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Indigenous adaptation practices for small-scale farmers: lessons for climate policy

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Abstract

Climate change poses a threat to the sustainability of food production among small-scale rural communities that are dependent on rain-fed agriculture. The small-scale farmers use local mechanisms to mitigate and cope with the negative impacts of climate change on rain-fed subsistence crop production. An examination of these indigenous adaptation practices is essential for formulating pragmatic strategies and policies to promote agricultural development and ensure food security. This review paper describes prevalent indigenous adaptation strategies employed by small-scale farmers to maintain agricultural output and guarantee food security. The review is derived from published dissertations, theses, reports, and articles identified purposely from data sources such as Google Chrome, Google Scholar, ResearchGate, and Semantic Scholar. The review findings show that weather forecasts, adjustments in planting seasons, cultivation of short-season crops, application of mulching, diversification of crops, and fallowing are the indigenous adaptation methods adopted to maintain subsistence crop production and provide food security at the household level. These practices are mitigation and adaptation strategies used to secure the long-term availability of food in households, considering the challenges posed by climate change. Integrating these indigenous methods into climate change adaptation policies can lead to the development of effective climate response policies that promote sustainable food security.

Keywords: Climate Change; Climate Change Adaptation; Small-Scale Farming; Indigenous Knowledge; Food Security

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1. Introduction

Climate change, manifested in unpredictable rainfall, droughts, floods, and shifts in temperature poses a significant threat to people's livelihoods (Intergovernmental Panel on Climate Change [IPCC], 2022). Studies assessing the impact of climate change have shown that alterations in precipitation patterns and temperature rise are placing strain on agriculture, water resources, and human well-being. These negative effects are expected to persist and worsen in the future (Guo and Liu, 2022; Pisor, et al., 2023). Food production in rain-fed agricultural communities is jeopardised by climate change (Rankoana, 2022). Gaining insight into the adjustments made by farmers and the factors influencing their decision-making in adapting to changing conditions is essential for formulating practical plans and policies to promote agricultural development and ensure food security (Legese et al., 2018). However, it is imperative to address the impacts of climate change and other environmental factors on the agricultural sector by implementing effective adaptation strategies to enhance resilience and minimise vulnerability. The often-employed adaptation strategies include the introduction of drought-tolerant animal breeds; implementation of crop irrigation and diversification practices; adoption of mixed-crop farming systems; and adjustment of planting schedules. Climate change mitigation and adaptation are essential in sustaining subsistence crop production, whereas climate change adaptation programmes were created by government and non-governmental institutions to mitigate the effects of climate extremes on agricultural production (IPCC, 2022). These activities encompass the recognition of shifts in climatic conditions, analysis of their causes and effects, formulation of strategies to mitigate risks, establishment and execution of adaptation policies, and subsequent monitoring and evaluation to enhance progress and growth. Adapting to climate change in this manner is crucial for mitigating climate-related risks. It focuses on reducing emissions and removing carbon, which in turn decreases greenhouse gas emissions. This ultimately reduces the exposure and vulnerability to climate hazards. It is crucial to note that small-scale farmers employ indigenous adaptation mechanisms derived from their traditional ecological knowledge. This study investigates the prevalent indigenous adaptation strategies employed by small-scale farmers to maintain agricultural production and guarantee food security. The review is grounded on publicly available dissertations, theses, and publications concerning the effects of climate change and the measures taken to adapt to subsistence crop production. The primary factor contributing to this is the predominant presence of small-scale farmers in the Limpopo Province of South Africa who depend on rain-fed subsistence agricultural output as their primary means of sustenance.

Most indigenous farmers in South Africa rely on rain-fed agriculture for their livelihoods (Kom et al, 2023). However, climate extremes in the form of increased rainfall variability and elevated temperatures are anticipated to significantly affect small-scale agricultural production (Adisa et al., 2018). The increased frequency and intensity of droughts, along with greater variability in rainfall, will adversely affect crop production (Olabanji et al., 2021). Limpopo Province, among the nine provinces of South Africa, faces the most severe climate risks that jeopardise crop production and the livelihoods of small-scale farmers (Maponya and Mpandeli 2013; Kom et al. 2022). The province's semi-arid characteristics exacerbate these risks, as around two-thirds of the agricultural land experiences an average annual precipitation of less than 450mm during winter seasons (Maponya and Mpandeli 2012). High temperatures, extended drought periods, and variability in rainfall are significant factors expected to considerably affect crop production (Afful and Ayisi, 2020). However, the farmers use indigenous knowledge to support the prevailing rain-fed subsistence crop production by tackling climate stressors and improving decision-making for adaptation (Maponya and

Mpandeli, 2014; Rankoana, 2022). Ubisi et al. (2017) assert that local farmers in the Limpopo Province utilise indigenous knowledge to address climate change challenges. An examination of these indigenous adaptation practices is essential for their analysis and subsequent recommendation in climate change response policymaking.

