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Values of Indigenous Knowledge in Droughts and Floods Forecasting in Semi-Arid Lands of Kenya

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A B S T R A C T

Droughts and floods weather conditions are among the most pressing environmental challenges in Kenya's semi-arid lands, at times resulting in severe negative consequences for people, livelihoods, ecosystems, and socio-economic development. Therefore, this study looked at the knowledge in application in Ikanga-Kyatune Ward of Kitui County, Kenya. The study employed a multidisciplinary approach, integrating field surveys, household interviews, and participatory discussions with community elders and local farmers. The data was subjected to descriptive statistics, with the findings bringing to the fore reliance on a variety of knowledge systems to forecast the changes in the weather, key being in use of indigenous knowledge. Based on the local social, cultural, economic and environmental circumstances, the study concluded that indigenous has a central place in sustainability of the lives and livelihoods of people in the rural areas. Consequently, the study recommended integrating the knowledge and practices with conventional meteorological forecasting systems. By recognizing and incorporating peoples' local expertise, the government and development agencies and climate scientists can develop inclusive and effective forecasting models tailored to the specific needs of communities.

Keywords: Participatory, knowledge systems, meteorological, livelihoods, effective forecasting.

Introduction

Droughts and floods are a critical challenge to lives, livelihoods and ecosystem sustenance in the ASALs. The two climate extremes disrupt livelihoods, undermine food security, and worsen economic hardship. The frequency and severity of droughts and floods is on an upward trend due to climate change and environmental degradation (IPCC, 2022). The effects of the two extreme events are more profound due to limited capacity to manage risks, weaker revenue capability, and lower institutional ability to upgrade infrastructure. One way to minimize the impact is by improving weather forecasting and better communication of weather warnings. The ability to provide timely and precise weather forecasts offers the potential to reduce the vulnerability of people to the impacts of extreme weather (Alley *et al.,* 2019; Antwi-Agyei *et al.,* 2021a). However, accurate forecasting of weather variables remains a major challenge for the scientific community (Mani and Mukherjee, 2016). The need to safeguard lives and livelihoods from extreme weather events has made the provision of timely weather forecasts an essential adaptation initiative (Oyekale, 2015). Improving the

weather forecast's accuracy is crucial for people's safety and protecting key economic sectors, including agriculture, aviation, water, energy, and emergency response (Parker *et al.,* 2021). In addition, availability, accessibility, and usability of accurate weather information are key for climate-informed decision-making (Mabe *et al.,* 2014; Nkiaka *et al.,* 2019). As weather forecasts become progressively more accurate and timelier, their use can inform climate change risk mitigation strategies. However, the benefits linked to these improvements will only be appreciated if the forecasts are used directly in management decisions (Blum and Miller, 2019). There is therefore urgency to assess the forecasting practices to minimize the devastating effects of extreme events (Woodhams *et al.,* 2018; Carter *et al.,* 2019). With improved warning systems, it is possible to reduce the extent of damage by improving the resilience of at-risk populations and reinforcing the preparedness of the population to cope with extreme events (Anaman *et al.,* 2017). The production and use of improved weather information to deliver early warnings and adequately manage these extreme events are essential in societal preparedness against extreme weather events (Anaman *et al.,* 2017). Studies have highlighted the importance of weather and climate services in mitigating risks such as drought, flooding, and loss of lives and livelihoods (Mabe *et al.,* 2014; Sena *et al.,* 2014; Oyekale, 2015; Mittal, 2016; Guido *et al.,* 2021; Kayaga *et al.,* 2021).

In Kenya, conventional meteorological systems, though important, face limitations in rural areas. They are constrained by inadequate weather stations, poor dissemination of forecasts, and the technical complexity of data that many farmers find difficult to apply in decision-making (Muthama *et al.,* 2021; Ong'ayo & Mutunga, 2023). As a result, communities often turn to indigenous knowledge systems which has been developed and refined over generations, to anticipate droughts and floods. These methods are deeply rooted in cultural practices, guiding agricultural planning, water management, and disaster response. Despite their proven value, indigenous forecasting techniques are often overlooked in mainstream meteorology and disaster management. Scientific forecasting tends to prioritize technology-based approaches, including satellite data and climate models, without adequately recognizing traditional knowledge (Munene *et al.,* 2020). This disconnect has limited the effectiveness of early warning systems in the ASAL regions. Given the accelerating impacts of climate change, integrating indigenous knowledge with modern meteorological science offers an opportunity to strengthen resilience and improve community preparedness (UNDRR, 2023).

