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# A bibliometric analysis of smallholder farmers' climate change adaptation challenges: a SADC region outlook

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## Abstract

**Purpose** – This paper aims to explore pathways in which adaptation challenges may occur. Focus is on the barriers to adaptation, challenges to adaptation and maladaptation with reference to smallholder farmers in the Southern African Development Community region.

**Design/methodology/approach** – Bibliometric analysis techniques were used to track the literature on smallholder farmers' adaptation challenges. Web of Science was the main data source. A total of 41 articles were retained for analysis and exported into Visualization of Similarities Viewer Software where the development of research on the subject, co-occurrence of keywords analysis, top publishers, citations and total link strength was done.

**Findings** – Results indicate that research on smallholder farmers' adaptation challenges is not new but has gained more consideration post-2020. The main adaptation challenges emanate from perception barriers and constraints based on determinants of adoption, limitations for resilience building and achieving sustainable adaptation as well as contestations around Climate Smart Agriculture technologies.

**Practical implications** – Effective design of adaptation policies should center on prioritizing the needs of the local people. This would reduce the occurrences of smallholder farmers' adaptation challenges, promote resilience building and contribute toward achieving sustainable adaptation.

**Originality/value** – It is equally important to document adaptation challenges. However, adaptation challenges are rarely shared with the same enthusiasm as its successes. This work focuses on the matter with the intention of conscientizing smallholder farmers to reduce the risk of repeating the same adaptation mistakes.

**Keywords** Adoption, Adaptation challenges, Barriers to adaptation, Dis-adoption, Maladaptation, Mis-implementation, Unintended adaptation outcomes

**Paper type** Literature review

## 1. Introduction

### *1.1 Background*

Smallholder farmers in the Southern African Development Community (SADC) region grapple with climate change impacts. The impacts coupled with the increase in population



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make it difficult to achieve food security (Mutengwa *et al.*, 2023). Although Mutengwa *et al.* (2023) referred to global food security, this is true at a regional scale, particularly in SADC where the majority of member states rely on agriculture to sustain livelihoods. The SADC Regional Indicative Strategic Development Plan for 2020–2030 noted that almost 70% of the population in the region relies on agriculture as a source of food (SADC, 2020). However, climate change has caused dire implications for agricultural production and food security leading to diminished food availability, accessibility, utilization and stability around the world including sub-Saharan Africa (SSA) (El Bilali *et al.*, 2020) where the SADC region is located. Mavodyo (2023) showed that climate change, in particular, variations in precipitation worsens food insecurity by impeding food affordability while worsening malnutrition in the SADC region.

National governments, non-governmental organizations (NGOs), civil society and local institutions are putting initiatives in place to improve adaptive capacity and build resilience of smallholder farmers across the SADC region. National governments formulate policies intended to reinforce smallholder farmers' adaptation to climate change (Chesterman *et al.*, 2020) and create enabling environments that support the implementation of adaptation strategies (Ogunyiola *et al.*, 2022). This is facilitated by having political will and commitment, addressing institutional barriers and improving communication and coordination (Nemakonde and Van Niekerk, 2023). NGOs provide support for smallholder farmers through funding adaptation initiatives, providing resources for adaptation (Davies *et al.*, 2019) and training smallholder farmers on how to implement adaptation strategies (Morahanye, 2020). Civil society organizations assist in developing locally appropriate technological innovations well suited to smallholder farmers' needs (Waters-Bayer *et al.*, 2015) and provide inputs that assist smallholder farmers adapt to climate change (Tofu and Wolka, 2023). Local institutions such as extension services assist in creating awareness of climate change impacts through information dissemination while seeking to meet smallholder farmers' needs (Makate, 2020). These are important strides made to ensure that essential resources are provided for smallholder farmers to enable successful and sustainable adaptation.

### *1.2 Adaptation: an overview*

The term adaptation has several definitions because it is a complex and dynamic process. There is neither an agreed theoretical nor operational definition of the term adaptation (Berrang-Ford *et al.*, 2019). Chaudhury *et al.* (2016) define adaptation as actions designed to ease the negative consequences of climate change. Schipper (2020) explains adaptation as a process involving changes and choices that seek to protect individuals and societies from adverse effects of climate change, to allow them to function and attain well-being under changing climatic conditions. These definitions illustrate that adaptation revolves around adjustments made in response to some climatic stimuli. However, earlier work by Smit *et al.* (2000) provides an anatomy of adaptation to climate change and variability and posits that a complete definition of the term adaptation should specify, what is being adapted to, who or what is adapting and how adaptation occurs. Further to this, Smit *et al.* (2000) emphasize that the definition of adaptation should characterize adaptation in terms of timing relative to stimulus (anticipatory, proactive or *ex ante*), intent (autonomous, spontaneous, automatic, natural or passive), spatial scope (localized or widespread), form (technological, structural, legal, institutional, regulatory or financial) and degree of necessity (retreat, accommodate, protect, prevent, tolerate or restore).

The nature and/or type of adaptation determines whether adaptation initiatives can succeed or fail. For example, top-down approaches that do not consider the local

perspectives and contexts often fail as observed by Narayan (2020). This is because adaptation efforts need to be locally led and blended well with local realities. Similarly, chances of failure are prevalent with adaptation planning done under uncertainty using imperfect information (Schipper, 2020). For example, uncertainties regarding changes in climate over time, space and whether the responses will be effective, breed difficulties in planning and decision-making (Barnett, 2001; Atteridge and Remling, 2018). However, adaptation failures are rarely researched and shared with the same enthusiasm in comparison to adaptation successes (Westoby *et al.*, 2020). Nonetheless, adaptation failures are equally important to document to ensure that the risk of repeating the same mistakes is reduced (Piggott-McKellar *et al.*, 2019).

This review paper aims to shed light on the possible pathways in which adaptation initiatives may fail. Focus is on the barriers to adaptation, challenges to adaptation and maladaptation in the context of climate change adaptation (CCA) with special reference to smallholder farmers in the SADC region. Although, the terms barriers to adaptation, challenges to adaptation and maladaptation in the context of climate change are related and may be precursors of each other, in this review we considered them different and not interchangeable.

The Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC) defines barriers to adaptation as "factors that make it harder to plan and implement adaptation actions" (IPCC, 2014:1758). These factors not only restrict the ability to implement adaptation measures but also depresses adaptation efficiency leading to failure of the adaptation process (Wang *et al.*, 2020). O'Neill *et al.* (2014) define challenges to adaptation as societal or environmental conditions that make adaptation more difficult. Workalemahu and Dawid (2021:593) define adaptation challenges as "factors that make it harder to plan and implement adaptation actions." These challenges to adaptation can weigh heavily on individuals making efforts to adapt. The Sixth Assessment Report (AR6) of the IPCC associates high challenges to adaptation with failure to proactively adapt (IPCC, 2022). Maladaptation differs slightly and is defined as an action taken to avoid or reduce vulnerability to climate change that instead impacts adversely on, or increases the vulnerability of other systems, sectors or other social groups (Barnett and O'neill, 2010, p. 211). Schipper (2020, p. 411) endorses that "the most accepted definition of maladaptation is when an adaptation strategy aimed at a group of people actually makes them more vulnerable to climate change than they were before."