This review presents information on the prevalent indigenous adaptation practices used by small-scale farmers in the Limpopo Province of South Africa. These results may assist policymakers in incorporating culture-specific adaptation strategies into existing climate response policies to enhance crop production and ensure food security. Kom et al. (2023) contend that scientific knowledge is inadequate for addressing climatic risks faced by indigenous farmers, emphasising the necessity for local adaptation practices.

2. Methodology

This review is based on a literature review to describe the indigenous adaptation practices adopted by small-scale farmers for sustainable food security in Limpopo Province, South Africa. The study employed a systematic literature review methodology to examine and analyse data about local climate change perceptions, its impacts on subsistence food production, and the local practices adopted by the farmers to mitigate and adapt to climate extremes. The main sources of information are databases like Semantic Scholar, Elsevier, Google Scholar, ResearchGate, Taylor & Francis, Sage, and Wiley online libraries. Research publications, dissertations, theses, and research reports were selected and used regardless of publication dates. Themes, sub-themes and topics relating to adaptation practices adopted by small-scale farmers were selected, compared and recorded.

3. Results and discussion

3.1. Indigenous adaptation practices in subsistence crop production

The indigenous adaptation strategies discussed in this review are derived from climate change research undertaken in Limpopo Province of South Africa, and other places in the country supported by studies conducted in other parts of the globe. These measures are implemented to cope with the effects of unpredictable and delayed rainfall, as well as increasing temperature trends, which have a detrimental impact on crop production. Subsistence crop producers adapt to the current and anticipated effects of climate change by mitigating damage and capitalising on any favourable circumstances that may arise. The review findings indicate that subsistence farmers employ indigenous practices to cope with the impact of climate change on agricultural yields. Farmers, for instance, are progressively depending on their proficiency in forecasting precipitation to adapt to climate change. According to Maponya and Mpandeli (2013), rural farmers in Limpopo Province are confronted with the difficulties posed by the effects of climate change on agricultural productivity, and as a result, they have devised adaptation strategies to mitigate these impacts. Rankoana (2017) acknowledges that indigenous knowledge empowers small-scale farmers to improve subsistence farming in the face of seasonal and climatic fluctuations. These observations corroborate Rajaskeran's (1993) acknowledgment that local communities employ practices to deal with the uncertainties of the local environment. For Kom et al. (2022), indigenous adaptation practices are structured and comprehensive

collection of information that is acquired by local communities via informal experimentation, practical experience, and a profound comprehension of their cultural surroundings used to cope with the negative impacts of climate change on crop production.

Regrettably, the documentation of these local adaption efforts has been inadequate. Despite the limited adaptation abilities of individuals in poor nations, it is undeniable that these abilities have successfully supported the production of crops for basic survival over time. Egeru (2012) acknowledges that African communities have persistently depended on indigenous knowledge for environmental conservation and managing natural calamities. Empirical data indicates that analysing the effects of climate change on food security at the micro or household level provides a focused approach to enhancing the ability of individual households to adapt to climate change to reduce vulnerability to food insecurity (Akaba and Akuamoah-Boateng, 2018; Dadzie et al., 2021). Utilisation of indigenous knowledge in subsistence farming can be advocated as an adaptable strategy to maintain the livelihood of rural populations, with the capacity to ensure food security (Kadi et al., 2011; Food and Agricultural Organisation [FAO], 2013; Gedefaw et al., 2018). However, the following adaptation practices were reported in the literature on climate change and indigenous knowledge evolved out of subsistence farmers' ecological knowledge and cultural values.

