

A REVIEW OF RURAL COMMUNITIES' VULNERABILITY TO CLIMATE CHANGE: THE CASE OF LIMPOPO PROVINCE IN SOUTH AFRICA

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Abstract:

Climate change threatens the livelihood of rural communities that depend on climate-sensitive resources. The risks and consequences of climate change, to which rural areas are especially susceptible, are discussed in this review. The review summarizes previous studies on rural communities' susceptibility to the impacts of changing climatic conditions. Previous studies on climate change in South Africa's Limpopo Province provide the information used in this review. The findings indicate that rural communities are vulnerable to rising temperatures and unpredictable precipitation. The communities are exposed to higher temperatures, less rainfall, and intermittent drought. Subsistence agricultural and livestock production and water supplies are two examples of climate-dependent livelihood resources vulnerable to weather variability and change. These resulted in food insecurity and water scarcity in many rural areas. This review helps fill a gap in understanding the importance of assessing the vulnerability of rural communities with climate-dependent livelihood resources. The study recommends detailed community-based adaptation measures to counteract the detrimental effects of climatic stresses on people's means of subsistence. Adaptation policies to climate change could be strengthened by incorporating indigenous adaptation techniques and community voices into response efforts.

Keywords: Climate Change, Climate Exposure, Climate Sensitivity, Vulnerability, Rural Community, Subsistence Production

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INTRODUCTION

The most noticeable stressors associated with climate change are rising temperatures and erratic rainfall patterns. These risks and threats to human livelihoods are common in developing countries where rural communities' livelihood patterns rely on natural resource exploitation. Rural communities are primarily made up of subsistence farmers whose livelihoods are heavily reliant on favorable weather conditions. These communities are particularly vulnerable to the devastating effects of climate change on their subsistence agriculture, livestock, and water supplies, which render them at risk of food insecurity, water scarcity, and poor health because of climate change stressors. The review's primary goal is to support the vulnerability assessment framework, which emphasizes climate risks and impacts to which rural communities are vulnerable. According to the findings of this review, rural communities are vulnerable to changes in unpredictable precipitation and temperature variations that negatively affect indigenous modes of livelihood, such as food production and water provision. Food instability and water stress are detrimental to people's livelihoods and health. The study proposes implementing community-based adaptation techniques

as part of climate change response policies to reduce the adverse effects of climate pressures on people's livelihoods.

Literature Review. Climate change, its risks, and its consequences are widely perceived and described by scientists and members of local communities, who have since observed changes in indigenous livelihood patterns due to natural environmental changes. Increasing temperatures, shifting rainfall patterns, and variations in the intensity and frequency of extreme weather events like drought and flooding negatively affect the livelihood of Southern African rural communities (IPCC, 2014). According to Kruger and Sekele (2012), the climate of South Africa varies from desert and semi-arid to sub-humid along the eastern coast. Extreme floods and droughts are predicted to become more common and severe in the country's northeast while decreasing in frequency and intensity in the southwest and adjacent interior (DEA, 2018b). The average annual precipitation in the country is only 450 mm (Zhou et al., 2022). There is a significant difference in annual precipitation between the western and eastern parts of the country (Maponya & Mpandeli, 2012). Average temperatures and precipitation changes are forecasted to occur by the year 2050 (Kruger & Sekele, 2012). The larger the changes, the more challenging it will be for rural communities to adapt (IPCC, 2014). The negative consequences on farm productivity are incredibly probable if greater temperatures and less rainfall are predicted (Maponya & Mpandeli, 2012; Mpandeli & Maponya, 2014; Mabapa et al., 2017; Zhou et al., 2022).

Increasing climate variability and increased frequency and intensity of extreme events are documented in detail in the Intergovernmental Panel on Climate Change's Fifth Assessment Report (IPCC, 2014). The study primarily examined specific locations that are vulnerable to climate change disruptions. However, there needs to be more knowledge about other critical areas essential for global climate change, particularly in impoverished nations. It is reported that due to limited economic capital and direct reliance on natural resources, rural and indigenous groups in developing regions are some of the most vulnerable to climate impacts (Almudi & Sinclair, 2022). Human health, infrastructure, and livelihoods are all negatively affected by climate change, as acknowledged (Dasgupta et al., 2014). There needs to be more literature on rural communities' vulnerability to the effects of unpredictable precipitation and increasing temperature. The hazards associated with climate change, such as shifts in annual mean temperature and precipitation and the frequency and intensity of extreme climate events like droughts and heavy rains, are predicted to leave rural people vulnerable to harsh environmental conditions. Africa will remain one of the most vulnerable continents to climatic variability and change because of its exposure to various stressors, reliance on natural resources, and low adaptive capability, as stated by the Intergovernmental Panel on Climatic Change 2007. African rural populations are more susceptible to the effects of climate variability than developed nations (IPCC, 2014), thus making climate change a danger to rural livelihoods in Sub-Saharan Africa (SSA). South African Society, especially rural populations that rely primarily on natural resources, faces environmental, social, and economic issues due to climate change (Ofoegbu et al., 2017).

