UNDERSTANDING THE POTENTIAL OF CONSERVATION AGRICULTURE TOWARDS IMPROVING FOOD SECURITY AND SUSTAINABILITY OF NATURAL RESOURCES IN CHONGWE DISTRICT OF LUSAKA.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

ABSTRACT

Conservation agriculture (CA) represents a promising solution to the challenges faced by smallholder farmers in Chongwe District. This paper outlines the potential benefits of CA, including increased crop yields, improved food production, reduced input costs, and enhanced nutritional quality and diversity of food crops. Policymakers, agricultural extension services, and development organizations need to prioritize the promotion and adoption of CA practices, providing support for training, capacity building, and access to resources for farmers. The paper also calls for targeted interventions to raise awareness about the benefits of CA, address misconceptions, and integrate CA principles into agricultural policies and programs. By prioritizing and supporting the shift towards CA, stakeholders can contribute to creating a more resilient and sustainable agricultural system that benefits farmers.

Keywords: Conservation Agriculture, smallholder farmers, sustainable farming, Chongwe District, agricultural policies

1. Introduction

Agriculture is one of the world's largest and most fundamental industries and constitutes the backbone of most African economies. Globally, economic growth is directed toward Sustainable Development Goals (SDGs), and agriculture, as the primary economic activity, can be a natural way to end hunger and poverty as well as bring about economic and social development. Global crop production has changed drastically in recent decades. The amount of food grown has increased rapidly as a result of two drivers; the amount of land used for agriculture has expanded, but the largest driver has been a rapid increase in crop yields [10]. Agricultural development lies at the heart of poverty reduction, and the increased food security of most developing countries and sub-Saharan Africa is no exception. However, it is the only region in the world where per capita agricultural productivity has remained stagnant for more than 40 years. A study by [5] also showed that this may be orchestrated by pandemics that halt many agricultural activities, as was the case in 2020. All such factors naturally demand large amounts of land for increased productivity to feed increasing populations; however, at the same time, sustainability demands that resources such as forests and land be sustained for future generations.

Although Zambia is readily available for agricultural production, the country has been struggling to utilize its agricultural potential to address food insecurity and poverty. This is partly attributed to climatic changes and variability [3]. Despite the increasing recognition of the potential benefits of conservation agriculture for improving food security and natural resources, there is still a lack of comprehensive understanding of what conservation agriculture can do to achieve such. This knowledge gap inhibits the development of evidence-based policies and interventions that can encourage and support the adoption of sustainable agricultural practices by farmers and other stakeholders. Therefore, this study aimed to understand the key drivers of and

barriers to the adoption and dissemination of sustainable agricultural practices. and their impact on food security and natural resource conservation. If this problem is not addressed, the impacts of unsustainable agricultural practices on the economy, society and natural environment will be exacerbated because mitigation and adaptation measures will not be effective at dealing with the change in this problem. This study specifically aimed to understand the farming methods practiced by farmers, examine how conservation agriculture helps improve food security and explore how conservation agriculture can help promote natural resource conservation as well as strategies to increase conservation agriculture adoption.

2. Methods and Tools

Description of the study area

Chongwe District (Figure 1) was upgraded to a municipal council on 27 February 2017. It is characterized by three distinct seasons, namely, the cool and dry season, the hot and dry season and the hot and wet season [4]. The region experiences seasonal rainfall ranging between 800 mm and 1000 mm on average, and the mean temperature ranges from 23.13°C each year. The crop-growing period lasts between 120 days and 150 days