The IPCC (2022) has high confidence that maladaptive actions are increasing. In AR6, the term maladaptation features 448 times compared to barriers to adaptation and challenges to adaptation that only feature 31 and 7 times, respectively. This suggests that maladaptation is becoming an emerging theme in CCA issues. In this review paper, we consider all three issues significant among smallholder farmers in the SADC region, as they all considerably affect marginalized and vulnerable groups of people such as smallholder farmers. Barriers to adaptation impede adaptation and lower adoption rates (Lamichhane *et al.*, 2022). Challenges to adaptation breeds dis-adoption which is defined "as having implemented a technology but later abandon it" (Wendland and Sills, 2008, p. 41). Maladaptation yields unintended effects (Barnett and O'neill, 2010) and negative outcomes (Juhola *et al.*, 2016) that increase risk and vulnerability. As such, adaptation is likely to be affected and its sustainability compromised as well. Sustainable adaptation is considered as "a set of responses which form the overlap between poverty reduction measures on one hand, and vulnerability reduction measures

on the other" (Eriksen and O'brien, 2007, p. 341). In the review, the term adaptation challenges will be used to refer to all three terms.

## 2. Rationale for the focus on smallholder farmers in the Southern African Development Community region

The narrative above suggests that adaptation initiatives can be problematic. Therefore, it could be difficult for smallholder farmers in the SADC to effectively address the climate change challenge (Maliki and Pauline, 2022). This warrants reason for concern and could be why small-scale farmers are given much consideration under the current and future trends in agriculture under climate change (Gosling *et al.*, 2020). A deeper consideration of barriers to adaptation, challenges to adaptation and maladaptation that continually dampen adoption rates, increase dis-adoption and yield unintended outcomes among smallholder farmers across the SADC region is needed.

The emphasis on smallholder farmers is based on a number of facts. For instance, excluding South Africa, smallholder farmers constitute the majority in SADC member states (Mutengwa *et al.*, 2023). Smallholder farming is a climate-sensitive livelihood that is jeopardized by the climate crisis despite its minimal contribution toward its causes (IPCC, 2022). The vulnerability of smallholder farmers in the SADC is compounded by the reliance on rain-fed farming systems, poor infrastructure and inadequate farmer advisory services (Mutengwa *et al.*, 2023), poor soils and land degradation (Mapfumo *et al.*, 2014), poverty and inequality (Murray *et al.*, 2016), water scarcity (Mabhaudhi *et al.*, 2019) among other factors. The AR6 report has high confidence that the future risk of smallholder farmers is likely to be severe given the current exposure to climate change (IPCC, 2022). It is for these reasons that smallholder farmers' adaptation challenges should be prioritized to seek solutions that would transform rural livelihoods and the well-being of this marginalized group in the SADC.

Chingombe and Musarandega (2021) recommended that interventions to come up with solutions to the adaptation challenges facing smallholder farmers are pertinent to address climate change impacts. Therefore, the focus of this review is on the barriers to adaptation, challenges to adaptation and maladaptation that continually drawback adaptation efforts among smallholder farmers in the SADC. To achieve this aim, we sought to identify emerging trends from research on smallholder farmers' adaptation challenges. This was done by examining published articles focusing on the barriers to adaptation, challenges to adaptation and maladaptation in the context of CCA among smallholder farmers in the SADC region using bibliometric analysis. In the process, we sought to identify the common barriers to adaptation that lead to low uptake of adaptation strategies, analyze challenges to adaptation that breed dis-adoption of adaptation strategies and analyze maladaptation practices that yield unintended effects of adaptation. The intention is to inform appropriate actions and interventions directed toward assisting smallholder farmers to make informed adaptation decisions. It is envisaged that the results of the analysis will provide information on the reasons for low uptake, insights on how dis-adoption can be reduced and suggestions on how to limit negative unintended outcomes of adaptation. It is hoped that this would improve the appropriateness of adaptation methods and the uptake of these, enhancing successful and sustainable adaptation among smallholder farmers in the SADC.

## 3. Methodology

Bibliometric analysis and the Visualization of Similarities (VoS) Viewer package were used to provide a regional outlook on smallholder farmers' CCA challenges. Bibliometric analysis

quantifies bibliographic material, giving a general picture of a research field (Merigó and Yang 2017). It was considered worthwhile because it establishes research trends and forecasts future directions the research field is taking (Leong, 2021). In the past, researchers used systematic literature reviews to summarize and analyze literature on CCA. Recently, the use of bibliometric analysis techniques coupled with VoS Viewer is increasingly being considered. However, bibliometric analyses on CCA for smallholder farmers in the SADC region are scarce. Existing analyses focus at the global level and smallholder farmers are left out. For example, Nalau and Verrall (2021) mapped the evolution and current trends in CCA science using a combination of bibliometric analysis and visualization techniques focusing at the global level and smallholder farmers were just thrown into the mix. Similarly, Wang *et al.* (2018) used bibliometric analysis and VoS Viewer to clarify the current situation, hotspots and development trends on CCA. Still, the analysis is at a global level and smallholder farmers are not considered. This analysis intended to fill this gap by conducting a bibliometric analysis coupled with VoS Viewer to provide an outlook of smallholder farmers' CCA challenges with a special focus on the SADC region.

### *3.1 Data source and search terms*

Clarivate Analytics Web of Science Core Collection (www.webofscience.com/wos/woscc/basic-search) was the main data source considered for its reputation in contemporary research (Li *et al.*, 2018), credible evaluation processes that guarantee reliable information (Pranckutė, 2021).

