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Factors Undermining the Use of Seasonal Climate Forecasts Among Farmers in South Africa and Zimbabwe: Implications for the 1st and 2nd Sustainable Development Goals

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The adverse effects of climate change on food production coupled with growing inconsistencies in Indigenous knowledge systems have necessitated some farmers' willingness to rely on seasonal climate forecasts (SCFs) to make informed farming decisions. SCFs provide information regarding the likelihood that the rainfall in the forthcoming season will be higher, lower or normal. While SCFs have scaled up food production among some rural households in Sub-Saharan Africa (SSA), some farmers find it difficult to plug into this vital technology. Failure to utilize SCFs could have severe consequences for household food and nutrition security, especially in semi-arid countries like South Africa and Zimbabwe. By systematically unpacking the literature in South Africa and Zimbabwe from 2011 to 2021, this article seeks to demystify the factors that hamper the use of SCFs in the aforementioned countries. Results indicate that failure to comprehensively understand and interpret probabilistic forecasts as well as ill-timing of forecast dissemination, among others, are factors that undermine the use of SCFs. These issues are discussed both within the broader theoretical debates revolving around ways to dismantle the barriers undermining the use of SCFs in SSA, which could hamper the attainment of both the first and second sustainable development goals.

Keywords: climate services, seasonal climate forecasts, sustainable development goals, Sub-Saharan Africa, smallholder farmers

INTRODUCTION

Although climate change has negatively affected all sectors of the global economy, no sector has been adversely affected like agriculture, especially in Sub-Saharan Africa (SSA) (Kgalatsi and Rautenbach, 2014; Carr et al., 2015; Antwi-Agyei et al., 2021). This is precisely why climate services have been rolled out to farmers in the region to facilitate informed decisions making that is necessary to improve food production. Climate services refer to the timely production, translation, delivery and use of climate information to enhance decision-making (Donkor et al., 2019). A core element in climate services is seasonal climate forecasts (SCFs). According to Ash et al. (2007), SCFs provide estimates of seasonal-mean statistics of weather, typically from a few weeks to about a year ahead of the season in question. Also, it provides information regarding the likelihood that the rainfall in the forthcoming season will be higher, lower or normal. The basis for such estimates arises from the high-resolution models used to monitor the ocean-atmosphere interactions (Ash et al., 2007), and to a lesser extent the land surface, on the atmosphere (Weisheimer and Palmer, 2014). The key paradigm for seasonal forecasting is El Ninõ, a coupled ocean–atmosphere phenomenon occurring primarily in the tropical Pacific and predictable 6 months and more ahead (Jin et al., 2008; Weisheimer et al., 2009).

Such information is extremely useful for a plethora of end-users in weather-sensitive sectors. Since its dissemination to farmers in SSA, success stories have emerged about its ability to enable farmers to make informed decisions (e.g., Tall et al., 2018; Grey, 2019). This is crucial in a time where some studies (Ziervogel and Opere, 2010; Mahoo et al., 2015) assert that Indigenous knowledge systems (IKS), which plays an instrumental role in enabling farmers make proactive farming decisions not limited to when to start planting and the quantity of food to produce in a farming season, is not as reliable as it has been in previous decades. Studies conducted in Burkina-Faso (Ouédraogo et al., 2018), Ghana (Antwi-Agyei et al., 2021) and Rwanda (Tesfaye et al., 2020), for example, show that farmers are now willing to pay for SCFs. This is testament to the impressive feature of SCFs in scaling up agricultural productivity and yield in the aforementioned countries, which is necessary to facilitate the attainment of both the first and second Sustainable Development Goals (SDG)—no poverty and zero hunger—in SSA.

The launch of the Global Framework for Climate Services (GFCS) by delegates of 155 nations in September 2009, which aims to strengthen the production, availability, delivery and application of science-based climate prediction and services (Tall et al., 2018), has resulted in increased investments in the production of SCFs that can be reliable and trusted by farmers globally including those in SSA (Dupar et al., 2021). However, its uptake in the region has been agonizingly low (World Bank, 2015). This is worrisome considering how erratic weather patterns have occurred in the last decade in SSA and, in particular, Zimbabwe (Manatsa et al., 2012; Mudombi and Nhamo, 2014; Belle et al., 2017) and South Africa (Mpandeli and Maponya, 2013a; Elum et al., 2017). In the past two decades, Zimbabwe has been ravaged by three disastrous Cyclones: (Eline, 2000), Dineo (2017), Idai (2019), and Mavhura (2020). In the same timeframe, Eline (2000), Dineo (2017), and Eliose (2021) had devastating consequences in some South African provinces. Also, from 2015 to 2035, both increased occurrences of droughts and erratic rainfalls have been projected to occur in both Zimbabwe and South Africa (Davis et al., 2017). Under the current state of affairs, these extreme weather events could have adverse consequences for rural livelihoods in both Zimbabwe and South Africa in the future, and could potentially undo the gains made toward achieving both SDGs 1 and 2. As the World Bank (2017) acknowledges, weather and climate-related disasters are reversing development gains, setting countries 10–20 years back. Hence, the utilization of SCFs by farmers in the aforementioned countries is overwhelmingly crucial to minimize the adverse effects of the anticipated weather conditions on food production.

It is noteworthy to mention that despite the concept of rurality being hotly contested, especially in South Africa, mainly due to the notion that households now obtain a substantial part of their livelihoods from off-farm activities not limited to social grants, remittances and wage labor (e.g., Ragie et al., 2020), there is evidence to suggest that farming continues to play an important role in contributing to rural livelihood (Ebhuoma et al., 2020; Tantoh et al., 2022). This reinforces the need to unpack this issue at such a crucial time in South Africa where the Ramaphosa's led-government is relentlessly striving to address issues not limited to bureaucratic delays and political influence that have stifled the success of land reform programme, which aims to tackle issues of land inequality and ensure more Black people become actively involved in food production (Kirsten and Sihlobo, 2021). In 1994, when South Africa successfully transitioned to democracy, White farmers owned approximately 78 million hectares of farmland out of the total surface area of 122 million hectares. It is estimated that 'through land reforms which include restitution, redistribution, private transactions and state procurement, 13.2 million hectares (17%) have already been transferred from White landowners to the state and an additional 3.08 million hectares have been transferred to Black owners' (Kirsten and Sihlobo, 2021, p. 1). Since its launch, land reform was accompanied by support solely targeting Black smallholders, primarily through the comprehensive agricultural support programme (OECD, 2021). Thus, the utilization of SCF may be an important tool to ensure this cohort of Black farmers make informed farming decisions.

