International Journal of Development and Sustainability
ISSN: 2186-8662 – www.isdsnet.com/ijds
Volume 11 Number 7 (2022): Pages 236-248
ISDS Article ID: IJDS22102401

Small-scale farmers' vulnerability to the impacts of climate change in Limpopo Province, South Africa: A review

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Abstract

Small-scale farmers in South Africa's five rural provinces are the backbone of subsistence livelihoods and are particularly at risk from climate change because of the country's high frequency of droughts in rural areas. Most rain is needed for subsistence crop production, making it a climate-sensitive agricultural system with limited ability for adaptation. Many factors have been identified as major contributors to farmers' susceptibility to climate change. However, this study is a review of the literature intended to describe the drivers that make small-scale crop farmers susceptible to the effects of climate change. Previous literature sources on climate change and its effects on small-scale farming, as well as the indigenous adaptation practices used, were reviewed to identify the factors that contribute to small-scale farmers' vulnerability to the negative effects of erratic and scant rainfall and rising temperatures on crop farming. The study findings present three main drivers of vulnerability to climate change that are related to the three facets of vulnerability identified by Turner et al. These are adherence to indigenous livelihood patterns, production of rain-fed crops, and use of indigenous adaptation practices to mitigate and cope with the impacts of changing rainfall and temperature patterns on crop production. These factors render the farmers vulnerable to the negative impacts of climate change despite being locally practised and related to the culture of the Bapedi communities. The study suggests using indigenous and technological adaptation practices to lessen the vulnerability of small-scale farmers to the impact of climate change.

Keywords: Climate change; Vulnerability; Small-scale Farmers; Subsistence Farmers; Rain-fed Farming; Limpopo Province

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Cite this article as: Rankoana, S.A. (2022), "Small-scale farmers' vulnerability to the impacts of climate change in Limpopo Province, South Africa: A review", *International Journal of Development and Sustainability*, Vol. 11 No. 7, pp. 236-248.

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1. Introduction

Small-holder farmers who rely on rain-fed agriculture are particularly at risk from the detrimental effects of climate change. Climate change and variability have severe effects on Africa, particularly on the continent's small-scale farming population, which accounts for the great majority of the continent's economically active population. In South Africa, climate change is stressful to smallholder farmers whose main source of livelihood is derived from agriculture (Mpandeli et al., 2015). In Limpopo Province, there has been a perceptible decrease in the total rainfall, with negative impacts largely affecting the rural populations that depend on agriculture for a livelihood (Polokwane Municipality Integrated Development Plan, 2021–2026). As a result, local food security measures are already vulnerable to rapid and uncertain changes in temperature and rainfall patterns (Shikwambana and Malaza, 2022). This is because climate change affects all four dimensions of food security: the availability, accessibility, utilization, and stability of food (Food and Agricultural Organization, 2018). The farmers' socio-economic standing, coupled with low adaptation capacity, are the main contributory factors to their vulnerability to climate variability and change (Dang et al., 2018).

This review describes the drivers of small-scale farmers' susceptibility to the negative impacts of changing precipitation and temperature patterns. It is limited to three drivers of vulnerability identified by Turner et al. (2003), exposure, sensitivity, and resilience. The paper is limited to previous literature sources on climate change and its effects on small-scale farming to describe the drivers of vulnerability to the negative effects of erratic and scant rainfall and rising temperatures on rain-fed crop farming. Sensitivity was measured by assessing the small-scale farmers' livelihood sources and the type of crops grown, followed by resilience measured by the type of indigenous adaptation practices adopted to cope with the impacts of climate change. The three drivers have proven to make subsistence farmers vulnerable to the negative impacts of climate change in many developing countries. These include following indigenous livelihood patterns, growing rain-fed crops, and employing indigenous adaptation strategies on farms to offset and cope with the effects of shifting rainfall and temperature patterns on agricultural output.