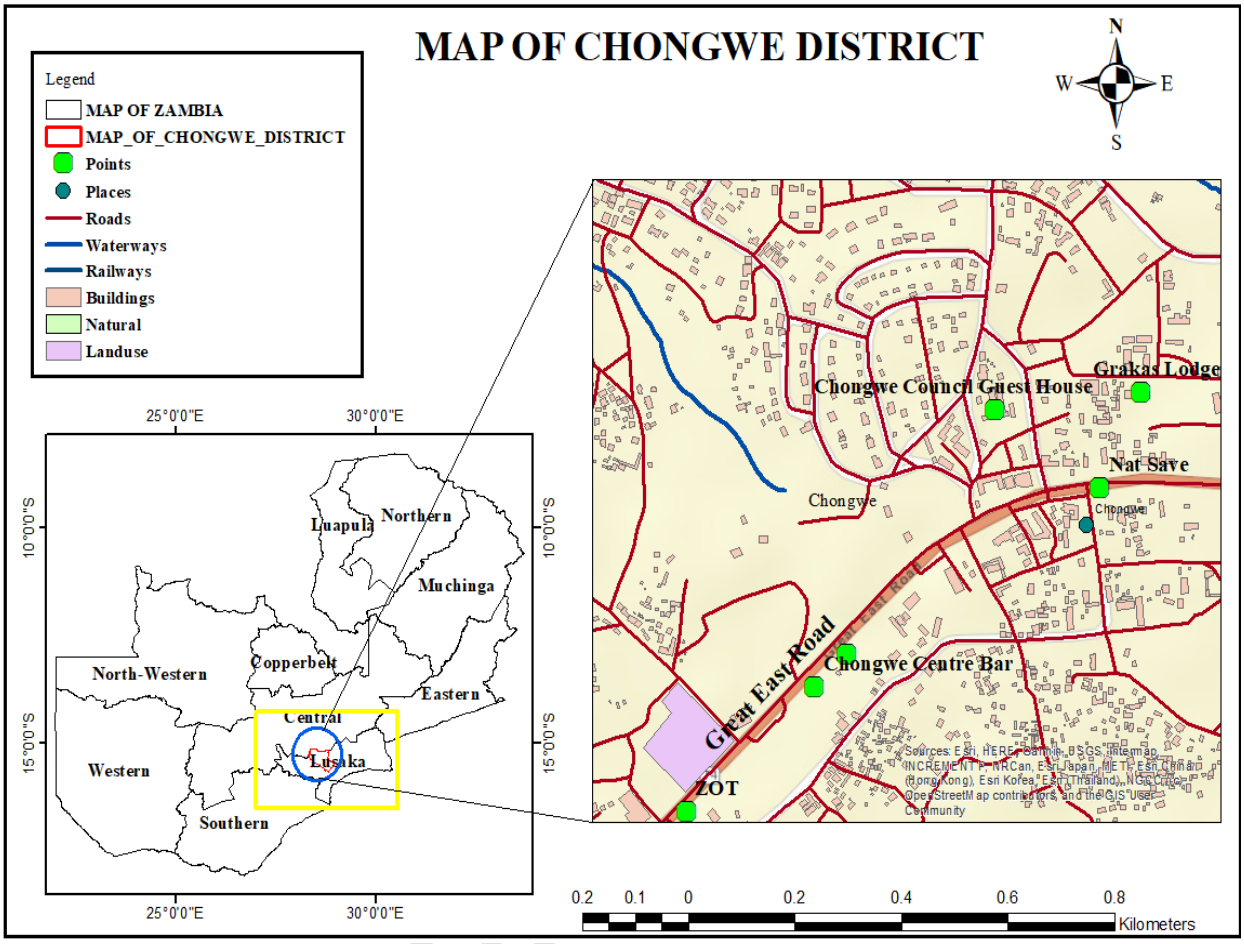

Figure 1: Geographical Setting of the study area.

[5]. Chongwe lies in a plateau area at an average altitude between 900 m and 1200 m above sea level. It has moderately leached clay to loamy slightly acidic soils, which are considered to be the best for crop production [5]. In Lusaka Province, where Chongwe is found, the main tree species are dry Miombo, also known as Brachystegia woodland, Mopane woodland and Munga (acacia) woodland. These tree species are important for timber and fuel wood production.

The target population for the study was the rural population of Chongwe District, with a population of 129,141 people, accounting for 91.4% of the district population. The average annual growth rate for the district is 3.2. Agriculture is the main economic

activity of the district, and the major activities include crop production and horticulture.

Research Approach and Design

This study employed a qualitative approach considering the nature of the research topic. A case study was used to collect, analyse and interpret the data. The use of a qualitative method is well described by [6]; [7]. The target population of this study included farmer farmers in Chongwe District and a few experts from relevant authorities. The total number of respondents and the model for selecting the participants were determined by the sample size and the sampling procedure.

Sampling and data collection

A sample of 56 peasant farmers was selected using a nonprobability purposive (heterogeneous) sampling technique to select representatives from the target population. The primary data were collected through interviews. The researcher conducted face-to-face interviews with participants. These interviews involved unstructured and generally open-ended questions intended to elicit views and opinions from the participants. The purpose of the interviews was to understand the subject matter of the research through interactive dialogue with them. Three focus group discussions targeting small-scale farmers practicing conservation farming were conducted.

Data analysis

Descriptive statistics, including tables and graphs, were used to analyse the quantifiable data. The quantifiable data were coded and grouped into frequencies and percentages for easy communication of the research messages. All qualitative data were analysed using a thematic analysis approach. The data were first inspected and cleaned, and the themes and codes were identified. The data associated with each theme were clustered to confirm the themes. Thereafter, conclusions and meanings were drawn.

Data Quality and Trustworthiness

To increase confidence and ensure consistency of the data, the study employed the use of interviews in combination with observation and checking of previous records on crop

production and land use from the District Agricultural Office (DAO), experts in the agriculture sector and the Forestry Department to determine whether participants said tallied with reality.

2. Research Findings

Sociodemographic profiling of participants

The research studied 26 participants whose demographic data were as presented in Figures 2-5. The demographic snapshots show the diversity of the crops cultivated by farmers; these crops were irrigated differently from natural and human-made sources of water, such as rivers and rainfall, as well as from borehole drilling.