3.1.1. Weather forecast

Evidence from the literature shows that small-scale farmers use indigenous methods to cope with the effects of global warming on their agricultural yields. Farmers, for instance, are increasingly depending on their knowledge and skills in forecasting precipitation to adapt to climate change. To forecast rainfall, it is necessary to observe the behaviour of different animal and plant species, as well as the movement and location of the moon and sun (Maponya and Mpandeli, 2013; Kom et al., 2022). The farmers employ indigenous knowledge forecasts to anticipate weather patterns through the observation of the behaviour of prominent fauna, avifauna, flora, insects, and celestial bodies (Makondo and Thomas, 2018; Shikwambana and Malaza, 2022). From the study of Rankoana (2022), indicators such as the emergence of tree leaves and flowers, to forecast rainfall are also relied upon to predict the next season. The onset of summer is characterised by the proliferation and foliage expansion of Senegali species. Furthermore, alongside the study of plant phenology, meticulous attention is given to the observation of celestial bodies such as stars, the moon, and the sun at the onset of September, signifying the commencement of a fresh season (Rankoana, 2022). The signals of these heavenly bodies are considered to indicate either a favourable or unfavourable season. For instance, if Mars is positioned in the western direction, it indicates a favourable year, however if it vanishes in the eastern direction, it forecasts an unfavourable season characterised by scanty rainfall (Shikwambana and Malaza, 2022). According to Maponya and Mpandeli (2013), there is a belief that when the horns of the crescent moon are directed towards the Earth, it results in rainfall, and when they are pointed away from the Earth, it prevents rainfall.

This form of rainfall prediction supports the notion that, before the development of scientific weather forecasting, previous generations, particularly in the rural regions of Tanzania, heavily depended on traditional knowledge to forecast weather (Kadi et al. 2011). For instance, individuals utilise the conduct of animals and plants to forecast the forthcoming agricultural season. Kaua (2020) demonstrate the significance of indigenous knowledge in agricultural decision-making to address expected low crop yields. Tanzanian farmers in the Malunga region utilise Senegali phenology as a method to forecast rainfall and predict the forthcoming rainy season. The Chibelela farmers validate their prediction of rain by utilising the moon and stars as celestial

indicators. Assessment and prediction frequently relied on a variety of indications, including plants, animals, insects, climatic conditions, and astronomical events (Egeru, 2012). A halo moon, characterised by a yellow ring surrounding the moon, serves as a reliable indicator for the imminent arrival of rain throughout both the short and long rainy seasons. In September, the north-south wind direction is considered a reliable signal of the beginning of a brief rainy season and a precursor of substantial rainfall in the future season (Roncoli et al., 2002). High temperatures and increasing warmth in the late stages of the dry season suggest a favourable rainfall season. Per Egeru's (2012) findings, a night with elevated temperatures will be succeeded by a rainy day. Signs of an unfavourable rainy season encompass the abundant blossoming of mango and peach trees. Birth patterns can be utilised to forecast weather or seasons. For instance, a substantial increase in the birth rate of male offspring and animals during a specific season is sometimes interpreted as an indication of an impending unfavourable season. Furthermore, the alignment of the moon can be utilised to forecast an unfavourable season; when the moon is tilted towards the horizon, it is believed that there would be reduced rainfall on the tilted side.

3.1.2. Change of planting season

If a bad season is anticipated, agricultural activities will be abstained from, particularly in the absence of adequate precipitation during the optimal season. The primary factors that exert pressure on the production of subsistence crops are increasing temperatures and the postponement of rainfall. Consequently, the farmers opt to modify the usual planting season, which typically occurs between late November and December (Maponya and Mpandeli, 2013). Raza et al. (2019) concede that changing the planting season would be beneficial due to the impact of climate change stresses on grain production, morpho-physiology, and yields. Local farmers already employ the strategy of postponing their planting activities to mitigate the risk of crop loss (Kelbessa, 2007). For Legese et al. (2018), in the subsistence agricultural sector, commonly used adaptation strategies involve adjusting planting schedules to mitigate the adverse effects of increasing temperatures and limited precipitation. Ali and Erenstein (2017) acknowledge that changing the time when seeds are planted is a crucial approach to reduce the risks associated with climate unpredictability and enhance the ability of crop plants to respond, thus assuring food safety and security. Selecting the appropriate time to plant crops is a critical strategy for managing the impact of weather-related pressures (Battisti et al., 2018).

3.1.3. Growing short-season crops

Higher temperatures and unpredictable rainfall patterns are anticipated to decrease crop yields. Nevertheless, farmers take preventive precautions to prevent crop loss by planting short-season crops in anticipation of unpredictable rainfall and the absence of rainfall during their growing season (Shikwambana and Malaza, 2022). Short-season crops possess significant potential to mitigate the difficulties posed by unpredictable and delayed precipitation. It is anticipated that crop production will be diminished because of rising temperatures and increasing fluctuations in rainfall patterns (Berhe et al., 2023). Early maturing varieties can be highly advantageous for farmers as they allow plants to go through important developmental stages before experiencing stress (Dhankher & Foyer, 2018). The primary component that reduces yield is referred to as this practice (Gardi et al., 2022). Acevedo et al. (2020) found that farmers adjust their production and farm

management practices to deal with climate change. These adjustments include changing the timing of planting, using irrigation when available, practicing intercropping, adopting conservation agriculture, utilising crop and seed storage infrastructure for both short- and long-term purposes, and switching to more climate-resilient crop varieties.