2. Literature review

Subsistence farming is the primary source of income in most rural areas of developing countries, with small-scale farmers accounting for the vast majority. As a result of climate change, smallholder farmers are increasingly vulnerable to shifts in precipitation patterns, decreased precipitation amounts, and higher temperatures. Farmers are losing their livelihoods as a result of this shift due to crop failures and low crop yields (Turpie and Viser, 2013; FAO, 2016; FAO, 2018). Shikwambana and Malaza (2022) agree with these findings, claiming that low crop yield productivity is a hallmark of subsistence agriculture as a result of climate change, resulting in widespread food insecurity. Low crop yields aggravate poverty levels and food insecurity among small-scale farmers in rural areas, especially where households have limited income sources (Chersich and Wright, 2019). This means the vulnerability of small-scale farmers who are more reliant on subsistence agriculture for their economic livelihood will be long-lasting.

Vulnerability can be referred to as the degree to which people or systems are exposed to, and unable to cope with, the unpleasant effects of a stimulus or stimuli (Nelson, 2010). Vulnerability, as defined by Turpie and Viser (2013), is the experience of being exposed to disasters and stressful stimuli and the subsequent

acquisition of coping mechanisms. There are two kinds of vulnerability: the one that results from exposure to external hazards and shocks and the kind that results from the presence or absence of internal safeguards that prevent the system or person from collapsing under pressure (Awazi et al., 2021). According to the Intergovernmental Panel on Climate Change (2013; 2014), vulnerability in the climate change landscape is predicated on magnitude, the degree of exposure of a system, its sensitivity, and the warranted adaptive capacity. The small-scale farmer's capability to cope with the harsh climate conditions can be gauged by looking at factors such as the crops planted, the adaptation methods used, the location, and the climate of the area (Nkomwa et al., 2014). The latest projections from the Intergovernmental Panel on Climate Change (IPCC, 2018) Assessment Report Six suggest an increase in the frequency of heavy precipitation over South Africa in the future, leaving smallholder farmers vulnerable to or unable to deal with the severe effects of climate change.

Poor socio-economic conditions in the world's developing countries render small-scale farmers mostly vulnerable to the negative impacts of climate change (IPCC, 2014). Mosase and Ahiablame (2018) support the idea that people living in rural areas with fewer employment opportunities depend on rain-fed subsistence food production for their livelihood. Turpie and Viser (2013) argue that vulnerability to climate shocks is compounded by poverty, and a lack of information access is just one of the factors that put small-scale farmers at a heightened risk of being negatively affected by climate change (FAO, 2019). The exception is that the ability to adapt to climate change is greatly aided by the enjoyment of rights and access to resources, both of which are largely determined by social, political, and institutional considerations (Ingty, 2017).

Small-scale farmers living in rural areas dominate the districts of Capricorn, Sekhukhune, and Mopani, allowing farmers to rely on climate-reliant subsistence food production. The Food and Agricultural Organization (FAO, 2018) justifies that the most vulnerable people in the world are those who rely on climate-sensitive resources like water and energy. In rural parts of Sub-Saharan Africa, subsistence rain-fed agriculture is the principal means of livelihood. Seventy percent of the world's farmers are considered small-scale, making them particularly vulnerable to the low agricultural output brought on by the fluctuating rainfall patterns produced by climate change (FAO, 2015; 2016). The livelihoods of rural farmers are particularly vulnerable because of their reliance on agriculture and natural resources that are threatened by climate change (Kettle and Dow, 2014; Hosen and Nakamura, 2020).

3. Method

The present study is a review of the literature on the factors that affect small-scale agricultural producers in the three district municipalities of Sekhukhune, Capricorn, and Mopani in Limpopo Province, South Africa. The districts are mostly inhabited by Bapedi. The study presents a review of the literature on climate change impacts on food security, small-scale farming, and local mitigation and adaptation practices. Prior studies on climate change among Bapedi mostly concentrated on the communities' perceptions of climate change, what effects it had on people's livelihood patterns, and how they adapted to it. This study, however, reviewed previous studies in order to describe the factors that render small-scale farmers susceptible to climate change's effects.