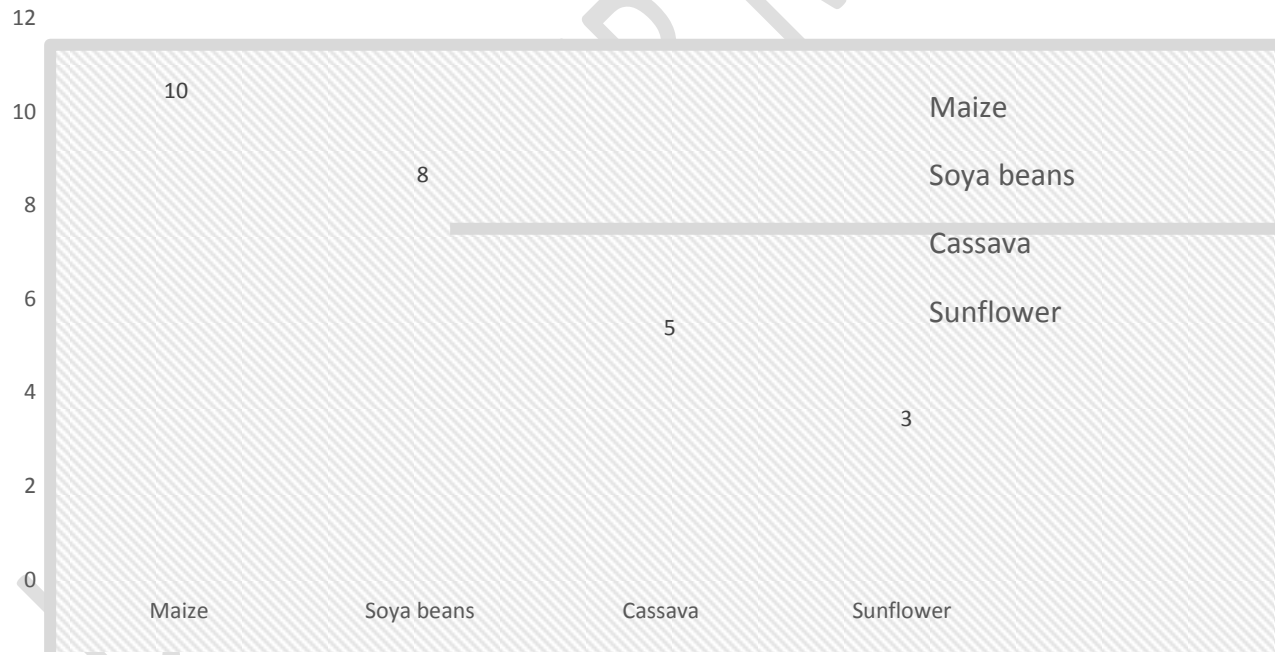

Figure 2: Type of crops grown

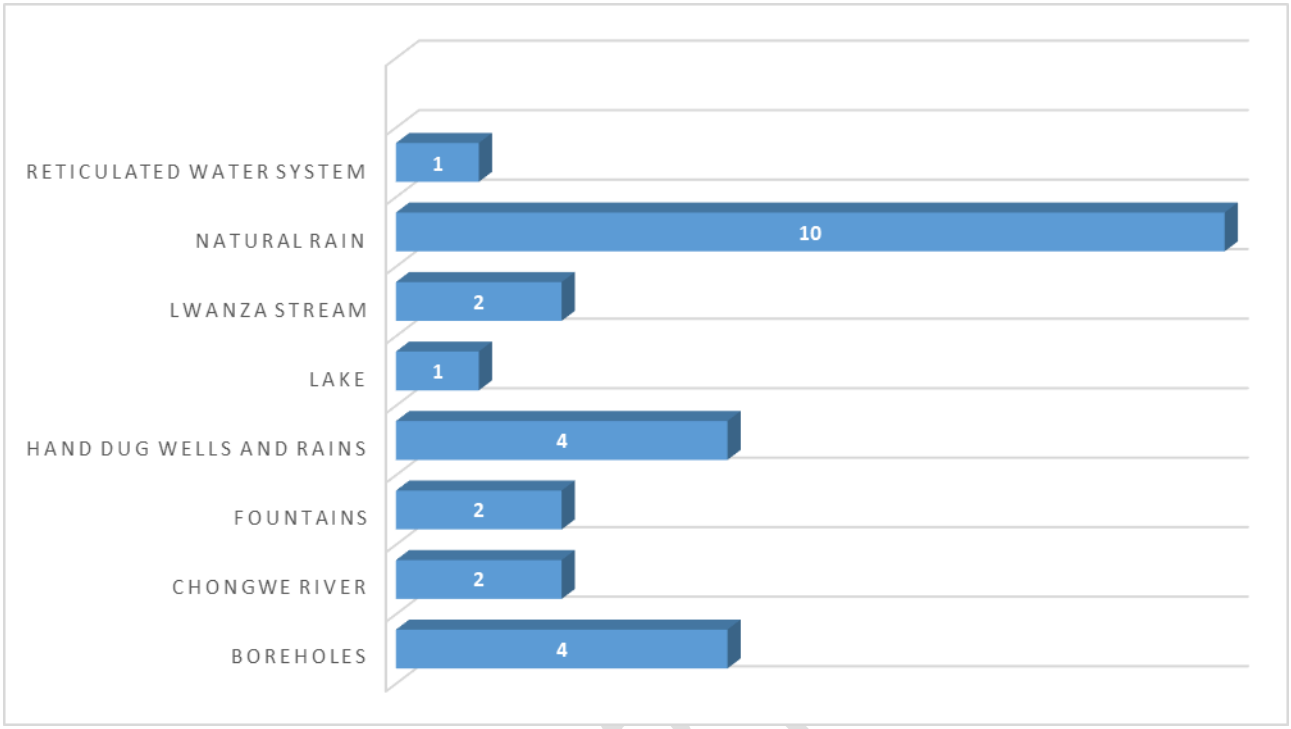

Figure 3: Sources of water for irrigation

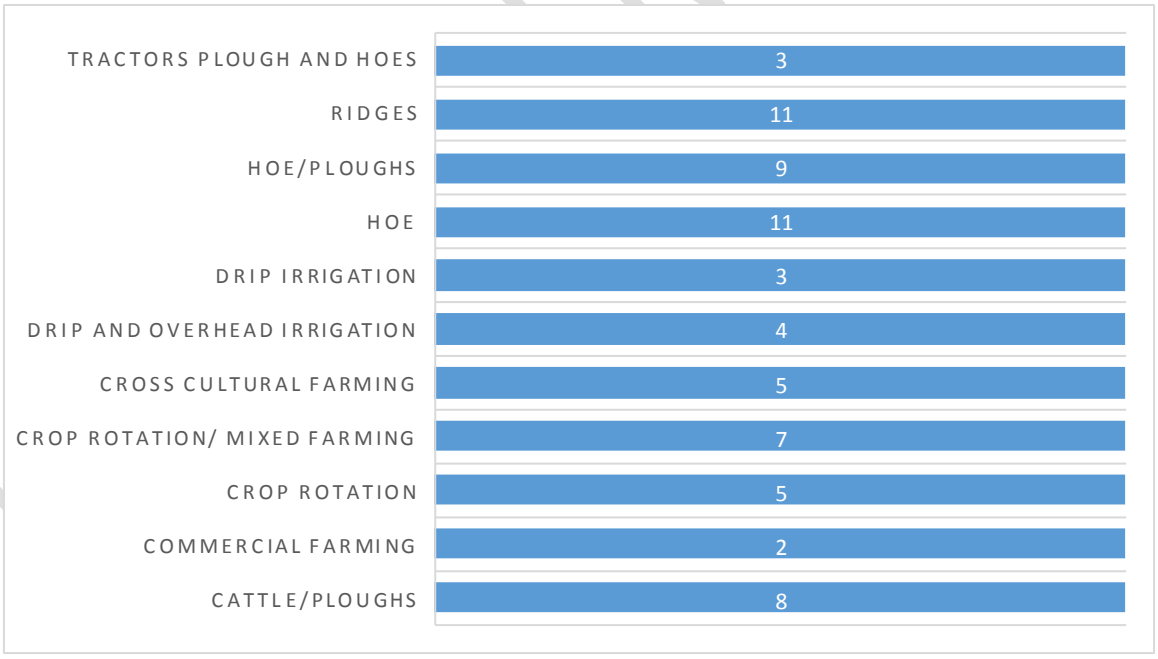

Figure 4: Frequency distribution of responses on how soil fertility was managed and maintained

Farmers, in their own words, highlight an integrated and sustainable approach to farming. Farmers often use fertilizers to supplement soil with essential nutrients such as nitrogen, phosphorus, and potassium. This helps enhance plant growth and yield. Fertilizers can be organic (e.g., compost, manure) or synthetic. Organic fertilizers improve soil structure, water retention, and microbial activity. Crop rotation involves planting different crops in the same field in sequential seasons. This practice helps break pest and disease cycles, improves soil structure, and enhances nutrient cycling [20]. Earlier study [21] further shows that although rotating crops may sometimes be challenged by excess weed, it can still help prevent the depletion of specific nutrients from the soil, as different plants have different nutrient requirements. Composting involves the decomposition of organic materials (e.g., kitchen scraps and yard waste) to create nutrient-rich compost.

Adding compost to soil helps retain moisture, suppresses disease, and promotes the availability of essential nutrients to plants. Lime is often applied to soil to increase its pH. Correcting the soil pH is crucial for ensuring optimal nutrient availability for plants. Lime can also be applied because it can improve soil structure, reduce soil acidity, and enhance microbial activity. Furthermore, manure, whether from livestock or other organic sources, is a valuable organic fertilizer. It provides essential nutrients, improves soil structure, and enhances water retention. Properly composted manure reduces the risk of pathogens and weed seeds, making it a beneficial addition to the soil. By conducting soil tests, farmers can determine the nutrient levels and pH of their soil. This information can guide the appropriate application of fertilizers and soil amendments. Soil testing allows for precise and efficient nutrient management, preventing overuse or underuse of fertilizers.

Benefits of conservation agriculture among smallholder farmers

Based on the findings in Table 1, the thematic focus of CA should be on the benefits of sustainable agriculture in terms of soil fertility, food security, economic well-being, and long-term sustainability. These findings support the idea that these practices not only benefit current agricultural output but also have positive implications for the future.

