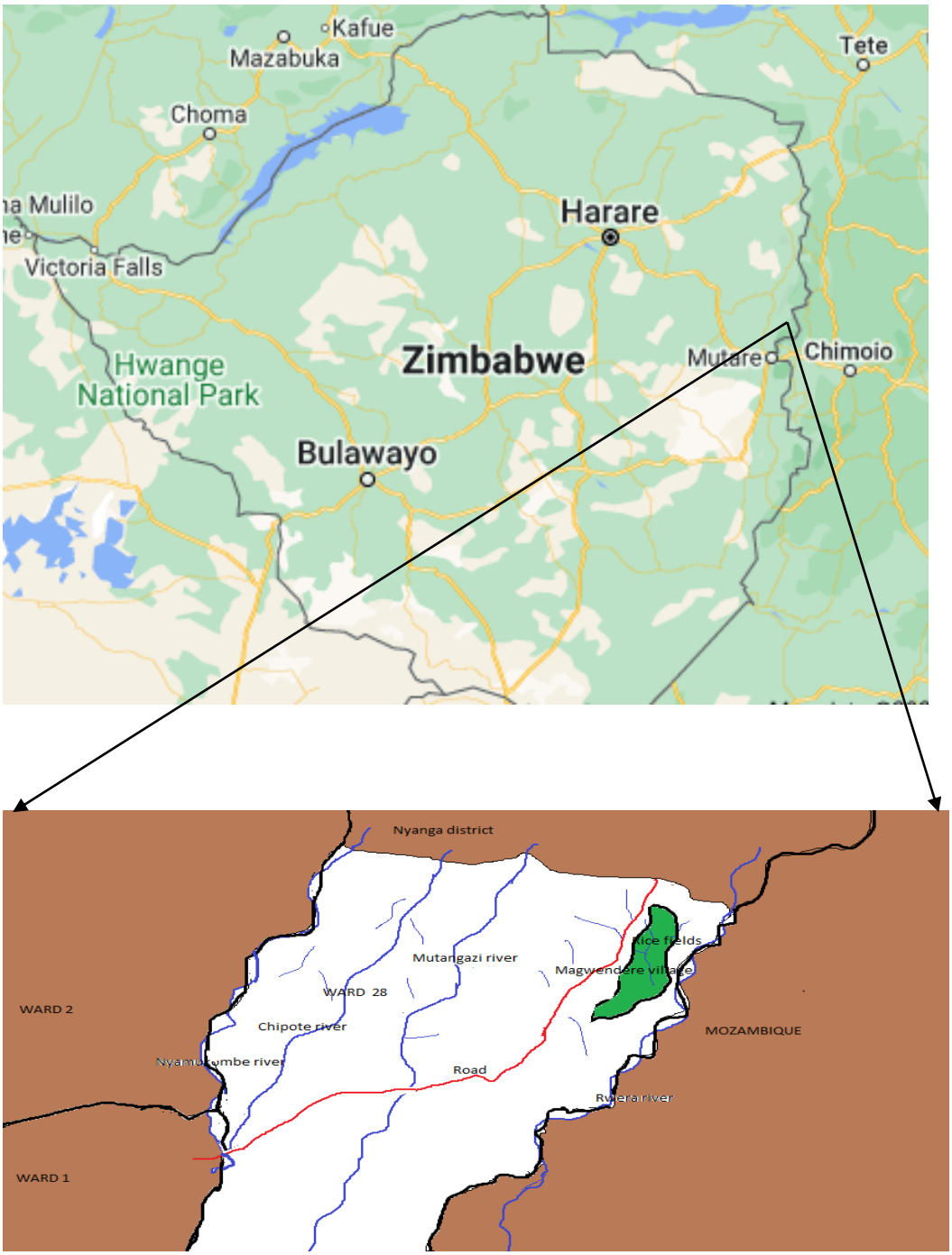

Fig1. Location of Magwendere village

1.12 **Delimitation**

The study will focus only on the impact of socio-economic and environmental factors on the cultivation of dry-land rice in Magwendere village in an environmentally sustainable manner.

1.13 **Definition of key terms**

The following terms are defined in the context of the study.

1.13.3 in the context of the study, smallholder farmers means a small farm operating under a small-scale agriculture model.

1.13.5 Growing dry-land rice means growing rice purely naturally on rainfall without the need for any irrigation or a traditional ponded "paddy" system.

1.13.6 Sustainable Agriculture means farming in such a way to protect the environment, aid and expand natural resources and to make the best use of nonrenewable

1.13.8 Climate change means long-term shifts in temperatures and weather patterns.

1.13 Limitations of the study

As expected, no research is without its limitations, but it is important to control the limitations within significant levels to come up with a credible comprehensive report. Though the author will strive to reduce, the effects of limitations to this study the author expect to encounter the following limitations in the collection and processing of data:

1.13.1 Language barrier: the community that grows rice in Chavanga are mostly elderly people who speak deep ''Chimanyika dialect'' which the author could not fully understand. To overcome the problem there was need to engage a community member who was conversant with English and the local 'Chimanyika dialect'' to facilitate communication.

1. 13. 3 Accessibility: the study area is hilly with steep slopes that are difficult to navigate during the rainy season. This was overcome by using a motorbike and caring out fieldwork during periods when the area was experiencing sunny conditions.

1.14 Dissertation Structure

The dissertation is made up of 5 main chapters, with each chapter focusing and addressing specific aspects of the research.

Chapter one covers a brief introduction and synoptic description of the research topic. The research problem and justification of the research is clearly presented. Research objectives and specific research questions guiding the study are presented in this chapter. Chapter two presents a comprehensive review of literature which is relevant and linked to the opportunities and challenges that impact the cultivation of dry-land rice. Of the different factors that affect dry-land rice cultivation, this chapter focuses on the socio-economic and environmental factors that affect the cultivation of dry-land rice. The chapter further reviews how previous researchers have explored how biophysical and socio-economic factors influence the cultivation of dry-land rice. The foundation and background upon which the other chapters in the dissertation are built on are premised on this crucial chapter. A review of secondary sources that included journal articles, newspapers and textbooks were used to gather information for the review of the literature. Chapter three discusses the research approach that has been adopted in carrying out the research. Also, discussed are the processes that dealt with instruments and the analytical tools used in data collection, research design, research paradigm, sampling size and sampling techniques. Both quantitative and qualitative methods were used. Focus groups, interviews and questionnaires were employed in the data collection process. Chapter four presents the findings of the research and the implication of the results. Chapter Five deals with recommendations and other issues related to dry-land cultivation in Magwendere, village and in Zimbabwe.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

This chapter gives a plethora of relevant literature that has been reviewed to give the background information and an overview of the relevant and significant information, so as to come up with a comprehensive and meaningful research from which credible findings could be drawn from. This chapter examines the contributions and discussions of different researchers on their understanding of the same topic. This research seeks to address the knowledge gaps that exist on socio-economic and environmental factors that impact dry-land cultivation, and inform action on discover new knowledge and inform action.

2.1 Conceptual framework

Agricultural productivity is influenced by numerous factors; the low productivity of agriculture in Africa can be attributed to the limited use of improved agricultural technologies, especially improved seeds, fertilizers and mechanization services, which in turn is an artifact of the lack of access to agricultural finance (Kamara et al, 2019). The conceptual framework diagram (fig 2) highlights the major concepts involved, the inputs, processes and outputs of dry-land rice cultivation in Magwendere village. Rice production systems can be simply classified into wetland (lowland) and dry-land (upland rice). In lowland rice, fields are usually flooded during part or all of the growing season while upland rice is generally grown on level or sloping (Saito, et al 2018). An analysis of the socio-economic and environmental factors that impact the cultivation of rice in Magwendere village will be pursued and best farming practices suggested so as enhancing food security in the study area and the rest of Zimbabwe. The variables that affect rice farming may be categorized under physical, social, economic and political. We will examine how the different variables affect and influence rice. The following variables; climate, labor, fertilizers, extension services, markets, socio economic, training, experience which all interplay in influencing rice yields will be considered. The NERICA varieties (upland rice), have

potential to replace the lowland varieties while giving the farmers several benefits (Hideo et al., 1999; Kaneda, 2007). Weed management, saving water, government support and strong policy, and training farmers are needed to boost rice production (Nawaz et al, 2022). Dry direct-seeded rice is an alternative cropping technique that should require less water and labor than classical transplanted-flooded rice (liu et al, 2015).

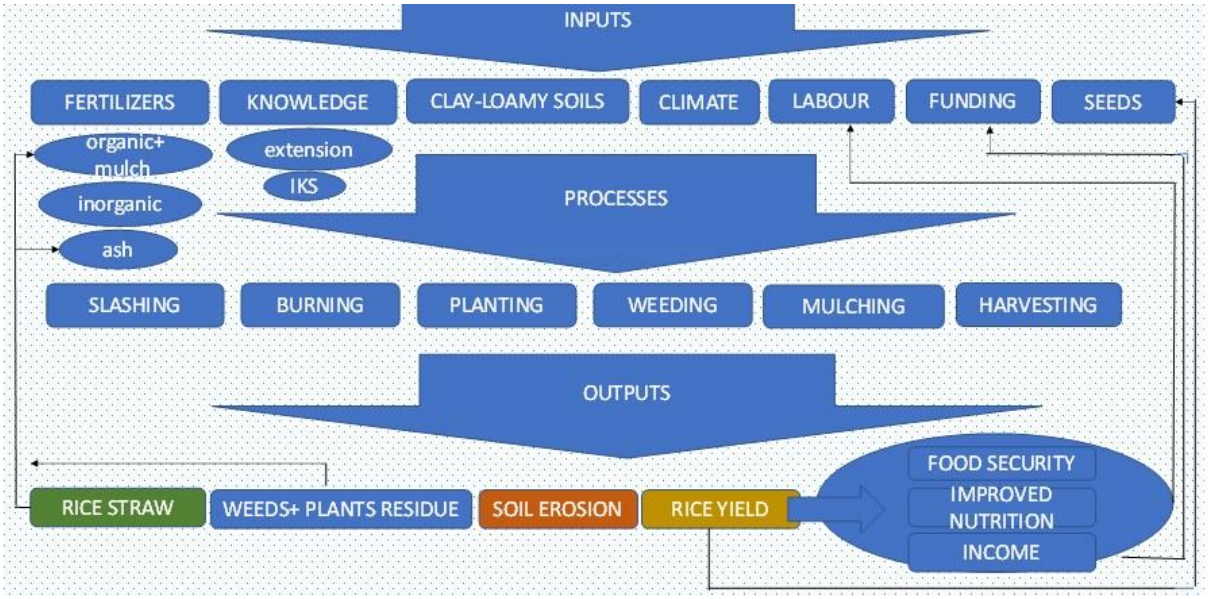

Figure 2, Factors that impact dry-land rice farming in general (Source; own making, 2023)

The lack of land tenure security is thought to be a hindrance to increased investment in land improvement technologies and to encourage the adoption of sustainable agricultural practices, and this leads to poor family incomes and nutrition (Bungu (2019). The consequence of the low productivity in the predominantly agro-based economies in SSA Africa is poverty and lack of economic development. More than half of the extreme poor live in SSA, with around 413 million people living on less than USD 1.90 per day (World Bank 2013, 2018); a staggering 249 million are undernourished (FAO 2019). Several experts have proposed that the expansion of smallholder farming can lead to a faster rate of poverty alleviation, and this is possible through raising the incomes of rural farmers and reducing food expenditure, thus reducing income inequality (Magingxa and Kamara 2003; Diao and Hazell 2004; Resnick 2004; Barham and Chitemi 2008).

According to Murniati (2020), climate change is a global threat affecting the world in diverse ways, and it is manifesting in various ways such as increases in frequency and intensity of floods, droughts, and extreme temperatures. In recent years, climate change has induced droughts, other extreme weather events and meteorological disasters in many countries including Zimbabwe, and there is need of effective management of climate change induced challenges through use of localized strategies which may vary from one part of the world to another and even within a country (Chipindu et al, 2012).

The cultivation of dry-land rice in Magwendere is obviously not spared from the socio-economic and environmental factors highlighted in figure 2. In this study, information will be gathered to explore the effects of these combined factors on how they impact dry-land rice cultivation, and improved strategies suggested in the study area.

2.2 Feasibility of growing dry-land rice using sustainable agricultural strategies

2.2.1 Global perspective

In a study of dry-land rice farming in Sarangani province, southern Philippines the cultural importance of upland rice and the farming rituals practiced by ethnic communities is highlighted and intergenerational information and practices are reported to be significant to dry-land rice cultivation in an environmentally sustainable manner (Zapico et al, 2020). It is considered to be of paramount importance to preserve the importance of IK systems in dry-land rice farming, because if it gets lost, valuable information disappears and can never be recovered since written records are usually absent (Saito et al., 2018).

Historical Studies on climate variability on rice yield and production in the Philippines from 1987–2016 showed that rain fed and irrigated rice production was affected by variation soil moisture content, brought about by the El Niño–Southern Oscillation (ENSO) (Stuecker et al, 2018). Shifting cultivation is an important land-use system used for growing dryland rice in the Philippines, and it spans 280 million hectares worldwide (Heinimann et al., 2017). It is a

traditional farming method that typically involves cycles of burning and clearing forests, cropping for a short time, and subsequent abandonment of the site for vegetation regeneration (Ramakrishnan, 2007). According to MacDicken, (2010), traditional shifting cultivation is only sustainable if it involves long periods of fallow. Under pressure from population growth, the fallow periods are being shortened and the fallow lengths now prevailing in most of the uplands in the Philippines are no longer sustainable in either economic or environmental terms (Menz and Grist 1996). Therefore, policymakers and research organizations are encouraging smallholders to adopt alternative forms of permanent fields that are more sustainable (MacDicken, 2010),

Dry-land rice farming in the Philippines is constrained by poor farmers, land degradation, soil and water losses, and increasing pest problems. Research and extension have offered farmers on-farm innovations to improve yields (Lafitte et al (2002). Philippines since 2009 (Zhao & Kumar, 2016) developed upland rice varieties that improved grain yield, plant height (intermediate plant type: 100–120 cm), crop duration (short to medium growth duration: 100–115 days), lodging resistance, drought tolerance, weed-suppressive ability, resistance to blast and bacterial diseases. The studies also showed that improved *indica* varieties Apo and B6144F-MR-6-0-0 which are more drought tolerant showed better yield performance than local traditional varieties. Furthermore, it was reported that B6144F-MR-6-0-0 produced 4.8 t/ha of grain, more than the local check (2.2 t/ha), (Chen, 2011. Results also showed good performance of B6144F-MR-6-0-0 in India and Nepal (Mandal, 2016). The studies clearly show the importance of improving rice varieties and the challenges that exist.