Subsistence rain-fed agriculture is the main source of livelihood and a local food security mechanism in South Africa's rural communities (Statistics South Africa, 2021; IDP, 2021–2022), despite the negative impacts of rising temperatures and unpredictable rainfall. The average annual temperature in the three districts ranges

between 25 and 40 degrees, making them hot and semi-arid. From October through March, daytime highs often range from 28 to 34 degrees Celsius, making for sweltering summer days. In the summer, lows range from a warm 16 degrees Celsius to a pleasant 21 degrees Celsius. Daytime lows in the winter range from 19.6 to 25.2 degrees Celsius, making the season feel more like spring or summer. Temperatures range from 4.3° to 12.1° C throughout the winter months. The area experiences rain from November through March as it is in Limpopo's summer rainfall belt. There is a heavy rainy season from November through February, with an annual average of 600 to 650 mm, according to the IDP (2021–2022). According to Statistics South Africa (2021), small-scale farmers are the most affected by a lack of employment opportunities and other socioeconomic issues. The goal of this research is to find out "what factors make small-scale farmers vulnerable to the effects of climate variability and change?"

4. Results and discussion

4.1. Evidence of changing climatic conditions in the districts

The Department of Environmental Affairs (DEA, 2017) reports of increases in temperature and precipitation pattern shifts over the past five decades lend credence to the study's estimates of climate change. From the literature, it is evident that some people think of climate change as merely a shift in average temperatures and precipitation. Extreme heat and drought in the summer have both been linked to a rise in average temperatures that can be dated back to the year 1970 (IDP, 2021–2022). Extreme heat and drought during the summer and sometimes unexpected precipitation during the winter have both been linked to a steady rise in temperature that can be dated back to the year 1970. Changes in temperature trends were noted, with the mean annual temperature rising by at least 1.5 times the global average of 0.5 C over the past five decades (IDP, 2021–2022). Similarly, food and feed shortages, poor rainfall, decreased water availability, and dying vegetation and animals are all ways that farmers in the Vhembe district (as described by Mpandeli, 2014) characterize increased temperatures and decreased precipitation in some parts of South Africa's Limpopo Province. The Republic of South Africa's Department of Environmental Affairs (DEA, 2017) adds that increasing temperatures and unpredictable rainfall are two key ways in which climate change is manifesting itself in South Africa (Rankoana and Mothiba, 2016). For the Limpopo province, the observed rate of warming has been 20 °C higher with windier days and drought (Department of Forestry, Fisheries, and the Environment [DFFE], 2020).

The Centre for Scientific and Industrial Research (CSIR, 2018) Report on South African Risk and Vulnerability Atlas supports that the country has a generally warm climate, with average annual temperatures exceeding 16°C in a large portion of the country. Due to the decrease in temperature as altitude increases, the southern and eastern escarpments have the lowest mean temperatures. The warmest areas are the KwaZulu-Natal coast, the Mpumalanga Lowveld, northern KwaZulu-Natal, the Limpopo Valley, the North West province, and the interior of the Northern Cape. Recently, a warming rate of 2 °C per century or greater has been reported in all the provinces (DFFE, 2020). According to the Food and Agriculture Organization of the United Nations (2016), small-scale farmers in Africa are already feeling the effects of climatic unpredictability and change. Temperatures in Southern Africa have been rising at a rate of 0.4 °C per decade between 1961 and 2014, according to trend analysis, which is consistent with findings from Awazi et al. (2021). The rural communities

in Southern Africa face the same predicament, as their livelihood patterns make them extremely exposed to the effects of rising temperatures (Hosen and Nakamura, 2020; Ndlovu et al., 2020). A similar study in Cameroon demonstrated that small-scale farmers' economic vulnerability to climate-related shocks like increased temperatures causes widespread production uncertainty (Ngondjeb, 2013).

