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Climate Variability and Adoption of Climate-Smart Agriculture in Zimbabwe

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Declaration

I hereby declare that I have done this thesis entitled "Climate variability and adoption of Climate-Smart Agriculture in Zimbabwe" independently, all texts in this thesis are original, and all the sources have been quoted and acknowledged by means of complete references and according to Citation rules of the FTA.

In Prague 16 April 2021

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Abstract

Climate projection points to consistent and long-term increases in mean monthly temperatures in Zimbabwe. These projected increases in temperature combined with concurrently reduced rainfall during farming seasons are widely viewed to increase the risks of crop failure and thereby threaten food security, particularly for smallholder farmers who mostly rely on rainfed cropping systems. Climate-smart agriculture practices offer alternative strategies for mitigating the impacts of climate change on agriculture and hence, safeguard sustainable agricultural production and food security. However, little is understood regarding the decision-making processes of Zimbabwean smallholder farmers when considering Climate-Smart Agricultural practices for adoption. Therefore, this study aimed to investigate the adoption of climate-smart agriculture by smallholder farmers in Zimbabwe. A survey of 112 farmers from Agro-ecological regions II and III was conducted using a structured questionnaire. The results from the Chi-square tests reveal significant differences in the adoption of crop rotation and reduced tillage between male and female farmers. Descriptive results on the reasons for adopting Climate-Smart Agriculture practices indicate soil protection accounting for 63.4%, increased crop yields 34.8%, and climate variability 25.9%. On the other hand, extensional services, radios, and phones are the prominent information sources with 67%, 51%, and 44%, respectively. Availability of information and knowledge about Climate-Smart Agriculture practices tailored towards farmers' preferential needs can influence and/or increase the rate of Climate-Smart Agriculture adoption in Zimbabwe.

Keywords: Adaptation, adoption, gender, climate-smart, smallholder, variability.

Contents

List of tables

List of figures

List of the abbreviations

AGRITEX	-	Agricultural, Technical, and Extension Services
BGS	-	British Geological Survey
CIAT	-	International Center for Tropical Agriculture
CIMMYT	-	The International Maize and Wheat Improvement Centre
CSA	-	Climate Climate-Smart Agriculture
DRSS	-	Department of Research and Specialist Services
ENSO	-	El Niño-Southern Oscillation
FAO	-	Food and Agriculture Organisation
FAOSTAT	-	The FAO Corporate Statistical Database
FTA	-	Faculty of Tropical AgriSciences
IPCC	-	Intergovernmental Panel on Climate change
ITCZ	-	Inter Inter-Tropical Convergence Zone
LSCFs	-	Larger Scale Commercial Farmers
MOA	-	The Ministry of Agriculture in Zimbabwe
MSD	-	Zimbabwe Meteorological Services Department
NGOs	-	Non-governmental organisation
NR	-	Natural Ecological Region
OCHA	-	UN Office for the Coordination of Humanitarian Affairs
SDGs	-	Sustainable Development Goals
SEEDCO	-	The African Seed Company
SSFs	-	Small Scale Commercial Farmers
WMO	-	World Meteorological Organization
ZIMSTAT	-	Zimbabwe National Statistics Agency
ZMSD	-	Zimbabwe Meteorological Services Department

1. Introduction

Climate change is a major challenge for farmers especially regarding sustained agricultural productivity in the subtropics. The livelihood of smallholder farmers in developing countries is largely dependent on agricultural activity and thus prone to the variability of natural weather patterns and its frequent extreme events (Asfaw et al. 2018). Current projections of the impact of climate change on food production and security lead to global nervousness. In Asia alone, for example, the agricultural harvest is expected to decline by 10-40% by 2050 due to climate change-related weather patterns (Kakraliya et al. 2018).

In Sub Saharan Africa, Zimbabwe is among the countries reportedly experienced with erratic and changing weather patterns (Mashizha 2017). In 2019, Zimbabwe was affected by Cyclone IDAI which destroyed not only the agricultural produce but also infrastructure and claimed human lives (FAO 2020). The erratic temperature and rainfall patterns are resulting in altered crop growing seasons. Climate change has increased the frequency of extreme events such as floods, storms, droughts, salinization, and ecosystems destabilisation (Kakraliya et al. 2018).

Zimbabwe's economy is significantly reliant on the agricultural sector as it contributes an estimated 15% annually towards the gross domestic product (GDP) and employs around 70% of the workforce. Over 69% of Zimbabwe's population resides in rural areas and is heavily dependent on agricultural activities for income, food, and the sustenance of their livelihood (FAO 2020). Hence, the Zimbabwean economy and livelihoods are indirectly prone to adverse changes in weather patterns that impact agricultural production. Maize (*Zea mays*) is Zimbabwe's staple food crop and is widely cultivated by Zimbabwe's smallholder farmers, who in turn are the drivers of the economy.

The Sustainable Development Goals (SDGs) of the United Nations (UN), among other goals, advocate for climate action responses (SDG13), the pursuit of zero hunger status (SDG2), and poverty reduction (SDG1). According to the UN, the realisation of SDG2 (zero hunger) is of crucial importance as it enables human development, thus further positively impacting not only national economies but also peoples' livelihoods.

This in turn makes it much more easier to work towards achieving other SDGs such as education (SDG4), equality, and social development (UN 2020). Since climatic shocks are one of the major threats to sustainable agricultural production and food security, it is therefore of great importance to dedicate significant resources to address this challenge in order to realise zero hunger and poverty reduction. The Food and Agriculture Organisation (FAO) stresses that, for agriculture to adequately meet the food requirements of the projected global population in 2050, in a manner that ensures sustainable rural development, there is the need to consider "Climate-smart-agriculture" (CSA).

CSA is an alternative to addressing the challenges of climate variability and climate changes. FAO (2018) defines CSA as an approach to developing the technical, policy, and investment conditions that are suitable for the achievement of sustainable agricultural development and food security during unusual climate conditions. CSA "is an approach that helps in guiding the actions required to transform or reorient agricultural systems to effectively support development and ensure food security in a changing climate" (FAO 2020).

CSA, therefore, aims to tackle the following three main objectives: i) sustainably increasing agricultural productivity and incomes, ii) adapting and building resilience to climate change, and iii) reducing and/or removing greenhouse gasses where possible. CSA adaptation is a broad term that encompasses activities such as minimal soil disturbance, crop residue retention, intercropping, and crop rotations. These activities either mitigate or offer potential solutions to the impact of climate change in Zimbabwe (Mazvimavi & Twomlow 2009; Mazvimavi 2010; Saj et al. 2017).

While numerous studies have been undertaken to investigate the usefulness of different CSA practices in mitigating the detrimental impacts of climate on agriculture in Zimbabwe, very few studies have been focused on the factors influencing the adoption of CSA techniques by Zimbabwean farmers. Hence, it is imperative to have a thorough understanding of how farmers' practices help to adapt to climate change variability which may affect agricultural productivity and food security. Therefore, the overall aim of this study was to investigate the adoption of climate-smart agriculture by smallholder farmers in Zimbabwe.

2. Literature review

2.1. Climate change and variability

Climate is the average weather condition of a given place over a longer period. The World Meteorological Organisation (WMO 2004) defines climate as the statistical variability and relevant mean of variables such as wind, precipitation, and temperatures in a period, not more than 30 years. The Intergovernmental Panel on Climate Change (IPCC 2014) defines climate change as “a change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties and that persists for an extended period, typically for a decade or longer”. Chamunoda (2011) describes climate change as statistically significant variation in either the mean state of the climate or its variability persisting over extended periods.

IPCC (2014) defines climate variability as “variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes, etc.) of the climate on all spatial and temporal scales beyond that of individual weather events”. However, climate variability infers variations in the mean state and other statistics (standard deviation, occurrence of extremes) of the climate on all seasonal time scales (Chamunoda 2011). Several factors can cause temperature fluctuations without causing long-term average changes. This phenomenon usually ranges from 2 months to as many as 30 months.

According to the British Geological Survey (BGS), climate change can be caused by natural phenomena such as volcanic activities, solar variability, plate tectonics, or shifts in the Earth's orbit (BGS 2021). However, climate change can also be attributable to human activity such as those which cause an increase in greenhouse gases. IPCC (2014) reported that global temperature increases of about 0.85°C from the year 1880 to 2012, concluding that the observed increase in global average temperature was caused by high emission of greenhouse gases and carbon dioxide (Brazier 2017).

Historically, Africa experienced and recorded a continuous significant change in climate and environmental conditions. Some studies reported radical changes in climatic variables such as drastic rainfall, temperature, and extreme weather events like floods and droughts which were experienced in Southern Africa (Handmer et al. 2012).

In many African countries, rainfall plays a significant role in agricultural production. Any alterations in rainfall patterns impact heavily on the economy and livelihood of the population, especially rural communities. In Southern Africa, rainfall patterns are mostly characterised by large-scale intra-seasonal and inter-annual climate variability. This variability often includes occasional El Niño-Southern Oscillation (ENSO) events in the Tropical Pacific resulting in frequent extreme weather events such as droughts and floods that reduce agricultural outputs leading to severe food shortages.

2.2. Zimbabwe's climatic characteristics

Zimbabwe is a landlocked country situated in central-southern Africa, between the equator and the Tropic of Capricorn. Extending from the latitudes 15°37' to 22°24' South, and longitudes 25°14' to 33°04' East. ZimStat (2020), estimated that Zimbabwe's population is 14.2 million. Zimbabwe covers an estimated total area of 390 757km^2. From the period 1901 to 2016, Zimbabwe experienced mean annual temperature and rainfall values of 21.33°C and 669.94mm respectively (World Bank 2021), which gives it a relatively mild subtropical climate with seasonal rainfall. The natural vegetation is predominantly Savanna woodland and grasslands. Despite significant local variations, the Miombo woodland is the most predominant ecosystem throughout most of the country. It is characterised by sparsely distributed trees, mostly of the *Brachystegia spiciformis* species, surrounded by grasses.