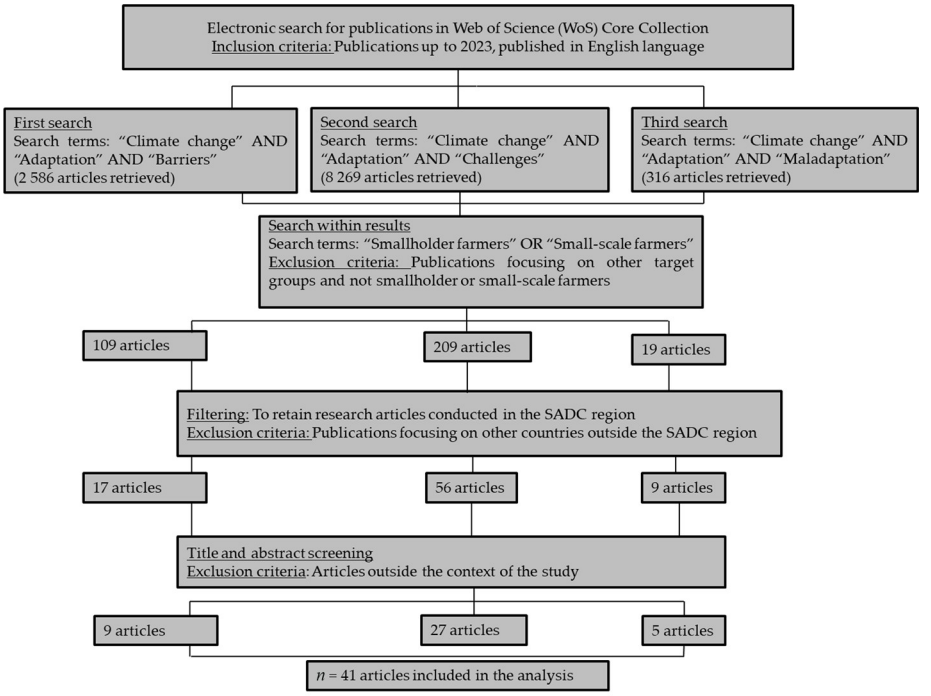
This review aimed to understand the barriers to adaptation, challenges to adaptation and maladaptation among smallholder farmers in the SADC. Articles published up to 2023 in English language were sought. Three keyword searches in Clarivate Web of Science were used. The first search used keywords "Climate change" and "Adaptation" and "Barriers". The search yielded 2 586 articles. A search within the results using "smallholder farmers" or "small-scale farmers" was conducted to retain research articles on this particular group and only 109 articles were retained. The results were filtered to retain research conducted in the 16 member states of the SADC region. Only 17 articles were retained. A title and abstract screening was conducted and articles that were outside the focus of the analysis (addressing other issues and not adaptation challenges) were removed. Only 9 articles were suitable for the analysis.

The second keyword search used the terms "Climate change" and "Adaptation" and "Challenges". The search yielded 8,269 articles. A search within the results using "smallholder farmers" or "small-scale farmers" yielded 225 articles. The results were then filtered to retain articles in the SADC region and only 56 articles were suitable for the analysis. A title and abstract screening yielded 27 articles as the rest were outside the focus of the analysis.

The third search used the terms "Climate change" and "Adaptation" and "Maladaptation," and this yielded 316 articles. A search within the results using "smallholder farmers" or "small-scale farmers" yielded only 19 articles. The results were filtered to retain articles for the SADC region only and 9 articles were suitable for analysis. A title and abstract screening retained only 5 articles. In total, 41 articles were suitable for the analysis. Figure 1 summarizes the search procedure.

### *3.2 Breakdown of literature sources included in the analysis*

Table 1 presents the breakdown of literature sources included in the bibliometric analysis. Full research papers constituted the bulk of the sources. Of the 16 member states in the SADC region, only six countries featured in research articles were retained for the analysis.




**Source:** Authors' analysis

**Figure 1.** Summary of the search procedure

**Table 1.** Summary of literature sources

| | | |
|---|---|---|
| Type | Full research | 37 |
| | Reviews | 4 |
| | Total | 41 |
| Location of studies in the SADC region | South Africa | 19 |
| | Zimbabwe | 8 |
| | Tanzania | 5 |
| | Malawi | 5 |
| | Botswana | 1 |
| | Zambia | 1 |
| | South Africa and Zimbabwe | 1 |
| | Sub-Saharan Africa | 1 |
| | Total | 41 |

**Source:** Authors' analysis

Most of the literature sources were from South Africa. One was for Zimbabwe and South Africa and one focused on the SSA constituting some countries in the SADC.

### *3.3 Analysis in Visualization of Similarities viewer*

Search results were exported as plain text for analysis in VoS Viewer. Analysis for the co-occurrence of keywords, development trends, top publishers, citations and total link strength was done (Table 2). To establish the co-occurrence of keywords, minimum number of occurrences was set at 5 and the analysis was based on label and node sizes as well as distances between nodes. The larger the label and node size, the higher the co-occurrence of a keyword. The higher the numerical value of the link strength, the stronger the link. Results were presented using network visualizations of clustered keywords. A common theme was deduced for each cluster of keywords. From each cluster, most recent articles were selected to obtain an overview of the theme. To track the development of literature on smallholder farmers' adaptation challenges, number of articles published per year was tracked. Top publishing institutions were established using number of publications, number of citations and total link strength.

## 4. Results and discussion

Results of the analysis are presented in this section. The three themes, barriers to adaptation, challenges to adaptation and maladaptation will be discussed under one umbrella term, adaptation challenges unless stated otherwise.

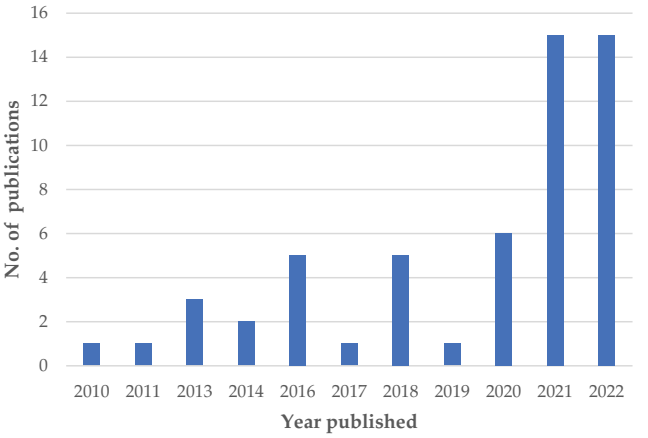
### *4.1 Development of research on smallholder farmers' adaptation challenges in the Southern African Development Community*

Figure 2 shows the development of research on smallholder farmers' adaptation challenges in the SADC between 2010 and 2022. Up to 2019, research was limited, inconsistent and highly fluctuating. An increase in research is noted from 2020 to 2021 and remained constant in 2022. Findings corroborate with the trend observed in existing literature which also shows limited research on factors that hinder adaptation in developing countries (Shackleton *et al.*, 2015) and a lack of detailed analyses of barriers encountered in achieving successful community-based adaptation (Piggott-McKellar *et al.*, 2019). The sudden increase in research from 2020 could be because research on the subject had become a "recent vintage"

**Table 2.** Terms used in bibliometric analysis

| Term | Description |
|---|---|
| Items | Objects of interest |
| Link | Connection or relation between two items |
| Link strength | Attribute of a link represented by a positive numerical value. The higher the value, the stronger the link |
| Network | Set of items and links between the items |
| Cluster | Set of items included in a map. An item can belong to only one cluster |
| Weight attribute: Number of links | Indicates the number of links of an item with other items |
| Weight attribute: Total link strength | The cumulative strength of the links of an item with other items |

**Sources:** Pauna *et al.*, 2019




**Source:** Authors' analysis

**Figure 2.** Development of research on smallholder farmers' adaptation challenges in the SADC

as observed by Lee *et al.* (2022:3). This illustrates that while research on the subject is not new, it is simply now being valued and given more consideration than before.

