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BACHELOR'S THESIS

Farmers' Adoption of Conservation Practices: Insights from Diverse Agro - Ecological Regions of Zambia

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Declaration

I hereby declare that I have done this thesis entitled ‘Farmers’ Adoption of Conservation Practices: Insights from Diverse Agro - Ecological Regions of Zambia’ independently, all texts in this thesis are original, and all the sources have been quoted and acknowledged by means of complete references and according to Citation rules of the FTA.

In Prague 09th May 2020

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Samuel Mwanza

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Abstract

In recent years, high food insecurity, poverty and hunger are critical issues faced by Zambia due to recent sharp declines in food crop yields which among other things is attributed to climate change. This study investigates the adoption of Conservation Agricultural practices among the smallholder farmers in distinctive Agro ecological regions of Zambia. Using a questionnaire survey on 182 farmers from six districts representing three Agro ecological regions, a descriptive analysis using Chi Square Test was employed to compare the differences and association of adopting minimum tillage methods, soil protection and crop rotation in three agroecological regions. Results on minimum tillage indicates Region I and III adopting more planting basins with 80% and 54.1% respectively, while Region IIa adopts ripping more (78.7%). Retaining crop residues was highly practiced by all regions with Region IIa leading (67%) in cover crops. Total average of 85% practiced crop rotation. Extension services, cooperatives, and conservation agriculture literature are found to be critical sources of information. Increased yields, soil protection, reduced labour, and mitigation towards variability in precipitation are found to be the main perceived benefits of adopting conservation practices. On the other hand, barriers constitute lack of conservation tools, high labour demands, rainfall, weeds, and pests. Improving accessibility to conservation mechanical services and implements, accessibility to conservation practices information tailored according to agroecological preferences can increase adoption of conservation agriculture in Zambia.

Key words: Conservation practices, agroecology, adoption, benefits, barriers, information sources, smallholder.

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List of abbreviations

AEZ	Agro-Ecological Zone
CA	Conservation Agriculture
CF	Conservation Farming
CFU	Conservation Farming Unit
FAO	Food and Agriculture Organisation
MT	Minimum Tillage
ZNFU	Zambia National Farmers Union
IDP	International Development Partners
ENSO	El Ni- ño–Southern Oscillation
SAPs	Sustainable Agricultural Practices
FBOs	Faith Based Organisations
MDGs	Millennium Developmental Goals

1. Introduction

Among the most critical agricultural problems faced by Zambia in the recent years are the aspects of high food insecurity, poverty and high prevalence of hunger which among other things is attributed to climate change (FAO 2011a). There has been a decline of up to fifty percent in the yield of the Zambian staple food crop in the year 2019 from that of 2018 (FAO 2019). Evidently, the decrease was observed in Southern, Western and partly in Central provinces of Zambia (FAO 2019). As a way of mitigating the negative impacts of low crop productivity of the Zambian small scale farmers, Conservation Agriculture (CA) practices have been promoted for almost three decades now (Mutale et al. 2017). Giller et al. (2015) alludes that conservation agriculture is now a government policy not only in Zambia but also in most of the Southern African countries.

Conservation Agriculture (CA) is defined as an approach to managing Agro-ecosystems for improved and sustained productivity, increased profits and food security while preserving and enhancing the resource base and the environment (FAO 2012). According to Mutale et al. (2017) & Thierfelder & Wall (2009), CA is as a system based on three corner-stones: crop rotations and diversification; minimum mechanical soil disturbance and permanent organic soil cover with crop residues or cover crops. The practicing and adoption of CA is needed to minimise food insecurity, mitigate climate change and land degradation (Mugandani & Mafongoya 2019). CA has also been cited to have the potential to reverse land degradation (Lal 2015) and has the potential to improve agricultural productivity (Fageria et al. 2005; Yadvinder-Singh et al. 2005; World Bank 2008; Grabowski & Kerr 2014; Kirkegaard et al. 2014). As the importance of increasing food security leans towards supporting the increased biodiversity of the agroecosystem, careful consideration should be given to CA practices which are at the heart of the campaign (Ntshangase et al. 2018).

The currently available estimates regarding the adoption of CA to the African small holder do not offer insight into the realities of their practice despite the extensive investments and promotions that have been undertaken (Brown et al. 2017). Particularly, the adoption of conservation agriculture by the farmers as influenced by the Agro-ecological regions in Zambia has not been given the attention it deserves. There are a number of studies that have focused on the adoption of CA practices by farmers in Zambia (Arslan et al. 2014; Mwale et al. 2016;

Nkomoki et al. 2018) but to the best of our knowledge, these studies have not studied exhaustively the role of Agro-ecological constraints in adoption and the potential interventions to stimulate adoption by the farmers. The promoted agricultural practices should be evaluated with help of respective climate, soil and land use systems for individual agricultural systems (Aertsens et al. 2013).

Since Zambia happens to be among the first three Southern African countries that have promoted CA practices (Andersson & D'Souza 2014) for almost three decades now, Zambian strategic location and its diverse Agro-ecological patterns can serve as a lesson book to the paradox of low adoption rates exhibited not only in Zambia but also in other Sub- Saharan African countries whose Agro-ecological regions are well represented in Zambia. The paradox therefore is which conservation practices are best suitable for smallholder farmers (Branca & Jolejole 2011). According to Brown et al. (2017), variations in the estimates and validity aspects still exists due to the poorly defined technologies and their adoption. As variations in the production systems continue due to varying environmental conditions, sufficiently flexible conservation practices must be promoted to curb the ever changing environments (World Bank 2008).

According to Arslan et al, (2014) the adoption and intensity of adoption of CA practices, scaled up and sustained adoption of conservation agriculture technologies requires among others due attention and analysis of the Agro-ecological factors such as such as soil type, length and amount and variability of the rainfall in Zambia. This study contributes to the knowledge on CA specifically filling in the research gap to understand the roles and suitability of Agro ecological regions in adopting sustainable practices. The study further draws attention to smallholder farmers and their perception on the benefits, challenges, and information sources in adopting conservation agricultural practices as promoted through the mandated and relevant stakeholders

2. Literature Review

2.1. Agriculture and Agro- ecological Regions in Zambia

Zambia is a land locked country with the total area of about 752,620 square kilometres (sq. km) of which 5.1% forms the arable land as of 2016. The Zambian agricultural sector is comprised of crops, livestock, and fisheries. The sector directly supports more than 58.2% of the Zambian total population which lives in the rural areas and is involved in agriculture (Chapoto 2019). The major drivers of the Zambian agriculture are smallholder farmers who use very simple technologies (hand hoe and or oxen) with little agricultural input investments (inadequate seed and fertilizers) which results in low productivity (Siegel & Alwang 2005). The Zambian agriculture sector has for some time been dominated by maize production (Arslan et al. 2013; NAIP 2013). Since independence, the government of Zambia has tried to promote the welfare of the smallholder farmers through the instruments of the National Agricultural Policy (NAP), the Second National Agriculture Policy (SNAP), National Agriculture Investment Plan (NAIP) that provide the roadmap in the attempt to foster diversification of the agriculture sector. The Zambian crop and livestock distributions and performance is highly dependent on the Agro-ecological zones which are divided according to the average annual rainfall occurrence and affects the soil type agronomic conditions.

Zambia is divided into three Agro-ecological regions with respect to expected annual precipitation. Region I is generally characterised by the lowest amounts of precipitation usually less than 800mm annually. Soils are shallow and loamy to clay. Region II region receives rainfall amounts ranging from 800mm to 1200mm annually. This region is further divided into two that is region IIa and IIb based on the soil differences i.e. Region IIb covers an alleviated western plateau which is characterised by ferrallic arenol- sols (Ng'ombe et al. 2017). Region IIa has better soils and is relatively higher in agricultural productivity. Region III covers the areas receiving more than 1000mm of annual Soils are leached and acidic.

2.2. Farmers Characteristics in Zambia

Zambian farmers can be classified into three main categories based on the size of the cultivated land. Sometimes, the categorisation of the farmer in the Zambian context is also viewed by considering the production focus and value associated with the crops they produce. The three main classifications of farmers include small scale farmers, emergent farmers, medium scale farmers and commercial farmers. According to Saasa (2003), the categorisation of Zambian farmers is as follows; Small scale farmers have total hectarage ranging from 0.5-9.0 Ha. This small-scale category grows mostly food crops for subsistence. Medium scale constitutes of farmers who have 10-60 Ha producing food /cash crop for subsistence and or commercial purposes. Medium scale category also includes a class known as emergent farmers who are differentiated by the size of their total hectarage which ranges from 10-20 Ha. Finally, large scale farmers own above 60 Ha and produce cash crops for commercial purposes and may further be sub-divided into two classes based on the size of hectarage. Small scale farmers constitute most farmers in Zambia.

2.3. Crop Production in Zambia

Zambia has an enormous potential for wide variety of crop production. The cropping season usually depends on rainfall supply which usually commences in November or December and ends in March (Kaonga & Coleman 2008). Mostly, the agricultural production accounts for maize crop because it forms the principal staple food in Zambia (Saasa 2003). The dominance of maize crop can be attributed to the expansion of maize-only credit facilities in the past where a one-crop message was promoted throughout the extension services. Groundnuts follow maize in being a smallholder crop, accounting for about 49.8% in 2018 having decreased from 52.9 % in 2017 (Chapoto et al. 2019). Wheat crop is mostly attributed to large scale farmers. Cassava is largely grown by farmers in high rainfall areas such as Northern, Luapula and North western provinces. Lately, paddy rice and rainfed rice has gained prominence among farmers in Eastern, Muchinga and Western provinces. Other crops important to Zambian farmers includes, Soybeans, Cotton, sunflower, Sorghum, tobacco, and millet.

2.4. Concepts of Conservation Agriculture Practices

The term CA was formally used by Food and Agriculture Organisation (FAO) during the beginning of the twenty-first century, a period in which the Millennium Developmental Goals (MDGs) were endorsed with the aim of getting rid of extreme poverty, ensuring environmental sustainability, and promulgation of gender equality and women empowerment (Wekesah et al. 2019). According to literature, as noted by Andersson & D'Souza (2014), principles of CA include crop rotation which may include diversification, minimum soil disturbance and, permanent soil cover which includes crop residues or cover. The main conservation agriculture practices include minimum tillage, crop diversification which mostly involves cereal and legume intercropping, crop rotations, soil and water conservation practices, and animal manure usage (Kassie et al. 2015). Wekesah et al.(2019) portrays CA as the continuous practice of minimum tillage, crop rotation, and permanent soil cover using crop remains. However, it is also common to find some modified CA practices in Sub-Saharan Africa. A major component of CF methods is the practice of minimum tillage which aims at leaving the soil as much intact as possible to avoid erosion, loss of nutrient and moisture (Carney & Carney 2018). According to FAO (2011b), crop residue soil cover should have a minimum of 30% soil covered at sowing. Crop rotation ensures the provision of nitrogen for the following crop which reduces the applied amounts of nitrogen by the farmer consequently reducing the cost of fertilizer (Varble et al. 2016). Conservation agriculture (CA) is currently promoted in sub-humid and semi-arid areas of sub-Saharan Africa as a means to increase crop water use efficiency and stabilize yields (Baudron et al. 2012).

2.4.1. Effects of Conservation Practices on Agriculture and Sustainable Productivity

There has been an increased support in conservation agriculture by international organisations, donors and non-governmental organizations aiming at improved and sustained agricultural productivity under a changing climate, food security, increased profits while maintaining and increasing the resource base (Fisher et al. 2018). In view of promoting the high intensity of agricultural productivity, emphasizing more on increased use of fertilizer and improved seed, the role of healthy agronomic practices has been over-sighted (Kassie et al.

2015). There is no question that if stable productivity is to be achieved even on the part of the small-scale rural farmers, proper and suitable technologies that have been tested and proven in specific environments must be promoted. An on-farm research conducted in Sub-Saharan Africa by Fisher et al. (2018), showed important benefits of CA when compared to conventional tillage- based agriculture. Conservation farming practices can reduce unit costs, reduce labour and equipment costs, enhance soil fertility, improve water retention and can ultimately (World Bank 2008), and can ultimately conserve land resources and biodiversity (Mwale et al. 2016).