The Zimbabwean climate is markedly varied by altitude and strongly influenced by the Inter-Tropical Convergence Zone (ITCZ) which develops because of the collision of warm moist air masses from the north and cool air masses from the south, resulting in the main rainfall season (Mamombe et al. 2017). As shown in **Figure 1**, Zimbabwe experiences a rainy season along with relatively high temperatures from October to March, and a dry season with low temperatures from June to August. The dry and cold winter is characterised by sporadic ground frost and reaches its peak around late June and mid/late July. After the winter season, the average temperature rises to a summer peak around October or November.

Zimbabwe tends to receive less than average rainfall during the warm phase of El Niño–Southern Oscillation (ENSO) during the rainy season from October to March, and it often experiences more than average rainfall during the cool phase of ENSO also during the rainy season. In addition, the Inter-Tropical Convergence Zone (ITCZ) also plays a vital role in affecting rainfall seasonality. The country receives more rainfall when ITCZ moves south, and vice versa.

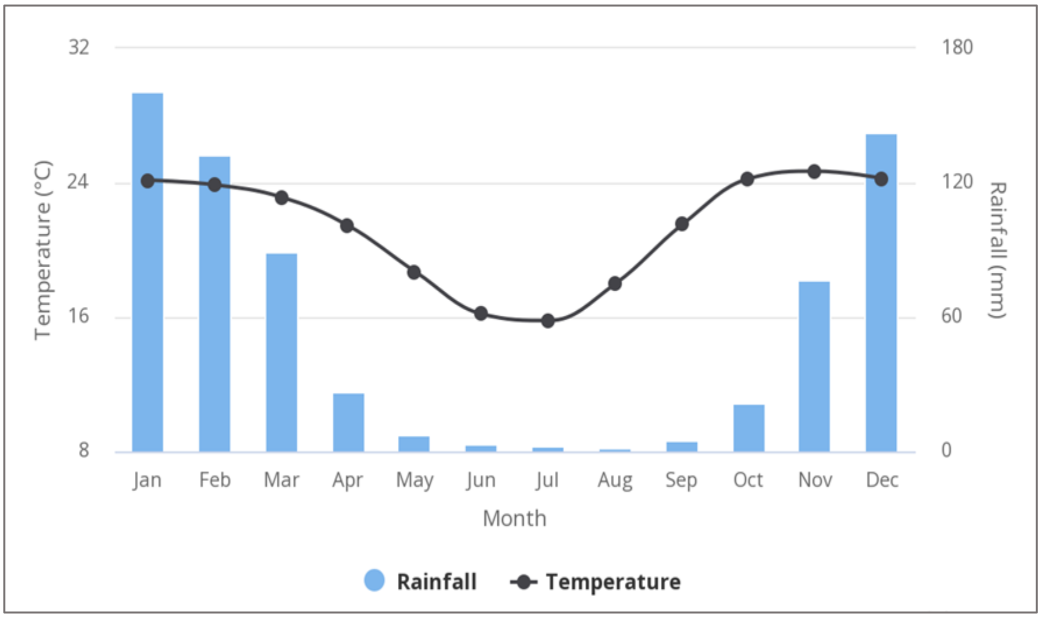

Figure 1. Average monthly temperature and rainfall in Zimbabwe (World Bank 2021).

Zimbabwe's mean annual temperature is projected to rise by an estimated 1.6°C (1.43°C to 3.13°C) in 2040-2059, while the annual rainfall will decrease by an estimated 61.68mm (-327.09mm to 184.36mm) within the same period (World Bank 2020). Among their recommendations to mitigate the detrimental impacts of climate change on the Zimbabwean agricultural sector, Hunter et al. (2020) encouraged the promotion of a more science-based crop production system, technologies, and management practices. There has been an overall decline of almost 5% in rainfall across Zimbabwe during the last century. The Meteorological Services Department of Zimbabwe indicated an increased number of years with below normal rainfall since 1980 and increases in the intensity of mid-season dry spells and/or droughts occurring frequently in the same season (Chamunoda 2011).

2.3. Agriculture in Sub-Saharan Africa

In Africa, the agricultural sector plays a significant role in rural livelihoods and national economic growth. Most of the African population resides in rural areas, and its livelihood greatly depends on agriculture activities, especially rain-fed agriculture. According to projections by Belloumi (2014), African agriculture is vulnerable and therefore, is likely to be impacted by the detrimental effects of climate change. However, little is known about the potential outcomes of the impact of climate change on different regions or crops (Dinar et al. 2012). Schlenker and Lobell (2010) recommended that it is crucial to prioritise investment that focuses on climate adaptation strategies and the potential use of scarce resources for agriculture development.

Ward et al. (2014) observed that over the past 50 years agriculture productivity has been gradually falling in Sub-Saharan Africa. Some of the major causes of poor performance in the agricultural sector involve issues such as inadequate supporting institutes, few initiatives towards agricultural intensification, unfavourable topography, and a poor policy environment. The impact of climate change, therefore, could negatively affect the livelihood of smallholder farmers thereby causing increased food insecurity in the region.

2.4. Agriculture in Zimbabwe

The agriculture sector contributes a large portion to Zimbabwe's economy relative to other sectors (FAO 2019). Smallholder farmers, especially rural communities have a significant contribution to the Zimbabwean agriculture sector. The rural communities largely derive their livelihood from their farming and other rural-related economic activities. The agriculture sector provides employment and income to over 65% of the national population (FAO 2019). Furthermore, the sector provides about 60% of the raw materials demanded by the Zimbabwean industrial sector and contributes about 40% of total export earnings (FAO 2020). Despite the high level of employment in the sector, it directly contributes 15-19% to annual GDP. This GDP figure, however, is significantly influenced by prevailing annual rainfall patterns (Brazier 2015). The situation is generally accepted that when agriculture performs poorly, the rest of the economy suffers.

This, therefore not only highlights the significance of the agriculture sector to the Zimbabwean economy but also reveals the vulnerability of the sector to fluctuations in climatic conditions. Historically in Zimbabwe, while tobacco has largely been the major exported cash crop, the staple food crop maize has been the most cultivated crop not only by production quantities but also by total harvested area (FAOSTAT 2020). Thus, maize, soybean, and tobacco have been the major cultivated crops over the past two decades. Among these, soybean and tobacco have interchangeably had the highest crop yields compared to maize as shown in **Figure 2** below.

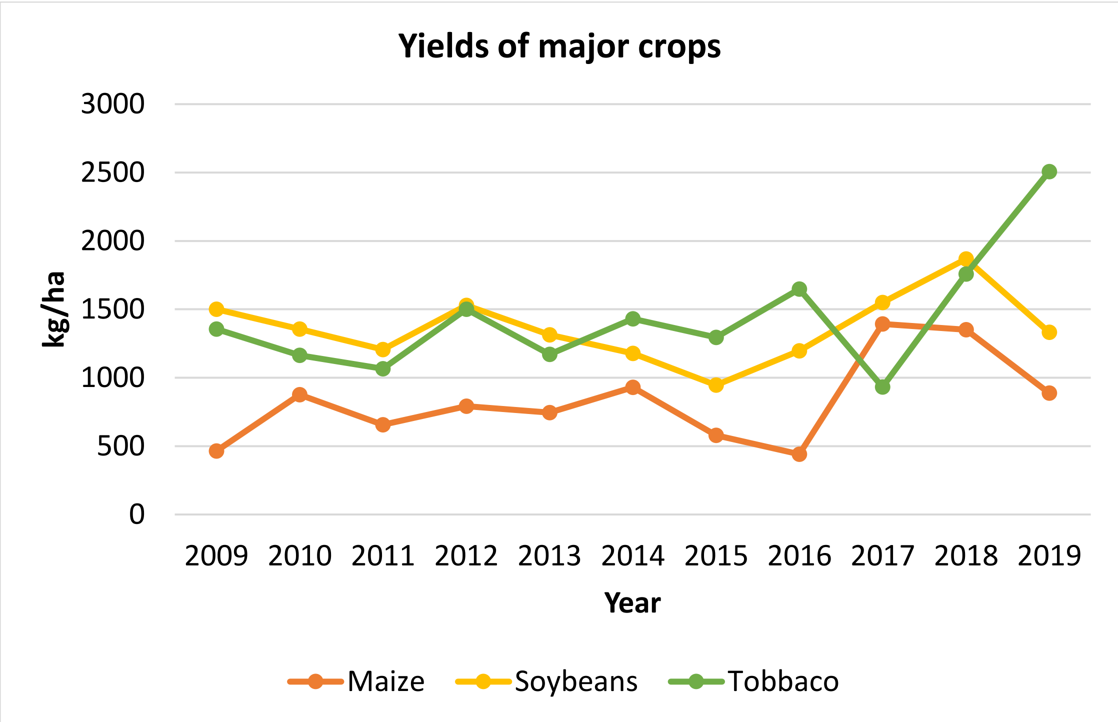

Figure 2. Agro-ecological zones and farming systems (FAOSTAT 2020)

2.4.1. Crop production

Zimbabwean agriculture system is immensely diverse with a wide range of crop production under rainfed and irrigated conditions. The farming season usually begins around October while it ends around April (Mazvimavi 2010). Zimbabwe's main agricultural products are maize (*Zea mays*), sorghum (*sorghum*), millet, wheat (*Triticum*), cassava (*Manihot esculenta*), cotton (*Gossypium*), tobacco (*Nicotiana tabacum*), coffee (*Coffea*), sugarcane (*Saccharum officinarum*), peanuts (*Arachis hypogaea*). Maize is the most important crop produced in Zimbabwe due to its attribute as the staple crop for most of the population (Marongwe et al. 2012). The maize crop for export and livestock feed is mainly produced by large-scale commercial farmers (LSCFs) whereas small-scale farmers (SSFs) production, which is the dominant production, meets the household demands with the surplus being marketed through formal and informal channels. The vast majority of SSF produce maize under rainfed conditions (Marongwe et al. 2012).