This review is limited to describing how the stresses associated with climate change are affecting indigenous peoples' livelihood patterns. According to the views, rural communities that rely on scarce, climate-dependent resources like water and food are particularly at risk (Yimam & Holvoet, 2022). Poverty, hunger, and water shortages are just some of climate change's effects on rural populations' lives (Poudel et al., 2020). The data presented here provide credence to the conclusion drawn by Phaswana-Mafunya and Olsson (2008), namely that resource-poor populations are concentrated in agrarian regions vulnerable to water shortages. Farmers in rural areas are particularly at risk because water availability and the ability to produce food depend on favorable climatic conditions (IPCC, 2018).

In the rural parts of sub-Saharan Africa, subsistence rain-fed agriculture is the principal means of livelihood (FAO, 2018a). Some locations are more susceptible than others due to climate variation because of their location, population density, and other factors. As a result of centuries of discrimination and segregation, the world's poor now disproportionately reside in environmentally vulnerable areas, such as on the edges of cities or low-lying, flood-prone plains (FAO, 2018a). People living in poverty and are socially marginalized often have to reside in areas more susceptible to the effects of climate change (Turpie & Viser, 2013). For example, black South Africans were forcibly evicted from their ancestral lands and resettled in homelands and reserves, where they now experience the effects of climate change due to the places' low soil quality and inability to collect rainwater adequately. People in low-lying areas, like the Limpopo Basin, are especially vulnerable to the consequences of climate change (Mosase & Ahiablame, 2018). Extreme weather and climatic events, such as droughts and floods, would have considerable consequences on natural resources and livelihoods throughout Africa (IPCC, 2011). Poverty and unemployment, reliance on agriculture for food security and employment, and insufficient access to water supply all contribute to Limpopo Province's vulnerability (UNICEF, 2011). This finding suggests that sensitivity to climate change may vary across space and be location-specific (IPCC, 2018). People in the Limpopo Basin and other low-lying places are especially at risk from climate change, as reported (Mosase & Ahiablame, 2018). The Intergovernmental Panel on Climate Change predicts that locations like these would be hit hard by droughts and floods, significantly affecting local economies and the availability of essential resources (IPCC, 2011). High poverty and unemployment, a reliance on agriculture for food security and employment, and inadequate access to quality water contribute to Limpopo Province's climate vulnerability (UNICEF, 2011). As a result, certain regions may be more at risk than others due to climate change (IPCC, 2018b), suggesting that vulnerability is place-dependent and geographically variable.

South Africa's rural and urban areas are highly vulnerable to climate change's effects, though the magnitude of these vulnerabilities varies depending on the context. Climate change is widely believed to impact rural areas severely (Hosea & Khalema, 2020). Due to their dependence on natural resources and lack of economic capital, rural and indigenous populations in developing nations are among the most at risk (Hosea & Khalema, 2020). Communities in developing nations that rely on climate-sensitive natural resources face a severe threat from climate change-induced pressures, as reported (Azene et al., 2018). Developing nations at lower latitudes are particularly vulnerable to climate change because they rely more heavily on rain-fed agriculture. As a result, the African continent's high reliance on natural resources suggests it will be hit harder than most by the adverse effects of climate change (IPCC, 2018b).

The term "vulnerability to the impacts of climate change" is used here to refer to the susceptibility of rural communities' livelihood resources to changes in temperature and precipitation patterns, as well as the likelihood that these communities will be negatively affected by these changes. The IPCC Working Group II Report (2014) provides the impact-risk framework that underpins this review (Quang, 2021), showing that the interplay of exposure and sensitivity to climate change produces the risk of impact from climatic hazards. There needs to be more research comparing the vulnerability of rural and urban areas and unraveling the effects on people's livelihoods (Samuels et al., 2022). However, a vulnerability analysis that takes inherent livelihood resources into account may aid in understanding the degree to which rural populations are vulnerable to climate risks and impacts.