Table 1: Thematic summary of participants' views on the benefits of conservation agriculture

Themes	***Findings***
Soil fertility	• these practices help to improve soil retention and aeration, which in turn leads to the production of healthy crops and increased productivity • Soil remains fertile for a longer period • Improves soil retention and aeration • Improved resilience, soil quality and improved harvest and soil fertility
Food security	• Ensure food security in household • Also increases productivity in certain areas for example containing or reducing financial constraints at a household level • Increases yield on a small portion of land
Sustainable and environmentally friendly	• It is sustainable and environmentally friendly
Economic benefit of sustainable agriculture	• It benefits the farmer in the future SNF It

	is cheap • It's cheap because no machinery is used. • It can be used by the next generation, it's cheap on the cost and provides readily available nutrients
Efficient use of resources	• Sustainability of land use • It helps use resources efficiently • It reduces soil erosion and soil degradation

Challenges of adopting conservation agriculture practices

The challenges that the farmers faced in adopting conversation agriculture practices are presented in Table 2 below. Farmers faced several challenges, which were clustered around lack of technical know-how, lack of awareness and equipment, lack of time and process for adaptation, resistance to change and market challenges.

Table 2: Thematic summary of participants' views on the challenges of adopting conservation agriculture practices

Themes	**Key findings**
Lack of technical know-how	• Many farmers lack the technical knowledge and skills necessary to adopt and implement conservation agriculture practices. • This hinders their ability to transition from traditional farming methods to more sustainable ones.

Themes	Key findings
Awareness and Equipment	• The lack of awareness about conservation agriculture, as well as the absence of necessary equipment, presents a barrier to its adoption among farmers. • This may include a limited understanding of the potential benefits of conservation agriculture and a lack of access to the tools and resources required to practice it.
Time and Process for Adaptation	• The process of adapting to conservation agriculture involves significant changes in farming practices and techniques. • This presents a challenge for native farmers who may be accustomed to traditional methods, requiring time and support to transition to new approaches.
Resistance to Change	• Many native farmers are resistant to changing their traditional farming methods. • This resistance may stem from a combination of factors including a lack of knowledge about conservation agriculture, skepticism about its effectiveness, and the comfort and familiarity of existing farming practices.
Market Challenges	• Adoption of conservation agriculture may be seen as difficult in the market, with concerns about potential impacts on yield and profitability. • Farmers may be hesitant to change their methods if they believe it will result in lower yields or economic challenges.
Lack of Awareness and Willingness to Change	• There is a pervasive lack of awareness about conservation agriculture among farmers, and some may be reluctant to make the necessary changes to their farming practices.

Themes	Key findings
	• This points to a need for increased education and outreach to build awareness and encourage the willingness to adopt new methods.
Education and Convincing	• Lack of education among smaller farmers presents a hurdle to convince them to practice conservation agriculture. • In many cases, this lack of education may contribute to their reluctance to adopt new farming methods even when presented with information about potential benefits.
Lack of Proper Knowledge and Understanding	• Many farmers lack the proper knowledge and understanding of the implications of conservation agriculture. • This includes a limited understanding of the potential benefits and long-term sustainability of these practices.

Strategies used to increase conservation agriculture adoption

To address the challenges that have been cited above, the participants suggested various strategies to enhance the adoption of CA. These strategies were combined into various themes, namely, cultivating conservation awareness, empowering agriculture for tomorrow, promoting sustainable agricultural synergy and harvesting prosperity in rural hubs (Table 3).

Table 3: Thematic summary of participants' views on the strategies used to increase adoption of conservation agriculture.

Themes	Strategies
Cultivating Conservation Awareness	• Educate farmers on the importance of conservation. • Regular campaigns and demonstrations. • Tax incentives for conservation practices. • Teaching through demo plots.
Empowering Agriculture for Tomorrow	• Introduce adaptive crops to showcase benefits. • Increase awareness campaigns. • Provide incentives and subsidies. • Form cooperatives and engage corporate firms. • Register and organize farm blocks. • Sensitize both commercial and subsistence farmers.
Sustainable Agriculture Synergy	• Workshops and virtual farmer field schools. • Collaborate with private sectors and seed companies. • Government and private sector partnership. • Promotion of awareness and strong policies. • Financial incentives and resource empowerment
Harnessing Prosperity in Rural Hubs	• Educate rural communities on sustainable practices. • Improve economic welfare through better markets. • Form cooperatives and clubs for community support.

Harnessing Prosperity in Rural Hubs	• Workshops physically and virtually for community education. • Collaboration with extension officers and farming cooperatives
Legal Framework for Sustainable Agriculture	• Pass laws and create conservation policies. • Enforce and monitor policy compliance. • Empower local communities with knowledge. • Sensitize on the importance of conservation. • Provide farming inputs on time

4. Discussion

The research findings on the benefits of conservation agriculture (CA) are consistent with previous studies [8], [9], [1]. that have emphasized the positive impact of CA practices on soil fertility, food security, sustainability, economic benefits, and the efficient use of resources. These findings align with a growing body of research that highlights the potential of CA to transform farming systems and contribute to sustainable agricultural development.

The improvement of soil retention and aeration through CA practices is a well-documented benefit. A study by [10] showed that CA leads to healthy soil structures and increased productivity. By minimizing soil disturbance and promoting the retention of organic matter, CA practices contribute to maintaining soil fertility over a longer period. This is in stark contrast to conventional farming methods, which often lead to rapid soil degradation [11]. Additionally, improved resilience, soil quality, and enhanced harvests are frequently reported outcomes of CA adoption. These findings coincide with previous research highlighting the positive

impact of CA on soil health and productivity.