Zimbabwe's main staple crop (maize) production faces huge yield variations. This is most visible during the periods of lower-than-normal rains, producers fail to meet the demand of the national consumption. However, the opposite is true when the country receives normal precipitation there is a surplus for export and national consumption because the produce is more (Dorosh et al. 2007). The period from October to December is known as the planting season. Therefore, any changes in precipitation levels in the planting season will affect the early production while variations of precipitation levels from January up to March affect the last production. It is crucial for farmers to properly plan and prepare for the farming season. Smallholder farmers also produce various "minor crops" such as legumes (groundnuts, bambara nuts, and cowpeas), tubers (yams and sweet potatoes), leafy green vegetables, and beans. These minor crops are considered important for nutrition and food security. Wheat production is dominated by LSCF, under irrigation during the winter season. Other crops produced in Zimbabwe are barley, tobacco (main cash crop), sugar cane, soybeans, a variety of horticultural crops, coffee, and tea (World Bank 2017). Tobacco, sugarcane, maize, and cotton are the main export crops.

However, over the years, Zimbabwe faces a decline in crop productivity due to precipitation deficits and diminished soil fertility. The IPCC (2007) report, projected a drop in yield on the rain-fed crop production of 50% in 2020 in some African countries. In addition, Lobell et al. (2008) study on the effect of climate change in Southern Africa shows that maize production will decline by 30% by the year 2030. Food imports (specifically maize, wheat, and rice) have been on the rise in demand due to the poor macro-economic environment and the effects of climate extremes such as droughts and floods which result in significant agricultural losses.

2.4.2. Livestock production

In Zimbabwe, livestock is considered a major form of insurance against crop failure for farmers, livestock can be sold to purchase food and other equipment needed during dry seasons. Tawonezvi et al. (2004) reported that smallholder farmers represent a major share of livestock in Zimbabwe. Cattle are the major livestock produced in Zimbabwe followed by goats, sheep, poultry, and pigs. Tawonezvi et al. (2004) revealed that about 50% of poultry, pigs, goats, and sheep are reared by smallholder farmers mostly found in agro-ecological regions III, IV, and V. This environment is suitable for livestock production. However, the intensity of drought will make it difficult for farmers to cope strategically in the future.

2.5. Farmer's characteristics in Zimbabwe

Since the year 2000, there have been four distinctive farming systems in Zimbabwe. These are determined by agro-ecological aspects, tenure systems, farm sizes, crop and livestock production, levels of technology use, management, and income levels. The farming systems had also been shaped by the modern government administrations as well as being strongly influenced by the historical development of the country during the colonial era. Zimbabwean farmers are grouped into four main categories: Larger scale commercial farmers (LSCFs), Small scale communal farmers (SSCFs), Old resettlement schemes, and communal farmers (CAFs).

LSCFs are the most dynamic and economically dominant sub-sector which covers about 4500 farms with an average of 2500 hectares each (Woodend 1995). A distinguishing feature of LSCFs commercial farming is that it primarily produces for sale. Furthermore, this farming system holds a free title to land. Commercial farming is highly mechanized and fully commercialized. In Zimbabwe, commercial farming is predominantly located primarily in the areas of high agricultural and economic potential, which are natural regions I, II, and III. The farming system constitutes high-cost horticultural operations and extensive livestock and game farm production. Small-scale farmers are proportionally the dominant group within Zimbabwe. Scattered across the country, these farmers control on average an estimated 2.5 hectares of arable land each, which is mostly utilised for crop husbandry and animal husbandry (Zimstat 2019).

An estimated 52.3% of these are communal farmers, peri-urban farmers, and resettlement farmers (located in the poorer agro-ecological regions). Altogether, their livelihoods are largely dependent on climate-sensitive, rain-fed agricultural systems. Communal farmers are distinguished by being small-scale farmers who produce mainly for their consumption. Land ownership is usually obtained either as a gift from a traditional leader or passed on from one generation to another within a family. This farming system is a labour-intensive production system that usually makes use of ox-drawn implements.

Old resettlement schemes and communal farmers (CAFs) were introduced by the government's land redistribution programmes. In the early 2000s, the government carried out a land reform exercise that redistributed land ownership from larger-scale commercial farmers to numerous smallholder farmers. The land was distributed on an individual basis and/or in cooperatives.

2.6. Agriculture adaptation to climate change and variability

Adaptation is currently the most trending topic in the discussion of climatic change. Adaptation is defined as the adjustment in natural human response to an unexpected change in the environment. IPCC (2007) defined climate adaptation as a strategy to adjust a system to respond to the changing environment effects that help to moderate possible damages and to cope with consequences that may exploit potential benefits.

Adaptation can be categorized into planned (by the government policies) and autonomous which aids smallholder farmers to effectively implement agricultural adaptation practices (Mersha & van Laerhoven 2018). This helps to mitigate the effects and possible damage to food production.

To adapt to the changing environment and the local variation of the weather, farmers have widely adopted climate-smart agricultural techniques (CIMMYT 2020). Climate-Smart Agriculture is a trans-disciplinary approach, which employs different techniques to mitigate the impact of climate variability and ensure agricultural production and food security (Singh 2018). Pretty et al. (2003), highlighted that the adaptation of multiple adaptation practices influenced positively the livelihood of local communities socially, environmentally, and economically.

Some studies have reported on the wide adoption of drought-tolerant crops and crop varieties promoted in dry regions of Zimbabwe as a drought mitigation measure, to ensure food security and economic stability for the country (Lunduka et al. 2019). Nhemachena & Rashid (2010) indicate that understanding farmers' perception was a crucial element to formulate better responses and strategies in African countries. Thus, perception influences farmers' adaptation and/or coping with changes. CSA technology is increasingly promoted as a strategic approach to combat land degradation, mitigate impacts on drought and improve on rainfed agriculture (Lahmar et al. 2012).

2.7. Climate-smart agricultural practices

The global climate is reportedly changing, a key element to the world’s food security according to the Zimbabwe Meteorological Services Department (ZMSD) (Chamunoda 2011). Therefore, it is fundamentally important to monitor the agricultural systems and natural resources to ensure effective improvement on production and/or achieve the world’s food security (FAO 2020a). For this to be achieved the understanding of farmers’ perceptions on climate change remains essential for analysing farmer’s decision-making process on the adoption of climate-smart agricultural practices (Zhai et al. 2018). This knowledge supports the development of effective strategies aimed to protect the most vulnerable groups and build resilience and the ability to adapt to changing climate sustainably.

According to FAO (2021), the agriculture sector employs 60-70% of the population, supplies approximately 60% of the raw materials for industries, and contributes 40% to the total export earnings in Zimbabwe. However, considering the pressure on available land and natural resources as well as the changing climatic conditions. Rainfed agriculture alone is no longer a sustainable approach. Higher dependence on natural resources by most of the population renders the livelihoods of rural communities even more vulnerable to the negative impacts of climate change. It is, therefore, against this backdrop that the adoption of CSA as an agricultural adaptation and mitigation strategy is increasingly becoming important in Zimbabwe.

Climate-smart agriculture is one of the key solutions to sustainable agriculture, resource management, and future development. Mullins et al (2018) suggested integrated response strategies across different development sectors to address future and current climatic threats. Climate-smart agriculture is not a new technique but rather a technique that uses traditional ways of farming to help combat the effects of climatic (Lipper et al. 2014). The Food and Agriculture Organisation defined CSA as an approach to identify production systems that best respond to the impacts of climate changes and to adjust to systems that best suit the (current and future) local environmental conditions. This approach can help transform agricultural systems to support sustainable development as well as food security in the changing environment (FAO 2020).

In Sub-Saharan Africa, CSA practices are highly promoted due to their desirable attributes towards production (Fentie & Beyene 2019). CSA is about increasing sustainable production and income while adapting and building resilience to the negative impacts of climate change. At the same time, they also help with minimising greenhouse gases emission. Marongwe et al. (2012) reported that the farmers viewed CSA practices as the best farming system that could help lessen the negative effects which limited agriculture productivity in Zimbabwe. Their study pointed out that technologies such as minimum soil disturbances, application of organic manure, and crop rotation showed great potential to mitigate numerous production constraints which were experienced by producers. Some of the most common sustainable agricultural practices explained below are implemented by farmers in Zimbabwe.

2.7.1. *Reduced tillage*

Tillage is the mechanical manipulation, through digging, stirring, or overturning of soil for crop production. This technique affects the soil structure such as soil moisture conservation, soil temperature, and evapotranspiration processes (Busari et al. 2015).

There are numerous types of tillage practices which include, primary and secondary tillage, intensive tillage, conservation tillage, zone tillage, and reduced tillage. Reduced tillage is one of the most widely practiced tillage systems in Zimbabwe, which falls under CSA methods. The practice of minimum tillage is the cultivation of crops with minimal soil disturbance (Ndiritu et al. 2014). According to Johansen et al. (2012), minimum tillage promoted minimum soil disturbance, reduced evaporation rate, and improved soil structure. This may involve the use of a mouldboard plough, field cultivators, or other handheld tools. It is thus applicable even by small-holder farmers. Reduced tillage helps to ease the farming operations. Reduced tillage is widely promoted by non-governmental organisations (NGOs) and the Agricultural, Technical, and Extension Services (AGRITEX) in Zimbabwe (Musiyiwa et al. 2017).

2.7.2. *Improved crop varieties*

The Zimbabwe Agriculture Investment Plan (2013) takes into consideration the importance of climate-smart agricultural practices on the use of drought-resistant varieties. The use of improved maize varieties is the key option available to farmers as a defensive measure against drought in Zimbabwe (Kassie et al. 2017). Improved seed variety strategy is there to protect (particularly smallholder) farmers' produce from the hush constantly changing climatic conditions which serve to boost crop yields.

