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Adoption of Conservation Farming Practices for Sustainable Rice Production Among Smallholders in Barotse Floodplains, Western Zambia

MASTER THESIS

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Declaration

I hereby declare that I have done this thesis entitled Adoption of conservation farming practises for sustainable rice production among smallholders in Barotse floodplains, western Zambia independently, all texts in this thesis are original, and all sources have been quoted and acknowledged employing complete references and according to Citation rules of the FTA.

In Prague, 22 April 2023

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Makumba Kasonde

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Abstract

Conservation agriculture is gaining importance worldwide, especially in Zambia's Western Province. This approach to farming aims to increase productivity while reducing environmental harm by using conservation techniques such as minimum tillage, crop rotation, and animal integration. In the Western Province of Zambia, smallholder farmers face multiple challenges, including low crop yields, poor soil fertility, and erratic rainfall. Conservation agriculture can help alleviate these difficulties by improving food security, promoting sustainable land use, and supporting livelihoods. However, there are several constraints to adopting these practices, such as limited input availability, equipment expertise, and government support. This study explores conservation farming practices – focusing on the cultivation of local rice varieties in Zambia's Western Province. Data was collected through 6 focus group discussions involving 12 lead farmers and Ministry of Agriculture officials, and a household survey of 348 respondents. Descriptive statistics and binary logistic regression were used to analyse the data. A binary logistic regression indicates that off-farm income, agriculture newspapers, and contact with agriculture increase the adoption of conservation agricultural practices. Therefore, efforts to advance conservation agriculture in Zambia's Western Province must consider these difficulties and give farmers the necessary tools and knowledge to apply sustainable methods effectively.

Keywords: Conservation agriculture, sustainable, climate resilience, barriers, livelihoods, Zambia.

Contents

List of Figures

List of Tables

List of Abbreviations

CAP	Conservation Agriculture Practices
CEA	Chinese Ecological Agriculture
CFU	Conservation Farming Unit
CSA	Climate Smart Agriculture
FAO	Food and Agriculture Organisation
FGD	Focus Group Discussion(s)
FISP	Farmer Input Support Program
FSP	Food Security Pack
ISFM	Integrated Soil Fertility Management
NGO	Non-Governmental Organisation(s)
NRC	National Research Council
UN	United Nations
USA	United States of America

1. Introduction

The use of heavy inputs such as fertilizers and chemicals has been used so much in modern agriculture to increase the production of crops to feed the ever-increasing human global population. Using these inputs has seen a rise in land degradation, water pollution and making the soil less fertile. With time, the land may not be able to absorb fertilisers and chemicals for food production. The effects of climate change make the temperatures unstable and the weather patterns difficult to support crop production. As people become aware of the effects of climate change and the adverse effects of modern agriculture on the environment, conservation agriculture has become an important aspect of dealing with the situation. Conservation farming practices aim to promote sustainable and eco-friendly farming systems that improve biodiversity in crop production (Ali et al., 2021).

Conservation farming has key principles, including plant cover, reducing tillage, and rearing livestock. The practise of conservation farming improves soil fertility, reduces the spread of pests and disease, prevents soil erosion, avoids land degradation, and, on an upper hand, improves the farmers' income due to reduced production costs. One of the important principles of conservation agriculture is the minimum tillage. This principle works well with farmers because there is less disturbance of the soil, reducing the emission of carbon dioxide into the atmosphere, contributing to global warming. Conservation agriculture has more benefits to the farmers than conventional ploughing of the land, which destroys the soil layers and which, in turn, degradation of the soil takes place (Vanlauwe et al., 2014).

Conservation Agriculture Practices (CAPs) benefit smallholders and contribute to sustainable farm production and mitigation of climate change. This helps to support the lives of people who depend on rice for consumption. Currently, rice supplies 3.5 billion people worldwide. In Africa, rice represents a traditional crop for many countries. In Zambia, one of the most important production areas is the Barotse floodplains in the upper watershed of the Zambezi River.

Regardless of the benefits of conservation agriculture practises, the smallholders have faced the challenges associated with their implementation have been experienced by the smallholders. For example, planting cover crops may need several inputs and manpower to establish the crop establish the crop.

Secondly, minimum tillage requires equipment, which may be costly for some smallholders to purchase. Farmers in Barotse floodplains plant traditional and improved rice varieties, taking advantage of their characteristics, but population pressure, structural changes and commercialization tendencies endanger the sustainability of the local rice farming systems. However, many successful conservation agriculture practises are being supported and implemented globally, and they are receiving enormous support from several governments and non-governmental organisations that encourage sustainable and eco-friendly farming systems (Kassam et al., 2015). Therefore, the master's thesis aims to provide an overview of policy papers and current development efforts in western Zambia toward sustainable rice production and document farmers' preferences towards local rice varieties and what conservation techniques are applied.

2. Literature Review

2.1. Conservation Agricultural Practices in Smallholder Farming Systems

Conservation agriculture practises are known to contribute positively to the development of the agricultural industry in a more sustainable manner. According to Hills et al. (2020), all conservation agriculture practises are defined as "farming practises that contribute to three key principles of reducing soil disturbance, maintaining the soil, and practising crop rotation". Conservation agriculture is a topic that has become increasingly popular worldwide in the view of promoting sustainable agriculture. According to the United States of America Congress (1990), sustainable agriculture refers to the "integrated system of plant and animal production practices that satisfy human food and fibre needs, enhance environmental quality by making the most efficient use of non-renewable resources, sustain the economic viability of farm operations, and enhance the quality of life" (Mishra et al., 2018). In the wake of increased climate change, much emphasis has been placed on conservation farming practices, and most governments today are making them mandatory in the hope that they are one of the long-term mechanisms of controlling climate change. It is worth noting that sustainable rice production should also be looked at from an economic and social point of view, which has improved the income of smallholders (Devkota et al., 2019).

Conservation agriculture, which is about producing crops and animals for the benefit of humans and the environment through the economic use of non-renewable resources, has received considerable attention for quite a long time now (Mishra et al., 2018). As part of sustainable agriculture, conservation farming practises are further conceptualised in terms of the complex process of minimising the external resources added to the environment to maximise agricultural output, and the maintenance of the farm for such are seen as having negative impacts on the welfare of nature in general (Etienne et al., 2022). Conservation farming involves studying and understanding the benefits of agroecological management and then manipulating and shifting its design to maintain a natural system without reducing productivity (Wezel et al., 2014).

It should be noted that conservation farming practises involve activities such as the input of organic matter (livestock manure, compost, green manure) instead of applying mineral and chemical fertilisers (Droppelmann et al., 2017).

It also includes improving soil drainage to reduce nutrients leaching (Jayne et al., 2019). Conservation farming practises also involve farming methods such as crop rotation and minimum tillage, as well as cultivating drought-tolerant crops (Pelletier et al., 2020). As highlighted earlier, the main aim of conservation farming practises is to maximise production while protecting the land as much as possible (Ngoma & Angelsen, 2018).

Conservation farming practices have been studied worldwide, whereby in the process, their essence, advantages and disadvantages have been conceptualized and mapped by several scholars. (Mishra et al., 2018) Conservation practices bring economic benefits and would strive at all costs to balance productivity and preserving the environment. Conservation farming practices emphasize the minimum use of external agricultural inputs, which does not exclude them. However, it advocates for a systematic way of incorporating them into the agricultural sector so that the preservation of the environment and the increase and maintenance of production are achieved (Mishra et al., 2018).

In the United States of America (USA) and Europe, for example, conservation farming practises and their importance can be traced to 1930, with the use of cover crops, no-tillage and crop rotation being promoted by the governments (Gonzalez-Sanchez et al., 2015). This extensive research was observed to be continuing throughout history where; for example, in 1950 and 1989, the National Research Council published work on what they termed “alternative agriculture” and, in another later publication settled for the term “sustainable agriculture” (Mishra et al., 2018). Additionally, other scholars have also attempted to research the factors that influence the adoption of conservation farming practises in and around the world and have discovered different insights depending on different places (Mishra et al., 2018). The political will in the USA has been promoting the idea of conserving nature by supporting farmers with funds to use in their conservation farming practises or doing activities that support wildlife habitats; for example, farmers are advised to abandon the land for agriculture production so that it can generate to natural grasslands(Lichtenberg, 2019). If many governments put deliberate policies that support conservation farming, this would improve the production of food in an environmentally friendly manner and reduce the emission of greenhouse gases, hence combating the effects of climate change.

In the past decade, there has been an increase in the price of oil that is used to manufacture fuels for economic development.

The agricultural sector is not spared because some farm activities, for example conventional agriculture, depend on fuel for use in tractors, generators, and other farm equipment. The increase in oil prices at global level has increased the prices of food, causing food shortages. In such situations, conservation agriculture becomes the way to help the agriculture industry become sustainable because it is eco-friendly and may not require fuel use (Wakeford & Swilling, 2014).

There has also been considerable attention paid to conservation farming practises in Asia, especially in rice-producing countries such as India, Bangladesh, Japan and China. For example, in the 1980s, particularly during the reign of Deng Xiaoping, there was a dramatic shift in Chinese agricultural practices (Chengjun et al., 2022). As further argued, from 1980, the Chinese government started to promote Chinese Ecological Agriculture (CEA) whose aim was to regulate the management of the environment while ensuring that production increased, nonetheless (Chengjun et al., 2022). Its main aim was to promote green food and organic agriculture to considerably reduce the use of inorganic external inputs on the soil the use of inorganic external inputs on the soil. Research shows that the Chinese experience provides a good example of the impacts and journey towards conservation farming practices (Chengjun et al., 2022). With a considerable shift in the Chinese economy and general regulations, agriculture in the 1980s became much more communalised and more power was handed down to the household than it was under pure communism. With intensified industrialisation in the urban centres, the result was that much land was cleared and with the government having eased pressure on its regulation of agriculture, was that there was massive land degradation. Some of the degradation practises included illegal logging, massive use of chemicals, and the use of land the government had initially protected. This aggravated the situation, and the government had to intervene to save the environment quickly; hence the establishment of the CEA (Chengjun et al., 2022).

Africa has not entirely turned a blind eye to conservation farming practices either. In Africa, it can be traced back to the Middle Ages in Egypt, where terraces were used for irrigation to conserve water and soil for agriculture production (Zhao et al., 2021). Historically, Africa has had a model that displays labour saving, capital saving, and land-using farm production systems (Jayne et al., 2019).

Scholars further claim that the rapid rise of population, reduction of farm sizes, and intensive use of land on the continent leading to extensive land degradation has made the need for conservation farming urgent (Adenle et al., 2019). Africa has continuously accepted the Green Revolution and the production of hybrid and genetically modified crops to lessen the need to rely heavily on external input to support plant and animal production. Integrated Soil Fertility Management (ISFM) as part of soil preservation mechanisms has increasingly become a preoccupation of many in Africa (Adenle et al., 2019); (Jayne et al., 2019). International organisations like World Vision, the Food and Agriculture Organisation (FAO), and the United Nations itself have been actively involved in helping Africa achieve conservation agriculture.

Talking specifically about Zambia itself, it should be noted that although not new, particularly having started as far back as the 1960s, emphasis on conservation farming took hype in the 1980s and has increased since then. In recent years, conservation farming in Zambia has been conceptualised in terms of Climate-smart agriculture (CSA) (Ngoma et al., 2021). This type of agriculture aims to increase productivity and resilience while cutting down on the land needed for agricultural expansion. As noted further, it is argued that Zambia loses about 250,000 ha per year of forests and that 60% of these lost forests are the result of subsistence farmers trying to compensate for food production to cope with the ever increasing levels of population and the diminishing value of the land that has been cultivated so far (Ngoma et al., 2021). (Curtis et al., 2018) Between 2001 and 2015 alone, smallholder agriculture accounted for between 27% and 92% of deforestation in of Africa, showing that continent is yet to achieve meaningful, sustainable agricultural practices (Curtis et al., 2018). households in Africa living on earnings below the poverty line, fertilizers have become expensive for them, and most cannot afford to buy them especially given the meagre wages they get. To compensate for that, they resort to using ash, leading to deforestation (Adenle et al., 2019).

2.2. The Potential of Conservation Agriculture to Combat Climate Change

The advent of climate change has caught the world by storm, and every country is trying its best to contain the rapid and gradual changes in the weather conditions observed over a long period.

Climate change is “a change in climate that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and that is in addition to natural climate variability over comparable periods” (Chengjun et al., 2022). It has called for governments around the world to put measures in effect to contain it. Conservation agriculture has the potential to tackle the effects of climate change in that it supports minimum tillage, use of cover crops, and crop rotation. All these three principles put together prevent the emission of greenhouse gasses that are harmful to the atmosphere. In Zambia, , the long-time Contingency Planning Unit of 1966 was superseded later by the Disaster Management and Mitigation Unit (DMMU) of 1994; National Communications on Climate Change, the National Adaptation Programme of Action and the Climate Change Facilitation Unit were all institutions put in place to lead and coordinate all efforts aimed at mitigating climate change (Funder & Mweemba, 2019). Recently, coordinating all efforts to mitigate climate change have been bestowed on some donors who seem inclined to food relief programs rather than establishing an indigenous and inclusive grassroots approach to mitigate climate change. Most reviewed research indicates that while small scale farmers constitute at least 85% of Zambian agriculture if there is anybody who has been roped in to contribute to mitigating climate change in the country are some donors and large-scale commercial farmers (Brown, 2013). However, some non-governmental organisations from the Czech Republic have supported smallholders in the Barotse flood plains in promoting conservation farming practices, but little support is coming from the Zambian government. Therefore, it is essential for the government to work with international organisations that put the interests of farmers first, other than donor organisations that want to take charge of the activities related to climate change. This has not only shown the exclusion of small-scale farmers in efforts to control climate change but has also led them to be overshadowed by some donors and large-scale farmers as if they are the only critical stakeholders in mitigating climate change. Owing to such a reality, research on the role of small-scale farmers in driving conservation farming practices in the era of climate change has remained scarce.