The linkage between CA and food security is a key area of interest in agricultural research. The ability of CA to ensure food security at the household level is a significant finding. This finding aligns with that of [12], who demonstrated the positive impact of CA on smallholder farmers' food production. Additionally, the increase in productivity in certain areas, which reduces financial constraints at the household level, aligns with the results by [13], which demonstrated the potential of CA to enhance crop yields and income generation. Furthermore, the observation that CA can increase yields on a small portion of land supports existing studies highlighting the efficiency of CA in maximizing land productivity.

The assertion that CA is sustainable and environmentally friendly is in line with the core principles of CA, which emphasize the conservation and preservation of natural resources. A study by [14] identified CA as a sustainable farming approach that promotes environmental stewardship by minimizing soil disturbance, reducing chemical inputs, and enhancing biodiversity. These findings are consistent with research emphasizing the role of CA in promoting agroecological practices and minimizing the environmental impact of agricultural activities.

The economic benefits associated with CA align with those of previous research that has underscored the long-term financial advantages of sustainable agricultural practices. The affordability of CA, attributed to the reduced reliance on machinery and the provision of readily available nutrients, is a recurring theme in studies examining the economics of CA adoption. This finding is consistent with that of [14], who highlighted the cost-effectiveness of CA in comparison to conventional farming systems, particularly in terms of input costs and long-term soil fertility.

The emphasis on the sustainability of land use and the efficient utilization of resources echoes the fundamental principles of CA. [15] emphasized the

role of CA in optimizing resource use, particularly in the context of water and soil conservation. The reduction in soil erosion and degradation associated with CA practices aligns with a wealth of research demonstrating the positive impact of CA on natural resource conservation.

While the presented findings align with existing research, it is important to note that the outcomes of CA adoption can be influenced by various factors, including agroecological conditions, local contexts, and the specific implementation of CA practices. Accordingly, comparative analysis should consider the variability of results across different studies and regions. Some studies may emphasize the immediate benefits of CA adoption, such as improved soil fertility and reduced input costs, while others may provide insights into the long-term impacts of CA on ecosystem resilience and farmer livelihoods.

Furthermore, contrasting findings in the literature may highlight potential challenges and limitations associated with CA adoption. For example, while the economic benefits of CA are often emphasized, some studies may also explore the initial investment required for transitioning to CA practices and the time lag in realizing financial returns. Additionally, contrasting perspectives on the scalability of CA and its applicability across diverse agricultural landscapes may provide insights into the contextual factors influencing the outcomes of CA adoption. In sum, while the presented research findings align with the established literature on the benefits of conservation agriculture, it is essential to conduct a comprehensive comparative analysis that considers the diversity of results, contextual factors, and potential limitations associated with CA adoption. By synthesizing a wide range of research findings, it is possible to gain a nuanced understanding of the multifaceted impacts of CA and its implications for sustainable farming practices. On the other hand, the research findings highlight several key challenges in the adoption of conservation agriculture. A lack of technical know-how stands out as a

major issue, as many farmers lack the necessary knowledge and skills to transition from traditional farming methods. This aligns with the findings of other studies that have also identified a skills gap as a barrier to the adoption of sustainable agricultural practices. Additionally, the lack of awareness about conservation agriculture and the absence of necessary equipment also emerge as significant obstacles, echoing findings from other research that emphasize the importance of accessing knowledge and resources for successful adoption. This approach may require environmental education via informal strategies that are adaptive to local communities, as suggested earlier by [16], whose study focused on what different sectors or industries, such as agriculture, expect for environmental education. The time and process required for adaptation are also noteworthy, as significant changes in farming practices are often needed when transitioning to conservation agriculture. This aligns with broader literature that highlights the challenges associated with changing established farming methods, particularly when new approaches require a significant shift in techniques and processes. Resistance to change is another common theme across the findings, with many farmers being hesitant to depart from their traditional methods. Similar sentiments have been echoed in other studies [17]; [11; [15]; [8], [18], indicating that resistance to change represents a common barrier to the adoption of innovative agricultural practices. Market challenges and perceptions about potential impacts on yield and profitability are also highlighted in the research findings. These concerns resonate with broader discussions in the literature regarding the economic considerations that influence farmers' willingness to adopt conservation agriculture. The reluctance to change existing methods due to uncertainty about their impact on yield and profitability is a widely recognized challenge in the realm of sustainable agriculture.

The persistent lack of awareness about conservation agriculture and the associated reluctance to change

farming practices is a recurring theme in the findings. This underscores the crucial role of education and outreach in promoting the adoption of sustainable agricultural practices. Similar studies have emphasized the need for targeted educational efforts and outreach programs to raise awareness and build willingness to adopt new methods among farmers. The lack of education among smaller farmers further reinforces the need for focused educational interventions tailored to different farming demographics. The findings also emphasize the importance of proper knowledge and understanding among farmers, particularly regarding the implications and benefits of conservation agriculture. This aligns with broader study by [16] that emphasizes the significance of knowledge and understanding in shaping attitudes and behaviours toward sustainable agricultural practices.