Undoubtedly, there are quite a substantial amount of published literature revolving around the use and factors undermining the use of SCFs in both South Africa and Zimbabwe. This article aims to reduce the burden for development and climate change practitioners consulting a plethora of articles just to acutely ascertain the factors that undermine farmers' use of SCFs in the aforementioned countries. For instance, in ScienceDirect, the world's leading compendium of Elsevier journals, the keywords "seasonal climate forecast in Southern Africa" returned 5, 782 articles. This can be off-putting for development practitioners who may not have the time to meticulously go through each article before identifying common trends. Thus, by systematically reviewing existing literature, this article seeks to become a "one-stop-shop" that succinctly pinpoints the factors that hamper farmers' utilization of SCFs in both South Africa and Zimbabwe. As Petrosino et al. (2001) argue, systematic reviews involve identifying, synthesizing and assessing all available evidence, quantitative and/or qualitative, to generate a robust, empirically derived answer to a focused research question. The article proceeds in four parts. The first tracks the progress made by both South Africa and Zimbabwe toward achieving SDGs 1 and 2. The second provides a concise description of food production from a smallholder farmers' perspective in both countries and provides a detailed explanation of the systematic review process. The third part discusses the identified themes in relation to what it could mean for the actualization of both SDGs 1 and 2 while the final part offers viable recommendation to facilitate the uptake and utilization of SCFs.

Tracking Progress of SDGs 1 and 2 in South Africa and Zimbabwe

The United Nations member states adopted a new sustainable development agenda in September 2015, named 'Transforming our World: The 2030 Agenda for Sustainable Development'. At the heart of the agenda are the 17 Sustainable Development Goals (SDGs), which strives to achieve what was not completed during the process of the Millennium Development Goals (MDGs). Poverty eradication, environmental conservation and fostering inclusive, just and peaceful communities are central to the SDGs. The 17 SDGs are further divided into 169 targets and 232 indicators. The Agenda entered into force on January 1, 2016, with signatories committing to meet the goals by 2030. The Sustainable Development Report (SDR) (formerly the SDG Index and Dashboards) publishes countries assessment of progress toward achieving the SDGs. This is against the backdrop of the complexities enshrined in developing methodologies to robustly measure some of the proposed indicators, particularly the qualitative indices. The assessment is conducted at a national level to ease comparison toward global progress. In the South African context, in 2021, there was stagnation toward achieving SDG 1, albeit SDG 2 showed slight improvement (Sachs et al., 2021). In Zimbabwe, there was no information regarding the progress of SDG 1. However, Mhlanga et al. (2020) posit that access to borrowing and taking out insurance, among others, may be critical to eradicating extreme poverty, a district study show that challenges remain in eradicating extreme poverty despite organizational intervention and availability of saving and lending schemes (Kabonga et al., 2021). These indicative that the country may be lagging behind in achieving SDG 1 partly because most smallholder farmers do not have access to lending schemes, citing inadequate collateral, exorbitant interest rates and liquidity problem as major bottlenecks (e.g., Dube et al., 2015; Mutambara, 2016). In terms of SDG 2, the report showed that the country stagnated in its quest toward achieving its target (Sachs et al., 2021). Despite the usefulness of the information provided by the SDR for both countries, national assessments may mask work being done at local levels, especially since both countries have introduced policies aimed at tackling poverty. In 2012, for example, the South African government introduced the National Development Plan (NDP), aimed at reducing poverty and inequality by 2030. The NDP 'identifies agriculture as primarily an economic activity in rural areas with the potential to create 1 million new jobs by 2030' (Drimie, 2016, p. 2). Arguably, the overarching impact of the NDP may be differentially felt across various localized context in South Africa. This is substantiated by Wernecke et al.'s (2021) assertion that the inability for South Africa not to fully achieve both SDGs 1 and 2, in 2019, may partly be attributed to inadequate sources of information or data to assess real progress across various local scales. Because policies must concurrently be partly accompanied by infrastructural development as well as education and training (OECD, 2021), NDP and various agricultural policies may not fulfill their utmost desired potential of improving farmers' lives without adequately utilizing technological advancement not limited to SCF. Notwithstanding, in Zimbabwe, Sachs et al. (2021) national assessment may be not be entirely far from the reality on the ground, mainly due to the country's agricultural policy guided by a framework — Zimbabwe Agricultural Policy Framework (1995 to 2020) — formulated in 1994. Nonetheless, it can be asserted that the narrative may change soonest partly due to the recently launched National Agricultural Policy Framework (2018 to 2030), which aims to provide a road map toward achieving food and nutrition security both at a household and national levels, among others.

MATERIALS AND METHODS

Snapshot of Agriculture in Zimbabwe and South Africa

Zimbabwe and South Africa, classified as semi-arid countries, are both located in Southern Africa (**Figure 1**). Agriculture is the major economic activity that drives the rural economies of Zimbabwe. Prior to 2000, Zimbabwe was described as Africa's "breadbasket" nation. During that period, agriculture made up between 9 and 15% of the gross domestic product (GDP) and about 20–33% of foreign revenues. Furthermore, agriculture contributed more than 60% of raw materials to agro-industries, with over 70% of Zimbabweans obtaining their livelihoods from the sector. The breadbasket status has since been lost, attributed to low agricultural productivity due to the changing agrarian structure following the land reform program (Kasiyano, 2018). Agriculture supplies 60% of the raw materials required by the industrial sector and contribute 40% of total export earnings (Raynold and Simbarashe, 2021). "Zimbabwe has five distinct regions that are classified largely on the basis of climatic conditions. Climatic suitability (largely for agriculture) deteriorates as one moves from region 1 to region 5. Accordingly, region 4 experiences low rainfall (450–650 mm mean annual rainfall), which is associated with periodic seasonal droughts and severe dry spells punctuating the rainy season" (Chanza et al., 2019, p. 773–774).

In South Africa, smallholder agriculture is a major contributor to rural livelihoods. Despite transitioning to democracy in 1994, the rural poor continue to have limited resource endowments, which negatively impacts their ability to optimize farm yields. About four million smallholder farmers have been largely confined in the former Bantustan (or tribal authority) areas, producing primarily for subsistence purposes with only around 5% able to rely on agriculture as an income generating activity (Partridge et al., 2018). Notwithstanding, with the NDP's projection that agriculture could potentially contribute 1 million new jobs in rural areas by 2030, the importance of this sector cannot be trivialized.

In a study that analyzed South African farmers' vulnerability to climate change and variability across the nine provinces, it was found that the Western Cape and Gauteng provinces, which have high levels of infrastructural development, high literacy rates, and low shares of agriculture in total