The joint or single practice of conservation agriculture practices significantly increases crop net revenue per hectare in Zambia (Ng'ombe et al. 2017). A study by Pittelkow et al. (2015), conducted among 63 countries in 48 crops with the aim to compare Zero tillage and conventional methods actually revealed that zero tillage on its own may reduce yields unless when practiced alongside crop rotation and residue retention when the negative effects are reduced. Furthermore, the combination of all the three facets of CA (zero tillage, crop rotation and soil cover) improved rainfed crop productivity in dry climates. In addition, Jena (2019) suggests that there is a reason why no yields are higher for adoption of single component of CA or combination of two components. CA practices can improve productivity when coupled with other appropriate agronomic practices such as right time of planting, weeding, fertilization and or irrigation in Kenya. Ward et al. (2018) alludes that farmers must make complex choices between mulching crop residues (and not till the soil) and or to choose intercropping and rotation.

For this study, a complete package of the conservation agricultural practices is considered. This includes tillage methods, soil cover protection and crop rotation as discussed below.

2.4.2. Tillage

Tillage refers to the work done on the land to prepare it for planting and this includes all the operations undertaken to prepare a seed bed to ensure that seeds germinate properly (CFU 2007). Tillage is a major component of agricultural operations (Hobbs et al. 2008). The history and importance of tillage was well explained by Lal (2001), by introducing the benefits of the industrial revolution in the agricultural sector leading to the current situation of the soil degradation and also stressing the need for proper land use practices. Organic matter and soil holding capacity in the soil can be increased by conservation tillage practices which include no-till, ridge-till, and mulch-till (Varble et al. 2016). Indicators classified under the minimum soil disturbance includes zero tillage, planting basins (Arslan et al. 2014), and ripping which involve using an original ripper as opposed to improvised ripper (Sumberg & Thompson 2019). According to Nyanga (2012), preparation of land in Zambia start in the middle of the month of August in the case of CA basins, thereafter, CA ripping followed after about 30 days.

2.4.2.1. Zero or Reduced tillage

Minimum Tillage (MT) can be viewed as no tillage or reduced tillage (only one plough pass) coupled with maintenance of crop residues with the aim of minimising soil disturbance whilst maximising water retention (Kassie et al. 2015). Early preparation of land in the case of CA plots help in earlier planting among the smallholder farmers than plots under conventional land preparations (Nyanga 2012). According to Kirkegaard et al. (2014) the relative constraints or expense in the labour during the peak periods of agricultural practices has been influencing the replacement of tillage with herbicide use in Africa and Asia. However, a study by Ndah et al. (2018) conducted in Zambia to assess reasons for positive CA adaptation revealed that CA farmers saved a lot of time by migrating from intensive ploughing to zero or minimum tillage while experiencing the same or more yields.

2.4.2.2. Planting basins

Planting basins technique is known to be the main conservation activity for small scale farmers using hand hoe (Haggblade & Tembo 2003). According to study by Grabowski et al. (2014) conducted among cotton farmers to examine the rates of important components of conservation agriculture and tillage methods in Zambia, it was observed that while the use of tractors and ox-drawn rippers plus herbicides has increased, the use of hand-hoe basins has reduced which was attributed to the increased use of ox-drawn ripping after the recovery of livestock populations.

2.4.2.3. Ripping

Unlike ploughing, ripping does not inverse the soil but it merely involves the opening of the soil (Sumberg & Thompson 2019). In Zambia, a locally developed ox-drawn Magoye ripper (See Figure 1 below) is widely used for the task, this helps in the dry season land preparation with ultimate benefits of early planting (Andersson & D'Souza 2014). Results from on-station research trials conducted by Sumberg & Thompson (2019) shows that only mulch accompanied ripping can be truly deemed as an ecologically sustainable tillage practice because it contributes to high organic matter and reduces erosion to a minimum. Zulu-mbata et al. (2017) found that higher probability for adoption of ripping was noted for male decision makers than on female decision makers.

Figure 1: Zambian Magoye ripper.

Source: Banner 2016

2.4.3. Permanent Soil Cover

Soil management is a vital area where behaviour change could occur in the Southern Africa. The loss of soils has become rapid and more common mainly due to poor agronomic practices, poor weather patterns and due to climate change (Ward et al. 2018). Particularly, due to water run off caused by high intensity of rainfall. Permanent soil cover with growing nitrogen fixing plants or with plant residues is one of the three (3) principles of CA (Thierfelder & Wall 2009). Soil cover may also include various residues of the dead crop left anchored or loose after harvest or when a cover crop (leguminous/non-leguminous) with biomass enough to cover the soil whilst fixing nitrogen in the soil (Hobbs et al. 2008). Soil cover through plant growth and mulches is one of the sure ways to mitigate climate change (FAO 2017). According to Aertsens et al. (2013), soil cover does not only improve the soil structure but also reduce soil erosion, N leaching, weeds, and increases water infiltration. Despite soil cover being a corner-stone in CA, very few farmers practice it (Baudron et al. 2007).

2.4.3.1. Retained crop residues

Crop residues are plant materials that remain in the field after harvesting of the crop and may include leaves, seed, pods, stalks (NRCS 2005). The good use of crop residues is an agronomic practice which aims at increasing water retention and reducing erosion and may comprise of retaining or burning of stubble or straw on the surface (Matouš et al. 2013). In Zambia, some farmers rake and burn the crop residues.

The good management of organic materials like crop residues can sustainably and ecologically contribute to meeting the nutrient demands of the crop production (Yadvinder-Singh et al. 2005). Maintaining crop residues and the role the residues play in acting as surface mulch in reducing the effects of culminating from practicing no-till methods as viewed in light of CA practices (Komarek et al. 2019). Retaining of crop residues can as well be the means to increase the efficiency of erosion control, water retention, irrigation, enhance soil biological activities and improving soil physical characteristics (Chen et al. 2014; NRCS 2005). The study by Baudron et al. (2012) to compare the performance of CA and current farming practices in Zimbabwe revealed that more crop residues were produced and retained in CA related fields as compared to current farming practices fields.

However, retaining crop residues is challenging not only in Africa but also in Asia and Australia especially in mixed farming systems where there is conflict of interest between feeding the residues to livestock or mulching (Baudron et al. 2007; Kirkegaard et al. 2014). Crop residues may also be the short term cause of reduced crop yields due to nitrogen immobilization and mineralisation (Yadvinder-Singh et al. 2005).

2.4.3.2. Intercropping

Intercropping constitutes the growing of any types of legumes with cereals in the same field either in alternate rows or at random. In systems that involve intercropping, there has been negative effects associated with the use of herbicides especially in events of lack of full understanding of the instructions or during unavailability of suitable products (Beuchelt & Badstue 2013). In the study conducted by Baudron et al. (2012) in Zimbabwe, the short and long term gains of legume intercropping was found to be the ability of the crop to form a closed canopy which is very cardinal in weed control. The decision of farmers to finally adopt some innovations like maize-legume rotation was constrained by host factors such as availability of inputs, labor scacity and also cultural preferences (Alomia-Hinojosa et al. 2018).

2.4.3.3. Mulching

To address the challenges soil erosion and land degradation, mulching with crop residues together with intercropping with legumes and reduced or minimum soil tillage has been promoted by the development organisations as a major principal in sustainable agriculture (Ward et al. 2018). A literature review by Martínez-Cruz et al. (2019) on the 30 year trajectory of conservation agriculture practices in the central region of Mexico, reduced soil erosion and water losses thanks to mulching reduces the loss of water through transpiration and increases organic matter. Mulching is thought to impede zero tillage because tillage is made difficult when the surface is covered with maize stems. The benefits of adopting zero tillage and mulching practices are visible to farmers (Ward et al. 2018). On the other hand, Fisher et al. (2018) in a study conducted in malawi reported little technical training in the area of mulching practices among some extension personel which led ill advising the farmers against adoption.

2.4.3.4. Cover crops

Cover crops are essential when the period from harvesting of previous commercial crop to the establishment of the next crop is too long. cover crops provide resilience of the agroecosystem against disasters like drought and heavy rainfall, it improves soil quality and consequential increase in crop yields (FAO 2012). The choice of the type of the crop cover one adopts highly depends on the desirable secondary uses for example edible seeds, fodder value and its availability (FAO 2012).

2.4.4. Crop rotation

Crop rotation referes to the sequence in which legumes and cereals are cultivated on the same plot of land over the years. According to FAO (2011), crop rotation is considered to be fulfilled when there is a minimum of three different crops. According to Beuchelt & Badstue (2013), there is a relationship between crop rotation and nutrition sensitive agriculture, intercropping and the potential for CA to contribute to nutrition- sensitive agriculture. Beuchelt & Badstue (2013), further indicate that such practices have the potential to raise the diversification of food crops grown hence raised diversity in the diet of the farmer and household follows.

2.5. Promotion of Conservation Practices in Zambia

Conservation Agriculture(CA) is taking prominency in the agricultural policies in many developing countries including in Zambia (Nyanga et al. 2017). According to Baudron et al. (2007), active support of conservation agriculture in Zambia has been done in seven (7) provinces out of the then nine (9) provinces and these supported provinces include Southern, Lusaka, Central and Eastern provinces belonging to Agro-Ecological Zones (AEZ) I and IIa, Copperbelt, Northern and Luapula provinces in Agro-ecological zone III. By the year 2003 the package of CA promoted practices were nitrogen fixing crop rotation, zero tillage, ripping, planting basins and leaving crop residues (Kabwe & Donovan 2005). By 2008/9 agricultural season, farmers from eastern, Lusaka and southern provinces of Zambia only allocated 25% of their agricultural to land CA (Umar & Nyanga 2011). Even when viewed in the light of advantageous crop yields when early planting is practiced among the farmers in AEZ I and IIa, it is still unclear why so few farmers adopt CA in Zambia (Ngoma et al. 2015). According to a study by Ng'ombe et al. (2017), adoption of minimum tillage together with crop residue retention results in the highest crop net revenue per hectare among all the possible combinations of CF practices in Zambia.

2.5.1. Zambia National Farmers Union

Minimum soil tillage in Zambia is said to have been stimulated by Zambia National Farmers Union (ZNFU). ZNFU is a national association which represents small and large-scale farmers and agribusinesses in Zambia. In 1980s, ZNFU aided the commercial farmers' visits to USA and Australia where they learned about minimum tillage methods (Haggblade 2016). Apparently, due to the then challenging ecological and economical changes, the techniques spurred motivation for quick adoption by farmers as evidenced by the benefits which offered solutions to the challenges of soil degradation and rises in fuel prices (Baudron et al. 2007; Mutale et al. 2017; Uri 2000). It is interesting how Zambia National Farmers Union (ZNFU), which was more of a commercial farmer's organisation, how it became the frontier in development of a minimum tillage technology for small holder hand hoe farmers (Grabowski et al. 2014). ZNFU is the biggest farmers' association with its full-time extension agents providing diverse kinds of extension services (MAL 2016)

2.5.2. Conservation Farming Unit

Conservation Farming Unit (CFU) was established in 1996 by ZNFU to adapt the hand hoe basin practice to the Zambian environment and to ensure its active promotion among the smallholder farmers. The Unit developed guidelines, field trials on cotton and maize and conducted trainings of government extension agents (Haggblade & Tembo 2003). For example farm trials for basins on maize and cotton farmers from the southern and central provinces were carried out in 1996 (Grabowski et al. 2014). CFU provides a supporting environment to small and medium scale farmers through imparting knowledge and practical experience to assist farmers to successfully adopt conservation farming practices. CFU achieves this by incorporating a hands-on extension approach with the help of lead farmers positioned within their local farming communities. In addition, CFU supplies necessary CA inputs, tools, and links farmers to necessary services providers from the private sector.