It is worth noting that rice production is inevitably a climate change issue as it interferes with wetlands which are known geographically to be very important in the environment, particularly their support of aquatic life and their contribution to atmospheric moisture. On the negative side, however, a lot of carbon has been observed coming from wetlands, as they contain a lot of life (Mishra et al., 2018).

By taking the Barotse flood plains as a case study, this research seeks to examine the role of small-scale farmers in driving conservation agriculture in the era of climate change in Zambia.

2.3. Dissemination and Adoption of Conservation Agriculture Practises

Access to information is an effective tool farmers use to implore conservation farming practices that later improve their farming activities. One of the ways farmers have access to information about conservation agriculture is through social interactions with fellow farmers (Bartkowski & Bartke, 2018). As farmers attend meetings in various areas for farmer field schools, demonstrations, and other multiple interactions, they share information on how their fields perform after using conservation farming methods. Later, they adapt the techniques learnt on their farmlands. Sometimes their interactions are linked to their social identity; for example, being a member of cooperative and farmer associations will influence the behaviour of a farmer following what the other members of a cooperative are doing.

In most cases, cooperatives undergo various trainings, including conservation farming practices. The market price of conservation farming products and the change in supply and demand of the products attract information sharing among the farmers and the customers (Ambrosius et al., 2019). Conservation agriculture products, for example, vegetables and cereals, usually have high demand on the market. A slight change in the dynamics of this business will immediately inform the public and the farmers, unlike commodities that come from conventional farming practices. This gives an opportunity for the farmers to produce depending on the market forces. The agriculture extension service system is another way farmers acquire information on conservation farming. This is an arm of government from the ministry of agriculture and sometimes from the private sector. In China, it is a way to improve the adoption of conservation agriculture by informing village workers about the need to use these techniques for sustainable agriculture (Fan et al., 2022).

In Bangladesh, farmers who use extension services have their yields increased to 980kg per hectare per year than those that do not use the extension services (Biswas et al., 2021).

In Zambia, the Conservation Farming Unit was at the forefront of promoting conservation agriculture among farmers; however, the adoption rate has been low (Ng'ombe et al., 2014). Other Non-Governmental Organisations NGO), such as People in Need from the Czech Republic, have followed suit in promoting the use of conservation farming practises. The meteorological department in Zambia also distributes information on conservation agriculture practises through radio and television (Mulenga et al., 2017).

Another critical issue facing small-holder farmers in their farming systems is access to rice seed. However, access to rice seed may not be as easy as may be perceived because, in most cases, there is an unreliable supply (Alibu et al., 2022). In Uganda, access to rice seed was introduced by a project from the Korean government through a program of international agriculture to enhance the production of improved varieties (van Campenhout, 2021). In most cases in Africa, rice seed comes from Korea, Japan, and many Asian countries implementing projects. In Zambia, JICA, a Japanese project, sends the seed to local farmers for production. Other sources of origin are from farmer to farmer. After harvest, some of the seed is kept for the next planting season. In most cases, some farmers access seed from government programmes such as farm input support programmes or food security packs (Blekking et al., 2021). Smallholder farmers also access seed from agro dealers, while others access it through seed companies, for example, SeedCo and "Kamano".

2.4. Conservation Agricultural Practices in Rice-Based Farming Systems

Mixing the rearing of animals and the production of crops in the same area is one of the conservation farming practices that improve soil fertility and increased moisture in the soil. This system is practised by commercial farmers in developed countries such as New Zealand and Australia; however, in sub-Sahara Africa, the system is predominantly practised by smallholders. In Africa, this is mainly done after rice harvesting, and then the farmers allow the animals to grace the rice straws with grass. As animals graze, their droppings fertilise the fields so that farmers will not spend much in the following season on input, improving their savings.

This system, in other words, explains the trade-offs that occur: the animals eat the grass and straws that work as mulch, while the fields benefit from the animal droppings (Valbuena et al., 2012).

In southern Asia, in the Indo-Gangetic Plains, information about conservation agriculture that can reduce the infestation of pests and armyworms in the rice production system has been lacking. Pests and armyworms have increased due to the use of conventional farming and artificial fertilisers. However, introducing zero tillage, transplantation and agroecosystem could reduce pests and eventually make them disappear due to changes in microecology (Kumar et al., 2022). With growing interest in research and development, an integrated crop management system was also promoted in rice production with other crops. This moved innovation so that one crop does not suffer on the expense of the other (Rodenburg & Saito, 2022). Apart from mulching, farmers with risk-averse tend to use conservation agriculture practices such as growing cover crops to reduce evaporation, especially farmers growing their rice on the upland where water scarcity is scarce (Husson et al., 2022).

2.5. Rice Farming Systems in Sub-Saharan Africa

In sub-Sahara Africa, rice research started one hundred (100) years ago with the help of National Agricultural Research Institutes (NARI), AfricaRice, Consultative Group for International Agricultural Research (CGIAR) centres and several organisations across the globe. These organisations played a vital role in making rice research and development recognised and its importance felt in Africa. However, becoming self-sufficient is a problem; demand is more than supply, hence the need to promote the improvement of local varieties. Many sub-Saharan African countries, including Zambia, grow their rice in three environments; lowland rainfed, upland rainfed, and lowland irrigated system (Rodenburg & Saito, 2022). However, these systems require huge research and development to increase production more sustainably.

Smallholder farmers experience many losses in their farming systems because of climate change and the use of monoculture in their rice farming. Sometimes, it could be too much rain, drought, or wind that destroys your crops. Farmers are encouraged to use conservation agricultural practices to fight this problem to improve soil fertility and curb climate change.

Furthermore, the governments in Sub-Sahara Africa developed policies to assist the farmers in implementing conservation agriculture practices (Akinyi et al., 2022). This move is to ensure that poverty levels are reduced among smallholder farmers.

There was also the introduction of the Rice Intensification System as one of the agricultural systems that helps fight climate change and increase food security. This was first assembled in Madagascar and introduced to southern and east Africa (Nhamo et al., 2014). However, the adoption rates are still meagre due to various factors such as lack of initial capital, lack of technology, and lack of knowledge about conservation practises, to mention a few. To curb food insecurity, there is also the need to work together as a team, including researchers, agriculture institutions, members of the public and the government. Current common conservation practises applied by farmers in the western province are the use of rippers when cultivating, mulching, straw retention, crop rotation, the use of herbicides and the use of dikes to control the flow of water, transplanting, no burning in plains, early planting, crop diversification, canal clearing, and the use of organic manure.

Rice is classified as one of the most critical staple foods in Zambia, with statistics indicating that rice consumption in Zambia increased from more than 15,000 metric tonnes to more than 59,000 metric tonnes per year between 2002 and 2015 (Mundia Mukwalikuli, 2018). In another statistical evidence, it is argued that between 2003 and 2017, the annual demand for rice increased from 20,000 to 70,000 metric tons annually (Ngoma et al., 2021). Rice production in Zambian has been one of the most critical sectors of the economy that not only supplement food production but also creates jobs (Mundia Mukwalikuli, 2018). Although large commercial farmers in the country are involved in rice production, most of it is done by smallholders in the swamps, especially on Barotse land (Makungwe et al., 2021a).

More information on rice production in Zambia shows that to meet the country's rice needs, the government been importing at least 5,000 to 20,000 tonnes annually (Ngoma et al., 2021), noted that in 2016 there was a dramatic shift in rice production with the government stepping up support for local rice production through the National Rice Development Strategy (NRDS). It should be noted, however, that this stepping up of effort did not necessarily take away the production of rice from the hands of smallholders. These continue to dominate the rice production sector in the country. It is also worth highlighting that Zambia is facing a deficit in rice production, which is why the government has resorted to importing as a solution.

For example, average yields per hectare are 1.3 tonnes, which is far from enough for rice generally demanded by the Zambian population annually, and this leaves the country at a 35,000 tonnes supply deficit (Ngoma et al., 2021). According to (Mundia Mukwalikuli, 2018), the supply deficit is caused by consumption growing faster than production.

As has already been highlighted, Zambia's greatest and most outstanding production is squarely based on smallholders who reside near swamps, especially in Barotseland. The most common method of rice production among these smallholders is rainfed paddy rice production which relies heavily on natural rainfall, which floods the farming land, especially during the rainy season (Makungwe et al., 2021a). It should be noted that some of these smallholder farmers barely use sophisticated farm implements beyond simple hoes and axes and neither do they have sophisticated knowledge and skills beyond just the basics of farming (Mundia Mukwalikuli, 2018). Under the rain-fed paddy rice production method, rice fields can be flooded by natural rainfall before any planting. Once the fields are sufficiently flooded, planting will commence, and the rice will continuously be cared for right in the water until it is ready for harvesting. However, apart from depending on flooding for rice production, there is the breeding of other rice varieties that grow well on the up land, for example, Nerica 4 does well on upland and does not require a lot of water for it to grow.

Unlike farming any crop, most rice varieties are heavily dependent on the availability of water, and this means that for a smallholder who can barely afford irrigation systems, especially the flood system, which is suitable for rice production, it means that the farmer should cultivate the same piece of land repeatedly. It should be borne in mind that rice fields which are prone to logging are easily affected by leaching, and monoculture does not bode well with lands either because the same type of nutrients is extracted in a similar fashion year after year, and this has the potential to harm the soil structure. Naturally, since such fields gradually lose fertility, external inputs, such as fertilisers, are ever needed in rice production and must be applied with care and skill (Mundia Mukwalikuli, 2018). However, to sustainably increase sustainable their rice yields, it is necessary to switch to conservation farming practises other than the continuous use of artificial fertilisers that destroy the land over time.

The use of the Rice Intensification System (SRI) is another sustainable way to produce rice that is used in Zambia. SRI aims to reduce plant population while providing good irrigation, soil and plant management systems that increase.

To reduce plant population while providing good irrigation, soil and plant management systems that increase rice production. Farmers are advised to make straight planting lines where they will transplant their rice; furthermore, thinning is done to reduce plant population in places with many seedlings. This system requires that farmers use dikes to control the amount of water in the field; if the water is too much, the farmer opens the dikes for the water to come out, and if the water is not enough, the same happens to allow water to enter the field. SRI has various benefits to using conventional farming systems. For example, women farmers do not spend much time in weeding because they use mechanical weeders, which move freely in a good space distance between the rows in the field; they also spend less money buying rice seeds (CIIFAD, 2014).Apart from increasing income for rural women, SRI reduces greenhouse gases; for example, methane is reduced by 22% under aerobic conditions as it reduces the flooding of the field (SRI-Rice, 2020).

Of great importance to note is the fact that the requirements of conservation agriculture and the reality of rice production by a smallholder in Zambia, given the circumstances, will inevitably clash. Some conservation agricultural practises may be neglected due to the need to meet their subsistence needs and the pressure to keep the land as productive as possible (Ngoma et al., 2021). This study also sought to examine the practise of conservation farming practises among rice farmers in Barotseland, given all these circumstances.

2.6. Factors Influencing the Adoption of Conservation Agricultural Practices

The effects of climate change in sub-Sahara Africa caused many variations in weather patterns, bringing change with the onset of rain and sometimes drought (Jew et al., 2020). In the recent past around 1990, there has been a growing concern to increase, food security among vulnerable members of society, especially in sub-Sahara Africa, in line with the Millennium Development goal on food security, which brought about technical assistance from donors. The Food and Agriculture organisation (FAO) coined the balance in increased food production, agriculture system resilience and the reduction of greenhouse emissions to promote climate smart practices (Tetteh et al., 2023).

As much as there is a global need to produce food, there is a need to produce it more sustainably that does not destroy the environment. Climate smart practises such as access to information about climate change, agroforestry practises, and conservation practises have helped farmers adapt to the effects of climate change, making farmers more aware and resilient (Antwi-Agyei et al., 2021). In 2004, Zimbabwe received technical support from the International Crop Research Institute for the Semi-Arid Tropics (ICRISAT) on a relief programme to support conservation agriculture (Makuvaro et al., 2017). This relief programme provided farmers with drought-resistant farming techniques and inputs, which motivated farmers to adopt conservation farming due to the high yields they experienced after adopting the practises.

Similarly in Zambia, the Conservation Farming Unit has existed since the 1990s and has spread the use of conservation farming, and some farmers have adopted the practise due to high yields coming from the same practise. modern technology has influenced the use of conservation farming techniques as part of climate smart practices. Farmers can demand technology based on the intensity of the technique (Jew et al., 2020). However, in Zimbabwe, there was no option in the introduction of conservation technology to farmers; every beneficially was expected to participate in the use of certain techniques. Eventually, some farmers were able to adapt while others were not. Farmers who were familiar with technology taught others that were failing, those who could easily adapt technology, can have huge harvests. Perception of the farmers in the community about conservation farming is at the centre of the adoption of the conservation practices and the technology being used.