3.1.4. Growing climate resilient crops

Amidst several native crops cultivated in the area, subsistence farmers opted to plant climate-resilient crops such millet, almonds, beans, and melons to cope with the challenges posed by climatic stressors. These crops exhibit resilience and can withstand and rebound from the impacts of climate change (Maponya and Mpandeli, 2013; Kom et al., 2022; Rankoana, 2022). They employ this strategy to uphold or enhance agricultural productivity in the face of challenging circumstances such as drought, flooding, and heat (Makonde and Thomas, 2018). Acevedo et al. (2020) corroborate that climate-resilient crops and crop varieties are adopted to tackle various challenges related to climate change and the sustainability of crop systems. These challenges include enhancing soil moisture retention, improving soil quality, mitigating erosion through the planting of cover crops and legumes, and reducing susceptibility to food insecurity. Acevedo et al. (2020) confirm that small-scale producers employ climate-resilient crops and types to mitigate abiotic pressures such as drought, heat, and flooding. Cultivating crops that are adaptable to climate conditions decreases the likelihood of complete crop failure due to drought and fluctuations in temperature (Dhankher and Foyer, 2018). Majority of subsistence farmers acquire climate-resilient seeds and fertilisers by utilising the assistance of agricultural extension agents Acevedo et al. (2020). In their 2018 study, Dhankher and Foyer suggest that in countries where subsistence agriculture is crucial for ensuring food security, a key proactive measure to address food insecurity resulting from unpredictable weather patterns is for farmers to embrace climate-resilient crops.

3.1.5. Mulching

Residual remains from previous harvests, such as maize stalks, dried beans, and nut plants, serve as effective soil stabilisers. After the harvest, which takes place between May and July, the leftover plant material is mixed into the soil to enhance its ability to hold moisture and increase its fertility (Rankoana, 2022). During instances of drought, mulching is crucial for the survival of crops. Applying mulch to the soil will decrease the rate of water evaporation. Mulching enhances soil quality by disintegrating clay particles, hence facilitating improved water and air permeability within the soil (Kom et al., 2022). The advantages of this approach encompass the preservation of moisture, deceleration of flood waters, mitigation of climate fluctuation and change, reduction in the requirement for pesticides, generation of healthier crops, and suppression of weeds (Maponya and Mpandeli, 2012; 2013). Mulching aids in the preservation of soil moisture, the prevention of soil deterioration, and the safeguarding of vegetables against heavy rains, extreme temperatures, and flooding (Pena and Hughes, 2007). Ullah et al. (2022) support that mulching refers to the application of organic or inorganic materials to the surface of the soil. This practice aims to enhance soil structure, preserve soil moisture, regulate soil temperature, and mitigate issues related to nutrient loss, salinity, and erosion. Koundinya et al. (2018) found that mulching is beneficial for restoring damaged soils, increasing land productivity, and promoting soil biodiversity (Wang et al., 2018), thus mitigating soil moisture evaporation, regulates soil temperature, inhibits weed proliferation, and diminishes soil runoff and erosion.

3.1.6. Crop diversification

The sowing of seeds is carried out in a random and disorganised manner by manually scattering them, without any consideration for different seed varieties, all of which are planted together in the same field. This approach optimises the simultaneous growth of all crops in the same field (Maponya and Mpandeli, 2012; Mpandeli et al., 2015). Inter-planting enables cropping systems to recycle their own stored nutrients. According to Maponya and Mpandeli (2013), the productivity per unit area is greater in this system compared to monocropping systems with equivalent management levels. Traditional multi-cropping is a farming practice where numerous crop seeds are planted together in a single field to maximise the chances of multiple crops reaching maturity simultaneously (Kom et al., 2022). In this type of crop production, the farmers employ a diverse range of crops with varying growth patterns in both fields and home gardens to optimise the potential for cultivating numerous crops (FAO, 2013). Crop diversification reduces the likelihood of crop failure by cultivating multiple varieties of crops that have different levels of vulnerability to factors such as droughts, floods, pests, and so on (Mirjam, 2008). In their study, Mahoo et al. (2007) found that farmers implemented crop diversification strategies to optimise crop productivity based on the amount of rainfall they had access to. Intercropping, mixed cropping, relay cropping, and strip cropping enhance agricultural production and productivity. In such conditions, the implementation of on-farm diversification is a viable approach for farmers to adjust to climate change. This technique is more advantageous than monocropping because if one crop fails, the loss can be offset by the output from another crop (van Zonneveld et al., 2020). Vernooy (2022) acknowledges that cultivating a diverse range of crop varieties is a strategic approach to counteract the negative effects of climate change on agriculture and enhance the ability of rural households and communities to withstand and recover from its repercussions.