Further examples of dry-land rice farming by smallholder farmers comes from Indonesia, where the importance on the development of rice cultivars that produce high yields, early maturity, blast resistance, and tolerance of aluminum toxicity and drought have been reported (Lubis & Kustiano 2009). Improved varieties derived from the cross Vandana × Way Rarem were released in Indonesia in 2011–2014 and were more tolerant to harsh environmental conditions such as droughts (Zhao et al., 2016). This is an example of success of empirical breeding in combining high yield with drought tolerance (Bernier et al, 2007).

According to Yusuf et al (2020), traditional farmers in Indonesia cultivate some varieties of local Dry-land rice intercropped with vegetables, tubers, and fruits and this reduced environmental concerns such as erosion as the soil was never left bare. Results show that the longer the fallow period, the higher the rice production and the shorter the fallow period, the lower the production (Bandan, 2020). The main problem that occurs in rice farming in Lampung Province of Indonesia is low productivity caused by use of poor seeds, lack of fertilizers, environmental factors, and socioeconomic conditions and farmer institutions (Asnawi, 2013). Problems experienced by the farmers can be overcome if the necessary production factors are availed (Soekartawi, 2011). Rice farmers must be able to allocate every input used so that their farming can be efficient and obtain sufficient profit (Waluyati et al, 2021).

The significance of climate as one of the most important natural inputs in any farming operation must never be overlooked. A study conducted in Sidomulyo Sub-district, Indonesia showed that the upland rice farmer's household was highly vulnerable due to climate change, and that climate change adaptation and mitigation strategies were indispensable for sustainable food security (Murniati, K. (2020). Shortening of the growing period and higher temperatures had a negative impact on yields, and the main cause of the decline in yields was reduced photosynthesis at extremely high temperatures and shortening of the growing season, and part of the adaptation options included shifting planting dates (van Oort & Zwart, 2018). Adaptations measures from the negative impacts of climate change are key and central if food security and household resilience are to be achieved.

Studies done in Sulawesi Province, Indonesia showed that slope-related soil physicochemical properties affect the growth and yield of upland rice subjected to slash-and-burn. Organic-Carbon, total-Nitrogen, available-Potassium and exchangeable-Calcium and Magnesium tended to increase further down the slope, leading to greater rice growth and yield. These findings indicate that organic-Carbon in the soil is important to the growth and yield of upland rice cultivation (Miyazaki et al (2918).

Temperature and precipitation are the two fundamental variables commonly used as indicators for changes in climate. The impacts of climate variability and change on crop yields has affected different crops including dry-land rice cultivation (Adams et al., 1998; Babel et al., 2011; Bhatt et al., 2014; Challinor et al., 2014). Thailand is among top ten largest rice-producing countries in the world (FAO, 2013), and has an annual average rice yield of 3.1 ton/ha. It has a tropical savannah climate (Peel et al., 2007), with an annual precipitation between 800 mm and 1800 mm, and the monthly mean temperature ranges from 25 °C to 30 °C. There are two main varieties of Jasmine rice in the area with a potential yield of 2.3 t/ha and 4.2 t/ha respectively. They have a life cycle of 120–140 days, roughly from July to November (Bureau of Rice Research and Development). The common technique for rice cultivation in Thailand is direct seeding. The effective precipitation is approximately 550 mm. The predominant soil types consist of coarse loamy, fine-silt, fine-loamy, and clayey-skeletal with average percolation and seepage losses up to 5 mm/day (Peel et al., 2007). Green Revolution has changed the traditional pattern of cropping which was important for efficiency, productivity and sustainability of agro-ecosystems (Singh, 2000). Environmental degradation is closely linked to agricultural modernization (Redclift, 1989).

2.2.2 African Perspective

According to Anbessa and Dereje (2018), Nitosols is the major soil types found in Weredas in Ethiopia where upland rice is grown. This soil type occurs in high rainfall areas on flat to slopping terrains. It is dark reddish brown to dark red in color, well drained, porous with high water holding capacity. The soil pH ranges from very moderate acidic (pH 5.46) to slightly acidic (pH 5.71), very low in organic carbon content (< 2 %), low in total nitrogen (0.11-0.17 %), low phosphorus (< 11 ppm) (Anbessa, B., & Dereje, G. (2018). The very low carbon content indicates low fertility status of the soil. Studies done in the area showed that application of N level at 138 kg ha-1 significantly ($P < 0.001$) increased the yield of rice by 47.2%, while 92 and 46 kg N ha-1 increased the grain yield by 36.2% and 32.5%, respectively (Anbessa, B., & Dereje, G. (2018). Studies carried out in Weredas also showed that the application of P increased rice grain yield by increasing the number of panicles per square metre and spikelets per panicle, Zaman et al. (1995) also reported similar response in rice yield and yield components to

increasing rates of applied P. (Kumar and Rao, 1992). Phosphorus application also improved number of panicles per square metre, panicle length and plant height thereby contributing to the increment of grain yield. Farmers in the study area of Weredas area need to apply 46 kg N and 10 kg P ha−1 in order to improve the grain yield and yield components of rice on Nitisols under rain fed conditions (Kumar and Rao, 1992).

It is argued that the education level of the household head has a positive and significant relationship with the probability of adoption of rice technology in studies done in Ethiopia (Mamiro et al, 2018). Educated farmers have more access to information and they become aware of new technology, and this awareness enhances the adoption of technologies (Mamiro et al, 2018). This result is consistent with finding of Umeh and Chukwu, 2013; Bekele et al, 2011), which suggested that the more educated the farmer was, the more likely to adopt new sustainable technology as compared to farmers with less education. The negative influence of lack of education as a hindrance to the adoption of improved farming methods was chronicled in Central Ethiopia, in studies by Tura et al (2010).

Studies done in West Africa showed that DLRSHF‘s knowledge is influenced by; household size, training, access to formal and informal knowledge sources and community, socioeconomic status and on personal experiences and (Arouna et al, 2020). IKS is commonly acknowledged as an untapped resource in the process which can play an important role in agriculture (Son et al, 2019).

In SSA the impacts that weeds have on agriculture have been highlighted by several authors, Rodenburg et al (2022) postulates that competition from weeds is the most important yield reducing factor in African rice production systems. DLRSHF‘s often lack access to affordable, good quality herbicides and knowledge for their safe and effective application to deal with weeds and the major types of weeds include grasses, parasitic weeds and broadleaved weeds (Daramola et al, 2020). Eradication of weeds include chemical, manual, weed tolerant cultivars, crop

rotations, intercropping, use of mulches and the integrated weed management approaches to reduce damage to the rice fields (Rodenburg et al, 2022). The negative impacts of weeds on rice yields is blamed for resulting in about 48 to100% yield reduction (Adeyemi et al., 2017). In Africa, weeds account for yield losses estimated to be at least 2.2 million tons per year, valued at $1.45 billion, and hoe weeding is the major weed management strategy systems in Africa (Adigun et al., 2017). However, the efficacy of hoe weeding is often compromised by the continued wet conditions during the cropping season as weeds fail to die. (Gianessi, 2013). Weeds need to be controlled using methods that are sustainable so as to improve rice yields (Daramola et al, 2020). Striga, commonly known as witch weed, is a genus of parasitic plants that occur naturally in parts of Africa, Asia, Australia, and striga species belong to the family Orobanchaceae (Babiker, (2007). Plants infested by the striga parasite show stunted growth long before Striga plants immerge and by then considerable damage will have been inflicted to the rice plants (Spallek et al, 2013). The most prevalent types include Striga hermonthica, asiatica and Kuntze (Babiker, (2007). Striga is known to attack sorghum, millet, maize, rice and sugarcane (Runo, S. & Kuria, E.K. (2018), and completely depends on its host for survival and can produce seeds in great abundance which can lie dormant for over 10 years until favourable conditions are available for it to germinate and attack the host plant. Striga parasite extracts water and nutrients such as minerals, carbohydrates, amino acids from the host plant causing the host plant to show stunted growth, and once established it is very difficult to destroy and may cause total crop failure (Ejeta, G. H. & Butler, L. G. (2000). Manifestations of striga are mainly in Asia and Africa (Parker; (2012). The impact of Striga attack is a function of the size of the seed bank, strain type, variants and races with different virulence, the reaction of the host cultivar, and the environment (Babiker, 2007). Striga affects over 50 million hectares of arable farmland under cultivation in SSA (Ejeta, G. H. (2007, Scholes, J.D. & M.C. Press (2008). The control measures of the parasitic striga weed include cultural, physical, biological, chemical, genetically modified crops, but the integrated Striga management method is deemed to be the most effective (Oswald, Dafaallah, 2019).

Studies by Nascente and Stone (2018) showed that using cover crops at off season in agricultural systems that involves soybean and upland rice at summer season in rotation for two growing

seasons improved soil fertility, by increasing Ca, Mg, K and Fe contents in the soil and reducing pH, Al and H + Al contents, reduced soil bulk density, improved total porosity of soil. It is also claimed that cover crops reduce soil erosion and it is better than fallow, because using continuous fallow increased the number of weeds in the fields (Castro et al, 2011). The length of the fallow period is considered to be a significant factor in soil fertility especially in upland ecosystems, the longer the fallow period the more fertile and the higher the yields (Chenoune et al, 2016).In SSA, rice production from smallholder farms is challenged by poor soils, and improving nutrient efficiency is particularly important by use of fertilizers (Tsujimoto et al, 2009).

The link between fertilizer use and profitability has been a major debate, and the value cost ratio (VCR), which is calculated as the additional revenue from the fertilizer application divided by its application cost has been used to unmask this important link. According to Xu et al (2009), a VCR of two is the typical benchmark to show profitability for farmers using mineral fertilizers, VCR values tend to be low in SSA compared to the rest of the world because the fertilizer is more expensive and less accessible owing to poor markets and poor roads, (Minten et al, 2007).Subsidy programs may be an option to lower cost of fertilizers to smallholder farmers (Koussoubé and Nauges (2017). An example of where fertilizer subsidy worked and produced positive results is the, Farm Input Subsidy Program of Malawi (FISP) (Sanzhez, 2015). However, excessive subsidies can be a burden to the governments of poor countries, making the cost to outweigh the benefits. For example, Zhang et al (2015), in studies in China found that excessive subsidies can reduce the efficiency of nitrogen by overdosing nitrogenous fertilizers or by using fertilizer application into less responsive fields and also polluted water bodies. Marenya and Barret (2009), posits that subsidy programs may not benefit small holder farmers because they often cultivate degraded infertile soils that are lesser responsive to fertilizers. Studies done in SSA shows that, placing P fertilizers in the planting hole when growing rice has the potential negative effect of burning seedlings due to high salt concentrations (Kamanda et al, 2018). Studies in West African countries (Niang et al, 2017) showed that farmers preferred to use mineral fertilizer in irrigated lowlands where more stable returns can be more guaranteed than drought-prone, upland fields.

Effective use of organic resources, for example, crop residue, farmyard manure, animal dropping, can be another option for smallholder farmers to increase soil fertility in an environmentally sustainable manner. Such an approach has been supported by studies done in the central highland of Madagascar where successful case of organic fertilizer management increased rice yields (Tsujimoto et al, 2009). Importance of rice straw residue in rice farming is supported by Goswami et al (2020), who posits that rice straw residues left in the fields improves the soil structure, soil water retention, and soil productivity. And such a practice is environmentally sustainable.

Bird problem has been cited as one of the main constraints to rice farming (Cheke, 2014). Quela birds are migrant pests which follow rainfall systems, and the dominant bird species feeding on rice in Senegal is the red-billed quelea (*Quelea quelea*). It is reported that red-billed quela bird are adapted to semi-arid habitats of SSA. Red- billed quela can gather in large flocks (up to several million) and breed in colonies covering vast areas sometimes exceeding 100 ha. Red - billed primarily feeds on seeds of cereal crops including rice (Rodenburg et al, 2014). Farmer surveys in Senegal revealed that rice producers know of little affordable and effective control measures against birds other than bird scaring, and clearing weeds in and around rice fields (Rodenburg et al, 2014).

2.2.3 Zimbabwe perspective

According to Mazarire et al (2013) farmers in Zimbabwe have been growing local rice cultivars mainly Blue Bell and Mhara, and these cultivars are characterised by low yields and susceptible to rice blast and prone to lodging. Zimbabwe falls short of producing enough consumption requirements which stands at 300,000 tonnes per annum and heavily depends on meeting its rice requirement through importation (Ministry of Lands Agriculture Water and Rural Resettlement, 2020). Studies conducted in Zimbabwe showed rice cultivars 70462, 60143, 70383, Arica 3, Sahel 177, 60040, 70537, 60409, and 70476 had the best performance and these genotypes could be used by rice breeders in the development of high yielding climate resilient rice cultivars in the country (Chitanda et al, 2022). In Zimbabwe, all NERICA varieties performed better than the local check variety, Mhara 1 using the nitrogen rate of 39.5 kg / ha (Mazarire et al 2013).

The use of indigenous knowledge systems IKS in farming in Zimbabwe according to Mugambiwa, (2018) has been employed in order to adapt to climate change. For example in Mutoko rural district through the Community-based adaptation, the use of mulching and creation of temporary walls on riverbanks has been used to store water during the dry season, and these adaptation measures have significantly helped smallholder farmers to have better yields. The use of IKS in farming is employed by women in the absence of modern technology, and these include seed and breed selection, seed protection and preservation, weeding and intercropping (Gwandure et al, 2018).

An analysis of conservative agriculture done in Zimbabwe, shows that the practice has the potential to increase crop yields and conserve soil moisture through the soil cover of crop residues which the crops can utilize and stay health during dry spells (Adohwa et al, 2014). Sustainable agriculture for food security in Zimbabwe has been impacted negatively by frequent droughts and prolonged dry spells due to climate change and variability In-field rainwater harvesting structures such as planting pits, contour ridges, and ridges can thus be used for climate change adaptation by smallholder farmers (Gwandure et al, 2018). Mitigation measures that may help smallholder farmers are also supported by Mutenje et al (2019), who allude that smallholder farmers in Zimbabwe can adopt several technologies that are environmentally sustainable simultaneously in cases where technologies are complimentary. For example, water conservation can be achieved through various techniques, including those that reduce soil erosion (minimum tillage and mulching), while a farmer keeping livestock may use the animal manure to improve soil fertility improvement which will lead to improved yields.