2.5.3. Agricultural Cooperatives in Zambia

Cooperatives have been known to have the potential to form the backbone of the Zambian agricultural sector if allowed to operate independently without political manipulation and interference (MAL 2013). The government has tried to strengthen the cooperatives by using them as avenues for acquisition of subsidized agricultural inputs for member farmers. The government through the Ministry of commerce implements some activities relating to trade and industry mostly in line with cooperative development trainings. Also linking cooperatives to service providers where the Government Zambia has prioritised the delivery of extension services to farmers through farmer groups, especially cooperatives (Arslan et al. 2013; NAIP 2013).

2.5.4. Extension Services in Zambia

In 1992, the then Ministry of Agriculture Food and Fisheries and the NGO staff formulated a participatory extension approach (PEA). PEA was aimed at empowering the farmers to identify and provide their suitable local solutions to their problems and needs (Beuchelt & Badstue 2013). The value of extension service provision in Zambia was amplified in the 9th objective of the National Agricultural Policy (NAP) which seeks to strengthen agricultural extension service delivery while raising the efficiency and effectiveness of the current extension agents, and also recognising private extension service delivery as a way of supplementing the public extension system (MAL 2016).

The extension service embraces several stakeholders which may be categorised into Farmer Organizations, International Development Partners (IDPs), Non-Governmental Organizations (NGOs), and the private sector players. The notable players under private sector are seed companies who actively provide extension services to their respective clients.

Similarly, there are several NGOs both international and local NGOs who operate using either their own extension staff or on the public extension agents to deliver services. Farmer organizations and cooperatives also play an active role in providing extension services to their members. ZNFU is one of the biggest farmer based organisation with its own extension staff at the grassroot focussing mostly on CA (CFU 2007; MAL 2016). Zambia National Agricultural Sector Investment Programme picked on core agricultural services and innovations which included better crop management, new crop varieties, on-farm seed production, integrated pest management, conservation tillage, nutrition education, and strengthening of extension system with technical services (Beuchelt & Badstue 2013).

Agricultural Extension is the use of scientific research and modern knowledge to agriculture through farmer education. Extension and training is very cardinal in the expansion of perceptions, knowledge and attitudes relating to agricultural innovations (Meijer et al. 2015). The study by Mengistu & Assefa (2019) conducted in Ethiopia reveals that one of the important factors in determining the decisions of farmers towards intensive innovative practices was the knowledge and the awareness. A research by Zulu-mbata et al. (2017) conducted in Zambia showed that adoption rates for CA were higher in areas with farmers who had better information and knowledge on the implementation and benefits of CA practices. According to Fisher et al. (2018), the low access to information and lack of knowledge by farmers may be addressed by farmer to farmer extension approach.

2.6. Determinants and Barriers of Conservation Agricultural Practices

The selection of the factors that are likely to affect the adoption of sustainable agricultural practices is based on prior published literature. The factors are broadly categorised as climatic, household and farm characteristics. The determinants include age of the household head, size of the household, education level, farm size (Feder et al. 1985; Kassie et al. 2013; Manda et al. 2016). Sumner et al. (2017), investigated the factors affecting the adoption of SAPs in Ethiopia and results indicated that access to knowledge and advice about farming (38.5%), access to agricultural credit (20%) labour availability (8.4%) land availability (23.2%), access to farm equipment and tools (3.1%) and also secured land tenure (2%) have the potential to affect the choices to practice SAPs on their farms.

The review by Wekesah et al. (2019) showed that women farmers adopted CA less and dis-adopted CA more as compared to men and it was mostly due gender barriers which includes access to credit facilities, extension services, land, and machinery. However, labour involvement, women's incomes, household food security, and also the possibility of having their land and crops dispossessed by their men when farming becomes economically attractive (Wekesah et al. 2019).

2.6.1. Climatic characteristics

The choice of the type and number of adaptation practices are determined by among other things climatic shocks hence the need to formulate adaptation strategies carefully based on Agro ecological conditions (Teklewold et al. 2019). Improvement of multifacets climate change adaptation strategies is crucial for improving household food security especially in relation to high risk climatic shocks. There is little empirical evidence supporting the varrying effects of climatic characteristics on adaption practices (Teklewold et al. 2019). However, study by Komarek et al. (2019) in Zambia suggests that high average rainfall amounts occuring in the Northern and North-Western province than other regions may also explain why low grain yields occur it leads to water logging and soil acidity. Komarek et al. (2019) adds that dry climates are usually favorable for no-tillage methods.

2.6.1.1. Agro-ecological regions

Agroecological zones play a very important role in the adoption of agricultural systems mostly due to the influence which the availability of water has on any agricultural practice and the type of the crop farmers opt for. Therefore, this suggests that CA could be more appreciated in certain climatic regions. The review on different CA applications supported the arguments that CA can be adjusted to to suit different agro climatic zones (Kassam et al., 2015). In certain cases, even when farmers have the equipment and implements to help in adopting technologies, the challenge lies in their susceptibility that comes with the weather and climatic dangers due to their lack of subsidies and crop insurance from the government (Findlater et al. 2019).

2.6.2. Farm characteristics

Adoption of CA is more probable on households with larger farm sizes than those with smaller farm sizes. This is true more especially as regards full CA adoption than partial adoption of CA (Zulu-mbata et al. 2017).

2.6.2.1. Land tenure

Secure land tenure is widely known to be cardinal in agricultural land management (Fraser 2004). In Zambia, land ownership occurs in two forms that is customary and statutory land. A study by Nkomoki et al. (2018) on the effect of land tenure on adoption of CA practices in Zambia revealed that adoption rate for planting basins, agroforestry, crop diversification and intercropping was higher among farmers with statutory (secure) land tenure compared to the farmers under customary (insecure) land tenure. According to Kassie et al. (2013), land tenure positively contributes to higher adoption rates in soil water conservation methods in Tanzania. Findings from Ethiopia by Miheretu & Yimer (2017) aimed at investigating determinants of farmers' adoption of land management practice showed that adoption of stone bund was positively and significantly influenced by the security of land tenure**.** There is consistency in the available literature suggesting that insecure land tenure contributes to reduced adoption rate for rights based agricultural interventions (Fraser 2004; Soule et al. 2000; World Bank 2008). Land tenure security therefore stimulates and offers benefits for investments in land management practices in Ethiopia (Miheretu & Yimer 2017). Implying that likelihood of adopting soil improving practices increased in the case of farmers who acquired title deeds as compared to farmers without title deeds in East Africa (Ng'ang'a et al. 2020).

2.6.3. Household head characteristics

2.6.3.1. Age

Age implies increased exposure to production technologies, environment and accumulation of social and physical capital (Kassie et al. 2013). A study conducted in south Africa focusing on the perception of farmers on adoption of CA practices indicated that the older group of farmers are more receptive to the conservation agricultural practice and that an addition by a year in age increases the adoption of CA by 1.06 times (Ntshangase et al. 2018).On the other hand, results from examination of underlying factors in the adoption of soil testing and fertilizer recommendations among farmers in rural Bangladesh showed that younger farmers (less than 40) had a positive uptake of technologies (Faruque-As-Sunny et al. 2018). The results of the research by Pilarova et al. (2018) on determinants and barriers influencing the adoption of conservation agriculture practices in Moldova showed that older farmers were less likely to practice sustainable agricultural practices.

2.6.3.2. Gender

Gender roles have received a considerable space in various investigations pertaining to their influence on adoption of CA technologies. The review by Wekesah et al. (2019) on the interplay of gender and CA in sub-saharan Africa, shows that regardless of its wide practice in the African set up, little is known about the interaction of CA and gender. According to the findings of Manda et al. (2016), female headed households are less likely to adopt most of the conservation agricultural practices in Zambia. Findings from Burkina Faso suggest that adoption rates for soil conservation package was the most adopted (25%) for all the plot managers, however, adoption rates for men were still higher than women (Kunzekweguta et al. 2017; Theriault et al. 2017). Ndiritu et al. (2014) in his study found that the adoption of minimum tillage and the use of manure were less probable among the female plot managers in Kenya. These findings were similar to results by Ntshangase et al. (2018) in South Africa . The low adoption suggests lower access of the female headed households to resources like land, education, information and improved agricultural technologies, socioeconomic imbalances (Doss & Morris 2001). Wekesah et al. (2019) further adds that gender access to credit facilities, extension services, land, and machinery as barriers among female farmers.

According to Doss & Morris (2000) adoption rate among female farmers living under male headed households and female farmers living under female households do not differ statistically in their behaviour towards adoption of agricultural technologies in Ghana. On the other hand, Ward et al. (2018) observed that more females in the households positively influences adoption of agricultural technologies. According to Doss & Morris (2000) ; Pilarova et al. (2018) in modolva , no differences occur on the gender of the household heads regarding the adoption of sustainable agricultural practices (crop rotation). Interestingly, the survey by Ng’ombe et al. (2017) conducted in Zambia insists that households with male decision makers have a lower adoption of CA components because it involves the promotion of hand hoe techniques that don’t match so well with males. The results by Zulu-mbata et al. (2017) from study on what drives the adoption of CA among small holder farmers in Zambia revealed that the choice of the type method of tillage was not influenced by gender of field decision maker. According to Kotu et al. (2017) female headed households were more likely to adopt intercropping and the use of improved seed than the male headed ones. This is due to the buffer production risks of intercropping, which allows them to grow multiple crops for increased dietary diversification, women are more attracted to intercropping than men.

2.6.3.3. Farming experience

Adoption and intensity is expected to be positively influenced by the experience of adopters with CA components because better judgements are expected by comparing conventional techniques with new technologies (Kunzekweguta et al. 2017). Findings by Kunzekweguta et al. (2017) on reduced tillage techniques indicate that adoption and intensity was positively influenced by experience in Zimbababwe. Implying that farmers who practiced reduced tillage for a longer time were likely to maintain practicing this component. On the other hand, negative impact from general farm experience was observed on the adoption of CA components although no influence was noted on intensity.

2.6.3.4. Household size

Families form a major source of labour for construction of land management practices and farm operations. In the study on factors influencing no-tillage in south Africa, Ntshangase et al. (2018) indicate that lager households adopted CA more although this was not related to labour supply but economic burden. According to Miheretu & Yimer (2017), adoption of soil bund in Ethiopia was significantly and positvely affected by the household size implying that households with more members who contribute labour are more likely to adopt labour demanding land management practices. Similar findings were observed from Zimbabwe by Kunzekweguta et al. (2017) where adoption and intensity was positively impacted by the availability of family labour, although this was not significant which suggested that it does not apply for intensity or adoption. Jena (2019) however, noted that household size does not have any link to the adoption of minimum tillage. Pilarova et al. (2018), however, notes that adoption of crop rotation was negatively influenced by the increase in the number of adults living in a given household in Moldova.

2.6.3.5. Marital status

According to Theriault et al. (2017), the marital status of the owner of the field has an effect on the probability to adopt yield promoting packages in the case of both males and females but packages relating to soil conservation to males. Owing to the fact that marital status is a personal characteristic it can therefore influence perceptions, knowledge and attitudes of farmers (Meijer et al. 2015).

2.6.3.6. Education

The ability of farmers to get and utilize information which aids in adoption of sustainable water conservation highly depends on the educational level of the household heads (Belachew et al. 2020). In the study it was found that households with better educated heads had an adoption factor of 2.812 times more than households with less education. Similarly, research by Asfaw & Neka (2017) conducted in Ethiopia showed that education status positively correlated with the adoption of the practices of soil and water conservation. To the contrary, similar study by Kunzekweguta et al. (2017) done in Zimbabwe showed that the availability of household head on farm and the education level of the decision maker did not influence significantly the intensity decision or the adoption. According to a study by Jena (2019) undertaken in Kenya, findings showed that education of household head did not affect the adoption of minimum tillage. Findings from a survey by Findlater et al. (2019) on South African grain farmers showed that self identified liberals showed no effect of education on CA principles or related practices on the other hand conservatives and moderates who had more education indicated of less soil disturbance. In addition, the survey revealed that moderates who had more education also tended to reveal less utilisation of of tillage implements (Findlater et al. 2019).