### *4.2 Institutions publishing research on smallholder farmers' adaptation challenges in the Southern African Development Community*

Co-authorship between institutions publishing research on smallholder farmers' adaptation challenges in the SADC is shown in Table 3. Ten institutions met the threshold with a minimum of 5 documents. South African universities dominated. University of KwaZulu Natal has the highest number of publications and highest total link strength (10). In terms of citations, University of Pretoria is soaring with more than 600 citations despite having less

**Table 3.** Institutions publishing research on smallholder farmers' adaptation challenges in the SADC

| Institution | No. of documents | Citations | Total link strength |
|---|---|---|---|
| University of KwaZulu Natal | 14 | 189 | 10 |
| Wageningen University | 6 | 212 | 7 |
| University of Pretoria | 7 | 658 | 6 |
| University of Cape Town | 9 | 144 | 5 |
| University of Witwatersrand | 5 | 32 | 5 |
| University of Limpopo | 7 | 39 | 4 |
| Midlands State University | 4 | 3 | 3 |
| Agricultural Research Council | 4 | 25 | 2 |
| University of Venda | 5 | 40 | 2 |
| International Maize and Wheat Improvement Center | 4 | 195 | 1 |
| University of Free State | 6 | 96 | 1 |
| University of Fort Hare | 5 | 69 | 0 |

**Source:** Authors' analysis

number of documents. Wageningen University, an international institution in The Netherlands, comes second in terms of number of citations (212), with total link strength of 7. University of Free State, University of Venda and University of Fort Hare, while producing research on the subject, they have fewer publications and low total link strength. This could be because these are rural-based universities and are ranked in the lower category in terms of research performance both nationally and globally. Their relatively low research performance is also reflected in research on smallholder farmers' adaptation challenges in the SADC.

### *4.3 Co-occurrence of keywords of research on smallholder farmers' adaptation challenges in the Southern African Development Community*

Only 42 out of 552 keywords met the threshold with minimum number of occurrences of 5. The top five most occurring keywords are adaptation, climate change, variability, food security and vulnerability (Table 4). The size of the nodes and labels of these keywords are relatively larger compared to others (see Figure 3). The analysis also yielded three different (blue, green and red) clusters. Cluster themes were deduced based on keywords in each cluster. The clusters are described in the following section.

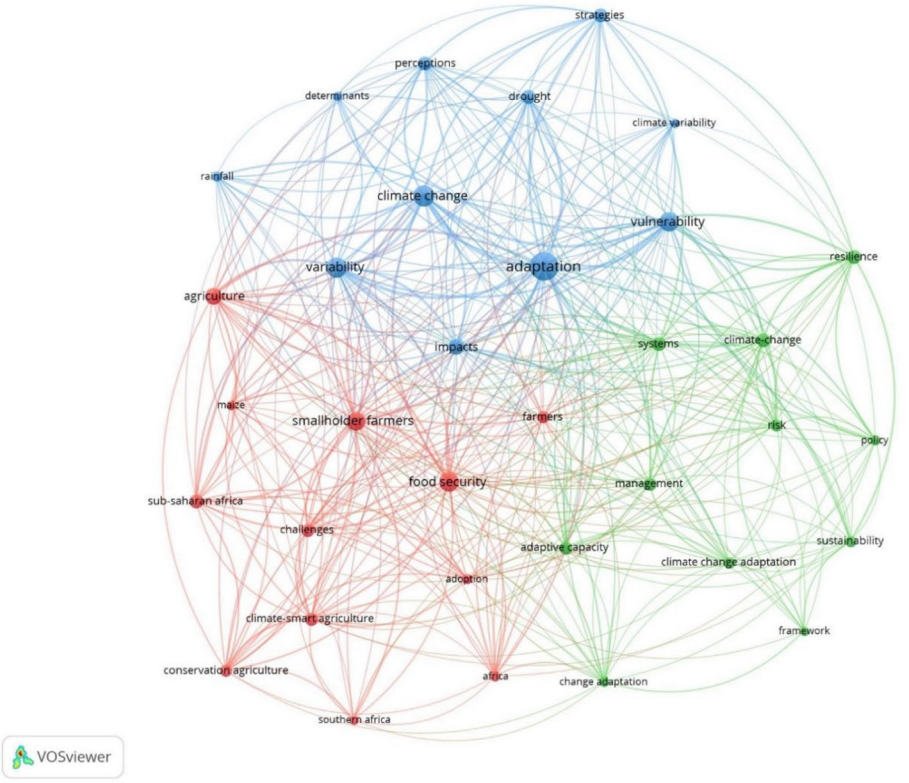
Table 5 describes the resultant clusters, the occurrence of keywords, the total link strength and selected publications that depict the cluster theme.

*4.3.1 Blue cluster: perception barriers and constraints based on determinants of adoption.* The blue cluster grouped keywords such as vulnerability, impacts, perceptions and determinants. Out of the four selected keywords, vulnerability had the most occurrences (21) and total link strength (132) within the blue cluster. The thematic focus for the blue cluster centers around adaptation challenges that increase vulnerability of smallholder farmers emanating from farmers' perceptions of climate change and associated impacts as well as constraints based on determinants of adoption. Farmers' perceptions of changes in climatic conditions are the first step in adaptation decision-making as these are crucial in designing policies that enhance adaptive capacity. A significant body of literature on smallholder farmers' perceptions of the changes in climate across the SADC exists. At least 20% of the articles reviewed in this paper mentioned the keyword perceptions in their titles, abstracts and list of keywords.

**Table 4.** Most occurring keywords in smallholder farmers' adaptation challenges research in the SADC

| Keyword | Occurrence | Total link strength |
|---|---|---|
| Adaptation | 54 | 281 |
| Climate change | 28 | 159 |
| Variability | 25 | 149 |
| Vulnerability | 21 | 132 |
| Agriculture | 24 | 122 |
| Smallholder farmers | 22 | 115 |
| Food security | 21 | 100 |
| Impacts | 14 | 85 |
| Drought | 12 | 81 |
| Perceptions | 14 | 80 |

**Source:** Authors' analysis




**Source:** Authors' analysis

**Figure 3.** Network visualization of co-occurrence of keywords on smallholder farmers' adaptation challenges in the SADC region

One of the main observations made in articles that mentioned the keyword perceptions is that attempts to validate farmers' perceptions with actual climate data are scarce (Olabanji *et al.*, 2021), yet perceptions may differ significantly from reality (Popoola *et al.*, 2018). For example, Chisale *et al.* (2022) found that forest-dependent communities in Malawi perceived increased erratic rainfall, high temperatures, strong winds and changes in seasons; however, these perceptions were not matched with the actual changes based on climatological data of the area. This could be the reason for poor adaptation planning in the SADC because decisions are based on inaccurate information that may be incompatible with the actual changes in climate. As such, accurate and appropriate climatic data and information are vital for adaptation.