Well-articulated government policy and laws toward conservation agriculture influence farmers to adopt the practises. In South Africa, the Department of Agriculture and Rural Development, through extension officers, affects farmers to practise conservation agriculture (Ntshangase et al., 2018). However, some farmers are still not fully adopting the practises and their harvests have been poor due to the high cost of production and the poor yields experienced by some farmers. Most of them are using an alternative method, such as conservation farming, to increase their yield. In addition, poor land management leads to land degradation. According to the Food Agriculture Organisation (FAO), many countries in sub-Sahara Africa use poor subsistence farming systems that contribute to soil degradation leading to poor harvest, especially in rural areas (Adoyo et al., 2022).

Factors such as age, gender, education, income, land size, access to credit, extension, training and active members influence farmers' participation in conservation farming practices (Ntshangase et al., 2018). Regarding age, in the European region, order farmers tend not to practise conservation farming due to risk aversion, and younger farmers tend to be more organic than older ones (Chatzimichael et al., 2014), which is different from South Africa. In KwaZulu Nata, the older the farmer, the more likely they are to adopt conservation farming methods due to the experience they have on the farm (Adoyo et al., 2022). Another factor that influences the adoption of conservation farming is education. The more educated the person, the more likely they are to adopt conservation farming practises. In terms of gender, women were more likely to adapt to conservation farming techniques than men (Chatzimichael et al., 2014). The size of the land is another factor that contributes to the adoption of conservation practises. Farmers with larger farms are likely to adopt new technologies in that they have the option of where they use the practices, especially those that require big space and having big pieces of land is a sign that the farm has more resources which can enable the farmer to adopt to various conservation techniques.

However, farmers with small pieces of land are more likely to adopt conservation practises because they will not use much labour to till the land (Lapple & Kelley, 2015). Access to credit is one of the factors also contributing to the adoption of conservation farming practices. However, farmers in Ethiopia and surrounding countries have a problem with access to credit. Cooperatives, banks, and other financial lending institutions cannot provide such services to the farmers, hence not being able to access various technologies that come with conservation farming (Girma, 2022). Farmers are more likely to adopt conservation farming techniques when they can access credit. Extension service is another factor that contributes to the adoption of conservation farming. In Ghana, most farmers live in rural areas far from the central districts where they can access extension services. The government uses extension officers to reach the rural areas where most farmers practice farming. Sometimes the extension officers from the government are cushioned by extension agents from the private sector. Extension officers from the government and the private sector provide conservation agriculture services to farmers (Danso-Abbeam, 2022).

Farmer training is another factor contributing to the adoption of conservation farming; the farmers that receive training through farmer field schools have their fields perform well and produce good yields (Chesterman et al., 2019). Lastly, are the actively economic members, those that participate actively in various economic activities. Farmers in this category find it easy to participate in conservation farming because they can buy equipment and other requirements for conservation farming to run smoothly. However, this does not mean that farmers without financial capacity cannot fully participate in conservation agriculture, v. Various methods can be used for them, such as using locally available materials within their disposal.

2.7. Conservation of Agricultural Practises in Zambia

The adoption and practise of conservation farming practises in Zambia, particularly among smallholders in general, has been subject to considerable research over the years. (Pelletier et al., 2020) and (Ngoma & Angelsen, 2018), who studied the adoption of conservation farming practices amongst smallholders in Zambia, reported it as low and unsatisfactory. Amongst the provinces listed as leading in the reluctance to adopt conservation farming practices are Luapula, Muchinga, Northern, North-Western and Western Provinces. They were the ones most notable for contributing to the expansion of smallholders into intact forests. Another most notable reality was the farmer's failure to adopt modern technologies in their farming, relying rather on the use of fire to clear forests, burning biomass and further reducing the usability of the land.

The reasons why smallholder farmers are reluctant to adopt and practise conservation agriculture have also been subjected to considerable research. Among the most notable factors are the unfavourable prices of the produce in the market, the general decline in soil fertility, and the need to increase subsistence needs since food production has generally declined in Zambia (Ngoma et al., 2021). Another dimension that explains why smallholders are not adopting and practising conservation farming practises fully is their inability to afford the modern technological tools needed to improve agricultural production. Technology improves agricultural productivity by ensuring high production in a small unit area. However, due to their smaller incomes, most smallholder farmers do not afford these technologies, hence clearing more land to compensate for their inability to afford modern agricultural technologies (Byerlee et al., 2014).

Another study shows that smallholders in Zambia were practising conservation smart agriculture (CSA) alongside other farming practices that were not friendly to the environment, significantly indiscriminate cutting down of trees, burning grass and encroaching into forests (Ngoma et al., 2021). The scholars noted that the proportion of CSA to bad farming methods among these farmers favoured the bad techniques. The researchers indicated that, as much as small farmers in Zambia wished to engage in agricultural conservation practises, many factors that have been highlighted worked against this will. The following are the conservation practices being practiced in Zambia:

Straw retention occurs when farmers wait for the straw to dry up after harvesting rice without cutting it and then plough back to the soil (Saikia et al., 2020). Instead of the farmers allowing the animals to graze in the fields or burn the straws, they plough it back to improve soil fertility, knowing that the straws decompose after a period. Apart from increasing the fertility of the soil, straw retention suppresses the growth of weeds hence improving biodiversity in the soil. However, in certain cases, farmers use the same straw as mulch on rice seed beds in preparation for transplantation. If you compare farmers' rice fields using straw retention and those who burn the fields or allow the animals to graze, the difference is so big that those who return the straws in the fields have huge harvests than those that do not use this conservation practice.

The use of rippers is one of the minimum tillage practices used by rice farmers, where they make lines on the points where they want to plant the rice only, unlike conventional tillage, where there is soil disturbance in the entire field. Conventional tillage destroys living organisms in the soil that support soil fertility and facilitates the removal of carbon dioxide, which is useful in the soil (Sharma & Dhaliwal, 2021). Using rippers is good for farmers because it allows them to transplant rice instead of using the broadcasting method, which puts a farmer at a loss due to the use of much seed for planting. The challenge comes with the means of purchasing the rippers, and most farmers cannot afford to buy rippers for their farming activities, hence going back to the traditional methods of burning the fields before planting, which according to them, is less costly. According to Das et al. (2021), minimum tillage is a way of conserving water and manure for a required plant and not spreading nutrients and water to weeds that may not help the farmer. This conservation method benefits farmers on the Barotse flood plains because sometimes the plains experience drought. In this manner, the crop may not experience some stress in case of drought or heat intensity in the crop.

Many farmers in the Barotse flood plains burn their fields after harvest to clear the weeds before planting their rice in the next planting season. This type of land preparation destroys beneficial organisms that support soil fertility and pollutes the environment (Jat et al., 2018). Burning straws contributes to carbon dioxide emission, which is not as valuable to the atmosphere as it contributes to climate change. The coming of non-governmental organisations in the Barotse flood plains, such as People in Need, Mendel university Brno, Caritas Czech Republic, Czech University of Life Sciences Prague, Conservation Farming Unit, JICA, and many others that have partnered with the government, has brought a change in the mindset of farmers. These organisations and the government have been teaching farmers the use and importance of conservation practises, such as preventing the burning of straws and grass.

The use of organic manure, such as compost and cow dung, are some of the organic practises that some farmers use in their rice fields. Farmers who use these methods have had good harvests compared to those who use artificial fertilisers. Moreover, the expense of buying synthetic fertilizer has been done away with by such farmers, making some profit in their farming business. The use of organic manure improves the soil fertility of their field with time though there are some expenses at the initial level of using organic manure; some farmers do not have animal; hence they end up buying cow dang from farmers who have the animals. Using organic manure can contribute to positively managing and conserving biodiversity in wetlands (Maltchik et al., 2017). This is the same situation happening in the Barotse flood plains, rice is grown in wetlands, so the use of organic manure supports a lot of living organisms in the water, and when those organisms die, they will also decompose hence improving the soil structures.

Farmers in the Barotse flood plains sometimes plant rice with maize and then rotate the crop with legumes, especially on the upper land where water does not submerge the crops. After they harvest the rice only or rice with maize, they plant legumes such as beans. This type of farming improves the growth of the crops because there is supplementation of nutrients where the other is lacking. Secondly, weeds do not grow as much in such fields, hence reducing the labour of weed removal from the area, which, in turn, promotes efficiency and productivity for farmers (Laik et al., 2014).

Crop diversification is defined as growing different types of crops on the same farmland (Nkomoki et al., 2018).

Rice production has been a traditional way of practising agriculture in the Barotse flood plains, and sometimes people have overused their fields for so long that soil fertility has deteriorated. The ministry of agriculture has been sensitizing farmers on the use of conservation practices such as crop diversification, and for some farmers they have abandoned their fields to fallow so that they build on their fertility. Farmers who depend on rice for their livelihood are now diversifying with other agricultural activities, such as growing crops other than rice, such as tomatoes, vegetables, and sweet potatoes. This move has made farmers realise their money from various crop production activities other than spending money on rice only when they did not gain profits. If taken seriously, diversification can make farmers productive and make profits (Laik et al., 2014).

Farmers in this area typically use two ways to plant their rice: broadcasting and transplantation. In the broadcasting system, farmers have realised that they spend so much seed on a small piece of land instead of transplanting. Transplanted fields have more plant population than broadcasted ones because, with transplantation, farmers plant the seedling on the point where it has manure and availability of water, as well as non-weed infested area, which saves the farmer money for other farm activities (Laik et al., 2014). Seedlings that are transplanted are given more time to absorb more plant nutrients on the seedbed such that when they are taken to the main field, they will not have problems adapting to the new environment. Those broadcasted compete for nutrients with weeds. With the coming of the JICA project in selected districts of the western province, farmers are shifting their attention from broadcasting methods to transplantation.

When growing rice, some farmers use pesticides and chemical fertilizers, which destroy the fertility of the soil with time. Rice farmers in the Barotse flood plains sometimes use mulching stored moisture and avoid escaping water in the form of vapour from the rice fields. The use of mulch is a strategy to minimise water usage for excellent rice growth (Li et al., 2021). Furthermore, the materials used as mulch, like straws and leguminous plant leaves can be used as manure after the decomposition of the material. Many farmers use this method to minimise the costs of manure and labour for clearing fields. In certain instances, the topography of the land where it is slanty, especially the upland where drought resistant varieties are usually grown, mulch is used to prevent runoff water that causes soil erosion (Jordán et al., 2010).

Herbicides are usually applied to rice fields with perennial weeds, which are difficult to control using hand picking or crop rotation. Selective herbicides can help reduce parasitic nematodes by toxic means (Baghel et al., 2020). In most situations, farmers who use the conventional way of farming are the ones that are heavily affected by nematodes and weeds, unlike those that use transplanting methods.

Dikes are embarkments surrounding the rice field to control water movement to and from the fields, generally made from the soil. There are situations whereby the field is flooded with water which may be too much at the level of the rice, so farmers open the dikes to allow water to come out of the field and only leave the required amounts. The opposite happens when the field is too dry; water allowed to enter the area by opening the dikes. This system has assisted farmers in their farming activities in that they can carry out other management activities in the rice fields. However, this system is too laborious that it requires a farmer to engage many workers or pay much money for the works to be done. This system is commonly used in most countries in south Africa where there is dependence on rainfed agriculture. In the Barotse flood plains, as in Madagascar, rice yields increased in some rain seasons (Rodenburg et al., 2014).

Canal clearing in the Barotse flood plains is a major crisis for the rice farmer; this system allows the clearing of streams or tributaries that take water to the Zambezi River to allow the top part of the land to dry. This can allow farmers to grow rice all year round because the top part will be dry, so if water is required in the fields, it can easily be pumped from the nearby tributaries. Without canal clearing, the fields are flooded, not allowing the farmers to work on the land. If farmers delay planting, the fields will flood and nothing can be done in terms of growing crops; in this situation, the farmer will depend on the hills for his rice production, but this means he cannot produce certain varieties such as Supa MG which performs well on the low land. Like the use of dikes, canal clearing helps improve security by increasing the production of not only rice but also other crops (Rodenburg et al., 2014). The government has been trying to clear some canals in certain areas, but this venture is too expensive, and some have been cleared.

2.8. Factors Affecting Adoption of Conservation Farming for Rice Cultivation in Zambia.

The western province of Zambia is well known for producing good quality rice, classified into two improved and traditional varieties. Improved varieties, such as Supa MG and Zahou 5, have attracted a lot of market from local people and those from outside the province due to the increased yields. From the effect of adoption, such theoretical literature has shown that improved agricultural technology can increase household and farm levels, which eventually reduces poverty levels household and farm production, reducing poverty levels (Assaye et al., 2022). However, the production of traditional rice varieties in the western province is declining because most farmers are not using sustainable agriculture practises. This chapter will document factors that affect farmers from practicing CAPs.

Farmers indicated that the lack of resources and equipment is a major challenge. Lack of labour, equipment, alternative crops, and good management hindered them from practicing sustainable agriculture practices such as crop rotation. To buy equipment, farmers must purchase a substantial initial investment to purchase the machinery and find people to train them on how to use a particular equipment. As an example of CAP, crop rotation not only requires many people to work but requires more time and effort; farmers need to spend more time in the field to monitor the progress and efficient use of resources (Rosenberg et al., 2022). From the focus group discussions, respondents indicated that most unemployed youths do not want to take up agriculture activities. This poses a challenge in terms of the labour force on farms because the elderly, especially women, cannot do complex tasks.

Ownership of land is another critical barrier to practicing sustainable agriculture practices. Farmers who own land have an advantage over those who do not own land for rice production. The owners of the land typically give unreliable rent agreements, which makes the grower find it difficult to invest and switch to other crops. For example, the landowner has the right to grab the land whenever they feel so, making it difficult for many farmers to invest in sustainable agricultural practises as they take a long time to give results (Nkomoki et al., 2018).

