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Small-scale farmers’ indigenous knowledge for rainfall forecasting: the case of a rural community in Limpopo Province, South Africa

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Abstract

Small-scale farmers rely on indigenous knowledge of weather and climate forecasting to effectively manage and adjust to unpredictable and severe weather changes caused by climate change. The objective of this study was to describe the local precipitation forecasting processes utilised by small-scale farmers, as they rely on rainfall and suitable weather conditions to plan their agricultural activities. A purposive sample of 45 small-scale farmers in the Waterberg District of Limpopo Province, South Africa, participated in semi-structured interviews. The study findings indicate that the farmers relied on their knowledge of weather and climate forecasts to predict rainfall. The primary indicators utilised to forecast the upcoming rainy season include observations of wind direction and intensity, the position and movement of celestial bodies such as the moon and stars, cloud formations, and temperature conditions. This study proposes the incorporation of traditional knowledge into scientific climate forecasts to formulate climate-smart adaptation policies that will strengthen the ability of small-scale farmers susceptible to climate change to cope with its impacts. Implementing such climate strategies despite their limitations in terms of lack of precision, availability, and proper understanding of meteorological data could enhance rainfall predictions and agricultural output to mitigate household food insecurity.

Keywords: Indigenous Knowledge; Climate Change; Weather Forecasting; Rainfall Prediction; Small-scale Farmers

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1. Introduction

Despite the availability of modern technology to predict the weather conditions over the next few days or months, the indigenous weather predictions have remained important forecasts to date. Many local communities, particularly small-scale farmers, plan their planting seasons based on indigenous rainfall predictions. Reliance on meteorological data to forecast the weather may inconvenience ordinary people, especially subsistence farmers in rural areas where access is mainly through networks and television. This study was inspired by the observation that small-scale farmers in rural South Africa continue to rely on rain-fed crop production to ensure household food security. Crop failure due to erratic rainfall and intermittent drought would result in household food insecurity. Erratic rainfall patterns in developing countries like South Africa harm small-scale farmers' efforts to improve food security and reduce poverty (Mpandeli et al., 2015; Shikwambana et al., 2021). However, small-scale farmers' vulnerability to climate shocks can potentially be reduced by using reliable climate and weather forecast information to actively influence important farm decisions. Indigenous weather and seasonal climate forecasting knowledge are important components of a potential strategy for making agricultural decisions and reducing vulnerability to environmental hazards. Early forecasting decisions are made entirely with knowledge accumulated over generations of local observations, according to Mafongoya et al. (2017). Indigenous Africans have relied on close observations of environmental phenomena for weather forecasting since time immemorial (Tasara and Maposa, 2012), which have been used to aid in decision-making under conditions of rainfall uncertainty.

Traditional rain-fed farmers employ indigenous knowledge, encompassing local indicators and experiences, to observe and forecast rainfall (Radeny et al., 2019). Kumar et al. (2021) argue that smallholder farmers make their farm decisions by relying on indigenous or local customs, which involve the use of specific local environmental indicators, traditional calendars, and belief systems. These indicators involve observing meteorological events derived from the environment and celestial bodies to predict the impending rainy season (Adanu et al., 2022; Mushimbei and Libanda, 2023). The most often employed local observations include variables such as plant and animal behaviour, meteorological fields (e.g., wind speed and direction), and astronomical indicators (e.g., the sun and stars) to regularly assess and forecast rainfall and seasonal climate patterns to inform their decision-making processes related to farming activities (Shoko and Shoko, 2013; Adanu et al., 2022). Paparrizos et al. (2023) support that weather and climate predictions related to animals, plants, and astronomy are common among subsistence farmers. According to Mafongoya et al. (2017), these types of climate predictions are useful in decision-making to best exploit the seasonal distribution of rainfall to increase or stabilise crop yields.

The current study describes indigenous rainfall forecasting techniques used by small-scale farmers in a rural community in South Africa's Limpopo Province. The study describes indigenous methods of rainfall forecasting from the community perspective. The study makes a significant contribution by emphasising the importance of indigenous knowledge systems in weather prediction, which is used to plan the planting season to adapt to and cope with the effects of erratic rainfall and drought on subsistence food production. The study proposes combining indigenous knowledge of rainfall predictions with meteorological data produced by scientists to improve rural farmers' resilience and adaptive capacity. Mafongoya et al. (2017) support this viewpoint, arguing that with a good understanding of indigenous knowledge, policy planners, and climatologists would be better able to integrate indigenous knowledge with scientific knowledge, instigate development initiatives that are both environmentally and socially appropriate, and thus more sustainable.