A study done in Zimbabwe showed that addition of nitrogenous fertilizers offers a solution to control striga multiplication. Striga emergence is reported to be greatly influenced by the level of soil fertility. Application of nitrogenous fertilizer or manure reduces Striga growth by reducing production of stimulatory compounds (Strigolactone) from the host plant, and this increases the crop yields (Sakadzo et al, 2021).

Many smallholder farmers in Zimbabwe rely on manual weed control using hand hoes (Mandumbu et al., 2011), which is labour intensive and is slowed down by the presence of residues (Vogel, 1994b). Hand hoeing may require up to four weeding times during the cropping season for effective weed control (Mashingaidze et al., 2012). Therefore, there is need for effective weed control strategies that reduce labour requirement while being feasible within the farmers' circumstances (Norsworthy and Frederick, 2005). Integration of highly competitive green manure cover crops into the farming systems may also reduce weed pressure (Caamal-Maldonado et al., 2001).

Herbicides are a potential strategy for effective weed control, however, most of the agro-chemical suppliers operate in urban areas, which cannot be easily accessed by farmers in remote areas in Zimbabwe, and pollution issues resulting from herbicides use have been raised of late. The generalized use of pesticides in agriculture is blamed to cause contamination of soil and other connected environmental resources, threatening in-soil and water living organisms that are supporting an important number of ecosystem services (Barthelmebs et al, 2019). In highly Striga infested fields, yield losses are as high as 100% (Badu-Apraku et al. 2014; Bozkurt et al. 2015). In Zimbabwe, complete crop failure has been reported by Mabasa (2003). No single completely effective and practical method to eliminate Striga is known (Bozkurt et al. 2015). The use of resistant varieties is the cheapest and most environmentally friendly Striga management option for the smallholder farmers in the semi-arid regions (Mrema et al. 2017).

Fertilizers are important in farming. Studies done in Zimbabwe in 2015 showed that around 91 % of farmers failed to buy adequate mineral fertilizers because of lack of funds, and that the furrowing of fields in some communal areas did not restore soil fertility to desired levels (Manzungu et al, 2020). High crop yields in Zimbabwe can be achieved through an integrated nutrient management, combining mineral and organic sources of nutrients to ensure productivity on poor soils (kafesu et al, 2018). Similar Studies done in Zimbabwe showed that environmentally sustainable practices of application cattle manure, and inorganic fertilizer increased soil fertility and increased the yields of grain (Motsi et al, 2019). According to Mapfumo et al (2021) different N fertilizer management strategies have the capacity to improve yields of cereals such as rice.

In Zimbabwe, according to Sachikonye (2011) mining and farming have often co-existed alongside many other informal income generation strategies. Peasant farming and artisanal mining are reported to be complementing each other as a source of income, although in some places conflicts between miners and farmers have been recorded in places such as Mhondoro Ngezi (Mkodzongi, G., & Spiegel, S. (2019) Mining causes extensive environmental destruction, creating artificial hills and open pits as well as promoting massive erosion, contaminating water and land making it unusable for agricultural purposes (Magidi, M., & Hlungwani, P. M. 2023).

The new agrarian structure has generated diverse forms of wage labour, and many former farmworkers are now taking up farming, besides selling labour (Shonhe et al, 2022). According to Bungu (2019) Fast track Land Reform Program created new patterns of land ownership where women managed to access land in their own right, and this allowed these women farmers to be involved in the production of food grain crops and export crops such as tobacco. Bungu (2019) highlighted that women farmers in Zimbabwe are now producing positive results through farming.

Studies on financial inclusion among the smallholder farmers done in Zimbabwe showed the percentage of households who were actively participating in the formal financial system was below 27 (Dunga et al, 2020). For instance many farmers are finding it difficult to access loans due to lack of collateral security due to lack of title deeds, so banks need to come up with services and products that are tailor-made for the smallholder farmers to access credit easily (Dunga et al, 2020). The government should review the land tenure for communal farmer's and partner with financial institutions to provide a variety of products and services at an affordable cost to smallholder farmers (Mhlanga, 2021). One of the measures adopted by the government of Zimbabwe is the command agriculture where input subsidy programs were initiated by state and donor agencies to plug the challenges faced by farmers in accessing expensive agricultural inputs, such as seeds and fertilizers (Mazwi et al, 2019).

A major constraint to cereals such as rice in Zimbabwe is the existence of quela birds which are reported to be causing havoc throughout the country, including Mbire district (Musiwa, A. R., &

Mhlanga, W. (2020). The Plant Protection Research Services Institute and Zimparks spray pesticides to control the invasion of quelea birds at major breeding and roosting sites in Zimbabwe. The major quelea breeding sites include Muzarabani, communal areas near Gonarezhou, Pandamatenga and Deka areas near Hwange, with other small breeding sites dotted around the country (Nyamutukwa, Herald, 2022). Drones are also used to access difficult breeding and roosting sites in Zimbabwe. Quelea birds have been a threat to subsistence small grains, especially sorghum and millets as well as wheat, rice and barley. Mubekaphi et al, 2021). Quela birds are attracted by the grain of the crops as the grains are exposed unlike those of maize, which is covered by leaves. Chasing birds is highly regarded as a strenuous activity that most farmers cannot embark on (Mubekaphi et al, 2021). The appropriate control measure to be adopted against quela will vary depending upon the circumstances (Dallimer, 2000).

Research studies in Zimbabwe (Makate, C, & Makate, M.2019), concluded that access to agricultural extension enhances crop productivity of smallholder farmers, and it was found that access to extension services contributed to environmentally sustainable agriculture. Extension was reported to improve access to better crop management such as use of organic fertilizers, organic manure, weeding management, access to credit, use of certified seeds and general access to production and marketing information. Modern revitalized extension services must be inclusive of various stakeholders such as the government, private sector, civil society and smallholder farmers (Makate, C., & Makate, M. (2019).

Climate change in Zimbabwe has received due recognition as there is strong evidence of erratic rainfall and a noticeable shortening of the agricultural seasons, crop failure and frequent droughts (Nciizah et al. Ndabaningi 2011). The adverse effects of climate change are more pronounced within the smallholder agricultural sector in Zimbabwe, compared to the commercial sector, which are better resourced. Smallholder agriculture is mostly practiced by families or households using mostly family labour (Mubekaphi et al, 2021). Traditional rain-fed agricultural systems are becoming increasingly unsustainable due to climate change, and the timing and amount of rainfall received are becoming increasingly uncertain, with current data showing that during the last 30 years there have been frequent droughts (GoZ 2014). The Food and Agriculture Organization (FAO 2007) observed that the crop failures have been a result of early termination

of the rains in most seasons in Zimbabwe. Gukurume (2013) perceived that climate change in countries like Zimbabwe has presented insurmountable challenges to the agricultural sector. Droughts, floods, increased temperature, increased rainfall variability negatively affected agriculture in Zimbabwe (Zimbabwe Agricultural Sector survey 2019). In a survey carried out by Great Zimbabwe University on climate change in Masvingo, most people perceived climate change to be taking place (Chipindu et al 2012). Smallholder farmers confirm that the onset of the rainfall season is now coming late and seasons time coming earlier than before with some dry spells in between (Simba, 2012b).

2.2.4 Chapter Summary

The chapter presents a review of literature on the factors that impact dry-land rice cultivation of dry-land rice by smallholder farmers. Socio-economic, political and environmental factors that influence the cultivation of dry-land rice farmers by smallholder farmers; globally, Africa, and Zimbabwe are discussed.

CHAPTER 3

RESEARCH METHODOLOGY

3.0 Introduction

A discussion on the research methodology, the research design, the target population, the sampling procedure, data collection tools and data analysis strategies adopted are covered in this topic.

3.1 Mixed Method Research (MMR)

Data for this paper were derived from qualitative and quantitative methods, employing the mixed method research (MMR) approach. Mixed Method Research involves collecting, analyzing, integrating both quantitative and qualitative data in a single project (Leavy, (2022). The phases of the research project are integrated or synergistic, with quantitative phase influencing the qualitative phase, or vice versa (Hesse-Bine, 2016). It leads to a comprehensive understanding of the phenomenon under investigation because of the integration of quantitative and qualitative data (leavy, 2022). In this research the MMR approach was used because it offered the researcher an opportunity to understand, describe, explain and evaluate the link between social-economic and environmental factors, with the production of upland rice. The methods used included field observation, in-depth interviews; methods included key informant and oral history interviews, telephone interviews, participatory observation, focus groups, and questionnaires.

3.2 Research Design

The research design is intended to provide an appropriate framework for a study; it deals with choice to make regarding research approach since it determines how relevant information for a study will be obtained and involves many interrelated decisions (Sileyew, K. J. (2019). It is a strategy to collect, study, and evaluate data, we talk about research design and it addresses

problems and creates a consistent and logical model for data analysis. The research design ensures neutrality and removes bias and that reliability and validity issues are addressed. It is a plan that provides the underlying structure to integrate all elements of a study so that the results are credible, free from bias, and maximally generalizable. Research design provides the glue that holds the research project together (Trochim, 2006). The research design determines how the participants are selected, what variables are included and how they are manipulated, how data are collected and analyzed, and how extraneous variability is controlled so that the overall research problem on the impact of socio-economic and environmental factors on upland rice farming by smallholder is farmers are explored.

3.3 Target Population

In this study the target population are the 31 smallholder farmers, 2 agriculture extension workers, 1 village head and 1 councillor and 20 local community members of Magwendere village, Mutasa district about 160 km from Mutare, Zimbabwe. The total target population amounted to 55 respondents. The respondents of this study came from diverse age, education, farming experience and were both male and female.

3.4 Sampling

An important step when designing an empirical study is to justify the sample size that will be collected. In this research, 31 upland rice farmers in Magwendere village were used out of total of 67 smallholder farmers in the study area, and this high number, will result in (Lakens, 2022) desired statistical power or a desired accuracy. Stratified random sampling was used, it is a method of sampling that involves the division of a population into smaller subgroups known as strata, and the strata are formed based on members' shared attributes or characteristics (Bhardwaj, 2019).

3.5 Land use

The ward is mainly agro-based and smallholder farmers are involved in the cultivation of bananas, maize, sugar cane, beans, and rice. The land is communally owned, and local leaders (Sabhuku) are in charge of the allocation of agricultural land to the villagers.

3.6 Awareness creation and securing commitment to participate

Before carrying out the study, participant awareness is necessary for a research project to be ethical. An ethical issue as any situation that may compromise, in whole or in part, the respect of at least one moral value (Swisher et al., 2005) and this will done to inform the participants of any risks they might be taking by participating in the research and to inform the participants what rights they have in the process, particularly the right of review of material and the right to withdraw from the process. Local leadership, Extension workers and the smallholder farmers made will take part in the awareness meetings.

3.7 Study Design

The selection of participants will be done using non-probability sampling method that is simple random sample. Thirty eight respondents will participate in the study.

3.8 Data collection

This study will employ a mixed type of study methods, the first part of the study will involve well-structured questionnaires for the farmers, extension workers and semi structured interviews with key stakeholders, government departments, NGOs. The other design will be to interview smallholder farmers, and field observations at selected sites (method) will be undertaken. To address the research objectives, this research used both quantitative and qualitative methods and a combination of primary and secondary sources. The qualitative analysis supports the quantitative data analysis and results. The results are triangulated since the author used the qualitative and quantitative data types in data analysis. Distribution of questionnaires was through the local extension officer of the study area. Some of the smallholder farmers are illiterate and there was need for helping the respondents in completing the questionnaire. The

researcher will take time to verify and correct data to make it more reliable and to have more confidence level in situations where doubts exist.

3.8.1 Key informant interviews

An interview is a question-and-answer session where one person asks questions, and the other person answers those questions. A qualitative research interview tries to understand the world from the subject's point of view, to unfold the meaning from peoples' experiences (Roulston, K., & Choi, M. (2018). Interviewing relies on an interactive method in which mutual learning occurs between those involved in the interview process. Interviewing is an active research process by which an interview or a "contextually bound and mutually created story" is produced by interviewer and interviewee(s) (Fontana & Frey, 2005). They also allow researchers to focus on the interviewees' perspective of what is important or relevant, thereby potentially highlighting issues that the interviewer might not have considered. Interviews may thereby even help to empower interview subjects themselves, allowing for changes in social policy and improved conditions for interviewees (Fontana & Frey, 2005. Interviews in this research are useful to get fist hand information and to clarify issues and in-depth information on the opportunities and challenges on upland rice growing in Magwendere village, as espoused by Minichiello et al (1995), who argue that interviews can be preferable to other methods in filling a knowledge gap. Interviews were carried out to get useful information from key informants who comprised the upland rice smallholder farmers, agriculture extension officers, headman, councillor and the local community. The interviews included narrative interviews, factual interview, focus group interview, and confrontational interviews. The interview questions will be semi-structured interviews which will facilitate two-way communication and provides an opportunity to learn answers to questions and the reasons behind the answers. The semi structured interview will also give respondents time to open up about sensitive issues. A downturn of interviews is that data collection process might take longer than expected since it requires more time for probing questions and follow-up probes.

3.8.2 Questionnaire

A questionnaire is a research instrument that consists of a set of questions or other types of prompts that aims to collect information from a respondent; it is typically a mix of close-ended questions and open-ended questions. Open-ended, long-form questions offer the respondent the ability to elaborate on their thoughts. The data collected from a data collection questionnaire can be both qualitative as well as quantitative in nature and researchers across all academic and industry sectors conduct surveys and questionnaires to uncover answers to specific, significant questions (Taherdoost, H. (2019). Open ended questions will be used to allow the smallholder farmers taking the survey to include more information on the opportunities and challenges in upland rice farming and this is significant as it gives more useful, contextual feedback. Furthermore the open ended questions will allow for a better understand of the respondent's true feelings and attitudes about the survey subject. However some concern of open ended question is the articulation ability, since they are some people who just aren't so good at talking, and open questions might be particularly susceptible to salience effects (Krosnick, 2018). Closed questions are also employed in the research and close-ended Yes/No responses or scaled Close-ended questions to gather quantitative data, and are easy to analyze and compare on a spreadsheet. In this research 38 farmers in Magwendere village will take part in the study and the respondents were picked through random sampling. The questionnaires will be distributed to the respondents by the researcher in collaboration with extension officers based in the study area of Magwendere village. The questionnaires sought to gather information on the socio-economic, political and environmental factors that impact dry-land rice, and possible mitigation measures in growing rice in dry-land rice Magwendere village.