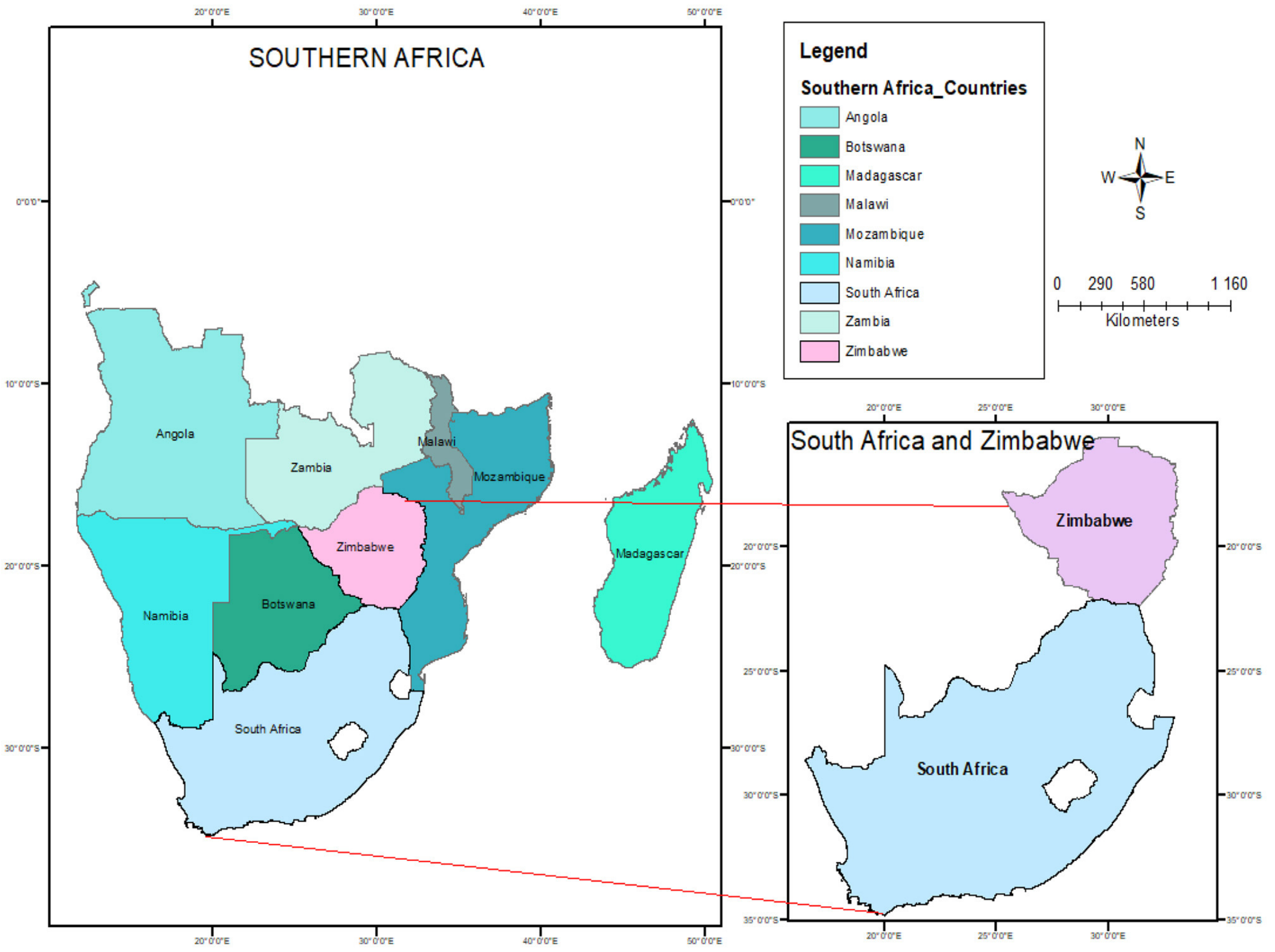

FIGURE 1 | Map of Southern Africa. Source: Author (2021).

GDP, were relatively low on the vulnerability index. In contrast, the highly vulnerable regions were Limpopo, KwaZulu-Natal and the Eastern Cape, characterized by densely populated rural areas, large numbers of smallholder farmers, extensive dependence on rain-fed agriculture and high occurrence of land degradation (Gbetibouo and Ringler, 2009).

Methodology

To accomplish the objective of this article, a systematic review was conducted to retrieve relevant literature from both Google Scholar and ScienceDirect, which are among the list of the most effective academic search engines (Tober, 2011). According to Clarke (2011, p. 64), "the purpose of a systematic review is to deliver a meticulous summary of all the available primary research in response to a research question." The methodology applied is explicit and precise and aims to minimize bias, thereby enhancing the reliability of the conclusions drawn. For the most part, keywords entered in both search engines were consistent to ensure uniformity and were formulated based on the author's expertise on climate services that such keywords would aid in identifying relevant literature through which the article's objective can be achieved.

Specific keywords entered in both search engines include "climate services in Southern Africa," "climate services in South Africa," "climate services in Zimbabwe," "forecast use among farmers in Zimbabwe," "forecast use among farmers in South Africa," "climate change adaptation in Zimbabwe," and "climate change adaptation in South Africa." It is noteworthy to mention that the keywords "climate services in Southern Africa," "forecast and farmers in South Africa," and "forecast and farmers in Zimbabwe" were restricted to ScienceDirect only due to the arduous process it can take to meticulously read through articles generated when each keyword was inserted in the search engine—each over 2,000 articles—to determine its suitability for further screening that the search engine generates. In both search engines, advanced searches were used to modify the searches to literature published from 2011 to 2021 due to the launch of the GFCS in 2009. Thus, it was befitting to select articles

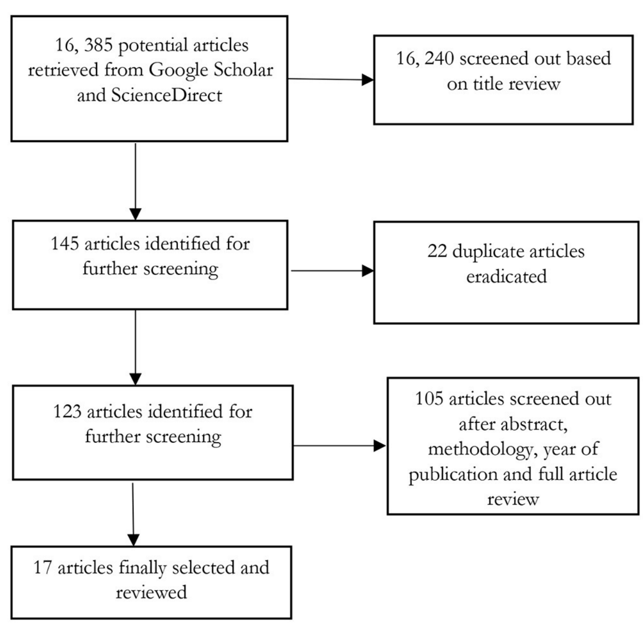

FIGURE 2 | Flow chart of article screening and selection process.

published after the GFCS was rolled out. Articles published in 2010 were excluded because most journal article review process takes months to over a year, with the studies conducted few years before the article is published. The review was strictly restricted to research articles only. Subject areas in ScienceDirect was restricted to environmental science; agricultural and biological sciences and social sciences.

In total, 16, 385 articles were retrieved. After screening based on titles, a total of 16, 240 were eradicated, and thus, 145 articles were remaining. Thereafter, duplicate articles, 22 in total, were eradicated, thereby resulting in 123 articles remaining. Next, abstracts, year of publication, methodologies and in some cases the complete articles were read to ascertain their suitability for the final review. This resulted in 105 articles being screened out for being irrelevant to the scope of the study. Finally, 17 articles informed the findings of this article. **Figure 2** schematically maps out the stepwise guide used to select the relevant articles that informed the findings of this article. The 17 selected literature was carefully read and thematically analyzed.