2. Method

2.1. Study area

The research is based on fieldwork in the Mogalakwena community in the Mogalakwena Local Municipality in Limpopo Province, South Africa, between 2014 and 2019. Mogalakwena community falls within the Rebone area, which has a total area of 20 km2 and some total residents of about 15579 (Mogalakwena Local Municipality Integrated Development Plan, 2023/2024). The family units are scattered along the N11 and R518 roads. The community is in the province's summer rainfall region, with the rainy season lasting from November to March. The average rainfall is 600-650 mm per year, with the highest amounts recorded in January and December. Thunderstorms occur fairly frequently. The summers are hot but pleasant, and the winters are mild and sunny. Summer temperatures range from 27°C to 30°C. The area's topography is defined by irregular, undulating lowlands with hills and low-lying mountains. Inadequate sanitation systems, erratic rainfall, drought, poor production of subsistence crops, and inconsistency in water supply are all environmental challenges. Mines and industrial activities have a negative impact on the quality of underground water. The local municipality is the largest contributor to domestic fuel burning releases, accounting for approximately 52% of emissions (Mogalakwena Local Municipality Integrated Development Plan, 2023/2024). Mogalakwena Community is a rural settlement with a mix of huts and modern brick houses as dwellings. The village is a residential area comprising demarcated housing stands with delineated ploughing fields located about 700 meters away from the village site in a flatter and red-sandy area. Even though rainfall is scarce and excessive heat is destroying crops, subsistence crop production continues (Rankoana, 2022).

2.2. Study design

2.2.1. Participant selection

A qualitative study was conducted to describe the indigenous knowledge utilised by small-scale farmers to predict rainfall. Forty-five subsistence farmers were purposely selected to participate in the study. Their identification was achieved by conducting daily walks on the village site and ploughing fields. The farmers were involved in cultivating traditional subsistence crops in their home gardens and fields exclusively for household consumption. The age of the farmers varied from 18 and 72 years, with a total of 33 males and 12 women. The farmers willingly accepted to take part in the study by signing the consent form.

2.2.2. Data collection

Information was collected by direct engagement with the farmers. The interview schedule functioned as a tool for gathering data on the indicators used for rainfall predictions. The interviews lasted for about 45 minutes to one hour for each participant. Semi-structured interviews were conducted in Sepedi and subsequently translated into English to facilitate the farmers' uninhibited and assured participation in the study. Nonetheless, a proficient linguist provided aid in translating and editing the responses.

2.2.3. Data analysis

The thematic content method was employed to analyse data. The utilisation of this analytical approach was beneficial as it examined and quantified the occurrence, significance, and correlation of specific words and concepts, thus drawing logical conclusions. The data were organised to identify and interpret thematic classifications, identify any inconsistencies and contradictions, and draw conclusions regarding the indigenous knowledge utilised for rainfall prediction. Thorough data reviews were conducted with the farmers to ascertain completeness and reliability of the acquired data. Subsequent inquiries and casual conversations with the farmers were scheduled to clarify and validate the data.

3. Results and discussion

The behavior of the animal and plant species, as well as the position and appearance of the moon and the sun, are used to forecast the onset of the rainy season and the amount of rainfall during the agricultural season. Farmers reported that these forecasts help them plan their planning schedules. They demonstrated that when rain is forecast to be scarce, cultivation of subsistence crops such as maize, nuts, beans, and melons is limited. Several indications have been reported as being used to forecast rainfall.

3.1. Atmospheric conditions

The farmers mentioned that they pay close attention to atmospheric parameters as they predict rainfall.

3.1.1. Wind direction

Farmers reported that if the wind blew continuously from south to north, they would expect more rain. Borwa (wind from the south) is the common name for the wind. The wind blowing from east to west in August foretells a dry season. The wind direction in the context of a locality is important in determining rainfall patterns (Okonya et al., 2013). The observations of Balehegn et al. (2019) support the idea that wind that flows from south to north indicates heavy and destructive rainfall.

3.1.2. Whirlwind

The farmers reported frequent whirlwinds in August to mid-September as a sign of good rain. Balehegn et al. (2019) concede that any form of wind in its strongest form predicts a good rain season.

3.1.3. Hail

For the farmers, small-sized hail during the first rainfall season signifies the prospect of a good rainfall season. The common belief is that hail size symbolises grain (sorghum, millet, and maize), indicating a good season with rainfall and a good harvest. Mosime (2018) agrees that local knowledge indicators are used to predict the onset of rainfall and the quality of the rainfall expected.