Drawing upon the Protection Motivation Theory (Rogers, 1975), the perceived threat and risk of climate change is assumed to stimulate adaptation behavior so that farmers can protect their livelihoods from climate change impacts (Ghanian *et al.*, 2020). However, in some cases, farmers are subjected to inaction where they are reluctant to do anything even if the perceived threats and risks are high. This is highly prevalent among smallholder farmers in the SADC. For example, from the sample of articles included in the analysis,

**Table 5.** Cluster identification

| Color recognition | Selected keywords | Occurrences | Total link strength | Cluster theme | Selected publications |
|---|---|---|---|---|---|
| Blue | Vulnerability | 21 | 132 | Perception barriers and constraints based on determinants of adoption | Akanbi *et al.* (2021); Henriksson *et al.* (2021); Ebhuoma (2022); Kerr *et al.* (2018); Halimani *et al.* (2021); Olabanji *et al.* (2021); Chisale *et al.* (2022); Popoola *et al.* (2020) |
| | Impacts | 14 | 85 | | |
| | Perceptions | 14 | 80 | | |
| | Determinants | 7 | 44 | | |
| Green | Management | 13 | 72 | Limitations for resilience building and achieving sustainability | Chingombe and Musarandega (2021); Mugari *et al.* (2020) Chisale *et al.* (2022); Rubekie *et al.* (2021); Kephe *et al.* (2022) |
| | Resilience | 11 | 63 | | |
| | Sustainability | 8 | 37 | | |
| | Policy | 6 | 35 | | |
| Red | Adoption | 13 | 74 | Contestations around CSA technologies | Gaworek-Michalczenia *et al.* (2022); Senyolo *et al.* (2021); Umar (2021); Nchanji *et al.* (2022); Hermans *et al.* (2021) |
| | Challenges | 13 | 70 | | |
| | Conservation agriculture | 8 | 49 | | |
| | Climate-smart agriculture | 8 | 48 | | |

**Source:** Authors' analysis

Akanbi *et al.* (2021), Olabanji *et al.* (2021) discovered that some farmers in the Vaal and Olifants catchment areas in South Africa, perceived decreasing annual precipitation and increasing temperatures, respectively, but did not respond. This results in maladaptation defined as inactions or actions that increase the risk of adverse climate-related outcomes, increase vulnerability to climate change or diminish welfare, now or in the future (Work *et al.*, 2019). Climate change risk is likely to increase if farmers choose to do nothing to reduce its impacts.

Farmers' perceptions are influenced by a set of determinants such as individual characteristics, access to information, cultural and geographical background (Fierros-González and Lopez-Feldman, 2021; Halimani *et al.*, 2021), among other factors. These determinants can encourage or discourage the adoption of adaptation measures. This is prevalent among smallholder farmers in the SADC. For example, Olabanji *et al.* (2021), included in the analysis, showed that farmers' level of income constrained adoption of irrigation because of high investment costs in the Olifants catchment area in South Africa. Ebhuoma (2022), also part of the sample for this analysis, indicated that high levels of illiteracy and lack of resources limited the adoption of Seasonal Climate Forecasts (SCFs) in South Africa and Zimbabwe. High levels of illiteracy undermined effective communication as the channels used to communicate the SCFs to smallholder farmers such as radios, televisions, mobile phones and the internet mostly use English language. Therefore, smallholder farmers grappled with language barrier. Furthermore, farmers had difficulties in understanding the probabilistic nature of the SCFs, and this impeded its adoption in both countries. Some farmers, especially in Zimbabwe, were resource-constrained and could not own the assets normally used in communicating SCFs. Apart from that, the inconsistent power supply in both countries undermined effective communication of SCFs.

Gender emerges as an important determinant in encouraging or discouraging adaptation among smallholder farmers. Existing interventions lack in accommodating the needs of women especially in the SADC. Henriksson *et al.* (2021) provided a gender assessment of the availability, accessibility and use of climate information among smallholder sugarcane farmers in southern Malawi. Findings showed that access and preference regarding climate information were gendered. Men preferred modern and advanced sources such as newspapers, WhatsApp, SMSs or the internet while women preferred extension agents, community leaders, NGOs who would assist them in understanding the climate forecasts. Kerr *et al.* (2018) used a political ecology approach to track smallholder farmers' knowledge dynamics in a changing climate in Mzimba and Kasungu Districts in Malawi. Findings of the study showed that knowledge of CCA was shaped by gender and other social inequalities. Women rely more on informal networks such as friends, relatives and other farmers than men. It was also shown that gender inequality bred grounds for social inequalities paving the way for contradicting ideas about CCA making it difficult for farmers to know how to act even when perceiving climate changes.

Availability of and accessibility to relevant and practical climate change information is one of the main determinants that influence adaptation among smallholder farmers. Popoola *et al.* (2020) found that public extension services do not play a major role in providing climate change information to smallholder farmers in Amathole District, Eastern Cape, South Africa. Farmers in the area do not have access to agricultural extension services and rely on other sources for climate change information. Despite the importance of other sources, Popoola *et al.* (2020) emphasized that the relevance of direct extension services should not be overlooked because of their potential to provide interpersonal communication, a significant driver of adoption. Table 6 shows selected studies, major results, insights and reflections depicting the theme.

*4.3.2 Green cluster: limitations for building resilience and achieving sustainability.* Keywords management, sustainability, resilience, policy and are grouped under the green cluster. Management had the most occurrences (13) and total link strength (72) within the green cluster. More than 50% of the articles mentioned one of the four selected keywords in the green cluster in the title, abstract and keywords list. The cluster reflects adaptation challenges associated with the management of strategies aimed at building resilience and achieving sustainable adaptation. Resilience is "the ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning" (IPCC AR4, 2007). Building resilience and achieving sustainability are two of the desired goals of adaptation and this is important for smallholder farmers in the SADC because they are highly vulnerable to climate change.

The SADC region is seemingly falling short of achieving the objective of building resilience and achieving sustainable adaptation. Mugari *et al.* (2020) established the responses to different impacts of climate change in key provisioning Ecosystem Services in Bobirwa sub-District of Botswana. Despite the frequent droughts experienced in the area, destocking was unpopular, grazing was uncontrolled and livestock ownership was not limited threatening the sustainability of natural pastures. This is common in other SADC countries where cattle are used as draft power, considered a main source of income and are a sign of wealth.