3.8.3 Focus Group Discussion

Focus group discussion is frequently used as a qualitative approach to gain an in-depth understanding of social issues (Nyumba et al, 2018). Focus group discussion is a technique where a researcher assembles a group of individuals to discuss a specific topic, aiming to draw from the complex personal experiences, beliefs, perceptions and attitudes of the participants through a moderated interaction (Cornwall & Jewkes, 1995; Hayward, Simpson, &

Wood, 2004).The technique emerged as a qualitative data collection approach and a bridging strategy for scientific research and local knowledge (Cornwall & Jewkes, 1995). A focus group discussion, researchers adopt the role of a "facilitator" or a "moderator" between participants and not between the researcher and the participants. The researcher takes a peripheral, rather than a centre-stage role in a focus group discussion (Hohenthal, Owidi, Minoia, & Pellikka,2015). An important consideration is the number of respondents to be invited for discussion, it is generally accepted that between six and eight participants are sufficient (Krueger & Casey, 2000), some studies have reported as few as four and as many as fifteen participants (Fern, 1982; Mendes de Almeida, 1980). One potential drawback in focus group discussion is the lack of guarantee that all those recruited will attend the discussion. To overcome this researcher in this study had to over recruit the participants. The focus group in this study had 30 members, and such a number of participants is considered large enough to gain a variety of perspectives and small enough not to become disorderly or fragmented (Krueger, 1994). Many qualitative researchers acknowledge the possibility of social desirability bias (a tendency to present reality to align with what is perceived to be socially acceptable) as a limitation when conducting focus group discussions (Bergen, N., & Labonté, R. (2020). In order to avoid and limit bias in this study the researcher explained the purpose of the study and established rapport with the participants. Focal group discussions and key informant interviews were used to crosscheck and generate information on farmers' experience of climate change, problems in farming practices, their indigenous knowledge systems and the different adaptation measures adopted. Discussions were also held with elderly farmers to tap into their long-term memory of climate events and experience in farming.

3.8.4 Field Observation

Field research was conducted during the rainy season, data showed temperatures ranged between 22.83–31.39 °C, relative humidity conditions were almost similar at around 80%, fastest wind speed (>9.61 km/h) and high rainfalls (> 1000mm) By watching intently in actual work settings, understanding "emerges from the researcher's own observations and interviews out in the real world rather than in the laboratory or the academy" (Patton, 2002:11). Observation can allow insights and access to information that is difficult to obtain via other methods. Observing people in the context of their work environment can be used to gain insight into how

individuals and teams perform their work. By watching intently in actual work settings, understanding emerges from the researcher's own observations and interviews out in the real world rather than in the laboratory or the academy" (Patton, 2002:11). Observation can allow insights and access to information that is difficult to obtain via other methods. It can enable insight and is most useful when combined with other methods for understanding human performance, including operator interviews or verbal protocol analysis (Hollnagel, E. (2012). Field observation in this study will be feasible because they will not interfere with the activities of the smallholder farmers. An observation guide will be employed that provides a set of topics or questions to focus attention while observing, however while an observation guide can be useful, it is also important to remain open to discovery. It is also important to describe the purpose of the observation to those being observed (Crandall et al., 2006). It is important for the researcher to be as unobtrusive as possible, so as not to interrupt or impede the work being observed, if those that are being observed understand the purpose for observing, they will be less likely to alter their behaviour due to your presence and more likely to work as they do normally. In this study the researcher will take measurements, detailed notes on the events and behaviour being observed. The researcher will capture the flow of activities as they happen and then organize or categorize the information at a later time.

3.8.4.1 Soil samples

Dominant soil type data were determined by taking a composite soil sample in a zigzag manner to a depth of 20 cm at 10 points, 20 metres from boundary of fields. A spade was used to cut the soil in a V-cross sectional format so as to extract soil from each layer to a depth of 20cm, as carried out by (Bondi et al, 2019). Soil samples were analysed by the Agricultural Department of Africa University (appendice).

3.8.4.2 Weed type and density

To determine weed type and density present in the rice fields of the study area 0, 5 x 0, 5 m, quadrants were randomly placed at 2 sites in 31 different rice fields of DLRSHFs as done in studies in Indonesia where weed diversity density of *Ludwigia hyssopifolia* and *Echinocloa crus-galli* in rice fields were conducted using quadrants 0, 5 x 0, 5 m (Mutakin et al, 2021). The use of quadrants to determine weed density is also in line with similar studies by Rugare et al (2014) that were used to evaluate the effects of weed control strategies using 0,5m x 0,5m quadrants in Zimbabwe.

3.8.4.3 Rice yields

To determine rice yields of DLRFs of Magwendere village, quadrants 1m x 1m were randomly placed at 2 sites in 31 different rice fields of DLRSHFs, mature rice panicles were harvested dried and weighed. The determination of rice yields used by the researcher was guided by similar procedures as outlined by Wang et al, (2020).

3.8.4.4 River discharge

To carry out river discharge measurements of Mutangazi River found in Magwendere village were DLRFs is practised, the researcher used the velocity -cross sectional approach as outlined by the United States Geological Survey (USGS). A red dye was used to determine the velocity of the river. The time that the red dye took to cover a distance of 10 metres was recorded at 3 sites along the river, at points that the river channel was fairly straight and away from man-made structures such as bridges and weirs which would disturb the free movement of water. Cross-sectional area was determined by getting the average depths across the river at 3 sites across the river. Measurements were done during the dry-land rice cropping season in January; 2023.The formula below was used to calculate river discharge in cubic metres per second.

Cross sectional area in metres x velocity in metres per second.

3.8.4.6 River nitrate, nitrites and PH measurements to determine possible water pollution due to DLRF

The researcher used disposable test strips to determine the levels of nitrites, nitrates and the PH in Mutangazi River and Muoperwa stream which are located in the Magwendere village were DLR is grown, such an approach has been used by Avidad et al (2001). Water samples were collected upstream (river Source) were no water contamination from farming activities exist, and downstream where farming operations could potentially leak nitrogen based fertilizers into the rivers and streams. Water tests were carried out during the cropping season in January, 2023. Water samples were collected using sterilized bottles, which were filled such

that they became airtight such that no air is left inside and placed in a cooler box to keep the water parameters constant during sample storage before the sample is subjected to analysis as done by Machona et al (2017). The water samples were taken to Mutare for analysis.

3.8.4.7 Online climate data sources

Climate data on precipitation and surface temperature used in the research were downloaded online from POWER | Data Access Viewer (nasa.gov) and also obtained from the extension workers domiciled in the study area, who operate a local weather station in the study area.

3.8.5 Reliability and validity

Reliability and validity are essential parts of a measuring instrument. The reliability of an instrument is concerned with the consistency of measurements (Mueller, R. O., & Knapp, T. R. (2018). Reliability besides dealing with consistency in measurement it also looks at the lack of error (Gidron(2020). Validity is the extent to which an instrument actually measures "what it is designed to measure" or "what it purports to measure," that is, it assesses the relevance of an instrument for addressing a study's purpose(s) and research question(s) (Mueller, R. O., & Knapp, T. R. (2018). In this study the researcher was guided by the work of Mayan et al (2018), who argue that reliability in qualitative research is rooted in the idea of data adequacy, which makes it possible to show consistent support for one's analysis across participants and the fundamental responsibility of the researcher for the continual checking and adjustment of research processes (i.e., verification) to ensure that the results are robust. Validity is defined as the precision of the result. In social science, data are generally collected through the use of written questionnaires or survey, and in order for the research findings to achieve empirical and scientific standing, the instrument must be properly calibrated so that they produces homogenous results and precise measuring (Louangrath, 2018). The questionnaires used in the study were concise, clear, and appropriate questions were crafted.

3.8.6 Data Analysis and Presentation Procedure

The analysis of data requires operations such as establishment of categories of raw data through coding, tabulation and then drawing statistical inference. In their raw form it is very difficult to present and analyse data that is why the researcher in this study organized and presented data in a compact manner. The data was subjected to tabulation; grouping and graphic forms were adopted for easy handling and analysis. The data was presented in a form(s) that were appropriate for the purposes of data analysis. Suliman (1997), alludes that statistics in the analysis of data facilitates decision making. Statistics serves the purpose of collecting, organizing, analysing and interpreting data. Frequency tables, charts, measures of central tendency (mean, mode), and range were used in the data processing and analysis of dry-land rice production by Magwendere village smallholder farmers.

3.8.7 Ethical Considerations

Ethical behaviour describes a set of actions that abide by rules of responsibility, accountability, liability, and due diligence. Every researcher must maintain ethics from the beginning to the end of a study project. Ethics in research defines guidelines for conducting professional research. It also teaches and regulates researchers to ensure that they follow a strict code of ethics when conducting research. The quality of behaviour of academic research is governed by research ethics, and this is important as it protects the dignity of research participants. Researcher faces the ethical dilemma at every stage of a study, from conception to conclusion. Concerns include the authors' potential impact on respondents and vice versa, as well as confidentiality and anonymity (Oswaldo, 2021). Other important moral and social values, such as corporate responsibility, human dignity, animal rights, and legal compliance are promoted by many research moral codes. Animals and humans' subjects, learners, and the public can all be adversely affected by ethics violations in research (Resnik, 2020). According to Willinger (2015), Authenticity and benevolence are two aspects of truthfulness that are directly related to ethics. When conducting research, we should always consider the possibility of harming others. Think about any moral issues that may arise (McLeod et al., 2016). Ethics in research methodology. The research method will not be completed without consideration of ethical issues. In this study the researcher strived to truthfulness in reporting data, respecting privacy, upholding issues of confidentiality throughout the research process. At every stage of the

research process in this study the researcher will adhere to ethical standards. Research's results will be accurate and fair if the research's design and sampling techniques, data collection method, data collection tools, materials, data analysis methods are ethically conducted (Knottnerus & Tugwell, 2018). Quality of work and code of ethics are closely related, and if researchers want their studies to be successful, they must adhere to ethical standards (Dola et al, 2021). It must be noted that ethical principles are abstract and general, but they are not an algorithmic blueprint for carrying out scientific work. One problem is that acceptable versus unacceptable behaviour can sometimes be hard to distinguish. The other problem in research is that the process of validation can take months or years (Makri, 2021). Another problem is that ethical principles can be in conflict with one another as sometimes the same action can be guided by different ethical rules that endorse or prohibit certain actions (Recker, J., & Recker, J. (2021). In this study, while the principle of anonymity was known and important to the researcher it ran against the data-collection method during the in-person interviews. In such cases, the researcher took appropriate actions to guarantee the confidentiality of the upland smallholder farmers of Magwendere village of Chavhanga. The researcher in this study will ensure that data will be maintained in such a way that no participant's identity can be revealed from any form of research disclosure, including reports, papers, and presentations. Voluntary participation must be respected and this means clarifying participants' right to withdraw from a study prior to its conclusion (Recker, J., & Recker, J. (2021). Participants were informed about the potential risks of participation and they took part in the study with their full consent.

3.8.8 Chapter Summary

Chapter discusses the research approach, the processes, instruments and the analytical tools used in data collection, research design, research paradigm, sampling size and sampling techniques employed in carrying out the research. Both quantitative and qualitative methods were used in gathering data and information used in this study.

CHAPTER FOUR

Data Presentation, Analysis and Discussion

4.0 Introduction

This chapter presents the results and findings and discussions of research on dry-land rice farming. The information in this chapter is drawn from published and unpublished reports, workshops and interviews with key informants, and field surveys conducted in 2022 to 2023.

4.1: Objective 1 was to examine the feasibility of growing dry-land rice by smallholder farmers in Magwendere village, in Mutasa District. To answer this question, questionnaires and interviews were used. Results and discussions indicated that:

4.1.1 Labor composition

Labor in dry-land rice in farming is gender biased. It is a female dominated practice. The key informants in the study area reported that:

"*Food crops in the study area are the preserve of the female who must make sure that food security at household level is achieved"* (Magwendere Village.2023).

The gender skewedness and the idea that food crop production by smallholder farmers at household level is dominated by female is supported by (Goheen, 2019), who posits that women cultivate food crops, while men grow cash crops. Women (fortmann, 2019), have nearly total responsibility for making sure the household is food secure through food crop cultivation. The study revealed that women were always busy attending the rice fields during the cropping season. Women in the study area, when there were presented with the importance of environmentally friendly farming argued that:

"*We are more sensitive to conserving the environment when farming unlike men, since we are more affected by issues such as shortage of firewood or water because it is our responsibility to provide these*" (Magwendere Village.2023).

Such claims of women taking environmental issues seriously in farming are supported by studies by Bojnec et al, (2021) who documented that stronger tendency of women farmers towards environmentally friendly farming activities exist in many parts of the world. Studies of rural farmers in the Niger Delta also confirm such findings, and showed that women farmers engaged more in environmentally sustainable practices of using organic manure on their farms (Uduji et al, 2019). The labor-intensive nature of rice cultivation provides additional sources of work and income to the rural poor, especially women (Otsuka et al. 2007). The high number of women in Magwendere village engaged in rice farming shows their contribution to social and economic sustainability which are important facets of sustainability. The researcher observed that the male population of Magwendere village were more engaged in the production of cash crops such as bananas and beans, and such produce are grown using sprinkler irrigation. The respondents argued that:

"… *Banana production was an important crop because it ensured that the household had a steady source of income throughout the year since bananas mature at different times, unlike rice which is seasonal and grown once a year*". (Magwendere Village.2023).

The study showed that key decision making at household level was the preserve of the male, and women played less important roles in decision making. This means that women in the study area are marginalised and this may mean that development in agriculture is stifled. The labour statistics in Magwendere village in DLR production seem to highlights the gender imbalance that exists in this study area. Though women played significant roles in ensuring food security at household level as evidenced in DLR production in Magwendere, their efforts from study finding were not well recognized. According to Terman et al (2016), although women did most farm work, it was men that made key decisions on what to grow and inputs to use and man controlled the proceeds from the family farms. Women were willing to practice some techniques that encourage sustainable agriculture (Terman et al, 2016). The gender imbalance can limit the potential of this sector. The age of the actors involved in the rice production process also affects productivity. If enabling structures are put in place to uplift the women and make their voices to be heard at household and community level this may make Chavhanga area to be food secure in an environmentally sustainable manner. Policy structures and frameworks that elevate

and empower women, from the study findings are none existent or if ever they are present there are simply being ignored.