2.7.3. *Crop rotation and Intercropping*

Crop rotation can be defined as regular recurrent succession of different crops on the same land through a considerable period of years. The study conducted in Zimbabwe by Mashizha (2017) revealed that those farmers who practised crop rotation in their farming system improved their livelihood drastically. Arslan et al. (2015) investigated the effects of adopting crop rotation on maize yields for smallholder farmers. Their findings reported that an increase in maize yields were observed in areas with variable rainfall and reduced yields were observed in those areas with stable rainfall.

Intercropping is the cultivation of two or more crops on a single field at the same time. Most often, intercropping involves the cultivation of leguminous crops with cereals on the same piece of land either in different lines or randomly (Nkomoki et al. 2018). In Zimbabwe, Baudron et al. (2012) indicated that legume intercropping was found to have provided positive attributes such as the ability of the crop to form a closed canopy which is very essential in weed control. The factors that most influenced the adoption of intercropping maize-legume were the availability of labour and inputs. Beuchelt and Badstue (2013) suggested that intercropping has the potential to contribute to nutrition-sensitive agriculture. This practice carried the potential to raise the diversification of food grown hence raised diversity in the diet of households.

2.7.4. Mulching

Mulching fields with grass and crop residues are of vital importance to soil management such as addressing soil erosion and land degradation. Mulching entails leaving between some crop residue cover on the soil postharvest rather than slash and burn. Mupangwa et al. (2012) highlighted that mulching promotes moisture retention by reducing evaporation and runoff, thus increasing infiltration and reducing crop protection in Zimbabwe. Based on Musiyiwa et al. (2017), farmers use CSA practices such as mulching to aid in pests/disease control and soil protection in Zimbabwe. Ward et al. (2018) in Malawi highlighted that to address the challenges of soil erosion and land degradation mulching of crop residue among other CSA practices has been deployed as a sustainable setoff agriculture practice.

2.8. Effects of climate-smart agriculture on productivity

Agricultural activity has always been dependent on climate to produce reliable food for human consumption. According to Mashizha (2017), climate change poses a greater threat to food production, induced by rainfall variations. However, this is threatened by the risk of climate change with smallholder farmers as the most vulnerable group. Therefore, there is a need to find adaptive strategies to mitigate these challenges.

Sustainable agriculture is the key solution to increase productivity, mitigating challenges of water scarcity and impacts of climate change (Alare et al. 2018). Some benefits can be ripped from practicing crop rotation, improved crop varieties, mulching, reduced tillage, manure application, contour ploughing, and intercropping to promote agricultural yields (Branca et al. 2011). Nkomoki et al. (2018) highlighted that crop diversification ensures food security and improves human nutrition. Makate et al. (2016) indicated crop diversification improved productivity, increased production, and ultimately results in improved household income and nutrition. Their assessment revealed that crop diversification has a positive effect on the stability of crop yields and crop security. In the event of one crop failure, the farmer can profit from another crop (Njeru 2013; Teklewold et al. 2013).

2.9. Factors associated with the adoption of climate-smart agriculture

Despite the multiple benefits CSA practices offer, it is considered not a permanent solution to all climate change and variability-related problems (FAO 2020). Based on literature they are factors that influence the adoption of sustainable agricultural practices. The factors are classified as follows: household characteristics, farm characteristics, and institutional characteristics (Lunduka et al. 2019). The key determinants include education, age of household, gender, household size, land size, farmer's experience, and credit facilities (Muchuru & Nhamo 2019; Teklewold et al. 2019).

2.9.1. Climatic attributes

According to Teklewold et al. (2019), the choice of adaptation practices is determined by factors such as climatic shocks among other things hence the need to articulate adaptation strategies based on agro-ecological regions. Mazvimavi and Twomlow (2009) indicated that institutional support and agro-ecological location significantly influence the adaptation to CSA practices for farmers' resilience. Therefore, it is important to take note of multiple adaptive strategies for the improvement of household food availability security and reduced poverty notably in areas of dry regions (Musiyiwa et al. 2017).

2.9.2. Education

Education is an important factor that affects farmers' adaptation to climate variability. A study by Muchuru & Nhamo (2019) indicated that most of the farmers in Zimbabwe lack appropriate knowledge on how to respond to changing climate. A study conducted in Ethiopia by Lemessa et al. (2019) focused on adaptive strategies in response to food insecurities confirmed that educated smallholder farmers can make a clearer evaluation on addressing the situation than uninformed farmers. In addition, Lunduka et al. (2019) pointed that educated households are more innovative and they are risk takers when adapting to new technology. Furthermore, Oyetunde-Usman et al. (2020) highlighted that educated persons process the information about new technologies quickly and more effectively rather than uneducated people in Nigeria.

2.9.3. Age

Farmer's age can also influence the adoption of CSA practices (Farnworth et al. 2019; Mugandani & Mafongoya 2019). Ketema et al. (2016) demonstrated that elderly farmers are risk-takers, with increasing age, they become more attracted to adopt CSA practices compared to the younger generation lacking experience and knowledge. Nkomoki et al. (2018) found that a one-year increase in age indicates a 0.5% likelihood of a farmer adopting crop diversification. The reason being is to invest in a short-term and ripe variety of crops.

2.9.4. Gender

Gender traditionally plays a crucial role mostly in African society and has a positive influence on the adaptation of CSA practices. (Diouf et al. (2019) revealed that gender-based issues affected men and women in different ways which negatively affected their willingness and ability to adapt and implement CSA practices. The issue of culture serves as an important element when choosing suitable innovative systems since social groups are the drivers of the community (Farnworth et al. 2019; Mugandani & Mafongoya 2019). Consequently, for smallholder (especially for women) farmers to cope with the challenges of climate change and become more resilient, there is the need to consider gender aspects (Murray et al. 2016).

Murray et al. (2016), further demonstrated that women in Malawi lacked access to modern technology, thus, creating a hindrance to the adoption of CSA. They elaborated that most women are trapped in poverty due to a lack of resources. However, women in Zimbabwe commonly face mobility constraints limiting them from attending agriculture meetings (Mugandani & Mafongoya 2019). Ndiritu et al. (2014) assessment shows that women farmers adopted CSA less because 60% of farm work requires intensive labour such as weeding which mostly is done by women which may encourage dis-adoption of CSA as a gender-based barrier. In the study conducted by Lee (2017) in Kenya, women who often lack the opportunity to make decisions, and/or do not own land were often restricted to adopt CSA practices like intercropping because these practices resulted in larger structural changes on the farm. Singh et al. (2017) argued that male respondents have better contact with extensional services. The males were more likely to have exposure to training on agricultural management practices in line with climate change.

2.9.5. Household size

A study conducted in Zimbabwe by Lunduka et al. (2019) suggested that household size can influence CSA adoption. For a family to ensure sustainable food supply because of an increased number of household demand for food also increases. Lemessa et al. (2019) revealed that household size has a positive influence on the adoption of improved crop varieties. Labour as a resource also contributed significantly to the adoption of CSA practices. The households with a larger family size were more likely to adopt CSA practices such as mulching which pointed to high labour demand (Musiyiwa et al. 2017).

2.9.6. Experience and exposure

Experience and exposure can be defined as the time spent by the farmer on the use of improved agricultural technologies. This exposure has a significant influence on farmers' perception of CSA practices in Zimbabwe (Mugandani & Mafongoya 2019). A study by Muchuru and Nhamo (2019) indicated that most of the farmers who lacked appropriate knowledge of climate change in Zimbabwe lessened their ability to adapt to CSA. The investigation further highlighted that without exposure and experience farmers could compromise their crop productivity, which could negatively affect food security, thus leading to poverty. In Muchuru and Nhamo (2019) assessment, most African farmers encountered financial constraints, unfavourable policies, and received inadequate information which slows down the adaptation process of CSA practices. Lokonon & Mbaye (2018) confirmed that policy implantation strengthens farmers' awareness of climate change and improves the adoption of appropriate methods in Niger.

2.9.7. Resource ownership

Teklewold et al. (2019) reported that there is a higher likelihood of households with communication infrastructure adopting climate change adaptation practices compared to those that lacked the ability. Their study alluded to the fact that farmers with financial resource constraints were less likely to adopt climate-smart agricultural practices. Thus, only affluent farmers could intensify and diversify their production as an adaptive strategy (Singh et al. 2017). Lee (2017) found that the lack of funds was one of the main constraints for farmers to adopt CSA in Kenya.

2.10. Agricultural information and extension services

Agriculture in developing countries depends greatly on the use of mass media in the mobilisation of people for development. Mugwisi (2015) suggested that farmers face challenges regarding access to information and knowledge concerning agriculture-related issues. Teklewold et al. (2019) argue that informed farmers are more likely to adopt and integrate agricultural water management practices into their farming systems. Farmers face challenges in selecting the best and most effective channel of communication and how to source information and this can limit access to an extent that can be a constraint for farmers on adaptation to CSA practices (Murray et al. 2016).

Mass media is used for information dissemination to offer a means of informing farmers of new developments, reaching a wide spectrum at a fast rate. Access to information has remained a cardinal element in realising the sound adoption of CA. Muchuru and Nhamo (2019) also indicated initiatives to introduce an information-sharing platform as a strategy to combat the effects of climate change and to help farmers become more resilient to climate changes.

According to ZimStat, Zimbabwean farmers obtain agriculture-related data and information from various sources in Zimbabwe, depending on their level of farming activity and income potential. Commercial farmers tend to obtain most of the information through brochures or pamphlets from agricultural service providers such as fertiliser suppliers, seed producers, and agrochemical distributors. ZimStat (2019) reported that smallholder farmers obtain most of their information from extension officers and electronic media such as radio and television. When faced with agronomy-related challenges, most rural-based smallholder farmers tend to consult the locally based agricultural extension officers employed by the government.

In addition, the small-scale farmers benefit from educational programmes regularly aired on national radio and television, and which are primarily focused on good, trending, or emerging agronomic practices. However, probably the most influential primary source of data in Zimbabwe is the Meteorological Services Department of Zimbabwe (MSDZ). Among its numerous roles, the MSDZ is mandated with observing and monitoring hydro-meteorological parameters; provision archived and real-time data; as well as forecasting hazards (MSDZ 2021). The MSDZ is the major institution that deals with rainfall and drought-related information. It is also the major source of primary data issued on national radio and television, especially concerning weather forecasts.