It is, however, important to note that the studies that informed this analysis are subject to the following limitations: firstly, although the strategies adopted to select the literature is indicative of a thorough and rigorous process that guarantees the quality of the selection process, it may not be sufficient to completely rule out all selection bias. This is arguably because climate services literature is so wide that the keywords used in the search engines may not be fully representative of the countries to be analyzed. Secondly, ScienceDirect and Google Scholar—chosen as the boundary for this analysis—even considering their wide scope, cannot prevent possible omissions in identifying relevant pieces of literature for the analysis. Despite these drawbacks, the study was extensive enough to permit the identification of important trends and key issues revolving around the factors undermining farmers' utilization of climate services to make informed decisions. It is noteworthy to mention that by virtue of the author attending a workshop regarding agrarian livelihoods in South Africa, in 2018, a key issue that may prevent some farmers not to seek out climate services came to the fore. This has been included as the last point in the next section of the article.

RESULTS AND DISCUSSION

Subsequent to the key findings of the systematically selected literature (**Table 1**), key findings were aggregated into seven themes. These include farmers' reliance on IKS, prioritizing the use of information and communication technologies (ICTs) to communicate SCFs, probabilistic forecast, lack of downscaled forecast, timing of forecasts, and competency of extension service officers and farmers' future aspirations.

Farmers' Reliance on IKS

Findings from key literature analyzed in this study indicate that IKS plays a pivotal role in decision making regarding when the plant, the quantity of food to produce (Mpandeli and Maponya, 2013a; Gwenzi et al., 2016; Wilk et al., 2017). A study conducted in the Guruve district in Zimbabwe revealed that 60% of respondents viewed IKS as more reliable than scientific forecasts (Gwenzi et al., 2016). Factors that continue to fuel indigenous farmers' trust and their resolve to rely on IKS—inherited from their forefathers—with high confidence., both in Zimbabwe and South Africa, is their concrete understanding of how indigenous forecast is generated, which is not the case with scientific meteorological forecasts. This aligns with studies conducted in SSA, which shows that a lack of understanding of how scientific forecasts are produced (Ebhuoma and Simatele, 2019) and the complexity of the ensuing information (Kolawole et al., 2014; Nyadzi et al., 2019) are drawbacks to farmers' utilization of scientific forecasts. Thus, to scale up the uptake and utilization of climate services, the advocacy for co-production of integrated forecasts between scientific forecasts and IKS has gained momentum (Ziervogel and Opere, 2010; Mahoo et al., 2015). The multiple evidence-based approach (**Figure 3**) has been proposed as a technique that can facilitate the co-production of integrated forecasts to ensure the hegemony of IKS is not tramped upon by meteorologists, which has, for decades, been perceived as an inferior body of knowledge. Arguably, co-producing forecasts will build farmers' trust in scientific forecasts, especially when scientific forecasts compensates for the limitations of IKS. Not only has IKS become unreliable in predicting the weather accurately as it has done in previous decades, its inability to predict the length of rainfall and cessation of rainfall in a particular planting season (Ebhuoma, 2020; Nyadzi et al., 2021) have become cogent reasons why scholars vehemently advocate for its integration with scientific forecasts.

It is noteworthy to mention that stakeholders—whose philosophies are underpinned by western ideologies—who are keen to co-produce SCFs with indigenous people must work

TABLE 1 | Factors undermining the use of climate services in South Africa and Zimbabwe.

Reference	Study area(s)	Methodology	Limitations to use of climate services
South Africa			
Mpandeli and Maponya (2013a)	Limpopo, South Africa	Random sampling, interviews and participatory rural appraisal	• Wrong timing of forecast dissemination: most farmers indicated that weather forecast information should be disseminated at least before September, the beginning of the planting season, either through the local radio stations or electronic print media • Level of expertise of forecast disseminators: Some of the extension workers who disseminate weather information do not understand the interpretation and the meaning of the values of the information mainly because most of them are not well-trained on climate forecast • The use of indigenous forecasts: The fact that farmers inherited Indigenous ways of forecasting the weather from their grandparents influenced their decision to utilize local knowledge with high confidence
Mpandeli and Maponya (2013a)	Limpopo, South Africa	Closed-ended questionnaires, interviews and focus group discussions	• Qualification of extension officers: Farmers lamented that some extension officers lacked the pre-requisite qualification to carry out their task successfully farmers • High levels of illiteracy, which hampers farmers ability to read weather information published in newspaper
Gandure et al. (2013)	Gladstone, Free State, South Africa		• Unreliability of forecast and lack of access to early warnings: the lack of access to early warning information and unreliability of seasonal forecasts are barriers promoting its use. However, it is unclear whether this is due to unavailability of and lack of regular access to early warning information or it is mere disbelief
Kgalatsi and Rautenbach (2014)	Nationwide study	Questionnaires administered to intermediaries at national and provincial levels as well as agricultural union structures responsible for scientific forecast dissemination	• Prioritize least effective channel of communication: Intermediaries considered open and direct discussions as being the most important method used to avoid distortion. The two most preferred methods (discussions and awareness/training) require direct interaction with end users. This was preferred by the extension services • Difficulties in understanding probabilistic forecasts
Archer et al. (2021)	Eastern Karoo	Individual discussions	• Tailored forecast is sparse and where tailored predictive product had been provided, inaccessibility to information to verify scientific forecast was deemed a barrier
Ofoegbu et al. (2016)	Makhado, Mutale and Thulamela communities in Vhembe district	Household surveys, discussions with village leaders and field observations	• Insufficient location-specific information about weather or long-term climatic conditions
Thinda et al. (2020)	Lejweleputswa and Thabo-Mofutsanyane (Free State), eThekwini, uGu, iLembe and Amajuba (Kwa-Zulu Natal), Mopani and Vhembe (Limpopo), and Dr Kenneth Kaunda (North West) in South Africa	Face-to-face interviews guided by open-ended questionnaires and closed-ended questionnaires	• Age of the respondent is negatively signed and statistically significant with the adoption of climate change adaptation strategies. This suggests that younger farmers are more likely to adopt new innovations and technology compared to their older counterparts • Inadequate information (on seasonal and long-term climate changes and agricultural production) increases downside risks due to failure to adopt new technologies and adaptation measures
Zuma-Netshiukhwi et al. (2013)	South-Western Free State province	One-on-one interviews and focus group discussions	• They are difficult to interpret and it is not easy to make decisions based on the probabilistic information given • Also, they are not point specific and there is a need for trustable downscaled weather/climate forecasts/predictions
Wilk et al. (2017)	Open and semi-structured interviews	Lambani and Mokwakwaila communities, Limpopo River Basin	• Trust in indigenous knowledge systems might override trust in seasonal climate forecasts • Farmers can only access SCFs information in local languages *via* extension staffs • Not all extension staff read or understand seasonal climate forecasts. Probabilistic forecast information perceived as confusing
Anderson et al. (2020)	Participatory workshops	Lambani and Mokwakwaila communities, Limpopo River Basin	• Farmers confuse SCFs with short-term weather forecasts • Few farmers present at community meetings where seasonal climate forecast information is disseminated
Zimbabwe			
Nyahunda and Tirivangasi (2019)	Mazungunye community, Masvingo province	Unstructured in-depth interviews and focus group discussions	• Unreliable meteorological information as they contradict the change in climate