2.6.4. Credit services

CA promotional activities are Zambia is sometimes implemented through provision of input and credit support as an attraction to adoption of CA technologies. According to a research by Ndiritu et al. (2014) in Kenya, results showed that having access to credit services was positively related to the probability of adopting both modern farming packages by female plot managers. Mengistu & Assefa (2019) in their study also state that the access to credit services by farmers was also found to positively contribute to intensified adoption of watershed management because it provided optional financial sources for farmers to address the financial demands needed when investing more into watershed management practices.

2.7. Channels and Information Sources

Communication channels coupled with information sources are an important way to create awareness and dispersing of information on conservation to farmers (Varble et al. (2016). However, access to Seasonal Forecasts (SF) remains low in Zambia. SF information in Zambia is made up by the Zambian Meteorological Department and then relayed by through the print media, radio, mobile phones and through the extension services just before the farming season. Using Zambia as a case study, Maggio & Sitko (2019) examined if receiving SF information about a potential ENSO-induced drought influenced smallholders' adoption of drought resilient practices. The results however showed that only 41 % of small holders received SF information before 2015/2016 El Ni- ño–Southern Oscillation (ENSO) events farming season which is attributed to challenges related to government extension services, fewer owned radios, fewer cell phones and poor coverage , poor distribution of print media.

Having an idea of the type and number of communication channels gives and insight on the influence of channels on conservation practice adoption. Conservation agriculture agencies can make use of the channels that are more often utilized by a group of farmers to deliver the designed information to meet the needs of the very group and enhance a rightful form of interaction (Varble et al. 2016).

2.7.1. Television

A higher likelihood to access sources of information for SF such as television, radio was found to be among the male headed and better educated farmers and where the community are less in need of social assistance (Maggio & Sitko 2019).

2.7.2. Phone

According to the study by Teklewold et al. (2019) in Ethiopia, results showed that households who owned mobile phones had the higher probability of improving the crop variety. The results suggest that the advancement in communication infrastructure and access to information played a big role in enhancing the use of climate change adaptation practices by promoting input and output transport which has a part in lessening the opportunity cost of farmers' time, and getting convenient information and other production related information on climate change.

2.7.3. Cooperatives

Local adaptation of the technologies using active farmer groups in conjunction with current research and extension services and value chains is vital to bottom -up approach of feasible and relevant technologies and top-down formulation of necessary institutional environments (Brown et al. 2018). According to Kotu et al. (2017), the likelihood of adopting CA related agronomic practices was higher for farmers who were members in social groups. The results suggested information sharing and knowledge systems had positive contribution on some CA practices.

2.7.4. Internet

The access of quality internet connections such as broadband, high speed access in rural areas can be very challenging. Hence, farmers who depend on the internet to access information on conservation practices may be well advanced in the way they use their technologies and are sometimes deemed as innovators or adoption leaders (Varble et al. 2016).

2.7.5. Extension agents

The effectiveness of the extension service is evaluated by the frequency of contacts a farmer has with either a public or private extension agent (Manda et al. 2016). Teklewold et al. (2019) observed that adoption of agricultural water management practices in Ethiopia was positively influenced by exposure to agricultural extension services which means that houlholds who are exposed to information are likely to adopt management practices that demand much knowledge. Incentive provision to farmers investing in CA implements can also motivate adoption especially through governmental susidy structures and programmes done jointly with extension packages (Zulu-mbata et al. 2017). The connections of farmers to formal and informal systems is vital for their access to information and the consequent explanation of the adoption. According to Kotu et al. (2017), farmers who reduced advise from lead farmers have higher chances of adopting intercropping (IC), crop rotation (CR) and soil water conservation (SWC) than farmers who did not receive any advise.

2.7.6. Faith Based Organisations

A study by Matouš et al. (2013) which analysed the roles of extension and social networks with regard to uptake of resource-conserving use among Ethiopian farmers, the results indicated that farmers who had their ethnicity or religion matching with the extension sources had better learnt about conservation agriculture. In addition, resource conservation recommendations from the agents to farmers who are socialy well linked are less likely to be received.

3. Aims of the Thesis

The overall objective of the study is to investigate the adoption of conservation practices in distinctive Agro ecological regions of Zambia among the smallholder farmers.

3.1. Specific objectives

1. To investigate and compare the conservation practices in Agro ecological regions.

2. To examine the perceptual benefits and barriers of smallholder farmers on adoption of conservation agriculture practices.

3. To identify the major information sources for promotion of conservation practices among smallholder farmers.

3.2. Research questions of the study

1. Do agro ecological regions affect the adoption of conservation agriculture practices?

2. What is the perception on the reasons and barriers in the decision making process for the farmers to adopt conservation agriculturepractices?

3. Which information sources are used to promote adoption of conservation agricultural practices?

4. Methodology

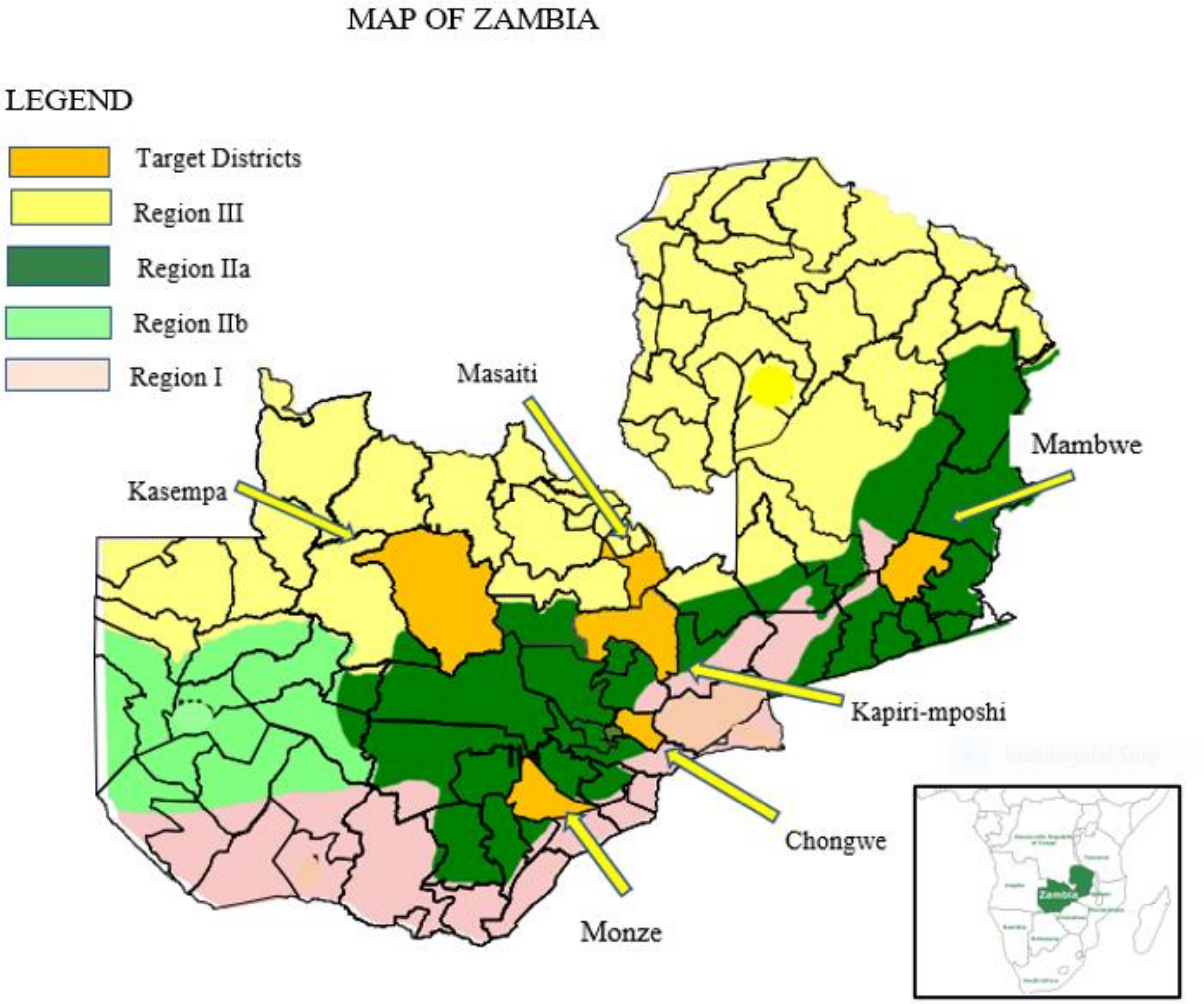
4.1. Study Area

The study is conducted across three different Agro ecological regions of Zambia. The agroecological zones are differentiated mainly on the basis of annual rainfall variations in particular areas (Baudron et al. 2007). The sample covers two districts from each Agro ecological region namely, Region I, Region IIa, Region III.

Region I is generally characterised by the lowest amounts of precipitation usually less than 800mm annually. This region runs along the Luangwa and Zambezi valleys in the parts of eastern, southern, and western provinces. Soils are shallow and loamy to clay. Crops favoured include cotton, millet, sesame, and sorghum due to their drought resistance.

Region II stretches along the middle part of the country from the eastern to the western part of the country and this region receives rainfall amounts ranging from 800mm to 1200mm annually. This region is further divided into two parts namely, IIa and IIb. Region IIa covers productive parts of eastern, Lusaka, central provinces. This region has better soils and is relatively higher in agricultural productivity. It can support a variety of crops for example maize, cotton, soybeans, sunflower, irrigated wheat, groundnuts tobacco and other crops. The majority of farmers in these zones practice mixed crop–livestock systems (Baudron et al. 2007). Region IIb is situated in the sandy areas of the western province. For the purpose of this study, only Region IIa was considered due to absence of CA promotional activities in Region IIb.

Region III covers the areas receiving more than 1000mm of annual rainfall and runs from parts of Muchinga, Northern, Luapula, Copperbelt and North-western provinces. Soils are leached and acidic favoured crops include beans, pineapples, cassava, rice, millet, and other crops.



Source: Author 2020

Figure 2: Map of Zambia showing target districts in different AERs.

AER I- (Mambwe & Chongwe), AER IIa-(Monze & Kapiri-Mposhi), AER III-(Kasempa & Masaiti)

4.2. Survey sampling procedure

The study area was selected using a multistage sampling method. The first step was to purposely select the provinces were conservation agriculture has been promoted. In Zambia, conservation agriculture has been promoted in 7 of the 10 Zambian provinces. The sampled provinces constitute six (6) of the seven (7) provinces were conservation agriculture has been promoted. The districts were conveniently selected from the provinces to capture all the three (I, II and III) Agro ecological regions of Zambia. Two (2) districts were selected from each Agro ecological regions and in total six (6) districts were covered. The villages and the household respondents are simple randomly with the help of the extension officers due to limitations to obtain exact number of farmers from the district offices. In each district a total of thirty-two (32) respondents were selected and in total one hundred and eighty (182) respondents were interviewed and their data processed which is relatively representative across the agroecological regions, provinces, districts, and household respondents

Table 1: Sample size distribution (n=182)

Agroecological Region	Province	District	Number of respondents
I	Eastern	Mambwe	30
I	Lusaka	Chongwe	30
II	Southern	Monze	30
II	Central	Kapiri-Mposhi	31
III	Copperbelt	Masaiti	31
III	North-Western	Kasempa	30
Total			182

4.3. Data collection process

The survey was conducted in December 2019. A structured questionnaire survey was used to collect data. The respondents were the household heads of the family and in situations where the household head was not around the person in charge of family maintenance was interviewed. A total of 182 questionnaires were processed. The mobile app Nest Forms was employed for data recording from the face to face interviews and GPS code stored. The survey was conducted by the researcher with the help of eight (6) trained enumerators from the district office in the Ministry of Agriculture Zambia. The questionnaire comprised of questions divided in sections namely: social demographic factors such as household head characteristics, farm characteristics; conservation practices; perception on conservation agriculture and Information sources to promote adoption of conservation practice.