Mwadzingeni *et al.* (2021) showed that undermining the role of social networks in adaptation to climate change threatens resilience building. The authors used the Livelihood Vulnerability Index and the Livelihood Vulnerability Index of the IPCC to compare vulnerability to climate change in three irrigation schemes, Exchange, Insukamini and Ruchanyu in the Midlands Province, Zimbabwe. Insukamini community had limited horizontal and vertical linkages in relation to social networks because of the low engagement

**Table 6.** Major results, reflections and insights on perception barriers and constraints based on determinants of adoption

| Source | Location in SADC | Major results, reflections and insights |
|---|---|---|
| Akanbi *et al.* (2021) | South Africa | Some farmers perceived changes in climate but did not respond demonstrating inaction a maladaptive behaviour |
| Henriksson *et al.* (2021) | Malawi | Access and preferences regarding climate information use were gendered |
| Ebhuoma (2022) | South Africa and Zimbabwe | Failure to comprehensively understand and interpret probabilistic forecasts due to high levels of illiteracy undermines the use of Seasonal Climate Forecasts (SCFs) |
| Kerr *et al.* (2018) | Malawi | Gender inequality breeds social inequalities that make it difficult for farmers to know how to act despite having perceived climate changes |
| Popoola *et al.* (2020) | South Africa | The relevance of direct extension services should not be overlooked because it provides interpersonal communication which is a significant driver of adoption |

**Source:** Authors' analysis

of farmers with government institutions and NGOs which significantly increased vulnerability threatening resilience building. Bahta (2021) explored the role of social networks and government in enhancing drought resilience in the Northern Cape Province of South Africa. A negative average perception index was deduced showing that it was insufficient and this threatened resilience building among smallholder livestock farmers in the area.

Resilience building is also limited among female farmers in farming communities in SADC region because of the gendered nature of adaptation interventions. Halimani *et al.* (2021) provided a gender lens and showed that resilience building among female smallholder sheep farmers in the dry eco-zones of Northern Cape, Western Cape and Eastern Cape Provinces is affected by low levels of education, rudimentary production systems and flair toward non-adapted breeds.

Resilience building in SSA is largely constrained by small farm sizes (Descheemaeker *et al.*, 2016). Fragmented and small farm sizes are considered an important limitation in improving smallholder farmers' resilience to climate change as they discourage investments in improved technologies. This challenge is expected to continue constraining smallholder farmers in the SADC region where population growth is rising at an increasing rate which means farm sizes could be fragmented and decreased even further.

The future sustainability of forest resources in communities that depend on them is highly compromised. Chisale *et al.* (2022) showed that the sustainability of forest resources for Phirilongwe and Mchinji forest reserves in Malawi is blurred. Low levels of knowledge, climate skepticisms and cultural and spiritual beliefs around the causes of climate change are some of the main challenges in mobilizing farmers toward adopting forest management practices that would preserve sustainability for future generations. This is compounded by uncontrolled harvesting of forest resources and unsustainable farming practices in the study areas.

Climate change exacerbates production costs and this impacts the profitability and sustainability of farming operations. Frameworks that assist farmers in making CCA decisions are scarce. Kephe *et al.* (2022) noted that tools to assist smallholder farmers when choosing the best crop combinations are limited in Limpopo and Free State Provinces of South Africa. This is true for measures such as crop rotation and intercropping. The sustainability of adaptation could be limited if wrong crop combinations are adopted. Cotter *et al.* (2020) raised the concern that decision support tools such as the RiceAdvice App are often tailor-made to certain environments such that when applied to other environments compatibility challenges arise. This limits wider goals for resilience building and it diminishes the sustainability of adaptation. This can be attributed to the slow pace of technology transfer in the SADC region.

Neglecting alternative crops such as sorghum narrows prospects of developing sustainable and resilient food systems in the SADC. Dunjana *et al.* (2022) examined some biophysical, socio-economic, socio-cultural and institutional barriers limiting the production of sorghum among smallholder farmers in South Africa. Poor soil fertility and weed infestation limit sorghum production in South Africa. This was attributed to the apartheid history of black South Africans which settled them in marginal areas with small land holdings that are continually fragmented. Limited access to improved seeds also constrains the production of sorghum in South Africa. The use of grain from previous harvests as seed is common however, it loses quality during storage and with seasons. The high prevalence of the *Quelea* birds in South Africa poses a challenge for sorghum production as the birds can destroy up to 4 tonnes of grain per day. The negative perception toward sorghum commonly referred to as the "poor man's crop" discourages production in SSA where the SADC is located (Hadebe *et al.*, 2017).

The intricate nature of adaptation barriers threatens resilience building and limits the achievement of sustainability goals. Chingombe and Musarandega (2021) highlighted that disregarding the causal interdependences of adaptation barriers yields ineffective adaptation intervention policies. If the intricate sub-challenges linked to the more visible ones are not realized, adaptation efforts will be drawn back. The same authors provided an example of how adaptation barriers are interlinked among smallholder farmers in Chimanimani District Zimbabwe. The lack of capital forced farmers to adopt cheaper options like cutting down trees to fence fields. This led to deforestation, breeding more ecological challenges and the cycle continued. This intricate connection of adaptation challenges threatens the sustainability of ecosystems and draws back resilience building.

The sustainability and resilience of coastal and marine resources are also threatened by human responses to climate change. Rubekie *et al.* (2022) provide an analysis of the threat of adaptation over coastal and marine resources and provide evidence of ineffective resource conservation and management in Bagamoyo district, a coastal area in Dar-es-Salaam, Tanzania where there was a shift in livelihoods from agriculture to marine and coastal ecosystems due to climate change. Some strategies adopted exerted pressure on marine and coastal resources. For example, farmers adopted livelihood diversification into charcoal making, increasing mangrove forest cutting. Fishermen lengthened fishing gears to access deeper waters, increased fishing frequency, used disapproved fishing gears and practices leading to overfishing. This compromised the sustainability of the coastal and marine ecosystems. Table 7 shows selected studies, major results, insights and reflections depicting the theme.