METHODS

The review is derived from analyzing existing literature on climate variation perceptions and impacts in South Africa's Limpopo Province. The impacts of climate change on subsistence farmers are the primary focus of these investigations. The main findings in these literature sources are that climate change is already impacting South Africa and that the country is aware of the potential consequences that require it to plan for adaptation strategies. Numerous examples are in the works of Kruger and Shongoe (2004), Kruger and Sekele (2012), Maponya and Mpandeli (2012), Mpandeli and Maponya (2014), Quinn et al. (2014; Long & Ziervogel, 2020), Ofoegbu et al. (2017), and Zhou et al. (2022). Extreme weather, such as severe rains and heat waves, is predicted as summers get hotter and dryer and winters become wetter and milder. Like the other provinces of South Africa, Limpopo will undoubtedly experience change due to future climate change (Tshiala et al., 2011; Maponya & Mpandeli, 2012; Quinn et al., 2014).

Most research indicates that average temperatures are rising, and rainfall is becoming more unpredictable in Limpopo Province, which is visible to ordinary community members. These effects harmed most rural communities' livelihoods (Maponya & Mpandeli, 2012; Mpandeli & Maponya, 2014; Nyahunda et al., 2021; Rankoana, 2020; 2022). These ecological conditions are consistent with observations of a 1-3°C increase in average temperature patterns, unpredictable rainfall, frequent and devastating droughts, and floods (Kruger & Shongoe, 2004; Kruger & Sekele, 2012), depletion of water sources and biodiversity, soil erosion, and decreased subsistence production, all of which harm human health and livelihood (Turpie & Viser, 2013), which may put communities at risk of poverty, hunger, malnutrition, and water scarcity (Ndlovu et al., 2020). The current review examines how susceptible Limpopo Province's rural areas are to climate change's effects.

RESULT AND DISCUSSION

Rural Communities' Vulnerability to Climate Change. Natural disasters are given more weight in vulnerability analyses because of the magnitude of the damage they can do to a system (Asfaw et al., 2021). Exposure to external risks and shocks, and the presence or absence of internal precautions to prevent the system or person from crumpling under pressure, are the two categories of climate vulnerability identified by the Southern African Development Community (SADC, 2020). However, this analysis sheds light on how people and places are at risk from climate change, with a particular emphasis on rural communities in Limpopo Province. The primary goal is to describe the community's vulnerability, focusing on describing climate stressors and the degree to which the community's indigenous livelihood resources are sensitive.

Vulnerability to Climate Stressors, Rising temperature. According to South Africa's Ministry of Environment, climate change is expected to raise average temperatures by 1°C to 3°C by 2050, with many provinces, including Limpopo starting to report warming rates of 2 °C per century or higher (DAFF, 2018). From April through September, average daytime temperatures range from 19.6 degrees Celsius to 25.2 °C (Kruger & Shongwe, 2004; Kruger & Sekele, 2012). Throughout the winter, the weather ranges from 4.3° to 12.1°C, with an annual rainfall of 700 mm and average temperatures ranging from 15°C to 28.1°C (Mabapa et al., 2017). These predictions support Davis and Vincent's (2017) observations that the global mean temperature has risen by 0.85 °C annual temperatures have risen by 0.3 to 2.5 °C since 1880, with another 0.3 to 2.5 °C rise expected by 2050. These results support the IPCC's (2007) claim that the average temperature across Africa has risen by around 0.7 °C during the twentieth century. These trends in South Africa will have severe repercussions for agriculture, biodiversity, and transportation (IPCC, 2014). The area surrounding Limpopo province, according to the Long-Term Adaptation Scenarios (LTAS), may experience a significant rise in temperature in the future (up to 2°C by 2035, 1-2°C between 2040 and 2060, and 3-6°C between 2080 and 2100 (Gandure et al., 2013; DEA, 2018b).

Increased carbon dioxide concentrations, rising temperatures, and decreased rainfall pose a risk to crop production and food safety (Grace et al., 2012). Temperature changes imply changes in the structure and functionality of forest ecosystems, which has several implications for a climate-reliant livelihood (Naidoo et al., 2013). Food insecurity, which leads to poverty and malnutrition, and water stress, which results in poor water quality and jeopardizes good health and well-being, make rural communities susceptible to climate variation (Rankoana, 2021). Increased food insecurity and poverty are possible outcomes of erratic rainfall in most areas that rely on rain-fed agriculture.