Scientific meteorology often fails to meet rural people needs due to limited infrastructure, weak dissemination of forecasts, and the complexity of data interpretation (Muthama *et al.,* 2021). Communities therefore rely heavily on indigenous weather prediction systems, which have been passed down for generations. These systems have historically been reliable but are increasingly threatened by climate variability, deforestation, and socio-cultural changes (Ong'ayo & Mutunga, 2023). Cognizance is indigenous forecasting methods remain poorly documented and are frequently dismissed in formal climate adaptation strategies. Their exclusion from mainstream systems has created a gap in early warning mechanisms, undermining disaster preparedness in vulnerable communities (Waweru *et al.,* 2022).

This study, therefore, sought to document and analyze the existing use of indigenous knowledge and its efficacy in forecasting. By examining how the inhabitants of the semi-arid area Kyatune-Ikanga community uses the knowledge, the research aimed to establish its potential for integrating the knowledge and practices with scientific approaches for enhanced reliability of forecasts, informing policy on climate adaptation, and contributing to sustainable development in climate-vulnerable regions. The study also aimed to establish the challenges affecting application of indigenous weather forecasting knowledge. Assessing the effectiveness of indigenous knowledge is envisaged to bridge the gap between traditional methods and modern meteorology, promoting their integration into formal adaptation strategies. Recognizing and incorporating indigenous knowledge is seen to not only empower local communities and foster participation but also ensure the preservation and transmission of valuable cultural practices to ultimately contribute to sustainable complements to scientific approaches to climate adaptation.

Methodology

Study Area

The study was carried out in the semi-arid Ikanga-Kyatune Ward of, Kitui County, Kenya. The region is characterized by low and erratic rainfall, frequent droughts, and occasional floods, making weather

forecasting central to community resilience. The area socioeconomic practices are characterized by agro pastoralism, a practice that is very sensitive to climatic changes. As is the rest of the County, poverty levels are above the national average.

Research Design

A mixed-methods design was adopted to capture both qualitative and quantitative insights. A descriptive survey was used to document indigenous forecasting techniques, while comparative analysis evaluated their accuracy against meteorological data from government agencies and historical climate records. This approach enabled a holistic understanding of traditional forecasting in relation to modern systems (Muthama *et al.,* 2021). The research focused on one geographical region which made the study face several limitations. Foremost, indigenous knowledge is mainly passed down orally, making it difficult to obtain consistent information. On the other hand, land tenure and land use changes, settlement patterns and climate change have altered natural indicators. The focus on one ward was experienced to limit generalization to other regions. Some cultural sensitivities affected the willingness of some respondents to share knowledge.

Sampling Methods

A total of 62 respondents were sampled, offering both indepth and diversity in perspectives. Participants in the study were selected through purposive and stratified random sampling to ensure a balance between key knowledge holders and broader community representation. Elders were included as custodians of indigenous knowledge, farmers and pastoralists as primary users of forecasts, and local leaders as facilitators of community decision-making. Meteorological officers and climate experts were also engaged to provide scientific perspectives.

Data Collection Methods

Data were gathered using multiple techniques to allow for triangulation. Semi-structured interviews and focus group discussions provided narratives on traditional forecasting indicators, their perceived accuracy, and challenges in knowledge preservation. Field observations documented environmental cues such as cloud patterns, animal behavior, and plant phenology. Secondary data from climate reports and previous research offered a basis for comparison and historical context.

Data Analysis

Qualitative data from interviews, discussions, and observations were analyzed thematically, focusing on recurring indicators and perceptions of reliability. Quantitative survey data were processed using descriptive statistics, including frequencies and percentages. A comparative analysis was conducted to identify alignments and discrepancies between indigenous forecasts and scientific meteorology, thereby assessing the potential for integration.