4.4. Data Analysis

Data processing was processed, cleaned, and coded in Microsoft Excel. Data analyses were conducted in Social Package for Social Sciences (SPSS) software 25. For the first objective descriptive statistics using means, frequency, and cross tables, followed by Chi Square Test to compare the adoption of conservation practices in three AERs. Bonferroni post hoc test was employed to see if the differences occurred among the different AERs. For the second and third objectives, descriptive statistics using cross tabs percentages was used.

5. Results and Discussion

5.1. Descriptive statistics

The results in Table 2 below shows some household and farm characteristics of the respondents. The findings indicate the mean age of 43.85 with the range from 18 to 79 years. The mean household size was found to be 6.54, the maximum being 30 members in a household which may suggest the presence of polygamous households. Mean number of years for the households engaged in farming was found to be 17.75 years with the range of 2 to 51 year. This may imply that some farmers enter into farming activities quite too early before the rightfull adult age of 18. Under farm characteristics, land was categorised into three which included titled (statutory), customary and rented land. Customary land was prominent with mean hectarage of 5.8. The results on land tenure indicate that most Zambian small scale farmers have unsecure land tenure system superseeded by the traditional leaders. Conventional tillage methods claimed the highest mean hectarage of 1.44. Ripping had the highest mean hectarage among the CA tillage methods which was about 1.04 ha.

Table 2: Descriptive statistics of continuous variables (n=182)

Variable	**Description**	**Mean**	**SD**	**Min.**	**Max.**
Household characteristics					
Age	Years of household head	43.85	11.95	18	79
Household size	Number of people in HH	6.54	3.19	1	30
Farming experience	Number of years in farming	17.75	11.27	2	51
Farm characteristics					
Land size (customary)	Numberof hectares owned	5.8	4.92	0	20
Land size (statutory)	Number of hectares owned	0.77	2.12	0	16
Land size (under rent)	Number of hectares	0.14	0.63	0	7
Zero tillage	Number of hectares	0.09	0.57	0	7
Ripping tillage	Number of hectares	1.04	1.66	0	10
Planting basins tillage	Number of hectares	0.7	1.16	0	11
Conventional tillage	Number of hectares	1.44	1.51	0	8
Livestock	Number of cattle owned	6.57	17.82	0	120
Small ruminants	Number of goats owned	6.69	10.76	0	72

In Table 2 below, the results from categorical descriptive variables show that the majority respondents of about 62% where males. 80% of the respondents were married. The majority of the respondents who formed 43.4% only attained primary level of education and this was followed by a 40.7% of farmers who had attained a secondary level of education. The results further indicates tertiary level of education comprising 12.6%. However, it is interesting to observe that there were still a few who had never attended school of any kind and these comprised of 3.3%. Farmers who had received some form of CA trainings were found to be at 83.5%. Regarding farming systems, the majority farmers 69.2% practiced a combination of crop and livestock as opposed to the rest 30% who only practiced crop production.

Table 3: Descriptive statistics of categorical variables (n=182)

Variable		**Description**	**Frequency**	**% of total**
Household characteristics				
Gender	-male	Sex of household head	113	62.1
Marital status		1= single	16	8.8
		2= married	146	80.2
		3= divorced	9	4.9
		4= widowed	11	6.0
Level of education		0= none	6	3.3
		1= primary	79	43.4
		2= secondary	74	40.7
		3= tertiary	23	12.6
Trainings	-yes	Household head underwent any trainings in CA (0= no, 1= yes)	152	83.5
Farm characteristics				
Farming systems		Type of agricultural enterprise practiced by Household- 1= crop production	56	30.8
		2= mixed (crop production & rearing livestock)	126	69.2

Figure 3 below, portrays results of gender distribution among the farmers in the agroecological regions under investigation. The average composition of respondents for all the agroecological regions was 62% for male and 38% for femlaes. Regions IIa and III had the same percentage of gender distribution of 69% and 31% for males and females respectively. Region I had slightly higher percentage of female farmers (52%) than males (48%).

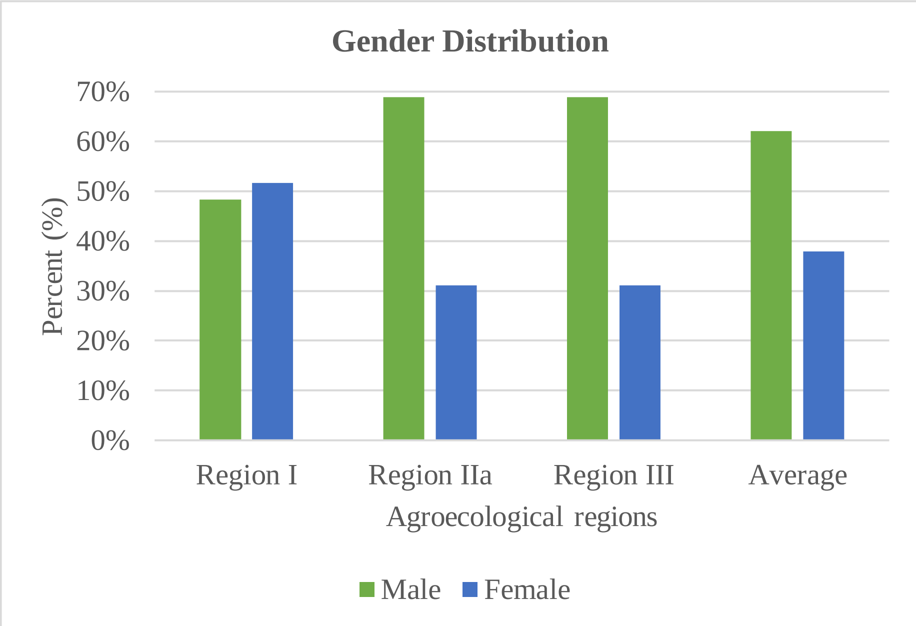


Figure 3: Gender distribution in diverse agroecological regions

Figure 4 below, shows the levels of education with regard to specific agroecological regions. From the results, farmers with tertiary education were more in Region III with 34% as opposed to the 2% observed in Regions I & IIa. This maybe associated with increased mining and economic activities present in region III as this motivates former employees who have relatively better educational background to settle on farms within this Region. Atleast 53% of the farmers in Region IIa had attained secondary level of education and this was followed by 46% of farmers with only primary level of education. From Figure 4, it is evident that Region I had more farmers with low levels of education as compared to agroecological regions IIa & III.

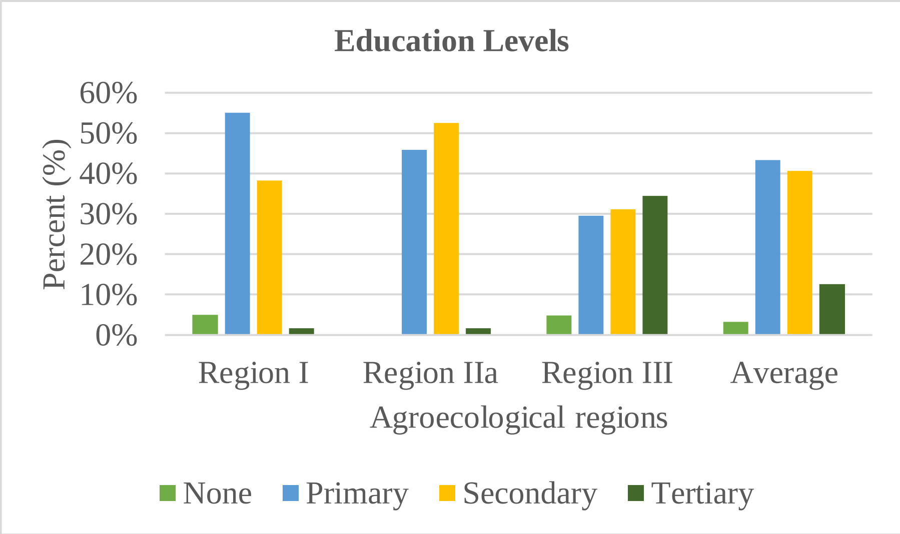


Figure 4: Levels of education of respondents

5.2. Principles of conservation agriculture

5.2.1. Conservation agricultural tillage methods

Figure 5 below, shows results for CA tillage methods as practiced in diverse agroecological regions. On average, planting basins tillage method superseeded ripping and zero tillage with 58%, 51% and 4% respectively. Highest percentage for planting basins was observed in Region I with 80%, followed by Region III with 54%. This may be attributed to hand hoe cultivation methods common in the Regions I & III. Planting basins seem to perfectly answer the need for soil water harvesting which is cardinal for survival of crops grown in drought prone Region I. Also in Regions I & III, draught animal populations are lower compared to Region IIa where more livestock populations occur and the region exhibited the highest percentage (80%) for ripping tillage method. Ripping was also common in Region I with 60% occurrence. Ripping and planting basins are the basic minimum tillage (MT) strategies promoted under CA in Zambia (Ngoma et al. 2015).

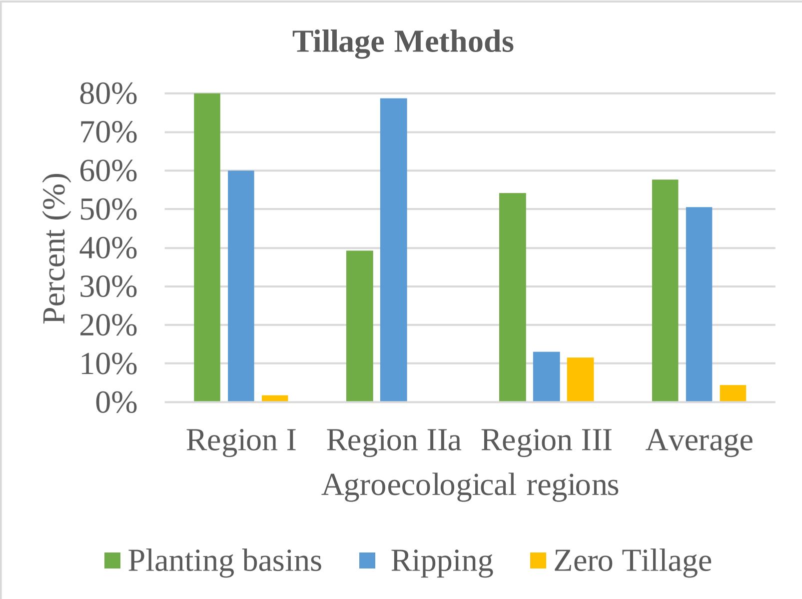


Figure 5: Conservation tillage methods in different AERs

Figure 6 below, show preferences of the three tillage methods are highlighted. Planting basins were more prefered by region I similar to its practice in Figure 5 above. However, in there seemed to be more preference for planting basins among farmers in region IIa as compared to what was actually practiced by the same region (See Figure 5 above). Region I & III exhibited uniformity in preference and also in practice; prefered and practiced more of planting basins. Ripping was however, highly favored by region IIa followed by region I.

Results by Grabowski et al. (2014) from the study in Zambia to examine components of Conservation Agriculture (CA) and minimum tillage (MT), a reduction of hand hoe tillage methods implying that preferences for minimum tillage and basins may have originated partly from the low populations of draft oxen of which have recently shown recovery of cattle populations. Grabowski et al. (2014) observed that the recovery of cattle from disease caused popularity on the part of ox-drawn ripping in Zambia. Interestingly, results by Baudron et al. (2012), for a study carried out in Zimbabwe showed that minimum tillage resulted in problems of soil compaction with consequent surface crusting.