Temperature variations threaten agriculture, food security, and water resources in Africa's Sub-Saharan region (File & Derbile, 2020). The trend of erratic rainfall and rising temperatures, resulting in poor production of subsistence food and drying water resources, indicates that climate change makes subsistence livelihoods in rural areas more complex and may aggravate poverty. Rising temperatures are expected to affect rural communities' livelihoods (Sonwa et al., 2012). According to Dessalegn and Akalu (2015), rising temperatures are pervasive stressors hitting people in rural areas. Most subsistence farmers and rural livelihoods are threatened by climate change (Davis & Vincent, 2017). Agricultural productivity can only meet the needs caused by unusual temperature patterns if sustainable and adaptive land management is implemented. Rural communities are at risk of poverty and malnutrition due to widespread food and water insecurity (Dessalegn & Akalu, 2015). Rose (2015) states that climate change is a significant issue for subsistence and small-scale farmers. Rose (2015) believes climate change, such as rising temperatures, poses significant risks to rural communities' livelihood patterns. Rising temperature patterns may impede nations' long-term development by reducing yield production, resulting in food insecurity. Poor individuals in underdeveloped nations that rely primarily on natural resources are hit hardest by climate change (Getu, 2015).

Even in modern South Africa, many rural areas still rely on rain-fed agriculture as their primary source of food and water. Rural areas and those in dry or semi-arid climates are especially susceptible to climate change impacts. In most of Limpopo's rural areas, agriculture is the province's primary economic activity (Maponya & Mpandeli (2012); LEDET (2013); Nkuna Odiyo (2016); Long & Ziervogel, 2020; Nyahunda et al., 2021) because temperature shifts and fluctuations have a disproportionately negative impact on the province. Gbetibouo's (2009) findings that rain-fed agriculture, densely populated rural areas, large numbers of small-scale farmers, and high rates of land degradation make the provinces of Limpopo, Eastern Cape, and KwaZulu-Natal particularly vulnerable to climate change-related problems are supported by this finding. According to LEDET (2018), Limpopo's agriculture is precarious because of the high population density in the province's rural areas, the prevalence of subsistence farming, the heavy reliance on rain-fed methods, and the prevalence of degraded soil. Rural and indigenous groups in developing countries have been characterized as among the most vulnerable due to their reliance on natural resources and low economic capital (Delgado & Lopez, 2021; Patrick, 2021).

Rankoana's (2022) research in Limpopo Province found that despite increasing temperatures being blamed for poor crop productivity, rural community members still prioritize subsistence crop cultivation. These adverse effects of climate variation on subsistence agriculture lend credence to the claim that indigenous peoples' methods of ensuring food security are in jeopardy due to climate change dangers such as drought, inadequate precipitation, and temperature swings (Maponya & Mpandeli, 2012). Poor crop yields, failures, and livestock losses result from rising temperatures in rural communities (Rankoana & Mothiba, 2015). According to UNICEF (2011), extreme poverty and unemployment, reliance on agriculture for food security and employment, and inadequate access to sanitation, water supply, and healthcare make Limpopo particularly vulnerable to the effects of climate change (FAO, 2018b). Low earnings, widespread poverty, and a reliance on expensive food

imports contribute to high food prices in Sub-Saharan Africa (Nath & Bhagirath, 2011; Ndhleve et al., 2014; Hosu et al., 2016). A decrease in food production due to climate change could force households to make difficult allocation decisions, perpetuating poverty and malnutrition and driving up demand for imported food (FAO, 2018a). Due to a lack of livelihood assets, rural households in South Africa are vulnerable to the effects of climate change (Ncube et al., 2016). Poor rural communities in South Africa are primarily vulnerable to climate change, resulting in increased hunger and malnutrition (Mugambiwa & Tirivangasi, 2017; Shisanya & Mafongoya, 2017). Similarly, Shackleton and Cobban (2016) show that households whose livelihoods are ecosystem-based have become more susceptible to climate extremes than those that rely on economic livelihoods.