(Continued)

TABLE 1 | Continued

Reference	Study area(s)	Methodology	Limitations to use of climate services
Belle et al. (2017)	Ntabazinduna, Umguza district, Matabeleland North Province	Face to face interviews and use of structured questionnaires	• Low levels of education
Zamasiya et al. (2017)	Hwedza District in Mashonaland East Province of Zimbabwe	Structured questionnaire, focus group discussions and key informant interviews	• Gender of the household head • Unreliable meteorological information • Lack of climate information, as information on the distribution of rainfall in the following season was not available
Mudombi and Nhamo (2014)	Seke and Murewa districts	Key informant interviews	• Inability to access timely, reliable rainfall forecasts and early warning information on droughts and violent storms • Wrong prediction of weather forecasts • Difficulties in interpreting weather forecasts
Mtambanengwe et al. (2012)	Nyahava ward, in Makoni district and Ushe ward, in Wedza District in eastern Zimbabwe	Focus group interviews, structural and unstructured interviews and closed-ended questionnaire	• Inappropriate channels of communication: The utilization of media (radio, television) imply that the existing flow of agrometeorological information to farming households makes its access a preserve of few who own electronic media • Poor timing and unreliability of forecast dissemination
Gwenzi et al. (2016)	Guruve District, in Mashonaland Central province of Zimbabwe	Focus group discussions and interviews	• Limited understanding of the meaning of probabilities given in the forecasts: Farmers were not sure of how the categories "normal/average, above normal and below normal" were generated and where the data were obtained from • Information was transmitted one way, but farmers preferred interaction during dissemination • Ambiguity in forecast terminology: Terminology used in short-term forecasts such as "scattered, isolated, numerous rain showers" and others were confusing, as the outcomes did not really agree with their understanding of the terms and their observations • Some farmers viewed IKS as more reliable than scientific forecasts: Farmers argued that IKS provided weather information at local level which was not captured in scientific forecasts i.e. scientific forecast is not downscaled
Manatsa et al. (2012)	Chiredzi district	Participatory research	• The probabilistic nature of the forecast renders it difficult to interpret by the farmers • The forecasts principally referred to the 'meteorological' component, neglecting the agricultural part required by the farmers • Inappropriate channel of communication: the communication channels chosen were not easily accessible (e.g., radio, TV and newspapers) to the poor farmers. Most farmers neither own a radio, nor own a TV set, and the majority have problems in timely accessing the newspaper, let alone being able to read it • The dissemination process is also very complicated, resulting in the late and distorted reception

with grassroots organizations trusted by the people and ascertain if any underlying political issues linger between farmers and the respective local, regional or national government. Some indigenous peoples in developing countries feel aggrieved that the increased unreliability of their IKS to accurately predict the weather is fuelled by their government's authorization of the exploitation of natural resources in their communities to ensure capital accumulation, thereby facilitating the degradation of the ecosystem that holds crucial indicators used to forecast the weather (Ding, 2003; Budnuka et al., 2015). For example, the felling of trees in indigenous communities for natural resources exploration purposes may cause indigenous people to rely on scanty ecological indicators to make informed farming decisions. This is because how specific birds construct their nests on trees (Ebhuoma and Simatele, 2019) and the shedding of leaves by specific tree species (Nkomwa et al., 2014) provides an indication of the amount of rainfall to be expected in a particular planting season. Thus, the loss of such trees will inherently result in the unavailability of such indicators for indigenous people who may be constrained to rely on scanty indicators to predict future weather conditions, a situation referred to as "decision pathology" by Wisner et al. (1977). Indigenous communities in South Africa and Zimbabwe can be classified as "express tunnels for state capital accumulation" owing to the vast amount of natural resources in these communities, yet community members live in abject poverty with a lack of physical assets such as good road networks and easily accessible pipe-borne water (Murombo, 2013; Mtero, 2017). Indigenous people who have been contending with such realities that have lingered on for decades could question the motive behind prioritizing co-production of knowledge in an environment where they have become accustomed to weather patterns courtesy of IKS and

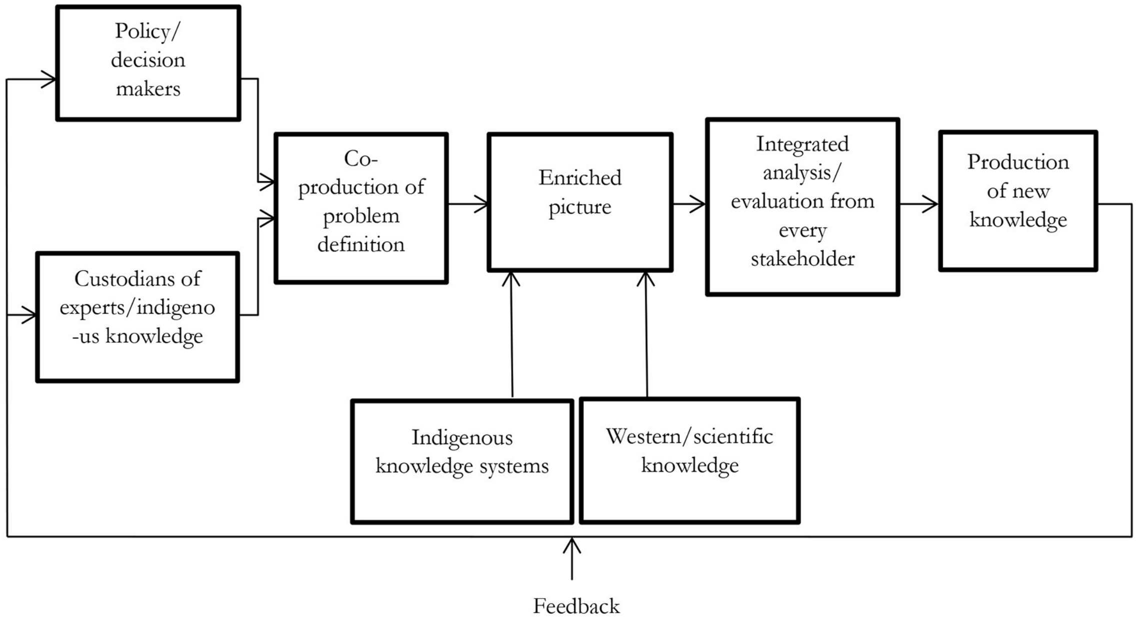

FIGURE 3 | Multiple evidence base approach. Source: Tengö et al. (2014).

believe that other pressing issues need urgent attention. Studies have shown that when farmers in SSA were asked to list their worries, climate-related issues did not rank high on the list at first. It was only when they were probed that the climate-related issues they grapple with became apparent (Müller-Mahn et al., 2020). This may likely be the case for most indigenous people in South Africa and Zimbabwe that reside in communities that contribute to the nation's gross domestic products (GDP) courtesy of the rich natural resources they possess. Thus, for scientists to make headway regarding co-producing integrated forecasts, the need to work with the respective local government to ensure some of their pressing needs are duly attended to might be a step in the right direction. Integrated forecasts may, in turn, catalyze the achievement of both SDGs 1 and 2 because it is deemed more effective in ensuring farmers make more informed decisions in comparison with using one strand—either IKS or scientific forecast (see Nyadzi et al., 2021).