Farmers, especially in Sefula, also indicated that the lack of a reliable crop market made it difficult for them to practice conservation agriculture practices.

Most farmers were selling their rice to a private company known as the “Kamano” seed company. However, since the company stopped buying from them, it has been challenging to find a reliable market. If farmers were to invest and diversify to other crops such as tomatoes, okra, green beans, watermelons, and sweet potatoes, they could not find reliable markets, and if they found some market from Shoprite, the farmers could not meet the demand for Shoprite due to limited capacity. This pushed farmers to grow their traditional monocrop rice system (Rosenberg et al., 2022).

Agriculture is improving daily, triggered by increased use of information and communication technology (ICT). Much equipment has been developed for weeding, fertiliser application, harvesting, and even remotely detecting pests and diseases. Introducing aerial equipment can improve their production; hence ICT, if made available to small-scale rice farmers, can enhance their production, increasing yield (Walter et al., 2017). However, the lack of modern communication equipment and skills has made it difficult for farmers to practise conservation agriculture. Currently, the use of these technologies, the use of cell phones, and the availability of the Internet are so much restricted to commercial farmers with the availability of resources, and yet most of the Zambian crop yield comes from small-scale farmers. Due to the lack of these technologies, farmers rely on information from the meteorological department to know rainfall patterns or drought in a particular season. These disadvantage most farmers because they live in rural areas where it is difficult to access information from the meteorological department.

The issue of awareness of conservation agriculture practices (CAPs) was one factor that made people either adopt or not adopt conservation agriculture practices in their rice farming activities. The response towards these practices indicates that farmers can practice in areas where the farmers have some information on CAPs. The lack of information is attributed to poor extension services provided by the government or private sector in the areas, and sometimes in areas where there are extension officers, the catchment areas are too large for them to attend to all the farmers. For example, in the Sianda camp in Senanga district, the officers cover more than 100 km to listen to a farmer at the farthest end of the camp. Mutyasira et al. (2018) also indicated that in Ethiopian highlands, farmers have a similar situation where access to information is a big problem, such that farmers cannot even practise certain basic sustainable agriculture practises.

In the end, most farmers depend on the information given to them by their parents or sometimes from their neighbours, who may not have adequate knowledge as well.

Access to credit is a recipe for adopting many agricultural practises, including sustainable ones. The focus group discussion held in the Kalabo district indicated that many farmers stated that farmers with access to credit could practise conservation agriculture practises. However, most farmers cannot practise conservation agriculture practices due to lack of access to credits, as most cannot practise conservation agriculture practices due to lack of access to credits, as most financial institutions require collateral that they do not have (Appau et al., 2019).

In the Limulunga district, farmers in the focus group discussion stated that age is a factor in adopting conservation agriculture practises. Elderly farmers were participating in conservation agriculture practices due to their experience in participating due to their expertise in farming than the youth who do not have access to land and other resources to use in agriculture. As indicated in the literature by Jiri et al. (2016), farmers in southern Africa are highly affected due to the effects of climate change. Despite the high rainfall patterns and sometimes extreme drought, elderly farmers use their experience to practise sustainable agriculture.

Increased levels of education contribute positively to adopting conservation agriculture practices in that for one to practice these practices, they have basic knowledge of agriculture (Kolawole et al., 2014). From the Focus Group Discussions (FGD) we had in Sefula, the lead farmers stated that the level of education plays a vital role in adapting conservation agriculture practises, and many farmers who have undergone formal training can grasp the basics of CAPs, unlike those who have no formal education.

Off-farm income also plays a role in the adoption of conservation agriculture. As stated by farmers in the Nalolo district, the leading farmers attested that the more they do other work outside of agriculture, the easier it is for them to adopt CAPs because they have an alternative source of income in the event of crop failure from agriculture. They use off-farm income to purchase inputs and equipment, just as other farmers in southern and east Africa who use equipment for minimum tillage in their fields (Marenya et al., 2017). This is not the case for farmers in the Nalolo district, as most farmers depend only on agriculture.

Livestock production is an essential aspect of a farm because it contributes to improved soil fertility. In the Nalolo district, farmers with livestock adopt the practice of conservation agriculture quickly because they can use the animal droppings from their crows, unlike the farmers who do not have animals and depend on buying manure or hiring the animals to fertilize their fields. The farmers with animals do not spend their money on purchasing fertilizer but use it for labour, increasing their yields. Farmers with livestock like to improve their farming activities and invest more in their farms (Mutyasira et al., 2018).

One of the barriers we identified was resistance to change (Antwi-Agyei et al., 2021). Behaviour change plays a vital role in sustainable agriculture practise. Some farmers are used to traditional ways of farming and fear adopting new agricultural techniques. Unfortunately, even some cooperative leaders find it challenging to change and influence other farmers not to adapt to new farming techniques.

This chapter reviews the literature that is pertinent to the study. In the process, conservation farming practices have been defined and reviewed, their essence, challenges and benefits were mapped, and it was also reviewed in terms of rice production, particularly in Zambia in general and then in the Barotse flood plains. Climate change, its definitions, and its relationship with agriculture were also reviewed. It should be noted that the most important outcome of the literature process was the realisation that rice production among smallholders in a case such as Zambia clashes with the dictates of conservation farming practises, yet this paradox has remained almost largely unattended, hence this study.

3. Thesis Aims and Research Questions

This master's thesis aims to investigate conservation farming practices – focusing on the cultivation of local rice varieties in Zambia's Western Province.

3.1. Specific objectives

1. Document the most common rice varieties among farmers and their pros and cons.
2. Describe current conservation practises adopted by rice farmers and factors affecting implementation.
3. Determine the barriers preventing the adoption of conservation farming techniques.

3.2. Research questions

1. What are farmers' common rice varieties and their pros and cons?
2. What are the current conservation practices applied by rice farmers, and what factors affect the adoption?
3. What barriers prevent the adoption of conservation farming techniques/rice intensification?

4. Methodology

4.1. Study Sites Characteristics

The five districts located in the Barotse floodplains were used for data collection. Mongu, Limulunga, Kalabo, Senaga, and Nalolo. With 25,828 rice farmers, the region is located in the upper Zambezi watershed and represents a unique agroecosystem in southern Africa, located in the agroecological region IIb with rains ranging between 800 mm and 1000 mm (Chabala et al., 2020). Local farming systems combine combined migratory (transhumance) and stationary (combined crop and livestock) farming systems, with rice as one of the major products. The Western province has traditional and improved rice varieties. Rice seeds are an important integral part of the rice industry if we want to meet the ever-increasing demand in the world in the world for rice consumption. Rice seed is categorised into two, traditional and improved varieties.

Improved varieties have been bred to increase yield and stability and withstand climate change's effects. The original seeds genes have been tempered and changed to adapt and suit certain climatic conditions (Wang et al., 2021). The traditional varieties, in this case, have their genes not been tempered from time immemorial, but they have characteristics that can be used to develop other varieties that suit certain weather. The advantages of improved varieties are that they increase the yield, the grains are large, and they are resistant to diseases. However, improved rice varieties require many inputs, such as fertilizer and chemicals, to grow properly (Addison et al., 2023). The advantage of traditional varieties is that they are climatised to the local environment, can resist pests and disease, and preserve the original rice seed. In Sri Lanka, traditional rice varieties are said to have more health benefits than improved varieties (Kuppusamy et al., 2016). Their disadvantage is that their yield is low, and the grains are tiny.

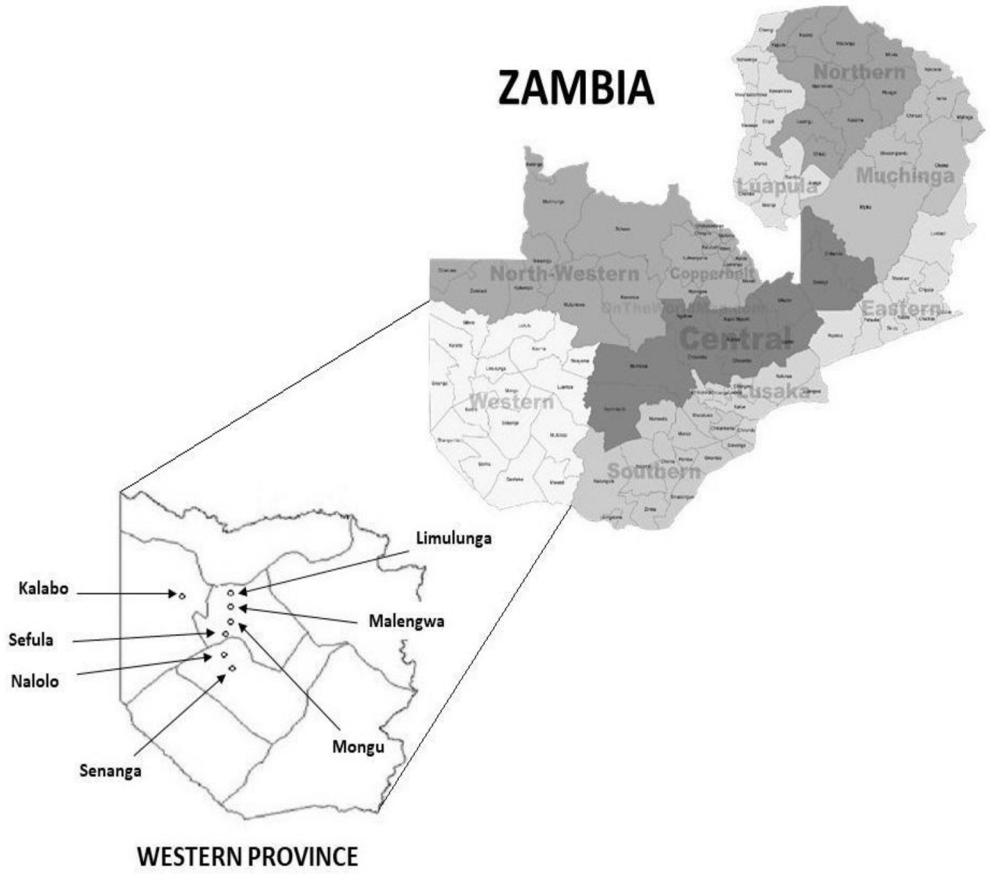

Figure 1. Map of Study Area Barotse Floodplains

4.2. Data Collection and Conceptualisation of the Research

Data were collected from Western Province because there is high rice production. First, one-on-one interviews with farmers and local advisory services (in-depth interviews with district officers) were conducted. Observations on farms were also made. Data was reviewed from available policy papers, scientific articles, government reports, and consequently in target areas. Focus Group Discussions with farmers in each selected district to verify and understand better the farmers' perspectives were undertaken The Focus Group Discussions helped formulate the questionnaire for the household survey. A pilot test was conducted with ten respondents; information was used to adjust the questionnaire accordingly. The semi-structured questionnaire formulated was printed and administered to individual rice farmers using agriculture extension officers.

The semi-structured questionnaire expected the farmers to provide information other than the options provided; for example, farmers were asked to provide information on the post-harvest activities in addition to animal grazing, straw retention, burning, and mulching. Lastly, a household survey was conducted among 15-20 households in villages selected purely to gather quantitative data on household resources, perceptions, and drivers.

4.3. Conceptual Framework

Rice farmers in the Barotse floodplains have suffered from the effects of climate change, of which many are caused by human activities and others are naturally based. These effects have manifested through land degradation, soil erosion, low yields, and pests. To solve these problems, institutional factors, farm characteristics, biophysical characteristics, and profile of household heads are needed, for example, improving extension services, allowing land ownership, especially for women, an increase of farm income and the use of cooperatives would affect the adoption of conservation farming practises. Engaging in these factors, farmers can use sustainable agriculture practices that will improve soil fertility, and the output will be increased yield.

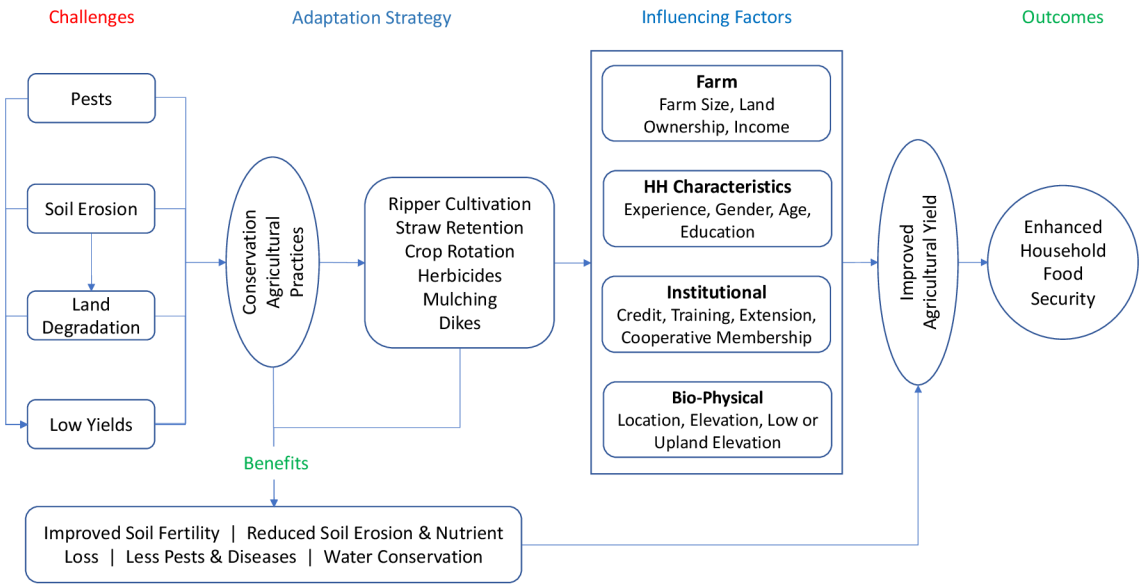

Figure 2. Conceptual Framework.