2.10.1. Major sources of information transfer in Zimbabwe

2.10.1.1 Agriculture extension services and representatives

In Zimbabwe, numerous institutions provide agricultural extension services regarding crop production. The Zimbabwe National Statistics Agency (ZimStat) defined agricultural extension services as “technical assistance, advice or a demonstration of agricultural techniques given to farmers or a group of farmers to improve their productivity” (ZimStat, 2019). The major provider of extension services in Zimbabwe is the government through the Ministry of Agriculture, Department of Research and Specialist Services (DRSS) (ZimStat, 2019). The extension services are carried out by qualified officers distributed throughout all of Zimbabwe’s constituencies and they cover all cultivated crops and are given to farmers in need, at no cost. Most of this help involves demonstrations and advice on emerging, trending, and appropriate agronomical practices. However, additional services are offered by other private and charity organisations. Private organisations which provide extension services are predominantly seed-producing institutions such as SEEDCO. SEEDCO, a plant breeding, and seed-producing company have a publicly available catalogue of agronomist extension officers who reside in all of Zimbabwe’s major provinces (SEEDCO 2020).

2.10.1.2 Farmer groups and cooperatives

Cooperatives play an important role in rural society's livelihoods. Farmer groups are an important platform for spreading and gaining agricultural information. Farmers share resources and information in various ways, but most commonly through community meetings, and/or agricultural groups (Mtambanengwe & Mapfumo 2009). Their study suggested that it is important to take advantage of such existing platforms to promote and influence the adoption of CSA technologies. Interpersonal communication is often preferred by farmers to obtain relevant information that can assist in the decision-making process (Roger 2003). Wanyama (2009) assessed that in Kenya the Ministry of Development and Marketing reported that 80% of the population in Kenya derived their income from cooperative activities. Cooperatives exist to help sustain rural livelihoods through offering agricultural inputs, employment, as well as information to the vulnerable and poor (Mhembwe & Dube 2004). Often members organise meetings to create a platform for sharing information and resources required for production.

2.10.1.3 Radios

Personal constraints attributed to lower levels of radio ownership; poor network coverage demonstrated a clear barrier to smaller holder farmers to adopt adaptive farming practices in Zambia (Maggio & Sitko 2019). Diouf et al. (2019) stressed that reliable information such as rainfall variability projection enables them to prepare and make necessary adjustments regarding their production and prepare for the losses which may affect the reliability of food and food insecurity.

2.10.1.4 Phones

The investigation by Teklewold et al. (2019) revealed that individual farmers who owned mobile phones had a higher likelihood of improving crop variety in Ethiopia. Their study highlighted that an advanced communication infrastructure that facilitated access to information played a crucial role in enhancing climate change adaptation practices and getting convenient information and other agricultural-related information.

2.10.1.5 Television

Mass media platforms such as radios, televisions, and newspapers influence greatly knowledge acquiring and behaviour and play a significant role in creating environmental awareness and information sharing about climate-related information (Goddard et al. 2010). The study reported that there is a need to improve communication channels for effective communication.

2.10.1.6 Literature

The method of communicating information is important in facilitating well-informed decisions about farming activities Oduwole & Okorie (2010). Ifukor and Omogor (2013) allude to the notion that farmers acquired information through various sources such as newspapers, pamphlets, printed materials, magazines.

2.10.1.7 Internet

Internet connection and in rural areas has always been a challenge. In rural areas, it is a major constraint to relay online information sources with the latest and up-to-date technologies. In a study conducted in Ethiopia by Teklewold et al. (2019), results showed that individuals who owned mobile phones stood a higher likelihood of improving crop variety. According to Shanthy and Thiagarajan (2011) as communication and infrastructure improve it removes the barriers for farmers to efficiently assess climatic information. The emergence of information communication platforms such as the internet and online materials proved to improve reliable sources of information access, particularly to the marginalised rural populations.

3. Aims of the thesis

The main aim of the study was to investigate the adoption of climate-smart agricultural practices among smallholder farmers in Zimbabwe.

3.1. Specific objectives

1. To examine the influence of gender on the adoption of climate-smart agricultural practices.
2. To identify the reasons for the adoption of climate-smart agriculture practices.
3. To determine the sources of information that farmers use to obtain knowledge on climate-smart agriculture.

3.2. Research questions

1. Does gender play a role in the adoption of climate-smart agriculture?
2. What are the main reasons associated with the adoption of climate-smart agriculture?
3. What are the major information sources for promoting climate-smart agricultural practices?

4. Methodology

4.1. Agro-ecological regions in Zimbabwe

According to the World Bank. (2017), Zimbabwe is divided into five agro-ecological regions also known as Natural Regions in **Table 1** below.

Table 1. Agro-ecological zones and farming systems (FAO 2006; MOA 2017).

Region	Area (km^2)	Annual Rainfall/mm	Farming Systems
I	7,000	Above 1,050mm. Rains throughout the year with moderate temperatures.	Specialised and diversified, dairy farming, beef production. Crops; forestry, tea, coffee, fruits, and maize production.
II	58,600	700-1,050mm. Rainfall is limited to summer.	Intensive farming, livestock Crops; tobacco, cotton, and maize production.
III	72,900	500-700mm. Heavy rains, and subject to seasonal droughts and dry spells.	Semi-Intensive, maize, livestock. Crops; tobacco, maize, sunflower, cotton, and fodder crops.
IV	147,800	450-600mm. Experience seasonal droughts and dry spells.	Semi-extensive; livestock production, irrigated sugarcane, resistance fodder crops, forestry, and wildlife.
V	104,400	Less than 500mm. Erratic rainfalls and poor soils.	Extensive farming system; suitable for cattle ranching, irrigated sugarcane, and forestry.

4.2. Study area

The study was conducted in the Mashonaland West province of Zimbabwe, within the Makonde and Mhondoro-Ngezi districts. Mashonaland West covers an area of 57,441km² (Zimstat 2013). The major economic activities in both sampling areas were reported to be agriculture followed by mining and construction (Zimstat 2013).

The Makonde and Mhondoro-Ngezi areas fall under NR II and NR III, respectively. The climatic conditions in Mashonaland West province are quite diverse, as characterised by the presence of four (NR's II, III, IV, and V) of the five agro-ecological regions. NR II and III are instrumental to the national maize production. Most of the farmers in these two regions are known to practice mixed farming systems and livestock production (FAO 2006). The Environmental Management Agency (EMA) of Zimbabwe (2020), identifies gully erosion and stream bank cultivation as some of the major threats to the environment within the Mashonaland West province. According to EMA (2020), the major driver for streambank cultivation is water shortage, whereas gully erosion is soil erosion on exposed soils.

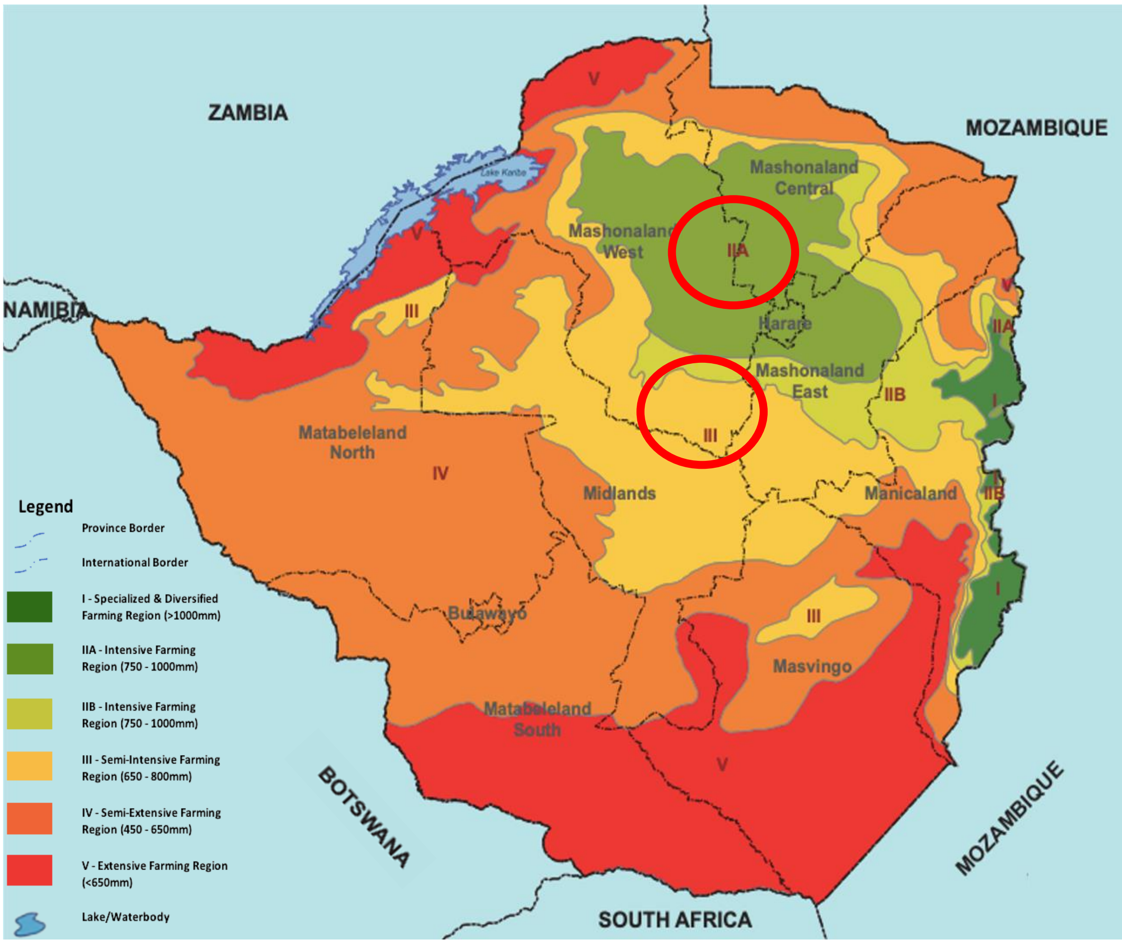

Figure 3. A map of Zimbabwe – Agroecological zones. Study sites highlighted by a red circle **Source:** Adapted from OCHA (2009)

4.3. Survey sampling procedure

The study area was selected using a multistage sampling technique. Studies revealed that Mashonaland West province has the highest adaptive capacity for improved agricultural practices among all 10 provinces (Hunter et al. 2020). These two agro-ecological zones are not only instrumental to the national maize production, but they are also predominantly located in regions where CSA practices have been highly promoted and publicised. Eight (8) wards were sampled using convenient means in each of the Mhondoro-Ngezi and Makonde districts. The respondents were selected using snowball sampling with the help of two knowledgeable extension officers who oversaw the respective wards along with 4 enumerators. A total of 112 respondents were interviewed; 60 in region III and 52 in region II.