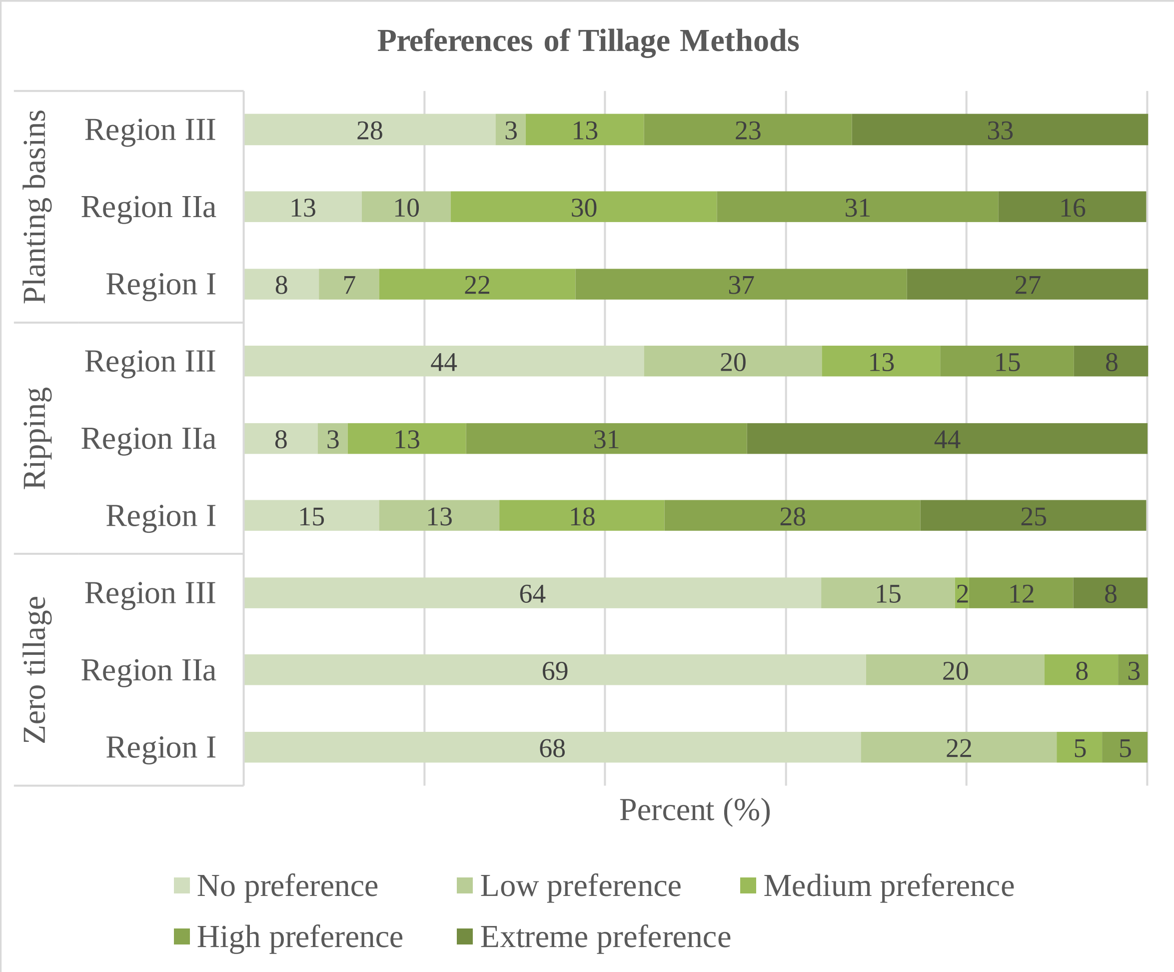


Figure 6: Agroecological regions and tillage preferences

From the Chi Square Test in Table 4 below, Regions IIa and III are not statistically different regarding adoption of planting basins as compared to Region I where adoption was very high (80%). In any case, our findings can be explained by the fact that Region I is perceived to experience late onset of rainfall (See Figure 16 below) coupled with little amounts of rainfall, hence farmers perceive planting basins as the best way possible to capture rainfall and to retain soil moisture. Kabwe & Donovan (2005) also have this view that planting basins are likely to be more in areas with eratic rainfal patern. Ripping is more adopted in Regions I & IIa which showed no statistical difference as compared to Region III. This can be attributed to low presence of animal draft power and lack of CA promotional activies in Region III. As can be observed in the Table 4 below, adotpion of zero tillage is generally low for all Regions although slightly high for Region III probably due to types of crops favored in this region .e.g cassava which can easily be propagated using without tilling the soil. It appears that were there is animal draft power and experience late onset of rainfall, zero tillage is not opted for.

Table 4: Chi Square Tests on tillage methods in AERs

CA practice	Region I Adopters (%)	Region IIa Adopters (%)	Region III Adopters (%)	X^2	P. Value
Planting basins	80.0^{a}	39.3^{b}	54.1^{b}	20.969	< 0.001
Ripping	60.0^{a}	78.7^{a}	13.1^{a}	55.663	< 0.001
Zero tillage	$1.7^{a, b}$	0.0^{b}	11.5^{a}	11.144	< 0.005

Each superscript letter denotes a subset of AER categories whose column proportions do not differ significantly from each other at the 0.05 level.

Figure 7: Zambian smallholder farmer in his ripped plot.

Source: Author 2019

Figure 8: Plot of planting basins in Monze district.
Source: Author 2019

Figure 9 below, shows the rankings of the responses from respondents using a Likert scale on the barriers of CA adoption in AERs. Results from Region I suggest that lack of CA tools, high labour demands, and rainfall are the main limiting factors in the adoption of CA technologies. Very low rainfall may indirectly limit adoption because some crop pests e.g termites, may proliferate during prolonged dryspells. Occurrence of weeds and pests, and lack of tools appears to be main barriers for farmers in Region IIa. Region III appears to have many aspects limiting the adoption but generally rainfall is perceived to be the main limiting factor. Too much rainfall as perceived by farmers which often results in water logging coupled with the leached and acidic soils in this region may hinder the practice of CA.

A research by Zulu-mbata et al. (2017) conducted in Zambia on factors driving the adoption of CA among small holder farmers revealed that adoption of CA was constrained by the limited access to CA implements that reduced labor. According to Zulu-mbata et al. (2017), this was partly solved by the introduction of draught and mechanical power although few households had the ability to aquire CA implements. Another similar study by Ndah et al. (2018) conducted in Zambia found seven main constraints which were ranked as: weed control

(17%), lack of markets for farm produce from legumes (17%), conflicting of CA with village rules (10%), Insect pests (7%), static mind-set on ploughing (7%), Land availability and ownership especially for women (7%) and seasonal changes in rainfall (7%).

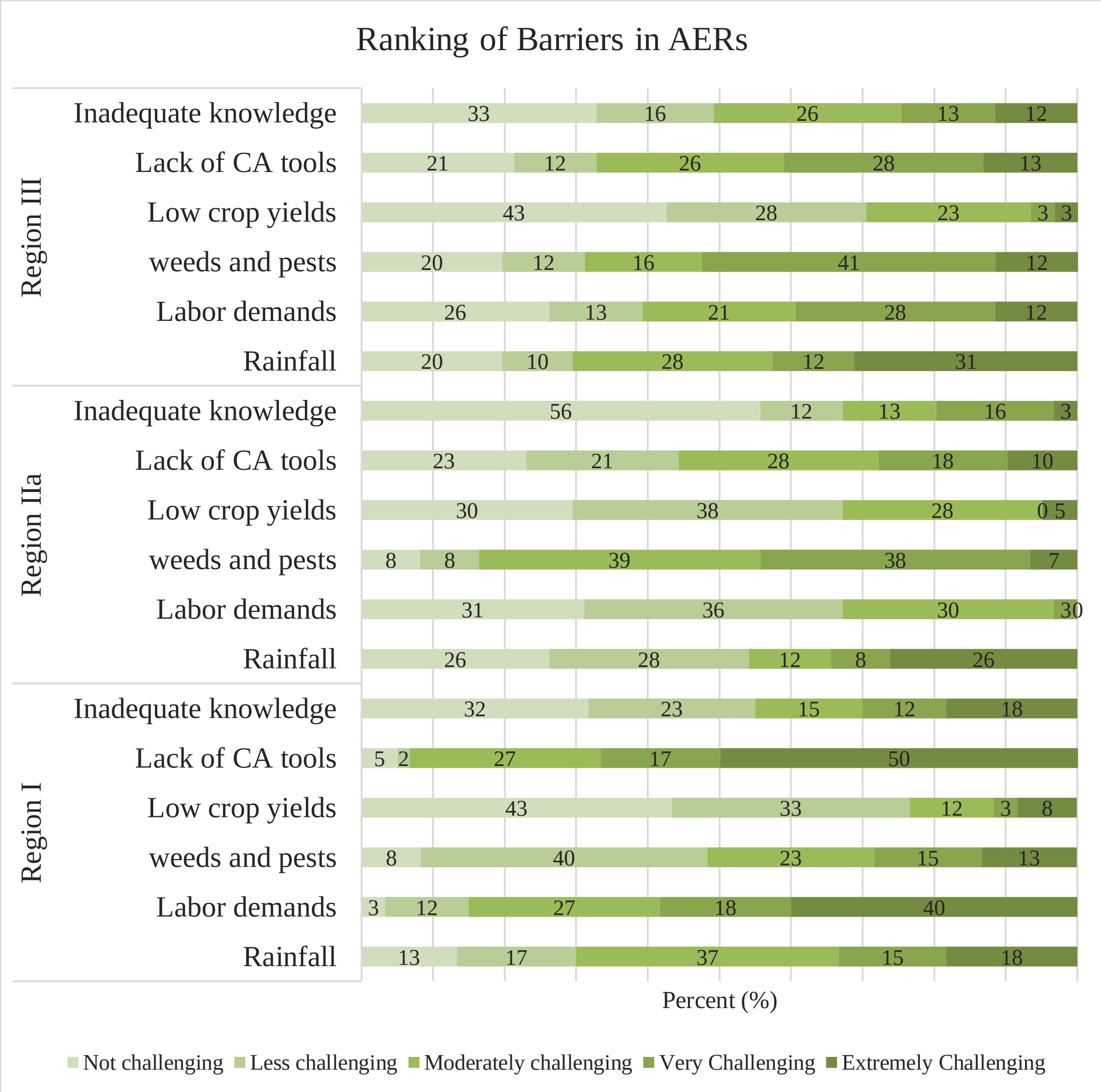


Figure 9: Ranking of barriers of CA adoption in different AERs

5.2.2. Soil cover and protection practices

Figure 10 below, potrays the results of the extent (in percentage) to which a given soil cover practice was being undertaken by farmers in a particular agroecological region. Retained crop residues were found to be most favorable soil cover practice in both Region I & IIa each bearing 97% while Region III had 77% for retained crop residues. Crop cover was notable in Region IIa at 67% which gives an indication for its vital role it plays as folder for livestock such as cowpeas(*Vigna unguiculata*) and velvet beans(*Mucuna pruriens*). Soil cover was not a significant predictor of conservation identity; however, there was a significant behaviour which is necessary to maintain soil cover which includes the avoidance to burn crop residues in South Africa (Findlater et al. 2019)

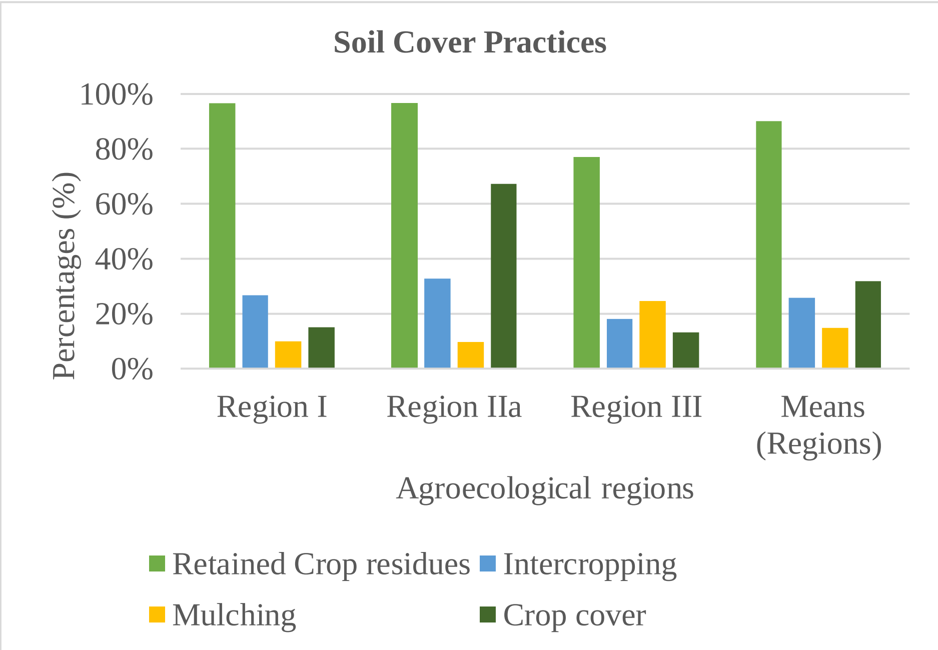


Figure 10: Extent of soil cover practice adoption

Figure 11 below, shows the reason why farmers of a given agroecological region opt for a given soil cover practice. It was notable that soil protection was an outstanding reason for soil cover practices. Soil cover scored 95% in Region IIa, followed by Region I with 90% and finally Region III with 62%. It is not surprising that Region III scored low especeially in view of how the region was neglected when it come to CA promotion activities. As earlier highlighted, the second most important reason for both Regions I & IIa was found to be the use of soil cover as folder for livestock with Region IIa scoring 48% and 32% for Region I. On the other hand, Region III ranked high in the use of soil cover as a means to lessen weeds which pause challenge in its control especially in the event of a prolonged duration of rainy season.