Records of the districts' weather patterns are supported by DEA (2017), which shows the average daytime temperatures in the months of April through September that are currently mild to warm, ranging from 19.6 degrees Celsius to 25.2 degrees Celsius (DEA, 2017). Temperatures range from 4.3° to 12.1° C throughout the winter months. Small-scale farmers are hit particularly hard by these shifts and fluctuations (DEA, 2017) where most of the indigenous crops grown do not resist rising temperatures with little or no rainfall. These observations support the IPCC's (2014) report that most of Africa warmed by roughly 0.7 degrees Celsius in the twentieth century, with Sahel and Southern Africa experiencing drier conditions and East and Central Africa experiencing wetter conditions. As Davis and Vincent (2017) point out, there has been a 0.85 °C increase in global mean annual temperatures since 1880, and another 0.3 to 2.5 °C increase is expected by 2050. Temperatures in Southern Africa have risen at a pace of 0.4 °C per decade between 1961 and 2014, according to a trend analysis of regional temperatures that is consistent with global climate changes (Davis and Vincent, 2017). These give evidence of the extreme global warming reported during the past sixty years (IPCC, 2014).

The cessation of cultural practices and significant livelihood patterns are also used to illustrate the effects of climate change. These embrace communal labor, hunting, fishing, and the consumption of traditional fruits and vegetables, as well as the brewing of traditional beer, the cultivation of traditional crops, and the celebration of first-fruit rites. The use of contaminated water, drought, and severe heat have all been cited as contributing factors to the rise in the prevalence of rain-induced diseases like cholera, bilharzia, and dysentery in the local population. While warming temperatures and shifting precipitation patterns are forecast to persist as a result of climate change, southern Africa is already experiencing the negative effects of altered rainfall and temperature patterns (DEA, 2013). South Africa is not immune to the effects of climate change; the country is already seeing more severe storms, droughts, and rising temperatures, which negatively impact the livelihood of most rural communities (Ziervogel et al., 2014). Furthermore, South Africa's devastating floods in KwaZulu-Natal province and other parts of the country are the first signs of climate change in South Africa (https://reliefweb.int/report/south-africa/floods-detail-effect-climate-change).

4.2. Drivers to small-scale farmers' vulnerability to the impacts of climate change

4.2.1. Livelihood sources

Higher rates of poverty are one of the most challenging socio-economic issues in the district municipalities. The districts' IDPs (2021–2022) show that the majority of residents lack the formal education necessary to improve their economic prospects. Small-scale farming of native crops for subsistence use is the principal economic activity in the area. The majority of Limpopo Province's rural small-scale households have no sustainable economic activities, making the local means of food production particularly vulnerable to climatic shocks (Statistics South Africa, 2021). Similarly, rural communities in Southern Africa face the same predicament, as their livelihood patterns make them extremely exposed to the negative effects of climate change (Hosen and Nakamura, 2020).

Awazi and Tchamba (2019) argue that the main cause of susceptibility to climate change is the type of settlement. Farmers in rural areas are especially vulnerable to climate change because their livelihoods rely on natural resources such as rainfall for subsistence food production (Rankoana, 2016). According to Mango et al. (2018), poverty is linked to food insecurity, which is exacerbated by the effects of climate change, with most small-holder farmers in rural communities facing low agricultural output, which has a negative impact on food production and security efforts (FAO, 2018). Poverty is linked to food insecurity, which is intensified by the effects of climate change, where most small-holder farmers in rural communities are faced with low agricultural output, which impacts negatively on food production and security efforts (FAO, 2018). The World Bank (2017), supported by Asfaw et al. (2021), reports that most of the world's poor live in rural areas as farmers, illustrating how their socio-economic conditions have always rendered them vulnerable to climate change (World Bank, 2017). Climate change, a global phenomenon that disproportionately affects humanity, is most acutely felt by small-scale farmers in rural areas (SADC, 2020). Residents of semi-arid regions are especially vulnerable to climate change due to poverty, a lack of education, and exposure to natural disasters (Statistics South Africa, 2021). The districts of Capricorn, Sekhukhune, and Mopani are dominated by small-scale farmers living in rural areas, a situation that lets the farmers rely on indigenous adaptation techniques in the face of climate-induced shocks (Statistics South Africa, 2021). Such adaptation practices embrace shifting planting seasons as a result of the late onset of rainfall, planting early-maturing crops, and using kraal manure to stabilize the soil (Rankoana, 2016; DFFE, 2020).