4.4. Data Analysis

Information was collected through FDGs and one–on–one interviews using printed semi-structured questionnaires. Data was entered into and coded in Microsoft Excel. Later, it was imported into SPSS (Statistical Package for Social Sciences), where descriptive statistics and frequencies were calculated. A binary logistics regression model was used to analyse the factors affecting Conservation Agriculture Practices (CAP). The dependent variable was the adoption of CAP (0,1). The independent variables included: age, gender, years of schooling, years of farming experience, number of household members, and total land under cultivation.

5. Results

5.1. Overview of Major Rice Varies in Barotse Floodplains.

Farmers in the Barotse flood plains have been surviving on local varieties for their farming. However, due to climate variability, farmers adopted new types such as Wayi wayi, Zaou, Koshikari, and Neria. Adopting these new varieties has improved farmers' yield which would be problematic for local varieties only. The table below shows the common varieties in the Barotse flood plains.

Table 1. Evaluation of local rice varies during focus group discussion in the study sites.

Rice Variety	Characteristics	Pros	Cons	Increased or Decreased Production	Traditional or Improved (Differences)
Supa MG	Released variety that performs well in paddy fields, Conventional variety that can be reused as seed for several seasons if it is not contaminated, (not sticky).	High to very yielding with productive panicles of up to 50, good aroma, tastes good, resistant to rice blast disease, low-temperature tolerance has a good market	Needs much water to mature, poor performance on the upland, late maturing	High to very high yielding with productive panicles of up to 50	Improved released variety with limited literature review.
Zahou 5	Improved variety, low land.	High yielding, medium maturity, for market	No aroma	Medium yielding	Improved variety
Nerica 1	Improved variety, upland, open pollinated variety.	Drought tolerant, high yielding, early maturing variety, subsistence	No aroma, poor performance in low land	Medium to high yielding in upland	Improved upland released variety
Nerica 4	Improved variety, upland.	Drought tolerant, early maturing variety (110 to 120 days), no aroma can be pounded into rice meal, and it is non-sticky, for subsistence.	No aroma, poor performance in low land.	Medium to high yielding in upland conditions	Improved upland released variety, scientific literature available, the source is known (it is a cross between glabellema (African rice) and Ozya sativa (Asian rice)
Aongola 1	Low land variety.	It helps in controlling high blood pressure.	Low yield.	Low yielding.	Traditional variety

Table 1. (Continued). Description Rice Varieties, Pros, and Cons

Rice Variety	Characteristics	Pros	Cons	Increased or Decreased Production	Traditional or Improved (Differences)
Aongola 7 or Crystal	Low land	Low carbohydrates, good for high blood treatment i.e., rich in iron, polished grains are purplish in colour as well as the lower parts of the growing panicles, for subsistence	Medium to late maturity (125 to 130 days).	High yielding.	Traditional i.e. no scientific literature available, source not known
Burma	Traditional variety, low land	Fair aroma, moderate yielding, subsistence	Late maturing	Low yielding	
Kajaketi	Traditional variety, low land, have extra awe on top of the husk (Giving it the name Jacket), no aroma (Can be pounded into rice meal).	High yielding, source of carbohydrates, proteins, rich in antioxidants, subsistence	Medium to late maturing (125 to 130 days).	High-yielding variety.	Traditional i.e., no scientific literature available, source not known
Blue bonnet	Traditional variety.	Source of fiber, fat, rice starches, and acids.	Medium maturity.	Low yielding	
Sumba wanga	upland	Fair aroma	Low-yielding, late maturity		Traditional variety
Koshikari	Low land, medium maturity.	Fair aroma, high yielding, for market	Poor performance in upland, sticky	High yielding	Improved variety
Wayi wayi	low land	High yielding, early maturing, for subsistence	Poor yield on upland	High yielding	Improved variety

Table 2. Descriptive Statistics: Continuous Variables (N=348).

Variable	Mean	SD
Age of respondent	47.54	(14.59)
Years of schooling	8.34	(3.17)
Farming experience (years)	15.53	(11.41)
Household size (number)	6.88	(2.86)
Farm size under cultivation (ha)	1.46	(1.59)
Total farm size (ha)	2.92	(3.85)

Data collected from the selected continuous variables (Table 2) show that age has the highest mean of 47.54, indicating that elderly farmers adopt the CAP due to the benefits they have seen in their life. Years of farming experience are also increased with the mean at 15.53, indicating that farmers with more years of experience have more understanding in CAP than those who have experience have more knowledge in CAP than those with less experience. We also noticed that farmers with more years of schooling adapt easily to CAP because they have come across information about CAP in their education. Table 3. Descriptive Statistics – Categorical Variables (N=348).

The results show that females have a higher percentage of respondents at 73.3%, indicating that women are more involved in agriculture at the household level and that they spend a lot of their time feeding their families, while men spend a lot of their time in recreation activities and beer drinking. Married people have 52.6%, which has a huge contribution to the adoption of CAP, meaning that families that work together adapt easily and find more benefits than those that are not married. Education, livestock ownership, and access to information about climate change indicate that they contribute positively to the adoption of CAP. Transplanting plays an essential role towards adoption, while lack of credit facilities makes farmers fail to adopt. Extension officers and farmer to farmer also play a significant role in the adoption of CAP as well as belonging to farmer organisations. The type of land ownership plays a vital role adopting CAP for rice production; customary ownership in this study was 83.0%.

Table 3. Descriptive Statistics – Categorical Variables (N=348).

Variable	Description	Percentage (%)
Gender	Male	26.70
	Female	73.30
Marital status	Single	26.40
	Married	52.60
	Divorced	4.60
	Separated	4.30
	Widow	12.10
Highest level of schooling	Illiterate	2.30
	Primary	42.50
	Secondary	49.70
	College/University	5.50
Livestock ownership (cow)	Yes	24.70
Type of land ownership	Customary	83.00
	Rented	10.90
	Statutory	4.90
	Leased	1.10
Availability of irrigation system	Yes	26.70
Types of rice seed	Traditional	30.20
	Improved	69.50
Types of rice planting methods	Broadcasting	38.50
	Transplanting	61.50
Access of rice seed	FISP	23.60
	Agri-market	20.10
	Food security pack	1.70
	Recycled	53.70
Access to credit facilities	Yes	33.60
Member of farmer organisation	Yes	79.00
Access to provision of input subsidies	Yes	35.60
Receiving information about climate change	Yes	98.30
Source of climate related information	Metrological department	77.60
	NGOs	20.70
Source of information		
Extension officers	Yes=1	89.40
Farmer to farmer	Yes	89.40
Radio and television	Yes	47.10
Agricultural newspapers	Yes	20.70
Attended training on SRI/ Conservation farming	Yes	60.90

5.2. Factors Influencing the Adoption of Conservation Agriculture

Table 4 presents the results of a statistical analysis, which aims to investigate the relationship between a set of independent variables (e.g., age, gender, education, farming experience, etc.) and a dependent variable of interest (adoption of CAP). The first column shows the estimated regression coefficients, and the second column shows their corresponding statistical significance levels.

The coefficients represent the change in the dependent variable associated with a one-unit increase in the independent variable, while holding all other variables constant. For example, the coefficient for "off-farm income" is 1.86, which means that on average, individuals who have off-farm income earn 1.86 units more of the dependent variable than those who do not have off-farm income, while controlling for the effects of other variables in the model.

The second column indicates the statistical significance of the coefficients, which determines whether the relationship is likely to be due to chance or reflects a real effect. A coefficient with a significant p-value ($p < 0.05$) means that the effect is unlikely to be due to chance and suggests a significant relationship between the independent variable and the dependent variable.

The ** symbols indicate that the coefficients are statistically significant at the 0.01 level, which is a more stringent criterion than the conventional level of 0.05.

The negative sign before the coefficient for "Access to credit facilities" suggests that individuals who have access to credit facilities tend to have lower values of the dependent variable than those who do not, while controlling for the effects of other variables.

Overall, the results suggest that off-farm income, agricultural newspapers, and agricultural extension services are positively related to the dependent variable, while access to credit facilities, radio and television, and the number of household members are negatively related. However, the coefficients for some variables, such as gender and farmer-to-farmer, are not statistically significant, indicating that these variables are not strongly related to the dependent variable.

Table 4. Binary Logistic Regression Model.

Variables	Estimate
Household and Rice Farmer Characteristics	
Age (years)	0.01 (0.15)
Gender (male=1)	0.02 (0.41)
Years of schooling (years)	-0.03 (0.06)
Years of farming experience (years)	-0.01 (0.02)
Household size (number)	-0.06 (0.06)
Farm Characteristics	
Total land under cultivation (ha)	0.02 (0.10)
Off farm income (yes=1)	1.86 (0.37)**
Institutional Characteristics	
Access to credit facilities in the past 3 years (yes=1)	-0.19 (0.44)
Member of farmer organization (Yes=1, No=0)	-0.10 (0.43)
Information Sources	
Farmer to farmer (Yes=1, No=0)	0.03 (0.50)
Radio & television (Yes=1, No=0)	-0.39 (0.38)
Agricultural newspaper (Yes=1, No=0)	2.70 (1.10)**
Agriculture extension (Yes=1, No= 0)	1.40 (0.46)**

**** Indicates that the coefficients are statistically significant at the 0.05 level. Standard errors are shown in parentheses.**

5.3. Barriers of Influencing Conservation Agricultural Practices

Figure 3 shows Likert scale of 1 to 5 was used to measure the level of adoption of six agricultural practices, including the use of dikes, ripper cultivation, herbicides, mulching, straw retention, and crop rotation. Where 1 = the least adoption; 2 = less adoption; 3 = average adoption; 4 = more adoption; 5 = the most adoption. The results revealed that of the 348 respondents, straw retention and mulching had the highest adoption rate (both 84.77%). Herbicides and rip cultivation had the second highest adoption rate, with 83.62% of the respondents taking up the practice.

However, the use of dikes had the highest non-adoption rate, at 18.68% – with 81.32% of the respondents adopting the practice. Ripper Cultivation had the highest percentage (25.57%) among the least adopted practices, while all practices had the highest averagely adopted rate, ranging from 38.51% for crop rotation to 47.41% for Herbicide use.

However, in the category of 'more adopted' practices (group 4), including crop rotation, straw retention and mulching, there was a lower adoption rate compared to averagely adopted practices (group 3), with rates of 28.74%, 25.86%, and 22.99%, respectively. Herbicide use and dikes use had a higher adoption rate in the 'most adopted' group (group 5) compared to the 'averagely adopted' group (group 3), with rates of 5.17% and 6.32%, respectively. Finally, ripper cultivation was the lowest-adopted practice in both the 'more adopted' and 'most adopted' ranges.

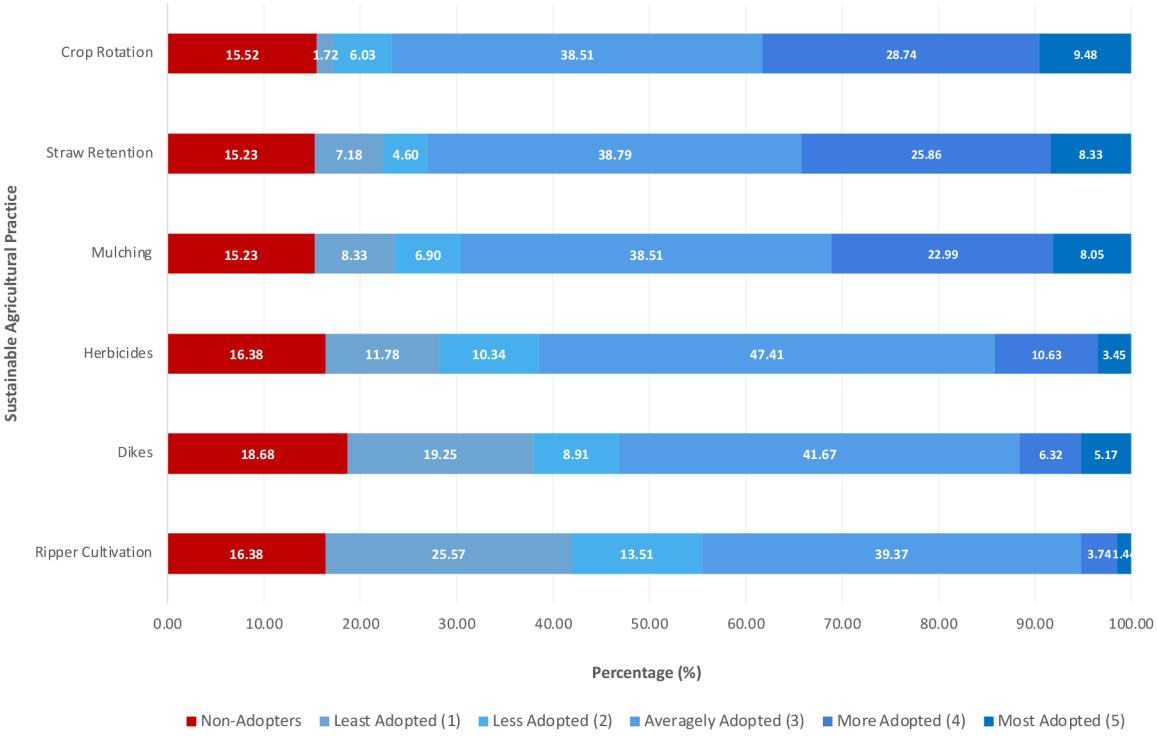

Figure 3. Sustainable Agricultural Practice Adoption Rate (%).