Ethical Considerations

Official approvals were sought from the administrative authorities before data collection. To ensure compliance with research ethics, informed consent was obtained from the research participants both verbally and in writing depending on participants' preferences and literacy levels. Confidentiality was ensured through anonymization of responses and secure storage of data. Cultural sensitivity was observed and consequently respect accorded to sacred or restricted practices.

Research Findings and Discussions

Indigenous Knowledge and Demographic Characteristics

Application of Chi-square tests revealed a significant association between gender and use of indigenous forecasts ($\chi^2 = 4.87$, $p < 0.05$), showing that women were more likely to apply traditional indicators in agriculture. Age was also significant ($\chi^2 = 6.21$, $p < 0.05$), with elders relying more on traditional knowledge than younger participants. Education level, however, was not significant ($\chi^2 = 1.93$, $p > 0.05$), showing that reliance on indigenous forecasts cuts across educational backgrounds. This reinforces Munene, Were, and Wambua (2020), who argue that indigenous knowledge remains resilient across demographics.

Women constituted the largest proportion (58.1%),) of respondents in the research, reflecting their central role in the day-to-day functioning and well-being of the resident agro pastoral community. This is due to a combination of demographic and socio-economic factors.

Men often migrate to urban areas in search of off-farm employment opportunities, leaving women as the majority of the remaining adult population and heads of household. A second reason relates to the roles played by women in land use and household where they play vital and often dominant roles in production, food security, and household management, including childcare and healthcare provision. Traditionally, women in rural areas have been regarded as people who belong at home, expected to minister to their husbands and children, but when it comes to making decisions on economic and political issues, men take the lead. In most households, women are the food farmers, and carry the burdens of life, growing over 80 % of household foods, including food for subsistence and food for markets. The women do almost 80% of the work to provide the proper transport and storage of food. They do almost 90% of the work to process food, including the tasks such as threshing, drying, winnowing, peeling, grating, sieving, and pounding. They also do almost 60% of the work related to marketing food. This makes them key informants for researchers studying indigenous knowledge linked to these areas. Because men are frequently absent, women are often the most accessible members of the household for researchers conducting surveys and interviews within the community. Women often form strong local networks that are useful for researchers employing purposive or snowball sampling methods to access participants. Despite the high women participation, the research experienced some challenges in accurately capturing women's contributions to development and use of indigenous knowledge in weather forecasting. A realization was drawn in that traditional gender norms can influence how women share what they know and practice. At the same time, rural women often have less access to formal education, technology, and information networks compared to men, which affect the scope and nature of data and information collected from them.

The women's work is considered to be part and parcel of their day's activities on top of household burdens of taking care of the children. In most households, the women carry out subsistence and near-subsistence agriculture, being over 80% of the agricultural labour force. They are also responsible for many other tasks such as planting, weeding, watering, harvesting, and storing of crops. Thus, the women make a major contribution to the economic production of the community and assume primary responsibility for the health of their families. Their active support is crucial to the utilization of development objectives. Women in the area have a tradition of participating in savings, production, marketing and mutual-aid organizations. Many women rely on cooperatives and market groups as a way to pool resources, reduce their workload, and optimize limited income.

People aged 56 years and above accounted for 38.7% of participants in the field survey, reflecting their position as the primary custodians of indigenous knowledge. Education levels were generally low, with 47.1% of respondents having completed only primary school, underscoring the reliance on oral traditions to preserve and pass down forecasting practices. Livelihoods were largely climate-dependent, with 96.8% engaged in crop farming and 83.9% in livestock keeping. A majority of respondents (59.7%) had lived in the area for more than ten years, enhancing their familiarity with local environmental patterns. These findings converge with Ifejika Speranza *et al.,* (2010) finding which observed that in Kenya's ASALs, indigenous knowledge is maintained mainly by elders and transmitted orally, while women remain central in food production and adaptation strategies. Similarly, Waweru *et al.,* (2022) noted that in Kitui County, long-term residency strengthens environmental observation, reinforcing the trustworthiness of indigenous forecasts. However, divergences appear in regions such as northern Kenya, where men dominate weather-related decision-making (Kagunyu *et al.,* 2016), unlike the gender-balanced roles in Ikanga-Kyatune.