4.2.2. Planting of rain-fed crops

Observations from Mpandeli (2014) and Rankoana and Mothiba (2016) indicate that the types of crops planted greatly increase the susceptibility of small-holder farmers to climate change. Farmers rely on the rainy season to cultivate rain-fed indigenous crops including maize, millet, sorghum, and groundnuts. Mixed farming is the primary method of production, and its principal goal is to ensure food security while producing only a small surplus for sale. These crops are grown primarily for human consumption within the home. No planting may take place unless and until sufficient rainfall is received. The crops are delicate and often damaged by weather shifts and fluctuations. Because of doubts about when the rainy season would begin, farmers delayed ploughing and planting. Thus, food shortages became increasingly severe as crops began to fail early in the season due to the droughts. As a result of the persistent drought, some farmers have abandoned crop cultivation in favour of non-agricultural pursuits such as paid labour and are facing increased food insecurity and a drop in their standard of living (Maponya and Mpandeli, 2013). Over the years, farmers saw that drought meant lower crop yields (Statistics South Africa, 2021). This indicates that fluctuations in weather conditions, such as temperature and precipitation, during critical periods of crop growth can lead to a loss in yield.

Subsistence crops require a relatively stable average daily temperature and precipitation amount in order to thrive (DEA, 2017). Due to decreasing precipitation and increasing drought, neither indigenous nor technologically advanced irrigation methods are being used. Changes in rainfall patterns and temperature increases have introduced unfavorable growing conditions into cropping calendars, modifying growing seasons and, as a result, crop productivity (Maponya and Mpandeli 2013). However, this is in jeopardy as climate change is continuous and unpredictable, threatening farming in rain-fed systems. Bapedi's crop yields have decreased as a result of climate change-induced stressors from both rainfall and temperature. In addition, the DEA (2017) shows that yield declines of 15% in 2030 and 24% in 2050 are possible because of

unpredictable and sporadic precipitation. Rainfall and temperature swings have a major impact on crop yields. Soil moisture is essential for plant growth, and it is determined by the amount of precipitation that falls on the earth. Similarly, precipitation is seen as the primary driver of yield variability because it varies by an order of magnitude more than potential crop evapotranspiration (Calzadilla et al., 2013). Higher temperatures, however, will reduce crop yields and shorten the crop cycle in arid and semi-arid regions due to the increased water needs of the crops (Crespo et al., 2011; Calzadilla et al., 2013). Climate change is predicted to reduce agricultural productivity in the poor world by 10–20% over the next 40 years, which Nelson et al. (2009) support because most rural people in developing nations are directly involved in agriculture and ecosystem services. Smallholder farmers are especially susceptible to the negative effects of climatic variability and change since they depend on rainfall on a continuous basis to cultivate these extremely sensitive crops (Awazi and Tchamba, 2019). In their study, Adeagbo et al. (2021) concluded that smallholder rain-fed systems in Africa and Latin America are projected to show a 10% decline in aggregate yields of maize by 2055.

Farmers with small plots of land are particularly vulnerable to the negative effects of climatic fluctuation and change because they rely on consistent rain to grow these delicate crops. This is consistent with a finding that when it comes to agriculture, smallholder farmers and farming systems that rely primarily on rain-fed techniques are the ones who feel the brunt of climate variability and change (Morton, 2007). Persistent reliance on rain-fed agriculture has resulted in falling crop production and crop failure in most situations as weather patterns change, which is particularly detrimental for crop growth (Awazi, 2022). Due to the high degree of dependence that farmers' crops have on rainfall, fluctuations in rainfall patterns can generate production instability (Maponya and Mpandeli 2013). This is informed by Morton's (2007) observations that climate change projections for the future are for less rain and higher temperatures in Sub-Saharan Africa, making the region's small-scale farmers especially susceptible to weather extremes (Ngondjeb, 2013). For their daily food requirements, more than half of the world's population relies on smallholder farms, which face serious dangers due to their extreme sensitivity and low resilience to the negative effects of climate variability and change (Awazi et al., 2021). After years of poor precipitation, food insecurity rates tend to spike (IPCC, 2013).