The data above indicate that time-consuming (40.2%) and uncertainty (45.4%) have been rated high by most farmers, while labour intensive was the least rated, indicating that some farmers find it difficult to try new farming systems introduced by extension agents. However, other farmers are aware of the labour-intensive nature (35%), indicating that farmers still need equipment to make their farming easy.

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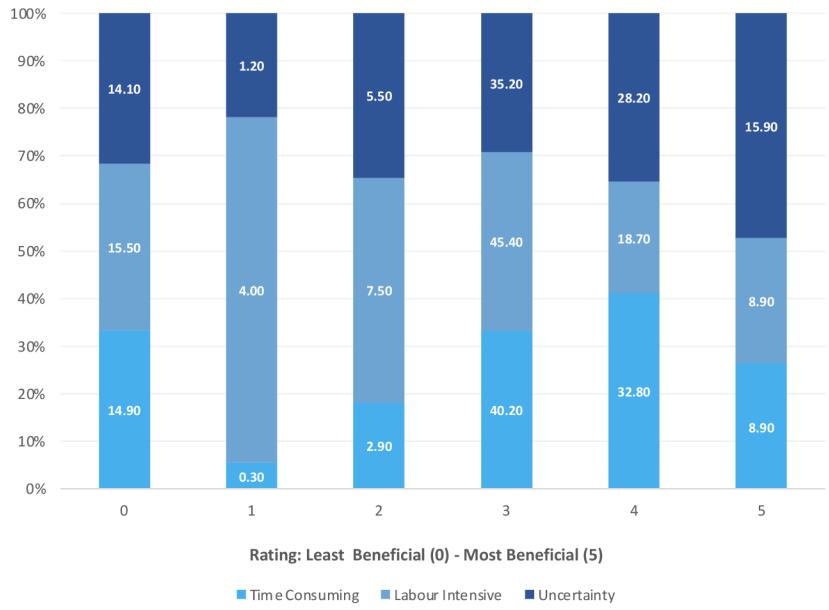

Figure 4. Barriers: Adoption of Conservation Agriculture – Rates (%).

6. Discussion

Data collected from the selected continuous variables shows that age has the highest mean with 14.59, showing that elderly farmers adopt the CAP due to the benefits they have seen. Years of farming experience are also high, with the mean at 15.53, indicating that farmers with more experience have more knowledge in CAP than those with little experience. We also noticed that farmers with more years of schooling adapt easily to CAP because they have come across information about CAP in their education (Adoyo et al., 2022).

Females have a higher percentage of respondents at 73.3%, indicating that women are more involved in agriculture at the household level and spend a lot of their time feeding their families, while men spend a lot of their time in recreation activities and beer drinking. Married people have 52.6%, which has a huge contribution to adoption of CAP, meaning that families that work together adapt easily and find more benefits than those that are not married. Education, livestock ownership, and access to information about climate change indicate that they contribute positively to the adoption of CAP. Transplantation plays a vital role in adoption, while lack of credit facilities makes farmers not adopt. Extension officers and farmer to farmer also play a significant role in the adoption of CAP as well as belonging to farmer organisations.

The type of land ownership plays a vital role in the adoption of CAP for rice production, and customary ownership had 83.0% showing that most of the land is owned by traditional leaders. Many farmers by belonging to the local tribes have the privilege of having access to land for cultivation. However, ownership is still a problem, especially for women. This makes some farmers fail to adapt to CAP because they are scared to invest where land can be grabbed from them in case of conflicts (Nkomoki et al., 2018).

Conservation farming practices improve soil fertility and eventually improves yield because it involves less tillage of the land, mixing the rearing of animals and growing crops. As indicated even in the results, we notice that farmers rate it high and have the potential to rejuvenate the less fertile soils (Vanlauwe et al., 2014). Small farmers use simple hoes and axes and do not have sophisticated knowledge or skill beyond just the basics of farming, especially on the Barotse floodplains. Using conservation agriculture exposes them to new technology (Mundia Mukwalikuli, 2018).

The System of Rice Intensification (SRI) is an example of a sustainable way of producing rice in Zambia as it aims to reduce plant population while providing good irrigation, soil and plant management (CIIFAD, 2014).

This requires an injection of equipment and labour in its initial stages, but with time, the farmer does not need to buy equipment and use much labour because the soil would have been established more sustainable. Farmers who have graduated from small to medium, in this case, see conservation farming as affordable because they have improved their farming systems, e.g., the use of irrigation facilities. However, some smallholders, though not many, feel it is expensive.

Other farmers indicated that uncertainty makes them fail to adapt to CAP because they are afraid to start new techniques as they are used to traditional ways of farming. Many farmers that fear taking some risks have failed to progress in their farming activities. As much as farmers indicate that conservation agriculture improves yield, there is much to be done. Our literature shows that demand is more than supply; hence, the government ends up supplementing supply by importing rice from other countries to meet the ever-growing demand for rice (Makungwe et al., 2021b). Therefore, it is very important for governments and various stakeholders to provide irrigation facilities and other equipment to allow smallholders to grow rice year-round sustainably.

It was revealed that that small-holder farmers, who are the majority of farmers in Zambia, use monoculture to produce rice. More awareness must be crucial given to them on using conservation farming practices such as intercropping rice with legumes and other crops so that their fields are boosted (Mutyasira et al., 2018). Monoculture destroys the structure of the soil because the same types of nutrients are extracted every year; due to , external inputs such as fertiliser and chemicals are ever added to rice fields (Makungwe et al., 2021a).

As indicated in our results, consistent planting of traditional varieties without proper management practices is one of the factors contributing to low yields by farmers. Therefore, it is important to advise the farmers to visit extension officers or join cooperatives where they can access information on how to grow their traditional rice varieties and improved varieties of rice more sustainably. As indicated in our methodology, both traditional and improved varieties are needed by the farmers (Kuppusamy et al., 2016).

In Sri Lanka, conservation farming among rice farmers is a mandate because they know that conservation farming is a possible farming system that improves the soil structure and increase in biodiversity. As much as farmers want to meet the demand for rice, it is essential to pay attention to biodiversity (Horgan et al., 2018).

Off-farm income was found to positively affect the adoption of conservation agriculture. According to farmers, the main farmers attested that the more job they perform outside of farming, the easier it is for them to embrace CAPs since they have a backup plan in place in case their crops fail. Like other farmers in southern and eastern Africa who utilize equipment for minimum tillage in their fields, they use off-farm money to buy inputs and equipment (Marenya et al., 2017).

In addition, information sources Many farmers that are not like using newspapers as a reliable tool for information dissemination in their farming systems. Elderly farmers especially prefer using newspapers and do not like using the internet because sometimes information from the internet is misleading and does not have reliable sources. On the other hand, agricultural publications can inform farmers about cutting-edge farming techniques they might not be familiar with. Additionally, they can offer helpful pointers and suggestions on how to control pests and illnesses, boost crop yields, and enhance soil fertility. Agriculture publications can feature the achievements of farmers who have adopted novel techniques and attained notable outcomes. Other farmers may be motivated and inspired by these tales to adopt comparable techniques and enhance their farming businesses. Agricultural newspapers can aid in the creation of networks between farmers, extension agents, researchers, and other agricultural industry participants. A stronger level of collaboration and innovation may result from this making it easier to share information, ideas, and experiences(Fan et al., 2022).

6.1. Study Limitations

Rice farming systems represent a long tradition for households in Barotse floodplains. Issues related to rice are somewhat sensitive. Furthermore, household were selected though rather convenient methods and therefore our database is not randomized. In addition, working with local extension officers could have had an influence on the responses of targeted farmers and households as well.

7. Conclusions and Recommendations

Smallholder farmers face several difficulties, including poor soil fertility, unreliable rainfall, and low crop yields. However, constraints including restricted availability of inputs, equipment expertise, and the lack of government support have made adopting these practices difficult.

This study identified different rice varieties used by smallholder farmers of the western province that can be grown on lowlands and upland. It also revealed the barriers affecting conservation farming systems. With the practice of conservation agriculture, the farmers in western province can improve their yield. The major reason for producing low yields is the practice of monoculture, lack of machinery and access to credit facilities, among other factors enabling the farmers to increase their yields.

To promote conservation agriculture effectively, it is crucial to address these challenges and provide farmers with the tools and knowledge necessary for sustainable farming. Community involvement and education are crucial for successful conservation in Zambia. Furthermore, collaboration between different organizations and stakeholders is important for conservation efforts to be effective. Therefore, local authorities in Zambia's Western Province must consider these difficulties and give farmers the necessary tools and knowledge to apply sustainable methods effectively. As a recommendation, the government must develop a deliberate policy to support farmers with credit schemes, machinery, land ownership for women and provide farmers with knowledge of climate change as they should produce rice in an eco-friendly manner.

References

Addison, M., Anyomi, B. K., Acheampong, P. P., Wongnaa, C. A., & Amaning, T. K. (2023). Key drivers of adoption intensity of selected improved rice technologies in rural Ghana. *Scientific African*, *19*. https://doi.org/10.1016/j.sciaf.2023.e01544

Adenle, A. A., Wedig, K., & Azadi, H. (2019). Sustainable agriculture and food security in Africa: The role of innovative technologies and international organizations. *Technology in Society*, *58* , 101143. https://doi.org/10.1016/j.techsoc.2019.05.007

Adoyo, B., Schaffner, U., Mukhovi, S., Kiteme, B., Mbaabu, P. R., Eckert, S., Choge, S., & Ehrensperger, A. (2022). Pathways towards the Sustainable Management of Woody Invasive Species: Understanding What Drives Land Users' Decisions to Adopt and Use Land Management Practices. *Land*, *11*(4). https://doi.org/10.3390/land11040550

Akinyi, D. P., Ng'ang'a, S. K., Ngigi, M., Mathenge, M., & Girvetz, E. (2022). Cost-benefit analysis of prioritized climate-smart agricultural practices among smallholder farmers: evidence from selected value chains across sub-Saharan Africa. *Heliyon*, *8*(4), e09228. https://doi.org/10.1016/j.heliyon.2022.e09228

Ali, S., Ghosh, B. C., Osmani, A. G., Hossain, E., & Fogarassy, C. (2021). Farmers' climate change adaptation strategies for reducing the risk of rice production: Evidence from rajshahi district in bangladesh. *Agronomy*, *11*(3). https://doi.org/10.3390/agronomy11030600

Alibu, S., Obura, M., Ekebu, J., Nampamya, D., Lamo, J., Asea, G., & Park, T. S. (2022). Modest Ag-Extension and Access to Seeds of Aromatic Rice Can Boost Returns of Smallholder Farmers in Uganda, A Case Study. *Agriculture (Switzerland)*, *12*(8), 1–16. https://doi.org/10.3390/agriculture12081172

Ambrosius, F. H. W., Hofstede, G. J., Bokkers, E. A. M., Bock, B. B., & Beulens, A. J. M. (2019). The social influence of investment decisions: A game about the Dutch pork sector. *Livestock Science*, *220*(October 2018), 111–122. https://doi.org/10.1016/j.livsci.2018.12.018

Antwi-Agyei, P., Abalo, E. M., Dougill, A. J., & Baffour-Ata, F. (2021). Motivations, enablers and barriers to the adoption of climate-smart agricultural practices by smallholder farmers: Evidence from the transitional and savannah agroecological zones of Ghana. *Regional Sustainability*, *2*(4), 375–386. https://doi.org/10.1016/j.regsus.2022.01.005

Appau, A., Drope, J., Witoelar, F., Lencucha, R., & Chavez, J. J. (2019). Why do farmers grow tobacco? A qualitative exploration of farmers perspectives in Indonesia and Philippines. *International Journal of Environmental Research and Public Health*, *16*(13). https://doi.org/10.3390/ijerph16132330

Assaye, A., Habte, E., Sakurai, S., & Alemu, D. (2022). Impact assessment of adopting improved rice variety on farm household welfare in Ethiopia. *Journal of Agriculture and Food Research*, *10*, 100428. https://doi.org/10.1016/j.jafr.2022.100428

Baghel, J. K., Das, T. K., Pankaj, Mukherjee, I., Nath, C. P., Bhattacharyya, R., Ghosh, S., & Raj, R. (2020). Impacts of conservation agriculture and herbicides on weeds, nematodes, herbicide residue and productivity in direct-seeded rice. *Soil and Tillage Research*, *201*(August 2019), 104634. https://doi.org/10.1016/j.still.2020.104634

Bartkowski, B., & Bartke, S. (2018). Leverage points for governing agricultural soils: A review of empirical studies of European farmers' decision-making. *Sustainability (Switzerland)*, *10*(9). https://doi.org/10.3390/su10093179

Biswas, B., Mallick, B., Roy, A., & Sultana, Z. (2021). Impact of agriculture extension services on technical efficiency of rural paddy farmers in southwest Bangladesh. *Environmental Challenges*, *5*(April), 100261. https://doi.org/10.1016/j.envc.2021.100261

Blekking, J., Gatti, N., Waldman, K., Evans, T., & Baylis, K. (2021). The benefits and limitations of agricultural input cooperatives in Zambia. *World Development*, *146*, 105616. https://doi.org/10.1016/j.worlddev.2021.105616