Less Rainfall and Intermittent Drought. Rainfall patterns in Africa have already shifted dramatically. South Africa, like other African countries, is already experiencing reduced rainfall, more severe storms, and drought Quinn et al. (2014) as it is located within a drought belt and a subtropical region of high pressure where rainfall is highly erratic and variable, with annual rainfall more than half the world average. South Africa experiences spells of dry periods, likely exacerbating floods and droughts (Kusangaya et al., 2014; Nkuna & Odiyo, 2016; Mmbadi, 2019). The main reason for these variations is that South Africa is mainly arid, putting it at high risk of droughts and floods in any given year (Kruger & Shongoe, 2004). Uncertainty in model projections for Southern Africa by DEA (2018b) is demonstrated by the LTAS's long-term forecast of decreased rainfall over Limpopo, while other studies suggest that rainfall may increase in the region (Shackleton & Cobban, 2016). Due to climate change and variability, Limpopo Province has steadily decreased precipitation over the past few decades. It will become increasingly challenging to ensure a reliable water supply in the river basin in the future (Zhu & Ringler, 2012). Due to rising temperatures, higher rates of evaporation, less predictable rainfall amounts, and more frequent floods caused by intense rainfall, the amount of water in rivers is expected to decline as the climate changes (Davis, 2010; Joseph et al., 2021).

High inter-annual rainfall variation in Southern Africa during the early twentieth century DEA (2018b) is controversially estimated to have forced much of South Africa's subsistence agriculture out of production. Rainfall decreases in South Africa have been anticipated by the DEA (2013) and Erasmus (2014), whose views are confirmed by a reported 4% decline in rainfall across the remainder of Southern Africa over the last century. As a result, indigenous peoples' ways of life may need to adapt (Kruger & Shongwe, 2004; Kruger & Sekele, 2012; Turpie & Viser, 2013; Nyahunda et al., 2021) to increased temperatures, the depletion of water sources, and biodiversity, soil erosion, and a drop in subsistence output.

Limpopo already struggles with the effects of climate unpredictability, such as drought, which will only worsen as the climate changes. The primary determinant of susceptibility to climatic shocks is reliance on and production of indigenous subsistence crops. Climate change's most apparent impact on rural Limpopo Province's people is a shift in the frequency and intensity of precipitation (Rankoana, 2019). Growing indigenous crops in backyard plots and farm fields is in jeopardy due to climate change impacts such as higher-than-average temperatures, less precipitation, and unpredictable drought (Mugambiwa & Tirivangasi, 2017; Nembilwi et al., 2021). For instance, Maluleke and Mokwena (2017) found that farmers have had to sell livestock because of the reduced availability and higher livestock feed prices (Nkuna & Odiyo, 2022). While rural areas will be hit the worst, urban communities that get food from the countryside will also feel the repercussions (Patrick, 2021).

Sub-Saharan African countries rely heavily on rain-fed agriculture as subsistence (FAO, 2018). Consequently, food crop farming and livestock production are at risk from climate change and variability, which hinders our ability to ensure food security. Changes in precipitation result in a

shorter rainy season, which has severe consequences for food crops and livestock production, which is responsible for community-based food security (File & Derbile, 2020). There has been a significant decline in rainfall overall, which has become problematic regarding time (late beginning and early termination) and intensity (Azene et al., 2018). Limpopo's rural communities already feel the consequences of drought and unpredictable precipitation. According to UNICEF (2011), Limpopo's climate vulnerability in terms of livelihoods is due to a combination of expected climate impacts, high levels of poverty and unemployment, reliance on agriculture for food security and employment, and insufficient access to sanitation, water supply, and healthcare. The most visible consequences of climate change are food insecurity and water scarcity.

Climate change has apparent consequences for food production, availability, accessibility, and usage, contributing to food insecurity and malnutrition, particularly in developing countries (FAO, 2018). The IPCC (2021) acknowledges that crop yield reductions in most tropical and subtropical regions due to increased temperatures and decreased rainfall spells would disproportionately affect the poorest countries. It also jeopardizes local food security by increasing crop failure and livestock deaths (Ndlovu et al., 2020). In Cameroon, a similar study found that small-scale farmers' economic vulnerability to climate-related shocks, such as rising temperatures, causes widespread production uncertainty (Ngondjeb, 2013). The effects of climate change and variability are already felt by Africa's subsistence farmers, according to the Food and Agriculture Organization of the United Nations (FAO, 2018).