4.2.3. Use of local adaptation practices

Small-scale farmers in developing nations would be most affected by climate change due to the type of adaptation mechanisms utilized to cope with the impacts of variable rainfall and rising temperatures on their agricultural systems. Because they cling to antiquated ways of life and lack the technical know-how to adapt to changing environmental conditions, small-scale farmers in rural areas continue to be particularly at risk from natural disasters. Evidence from the literature shows that Bapedi subsistence farmers are using indigenous methods to mitigate the effects of global warming on their crops. Farmers, for example, are increasingly relying on their expertise in predicting when it will rain to cope with climate change. Predicting whether or not it will rain necessitates observing the behavior of various animal and plant species, as well as the movement and position of the moon and sun (Maponya and Mpandeli, 2013; Rankoana and Mothiba, 2016; Rankoana, 2016; 2022). For instance, the beginning of the rainy season is signaled by the blooming of Senegali species around the start of September. If the blooms are a deep yellow, it means that enough rain is on the way, but if they are lighter in color, it means that rainfall will be scarce. Increased insect activity in the spring is an indicator of a dry summer. Changes in crop management strategies, such as planting dates, planting densities, crop types, short-season crops, tillage practices, opting for early-maturing and drought-resistant plant

varieties, and soil fertility management, are just some of the numerous options available for farmers seeking to cope with climate change on the farm. Traditional multi-cropping involves sowing many crop seeds in one field at once to increase the likelihood that multiple crops may mature at the same time (IDP, 2021–2022).

Indigenous adaptation practices similar to the ones used by Bapedi smallholder farmers are part of their culture and have remained relevant to improve subsistence farming during times of seasonal and climatic variability. The ability to apply locally sustainable risk-mitigation and adaptation techniques to changing conditions is a major factor in determining adaptive capacity. Expanding and maintaining local knowledge systems to deal with the negative effects of climate change is crucial to creating resilience (Ingty, 2017). To this end, understanding the adapted coping strategies of the local population is crucial for reducing vulnerability (Kettle and Dow, 2014). A person's or community's ability to adopt locally sustainable mechanisms to mitigate risk and adapt to changing conditions is a major factor in how well they will fare in the face of climate change (Maponya and Mpandeli, 2013). However, adapting to climate change's negative effects requires strengthening and maintaining local knowledge systems (Ingty, 2017). Thus, familiarity with the adapted coping strategies of a population's local residents is directly correlated with that population's degree of vulnerability (Kettle and Dow, 2014). The resilience of smallholder farmers should not be downplayed because of factors like family labor, existing patterns of diversification (including non-farm activities), and a wealth of indigenous knowledge. Access to indigenous knowledge determines a population's adaptive potential, and this information enables the farmers to recognize when a paradigm shift has occurred and the subsequent requirement for adaptation (Hosen and Nakamura, 2020).

The use of indigenous adaptation strategies such as rainfall prediction and observing the behavior of various animal and plant species, as well as the movement and position of the moon and sun, stands in sharp contrast to that of many earlier theorists, who viewed conventional wisdom and established practices as obstacles to development. Attempts by small-scale farmers to break out of poverty are hampered by climate change because they are overly reliant on weather patterns that are prone to being unexpected, and they lack the means to deal with the inevitable shocks that will come their way due to the changing climate (Tupie and Viser, 2013). Newsham and Thomas (2011) in Namibia found that small-scale farmers are particularly vulnerable to climate change because their low incomes prevent them from taking advantage of adaptation alternatives. However, multiple adaptation strategies have been created by small-scale farmers in response to a changing climate, as attested to by the Intergovernmental Panel on Climate Change (2013) and Ziervogel et al. (2014). Farmers adopt a wide variety of solutions to the problem of climate change to deal with the threats that climate change poses to their productive activities if they are to achieve a sustainable level of output (Ojo and Baiyegunhi, 2020b). According to Stringer et al. (2020), many of these alternative adaptation options are influenced by the farmers' perspectives on climate change (Hasan and Kumar, 2019; Khan et al., 2020).