3.1.4. Clouds

Dark clouds, according to the farmers, bring rain. Their appearance indicates a high likelihood of rain. This observation supports studies conducted in Limpopo Province, South Africa, by Mpandeli et al. (2015) and Jiri et al. (2016), which found that black clouds indicate the impending arrival of heavy rain. Mashonjowa et al. (2015) confirm that dark, towering clouds frequently observed in the southwest predict rainfall.

3.1.5. Increased temperature

A common saying among the farmers was that '*Letšatši le fiša kudu, le tliša pula*', literally meaning temperatures are high and will bring rainfall. High temperatures, particularly in September and October, indicate a wet season ahead. Another observation was that higher temperatures at the start of spring portend a pleasant season with plenty rain, whereas high temperatures at night indicate a chance of rain the next day. These findings back up Ogallo et al.'s (2000) claim that high temperatures in October and November signal the start of a good rainy season. These observations also corroborate the small-scale farmers' assumptions about the coming season by observing natural phenomena such as the period, intensity, and duration of cold or hot temperatures (Elia et al., 2014). Rainfall forecasts are commonly associated with the occurrence and intensity of high temperatures (Afful and Ayisi, 2020).

3.2. Plants

The use of tree phenology as a predictor of rainfall probability was mostly reported by the farmers. As a result, the flowering and leaf sprouting of the Senegali species signal the start of the summer and rainy season. Although key plant species have disappeared due to deforestation and climate change, the few that remain continue to provide signals observed many years ago. For example, the flowering density of Senegali species predicts the type of season to come. Accordingly, at the beginning of September, the Senegali plant species produce yellow flowers, signaling the beginning of a good season with impending rainfall. If the flowers are pale, they indicate a bad upcoming season with little rain, while deep yellow flowers predict a good season with plenty rainfall. These findings support Archaya's (2011) and Kom et al.'s (2022) findings that unusual flowering of plants and increased length of inflorescence are traditional indicators of impending rainfall.

3.3. Animals

3.3.1. Livestock

The farmers observed changes in the behavior of their livestock closely as they also predict the rainy season. For example, it is reported that the male dominance of livestock calves as opposed to the female dominance or a balance thereof, predicts famine, which simply means a season of less rainfall and lower crop yields.

3.3.2. Locusts

The appearance of a swarm of tšie (edible insects) in the springtime has been linked to erratic rainfall. Chang'a et al. (2010) reported a similar prediction in Tanzania, where the presence of more grasshoppers each year indicates less rainfall and hunger.

3.3.3. Birds

Rainfall is predicted by the song and movement of the hlahlamedupe (rainbird). The bird sings from tall trees, such as the Senegali species. Farmers forecast the amount of rainfall based on whether or not the bird is ever seen or heard singing for rain. According to Mapara (2009), people could also predict whether rain would fall in the next hour or two if they heard the dzvotsvotsvo (rain bird). However, when the migratory birds disappear from a specific area or region, it is an indication of a decrease in rain (Mapara, 2009). Okonya et al. (2013) add that bird song early in the morning in October indicates the start of the rains and a good rainy season.

3.3.4. Butterflies

The farmers believed that the appearance and movement of butterflies were good indicators of impending rainfall. The intensity and movement of butterflies from west to east indicate a rainy season. Chang'a et al. (2010) made a similar observation, stating that the appearance of many butterflies indicates the onset of early rainfall and the possibility of a good season. In Uganda, on the other hand, butterflies are an important indicator of the end of the rainy season (Nkuba et al., 2020).

3.4. Astronomical

The farmers reported that at the beginning of September, the presence and position of stars, the moon, and sun are carefully observed as they predict the beginning of a new season. The following were reported:

3.4.1. Sun

The farmers predicted impending rain by observing the sun's position prior to the rainy season. When the sun is positioned in the northwest prior to the rainy season, it predicts imminent rainfall. These observations in search of rainfall clues are very common among many indigenous people (Mafongoya et al., 2017).

3.4.2. Star

For the farmers, the movement of the stars from west to east at night under a vibrant sky indicates that rain will fall for a few days. The appearance of star constellations and their timing indicate rainfall patterns and when farmers should plant their crops (Mpandeli et al., 2015; Mafangoya et al., 2017).

3.4.3. Moon

Farmers also look to the moon to forecast the arrival and intensity of the rainy season. Its appearance was thought to chase away rain. As a result, rain is usually abundant when the moon does not appear for an extended period during the night. Similarly, seasonal changes in Malawi have been predicted using astronomical signals such as a circle around the moon (Kalanda- Joshua et al., 2011). Mafangoya et al. (2017) support that the full moon will indicate dry weather. There have been observations that when the moon crescent faces upwards, it indicates water retention, and when it faces downwards it indicates water release (rain) (Zuma- Netshiukhwi et al., 2013), whereas the disposition of the new moon indicates more disease and erratic rainfall.