Women utilize their indigenous knowledge of weather forecasting to inform and plan their land use and social activities. The traditional methods often rely on observing natural indicators like animal behavior, plant changes, and celestial patterns, and play a crucial role in managing agricultural risks and sustaining livelihoods. The women are also keener in participating in divine rituals to influence the weather towards the positive. It is however realized that men are favored in being imparted with indigenous knowledge than women. Even the old women are more prone to passing their knowledge to the male gender. The aspect may explain why the male gender often possesses more extensive indigenous knowledge regarding weather forecasting. Men are particularly knowledgeable ecological, considerations in weather forecasting to anticipate weather patterns by observing a variety of natural indicators, such as the behavior of animals, the flowering of plants, and atmospheric changes.

While contemporary meteorological science is accessible through national services traditional forecasting methods remain vital in the rural areas. The more advanced in age, the more than the leaning towards indigenous knowledge use. The knowledge often becomes part of a broader cultural understanding of the local environment and is instrumental in decisions making regarding land uses, particularly in determining optimal planting times, harvesting schedules, water management and, livestock management. 79% of the responses vouch for documenting and disseminating indigenous knowledge as part of climate adaptation strategies in the semi-arid settings and, the need for an integrative approach that blends local knowledge with scientific meteorological data to enhance the accuracy and accessibility of early warning systems.

Weather Management Systems

The study findings indicated that 54.8% of respondents relied exclusively on indigenous methods of weather forecasting, while only 4.8% depended solely on modern meteorology. A significant proportion (40.3%) combined both systems, suggesting a growing acceptance of hybrid approaches. Indigenous forecasts were frequently used, with 66.1% reporting that they always relied on them and 32.3% stating they sometimes did. The most common weather change indicators included animal behavior (77.4%), vegetation changes (74.2%), and cloud patterns (29%). These results converge with Chang'a *et al.,* (2010), who found that East African communities rely heavily on natural signs for forecasts.

Chi-square analysis showed a significant relationship between education level and reliance on hybrid systems ($\chi^2 = 7.32$, $p < 0.01$), suggesting that those with secondary education and above were more likely to combine indigenous and modern forecasts. Gender differences were not significant ($\chi^2 = 1.42$, $p > 0.05$). This suggests that formal education encourages blending of knowledge systems, aligning with Muthama, Ogallo, and Ouma (2021), who saw this as an opportunity for integration of local and scientific forecasting methods.

Respondents highlighted several indicators for droughts and floods. For drought, key signs included drying rivers (75.8%), early leaf shedding (72.6%), changing wind patterns, and reduced morning dew. Floods was indicated to be foreseen through heavy rains (66.1%), rising river levels (54.8%), and animal migration (43.5%). Animal behavior was significant, with 74.2% citing bird migration, termite activity (45%), and livestock behaviour (75%). Plant cues, such as premature leaf fall and fruiting cycles, were reported by 95.2%. The findings are similar to ones of Kagunyu *et al.,* (2016) that noted reliance on animal and environmental cues in northern Kenya.

Inferential analysis indicated that age significantly influenced reliance on plant-based indicators ($\chi^2 = 5.84$, $p < 0.05$), with elders more likely to cite vegetation changes. Gender did not significantly influence the choice of indicators ($\chi^2 = 0.97$, $p > 0.05$). These results suggest that age-based knowledge accumulation shapes indicator diversity, echoing Waweru *et al.,* (2022), who found that generational experience strengthens forecasting precision.

Efficacy of Forecasts

The community expressed strong confidence in indigenous forecasting. For drought, 33.9% rated forecasts as very accurate and 66.1% as somewhat accurate. For floods, 35.5% considered them very accurate and 64.5% somewhat accurate, with none labeling them inaccurate. Regarding utility, 30.6% said forecasts always helped them prepare, while 67.7% said they often did.