*4.3.3 Red cluster: contestations around climate-smart agriculture technologies.* The red cluster grouped keywords such as Conservation Agriculture (CA), Climate-smart Agriculture (CSA), adoption and challenges. The keywords deduced a thematic focus

**Table 7.** Major results, insights and reflections on limitations for resilience building and achievement of sustainability

| Source | Location in SADC | Major results, insights and reflections |
|---|---|---|
| Chingombe and Musarandega (2021) | Zimbabwe | The intricate nature of adaptation barriers threatens resilience building and limit the achievement of sustainability goals |
| Mugari *et al.* (2020) | Botswana | Measures that preserve and encourage ecosystem balance like destocking are unpopular in smallholder farming communities. Unlimited livestock ownership and uncontrolled grazing threatens the sustainability of natural pastures |
| Chisale *et al.* (2022) | Malawi | The sustainability of forest resources is compromised by low levels of knowledge, climate skepticism and belief in the cultural and spiritual causes of climate change among farmers that limit the adoption of forest management practices |
| Rubekie *et al.* (2022) | Tanzania | The shift of livelihood from agriculture to marine resources dependence with ineffective resource conservation and management led to degradation |
| Cotter *et al.* (2020) | Madagascar | Incompatibility of agricultural decision support tools to new environments limits resilience building |

**Source:** Authors' analysis

centered on the controversies surrounding CSA practices that limit adoption. CSA practices are an integrated approach aimed at managing crops, livestock to address food security and climate change challenges (World Bank Group, 2021). CSA technologies are introduced to smallholder farmers as adaptation interventions by humanitarian organizations and national governments, nonetheless, the primary needs of the communities are overlooked. This creates unintended outcomes that are maladaptive. Gaworek-Michalczenia *et al.* (2022) illustrated this scenario by evaluating the impacts on participating and non-participating households of the Global Climate Change Alliance (GCCA) project in East Usambara Mountains, Tanga Region, Tanzania. The GCCA project is a European Union initiative implemented to reduce households' vulnerability and improve livelihood resilience through encouraging the uptake of CSA technologies. Unintended consequences and maladaptation existed for both participating and non-participating households. The project led to the introduction of some by-laws that prohibited the growing of yam near water courses. This disproportionately affected non-participating households with no alternative solution to provide food for their families. Non-participating households struggled to access extension services as the district staff were more focused on the project activities. For participating households, the overall goal of improving agricultural incomes was not realized. This was because of poor uptake of CSA technologies, especially soil conservation technologies, long maturing periods of cash crops like sugarcane, coffee and tea and poor performance of drought-resistant seeds.

Senyolo *et al.* (2021) explained challenges regarding the role of public–private partnerships in enhancing the adoption and diffusion of climate-smart technologies by South African smallholder farmers using the Water Efficient Maize for Africa (WEMA) case. The overall goal of WEMA was affected by disputed outcomes over the release process, stakeholder concerns on export implications and whether to release the double- or triple-stacked seed as the former was deemed inferior to the later, shortage of seed which hampered technology transfer and the high level of expertise required.

The lack of national Climate Smart Agriculture Investment Plans is one of the factors that drawback adoption and diffusion of CSA technologies in Africa (Barasa *et al.*, 2021), especially in the SADC. In a scientific mapping and analysis of CSA research in Africa conducted by Barasa *et al.* (2021), it was found that South Africa and Zimbabwe were the only SADC countries among the top ten leading countries in CSA research publications. The rest of the SADC countries were missing possibly because of a lack of investment plans and gaps in policies that promote the adoption and diffusion of CSA technologies.

Gender inequality is a persistent challenge constraining the adoption of CSA practices. Nchanji *et al.* (2022) provided a gender lens on the adoption of CSA practices among bean farmers in Linthipe Extension Planning Area in Dedza District in Malawi. There were differences in terms of adaptation and use of CSA practices among men, women and youth with women more inclined to the use of simple, non-technical measures such as fertilizer use, improved seeds and early planting compared to men who used more technical measures like irrigation while youths used scientific measures such as the use of pesticides and CA This was attributed to lack of gender-responsive CSA technologies as most technologies are designed with men as the farmer in mind sidelining women. Furthermore, land ownership and access in most SADC countries is limited for women farmers while men have greater access, as such, women live with a pre-existing disadvantage because they do not have land rights.

Umar (2021) conducted a gendered analysis of CA in selected districts of Eastern Zambia. The study established that CA could serve as a CSA option for both men and women. However, it is pertinent to consider gender differences in CA challenges such as high weed pressure, high labor requirements, difficulties in accessing manure, lack of fertilizers, unavailability of hoes among other challenges. Both men and women did not appreciate the value of the challenges faced by the opposite gender class. This demonstrates that gender-neutral and gender-responsive interventions are missing in the CCA discourse which also exacerbates smallholder farmers' adaptation challenges.

The assumption that technology transfer is always linear poses challenges to the adoption of CSA practices. Hermans *et al.* (2021) posited that the framework does not incorporate the dynamic decision-making processes that farmers undergo in adopting CSA practices. Focusing on two Malawian communities, Mwansambo and Lemu, the concept of adoption was used to reconsider how decision-making takes place after the introduction of CA. It was found that the model of technology transfer and adoption is not always linear and effective. However, the level of trust between the farmer and the source of information, acceptability of CA practices, group dynamics, common beliefs and experience are important in influencing farmers' decisions and CA diffusion and adoption. Table 8 shows selected research studies, major results, insights and reflections depicting the theme.

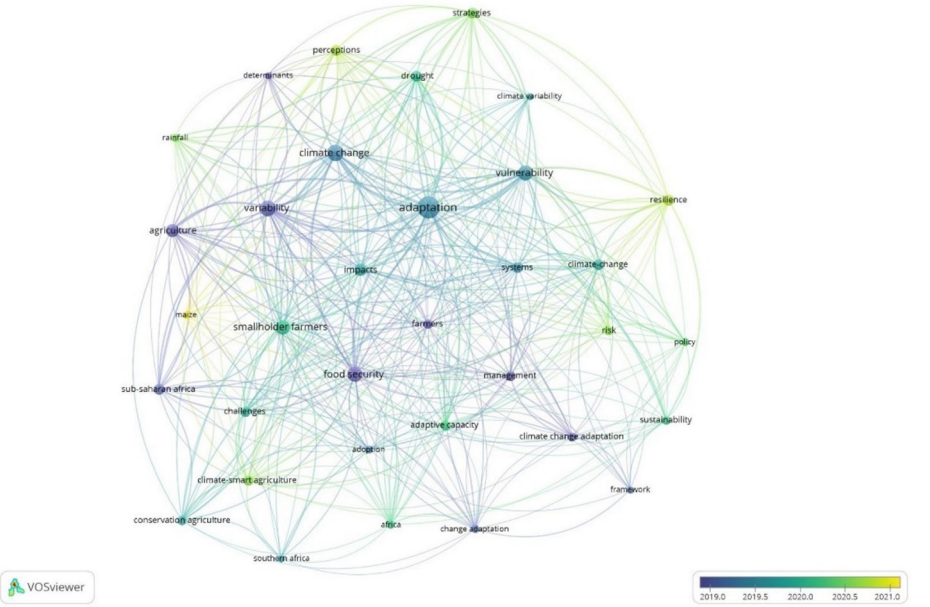
### *4.4 Current and emerging trends in research on smallholder farmers' adaptation challenges*