3.1.7. Fallowing

Intensive crop cultivation leads to a gradual decrease in soil fertility. This frequently necessitates the farmer to grant his field a period of repose. The duration of the period in which the field is permitted to rest or remain uncultivated ranges from one to three years (Shikwambana and Malaza, 2022). As an uncultivated field exhibits robust flora the foliage will naturally decay, enhancing the soil's nutrient content. Field fallowing allows for the restoration of soil fertility (Rankoana, 2022). In addition, cattle, sheep, and goats are herded into the fields to graze on coarse grass, simultaneously contributing to soil fertility through their droppings (Maponya and Mpandeli, 2013). According to Traba and Morales (2019), fallow is an agricultural practice where cultivated land is intentionally left uncultivated for one or more growing seasons. This allows the land to regenerate and accumulate organic matter, while also preserving moisture and disrupting the life cycles of pests and soil-borne pathogens by temporarily removing their hosts (Gedefaw et al., 2018).

3.2. Policy implications

Subsistence food production is essential to achieving the objective of ensuring food security, particularly at the household level. Nonetheless, subsistence production cannot attain food security amidst the prevailing threats of climate change unless farmers employ indigenous knowledge to mitigate and adapt to climatic extremes. Indigenous knowledge has intrinsic norms of organic sustainability that have sustained communities for years. Indigenous knowledge in agriculture fosters sustainable cultivation practices through the application of eco-

friendly farming techniques. Indigenous agricultural practices are intricate, ecologically sustainable, economically viable, and culturally specific; they are essential for the cultivation of native crops among indigenous communities (Vilakazi et al., 2022). These knowledge systems encompass diverse cultural practices, wisdom, traditions, and epistemologies that yield precise and valuable information, observations, and solutions regarding climate change (Kom et al., 2022). For the past century, indigenous knowledge has assisted rural farming households in addressing climate stressors and improving adaptation decision-making (Kom et al., 2022; Diko, 2023). Mafongoya and Ajayi (2017) concede that this knowledge can play a crucial role in enhancing climate resilience within smallholder farming communities by facilitating a deeper comprehension of methods to promote climate-resilient innovations that are acceptable to these communities. This is because of the notion that Western scientific assessment methods have only recently recognised the intrinsic worth of indigenous and local knowledge (Diko, 2023). Climate response policies must incorporate the traditional, ecological, economic, and socio-cultural knowledge of local farmers (Ajani et al., 2013). Integrating the knowledge of small-scale farmers into agriculture may facilitate the formulation of new policies and adoption strategies that correspond with their expertise and practices for the effective implementation of climate mitigation measures. The suggestion to incorporate indigenous adaptation strategies into climate change adaptation is endorsed by Article 6 of the UNFCCC (2015), and the IPCC (2022) which established a mandatory obligation for countries to encourage public involvement in tackling climate change.

4. Conclusions

Subsistence food production is essential to achieving the goal of ensuring food security, especially household-level food security. However, subsistence production cannot achieve food security under the current threats of climate change impacts unless the farmers use local mitigation and adaptation practices. The present review outlines the local adaptation practices adopted by small-scale farmers to address the negative impacts of unpredictable rainfall and rising temperatures on rain-fed subsistence food production. The review findings indicate that weather forecasts, alterations in planting seasons, cultivation of short-season crops, application of mulching, diversification of crops, and fallowing are the indigenous adaptation strategies commonly used to sustain subsistence crop production to provide food security at the household level. These indigenous adaptation strategies bear resemblance to the strategies employed by small-scale farmers in Africa and other regions across the globe. Developing climate response policies that incorporate indigenous knowledge coping mechanisms can lead to effective and sustainable responses to the impacts of climate change on food production.

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