4.1.2 Soils and rice farming in Magwendere village

Quality of soils are an integral part in any successful rice farming, and the study findings indicated that the major soil types of Zimbabwe can be categorised into 6 categories (Figure 3). The soils of the study area based on classification, Fig 3 are the oxisols.

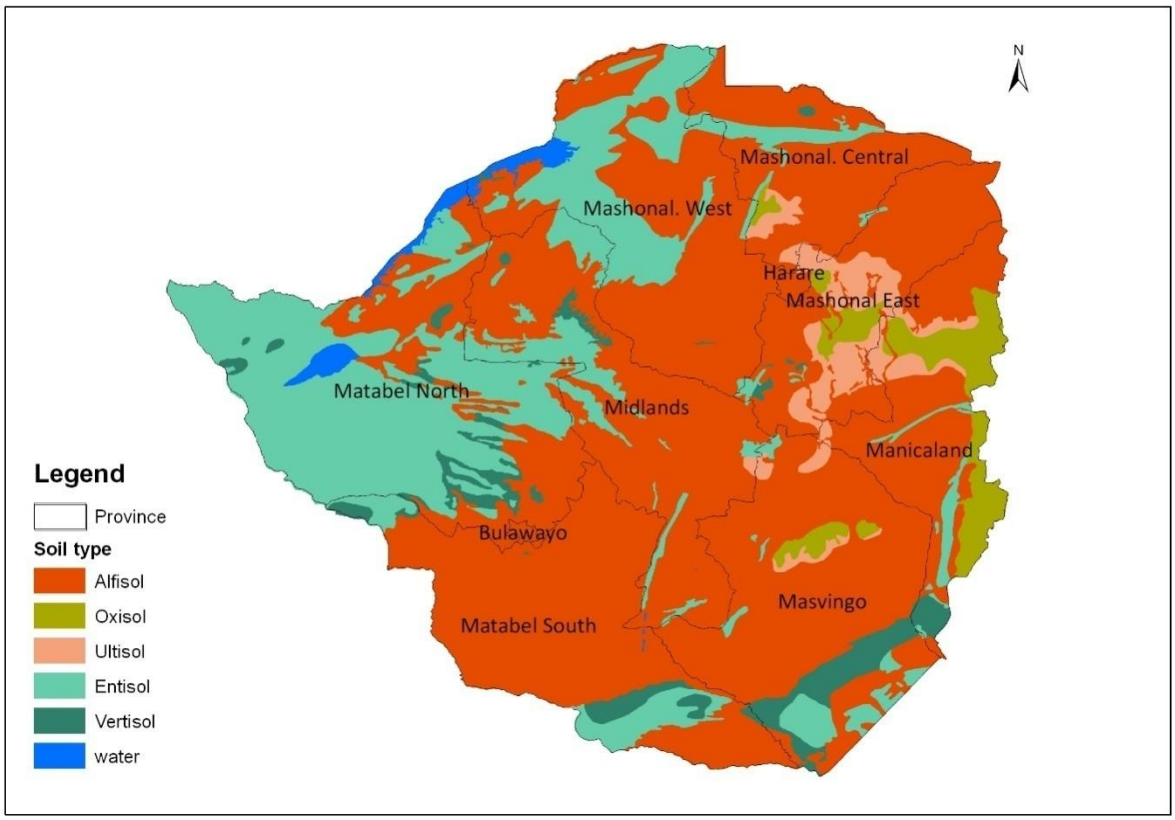

Figure 3, Soil map of Zimbabwe **(**department of research and soil services, Zimbabwe)

Semi-structured interviews and discussion groups were used in research in order to accurately assess farmers' knowledge at the individual and group level and to identify if differences in soil quality perception occur between farmers. Studies in the area revealed that the farmers have never done a soil test to determine the soil nutrients present in the soil they cultivate their crops. The study findings showed that the SHFs use IKS to categorize their soils. Semi-structured interviews were used for gathering information on perceptions of soil quality indicators. These interviews took place at the farmer's house or in upland rice fields. The farmers were presented

three open and broad questions: (1) “What are the indicators of a good soil?” and (2) “How do you recognize a good soil?”, and (3) “How do you look after the soil so that it is not degraded?” results obtained are shown in table 4. The upland rice farmers of Magwendere village used soil colour as an important attribute to distinguish soil quality. By using soil colour as a proxy for soil quality the smallholder farmers’ perception considered black soil as the best soil because it contains more organic matter, has better infiltration, is more fertile, has more soil organisms and nutrients, and thus produces more rice yields. The upland rice smallholder farmers indicated that:

“*Presence of anthills shows that the soil is very fertile and at such sites we even plant cucumbers in the rice fields*”. (Magwendere Village. 2023)

The also farmers remarked that:

“*At anthills we do not even add fertilizer because the soil is rich and the darker soil type is better for rice crop”*. (Magwendere Village.2023).

The smallholder farmers also stated that:

“Good soils were not hard and difficult to work with, and promoted the development of roots”. (Magwendere Village. 2023).

A young female smallholder farmer argued that:

“Good soils can also be seen on the development of the rice plant, rich soils produce big, thicker and taller rice stalks, while poor soils show thin rice stalks”. (Magwendedre Village. 2023).

It was also revealed by a male rice farmer that:

“The *greener the rice plants, the richer the soils, poor soils are shown by yellowish rice plants”.* (Magwendere Village.2023).

One elderly farmer revealed that:

“Number of people tilling the rice fields was important, when the labour supply was high it meant that activities such as weeding, and application of fertilizers was timely done and this improved rice yields”. (Magwendere Village.2023).

The study findings indicated that some rice farmers did not have enough workers to till the rice fields and they were overwhelmed with work and failed to adequately attend to the rice fields leading to high weeds.

One smallholder farmer said*:*

"When growing up-land rice we do not disturb the soil by using holes, we plant without ploughing or turning the soil and this reduces soil erosion and makes our practices to be environmentally friendly". (Mangwendere Village.2023).

One elderly farmer in the study area argued that:

"Fertilizers poison the soil and are responsible for the new diseases that are killing us, when we were growing up we used cow dung and I will continue to use natural ways in my field". (Magwendere Village.2023).

Study findings seem to suggest that farmers in the study area have an in-depth IKS on soil quality indicators and environmentally sustainable techniques that included hand weeding and such knowledge play a key role in the environmentally sustainable farming of DLR.

4.1.3 Rice yields and cultivation methods in Magwendere

Field observation, by researcher on the 19th of November 2022 revealed that dry-land rice in Magwendere village is grown under two main methods, shifting cultivation and permanent fields. The smallholder up-land rice farmers revealed that they are now having farrow periods that are less than two years and the soils natural fertility has decreased and this has affected their yields immensely. The research revealed that the yields ranged from 0, 75 t/ha to 3,5t/ha (Table 5), based on the rice yield calculations done by the researcher. The length of the fallow period is a significant factor in soil fertility especially in upland ecosystems, the longer the fallow period the more fertile and the higher the yields (Chenoune et al, 2016). In Magwendere village the low yields could be partly due to the short furrow period as argued by Chenoune et al, 2016). According to Manzungu et al (2020), in some parts of Zimbabwe's communal areas, soil fertility remained poor regardless of period to which a field has been abandoned, and crop yields remained poor and too low. kafesu et al, (2018), posited that High crop yield in Zimbabwe can be achieved through adopting an integrated nutrient management, that combines mineral and

organic nutrients to improve poor soils. Similar Studies done in Zimbabwe (Motsi et al, 2019) showed that Cattle manure and inorganic Fertilizer increased soil fertility and increased the yields of grain.

Table 1 Rice yields in Magwendere village

Rice yield per ha	Freq	Percent	Cum
0,7-0,8	7	22.58	22.58
0,9 - 1	21	67.74	90.32
2 t plus	3	9.68	100

4.1.4 Presence of unoccupied land

Dry-land rice farming is usually practised in areas that are hilly or flat. Studies revealed that in Mangwendere village there is evidence of forested upland/hilly were rice could be grown (figure 4). The study revealed that soil erosion was a serious threat that affected rice farmers in the study area. Such findings in the study area confirm similar observations made in India, where due to increasing human population, the farrow cycles which used to be 20–30 years, has now been reduced to 3–6 years (Arunachalam, 2002; Borthakur, 1992). According to the extension officer based in the study area," the rice fields are located in areas with steep slopes and are prone to soil erosion and landslides". Studies have shown that upland rice farming on hills in Northern India causes soil loss of 41 t/ha and the corresponding nutrient losses are 703 kg/ha of organic carbon, 146 kg/ha of phosphorus and 7 kg/ha of potash, (Roy et al, 2018). The study revealed that an important strategy employed by the farmers in Magwendere village included land preparation that avoided ploughing, and this had the effect of making the soil less susceptible to rain-wash on the steep slopes. The extension worker remarked that:

"*shifting cultivation was an appropriate farming strategy in the area because the farmers minimally disturbed the soil by digging small holes for planting in steady of ploughing using*

holes or ox-drawn ploughs, and offered rest periods to the land and this was important because it made the soil to regain its fertility and was environmentally sustainable" (Magwendere. Village, 2023).

Such a practice is supported by Bhuyan, R. (2019) who posits that shifting cultivators are constantly incorporating new measures into shifting cultivation to make it ecologically less destructive. Observations made during the study indicated that during land preparation the vegetation is cleared and later burnt.

The extension worker remarked that:

"The ash from the burnt vegetation provided potash and this was important as this means less artificial fertilizers are used and also the farmers save money". (Magwendere Village. 2023).

The village head indicated that:

"During land preparation we are concerned about the environment and we urge farmers to follow our tradition of avoiding cutting down big trees and wild fruit trees, offenders will be summoned to the village court where they are made to pay a fine or livestock such as chickens and goats depending on the severity of the offence". (Magwendere Village. 2023).

Such practices of respecting traditional values in protecting the environment practiced by the DLRSHFs of Magwendere is in line with the 2002, Globally Important Agricultural Heritage Systems (GIAHS), put forward by the Food and Agriculture Organization (FAO) in an effort to protect traditional agricultural systems with important values that conserve the environment and biodiversity. The findings on the role of the traditional leaders in Mangwendere village suggest that some effort exist in making DLRF a crop that is produced in an environmentally sustainable way.

Figure 4, DLR field in Magwendere village (Source; author 2023)

4.2.1. Objective 2 was to find out about the effects of climate change on dry-land rice farming by smallholder farmers in Magwendere village, Mutasa District. We first of all looked at rainfall and temperature. Results indicated that precipitation plays a pivotal role in any farming system, and data on precipitation for Magwendere village was obtained from NASA's meteorological department, extension workers and local community. Rainfall totals from 1981 to 2021 of Magwendere village revealed that the area received rainfall as high as 2000 mm per annum. Rainfall totals supplied by the agriculture extension worker of the study area revealed that a total of 1076, 4mm of rain was recorded during the 2022 to 2023 cropping season between October and April. The rice yields ranged of the 2022-2023 cropping season ranged from 0,7t/ha to 0ver 2t/ha. Such findings are comparable to studies done in Thailand were the total rainfall amount of a growing season of 466 mm - 663mm produced yields from 700 to more than 3400 kg/ha (Phapumma et al, 2020).

The smallholder farmers said that:

"2022 to 2023 cropping season was one of the good years because we had adequate rains and our rice yields were satisfactory". (Magwendere Village. 2023).

Interview with the agriculture extension worker revealed that the rainfall distribution within the growing season is also of great concern if it comes in high intensity and long duration, since it

resulted in serious land degradation through rill and gully erosion which affects the growing of rice, from erosion which may result in poor yields.

Studies revealed that in Magwendere village the annual temperature average are high around 24 degrees Celsius annually. Such temperature are ideal to upland rice farming as they are similar rice growing temperature conditions in the Philippines (stueker et al, 2018), of above 25 degrees Celsius annually. Future climate projections by the end of the century, according to Stueker et al (2018), temperatures might exceed known limits to rice production if warming continues unabated. Therefore, necessary information to guide agriculture management to mitigate the compounding impacts of soil moisture variability and temperature stress are needed to come up with environmentally sustainable means to grow rice in Magwendere village in Chavhanga. Studies in the study area revealed that high temperatures and low rainfall are sometimes experienced during the cropping season and this results in poor rice yields, especially during the panicle stage of the rice.

4.2.2 Farmers perceptions on climate variability and the effects

Upland rice smallholder farmers were asked how the weather had changed over the years, based on their experience over the past 3 decades. Questionnaire and survey were used by the author to investigate farmers' perceptions of climate change. Results showed that over 50 percent of dry-land smallholder farmers perceived climatic and weather patterns to have changed over the past decade or two, as indicated by erratic rainfall patterns, decreased rainfall and temperature increases, leading to crop productivity decline. Study finds also indicated that most farmers have heard about increasing global temperatures and erratic rainfall from mass media or through conversations with other farmers. DLRSHFs in Magwendere village remember the severe floods that occurred in the years 1999, 2007, 2015 and 2018. The effects of climate change on rain fed rice production systems are noted by Stueker et al (2018) who alluded that dry-land rice is more sensitive to soil moisture variability caused by climate change. The farmers revealed that over the past 2 decades, the onset of the rainy season had shifted from mid-October to end of November and early December. Focus group discussions showed that high rainfall amounts were now received in January and February lately have led to serious erosion and water logging in the

area. Another observation noted was the unpredictability of the rainy season, ending abruptly and early. A community member in her 70s indicated that:

"When I was growing up meaningful rainfall used to start early in the month of October, but nowadays, the onset of the rainy season is delayed and can be as late as December" (Magwendere Village.2023).

The farmers and community members also reported that the distribution of rain had become more unpredictable and erratic and was no longer evenly distributed as before. The farmers bemoaned how difficult it has become to plan their agricultural activities, and one farmer revealed that:

"Sometimes we replant our fields due to poor germination as a result of moisture stress". (Magwendere Village. 2023).

One community member remarked that:

"*Due to climate change, high temperatures and strong winds that are being experienced in Magwendere village have resulted in uncontrollable veld fires that have destroyed forests, crops and other properties".* (Magwendere Village.2023).

The damage caused by veld fires that have become common in the study area due to high temperature.

The village head reported that:

"Rise in temperatures and heat waves have resulted in crop failure and poor health to the community". (Mangwendere Village.2023).

One elderly female farmer said that:

"*Now we receive increased rains and lightning in the month of June and July which is winter period in Zimbabwe".* (Mangwendere Village. 2023).