Brown, W. (2013). Sovereignty matters: Africa, donors, and the aid relationship. *African Affairs*, *112*(447), 262–282. https://doi.org/10.1093/afraf/adt001

Byerlee, D., Stevenson, J., & Villoria, N. (2014). Does intensification slow crop land expansion or encourage deforestation? *Global Food Security*, *3*(2), 92–98. https://doi.org/10.1016/j.gfs.2014.04.001

Chabala, L. M., Chimungu, J. G., Lark, R. M., Mtambanengwe, F., Nalivata, P. C., Phiri, E., & Sakala, G. M. (2020). Eliciting experts' tacit models for the interpretation of soil information, an example from the evaluation of potential benefits from conservation agriculture. *Geoderma*, *376*(July), 114545. https://doi.org/10.1016/j.geoderma.2020.114545

Chatzimichael, K., Genius, M., & Tzouvelekas, V. (2014). Informational cascades and technology adoption: Evidence from Greek and German organic growers. *Food Policy*, *49*(P1), 186–195. https://doi.org/10.1016/j.foodpol.2014.08.001

Chengjun, S., Renhua, S., Zuliang, S., Yinghao, X., Jiuchen, W., Zhiyu, X., & Shangbin, G. (2022). Construction process and development trend of ecological agriculture in China. *Acta Ecologica Sinica*, *42*(6), 624–632. https://doi.org/10.1016/j.chnaes.2021.05.004

Chesterman, N. S., Entwistle, J., Chambers, M. C., Liu, H. C., Agrawal, A., & Brown, D. G. (2019). The effects of trainings in soil and water conservation on farming practices, livelihoods, and land-use intensity in the Ethiopian highlands. *Land Use Policy*, *87*(June), 104051. https://doi.org/10.1016/j.landusepol.2019.104051

CIIFAD. (2014). *SRI and Its Impacts on Women*. 1–4. http://sri.ciifad.cornell.edu/conferences/IRC2014/booth/SRI_gender_handout_2014.pdf

Curtis, P. G., Slay, C. M., Harris, N. L., Tyukavina, A., & Hansen, M. C. (2018). Classifying drivers of global forest loss. *Science*, *361*(6407), 1108–1111. https://doi.org/10.1126/science.aau3445

Danso-Abbeam, G. (2022). Do agricultural extension services promote adoption of soil and water conservation practices? Evidence from Northern Ghana. *Journal of Agriculture and Food Research*, *10*(May), 100381. https://doi.org/10.1016/j.jafr.2022.100381

Das, A., Rangappa, K., Basavaraj, S., Dey, U., Haloi, M., Layek, J., Idapuganti, R. G., Lal, R., Deshmukh, N. A., Yadav, G. S., Babu, S., & Ngachan, S. (2021). Conservation tillage and nutrient management practices in summer rice (Oryza sativa L.) favoured root growth and phenotypic plasticity of succeeding winter pea (Pisum sativumL.) under eastern Himalayas, India. *Heliyon*, *7*(5), e07078. https://doi.org/10.1016/j.heliyon.2021.e07078

Devkota, K. P., Pasuquin, E., Elmido-Mabilangan, A., Dikitanan, R., Singleton, G. R., Stuart, A. M., Vithoonjit, D., Vidiyangkura, L., Pustika, A. B., Afriani, R., Listyowati, C. L., Keerthisena, R. S. K., Kieu, N. T., Malabayabas, A. J., Hu, R., Pan, J., & Beebout, S. E. J. (2019). Economic and environmental indicators of sustainable rice cultivation: A comparison across intensive irrigated rice cropping systems in six Asian countries. *Ecological Indicators*, *105*(June), 199–214. https://doi.org/10.1016/j.ecolind.2019.05.029

Droppelmann, K. J., Snapp, S. S., & Waddington, S. R. (2017). Sustainable intensification options for smallholder maize-based farming systems in sub-Saharan Africa. *Food Security*, *9*(1), 133–150. https://doi.org/10.1007/s12571-016-0636-0

Etienne, L., Franck, P., Lavigne, C., Papaïx, J., Tolle, P., Ostandie, N., & Rusch, A. (2022). Pesticide use in vineyards is affected by semi-natural habitats and organic farming share in the landscape. *Agriculture, Ecosystems and Environment*, *333*(April 2021). https://doi.org/10.1016/j.agee.2022.107967

Fan, L., Ge, Y., & Niu, H. (2022). Effects of agricultural extension system on promoting conservation agriculture in Shaanxi Plain, China. *Journal of Cleaner Production*, *380*(P1), 134896. https://doi.org/10.1016/j.jclepro.2022.134896

Funder, M., & Mweemba, C. E. (2019). Interface bureaucrats and the everyday remaking of climate interventions: Evidence from climate change adaptation in Zambia. *Global Environmental Change*, *55*(January), 130–138. https://doi.org/10.1016/j.gloenvcha.2019.02.007

Girma, Y. (2022). Credit access and agricultural technology adoption nexus in Ethiopia: A systematic review and meta-analysis. *Journal of Agriculture and Food Research*, *10*(March), 100362. https://doi.org/10.1016/j.jafr.2022.100362

Gonzalez-Sanchez, E. J., Veroz-Gonzalez, O., Blanco-Roldan, G. L., Marquez-Garcia, F., & Carbonell-Bojollo, R. (2015). A renewed view of conservation agriculture and its evolution over the last decade in Spain. *Soil and Tillage Research*, *146*(PB), 204–212. https://doi.org/10.1016/j.still.2014.10.016

Hills, T., Motaroki, L., Ouma, G., & Kalele, D. (2020). African Handbook of Climate Change Adaptation. *African Handbook of Climate Change Adaptation*, *October*. https://doi.org/10.1007/978-3-030-42091-8

Horgan, F. G., Kudavidanage, E. P., Weragodaarachchi, A., & Ramp, D. (2018). Traditional 'maavee' rice production in Sri Lanka: environmental, economic and social pressures revealed through stakeholder interviews. *Paddy and Water Environment*, *16*(2), 225–241. https://doi.org/10.1007/s10333-017-0604-0

Husson, O., Tano, B. F., & Saito, K. (2022). Designing low-input upland rice-based cropping systems with conservation agriculture for climate change adaptation: A six-year

experiment in M'bé, Bouaké, Côte d'Ivoire. *Field Crops Research*, *277*(April 2021), 108418. https://doi.org/10.1016/j.fcr.2021.108418

Jat, H. S., Datta, A., Sharma, P. C., Kumar, V., Yadav, A. K., Choudhary, M., Choudhary, V., Gathala, M. K., Sharma, D. K., Jat, M. L., Yaduvanshi, N. P. S., Singh, G., & McDonald, A. (2018). Assessing soil properties and nutrient availability under conservation agriculture practices in a reclaimed sodic soil in cereal-based systems of North-West India. *Archives of Agronomy and Soil Science*, *64*(4), 531–545. https://doi.org/10.1080/03650340.2017.1359415

Jayne, T. S., Snapp, S., Place, F., & Sitko, N. (2019). Sustainable agricultural intensification in an era of rural transformation in Africa. *Global Food Security*, *20*(January), 105–113. https://doi.org/10.1016/j.gfs.2019.01.008

Jew, E. K. K., Whitfield, S., Dougill, A. J., Mkwambisi, D. D., & Steward, P. (2020). Farming systems and Conservation Agriculture: Technology, structures and agency in Malawi. *Land Use Policy*, *95*(July 2018). https://doi.org/10.1016/j.landusepol.2020.104612

Jiri, O., Mafongoya, P. L., Mubaya, C., & Mafongoya, O. (2016). Seasonal Climate Prediction and Adaptation Using Indigenous Knowledge Systems in Agriculture Systems in Southern Africa: A Review. *Journal of Agricultural Science*, *8*(5), 156. https://doi.org/10.5539/jas.v8n5p156

Jordán, A., Zavala, L. M., & Gil, J. (2010). Effects of mulching on soil physical properties and runoff under semi-arid conditions in southern Spain. *Catena*, *81*(1), 77–85. https://doi.org/10.1016/j.catena.2010.01.007

Kassam, A., Friedrich, T., & Derpsch, R. (2015). Overview of the global spread of conservation agriculture. *Sustainable Development of Organic Agriculture: Historical Perspectives*, *8*(December), 53–68.

Kolawole, O. D., Wolski, P., Ngwenya, B., & Mmopelwa, G. (2014). Ethno-meteorology and scientific weather forecasting: Small farmers and scientists' perspectives on climate variability in the Okavango Delta, Botswana. *Climate Risk Management*, *4*, 43–58. https://doi.org/10.1016/j.crm.2014.08.002

Kumar, R., Choudhary, J. S., Mishra, J. S., Mondal, S., Poonia, S., Monobrullah, M., Hans, H., Verma, M., Kumar, U., Bhatt, B. P., Malik, R. K., Kumar, V., & McDonald, A. (2022). Outburst of pest populations in rice-based cropping systems under conservation

agricultural practices in the middle Indo-Gangetic Plains of South Asia. *Scientific Reports*, *12*(1), 1–11. https://doi.org/10.1038/s41598-022-07760-w

Kuppusamy, E., Dhamodharan, K. I., & Jayakumar, S. (2016). Journal of {Coastal} {Life} {Medicine}. *Journal of Coastal Life Medicine*, *4*(11), 902–917.

Laik, R., Sharma, S., Idris, M., Singh, A. K., Singh, S. S., Bhatt, B. P., Saharawat, Y., Humphreys, E., & Ladha, J. K. (2014). Integration of conservation agriculture with best management practices for improving system performance of the rice-wheat rotation in the Eastern Indo-Gangetic Plains of India. *Agriculture, Ecosystems and Environment*, *195*, 68–82. https://doi.org/10.1016/j.agee.2014.06.001

Lapple, D., & Kelley, H. (2015). Spatial dependence in the adoption of organic drystock farming in Ireland. *European Review of Agricultural Economics*, *42*(2), 315–337. https://doi.org/10.1093/erae/jbu024

Li, R., Li, Q., & Pan, L. (2021). Review of organic mulching effects on soil and water loss. *Archives of Agronomy and Soil Science*, *67*(1), 136–151. https://doi.org/10.1080/03650340.2020.1718111

Lichtenberg, E. (2019). Conservation and the Environment in US Farm Legislation. *EuroChoices*, *18*(1), 49–55. https://doi.org/10.1111/1746-692X.12214

Makungwe, M., Chabala, L. M., Van Dijk, M., Chishala, B. H., & Lark, R. M. (2021a). Assessing land suitability for rainfed paddy rice production in Zambia. *Geoderma Regional*, *27*(September), e00438. https://doi.org/10.1016/j.geodrs.2021.e00438

Makungwe, M., Chabala, L. M., Van Dijk, M., Chishala, B. H., & Lark, R. M. (2021b). Assessing land suitability for rainfed paddy rice production in Zambia. *Geoderma Regional*, *27*(May), e00438. https://doi.org/10.1016/j.geodrs.2021.e00438

Makuvaro, V., Walker, S., Munodawafa, A., Chagonda, I., Masere, P., Murewi, C., & Mubaya, C. (2017). Constraints to crop production and adaptation strategies of smallholder farmers in semi-arid Central and Western Zimbabwe. *African Crop Science Journal*, *25*(2), 221. https://doi.org/10.4314/acsj.v25i2.7

Maltchik, L., Stenert, C., & Batzer, D. P. (2017). Can rice field management practices contribute to the conservation of species from natural wetlands? Lessons from Brazil. *Basic and Applied Ecology*, *18*, 50–56. https://doi.org/10.1016/j.baae.2016.10.002

Marenya, P. P., Kassie, M., Jaleta, M., Rahut, D. B., & Erenstein, O. (2017). Predicting minimum tillage adoption among smallholder farmers using micro-level and policy variables. *Agricultural and Food Economics*, *5*(1), 1–22. https://doi.org/10.1186/s40100-017-0081-1

Mishra, B., Gyawali, B. R., Paudel, K. P., Poudyal, N. C., Simon, M. F., Dasgupta, S., & Antonious, G. (2018). Adoption of Sustainable Agriculture Practices among Farmers in Kentucky, USA. *Environmental Management*, *62*(6), 1060–1072. https://doi.org/10.1007/s00267-018-1109-3

Mulenga, B. P., Wineman, A., & Sitko, N. J. (2017). Climate Trends and Farmers' Perceptions of Climate Change in Zambia. *Environmental Management*, *59*(2), 291–306. https://doi.org/10.1007/s00267-016-0780-5

Mundia Mukwalikuli. (2018). Determinants of Technical Efficency of Smallholder Farming in Lukulu. *World Journal of Research and Review*, *6*(4), 60–65. www.wjrr.org

Mutyasira, V., Hoag, D., & Pendell, D. (2018). The adoption of sustainable agricultural practices by smallholder farmers in Ethiopian highlands: An integrative approach. *Cogent Food and Agriculture*, *4*(1), 1–17. https://doi.org/10.1080/23311932.2018.1552439

Ng'ombe, J., Kalinda, T., Tembo, G., & Kuntashula, E. (2014). Econometric analysis of the factors that affect adoption of conservation farming practices by smallholder farmers in Zambia. *Journal of Sustainable Development*, *7*(4), 124–138. https://doi.org/10.5539/jsd.v7n4p124

Ngoma, H., & Angelsen, A. (2018). Can conservation agriculture save tropical forests? The case of minimum tillage in Zambia. *Forest Policy and Economics*, *97*(April), 153–162. https://doi.org/10.1016/j.forpol.2018.10.001