Comparing these findings with existing research [19], it is evident that the challenges identified in the research are consistent with broader discussions in the literature. The lack of technical know-how, awareness, access to equipment, and resistance to change are well-documented barriers to the adoption of conservation agriculture. Additionally, the importance of education, awareness-building, and targeted outreach has been repeatedly highlighted in a study by [20] as essential factors for overcoming barriers and promoting the uptake of sustainable agricultural practices. While the research findings shed light on the specific challenges faced by farmers in adopting conservation agriculture, it is important to note that these barriers are not insurmountable. [20] have also documented successful strategies and interventions that have effectively addressed these challenges. For example, targeted training and capacity-building programs have proven to be effective at equipping farmers with the necessary technical knowledge and skills. Furthermore, collaborative initiatives involving government agencies, nongovernmental organizations, and agricultural

extension services have been successful at raising awareness, providing access to equipment, and promoting the adoption of conservation agriculture practices. While the challenges identified by the research align with broader discussions in the literature, it is essential to recognize that targeted interventions and evidence-based strategies can overcome these barriers. By addressing a lack of technical know-how, raising awareness, providing access to resources, and fostering a supportive policy and market environment, the adoption of conservation agriculture can be promoted effectively among farmers. Furthermore, a nuanced understanding of the specific contexts and needs of different farming communities is crucial for developing tailored interventions that can effectively facilitate the transition to sustainable agricultural practices.

The introduction of adaptive crops to showcase benefits, as proposed in the "empowering Agriculture for Tomorrow" strategy, is consistent with the idea of demo plots and hands-on demonstrations, which were suggested in an earlier study [15]. This approach aligns with the broader approach of providing practical examples to farmers, underscoring the potential benefits of conservation agriculture in a tangible and visible manner. The idea of forming cooperatives and engaging corporate firms, as highlighted in the "Empowering Agriculture for Tomorrow" and "Harnessing Prosperity in Rural Hubs" strategies, resonates with the well-documented role of collective action and partnership in promoting sustainable agricultural practices. Similarly, collaboration with private sectors and seed companies, emphasized in the "Sustainable Agriculture Synergy" strategy, aligns with the notion of engaging multiple stakeholders in knowledge dissemination and resource provision.

Financial incentives and resource empowerment, which are proposed in the "Sustainable Agriculture Synergy" strategy, are consistent with findings from other studies that highlight the importance of addressing financial constraints and ensuring access to

necessary resources as key factors in the adoption of conservation agriculture practices. The promotion of strong policies is a common theme in the "Sustainable Agriculture Synergy" strategy and resonates with studies emphasizing the need for supportive regulatory frameworks and policies to encourage the adoption of sustainable agricultural practices. Improving economic welfare through better markets, as suggested in the "Harnessing Prosperity in Rural Hubs" strategy, aligns with the understanding that addressing market concerns and ensuring profitability are crucial components in convincing farmers to adopt conservation agriculture practices. While the research findings offer valuable insights into strategies for increasing the adoption of conservation agriculture, it is essential to acknowledge that the success of these strategies may vary across different contexts. Factors such as local agroecological conditions, socioeconomic dynamics, and institutional support can influence the effectiveness of these approaches in promoting conservation agriculture [9].

The strategies outlined in the research findings resonate with the broader body of literature on promoting sustainable agricultural practices, emphasizing the importance of education, awareness-building, partnership, policy support, and economic incentives. By aligning these findings with existing research, these strategies provide a comprehensive framework for addressing these challenges and promoting the adoption of conservation agriculture practices among farmers. However, further research and on-the-ground implementation will be necessary to refine and tailor these strategies to diverse agricultural landscapes and farming communities.

5. Conclusion and recommendation

In light of the information provided, it is clear that the narrative of Conservation Agriculture (CA) is deeply rooted in ecological principles and holds significant potential for improving food security and addressing the challenges faced by smallholder farmers in Chongwe District and beyond. The detrimental

consequences of intensive tillage and overreliance on chemical inputs have been well documented, leading to low agricultural productivity, soil fertility degradation, and environmental hazards. Conservation agriculture offers a promising alternative by promoting sustainable farming practices that conserve soil and water resources, reduce reliance on chemical inputs, and promote more diverse cropping systems. The potential benefits of CA include increased crop yields, improved food production, reduced input costs, and enhanced nutritional quality and diversity of food crops. Moreover, the diverse methods used by farmers to manage and maintain soil fertility, such as crop rotation, composting, and soil testing, underline the potential for a shift toward more sustainable and regenerative agricultural practices. Based on the evidence presented, it is recommended that policymakers, agricultural extension services, and development organizations in Chongwe District prioritize the promotion and adoption of conservation agriculture practices. It is crucial to provide support for training, capacity building, and access to resources that enable farmers to transition towards CA practices. This may include providing access to appropriate tools and equipment, facilitating knowledge transfer and peer learning, and offering incentives to encourage the adoption of CA principles. Additionally, there is a need for targeted interventions to raise awareness about the benefits of CA, address misconceptions, and provide technical assistance to farmers seeking to adopt these practices. This may involve the establishment of demonstration plots, farmer field schools, and knowledge dissemination through local agricultural extension services and community-based organizations. Furthermore, there is a need for collaborative efforts to integrate CA principles into agricultural policies and programs at the local, regional, and national levels. This includes incentivizing environmentally friendly farming practices, providing support for research and innovation in sustainable agriculture, and fostering partnerships between government

bodies, nongovernmental organizations, and the private sector to promote the widespread adoption of CA. The adoption of conservation agriculture practices holds great promise for addressing the challenges faced by farmers in Chongwe District, particularly concerning improving food security, enhancing farm productivity, and promoting environmental sustainability. By prioritizing and supporting the shift towards CA, stakeholders can contribute to creating a more resilient and sustainable agricultural system that benefits both farmers and the broader community. It is essential to empower farmers with the knowledge, resources, and support necessary to embrace CA principles, ultimately leading to more sustainable and prosperous agricultural livelihoods in Chongwe District and beyond.