The farmers in the study area are aware of climate change. 55 percent of the dry-land rice farmers indicated that they had experienced reduced crop production due to some of the weather change The perceived effects of climate change in Magwendere village can be supported by Botha (2019) who argued that, the average temperature increased in Southern Africa due to climate change has resulted in an increase in rainfall variability and heatwaves that have caused veld fires growing in frequency. According to the Zimbabwe Meteorological Services

Department the average total rainfall in Zimbabwe since 1980s has been deviating more from mean in a negative way with an increased magnitude, and there are shifts in natural ecological zones in Zimbabwe and these points to climate change (Makarau et al (2012)

4.2.3 Impacts of perceived climate change and adaptation measures by the DLRSHFs

The village head revealed that the timetable management for upland rice farming activities followed a calendar that he specifically monitored and sanctioned in line with their traditional values and believes **(**table 2) handed to them from their forefathers. The village head said:

"Rainfall petitioning ceremonies are an integral part of our culture, and the spirits of late are not giving us enough rains and this has affected our crops, forests and livestock".
(Magwendere Village. 2023)

The village head blamed the poor harvests on modernization, he remarked that:

"A lot of young people claim that they are educated and have lost respect of their culture and this has led the ancestors to be angry with us". One villager of the apostolic sector said "the droughts and floods that are now common in our area is because of the sins that have become part of our life, and god is punishing us". (Magwendere Village. 2023)
Another smallholder farmer remarked:

"T*he political disturbances that have led to many deaths across the country are to blame for the long dry spells and this can be solved by cleansing ceremonies*". (Magwendere Village. 2023)

The study revealed that a variety of community based approaches (CBA) were being implemented to reduce the vagaries of climate change. An extension worker based in the area said:

"As part of adaptation strategies farmers in the study area now get weather data and farming solutions online using their mobile phones from extension workers, radio and television to help them plan their farming operations in an informed manner". (Magwendere Village. 2023)

As part of adaptation strategies to climate change the village head said:

"We are now encouraging farmers to sow their rice in batches, in such a way that one section of the field has an early crop and the other part is sowed later". (Magwendere Village. 2023)

Focus group discussions revealed that by having an earlier rice crop and a later rice crop in the rice fields was a way of distributing the risk, because if one batch is affected by moisture stress the other batch may be free from such environmental hazards. Another important climate change adaptation noted in the area included use of irrigation by some DLRSHFs. Field observation noted the presence of polythene pipes that conveyed irrigation water to homesteads and to 2 rice fields. The use of irrigation to reduce the impacts of moisture stress offers great potential to the DLRSHFs of the study area to grow the cereal productively. Such a notion is shared by Oguge, N., & Oremo, F. (2018) who proclaims that irrigation can lead to climate resilient food production if technologies are adopted. Another climate change hazard which was mentioned by the DLRSHFs was the heat waves which caused a danger to the health of the community. Some of the coping strategies to counter heat waves revealed during the focus group discussions included wearing straw hats, keeping hydrated, and working in the fields at day break and late afternoon, to avoid the scorching sun. Such measures of avoiding working in the fields during mid- day may have a negative effect on crop productivity in Mandwendere since it means reduced time of work in the fields. Study findings also exposed the importance of IKS in fighting the impacts of climate change and variability in the Study area. The 'Zunde raMambo' (work party) is a communal labour pooling and livelihood strategy community members under the chiefs instructions work in communal fields to produce food crops that are stored in a communal granary for dispersal during times of hunger as a result of environmental hazards. The 'Zunde raMambo' in Magwendere village means that the community members have an IKS guided response to the climatic change perturbation which utilizes the social, natural and physical capital of the study area. The importance of local leadership and IKS in managing climate changes in rural communal areas is supported by Musarandega et al (2018). Another community based adaptation measure observed in the study field was the sowing of rice together with other crops such as millet and cucumbers. The

importance of intercropping as way to minimize environmental hazards such as erosion and climate change is supported by Yusuf et al (2020), in Indonesia dry-land rice farmers grow rice with other crops such as tubers, vegetables, etc. Millet is a drought resistant cereal, and by sowing it in the same field with rise in Magwendere village this means that the farmers are assured of a harvest should insufficient rains affect the rice crop which requires more rainfall. One farmer said,

"I *have always grown rice together with Millet in the same field, and the millet yields have always been satisfactory and this afforded me a decent livelihood".* (Magwendere Village. 2023)

Table 2, Timetable of management activities for upland rice production in Magwendere village, Chavanga

May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr
---------fallow/pasture---------				land Preparation	sowing	weeding----------			bird guarding, harvesting		

Part of the reason why dry-land rice small holder farmers in Magwendere village blamed yields dwindling due to climate change could be explained by Weber (2010), who posits that most farmers' knowledge and exposure to climate change has been influenced indirectly by the media from events occurring in distant areas, rather than local events. Slegers (2008) also indicates that experience is an important factor that shapes farmer perceptions on climate change and variability. Zimbabwe's rainfall averages as a country have drifted from the mean (Zimbabwe Meteorological Services Department, 2002) and this points to climate change.

4.3. Objective 3 was to find out the challenges and opportunities that are faced by smallholder farmers in the production of up-land rice in an environmentally sustainable manner in Magwendere village, Mutasa district.

4.3.1 Weeds

Study findings indicated that in weeds, in particular striga weed was one of the factors that compromised on the quality and quantity of rice yields in Magwendere village. The researcher observed that the presence of weeds was a serious issue and it was noted that it is difficult to eradicate especially**,** when continuous wet spells are experienced. From the field observations and quadrant survey carried out by the researcher it was established that the weed density was as

high as 11, 63 weeds per square meter, and that Striga weed was not the only weed dominant in the study area. The researcher observed that no chemicals or herbicides were used, and the smallholder farmers bemoaned the lack of money to buy herbicides. The field observation done by the researcher revealed that 24 smallholder upland rice farmers mentioned striga weed as a constraint to rice production that affected their yields. The dry-land rice farmers noted that:

"*Eradication of the weeds included manual hand hoeing and burning is the most control measure used in our area".* (Magwendere Village. 2023)

A survey done by the researcher revealed that the local dealer shops did not have herbicides for weed control and the shop owners proclaimed that such products were relatively expensive and were beyond the reach of the upland smallholder. Herbicides have been reported to be effective and economically feasible in the smallholder farming sector where CA is being practised (Muoni et al., 2013). Herbicides have the ability to reduce substantially the weeding pressure but there are potential toxic side effects for humans and the environment (Kolpin et al., 1998).)

4.3.2 Quela birds and rodents

Questionnaires filled by the smallholder farmers revealed that quela birds have become a big problem in Magwendere village. One of the smallholder farmers remarked that:

"Quela birds were capable of wiping out entire fields of rice and that there was need to find ways of controlling the birds". (Magwendere Village. 2023)

The agriculture extension officer based in the study area proclaimed that:

"*Damage to the rice crop starts when it has reached milk dough stage and hard dough stage, and Rice wheat, and millet attract swarms of birds from far off land and if your field is small you can harvest nothing".* (Magwendere Village. 2023)

The researcher observed that the smallholder farmers have come up with various strategies to control bird damage to the rice crop in the study area. Some of the strategies observed include, clearing one site where all rice farmers will each receive a potion to cultivate their rice crop. The smallholder farmers claimed.

"*Having all rice fields in one area it is easy to manage bird swam as farmers can take turns to guard the rice fields against the quela birds*". (Magwendere village. 2023)

It was observed that the farmers have also adopted a common calendar where the land preparation and sowing takes place at the same time, to share the risks against bird damage. One of the farmers who planted 2 months earlier than the rest of the farmers reported that he suffered heavy losses against bird damage as his rice field was the only one where quela birds fed from. The farmer who planted earlier said that:

"Quela birds inflicted a lot of damage, and these birds are very difficult to control since they invade the rice fields early in the morning before first light". (Magwendere Village. 2023)

The researcher also observed another innovative strategy that made use of bird scare ribbons. Some of the smallholder farmers claimed that:

"The *bright light combined with the movement and the metallic sound of the reflective ribbons scares off the birds*". (Magwendere Village. 2023).

Another farmer claimed that:

"Bird *scare ribbons were easily available at no cost and were obtained from disused video tapes that are disposed by people and electronic repair shops*". (Magwendere Village.2023).

Use of reflective scare ribbons as an environmentally sustainable technique which is cost effective is documented by Firake et al (2016), who posits that it is a common practice in rice fields in Asia and parts of Africa. . SHFs also claimed that:

"*Empty tins and drums can also be beaten especially by children to make noise that scares off the birds*". (Magwendere Village. 2023).

A community member in the study area said that:

"We *occasionally trap the quela birds as a source of cheap protein, but it was impossible to catch the birds in large numbers as a bird control measure".* (Magwendere Village.2023).

Some SHFs who were wary of environment concerns on the use of chemicals on bird dame control said:

"*Use of chemicals to control bird damage is bad because it may also poison are water sources and will affect our livestock since the animals also graze in the rice fields and surrounding pastures*". (Magwendere Village.2023).

The study on quela birds control revealed that scare ribbons and mass capture were the most popular, and the SHFs claimed that such methods were more environmentally friendly. Such claims are supported by (Elliott et al, 2014), who argue that use of pesticides have been reported to have negative side-effects on non-target organisms and on the environment, mass-capture techniques have been suggested as an alternative where birds caught could improve nutrition of the farmer.

Questionnaires filled by the rice farmers indicated that rodents were a serious problem when rice was still in the fields. Studies in Myanmar, confirms concerns of rodent damage by SHFs farmers in Magwendere village were losses of rice grain in Myannar is a significant food security issue caused by rodents (Singleton et al, 2017). Field observations in the study area indicated the presence of weeds in the rice fields, and dense vegetation near rice fields and bean fields (Figure 5) which offered refugee for rodents to hide and reproduce throughout the year, thus making rodents to be a threat to rice yields and other grains. According to Johnson et al (2019), there were larger economic benefits for best weed management and effective rodent control in and around rice fields combined with coordinated community trapping of rodents during the early ripening stage of rice. The rodent management system of Magwendere village lacks community effort and has the potential of affecting rice yields negatively. One farmer said:

"*When we plant rice we put into consideration that part of the yields is going to be affected by pests such as rodents, and as general rule we plant an extra potion to cater for such losses".* (Magwendere Village. 2023)

Though the rodent management system of Magwendere may not harm the environment it causes a social threat to the resilience of the farmers in the study area making it less sustainable.

 Figure 5, Weeds and vegetation in and around the rice fields offers refugee to rodents (source; author)

4.3.3 Fertilizer use by small holder farmers of Magwendere village and its economic and environmental implication

Fieldwork, interviews and focus group discussions in the study area indicated that a total of 18 out of 31 (58%) farmers did not use any commercial fertilizer (neither fertiliser basal nor top dressing). Of the remaining 13 farmers who reported using commercial fertiliser for their rice fields, 2 used top dressing only, and 11 farmers reporting applying both basal and top dressing fertilzer to their rice fields. Among the farmers who applied artificial fertilizer, the amount of basal ranged from 20-25kg. The smallholder farmers reported that:

"The low number of farmers using fertilizers was due to the high cost of buying fertilizers, with prices varying above $ 30 dollars a bag of 50 kgs of Compound D and Ammonium top dressing". (Magwendere Village. 2023)

Some respondents also pointed out that:

"*The non- availability of the fertilizers at the local dealer shops as one of the low fertilizer usage and sometimes farmers had to travel to Hauna growth point which is over 50 km, and the prohibitive transport cost was said to be beyond the reach of many of the smallholder farmers".* (Magwendere Village. 2023).

One respondent said:

"Ash derived from the burnt vegetation was a good substitute for fertilizer". (Magwendere Village.2023).

Field observations indicated that rice grain size length averaged 4mm. According to Zheng et al, (2010), the addition of nitrogenous fertilizers have a positive effect on the activities of enzymes of physiological importance through increasing the grain size to lengths of around 4mm, and such a length is comparable to study findings of Magwendere village. The Link between grain size and nitrogen has also been supported by Deng et al (2010) who indicated that rice grain size and yield increased progressively with N rate. Results from field observations by the author on the study site together with published sources suggest that the use of fertilizers such as Nitrogenous fertilizers as the potential of increasing rice yields. Nitrogen (N) is one of the most yield-limiting nutrients for crop production in the world. In Ethiopia in is 64 kg (46 kg N from urea and 18 kg N from DAP/NPS fertilizer) that are blanket recommended, and 20 cm respectively (Tilahun, Z. M. (2019). Field observations indicated that some DLRSHFs in Magwendere village burned rice straw residue in the fields. One elderly farmer said:

"Burning *the residue is part of the land preparation for sowing, additionally, the ash produced after burning the rice straw residue acts as fertilizer which is needed by the rice plants*". (Magwendere Village. 2023)

The burning of rice straw residue by the DLRSHFs, while it may act as a source of fertilizer to the soil, it potentially creates environmental challenges in Magwendere village. The burning of crop residue causes air, loss of precious nutrients, radiation imbalance, and high aerosols in the air, acid rain and global warming (Singh et al 2020). The burning of crop residue done by the DLRSHFs in Magwendere is not a practice that promotes sustainable agriculture, because it emits greenhouse gases that are responsible for climate change.

4.3.4 Water quality

The water quality results indicated that there is no difference in the water PH, Nitrite, Nitrate, smell and clarity of the stream water upstream and downstream of the study area. Over application of animal manure and nitrogen fertilizers in fields may contaminate water sources. The water quality in Magwendere village is within the ZINWA and WHO recommendations of

drinking water. The study finding on the water quality means that the DLRSHFs are not causing any noticeable pollution through the leaking of nitrogenous fertilizers or animal manure in the rivers and streams.

4.3.5 Seed varieties

Study findings revealed that none of the Magwendere DLRSHFs was procuring rice seeds from registered seed distributors. The farmers use seeds from previous harvests in their farming activities. A female young farmer said that:

"*We keep some of the harvested rice as seed for the upcoming agricultural season and we also get some from neighbours".* (Magwendere Village. 2023).