ICTs as the Main Channel of Communication

In the literature on SCFs communication, ICTs – television, radio broadcasts, mobile phones and *via* internet websites – are the major channels used to communicate SCFs to end-users in SSA countries (Mahoo et al., 2015; Tall et al., 2018; Hansen et al., 2019; Ebhuoma and Leonard, 2020; Nyadzi et al., 2021). Unfortunately, this is a major challenge that undermines its uptake and utilization both in South Africa (Mpandeli and Maponya, 2013a,b) and Zimbabwe (Mtambanengwe et al., 2012; Mudombi and Nhamo, 2014). The major reasons for the ineffectiveness of ICTs have been attributed to language barrier (Wilk et al., 2017), high illiteracy levels (Mpandeli and Maponya, 2013b), the fact that some rural farmers, especially in Zimbabwe, are unable to own ICT assets because they are resource-constrained (Mtambanengwe et al., 2012; Mpandeli and Maponya, 2013b) and the lack of constant power supply in Zimbabwe (Mudombi and Nhamo, 2014). These findings corroborate studies conducted in Nigeria (Ebhuoma and Leonard, 2020), Ghana (Antwi-Agyei et al., 2021), and Kenya (Ochieng et al., 2017), respectively. However, this does not imply that ICTs have not recorded considerable degree of success as an effective medium for communicating SCFs in both South Africa and Zimbabwe (e.g., Kgalatsi and Rautenbach, 2014; Grey, 2019). In climate literature, it is documented that with the exception of elderly illiterate farmers in some SSA countries who choose to receive SCFs through the radio broadcasts advocated for it to be communicated in their local dialect through the rural radio stations to make it easier for them to understand the message (Ndiaye, 2011; Ndiaye et al., 2013; Jost et al., 2016), elderly farmers are more likely to utilize weather information *via* IKS and SCFs from extension workers (Belle et al., 2017; Thinda et al., 2020). This is contrary to younger farmers who are more open-mined to open-minded to trying new technologies to facilitate food production (Thinda et al., 2020).

It is therefore unsurprising to note that in a bid to scale up the communication of SCFs for optimal utilization among rural households in South Africa, efforts have been made to ensure extension workers and other intermediaries communicate such information through community meetings and workshops. This method of communicating SCFs may help to prevent message distortion which may likely occur for most illiterate farmers. Indeed, intermediaries including extension services in South Africa consider open and direct discussions as being the most important communication method to avoid information distortion or misinterpretation when presented to rural farmers (Kgalatsi and Rautenbach, 2014). This observation aligns with the state of affairs in Botswana. Kolawole et al. (2014) documented that in addition to disseminating weather information through ICT channels, officials of Botswana's meteorological service department are statutorily obligated to engage directly with community members through workshops and community meetings for the purpose of furnishing community members with weather information. However, such face-to-face meetings should not be viewed as a panacea that once utilized, it will facilitate the adoption of SCFs by end-users. A study by Kgalatsi and Rautenbach (2014), for instance, revealed that extension officers bemoaned that not every farmer shows up for community meetings. Also, a study by Anderson et al. (2020), in South Africa, revealed that the extension officers assigned to a pilot program in a rural community emphasized that community meetings should not replace additional meetings with farmers. This is primarily because to build trust and recommend actions based on SCFs, repeated visitations to farmers—either individually or in small groups—is crucial. Thus, efforts must be made to ensure they arrange meetings and workshops repeatedly, especially because farmers are extremely busy people. Despite their overwhelming dependence on food production, rural farmers often engage in a multiplicity of activities on a small scale to obtain their livelihood (Ebhuoma et al., 2020; Ragie et al., 2020), which reduces the time they are available to engage in such discussions. The use of such platforms, in combination with ICTs medium of communication, have resulted in South African smallholder farmers better appreciating the value of SCFs (Moeletsi et al., 2013), as it helps to prevent message distortion (Kgalatsi and Rautenbach, 2014) and arguably could erode the ambiguities that hamper the utilization of SCFs. Unfortunately, the same cannot be said of Zimbabwean farmers because extension services are underfunded, thereby hampering their ability to communicate SCFs in rural communities (Zamasiya et al., 2017). As Manatsa et al. (2012) aptly highlight:

> "…while in the past the extension officers used to visit farmers, now only those farmers who own bicycles, or those who can walk the long distances, can visit the extension officers. The lack of resources has created asymmetrical access to information by farmers. Due to their mobility, the male-headed households are more likely to have access to information."

Although meteorological services department officers (MSD) have started infiltrating some rural communities to directly communicate weather information, they admitted that "resources required for such activities are immense and might not be sustainable in the long run for the department" (Grey, 2019, p. 5). Thus, if the efforts made by governments in ensuring SCFs get to the end-users is used as a yardstick to measure the tendency of both countries to attain SDGs 1 and 2, South Africa may be miles ahead of Zimbabwe. This assertion implicitly reinforces Crespo-Cuaresma et al. (2020) finding where poverty paths were calculated for SSA countries up to the year 2030. The study concluded that with 300 million individuals anticipated to live in extreme poverty in SSA by 2030, from mostly financially constrained countries, it will be challenging to achieve the target of the first SDGs.

It is noteworthy to mention that women, especially female-headed households, may be more at a disadvantage by using ICTs to communicate weather information because they may lack access to such assets. As argued by GSMA (2018), men usually own communication assets such as radios and mobile phones more than women in SSA. This could potentially hamper women from accessing SCFs communicated through these mediums. Lack of financial assets is a deterrent to women's ownership and use of such vital ICT gadgets. However, caution must be taken not to think that only female-headed households may be vulnerable to not accessing climate information as spousal disapproval has been found to limit some women from owning communication gadgets (GSMA, 2012). It is argued that when women are able to access gadgets through which climate information is disseminated, they are more likely than men to confront challenges to using such devices and understand the transmitted information. Since women's role as the primary driver of food production coupled with their role in the house including taking care of the children may restrict the time available for them to listen to radio and television programs where such gadgets are available (Ebhuoma and Leonard, 2020), it is recommended to broadcast such information as many times as possible, especially in the early hours of the morning (around 7 am) and late in the evening (around 7–9 p.m.), and prioritize other ICT mediums like farmers' group meetings to facilitate the widespread reach of such information.

Probabilistic Forecasts

The probabilistic nature of weather forecasts has been pinpointed as a factor that impedes understanding of SCFs in South Africa (Zuma-Netshiukhwi et al., 2013; Kgalatsi and Rautenbach, 2014) and Zimbabwe (Manatsa et al., 2012; Mudombi and Nhamo, 2014), respectively, a finding that aligns with studies conducted in other SSA countries (Patt and Gwata, 2002; Motha and Murthy, 2007; Hansen et al., 2011). In the Delta State of Nigeria, for example, Ebhuoma and Leonard (2020) found that the inability to understand weather warning messages was partly responsible for a respondent who received a flood warning not to take proactive action, which resulted in devastating consequences. The respondent revealed that:

> Before the flood occurred, it was announced on the radio that there was going to be a flood incident, which would affect most parts of the nation. However, due to a lack of scientific understanding of the message's content and not being certain that my community will be affected, I ignored the warning.