COMPETING INTEREST

Authors declare no competing interest.

References

1. Friedrich, T., and Kassam, A. H., (2009). Adoption of Conservation Agriculture Technologies: Constraints and Opportunities. Proceedings of the IV World Congress on Conservation Agriculture, 4-7 February, 2009. New Delhi: ICAR.
2. Muchanga, M., Souza, B., Negumbo, E. Tembo, T., Chipere, T.R. and Nhnyete, S. (2020). Exploring educational lives of the excluded youth under COVID-19 in the SADC region https://www.jet.org.za/resources/sadc-theme-3-exploring-educational-lives-of
3. Chisanga, C.B. Mubanga, K.H., Sichingabula, M. H., Banda, K.; Muchanga, M., Ncube, L.; van Niekerkd, Helena, J., Zhao, B., Mkonde, D.A. Amanda, R. & Sonwabile, K. (2022). Modelling climatic trends for the Zambezi and Orange River Basins: implications for water security. *Journal of Water and Climate Change*, p.1-18.
4. Central Statistical Office (CSO), (2014). Agricultural and Pastoral Production. Lusaka: Central Statistical Office.
5. Government of the Republic of Zambia (G.R.Z), (2002). Zambia National Action Programme for Combating Desertification and Mitigating Serious Effects of Drought in the Context of the United Nations Convention to Combat Desertification. Lusaka:

Ministry of Tourism, Environment and Natural Resources (MTENR).

6. Yin, R. (2003). K. (2003). Case study research: Design and methods. Sage Publications, Inc, 5, 11.

7. Flyvjberg, B., (2004). Five misunderstandings about case-study research. In: Seale, C., Combo, G., Gubrium, J.F., Silverman, D. (Eds.), Qualitative Research Practice. Sagem, Thousand Oaks, CA, pp. 420–434.

8. Nyanga, P. H., (2011). Smallholder Farmers‟ Perceptions of Climate Change and Conservation Agriculture: Evidence from Zambia. Journal of Sustainable Development, Vol. 4, (4), 73-85.

9. Dumanski, J., (2006). Weed Community and Species Response to Crop rotation, Tillage and Nitrogen fertility. Weed Technology Vol. 12, 533-536.

10. Conservation Farming Unit (CFU), (2009). Conservation Farming &Conservation Agriculture Handbook for Hoe Farmers in Agro-Ecological Regions I and IIa-Flat Culture,2009 Edition. Lusaka: CFU.

11. Conservation Farming Unit (CFU), (1996). CFU were established in Zambia in 1996 Conservation Agriculture. The practice of Conventional and Conservation Agriculture in East and Southern Africa, Lusaka: CFU.

12. Campbell, D. (2011). Zambia Environmental Threats and Opportunities Assessment. United States Agency for International Development (USAID): Washington, DC.

13. Central Statistical Office (CSO), (2020). Agricultural and Pastoral Production; Structural Type and Post-Harvest Data for Small and Medium Scale Farmers. Lusaka: Central Statistical Office.

14. Jayaraman S. (2021). Conservation Tillage and Mulching for Optimizing Productivity in Maize–Wheat Cropping System in the Outer Western Himalaya Region. A Review. Indian Journal Soil Conservation, Vol. 33 (1), 35-41.

15. Food and Agriculture Organization of the United Nations (FAO) (2002). Conservation agriculture: Case studies in Latin America and Africa. FAO Soils Bulletin 78. Rome: FAO.

16. Chisenga, M.E. Mando, P Chilumba, M. Kasonde, P Phiri, E Nelly, N. (2021). *Expectations of the industries from Environmental Education: a case study from Zambia,* Lusaka: University of Zambia.

17. Conservation Farming Unit (CFU), (2007). Conservation Farming & Conservation Agriculture Handbook for Ox Farmers in Agro-Ecological Regions I & lla 2007 Edition. Lusaka: CFU.

18. Pretty J., (2001). Agricultural Technologies and Tropical Deforestation, CAB International.

19. Haggblade, S., and Tembo, G, (2003a). Early Evidence on Conservation Farming in Zambia, a paper prepared for the International Workshop on "Reconciling Rural Poverty and 48 Resource Conservation: Identifying Relationships and Remedies." May 2-3. New York: Cornell University, Ithaca

20. Haggblade, S., and Tembo, G., (2003b). Development, Diffusion and Impact of Conservation Farming in Zambia. Working Paper No. 8, Food Security Research Project. Lusaka: Government printers.

21. Umar, B.B. (2012). A Multi-Tactic Approach to Manage Weed Population Dynamics in Crop rotations. *Agronomy*. Vol. 97, 1579-1583.