A chi-square goodness-of-fit test confirmed that community perceptions of accuracy were significantly skewed toward positive ratings ($\chi^2 = 12.45$, $p < 0.01$). Logistic regression further showed that elders had higher odds (OR = 1.9, $p < 0.05$) of rating forecasts as very accurate compared to younger respondents. This suggests that confidence increases with accumulated experience, reinforcing indigenous knowledge resilience.

Integration with Modern Forecasting

Chi-square results indicated a significant association between education and support for integration ($\chi^2 = 8.14$, $p < 0.01$), showing that more educated respondents favored hybrid systems. Gender was not significant ($\chi^2 = 1.21$, $p > 0.05$). This resonated with Ong'ayo and Mutunga (2023), who highlighted education to be a critical factor in shaping attitudes toward modern climate information services. Community perspectives on integration revealed divided opinions with close to half (48.4%) supporting merging the systems, while 51.6% were skeptical. Key challenges included lack of government support (74.2%), poor documentation

(58.1%), mistrust between communities and scientists (16.1%), and weak communication (6.5%). Suggested improvements included policy support (86.9%), public awareness (37.7%), and workshops (3.3%). These findings align with Tam and AICCRA (2024), who argue for blending indigenous and scientific forecasts to enhance resilience. The integration of indigenous and scientific knowledge in weather forecasting is vouched for to offer substantial benefits, leading to more accurate, relevant, and resilient predictions, particularly at the local level. Blending these insights helps fine-tune forecasts for specific microclimates. The forecasts that incorporate locally recognized indicators are likely to be often more credible and relevant to the communities that rely on them for decisions as they will have bridged critical gaps in scientific monitoring networks, increasing trust and ensuring the information is effectively used. Indigenous knowledge systems often include long-term observations of climate variability over generations, offering valuable insights into local climate resilience and long-term adaptation strategies that complement modern climate science. Subsequently, combining both approaches fosters a more holistic understanding of the complex environmental systems that drive weather and climate. The synergy is reputed by 0ver 70% of the respondents to represent a powerful approach to creating more effective, inclusive, and culturally appropriate climate services.

56.7% preferred a hybrid model, 40% favored strengthening indigenous practices, and 3.3% supported modern systems exclusively. To preserve knowledge, 60.7% recommended documentation, 42.6% proposed integration into policies, and 31.1% called for financial support for knowledge holders. Quarterly consultation meetings were also emphasized (81.7%). Chi-square analysis showed significant association between occupation and forecasting preference ($\chi^2 = 9.32$, $p < 0.01$). Farmers were more likely to support hybrid systems, while pastoralists leaned toward strengthening indigenous practices. This reflects differential livelihood vulnerabilities, consistent with Munene *et al.,* (2020), who observed that adaptation choices vary with livelihood dependency. Users of weather information mainly access information related to rainfall and temperature, and the information is accessed mainly through radio, mobile phones, and television. Most of the information provided focuses on generic meteorological forecasts instead of tailored impact-based forecasts. Only very few users can access, or benefit from the information produced due to poor communication and technical understanding of weather information. In addition, a lack of downscaled information, logistics, and trust hinders the uptake and use of climate information. Consequently, mainstreaming capacity-building of key stakeholders is required to promote effective adoption and strengthening of climate information services in the semi-arid areas.

Conclusion and Recommendations

The strong confidence expressed in the accuracy and utility of indigenous knowledge system forecasts underscores their resilience, even in the face of modern meteorological alternatives. The study concludes that provision of timely and precise weather information have capacity to reduce the vulnerability related climate change risks and conclude to sustainable development. It also agrees that indigenous knowledge has its role in providing valuable and time tested skills and knowledge in weather predictions of capacity to contribute to resilience-building and climate adaptation. The study therefore calls for policies that support knowledge-sharing between grassroots communities and scientific institutions, ensuring that local expertise is acknowledged and utilized to improve droughts and floods preparedness, living in the period and making recovery in the semi-arid areas.

Conflict of Interest

The authors declare no competing interests.

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