One community member said:

"*We also get seed from our relatives in Mozambique"*. (Magwendere Village. 2023)

The field observation revealed that people from Magwendere village and Mozambique could freely move across the border in the area without any restrictions and shared resources such as seeds, knowledge and even performed ceremonies such as rain petitioning together. One community member in his 90s said:

"*Dry-land" rice cultivation was a practice that we copied from Mozambique during the war of liberation when we took refuge in that country. We have been using the retained seeds ever since the 70s".* (Magwendere Village. 2023)

Poor rice varieties produce low yields and are susceptible to the effects of droughts and diseases (Munira et al, 2019). According to Britwum, K., & Demont, M. (2021), rice breeders in Africa must produce rice seed varieties that are suited to changes in climate conditions, are resistant to droughts, pests and other diseases, and must produce high yields. Rice breeders in Zimbabwe must make new rice varieties that are well suited to the climatic conditions experienced in the country and to the needs and preferences of the population.

4.3.6 Presence of rivers and streams

Study findings through field work indicated that the area is endowed with perennial rivers and streams that offer potential for irrigation. The major rivers in the study area are Rware, Nyamukombe, Mutangazi, Chipote. Some of the impotent streams in in the study area are Muoperwa and Rusamba. River discharge recordings done by the author in the study area revealed that Chipote River have an average river discharge of 8cumsper sec (Fig 6). Study findings indicated that the smallholder farmers draw water from some of the rivers and streams to irrigate crops such as bananas and beans using sprinklers and water moves in polythene pipes through natural gravity, cutting costs of pumping water using electricity. The study revealed that very little erosion resulted from the method of irrigation used in the area. Using water from the rivers and streams had the potential of transforming rice dry-land rice farming from subsistence to commercial. One of the farmers who used irrigation to grow his dry-land rice indicated that,

"I plated my rice field 2 months earlier and I was quite happy with the rice quality and this year I will experiment with a larger plot and I am even considering growing the rice this coming winter season under irrigation instead of waiting for summer rains". (Magwendere Village. 2023).

Importance of irrigation to rice farming is supported by farmers' positive perceptions in Benin who view use of irrigation as an insurance against drought. (Kwadzo etb al, 2018). According to Singh et al (2015), the implementation of water saving irrigation can improve water use efficiency in rice farming by reducing percolation and seepage losses. Studies in the study area revealed that the Smallholders were reducing water loss of through evaporation in irrigated banana fields by the application of mulch, and if such a technique is adopted to rice farming this has the potential to save water and fight climate change.

Fig 6, Chipote river in Magwendere village (source, author)

4.3.7 Rice diseases and pesticide use

From the study findings it was revealed that no major rice diseases exist. The DLRSHFs said

"We have never experienced a major disease that affects our rice". (Magwendere village. 2023).

Another farmer said:

"We have never used any pesticides in our rice fields because we don't know of any rice disease in our area". (Magwendere Village. 2023).

The absence of rice diseases in Magwendere village means that rice diseases is not a factor that reduces quality as well as quantity of the rice crop in the area. According to Iqbal (2020) yield losses due to diseases of about 1.2 to 2.2 tons/ha have been reported in rice fields in Asia. The non-use of pesticides as revealed by the DLRSHFs means that no threat exist to the health of the farmers. Absence of health challenges in the DLRSFs of Magwendere means that the farmers can productively cultivate their fields. Occupational health exists due to the use of pesticides in agriculture leading to poor health and possibly death (Elahi et al, 2019). The non-use of pesticides by the DLRSHFs of Magwendere also means that air, soil and water quality are

not threatened by pollution. Excessive use of pesticides may lead to the destruction of biodiversity (Shahzad et al, 2019).

4.3.8 Accessibility and communication

Field observation by the researcher indicated that the area is hilly and the roads are greatly eroded and difficult to navigate (figure 7). Interviews with the community members revealed that the movement of farm inputs and outputs is greatly affected by the poor state of roads. One community member said:

"*Farm produce such as bananas and avocadoes sometimes they rot by the roadside as we fail to get transport to move them to the markets due to the poor state of roads".* (Magwendere Village. 2023).

One community member said:

"We *rely on motorbikes for transport, since bus and minibus operators do not wish to ply this route and complain that the poor roads damage their vehicles and that spare parts are expensive to buy*". (Magwendere Village. 2023).

The councilor of the area said:

"*We hope that the District Development Fund will be used to fix roads in our area, poor roads in our area have stifled development for a long time*". (Magwendere Village. 2023).

Another community member weighed in on the state of the roads and said:

"*The eroded material from the roads has contributed to damaging road culverts and siltation of rivers and streams*". (Magwendere Village. 2023).

Such environmental destruction due to erosion and subsequent siltation of water sources in Magwendere village means that the achievement of sustainable agriculture on a commercial basis is highly debatable. The importance of accessibility in farming is supported by studies of subsistence farmers in the Eastern Cape Province in South Africa that revealed that poor physical infrastructure such as poor roads prevents sustainable agriculture (Khapayi, M., & Celliers, P. R, 2016). The findings are also in line with (Kiprono, P., & Matsumoto, T, 2018), who suggests that road infrastructure investment in South-Western Kenya fostered participation

by rural smallholder farmers to engage in sustainable agriculture and high productivity. Improvement of roads and communication network in Magwendere village has the potential of transforming the smallholder farmers to commercial farmers in a sustainable manner.

Figure 7, Poor roads leading to Magwendere village (Source; author 2023

4.3.9 Extension services

The study revealed that the area is served by two agricultural extension officers, and the agricultural officers cover the whole of ward 28. The study also highlighted the importance of the extension services as stated by the Chavanga community. One, community member stated that:

"*Without the invaluable services offered by the agricultural extension officers it was going to be difficult to carry out sustainable agriculture*". (Magwendere Village. 2023).

Another village community worker said:

"*Our farming operations are guided by informed decisions that we get from the agricultural extension officers*". (Magwendere Village. 2023).

The village head said that:

"*The extension services that we get are invaluable, we have been taught to practice conservative agriculture and it has made us to deal with climate change challenges and to conserve our soils and forests".* (Magwendere Village. 2023).

The study revealed that part of the services offered by the extension workers come in the form of 'field days' where farmers share experiences and best practices. The farmers however, shared a common sentiment on what they perceived as a challenge to extension services. 10 farmers said that:

"The extension officers were overwhelmed by the large number of smallholder farmers that they had to serve". (Magwendere Village. 2023).

According to Zimstas (2022) Chavanga village has 1,172 households which potentially require extension services. The extension officers remarked that:

"*We are overwhelmed by work and we do not attend to all situations that need our services timeously, and this obviously has affected the community and our reputation".* (Magwendere Village. 2023).

The extension worker also claimed that*:*

"Sometimes we do not have adequate fuel for our extension operations in the ward''. (Magwendere Village. 2023).

Sentiments by the extension workers of the study area on challenges that they encounter are similar to findings by Makate, C., & Makate, M. (2019) who alluded that ARITEX's major challenges in Zimbabwe are poor funding, poor remuneration, lack of appropriate technology, as well as poor operational resources like transport to reach all farmers. The field observation revealed that the each extension officer had a motorcycle that they use to reach out to the SHFs

in the ward. The study also showed that the extension workers were in possession of smartphones that they use to provide improved extension and advisory services through digital ways. Such findings are in line with the report of Chikwati, (Herald, 2021) who posits that the government of Zimbabwe in collaboration with the Food and Agriculture Organisation, launched the Technical Cooperation Programme (TCP) aimed at strengthening agricultural extension services in Zimbabwe, to support digitalisation of the extension system, train farmers on emerging issues relating to climate proofing agriculture. The role played by agricultural training and extension services has been highlighted by Pede et al (2018), who claim that such efforts has the potential to diffuse relevant new technologies to increase sustainable agriculture and productivity and alleviate rural poverty in Sub-Saharan Africa. The important services offered by the extension workers operating in Magwendere village means that they is great potential of DLRF to be carried out through sustainable agriculture, and if their efforts are bolstered through giving them more resources to discharge their duties more rice yields may be realised.

4.4.0 Funding

The focus group discussions revealed that the dry-land rice smallholder farmers did not get any funding from any organization, and solely depended on own funding for all their farming operations when growing rice. The focus groups also exposed the farmers main source of funding for rice activities, comes from selling farm produce such as bananas, avocadoes, beans and sugarcane. Interviews held with the smallholder farmers revealed that some supplement their income through hiring out their labour to the Eastern Highlands Plantation estates during certain periods in the agricultural calendar year. Other off farm activities noted during the research included selling of second hand clothes to get money for buying farm implements and sustenance at household level. One respondent remarked that:

"*We supplement our income through selling second hand clothes that we obtain from Mozambique and this has made it possible for us to fund our farming operation*s". (Magwendere Village.2023).

The study also revealed that some smallholder farmers were engaged in the brewing of homemade beer that they sell to the community to fund their farming activities and for other purposes such as payment of school fees. It was also noted during the study that sometimes the smallholder farmers invited community members to help in farming operations such as sowing, weeding and harvesting, and the participating members would be treated and served with 'mahewu' (a drink made from porridge) or 'seven days' (a local brew) together with breakfast and lunch. One farmer said:

"*Rice has become an important produce in our lives, and the government must consider it under the presidential input scheme"*. (Magwendere Village. 2023).

A young female farmer remarked that:

"*If we are to grow rice productively, it is imperative to put the crop under the Pfumvudza programme".*

Table 4 on the DLRSHFs financial inclusion status in 2023 in Magwendere village showed that only 2 DLRSHFs had active banking accounts. This shows that the majority of DLRSHFS are not using formal financial institutions for banking purposes. This confirms claims that lack of access to credit from banks by SHFs in SSA makes their farming less sustainable and efficient (.Teye, E. S., & Quarshie, P. T, 2022). Resultantly, financial exclusion of DLRSHFs of Magwendere village may mean that the farmers will fail to adopt environmentally sustainable farming practices that are productive which usually needs financial capital.

Table 3, Key financial inclusion indicators of DLRFs in Magwendere village, in 2023

Indicator	Percent (n=31)
Financially excluded	98
Formally served	2

CHAPTER FIVE

Summary, conclusions and recommendations

5.0 Introduction

This thesis took a bottom-up approach to analyse the feasibility of growing dry-land rice through sustainable agriculture on a commercial basis by smallholder farmers in Zimbabwe, a lesson from Magwendere village, Mutasa, District, Zimbabwe. Study findings unearthed important environmental, socio-political and economic factors that influence the feasibility of growing DLR in a sustainable manner. The challenges and opportunities that exist in the growing of DLR sustainably are highlighted and discussed. The impact of climate change and coping adaptions that are employed by the farmers are discussed. Improved DLR farming strategies are suggested in order to make the growing of the crop sustainably on a commercial basis.

5.1 Summary of findings

5.1.1 The feasibility of growing dry-land rice by Smallholder farmers in a sustainable manner in Magwendere village.

Objective one, tried to analyze the feasibility of growing dry-land rice by smallholder farmers in Magwendere village, Mutasa district through sustainable agriculture productively. To answer this question, data were analyzed and the major findings and literature indicated that soils, rainfall, and temperature are important prerequisites conditions that influence dry-land rice production in the study area and also in other regions in Africa, Asia and Latin America. The study findings revealed that the soil in the study area lacked important soil nutrient such as nitrogen, which is important in production of rice. Rice tillers and panicles are a major factor influencing rice yields. The rice yields are generally low owing to the low use of artificial fertilizers, which are beyond the reach of many Smallholder farmers. The soils where dry- land rice are prone to erosion owing to the topography of the area that has steep slopes. Lack of bunds, terraces and contour ridges to limit sheet, rill and gully erosion threaten sustainable agriculture to take place in the area. Study findings indicated that the area receives rainfall, above 1000 mm per annum

which is adequate for dry-land rice farming. The temperatures experienced in the study areas are high, around 24 degrees throughout the year, and such high temperatures promotes rapid rice growth, and sometimes causes moisture stress to the rice plants.

5.1.2 The impact of climate change on the growing of dry-land rice by smallholder farmers in Magwendere village.

Objective Two, which tried to assess the impact of climate change on the growing of dry-land rice by smallholder farmers in Magwendere village. To answer this question, data were analyzed and the major findings of the objective was that the smallholder rice farmers' perception indicated that climate change had significantly affected their farming operations, climate data analysis of the study area on temperature confirms farmers' perception. However, rainfall and soil wetness trend analysis refutes farmers' perception in the study area and literature also supports the existence of such contradictions. Literature indicates that rainfall monthly distribution and variability have changed, making rainfall prediction difficult. Due to climate change, farmers in the study area are now finding it very difficult to plan their farming operations. Farmers have now adopted adaptation measures such as late planting, irrigation, inter cropping, Zunde raMambo, use of IKS, sowing rice at different periods so that it matures at different time periods

5.1.3 The challenges and opportunities that exist in dry-land rice farming by smallholder farmers in Magwendere village.

Objective 3 was to examine the challenges and opportunities that exist in the feasibility of growing dry-land rice through sustainable agriculture on a commercial basis by smallholder farmers from Magwendere village. To answer this question, data were analyzed and the major findings show that challenges and opportunities which influence dry-land rice farming operates in the area. The presence of perennial rivers with high river discharge offers great potential for irrigation in the study area, and such findings on the use of rivers for irrigation of dry-land rice fields are supported by literature. Study findings have indicated that the high rainfall offers great potential for rain fed dry-land rice production. Pests such as quela birds and rodents were

identified as some of the challenges to dry-land rice farming and the pest management strategy used did not include the use of chemicals. The presence of weeds such as Striga was observed to contribute to low rice yields, and hand weeding was the major weed control method used.in the study field. The negative effects of striga on dry-land rice production and its management is well documented in Africa and Asia, and some of the control measures included use of mechanical and chemical means. Study findings indicated that the high costs of inputs such as fertilizers jeopardize the successful and productive cultivation of dry-land rice by smallholder farmers in Magwendere village. Lack of adequate use of fertilizer by smallholder farmers have also been cited by various authors in different parts of the world. However, literature also exposes the potential danger that artificial fertilizers pose when excess fertilizer leaks into water sources; the use of organic manure and rice straw residues has been mentioned as an environmental friendly substitute for inorganic fertilizers. Poor state of roads and communication networks were noted to be a major impediment to productive rice cultivation as it makes it difficult to move agriculture inputs such as fertilizers, and to transport farm produce to markets. Extension work has provided DLRFs with invaluable information and skills in conservative agriculture. However, efforts of extension workers are frustrated by a lack of adequate resources to discharge their duties. Lack of funding and exclusion of DLRFs from formal banking has been observed in the study area to be responsible for the low adoption of sustainable farming practices, similar observations have been cited in other dry-land rice farming regions in SSA and Asia. No diseases that affect dry-land rice have been observed in the study area, despite the high prevalence of diseases such as ‘rice blight’ which is a common disease mentioned in many studies elsewhere. The rice variety grown in the study area is obtained from recycled seed from previous harvests, and such seeds have less vigour and this affects rice yields. Literature indicated that new rice varieties have desirable traits such as high yields, diseases and stress tolerant. Land is owned communally, and this makes DLRFs reluctant to invest in measures such as afforestation and terracing to protect the rice fields and surrounding areas. Such a mentality by DLRFs of failing to adopt environmental protection leads to the tragedy of the commons and it has been mentioned as the trend in areas where the people do not have land rights by several writers. Rice polishing is manually done in the study area, and it is a laborious process. The use of appropriate and simple technology in rice polishing has been cited as having made dry-land rice production productive in Asia.