Since farmers want rainfall forecast for the forthcoming planting season, only long term predictions—months ahead—can be provided. Due to the chaotic nature of the atmosphere, long term predictions can only be probabilistic (McIntosh et al., 2007). "Forecast probabilities are typically provided as maps of tercile probabilities that are homogeneous over large areas, without any information about the spatial and interannual variability of the underlying local climate" (Hansen et al., 2019, p. 3). A probability is designated to each category, indicating the chance of the particular category to occur in each region during the target season. Farmers may find it difficult to understand what normal/average, above normal and below normal rainfall mean and how to plant accordingly. As Manatsa et al. (2012) argue, the probabilistic nature of SCFs may be incomprehensible and usually too difficult for farmers to interpret. Because forecast is probabilistic and not a definitive prediction of what the season would be, it may further cast doubt on the need to rely on it in sensitive sector like agriculture, as farmers cannot trust the message. To attain a high level of trust in SCFs by farmers, it has to be often associated with a high degree of accuracy, which indicates that the forecast unfolds as predicted. However, because climate information is inherently characterized by some degree of uncertainty, it may not always unfold exactly as predicted (Tall et al., 2018).

This issue is further compounded by ambiguity in forecast terminologies. "Terminology used in short-term forecasts such as 'scattered, isolated, numerous rain showers' and others were confusing, as the outcomes did not really agree with their understanding of the terms" (Gwenzi et al., 2016). Addressing this issue will require concerted effort, which can be achieved *via* face-to-face meetings. To reinforce face-face meeting as an avenue that can help to dismantle terminology barriers enshrined in SWF, a meteorological services department officer in Zimbabwe commented:

> "… the major challenge is understanding of the terms we use when disseminating weather information. But, in some places where we have had workshops, there is now a better understanding of our risk warnings and weather forecasts. For example, in Zvishavane, Gutu, and Chirumhanzu districts where we had workshops, there is a very good understanding of these terms and seasonal weather forecasts in general…" (Grey, 2019, p. 7).

The onus, therefore, is for meteorological agencies to work closely with rural communities, extension officers and other intermediary organizations responsible for disseminating SCFs to farmers to identify the terminologies they struggle to understand so that simpler terminologies can be used to facilitate understanding.

Lack of Downscaled Forecasts

From the review of selected literature, lack of downscaled forecast was found to be an issue that impeded the use of SCFs in Zimbabwe and South Africa (Manatsa et al., 2012; Ofoegbu et al., 2016). This corroborates various studies in SSA which reveals that SCFs fail to specifically target vulnerable groups and is often not tailored to suit their needs (Ziervogel and Calder, 2003; Ebhuoma and Leonard, 2020). The lack of downscaled forecasts may increase the unreliability of SCFs, which may cause farmers' trust in scientific forecast to wane. This is partly responsible for farmers' continued reliance on IKS because depending on regional and national generated SCFs may be unsuitable to provide reliable weather information at the local level (e.g., see Gandure et al., 2013; Mushore, 2013; Zamasiya et al., 2017). A study by Gwenzi et al. (2016) in Zimbabwe revealed that 60% of farmers stated that IKS is more reliable than scientific forecasts because IKS provided weather information at the local level which was not captured in scientific forecasts. Thus, the fact that IKS is tailored to local-context boosts farmers' confidence in its use. As studies conducted both in Zimbabwe (Mudombi and Nhamo, 2014) and South Africa (Wilk et al., 2017) show, the lack of downscaled SCFs reinforce farmers' reliance on IKS.

Having high accurate downscale forecast in SSA is often a challenge due to incomplete historical climate data available, especially in local communities, which is necessary to enhance the forecasts skill. Numerous countries in SSA have few and obsolete weather station infrastructure, thereby resulting in low quantity and quality of weather and climate data (Tall et al., 2018). Poor climate data in SSA could be as a result of damaged weather stations due to conflicts or poor maintenance mainly due to lack of funds (Mason et al., 2015). A brief by the World Bank revealed that Africa has the least developed weather, climate and hydrology observation network, with only one eighth (1/8) of the required density and (<300) weather stations that meet the World Meteorological Organization (WMO) observation standards (World Bank, 2017). Nonetheless, South Africa is one of the few countries in SSA that has made significant strides in providing accurate downscaled SCFs (Landman, 2014). The dearth of historical climate data undermines the quality, usefulness and value of SCFs for end-users including farmers. In addition to the paucity of weather data, there is also limited time-series data on agricultural yields and soil quality, which are core ingredients for robust evaluations (Tall et al., 2018).

Timing of Forecast Dissemination

In the reviewed literature on SCFs in both South Africa and Zimbabwe, poor timing of forecast dissemination was found to be an issue that hampered the use of weather and climate information to make farming decisions. Even in rural communities in the aforementioned countries where farmers' rely on ICTs to obtain weather information (Tengö et al., 2014), inappropriate timing of forecast dissemination has undermined its uptake and use (Mtambanengwe et al., 2012; Mpandeli and Maponya, 2013a). Arguably, disseminating SCFs between 1 and 2 months ahead of the planting season to farmers is necessary as this will give them an indication of the onset of the rainy season and how the amount of rainfall to be expected in the forthcoming planting season. Consequently, this would enable farmers to optimize labor and land allocation to obtain seeds of different varieties, pending the outlook of the SCFs, and to prepare available fields in various locations since their agricultural practices are labor intensive and highly dependent on family labor, among other strategic responses. Unfortunately, not receiving the SCFs on time has hampered proactive measures that farmers can employ.

This finding is corroborated by Talanow et al. (2021) who revealed that information constraints led to a reported lack of awareness of climate change. This issue is rife in SSA as studies conducted in Botswana (Kolawole et al., 2014) and Mali (Carr et al., 2015) have underlined lack of promptness in disseminating weather information as a factor that undermined farmers' use of SCFs. "To be useful and integrated into farm-level decisions, climate information must be provided well ahead of the agricultural season" (Tall et al., 2018, p. 3). Forecast accuracy must be balanced with timeliness. Nonetheless, it can be argued that a less accurate forecast with ample lead-time may be more valuable than a highly accurate forecast communicated after irrevocable decisions have been taken by farmers. Consequently, it was not surprising to observe that farmers in Vhembe district of South Africa requested that climate forecast information should be disseminated at least before the beginning of the season (Mpandeli and Maponya, 2013a), a suggestion also likely to appeal to most Zimbabwean rural farmers, which in turn may facilitate the actualization of SDGs 1 and 2.