4.4. Data collection process

The data was collected during the period from December 2020 to January 2021. The survey was conducted using a structured questionnaire. Heads of households were interviewed, and in circumstances in which the head was not present, the person second-in-charge of the household was interviewed. The Nest Forms-Survey Builder™ v.3.2.2 (2018) (https://www.nestforms.com) mobile application was used for data collection based on face-to-face interviews, with the global positioning system (GPS) location of the corresponding respondent subsequently captured and recorded. The survey was conducted by the researcher with the assistance of two agriculture extension officers and two others trained enumerators. The questionnaire had 17 questions which were divided into 2 major sections which consisted of farmer's characteristics, institutional characteristics, farm characteristics, climate-smart agricultural practices, challenges of climate climate-smart agriculture practices, and the major sources of information.

4.5. Data analysis

The obtained data was sorted, coded, and processed in Microsoft Excel sheets. Further analysis was conducted using descriptive statistics (mean, percentages, and frequencies). Furthermore, the Chi-square test was used to test the differences in adoption of CSA by gender. The analysis was carried out with the help of the Social Package for Social Sciences (SPSS) software 27.0.

5. Results and Discussion

5.1. Descriptive analysis

The study group of respondents was comprised of 112 individuals, 69.9% males and 30.4% females, the majority of whom were married (77.7%). The observed proportion of married individuals was comparable to the value (62%) reported by Zimstat (2013) on the province of Mashonaland West, the administrative region under which both study areas fall. As shown in **Table 2** below, the results revealed that attainment of secondary education level accounted for the largest proportion of the respondents (74.1%), followed by tertiary (15.2%) and then primary education (10.7%). Notably, all the respondents attained at least some form of education. More farmers practiced mixed farming (62.5%), compared to those who practiced only crop husbandry (37.5%). CSA techniques were quite popular among the farmers, as most of them (95%) had some knowledge about the farming practices. However, the study revealed that credit lines and cooperatives were less popular as they were utilised by only 18.8% and 39.3% respectively.

Table 2. Descriptive statistics of categorical variables (n=112)

Variable	Description	Frequency	%
Farmer's characteristics			
Gender	Male	78	69.9
	Female	34	30.4
Marital status	Single	4	3.6
	Married	87	77.7
	Divorced	2	1.8
	Widowed	19	17.0
Level of education	Primary	12	10.7
	Secondary	83	74.1
	Tertiary	17	15.2
Informed about CSA	Aware of CSA	107	95.5
Institutional characteristics			
Credit	Had financial support	21	18.8
Cooperatives	Member groups	44	39.3
Farm characteristics			
Farming system practised	Crop production	42	37.5
	Mixed production	70	62.5

The results in **Table 3** below show the continuous variables of household characteristics and farming characteristics of the respondents. The respondents' age ranged from 20 to 79 years, and the mean age was 46.81. This indicated that most of the farmers engaged in farming, earlier in their life. Farmers within the study group attended school for a minimum and maximum of 3 and 19 years respectively, and the observed mean number of schooling years was 10.73. The average household size was 6.88 members and the mean farming experience of 13.97 years.

Concerning the farming characteristics, the average total land size of 6.68 hectares was reported with a minimum and maximum of 0.9 hectares and 22 hectares, respectively. The results indicated an average of 15.87 livestock with a minimum range of 0 and a maximum of 110 animals. This result indicated that not all the farmers were in a position to own livestock. Some of the farmers revealed that they had challenges purchasing livestock due to financial constraints.

Table 3. Descriptive statistics of continuous variables (n=112)

Variable	**Description**	**Mean**	**SD**	**Min**	**Max**
Farmer's characteristics					
Age	Years	46.81	13.86	20.0	79.0
Education	Years of schooling	10.73	2.61	3.0	19.0
Household size	Individuals in house	6.88	3.11	2.0	20.0
Farming experience	Years of farming	13.97	10.50	2.0	49.0
Farming characteristics					
Land size	Hectares	6.68	3.70	0.9	22.0
Livestock	Number of livestock	15.87	26.49	0.0	110

Note: *SD denotes the Standard Deviation which is the measure of dispersion or spread of a set of values. The lower the SD, the closer it is to the mean value of the range of values.*

The study (**Table 4**) showed that mulching was the most popularly adopted (96.4%) of the four CSA techniques. This may be because the farmers viewed mulching as an easier technique to practice. Findlater et al. (2019) revealed the sustainable use of crop residues, by avoiding the burning of crop residues that can be utilised as soil cover in South Africa. In contrast to other techniques which require capital for purchasing additional resources, mulching often entails the use of abundant and readily available materials as mulch, such as crop residue, tree leaves, and grasses. Musiyiwa et al. (2017), suggested that mulching is rather difficult to practice due to poor crop biomass production and competition to be used as animal feed. While Alare et al. (2018) revealed that mulching was difficult to practice because of low crop residue which resulted from lower productivity.

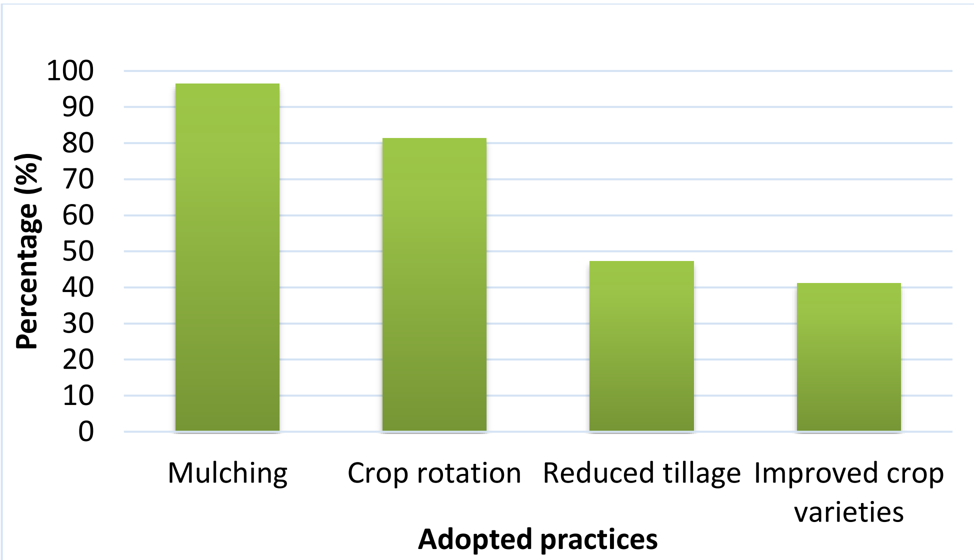

Figure 4. Adoption rates of CSA techniques among farmers.

The obtained results demonstrated that crop rotation is widely implemented by the farmers (81.3%). Among the four surveyed CSA techniques, crop rotation presents the most multidimensional benefits. Crop rotation improves crop productivity, food diversity, soil structure, soil biological activity and it further helps with pest management. Silva et al. (2020) revealed that crop rotation soybeans and maize improved maize yields in Brazil. According to Thierfelder et al. (2012), their study confirmed that crop rotation has the advantage of improving soil water infiltration, soil structure, and biological activity. The increased infiltration minimises water loss due to runoff, thus increasing water availability to plants.

Generally, it is a common tendency among smallholder farmers in Zimbabwe to cultivate various underutilised or neglected crops such as bambara nuts, peanuts, cowpeas, sorghums, and millets, alongside the principal or staple crop (Thierfelder et al. 2012). This crop diversity presents a conducive environment for practicing crop rotation. Thus, the favourable environment combined with the multi-benefit role of crop rotation would therefore be expected to make the practice quite popular as farmers attempt to integrate these predominantly leguminous crops into their fields.

The study revealed that 47.3% of farmers practised reduced tillage. According to Musiyiwa et al. (2017), reduced tillage is a conservation farming technique preferred by farmers in some regions such as, Kadoma and Mazowe/Goromonzi, two sub-humid regions of Zimbabwe. However, the observed implementation rate of this technique was still below 50%, suggesting some general disinterest in the technique among farmers. This may be due to the well-documented additional labour required to implement this technique. Instead of utilising machinery or widespread ox-drawn ploughs for preparing fields, which are both less physically demanding, this technique often requires the use of more laborious hand-held equipment to dig individual holes into which seed will be sawn. This idea is supported by Teklewold et al. (2019), who suggested that the low adoption rates (9%) reported for the technique in Ethiopia were largely attributed to a general dislike for the additional labour by farmers. The study revealed that improved crop varieties were the least implemented practice (41%) among all four of the surveyed techniques. This situation could be attributed to the additional expense involved in acquiring the seeds of the improved varieties.

Zinyengere et al. (2011) highlighted that most of the farmers relied on the government and/or NGOs for support with the farming inputs, as growers are quite unlikely to manage to purchase the expensive crop seeds. Landrace crop varieties are quite popular among farmers in rural Zimbabwe and some often recycle seeds from the previous harvests. Those who use improved seed varieties often receive them as free inputs provided by the government and other NGOs through cooperatives.