5.1.4 Proposed and improved strategies that have potential of making dry-land rice farming in Zimbabwe on a sustainable and productive basis possible.

Objective four, which tried to propose improved strategies that, has the potential of making dry-land rice on a commercial basis in Zimbabwe. To answer this question, data were analyzed and the major findings of the objective were that Zimbabwe could become a major dry-land rice producing nation if sufficient measures are adopted. Literature indicated that improved dry-land rice producing strategies include use of improved rice cultivars that produce high yields, drought and pests resistant varieties. Farmers must also get training from extension officers and agricultural institutions in order to become competent and to be more informed in their operations. Extension workers need to be capacitated and well resourced. Access to fertilizer use must improve in order to improve rice yields, and it must be applied in a sustainable manner to avoid contamination of water sources. The use of organic manure and other organic fertilizers must be encouraged and adopted by dry-land farmers in Zimbabwe. Development of appropriate and affordable machinery for use in the rice fields and in rice polishing will encourage more smallholder farmers to become more productive. The abundance of water bodies in Zimbabwe can also be a source of water for smart agriculture such as drip irrigation, which does not waste water and does not cause erosion.

5.2 Conclusion of findings

5.2.1 This section presents conclusions of the findings of the study looking at:

The conclusion on objective one, which sought to analyze the feasibility of growing dry-land rice through sustainable agriculture on a commercial basis by smallholder farmers in Zimbabwe, a lesson from Magwendere village, Mutasa district, Zimbabwe is that the area has sufficient feasibility for the cultivation of dry-land rice through sustainable agriculture at levels that are productive. The presence of soils that can respond well to the addition of fertilizers makes the area a suitable site for the cultivation of DLR. However, it is important that the farmers have access to fertilizers at prices that are affordable, and the right doses must be applied so that no pollution of water sources takes place. The use of alternative fertilizers such as organic manure

also offers plausible solutions that the DLRFs in Magwendere and Zimbabwe can adopt to reduce input costs. The geographical area of the study site enjoys favorable climatic conditions in terms of rainfall and temperature. Literature indicates that rainfall of around 540 mm during the cropping season is adequate for the productive cultivation of dry-land rice, and the study area together with other places in Zimbabwe display such rainfall characteristics. Excessive heat is a major threat to dry-land rice cultivation as this leads to moisture stress and this affects yields. Use of mulch in rice fields to reduce evaporation has been employed in many countries in Asia and such adaptation practices can be adopted by farmers in Zimbabwe

The conclusion on objective two, which sought to examine the challenges and opportunities that exist in the production of dry-land rice through sustainable agriculture by smallholder farmers productively in Magwendere village, exposed a plethora of findings. Water for irrigation plays a pivotal role in dry-land rice farming because it can supplement rainwater. The presence of rivers that can be utilized for dry-land rice cultivation through drip irrigation systems that use limited water. In countries in Asia, according to literature rice is grown throughout the year and this is achieved by the use of irrigation systems, and Zimbabwe being a country endowed with many rivers it can ride on this important resource to become a rice producing nation. Rice diseases, pests and weeds are among the major challenges that have been documented in many studies that reduces rice yields, and a number of management systems to control these have been suggested. The best management strategy is an integrated approach that controls such undesirable elements in a sustainable manner which does not harm the environment including the health of people. The use of artificial fertilizers by DLRSHFs in Mangwendere village and Zimbabwe while it must be encouraged to boost rice production, its use must be monitored to avoid possible poisoning of the natural environment that may lead to water contamination. The use of organic manure and rice straw residues are alternative sources of Nitrogen that is needed by rice plants and its use is more environmentally friendly advocates of the environment have been lobbying for its use in sustainable agriculture. Thus, DLRSHFs in study area and Zimbabwe can also adopt the use of rice straw and other farm wastes to fertilize the soil. Communication networks such as roads must be improved in the study area and Zimbabwe so that it is easy to move inputs and outputs. The state of roads in many SSA countries has been noted to be a major impediment

to crop production, and it is important to improve the communication network to spur development in these areas. Extension services are of paramount importance that must be provided to DLRF so that they are abreast with best practices that are productive and sustainable in order to meet the rice requirements of the country. Access to credit and funding of DLRSHFs is an important step in empowering the rice farmers. When farmers have access to funding they are more likely to engage in sustainable practices because such activities such as drip irrigation requires financial capital and for this to take place the government must put structures in place to enable farmers to benefit. New rice varieties that resist disease, pests and harsh environmental conditions must be developed and made available to the rice farmers at affordable prices. Communal ownership of land in the study area and the rest of Zimbabwe by smallholder farmers have proved to be the elephant in the room to that has resulted in the tragedy of the commons. Changes in policies that gives some security to the land that DLRSHFs and other farmers has the potential to make them invest sustainable practices such as terracing the land, afforestation, reforestation. Rice processing has been cited by many authors as a major issue that makes many potential rice farmers not to venture into rice farming. The use of appropriate and simple technology in rice sowing, weeding, harvesting and polishing if adopted in the study area and the rest of Zimbabwe this can make DLRF productive. EE has also been cited as an important process that is needed in making farmers to practice sustainable agriculture, and in Zimbabwe it is important that such education is provided informally and formally.

The conclusion on objective three, which sought to assess the impact of climate change on the growing of dry-land rice by smallholder farmers in Magwendere village has exposed that the vagaries of climate change. Especially temperature is of great concern to the farmers, the high temperature have the negative effect of making crops to wilt, and the accompanying heat waves causes health challenges to people and this affects their ability to till the land. Rainfall variability has also caused challenges to the farmers who are now finding it difficult to predict weather patterns. The occurrence of adverse weather such as floods and droughts according to literature has increased and this has created environmental problems and disrupted production of crops in many parts of the world. To fight climate change, strategies of adaptations that include EBA, smart agriculture, mulching, irrigation, conservative agriculture and use of rice varieties that are drought tolerant need to be adopted.

The conclusion on objective 4, which sought to propose improved strategies that has the potential of making dry-land rice on a commercial basis in Zimbabwe is that a lot of effort is needed from community to national level. Policy challenges and introduction of institutions that promote a participatory approach of all stakeholders involved in farming is necessary. Policy changes that appreciate the important roles that women and other marginalized people play in farming offers great prospects of dry-land rice production to be grown sustainably, bearing in mind that women in many smallholder farming communities are involved in the cultivation of food crops according to literature. Developing high rice yielding varieties, with incorporated drought tolerance and disease resistance can transform DLRF to be sustainable and productive. Efficient fertilizer use coupled with improved weed management can greatly improve rice yields. Smart agriculture that makes use of drip irrigation can reduce water waste and crop failure arising from water stress due to drought events. Soil quality improvement that makes use of organic material must be adopted. Zero tillage need to be considered by DLRSHFs in order to achieve sustainable agriculture productively in Zimbabwe. Access to credit, improved marketing, use of affordable appropriate machines need to be adopted in order to get positive results in rice production.

5.4 Implementable recommendations

The study recommends that they should be feasibility of growing dry-land rice by smallholder farmers in Magwendere village, Chavhanga, Mutasa, Zimbabwe by encouraging farmers to:

- Adopt intensive and increase the cropping area, improve the soil fertility and moisture holding capacity, and manage soil erosion, discourage the burning of rice straw, but instead use it as mulch or manure in rice fields and adopt an integrated weed and pest management approach.

The study also recommends that, policies and institutions are put in place that:

- Improve access to lines of credit and funding to farmers, access to Environmental Education on sustainable use of the land by smallholder, develop simple and affordable technologies be developed to modernise dry-land rice farming, capacitation of extension workers and access to new rice varieties, encourage the participatory approach and Land tenure that promotes sustainable use of resources in dry-land rice farming.

In addition the study recommends that the government must:

- Improve weather forecasting, develop an integrated water management approach to make irrigation more efficient, spearhead in research of improved cultivars that are tolerant to harsh environments, promote the use of IKS in combating climate change, improvement of transport networks so as to increase accessibility, improve management of rice disease and improved extension services, and encourage the value chain in dry-land rice production.

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Appendix 1

QUESTIONNAIRE FOR DRY-LAND RICE FARMERS			
Welcome • Thank you for taking the time to meet with me and to respond to this questionnaire. • I am a student from Bindura University of Science Education carrying out a study **on the feasibility of growing dry-land rice, and to assess the effects of climate change on rice cultivation in Magwendere village.** • Informed Consent: We would be grateful for your cooperation and we promise that everything you say will be kept confidential. The information gathered will be purely used for study purposes only.			
1	Sex:	Male Female	Tick one
2	Age of Respondents	18 -24 25-34 35-44 45-59 60+	Tick one
3	Level of education	Primary Secondary Tertiary	Tick one
4	Size of household	Mother only Father only Mother and father only Mother, father and children	Tick one
8	How long have you been growing dry-land rice	One year Two years Three years More than 4 years	Tick one

6	What is the size of land that you cultivate dry-land rice ?		
7	Do you cultivate the same piece of land every year	Yes No	Tick one
8	Where do you procure the rice seed that you cultivate?		
9	What method of land preparation and cultivation do you employ		
10	How much basal fertilizer do you apply per hectare		
11	How much top fertilizer do you apply per hectare		
12	What is your perception of the soil fertility where you cultivate your rice?	Poor Moderate Rich	Tick one
13	How many times do you weed your rice field		
14	What are the major challenges to dry-land rice cultivation?		
16	What is your understanding of climate change?		
17	How has climate change affected dry-land rice cultivation?		
What are your recommendations?			

Appendix 2

FOCUS GROUP QUESTIONS F0R COMMUNITY MEMBERS AND DRY-LAND SMALLHOLDER FARMERS

Purpose: To collect quantitative information on feasibility of growing dry-land rice, and to assess the effects of climate change on rice cultivation in Magwendere village

- To identify the feasibility of dry-land rice cultivation.
- To examine the feasibility of dry-land rice cultivation.
- To identify and assess the effects of climate change on dry-land rice farming.
- To identify and propose improved methods of growing dry-land rice.

Welcome

- Thank you for taking the time to meet with me and to respond to this questionnaire.
- I am a student from Bindura University of Science Education carrying out a study **on the feasibility of growing dry-land rice, and to assess the effects of climate change on rice cultivation in Magwendere village.**
- Informed Consent: We would be grateful for your cooperation and we promise that everything you say will be kept confidential. The information gathered will be purely used. For study purposes only.

Guiding questions.

1. **To what extent is cultivation of dry-land rice important in Magwendere village?**
2. **Do you think that the dry-land rice cultivation is carried out on a sustainable basis?**
3. **The use of virgin land for the cultivation of dry-land rice has it resulted in any environmental impacts. Explain how?**
4. **Do you think that the land preparation of dry-land rice appropriate?**
5. **The disposal of rice straw residue does it help in maintaining the soil fertility?**
6. **The use of ash from burnt vegetation as a form of potash to improve the soil fertility is it an appropriate technology that does not cause harm to the environment?**
7. **The use of artificial fertilizers in agriculture in the area has it posed environmental issues in the area?**
8. **How has the local leadership helped in the growing of dry-land rice in a sustainable basis?**
9. **Has the use of indigenous knowledge systems helped in the growing of rice in a sustainable manner productively?**

Appendix 3

INTERVIEWE INFORMATIONS FOR AGRITEX OFFICERS			INSTRUCTIONS
Welcome • Thank you for taking the time to meet with me and to respond to this questionnaire. • I am a student from Bindura University of Science Education carrying out a study **on the feasibility of growing dry-land rice, and to assess the effects of climate change on rice cultivation in Magwendere village.** • Informed Consent: We would be grateful for your cooperation and we promise that everything you say will be kept confidential. The information gathered will be purely used. for study purposes only.			
SECTION 1: DEMOGRAPHIC INFORMATION			
1	Sex:	Male Female	Tick one
2	Age of respondent		Tick one
3	Level of education	Secondary Tertiary	
4	How long have you served in the area?	One year Two years Three years More than 4 years	Tick one
5	How long have you worked with dry-land rice farmers?	One year Two years Three years More than 4 years	Tick one

6	What is the size of the households that you work with?	

7	What are the challenges that you face when doing your duties?	
8	The cultivation of dry-land rice is it a sustainable practice in the area?	
9	What are the challenges and opportunities for dry-land rice in the area?	
10	How has climate change impacted the dry-land rice farming in the area?	
11	What recommendations can you give for the sustainable growing of dry-land rice in the area?	

Appendix 4.

INTERVIEW INFORMATIONS FOR LOCAL LEADERSHIP/ COUNCILLOR			INSTRUCTIONS
Welcome • Thank you for taking the time to meet with me and to respond to this questionnaire. • I am a student from Bindura University of Science Education carrying out a study **on the feasibility of growing dry-land rice, and to assess the effects of climate change on rice cultivation in Magwendere village.** • Informed Consent: We would be grateful for your cooperation and we promise that everything you say will be kept confidential. The information gathered will be purely used for study purposes only.			
SECTION 1: DEMOGRAPHIC INFORMATION			
1	Sex:	Male Female	Tick one
2	Age of respondent		Tick one
3	Level of education	Secondary Tertiary	
4	How long have you served in the area as a leader?	One year Two years Three years More than 4 years	Tick one
5	How long have you worked with dry-land rice farmers?	One year Two years Three years More than 4 years	Tick one

6	As a leader what programs have you spearheaded for the sustainable management of agriculture in the area?
7	What assistance do farmers need to be given in order to improve the cultivation of dry-land rice farming?

8	As a leader what measures have you put in place to mitigate and adapt to the impacts of climate change on dry-land rice farming?	
9	What other factors do you think are important in the implementation of sustainable agriculture?	
10	What role can the government play in the growing of dry-land rice in the area?	
11	What recommendations can you give for the sustainable growing of dry-land	

	rice in the area?	