Ngoma, H., Pelletier, J., Mulenga, B. P., & Subakanya, M. (2021). Climate-smart agriculture, cropland expansion and deforestation in Zambia: Linkages, processes and drivers. *Land Use Policy*, *107*(August 2020), 105482. https://doi.org/10.1016/j.landusepol.2021.105482

Nhamo, N., Kyalo, G., & Dinheiro, V. (2014). Exploring options for lowland rice intensification under rain-fed and irrigated ecologies in East and Southern Africa: The potential application of integrated soil fertility management principles. In *Advances in Agronomy* (Vol. 128). Elsevier. https://doi.org/10.1016/B978-0-12-802139-2.00005-6

Nkomoki, W., Bavorová, M., & Banout, J. (2018). Adoption of sustainable agricultural practices and food security threats: Effects of land tenure in Zambia. *Land Use Policy*, *78*(July), 532–538. https://doi.org/10.1016/j.landusepol.2018.07.021

Ntshangase, N. L., Muroyiwa, B., & Sibanda, M. (2018). Farmers' perceptions and factors influencing the adoption of no-till conservation agriculture by small-scale farmers in Zashuke, KwaZulu-Natal province. *Sustainability (Switzerland)*, *10*(2). https://doi.org/10.3390/su10020555

Pelletier, J., Ngoma, H., Mason, N. M., & Barrett, C. B. (2020). Does smallholder maize intensification reduce deforestation? Evidence from Zambia. *Global Environmental Change*, *63*(June), 102127. https://doi.org/10.1016/j.gloenvcha.2020.102127

Rodenburg, J., & Saito, K. (2022). Towards sustainable productivity enhancement of rice-based farming systems in sub-Saharan Africa. *Field Crops Research*, *287*(August), 108670. https://doi.org/10.1016/j.fcr.2022.108670

Rodenburg, J., Zwart, S. J., Kiepe, P., Narteh, L. T., Dogbe, W., & Wopereis, M. C. S. (2014). Sustainable rice production in African inland valleys: Seizing regional potentials through local approaches. *Agricultural Systems*, *123*, 1–11. https://doi.org/10.1016/j.agsy.2013.09.004

Rosenberg, S., Crump, A., Brim-DeForest, W., Linquist, B., Espino, L., Al-Khatib, K., Leinfelder-Miles, M. M., & Pittelkow, C. M. (2022). Crop Rotations in California Rice Systems: Assessment of Barriers and Opportunities. *Frontiers in Agronomy*, *4*(June). https://doi.org/10.3389/fagro.2022.806572

Saikia, R., Sharma, S., Thind, H. S., & Singh, Y. (2020). Tillage and residue management practices affect soil biological indicators in a rice–wheat cropping system in north-western India. *Soil Use and Management*, *36*(1), 157–172. https://doi.org/10.1111/sum.12544

Sharma, S., & Dhaliwal, S. S. (2021). Conservation agriculture based practices enhanced micronutrients transformation in earthworm cast soil under rice-wheat cropping system. *Ecological Engineering*, *163*(April 2020), 106195. https://doi.org/10.1016/j.ecoleng.2021.106195

SRI-Rice. (2020). *The System of Rice Intensification (SRI)…… is climate-smart rice production*. 2–3.

Tetteh, P., Abdulai, S., & Fraser, E. D. G. (2023). Geography and Sustainability (Re) assessing Climate-Smart Agriculture practices for sustainable food systems outcomes in sub-Saharan Africa : The case of Bono East Region , Ghana. *Geography and Sustainability*, *4*(2), 112–126. https://doi.org/10.1016/j.geosus.2023.02.002

Valbuena, D., Erenstein, O., Homann-Kee Tui, S., Abdoulaye, T., Claessens, L., Duncan, A. J., Gérard, B., Rufino, M. C., Teufel, N., van Rooyen, A., & van Wijk, M. T. (2012). Conservation Agriculture in mixed crop-livestock systems: Scoping crop residue trade-offs in Sub-Saharan Africa and South Asia. *Field Crops Research*, *132*, 175–184. https://doi.org/10.1016/j.fcr.2012.02.022

van Campenhout, B. (2021). The role of information in agricultural technology adoption: Experimental evidence from rice farmers in uganda. *Economic Development and Cultural Change*, *69*(3), 1239–1272. https://doi.org/10.1086/703868

Vanlauwe, B., Wendt, J., Giller, K. E., Corbeels, M., Gerard, B., & Nolte, C. (2014). A fourth principle is required to define Conservation Agriculture in sub-Saharan Africa: The appropriate use of fertilizer to enhance crop productivity. *Field Crops Research*, *155*, 10–13. https://doi.org/10.1016/j.fcr.2013.10.002

Wakeford, J., & Swilling, M. (2014). Implications of increasing world oil scarcity for national food security in South Africa. *Agrekon*, *53*(4), 68–91. https://doi.org/10.1080/03031853.2014.974626

Walter, A., Finger, R., Huber, R., & Buchmann, N. (2017). Smart farming is key to developing sustainable agriculture. *Proceedings of the National Academy of Sciences of the United States of America*, *114*(24), 6148–6150. https://doi.org/10.1073/pnas.1707462114

Wang, X., Jing, Z. H., He, C., Liu, Q. Y., Jia, H., Qi, J. Y., & Zhang, H. L. (2021). Breeding rice varieties provides an effective approach to improve productivity and yield sensitivity to climate resources. *European Journal of Agronomy*, *124*(February), 126239. https://doi.org/10.1016/j.eja.2021.126239

Wezel, A., Casagrande, M., Celette, F., Vian, J. F., Ferrer, A., & Peigné, J. (2014). Agroecological practices for sustainable agriculture. A review. *Agronomy for Sustainable Development*, *34*(1), 1–20. https://doi.org/10.1007/s13593-013-0180-7

Zhao, X., Sheisha, H., Thomas, I., Salem, A., Sun, Q., Liu, Y., Mashaly, H., Nian, X., Chen, J., Finlayson, B., & Chen, Z. (2021). Climate-driven early agricultural origins and development in the Nile Delta, Egypt. *Journal of Archaeological Science*, *136*(June), 105498. https://doi.org/10.1016/j.jas.2021.105498

Appendix

Questionnaire

SECTION A: FOCUS GROUPS

Focus Group Number:
Names of Respondents:
Phone Numbers:
District:
Village:

PART I – RICE PRODUCTION

1) **Would you please specify your rice production system?**

_____
_____
_____

2)

Name of varieties	Improved seed (1) Traditional seed (2)	Farm location (upland, lower land, scheme irrigation)	Approximate yield per hectare	Main attributes of the preferred rice varieties (consumers)	Cultivating more or fewer varieties from the past (+, – or =)	Advantages of rice varieties	Barriers to the rice varieties

3) **What are the methods of rice planting?**

_____
_____

4) **Which type of tillage methods are used in rice production?**

_____
_____

   a. **What are some of the benefits of each method?**

_____
_____

5) **What type of hazards affects the production of rice? Please may you rate the effect of the risk?**

Hazards Affecting Rice Production	Lowest	Low	Moderate	High	Highest

6) **What are some of the activities for adapting to climate change promoted at the community level? How would you rate the acceptance of the activities?**

Activities	Lowest	Low	Moderate	High	Highest

7) **What are some of the effects of climate variability on rice cultivation? Please rate the effects from 1 (Less) – 5 (more).**

Effects	1	2	3	4	5

8) **Have you adopted new rice varieties because of climate variability? If yes, may you mention it?**

_____

From where do farmers access your rice seeds?

_____

PART II – INFORMATION BEHAVIOUR

9) **What are some of the off-farm income activities?**

_____

_____

10) **How do farmers acquire information about rice production? How do you rate the delivery of the information? Scale 1- Poor to 5-Excellent.**

Information sources	1	2	3	4	5

11) What are some of the challenges for information delivery to rice farmers? Please rate these on a scale of 1-Least to 5- Most.

Challenges	1	2	3	4	5

12) What prominent institutions provide information about climate change and environmental data?

_____

_____

PART III– CONSERVATION AGRICULTURE

13) What are some of the conservation methods farmers are trained in? May you please rate the following according to the commonly used?

Practices	Lowest	Low	Moderate	High	Highest

14) What are some of the sustainable rice intensification practices?

_____

_____

15) What are the benefits of conservations agriculture practices? Rate on a scale of 1- Least to 5-Most benefit.

Benefits	Least	Less	Moderate	More	Most

16) What are the barriers to adopting conservations agriculture? Rate on a scale of 1- least to 5-Most challenging.

Barriers	Least	Less	Moderate	More	Most

SECTION B: HOUSEHOLDS

Name of Respondent:

Phone Number:

District:

Village:

PART I – HOUSEHOLD HEAD CHARACTERISTICS

1) **Age** _____

2) **Gender**

□ Male □ Female

3) **Marital status**

□ Single
□ Married
□ Divorced
□ Separated
□ Widow(er)

4) **Highest level of completed schooling.**

□ Illiterate
□ Primary school
□ Secondary school
□ College/University degree

5) **How many years of schooling do you have?** _____

6) **Do you have any farming knowledge?**

□ Yes □ No

7) **If yes, how many years have you been involved in farming?** _____

8) **How many people are living in your household?** _____

9) **Do you own your livestock?**

□ Yes □ No

PART II – RICE PRODUCTION

10) **What is your total land size in hectares?** _____

11) **How many hectares are under cultivation?** _____

12) **Land ownership**

□ Customary land
□ Rented land
□ Statutory
□ Leased out land

13) Please specify your rice production system

□ Rainfed upland □ Irrigated lowland

□ Rainfed lowland

14) What methods of rice planting did you use in the past 3 growing season?

□ Broadcasting □ Transplanting

□ Other (Specify) _____ □ Fallow/ Drill

15) Which type of tillage method(s) did you use in rice production?

□ Zero till – direct seeds □ Riper

□ Conventional ploughing □ Potholes

16) What type of rice seed did you use in the previous growing season?

□ Improved seed □ Traditional seed

Is it recycled seed?

□ Yes □ No

17) What type of hazards affected rice production? Please rate the effects of the dangers in the table below.

Hazards Affecting Rice Production	Lowest	Low	Moderate	High	Highest
Prolonged dry spells					
Floods					
Soil degradation					
Pests (Black beetle)					

18) What are some of the effects of climate variability on rice cultivation? Please rate the outcomes from 1 (Less) – 5 (more).

Effects	1	2	3	4	5
Low yields					
Crop loss					
Soil degradation					

19) What are some of the activities for adapting to climate change at a community level? Please rate the acceptance of these activities below.

Activities	Very Difficult	Difficult	Moderate	Easy	Very Easy
Planting trees					
No burning on plains					
Early planting					
Crop Diversification					
Canal clearing					
Alternative livelihood					

20) Have you adopted new rice varieties because of climate variability?

□ Yes □ No

21) Where do you access your rice seeds?

□ FISP – Ministry of Agriculture □ Market – Agro dealers

□ Food Security Package □ Recycled

□ NGOs

22) Which of the following post-harvest practices did you use during in the last 3 growing season?

□ Straw returns □ Burning □ Mulching

□ Animal graz □ Other (Specify)

PART IV – INFORMATION SOURCES

23) Did you have any access to credit facilities in the past season?

□ Yes □ No

24) Do you have off-farm income?

□ Yes □ No

25) Are you a member of a farmer organisation?

□ Yes □ No

26) Did you have access to the provision of input subsidies?

□ Yes □ No

a. If yes, from where?

□ Government support □ NGO □ Other _____

27) Please rate some of the challenges in information delivery on a scale of 1-5.

Challenges	1	2	3	4	5
Language barriers					
Delay in delivery					
Lack of Technological device					

28) How do you acquire information about rice production?

Source	Yes or No	Please rate the quality (Poor, Fair, Good, Very Good, Excellent)	Usage (Never, Occasionally, Moderately, Frequently, Very Frequently)
Extension officers			
Farmer to farmer			
Radio			
Television			
Internet			
Agricultural newspaper			

29) Do you receive information about climate change?

□ Yes □ No

30) From where do you get information on climate related impacts and consequences?

□ Meteorological Department □ Extension

□ NGOs □ others _____

31) Did you attend any training on a rice intensification (SRI)/ Conservation Agriculture system?

□ Yes □ No

If yes, please rate the quality of training received.

Training Quality	Poor	Fair	Good	Very Good	Excellent

32) Have you used sustainable rice intensification (SRI) in the past three years? Please rate the usage from the least to the most.

Practices	Lowest	Low	Moderate	More	Most
Seedlings transplanted at a younger age					
Single seedling per hill					
Transplanted at wider apart					
Intermittent application of water					
Rotary weeding					
Use of organic manure					

33) Did you use any conservation farming methods during the past three years?

□ Yes □ No

If yes, please rate the following according to the commonly used one?

Practices	Lowest	Low	Moderate	More	Most
Ripper cultivation					
Crop rotation					
Herbicides					
Straw retention					
Mulching					
Use Dikes					

34) What are the benefits of conservations agriculture practices? Rate them on a scale from least to most beneficial.

Benefits	**Least**	**Less**	**Moderate**	**More**	**Most**
Improved soil fertility					
Improved yields					
Moisture conservation					
Affordable					

35) What are the barriers to conservations agriculture practices? Rate them on a scale of 1-least to 5-most.

Barriers	Lowest	Low	Moderate	High	Highest
Time-consuming					
Uncertain/ do not want to risk					
Labour intensive					

Data Collection