5.2. Gender and adoption of climate-smart practices

Table 4 below highlights the differences in adoption rates of CSA practices between males and females. Corresponding to the results, all the 34 women adopted mulching while 74 out of 78 men adopted the same practice. Generally, there was a higher likelihood of women adopting the practice (100%) compared to men (94.87%). In rural Zimbabwe, despite joint fieldwork activities, women are traditionally the principal custodians of small home gardens, in which vegetables are predominantly grown, whereas men oversee the activities involved with the larger crop fields, in which maize and other cash crops are grown. Mulching is principally adopted for enhanced moisture retention and is a more basic requirement for vegetable gardens in contrast to the larger fields, hence, it would appear to be more popular among women. Statistical analysis with the Chi-square test, however, demonstrated that this difference in adoption rates is not significant.

With regards to crop rotation, 59 out of 74 men adopted the practice compared to 32 out of 34 for women. This equated to adoption rates of 79.72% and 94.11% for men and women, respectively. Statistical analysis further showed that the differences in adoption rates are statistically significant. This implies that women were more likely to adopt crop rotation compared to men. Crop rotation is characterized by crop diversification which attracted women. This is attributed to females adopting crop rotation to diversify their produce for marketing and income generation. Farmers revealed that diversifying crops minimised the risk of crop failure, and by growing more crops they could sell and generate income as compared to men who focused more on mass production of one major crop (maize) for resale. This is supported by Nordhagen et al. (2021), who suggested that women were more likely to adopt crop rotation to create and diversify their income generation.

The results indicated that 42 out of 78 men practised reduced tillage while only 11 from 34 women utilized the same practice. This implies that reduced tillage was more likely to be adopted by men compared to women, and further analysis revealed that the difference was statistically significant (P-value = 0.036).

The discrepancy may be attributable to the increased labour demand of the practice. Thus, women the less physically active, were less likely to adopt reduced tillage as it required more labour. The situation was similarly observed and explained by Pilarova et al. (2018) in their study in Moldova. In this study, women cited additional time-consuming responsibilities and household chores when compared to men, which include cooking, fetching firewood, taking care of children, as a major impediment in implementing the practice. This factor was similarly reported by Ndiritu et al. (2014), who concluded that women farmers are less likely to adopt reduced tillage because they generally carry out most of the farmwork compared to men, leaving them more unwilling to adopt practices that require additional effort.

Table 4. Chi-square Test - Gender and implementation of practices (n=112).

Practice	**Gender**				**χ^2 -value**	**P-value**
	Female		Male			
Adopted practices (N)	Yes	no	yes	no		
Mulching	34	0	74	4	1.808	0.179
Crop rotation	32	2	59	19	5.306	0.021*
Reduced tillage	11	23	42	36	4.388	0.036*
Improved varieties	10	24	36	42	2.742	0.098

***Significance at 0.05. P-value denotes the statistical difference between males and females expected values*.**

The study revealed that improved crop varieties were more popular among men, with an adoption rate of 36 out of 78 (48.64%), compared to women, with an adoption rate of 10 out of 34 (29.41%). Notably, both adoption rates were still below 50%. This situation is likely because, in contrast to other techniques, improved varieties require significant financial capital. Most of the rural smallholder farmers may not be able to meet the expense of improved seed varieties and the inputs needed to support the practice, instead make use of landrace varieties, or recycle seeds from the previous harvest. The higher likelihood of men adopting the practice compared to women may be because men within the study area are much more likely to achieve higher forms of education compared to women (Zimstat 2013). Better education implies that men are more empowered to make technical decisions. This knowledge is usually obtained from school or their interactions with extension service officers. Generally, farmers with better formal education are more likely to find it easy to understand the techniques recommended by extensional officers. Furthermore, according to the prevailing socio-cultural customs, men usually attend organized community meetings, where they get informed of emerging or popular trends in crop husbandry, while women are expected to stay at home and perform household duties. According to Ouédraogo et al. (2019) farmers who were in contact with extension services increased knowledge and adopted more CSA practices. However, the Chi-square test revealed that there is no statistical difference in gender when implementing improved seed varieties.

5.3. Reasons for adopting climate-smart agriculture

Farmers were interviewed on the major reasons for adopting CSA practices. Their reasons were put in one of the three categories based on preference, namely, low, medium, and high preference. Notably, most of the farmers (63.4%) had a high preference for practices that contributed to soil conservation. The study revealed that the highest priority was placed on soil protection by most of the farmers. Soil is the medium in which farmers practice agriculture and is one of the primary physical assets on which farming is heavily reliant. Good soil properties, such as structure and fertility, are important limiting factors in agricultural production. Most households are concerned about food security and availability, with farmers, therefore, tending to adopt techniques that preserve and protect beneficial soil properties, thus safeguarding the major asset they possess.

Furthermore, the main objective of smallholder farmers engaging in agricultural activities is to ensure food security, hence, together with increased crop yields, the two were the topmost reasons for adopting CSA.

The availability of CSA inputs was also among other reasons influencing its adoption. Farmers were more willing to participate in the implementation of CSA when they are supported with agricultural inputs. Farmers highlighted that governmental and/or NGO's support encouraged the adoption of CSA practices and as a result, they benefited from the free inputs distributed to them. This idea was supported by Lee (2017) in Kenya who pointed out that farmers' decision of adopting CSA was influenced by the availability of agricultural inputs.

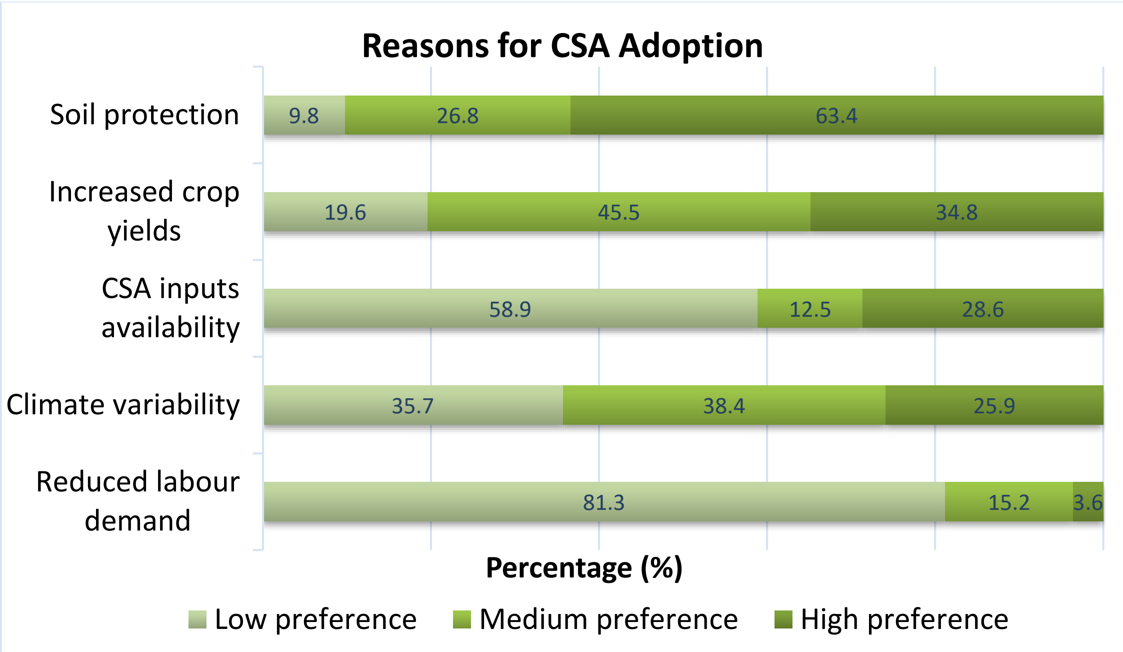

Figure 5. The major reasons for CSA implementation.

Climate variation was also cited among the reasons for adopting CSA practices. Large-scale crop failure due to a decline in precipitation persuaded farmers to search for alternative solutions for more sustainable production. Nevertheless, relatively less consideration was placed on this factor compared to other factors. Practices that call for special techniques, skills, or procedures which farmers lacked appeared to be discouraging for them to adopt. Lee (2017) indicated that CSA was mostly adopted by farmers with technical and/or practical knowledge in Kenya.

The majority of the farmers acknowledged the reason that CSA techniques offered the benefits of reduced labour demand (3.6%).

5.4. CSA information sources

In **Figure 6** below, farmers disclosed the major information sources mostly used in specific growing seasons. With the help of the scale, farmers were asked to rank how regularly they received information about CSA. They indicated that rare (0-2 times), moderate (3-4 times), and regular (more than 5 times). Nyasimi et al. (2017) emphasized that reliable information such as planting dates, crop rotation, proper spacing among others will enable farmers to better prepare and make necessary adjustments regarding agricultural production.

The majority of the respondents (67%) disclosed receiving most of their oral information from extension services. Extension services are supported by the Zimbabwean government. Therefore, extension agents are mandated to visit, advise, and deliver other agricultural-related information required by farmers for agricultural activities. Similarly, in the investigation conducted by Gwandu et al. (2014) extension services were reported to be the most preferred source of information by respondents in Zimbabwe. This is attributed to the reliability and availability of extension services to farmers (Nyasimi et al. 2017). Musiyiwa et al. (2017), demonstrated that the majority of farmers obtained information regarding soil and water management from extension officers and other NGOs in Zimbabwe. Furthermore, Asfaw & Neka (2017) stressed that those farmers exposed to extension agents had a higher probability of accessing agricultural information in Ethiopia. This, therefore, encourages and influences farmers to adopt the soil and water conservation practices because of the information they receive on the advantages of the CSA practices. Teklewold et al. (2019) further confirm the importance of extensional services and how they positively influence the adoption of climate-smart agriculture in Ethiopia. In contrast, Pilarova et al. (2018) reported that sustainable agricultural practices were not affected by the utilisation of extension services in Moldova.