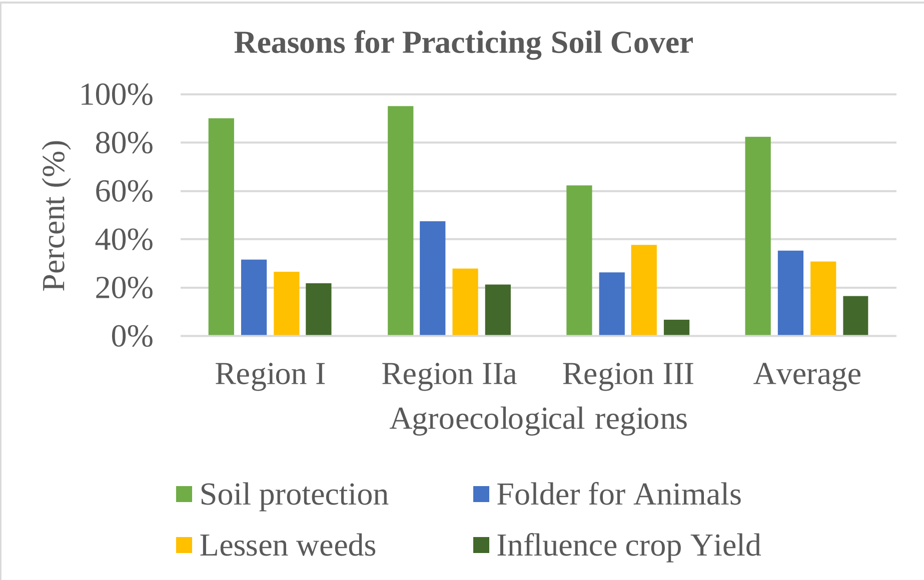


Figure 11: Farmers' reasons for practicing soil cover

In the Table 5 below, no statistical differences are be observed among the diverse AERs for both intercropping and mulching. In any event, their adoption is very low. Retained crop residues on the other hand shows statistical differences. Region III shows relatively lower adoption of retained crop residues as compared to Regions IIa & III. Probably, this low adoption is due to inadequate sensitization on CA as respondents in this region rank highest in inadequate CA information as reflected in Figure 9 when compared to Regions I & IIa. Lack of retaining residues may also imply that farmers have less control over bush fires which are normally set for some rural livelihood practices such as hunting, charcoal burning, collection of carterpillers, and many other forestry related benefits that come with burning of bushes (Eriksen 2007).

Table 5: Chi Square Test on Soil Cover Practices

CA practice	Region I Adopters (%)	Region IIa Adopters (%)	Region III Adopters (%)	X^2	P. Value
Retained crop residues	96.7^{a}	96.7^{a}	77.0^{b}	17.562	< 0.001
Intercropping	26.7^{a}	32.8^{a}	18.0^{a}	3.499	0.174
Mulching	10.0^{a}	9.8^{a}	24.6^{a}	6.911	0.032
Crop cover	15.0^{a}	67.2^{b}	13.1^{a}	52.841	< 0.001

Note: Each superscript letter denotes a subset of AER categories whose column proportions do not differ significantly from each other at the 0.05 level.

Figure 12: Zambian smallholder farmer in his plot with retained crop residues

Source: Author 2019

5.2.3. Crop Rotation

In Figure 13 below, the component of crop rotation was analysed using percentages within AERs and using the average of the total percentages for all the AERs. Farmers who were practicing crop rotation were at 92% and 98% for Regions I & IIa respectively. Meanwhile, Region III had 66% of those who practiced crop rotation. 90% and 98% of farmers from Region I & IIa respectively rotated legumes and cereals. The study by Brown et al. (2017) in on the limitations in CA adoption revealed that the most practiced CA component in Kenya, Malawi, Ethiopia, Mozambique and Tanzania was legume diversification. Region III had the highest (23%) tuber and cereal rotation sequence as compared to Regions I & IIa, this maybe associated with the relatively higher inherent production of tuber crops especially cassava which suplies a large part of carbohydrates in the diets of many farmers of Region III. Cassava fits well in region III due to its relatively good perfomance even in poor soils and its tolerance to weeds, pests, diseases and varriable amounts of annual precipitation.

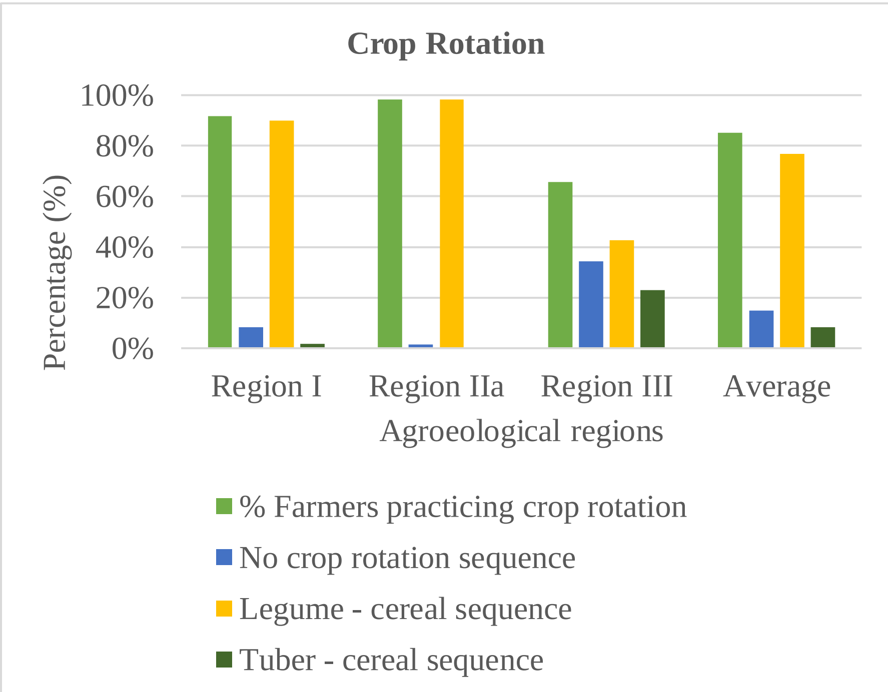


Figure 13: Crop rotation

Table 6 below, shows Chi Square Test results on crop rotation for different AERs. Regions I & IIa shows higher adoption than Region III. This can be explained by the types of favorable crops grown in Region III which are usually perenial and less favourable to annuall crop rotation pattern. On the other hand, Regions I & IIa have higher adoption probably due to increased awareness of the benefit of CA.

Table 6: Chi Square Test of Crop Rotation Practice in AERs

CA Practice	Region I Adopters (%)	Region IIa Adopters (%)	Region III Adopters (%)	X^2	P. Value
Crop Rotation	91.7^a	98.4^a	65.6^b	28.945	< 0.001

Note: Each superscript letter denotes a subset of AER categories whose column proportions do not differ significantly from each other at the 0.05 level.

Figure 14: Zambian smallholder farmer on her crop rotated plot.

Source: Author 2020

5.3. Reasons for practicing Conservation Agriculture

Figure 15 below, reveals the reasons for practicing CA by farmers from respective agroecological zones. Generally, our observation from the total in the figure indicate that the major reasons for adopting CA among the farmers was on the basis that CA increased crop yields and this scored 82%. The second reason was the aspect of soil protection which scored 79% followed by variability in precipitation scoring 57% and reduced labour had 35%. It is worth noting that the results indicate regions I & III scoring 21% each when it comes to variability in rainfall which attests to the fact that, these regions fall on extreme ends of the climate related risks in Zambia i.e Region I with low rainfall amounts and Region III high rainfall amounts. Though with minimal variations, Regions I & IIa seem to indicate adoption of CA because of soil protection and increasing of crop yields. Generally, Region III has lower scores which may be alluded to the fact that this region was neglected in CA promotion activities resulting in low awareness.

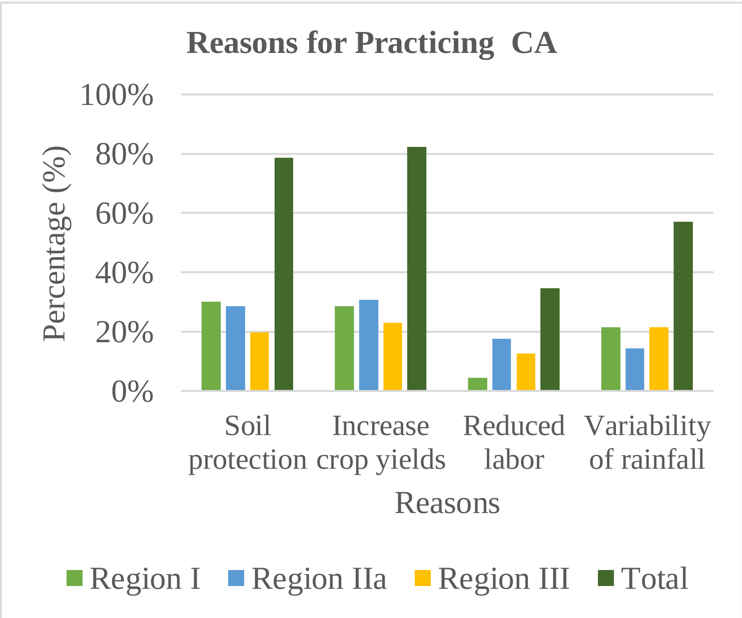


Figure 15: Reasons for practicing CA

5.3.1. Farmers perception on onset of rainfall

Figure 16 below, shows farmers'perception on the onset of rainfall in different agroecological regions. Majority of the respondents (83%) had perception of late onset of rainfall. Interestingly, results for Region III indicate that 65.6% represented perceived rainfall as late onset and 34.4% with view of early onset. Region IIa showed 86.9% for late onset and 13.1% for early onset of rainfall. As for Region I, 96.7% and 3.3% represented late and early onset respectively.

The results therefore suggest higher vulnerability of farmers in Region I to late onset of rainfall as this is the Region which receives the least amounts of annual precipitation.