The vulnerability to unpredictable rainfall and intermittent drought harms crop production. Another cultural value that demonstrates the communities' susceptibility to climate stressors is cattle production. Cattle are essential in smallholder mixed crop/livestock and pastoral systems for rural income, nutrition, food security, and resilience. They are used as a source of bride price and are slaughtered for ritual purposes. Cattle also provide manure for crop production. As many families no longer raise cattle, goats, and sheep, and instead, stock feed is obtained from nearby white farms. Livestock feed like grass, leaves, fruits, and pods have decreased noticeably due to irregular rainfall patterns, dryness, and shifting meteorological conditions Rankoana and Mothiba, (2015), while reduced milk production and fertility in dairy cattle have been related to increased heat stress in cattle, which is anticipated to worsen as temperatures rise (Maluleke & Mokwena, 2017; Maluleke et al., 2020). Farmers have already had to sell their livestock to cope with reduced availability and higher livestock feed prices during the drought (Maponya & Mpandeli, 2012). There will be an increase in livestock illness and mortality due to decreased rainfall and feed and pasture quality and availability (Maluleke et al., 2020). Delgado and Lopez's (2021) research confirms that disruptions in livestock production will have severe consequences for the lives and livelihoods of the world's millions of small-scale farmers and livestock keepers.

Another finding from the literature is that Limpopo's rural communities need more modern water supply technology. For household consumption, the communities rely on boreholes and river water (DAFF, 2018). Water levels in boreholes, rivers, and springs have reportedly dropped due to persistent drought, with many people finding that a lack of recharging rainfall has disrupted their access to safe drinking water (Rankoana & Mothiba, 2015; DEA, 2018b). According to the Limpopo Socio-Economic Review and Outlook 2022-23, freshwater access for household consumption is already a severe concern in Limpopo. It is predicted to deteriorate due to climate change, which might severely affect sectors like agriculture and human livelihoods. This result aligns with the DEA's (2018b) conclusion, which states that rural water services use less than 5% of all government water supplies. Water is scarce in Limpopo Province, which is predicted to worsen as time passes (Munjonji, 2017). The province still has less than 1,000 households that get their water directly from dams, rivers, streams, or springs; the rest are from water carriers, tankers, or vendors (Limpopo

Socio-Economic Review and Outlook, 2022-23). It suggests that the province's level of access to water still needs to be improved, considering the adverse effects of climate change and increased water needs. These observations support the Intergovernmental Panel on Climate Change's Fifth Assessment Report, which revealed that climate alteration would reduce water resources in southern Africa (IPCC, 2007). Rising temperatures, increased evaporation, unpredictable rainfall, and shifts in the timing of high and low flows pose risks to the water supply (DST, 2010; Zwane, 2019; Patrick, 2020; 2021). South Africa ranges from semi-arid to dry, and its scarce water supplies are depleted by the erratic weather patterns brought on by global warming. Zhu and Ringler (2012) predict that by 2050, South Africa will face severe shortages in its water supply. In a predominantly agricultural province (Limpopo), where roughly 48% of the population lacks access to piped water within their residence or yard, the likelihood of increased water stress is substantial (SANBI, 2011; Zhu & Ringler, 2012). There is a growing concern that drought, one of the world's most destructive natural disasters, could adversely affect agriculture, water supply, energy production, and public health in areas with annual rainfall of less than 500 mm (Patrick, 2021). More thorough policy and spatial research are required to understand the effects of climate change on climate-sensitive resources in these rural areas and the associated coping and planning alternatives (Hosea & Khalema, 2020).

CONCLUSION

The review found that rural communities in Limpopo Province are especially at risk of poverty, hunger, malnutrition, and poor health conditions due to climate variation. These are instigated by climatic conditions such as higher temperatures, less dependable precipitation, and more frequent droughts. These pressures render the communities' livelihoods vulnerable to climatic pressures since they continue to rely on natural resources for food and water. The primary food resources, subsistence crops, and livestock production are rain-fed and thus negatively impacted by climate stressors. Similarly, with poor and low-quality water, water resources are nearing depletion. The trend of erratic rainfall and rising temperatures, resulting in poor subsistence food production and water stress, indicates that climate change makes subsistence livelihoods in rural areas more difficult. The review suggests that more research on rural communities' methods to adapt to climate change and protect their indigenous sources of livelihood is needed. Incorporating indigenous adaptation practices and community voices into climate change adaptation policies could foster the sustainable livelihood of rural communities.

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