Competency of Extension Service Officers

Extension officers' low skill competency in interpreting SCFs is a factor that has hampered some farmers' use of SCFs both in Zimbabwe and South Africa. While the lack of adequate and follow-up trainings are the primary causal factors for this state of affairs in South Africa (Mpandeli and Maponya, 2013a,b), the situation seemed worse off in Zimbabwe as extension officers lack formal training on how to interpret and adequately communicate SCFs to end-users (Ngara, 2017). This can be attributed to Zimbabwe being resource-constrained and as such, training extension officers is not deemed a priority. Thus, against the backdrop of studies that unanimously agree that vulnerable farmers who depend on agricultural extension officers as a crucial source of information had a better chance of adopting approaches that could help to cushion the adverse effects of climate change (Mutandwa et al., 2019), the same cannot be confidently said with regards to SCFs disseminated by the same cohort of people in Zimbabwe and South Africa. A study conducted in South Africa revealed that despite various training and awareness workshops, extension officers reported that they did not notice any improvement in the understanding and interpretation of SCFs information (Kgalatsi and Rautenbach, 2014). They proposed further retraining to improve their understanding of SCFs information.

A factor that may have caused this issue to linger on, especially in South Africa, is the absence of viable platforms for extension officers to express their concerns regarding SCFs. As Anderson et al. (2020) note, the majority of extension officers expressed that forums are needed where they can give feedback on SCFs and communicate signs of emerging drought conditions and where they can receive relevant site-specific recommendations. Although extension officers are among the people who observe field conditions first-hand (Muzawazi et al., 2017) and are highly trusted by rural farmers (Hansen et al., 2019), they are barely involved in discussions or consulted at district and provincial forums where important strategical decisions and policies regarding climate change are made (Anderson et al., 2020). Some extension officers in South Africa observe that the advice they get from higher administrative levels is not pertinent or ideal for the issues they notice on the ground (Anderson et al., 2020). Like rural farmers in Zimbabwe and South Africa, some extension officers find it difficult to understand the probabilistic nature of forecasts (Ngara, 2017; Wilk et al., 2017).

Nonetheless, great strides have been made with extension officers and other intermediaries in facilitating the utilization of SCFs among rural farmers in South Africa (e.g., see Kgalatsi and Rautenbach, 2014; Wilk et al., 2017). This, however, does not imply that extension officers and intermediaries have not been instrumental in facilitating uptake and utilization of SCFs in some rural communities in Zimbabwe (e.g., see Grey, 2019). For example, it is acknowledged that ICT broadcast of climate information was followed by an extension visit in Murewa district (Mudombi and Nhamo, 2014). Nonetheless, this may be one of the few exceptions, as lack of funding is a major bottleneck that has hampered extension workers' ability to carry out their tasks in vulnerable communities. As Muzawazi et al. (2017) state:

> "Today the extension service is a sorry reflection of past glories. Many qualified staff left or passed away, posts are unfilled, and the transport capacity is virtually non-existent and the ability to offer up-to-date advice severely hampered by the parallel decimation of government research services" (p. 111).

Farmers' Future Aspirations

In climate literature, rural households are classified as rural poor, smallholder and emerging commercial farmers. However, scholars like Cousins (2015) and Bernstein (2018) argue that the term "smallholder" is problematic because it tends to obscure inequalities and class-based differences within the large population of households engaged in agricultural production on a relatively small scale. A substantial amount of climate literature suggests that smallholders are, by and large, a relatively homogeneous group, thereby failing to distinguish between those producers for whom farming constitutes only a partial contribution to their livelihood, those for whom most of their livelihood is heavily dependent on food production, those for whom farming produces a significant surplus, allowing profits to be reinvested and, for some, capital accumulation in agriculture to begin. Thus, a class-analytic perspective, centered on the key concepts of "petty commodity production" and "accumulation from below," is essential for understanding the differentiated character and diverse trajectories of small-scale agriculture within capitalism. This type of analysis is overwhelmingly crucial because whichever trajectory rural households decide to take based on their future aspirations, it may inherently influence their decision to utilize SCFs. For example, the cohort of farmers who obtain a partial or insignificant portion of their livelihood from food production and are constantly remitted and/or have rental properties where they obtain a significant portion of their livelihood, may not necessarily see the need to utilize and/or integrate SCFs with IKS to make farming decisions. Also, farmers who do not aspire to scale up food production may not invest the time, necessary family labor and finances needed to acquire equipment such as draft animals and plows as well as assets needed to respond to climate advisories in a timely manner (Carr and Onzere, 2017). This group of farmers may not avail themselves for community meetings with extension officers and other intermediaries responsible for communicating SCFs. The fact that rural farmers have differential future aspirations may influence their decision to utilize SCFs. Perhaps, the onus is on researchers to use the class analytic approach to disaggregate the preconceived homogenous rural groups in order to effectively understand the possible barriers that could impede a class or classes of rural farmers from utilizing SCFs. This form of analyzing rural spaces would provide a deeper understanding of complexities enshrined in rural spaces. The argument here is that for SCFs to flourish, an interdisciplinary lens is needed. This would enable researchers and development practitioners to excavate some factors that could influence the uptake of SCFs. Due to brevity coupled with the alarming rates in which climate change is occurring, a "quick fix" approach to get a comprehensive understanding of farmers aspirations would be to partner with grassroots organizations to effectively unpack farmers' future goals and aspirations.

CONCLUSION

The adverse effects of climate change on food production coupled with growing inconsistencies in IKS have necessitated some farmers' willingness to rely on SCFs to make informed farming decisions. SCFs provide information regarding the likelihood that the rainfall in the forthcoming season will be higher, lower or normal. While SCFs have scaled up food production among some rural households in SSA, some farmers continue to find it difficult to plug into this vital technology. Failure to utilize SCFs to make informed farming decisions could undermine the achievement of both the first and second SDGs in SSA. With extreme weather conditions not limited to erratic rainfall and rising temperatures including cyclones becoming increasingly rampant and with devastating consequences in Southern Africa, this article analyses the factors that hamper the utilization of SCFs by rural farmers in both South Africa and Zimbabwe. A systematic review of existing literature was applied to identify relevant literature, which informed the analysis of this article, albeit by virtue of the author attending a workshop regarding agrarian livelihoods in South Africa, in 2018, a key issue that could prevent some farmers not to seek out climate services came to the fore and was included as the last factor.

Findings reveal that farmers' reliance on IKS, prioritizing the use of ICTs to communicate SCFs, probabilistic forecast, lack of downscaled forecasts, timing of forecasts dissemination, competency of extension service officers and farmers' future aspirations were factors that stifled farmers use of SCFs. To enhance the use of SCFs, which will likely facilitate the achievement of SDGs 1 and 2, it is recommended that SCFs should, as a first point of departure especially for farmers that do not trust scientific forecasts, compensate for the limitations of IKS. Also, place and gender-specific SCFs should strongly influence dissemination of SCFs to ensure enhanced equity and effectiveness at the local level both in Zimbabwe and South Africa. In addition, SCFs should be communicated 1–2 months lead time before the commencement of the growing season through diverse communication channels to ensure widespread reach. Finally, a critical understanding of farmers' future aspirations is necessary before channeling resources to ensure extension service officers and other intermediaries meet with farmers face-to-face to disseminate SCFs. This would ensure the maximization of scarce financial resources, especially in Zimbabwe.

AUTHOR CONTRIBUTIONS

EE conducted the analysis and wrote the entire article.

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