In this study, the farmers continue to rely on traditional weather forecasting knowledge by observing environmental changes such as the flowering and fruiting of plants, the lunar cycle, and insect behavior, to generate early warning signs of drought events. The forecasts help to predict rainfall in the coming seasons. The predictions have cultural and religious dimensions because they are informed by the people's cosmological views. These are embedded in the views and understanding of the interconnectedness of natural phenomena and resources reinforced by the weather and rain predictions, in which small-scale farmers use plant phenology, birds, insects, wind direction, and the solar system to predict the weather. These observations corroborate the findings that subsistence farmers rely heavily on local climate indicators such as mist cover on mountains, stars and moon movements, the presence of red and black insects, and the flowering and budding of specific plants (Acharya, 2011; Balehegn et al., 2019). For Matakala and Brigadier (2023), prominent indicators of rainfall prediction that affect plants are weather-related parameters, astrological indicators, biological and meteorological indicators. Similarly, Zongo et al. (2022) reported the main categories of rainfall prediction indicators as animals, plants, celestial bodies, and atmospheric conditions. Rainfall is predicted in the environment by the behavior of some birds and insects, the phenology of some plant species, the direction of the wind, and the moon and star cycles (Zongo et al., 2022). These are the indigenous ecological indicators described by Nyadzi et al. (2020) as the most used signs by rural communities to predict the weather and seasonal climate. In the study, the farmers' prediction of rainfall is mostly about the timing and intensity measured through observations of phenomena in the natural environment. This type of forecasting knowledge is primarily based on experiences (Nyadzi et al., 2020) and is used to predict the start and the end of the rainy season as well as the nature of the upcoming season. The farmers' forecasts, according to Mafangoya et al. (2017), focus on the type and timing of rainfall rather than total quantity, which is critical in scientific forecasting.

Afful and Ayisi (2020) make an outstanding observation that small-scale farmers in the rural areas have limited knowledge about the concept of climate variability and change, but they observe and experience changes, such as decreasing rainfall, early cessation of rainfall, increases in temperature, increased frequency of drought, and shorter growing seasons. According to Mafongoya et al. (2017), as the world warms, traditional weather indicators may become less valuable as individual species will adapt to local climatic impacts in unpredictable and idiosyncratic ways. Animals' behaviour may change, whereas plants may begin flowering at different times. These modifications will render indigenous forecasting systems less useful in the future. However, increasing farmers' access to scientific knowledge and technologies like early warning systems may help reduce their vulnerability to climate change.

4. Conclusion

The study describes the indigenous rainfall forecasts used by subsistence farmers. The findings present atmospheric conditions, plant phenology, animal behaviour, and astronomical observations as prevalent environmental indicators employed in rainfall prediction. In the study, subsistence farmers rely on this indigenous knowledge to predict rainfall and make decisions about crops and farming practices. Nevertheless, the persistent reliance on rainfall in subsistence crop production highlights the necessity for more dependable climate and weather forecasts to inform decision-making. A comprehensive approach is recommended to formulate climate change adaptation policies that use indigenous knowledge and scientific weather and climate projections in order to strengthen the resilience of vulnerable subsistence crop producers. Integration of the two prediction methods could have the potential to significantly improve rainfall forecasts and ultimately agricultural productivity at the farm level (Mushimbei and Libanda, 2023). Kom et al. (2023) contend that indigenous knowledge of rainfall forecasts cannot easily be abandoned in favour of other knowledge systems as is suitable, credible, and easily used by rural farmers than western scientific weather information. Mudekhere et al. (2023) support this contention by showing that small-scale farmers in Kenya embraced different climate change adaptation strategies, including the use of indigenous and scientific weather forecast methods for agricultural decision-making. Adoption of this integrated adaptation approach is justified by Paparrizos et al. (2023), who argue that although scientific weather forecasts are available, many farmers, especially in the Global South, have limited access to this information, and they rely on local forecast knowledge to make farming decisions. Research conducted since the year 2010 indicates that smallholder farmers around the globe use both local and/or scientific forecasting knowledge on weather and climate (Gbangou et al., 2021; Kumar et al., 2021; Orlove et al., 2010). However, the promotion of this integration may be restricted by limitations that could hinder the complete utilisation of the scientific seasonal climate and weather forecast for the advantage of farmers. An example of a significant constraint on the establishment of comprehensive climate change adaptation policies could be the lack of precision, availability, and proper understanding of meteorological data.

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