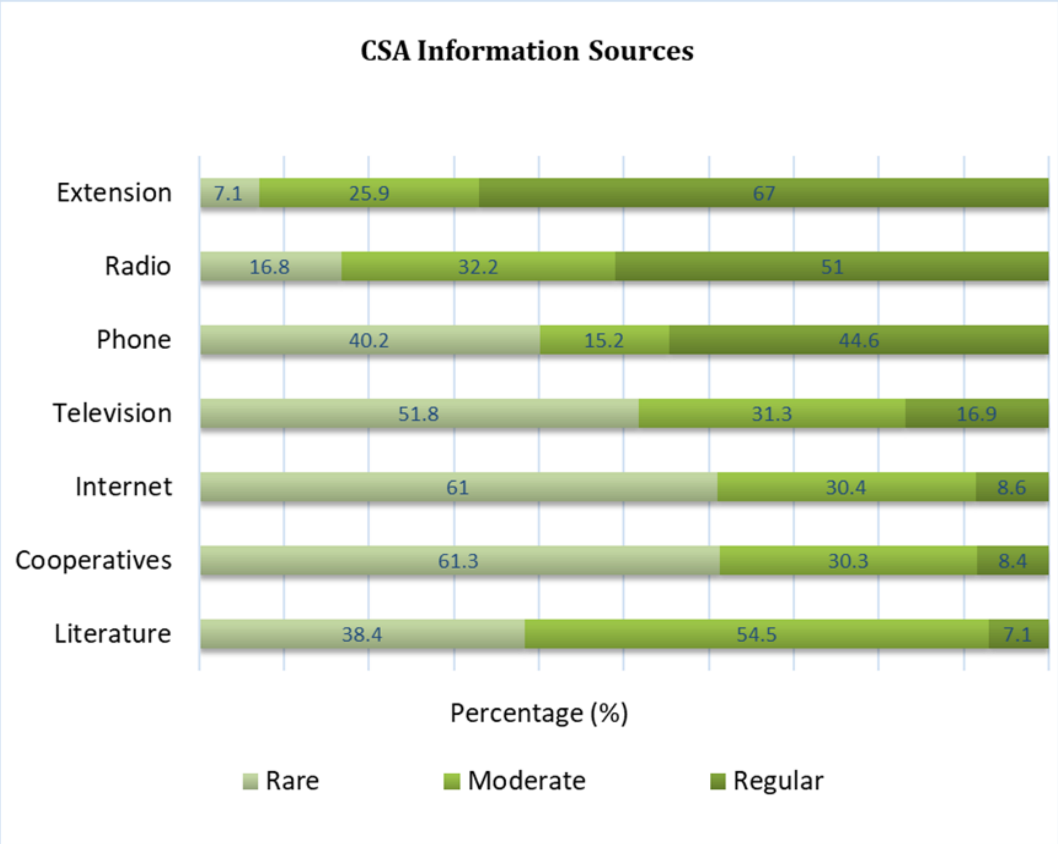

Figure 6. Major CSA information sources.

Radios and television were ranked among the most preferred forms of communication by respondents. Farmers seemingly preferred to listen to airing agriculture programmes such as Murimiwanhasi and Talking farming, airing live on radio or television every week. Maggio & Sitko (2019) further elaborated that well-educated male-headed households who had access to radio and/or television accessed valuable information in Zambia. Additionally, Diouf et al. (2019) revealed that women prefer radios as a communication channel to men, as a means of assessing information such as daily rain forecast, dry spells, and planting dates in Senegal.

Mugwisi (2015) confirmed that farmers obtained agricultural-related information on television broadcasted by various agricultural institutions in Zimbabwe. Regardless of the potential role offered by mass media, their study concluded that media houses have limited staff who dedicate time and effort to agriculture-related information. Television was among other preferred sources of information access and was considered a fairly useful form of CSA information access.

The study also revealed that cooperatives were rarely used as CSA information sources in study areas. Normally, cooperatives were formed for a short duration of time and intended to serve a specific purpose such as input support then dissolve. This was supported by Gwandu et al. (2014), highlighting that most farmers were unwilling to participate and access information from farmer groups due to a lack of trust and confidence in the quality of the information in Zimbabwe. In contrast to the results, Diouf et al. (2019) pointed out that women received climate-related information during social gatherings in Senegal.

Literature was rated as the least CSA source of information. This may be because respondents considered researching for information to be draining, time-consuming, and often had a limited understanding of the published information sources. This agrees with Mwalukasa (2013), which unveiled that the majority rural population is often characterised by a low literacy rate hence, limiting their understanding of the published materials in Tanzania.

5.5. Challenges in practising climate-smart agriculture

From the interviews, farmers outlined some of the challenges faced when practicing climate-smart agriculture in their respective agro-ecological regions. Based on their response unavailability of CSA information, lack of appropriate tools, high labour demands, and the variability of rainfall were highlighted among some of the challenges encountered in practicing CSA. Farmers reportedly experience high labour demand due to the recurrence of weeding which appears to be a major setback when implementing minimum tillage. Furthermore, farmers revealed that pests and diseases such as the fall armyworm (*Spodoptera frugiperda)* in maize, and termites, were among the challenges faced by farmers when practicing CSA.

Farmers also reported that the government, through extension services under the AGRITEX provided farmers with little or no financial support regarding CSA practices. Farmers indicated that it was more difficult to adopt new strategies risking their production without adequate knowledge and resources to support them. Farmers highlighted that without governmental support with farm inputs, agriculture, and equipment, discouraged them from adopting CSA practices despite the advantages offered.

6. Conclusions and Recommendation

The first objective was to examine the influence of gender on the adoption of climate-smart agricultural practices. The study revealed that gender played a role in the adoption of some of the CSA techniques. The adoption of crop rotation and reduced tillage in the study area was influenced by gender, whereas that of improved varieties and mulching were not influenced by gender. Crop rotation is more likely to be adopted by females than males whereas reduced tillage is more likely to be adopted by men compared to women. To improve adoption rates of practices within the study area and possibly the whole country, it is therefore recommended that different CSA stakeholders target the gender which is less receptive to practices in their educational and awareness campaigns.

The second objective was to identify the reasons for adopting climate-smart agriculture practices. The findings showed that climate variability benefit was less likely to influence the implementation of CSA when compared to reasons of enhancing soil fertility and increasing crop yields. For sustainability and improved productivity, the government of Zimbabwe must encourage and promotes climate-smart agriculture to favour environmental management controls. Another recommendation could be structured towards supporting farmers with an increased quantity of subsidised inputs to ensure enhanced use of practices such as improved seed varieties.

The third objective was to determine the sources of information that farmers use to obtain knowledge on climate-smart agriculture. The results indicated that extension services followed by radios and televisions are the most influential sources of CSA-related information among rural smallholder farmers in Zimbabwe. Extension agents are mandated by the government to offer free services to farmers concerning their farming activities. As the most influential channels of information dissemination, it is therefore recommended that different stakeholders adopt this route in spreading CSA-related information in the future. These sources of communication require some form of education to access the information. Therefore, the government of Zimbabwe needs to invest more in the education and capacity building of extensional workers to ensure improved service delivery, as well as the effective and efficient flow of information about CSA advantages. Interestingly in this study, smallholder farmers used cooperatives as a route to access agricultural inputs, not necessarily to acquire knowledge about CSA.

Further research to understand the reasons and the sources of information used to acquire more about CSA in all the five distinctive agro-ecological regions with different climate, soils, and rainfall patterns would help to ascertain the factors influencing the adoption of CSA techniques for specific regions.

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Appendix 1: Questionnaire

Climate-smart agricultural practices

GPS Location: ……………………………………………………………..

Photo of the farmer/field: ……………………………………………................

Enumerator: ………………………………………………………..............

Phone No: ……………………………………………………………………

Agro Ecological Regions

o Region II o Region III

Province: ………………………………………………………………………

District: ………………………………………………………………………..

Section A

Part 1. Farmer's characteristics

1. Please indicate your gender

o Male o Female

2. Please indicate your age ………………………………………………………

3. Marital status

o Single o Married o Divorced o Widowed

4a. Level of education

o Non o Primary o Secondary o Tertiary

4b. How many years of schooling? ………………………………………..

5. Household size ……………………………………………………….

6. How many years have you been involved in farming system?

7. Have you heard about Climate-Smart Agriculture?

Part 2. Institutional characteristics

8. Do you belong to any cooperative or farming group?

o Yes o No

9. Did you receive any credit from any CSA promoting organization in the past 2 years?

o Yes o No

Part 3. Farm characteristics

10. What type of farming system do you practice?

o Crops o Animal o Mixed

11. Please indicate your total land size (in ha)…………………………………………

12. Which major types of crops do you cultivate?

o Maize o Soybeans o Groundnuts o Cowpeas

o Beans o Sorghum o Tobacco o Vegetables

13. Please indicate the number of livestock that you have (cattle and non-ruminants)? ....

Section B

Part 1. Climate-smart agriculture practices

14. Which of the following practices did you use in the past 2 growing seasons?

o Reduced tillage methods

o Improved seed varieties

o Crop rotation

o Mulching

o Non

Part 2. Reasons for Climate-smart agriculture

15. What are the major reasons for preferring CSA methods? Please rate from (1= lowest to 2= medium, 3= high)

- o Soil protection
- o Increase in crop yields
- o Reduced labour demands
- o Climatic variability
- o Availability of CSA inputs
- o Any other

Part 3. Challenges of Climate-smart agricultural practices

16. What are the challenges faced in practicing Climate -Smart Agriculture?

…………………………………………………………………………………….

Part 4. Major information sources

17. With the help of the scale given below, rank how regularly you receive information on CSA from the following sources in the past 2 years? rare (0-2 times), moderate (3-4 times), and regular (more than 5 times).

a. Radio

b. Phone

c. Cooperative

d. Television

e. Extension representatives

g. Literature

h. Internet

The End. Thank you for your cooperation.