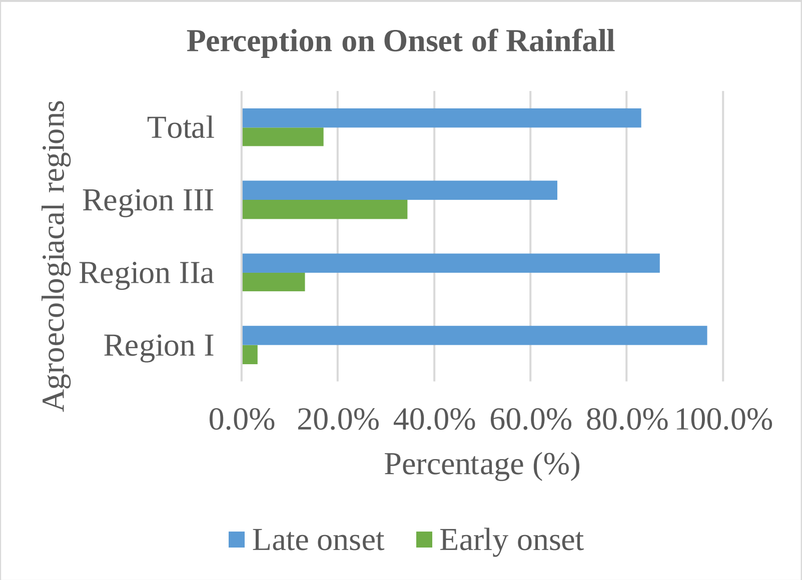


Figure 16: Farmers' perception on onset of rainfall

5.4. Institutional characteristics and information support

5.4.1. Famers group membership

The Table 7**Error! Reference source not found.** below, shows percentages of members and non-members farmer groups. Region IIa had the highest percentage (95%) of farmer group members. This was followed by Region III with 80%, and finally Region I had 68%. The higher percentage of membership is mainly due to the promotion of farmer groups by the incumbent Zambian government as the only channel to access agricultural inputs and services.

Table 7:Percentage of farmers belonging to farmer groups

	Members	Non-members
Region I	68%	32%
Region IIa	95%	5%
Region III	80%	20%
Average	81%	19%

5.4.2. Information Sources

Figure 17 below, shows the gradients of a 1 – 5 point likert scale which reflects sources of information for Conservation Agriculture as expressed in the percentages. The Figure 17 shows that extension agents were the major source of CA agriculture information. These extension agents included not only officers from the ministry of agriculture but also others from different CA promoting agencies and NGOs. This is in consistence with Miheretu & Yimer (2017), agriculture extension services are the main source of information for improved agricultural innovations in Ethipia. The research by Pilarova et al. (2018) indicates that contrary to the expectation that extesnion services have positive influence on the adoption of CA practices, the results however indicated that sustainable practices were not affected by the utilisation of extension services in Moldova. Farmer groups were also an important source of informationbut internet on the other hand was the least in terms of being the source of information for conservation agriculture. Internet facillities were beyond reach of many small holder farmers mainly due to non afordability and poor coverage by the communication service providers.

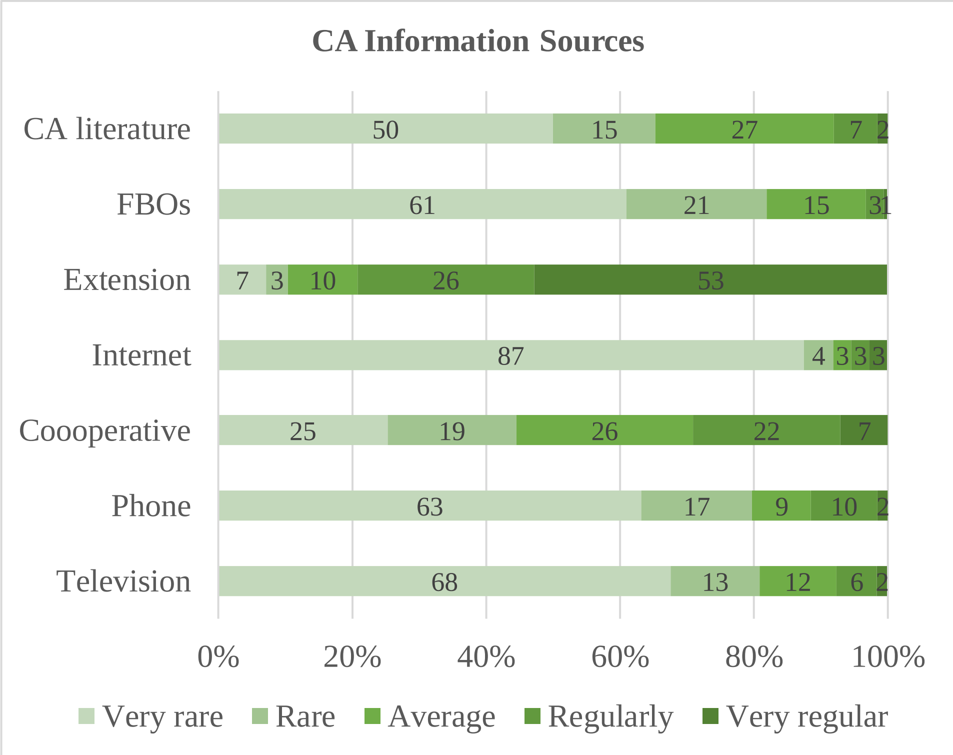


Figure 17:Rankings of farmers sources of CA information.

6. Conclusion

This study investigated the adoption of conservation agricultural practices in distinctive Agro ecological regions of Zambia among the smallholder farmers. This was done by comparing the conservation practices in specific Agro ecological regions. The benefits of adopting conservation practices were examined as perceived by smallholder farmers. Further, major information sources for promotion of conservation practices among smallholder farmers were identified. All these aspects were analysed descriptively.

The study results indicate that planting basins were highly adopted by Region I (80%) as compared to Regions IIa and III which had 39.3% and 54.1% respectively. Ripping on the other hand was highly adopted by Region IIa (78.7%) as compared to Regions I and III where planting basins were more practiced and preferred than ripping. Zero tillage was found to be the least adopted CA tillage method in all the AERs although Region III ranked high in its adoption.

The research further unveiled that retaining crop residues was the most favourable soil cover practice for all AERs. Among all the regions, crop cover was highest (67%) in Region IIa although it ranked second within the Region. Cowpeas *(Vigna unguiculata)* and velvet beans *(Mucuna pruriens)* appeared to be main crop cover species which were also planted as folder for animals. 85% of farmers practiced crop rotation of which 77% alternated cereals with legumes while only 8% farmers mainly from Region III alternated cereals with tubers. The benefits of adopting CA were cited as increased crop yields, soil protection, mitigation towards variability in precipitation and reduced labour. The study further revealed that lack of CA tools, high labour demands, rainfall, weeds, and pests were the main barriers in the adoption of CA technologies in Zambia.

Results of the study also revealed that 81% of farmers belonged to farmer groups and on average, 23% farmers had received credit and input support towards promotion of CA practices. Extension services, cooperatives, and CA literature formed the main and preferred sources of CA information.

6.1. Recommendations

In order to improve and enhance the adoption of CA practice among the small holder farmers in Zambia, there is need to consider the following.

- New and existing innovations should be formulated and or redesigned to favour the preferences and conditions of farmers in diverse agro ecological regions as an assurance of adoption and sustainability.
- Raising the accessibility of farmers to CA mechanical services and implements through encouraging machinery owners to be involved in hiring services would be a sure way to increase the adoption of CA in Zambia.
- Creating linkages between CA based credit and input providers with active and viable cooperatives aimed at raising the asset base of cooperatives with respect to CA tools and implement. This will make easy access of rare CA tools to farmers.
- Access to information has remained a cardinal element in realising sound adoption of CA. Hence equipping and intensifying extesnion services coupled with development of literature suitable for the smallholder farmers can greatly increase adoption.

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Appendix 1: Conservation Agriculture Practices Survey Questionnaire

GPS Location:

Photo of the farmer/field:

Enumerator:

Phone No.

Agro Ecological Zone

- Zone I
- Zone IIa
- Zone III

District

- Mambwe
- Monze
- Masaiti
- Chongwe
- Kapiri-Mposhi
- Kasempa

Part A. Socio-demographic profiling

1. Please indicate your gender
   - Male
   - Female

2. Please indicate your age

3. Marital Status
   - Single
   - Married
   - Divorced
   - Widowed

4. Level of Education
   - Non
   - Primary
   - Secondary
   - Tertiary

5. Household Size

a. Number of children (below 15years) living under your household

b. Number of Adults (16-59) living under your household

c. Number of Elderly above (60yrs)

6. What type of farming do you practice?
   - Crops
   - Mixed
   - Animal

7. How many years have you been involved in farming?

a. Please Indicate your total land size (in ha) under customary

b. Please Indicate your total land size (in ha) under Title

c. Please Indicate your total land size (in ha) which you are renting

9. Which major types of crops do you grow?

- ☐ Maize
- ☐ Soybeans
- ☐ Groundnuts
- ☐ Cassava
- ☐ Vegetables
- ☐ Cotton
- ☐ Beans
- ☐ Sorghum
- ☐ Tobacco

10. Please indicate the number of Cattle that you have

11. Please indicate the number of small ruminants (Sheep /Goats) you have

Part B. Perception on conservation agriculture

12. Have you learnt about Conservation Agriculture?

○ YES ○ NO

13. Which CA tillage method do you practice?

- ☐ Planting basins
- ☐ Ripping
- ☐ Zero tillage

14. How many Hectares do you cultivate under the following tillage methods?

a. Zero tillage

b. Ripping

c. Planting basins

d. Conventional

15. Please indicate your preference to the following tillage methods.

(E.g.- Low preference 0 1 2 3 4 Highly preferred)

a. Zero tillage ☐

b. Ripping ☐

c. Planting basins ☐

d. Conventional ☐

16. Do you think there are some advantages in practicing the CA tillage methods

- ○ YES ○ NO

17. What are the major reasons for preferring CA tillage methods

- ☐ Soil protection
- ☐ Increase in crop yields
- ☐ Labour aspects
- ☐ Low rainfall
- ☐ High rainfall
- ☐ Availability of CA tools

18. How do you perceive rainfall in the past two seasons

- ○ Early onset ○ Late onset

19. Are there some challenges faced in practicing Conservation Agriculture?

- ○ YES ○ NO

20. If yes in question 19 above, rank each challenge faced regarding CA tillage methods below

(E.g. Not Challenging – 0 1 2 3 4- Extremely Challenging)

a. Rainfall pattern ☐

b. High labour demands ☐

c. Weeds and pests ☐

d. Low crop yields ☐

e. Lack of CA tools/implements ☐

f. Inadequate knowledge ☐

Part C. Soil cover

21. Please choose the crop cover practice you used in the past two farming seasons

- ☐ Retained crop residues
- ☐ Intercropping
- ☐ Moisture content
- ☐ Mulching
- ☐ Crop cover
- ☐ Green manure
- ☐ Others

22. Give a reason for your answer in question above
- ☐ Soil protection
- ☐ Folder for L/stock
- ☐ Lessen weeds
- ☐ Influence crop Yields
- ☐ Others

Part D. Crop rotation

23. Do you practice crop rotation?
- ○ YES ○ NO

24. Which sequence of crop rotation do you practice?
- ○ Legume – cereal ○ Tuber – cereal ○ Non

25. What is your preferred period of crop rotation?
- ○ Non
- ○ Every year
- ○ Every two years
- ○ More than two years

Part E. Extension service

26. Do you belong to any farmer group?
- ○ YES ○ NO

26a. How many farmer group(s) are you a member of? ☐

26b. Did you receive any credit/ subsidized inputs from any CA promoting organization in the past 2 years?
- ○ YES
- ○ NO

26c. Do you think you have adequate experience on CA practices?
(Not experienced -0 1 2 3 4 -Very experienced)

27. With the help of the scale given below, rank how regular you receive information on CA from the following sources?
Not experienced -0 1 2 3 4 -Very experienced)

a. Television

b. Phone

c. Cooperative

d. Internet

e. Extension agents

f. Faith Based Organisation

g. CA Literature

The End. Thank you for your cooperation