Smallholder farmers' vulnerability to climate change is likely to increase due to socio-economic characteristics such as small farm sizes, low capitalization, limited technologies, and a wide range of other non-climate stressors. Resilience factors such as family labor, existing patterns of diversification, including non-farm activities, and possession of a store of indigenous knowledge should not be underestimated. Access to indigenous knowledge determines a population's ability to adapt, and the realization that a paradigm shift has occurred necessitates adaptation by all societies (Hosen and Nakamura, 2020). However, low adaptation ability renders the farmers particularly vulnerable to the risks and uncertainties brought on by climate change (Awazi, 2022). Their means of subsistence are under severe attack, and as a result, smallholder farmers are

extremely exposed to the effects of climate change because of their low levels of resistance (Awazi et al., 2021). Additionally, low adaptive ability contributes to greater climate-related risk and uncertainty in food security. When it comes to the effects of climate change, small-holder farmers are among the hardest hit as their way of life is in jeopardy due to their low levels of resistance (Awazi et al., 2021). The small farm sizes, low capitalization, limited technologies, and a wide range of other non-climate stressors will tend to increase smallholder farmers' vulnerability to climate change (IPCC, 2014).

The Food and Agricultural Organization (FAO, 2019) supports the fact that over 90% of dry land in Africa is solely used for rain-fed agriculture, and with a lack of adequate climate-smart adaptation initiatives, the results of climate change are expected to be disastrous for the farmers. Farmers in rural areas are particularly at risk from the effects of climate change because they lack access to technologies that could help them adapt (Awazi et al., 2021). The high cost, structural exclusion from participating in decision-making processes, a lack of skills and illiteracy, and a lack of early disaster warning systems are responsible for rural farmers' limited access to the appropriate technologies for adaptation (Nyambe and Belete, 2013). Poor adaptation capability, coupled with poverty, inequality, and marginalization, is claimed to be at the root of small-scale farmers' vulnerability to climate change (Mango et al., 2018). To counter this, South Africa's National Climate Change Response Policy (NCCRP, 2011) prioritizes research-informed and locally tailored adaptation methods. Strong and sustainable socio-economic development, according to Chaudhury (2017), can make people less vulnerable to and more resilient in the face of climate change.

5. Conclusion

Many rural populations in developing countries rely on rain-fed crop production as their primary means of subsistence, which is currently threatened by climate change. This review describes the factors that make small-scale farmers vulnerable to climate change's negative effects, such as unpredictable precipitation and rising temperatures. According to the study, the farmers' reliance on rain-fed agriculture, lack of adaptation skills, and adherence to traditional ways of life all increased their susceptibility to the negative effects of climate change. All of these challenges have made farmers' ability to adapt weak, rendering them more vulnerable to the predicted effects of climate change. The results are consistent with the vulnerability components of exposure, sensitivity, and resilience identified by Turner et al. It can be deduced that climate change poses a threat to food security in rural areas that rely on rain-fed crop production. As a result, it makes people more susceptible to poverty, hunger, and ill health and slows down progress toward the Sustainable Development Goals that have been set for 2030. Since many small-scale farmers in South Africa rely on the smallholder farming system, the study suggests the use of indigenous practices such as those currently used by Bapedi small-scale farmers and technological interventions such as the services of agricultural extension officers to assist the farmers in becoming more resilient to climate change. In particular, farmers' resilience can be improved by the employment of agricultural extension services in addition to indigenous adaptation strategies. To increase the adaptive capacity of subsistence rain-fed-dependent farmers to withstand the vagaries of climate variability risk, it is necessary to promote adaptation interventions such as expanding small-scale irrigation, gaining access to microfinance services, receiving early warning and timely information, training and skill development, expanding infrastructure, expanding climate awareness campaigns, and installing weather stations in rural communities.

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