Figure 4 shows an overlay visualization of the past, current and future trends in research on smallholder farmers' adaptation challenges in the SADC region. Previous research, prior to and during 2019 focused on adaptation challenges smallholder farmers faced in achieving food security. This is shown by keywords such as adaptation, CCA, farmers, food security, vulnerability and agriculture grouped in the turquoise blue and blue clusters. Studies by Quinn *et al.* (2011), Mkonda and He (2018), Kerr *et al.* (2018) support this claim. Quinn *et al.* (2011) were concerned about the narrow considerations given to CCA in rural South Africa where it was viewed in isolation leaving out the social, economic and political conditions that also shape vulnerability. Kerr *et al.* (2018) raised concern in Malawi over the

**Table 8.** Major results, reflections and insights on contestations around CSA technologies

| Source | Location in SADC | Major results, insights and reflections |
|---|---|---|
| Gaworek-Michalczenia *et al*. (2022) | Tanzania | Overlooking primary needs of end-users of the CSA technologies yield unintended consequences and maladaptive outcomes |
| Senyolo *et al*. (2021) | South Africa | Public-private partnerships affect the adoption and diffusion of CSA technologies among smallholder farmers |
| Umar (2021) | Zambia | Both men and women do not appreciate the value of the challenges faced by the opposite gender class demonstrating the absence of gender-neutral and gender-responsive interventions in the climate change adaptation discourse |
| Hermans *et al*. (2021) | Malawi | Assuming that technology transfer is always linear poses challenges in the adoption of CSA practices |

**Source:** Authors' analysis




**Source:** Authors' analysis

**Figure 4.** Overlay visualization of past, current and future trends on research on smallholder farmers' adaptation challenges in the SADC

gendered nature of agricultural science and the state of the agricultural system that limited women's exposure to agro-ecological measures that would improve their food security status. Mkonda and He (2018) suggest that substituting maize with small grains such as sorghum and finger millet as an alternative strategy for improving household food security may not be the best adaptation option in Tanzania. Maize was found to be the most vulnerable to climate change and over-reliance on maize could pose significant implications for household food security.

Toward 2020, there was flair toward research on challenges that limit smallholder farmers' adaptive capacity building and enhancing sustainability as well as challenges in formulating locally appropriate adaptation policies. This is shown by keywords such as adaptive capacity, sustainability and policy grouped in the green cluster. Kephe *et al.* (2020) raised several issues with regard to certain types of institutional support limiting the adaptive capacity of smallholder farmers in Limpopo, South Africa. One challenge cited was inadequate support from public institutions such as extension services due to the high officer-to-farmer ratios and the non-existence of policies that regulate the way extension and advisory services take place.

Current and future trends point toward research on challenges in reducing risk and improving resilience of smallholder farmers. This is shown by keywords risk, resilience, perceptions and maize. The target is toward understanding smallholder farmers' perception barriers, challenges in enhancing adoption of CSA practices possibly in the maize farming systems since it is the main staple food in the SADC. Chisale *et al.* (2022) suggest that there could be challenges in convincing climate skeptics in forest-dependent communities of Malawi to participate in CCA practices. Nyoni *et al.* (2022) using a case of rural poultry farmers in Limpopo, suggested that perceptions vary over time and in making adaptation decisions, challenges may arise which may lead to changes in production decisions and unexpected alteration of the initial plan.

## 5. Policy implications

The analysis provides important insights regarding the existing CCA policy framework of the SADC region. Findings unearthed dimensions useful for improvements in policy development. Failure to validate farmers' climate change perceptions with actual climate data result in poor adaptation planning based on inaccurate information. This slows down progress in CCA efforts among smallholder farmers. This is in line with discoveries made at the Conference of Parties 28 (COP 28) that progress is slow across all areas of climate action including strengthening resilience of smallholder farmers. As such, validation of farmers' perceptions of climate changes with meteorological data is pertinent to ensure proper and effective design of adaptation policies.

Gender emerged across the three themes as one of the main factors that determine the uptake of adaptation strategies. This illustrates a gap in existing adaptation policies that disadvantage female farmers. These gaps should be addressed to ensure that socio-economic inequalities between men and women farmers are reduced. Ultimately, adaptation policies should be responsive to the needs of female farmers so that they are at par with their male counterparts.

One of the factors driving smallholder farmers' adaptation challenges is a lack of knowledge, information and awareness. Although programs aimed at information dissemination and raising awareness exist, they are ineffective. The needs of the local people should be incorporated during program development to improve attendance and participation so that the information reaches the targeted audience.

Research on smallholder farmers' adaptation challenges is considered a "recent vintage". This trend should be maintained or possibly grown further so that up-to-date empirical results can inform adaptation policy decisions and enhance efforts to strengthen resilience. This could also contribute to one of the aims of the GGA, to guide adaptation planning and strategies at all levels. As such, empirical research results are crucial to achieve this aim.

## 6. Limitations of the study

Although the focus on the SADC region was important to fill the scope gap, the narrow focus yielded a relatively small sample of studies. Moreover, SADC region countries are generally on the same level of economic development. We recommend further analysis with a broadened scope that spans across Africa to incorporate countries at different stages of economic development. It is envisaged that this would yield more and varied literature sources and provide robust findings.

## 7. Conclusions and recommendations

Essential resources have been provided for smallholder farmers to enable successful adaptation. However, the nature and/or type of adaptation initiatives determine whether adaptation initiatives can succeed or fail. Literature on adaptation successes is broad in scope and depth. Nonetheless, adaptation failures are rarely shared in comparison to adaptation successes, yet they are equally important. This paper aimed to shed light on the possible pathways in which adaptation initiatives may fail. Focus was on the barriers to adaptation, challenges to adaptation and maladaptation in the context of CCA on smallholder farmers in the SADC.

Smallholder farmers' adaptation challenges are many and varied. Barriers come in the form of incorrect perceptions of climate change that are not validated with actual meteorological findings. Barriers also come in the form of undesirable determinants of adoption including social, cultural and geographical background. Challenges come in the form of political and religious factors. Political, historical and colonial histories have resulted in fragmented and small farm sizes. Religious factors such as beliefs in cultural and spiritual causes of climate change have caused climate skepticisms that sometimes discourage adoption of adaptation measures. Maladaptation is represented as a form of imposed adaptation initiatives that disregard the needs of the smallholder farmers which often leads to dis-adoption.

Validation of farmers' perceptions of climate changes with meteorological data is recommended to ensure the proper and effective design of adaptation policies. Formulation of gender-responsive policies that put women farmers at par with their male counterparts while reducing socio-economic inequalities is recommended. Programs aimed at raising awareness among smallholder farmers are recommended to avoid inaction that leads to maladaptation when perceived threats and risks of climate change are high. Improvements geared toward knowledge, information and technology transfer are also recommended. Alternative strategies such as the role of social networks to enhance resilience building and achieve sustainability goals should be embraced. The needs of the local people should not be neglected to reduce occurrences of dis-adoption and unintended outcomes, especially on CSA technologies. Further research is needed to establish the link between farmers' perceptions and determinants of adoption and to explore the possible pathways that may discourage adaptation among smallholder farmers.

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