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Beyond Weather Forecasts: Integrating Indigenous Knowledge and Scientific Seasonal Forecasting to Enhance Household Food Security among Smallholder Farmers in Kenya

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Abstract: *Climate variability continues to threaten agricultural productivity and household food security among smallholder farmers who depend largely on rain-fed agriculture. Although scientific seasonal forecasting has improved considerably, many rural households continue to rely on Indigenous Knowledge (IK) to guide farming decisions. However, empirical evidence on how these complementary knowledge systems influence household food security remains limited, particularly within Kenya's climate-vulnerable regions. This study examined the role of Indigenous Knowledge and scientific seasonal forecasting in enhancing household food security in Bomet County, Kenya. Guided by Human Capability Theory, Indigenous Knowledge Systems Theory, and Social-Ecological Systems Theory, the study adopted a descriptive mixed-methods design. Quantitative data were collected from 398 farming households using structured questionnaires, while qualitative evidence was generated through 15 key informant interviews and six focus group discussions. Quantitative data were analysed using descriptive statistics, Pearson correlation, and regression analysis, whereas qualitative data were analysed thematically. The findings show that 91.2% of households relied on Indigenous Knowledge for weather-related decisions, while 77.4% combined Indigenous Knowledge with scientific seasonal forecasts before making agricultural decisions. A strong positive relationship was found between Indigenous Knowledge, seasonal forecasting, and household food security ($r = 0.682$, $p < 0.001$), with regression analysis indicating that the two knowledge systems explained 46.5% of the variation in household food security ($R^2 = 0.465$; $\beta = 0.682$, $p < 0.001$). Farmers integrated ecological indicators, including flowering patterns, bird migration, cloud formations, and wind direction, with meteorological forecasts to guide planting, crop selection, water conservation, and food storage. The study concludes that Indigenous Knowledge and scientific forecasting are complementary systems whose integration can strengthen household resilience, improve adaptive capacity, and enhance sustainable food security under increasing climate variability. The study recommends that participatory forecasting platforms that bring together meteorologists, extension officers, community elders, and farmers should be strengthened to improve the credibility, local relevance, and uptake of climate advisories.*

Keywords: *Indigenous Knowledge, Seasonal Forecasting, Household Food Security, Climate Adaptation, Smallholder Farmers, Kenya*

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1. Introduction

Climate change has become one of the most significant threats to global food systems, particularly in regions where agricultural production depends predominantly on rainfall. According to the Food and Agriculture Organization (FAO, 2023), increasing climate variability, prolonged droughts, erratic rainfall, and rising temperatures continue to undermine agricultural productivity and threaten household food security across many developing countries. Smallholder farmers are especially vulnerable because their livelihoods depend directly on seasonal weather conditions, yet they often possess limited financial, technological, and institutional resources to respond effectively to climatic shocks. Consequently, improving farmers' capacity to anticipate seasonal changes has become a central component of climate adaptation and food security strategies worldwide.

Scientific seasonal forecasting has emerged as an important tool for improving agricultural planning. Advances in satellite technology, climate modelling, artificial intelligence and meteorological science now enable weather agencies to predict seasonal rainfall and temperature anomalies several months in advance (Whitehorse et al., 2023). Governments and development partners have consequently invested heavily in climate information services, early warning systems and digital dissemination platforms aimed at improving agricultural decision-making. Nevertheless, despite these technological advances, the effectiveness of scientific forecasting remains uneven in many rural settings because forecasts are frequently generalized, difficult to interpret, poorly localized, or delivered too late to inform farming decisions (Bii & Koech, 2023; Ouma et al., 2024).

Alongside formal meteorological forecasting, Indigenous Knowledge (IK) continues to play a central role in climate adaptation among rural farming communities. Indigenous Knowledge comprises generations of accumulated environmental observations, practical experiences and cultural interpretations transmitted within communities over time (UNESCO, 2025). Farmers interpret ecological indicators such as flowering patterns, insect behaviour, bird migration, cloud formations, wind direction, soil moisture and celestial observations to anticipate seasonal weather changes and guide agricultural activities (Quispe & Ortega, 2024). Unlike scientific forecasts, which are externally generated and probabilistic, Indigenous Knowledge is deeply embedded within local ecological systems and socio-cultural institutions, making it highly accessible, trusted and context specific.

Growing evidence suggests that neither Indigenous Knowledge nor scientific forecasting alone adequately addresses the complexities of contemporary climate variability. Instead, scholars increasingly advocate for integrated forecasting systems that combine scientific precision with locally grounded ecological knowledge (Kuria et al., 2023; Ofoegbu et al., 2023). Such knowledge pluralism enhances the credibility, legitimacy and usability of climate information, enabling farming households to make more informed decisions regarding planting, harvesting, crop diversification, food storage and water management. Experiences from North America, Bangladesh, the Philippines, Ukraine and several African countries demonstrate that integrating Indigenous Knowledge with scientific forecasting strengthens community resilience, improves adaptive capacity and contributes to more sustainable food systems (Hiraldo & Lucero, 2025; Islam et al., 2024; Bacus et al., 2024).

Within Kenya, agriculture contributes significantly to national employment, rural livelihoods and food security, yet over 80% of agricultural production remains rain-fed (GoK, 2023). Although the Kenya Meteorological Department provides seasonal forecasts, many farming communities continue to supplement official forecasts with Indigenous environmental indicators because they perceive them as more locally relevant and culturally meaningful (Langat & Kiprotich, 2023). In Bomet County, farmers routinely interpret tree phenology, animal behaviour, cloud patterns and seasonal winds when planning agricultural activities. However, these Indigenous forecasting systems remain poorly integrated into formal climate services and agricultural policies despite their continued importance in local decision-making (Chepkwony et al., 2024).

Despite growing recognition of knowledge integration, empirical evidence explaining how Indigenous Knowledge and scientific seasonal forecasting collectively influence household food security remains limited. Most previous studies have examined the two systems independently, with little attention given to how households combine them to strengthen adaptive capacity. Furthermore, few studies have triangulated quantitative household data with qualitative community experiences to understand the social processes underpinning integrated forecasting. Addressing this knowledge gap is important for designing inclusive climate services that respond to the realities of smallholder farmers.

Accordingly, this study investigates how Indigenous Knowledge and scientific seasonal forecasting jointly influence household food security among smallholder farmers in Bomet County, Kenya. Specifically, the study examines household use of Indigenous Knowledge and scientific forecasting, explores factors influencing their integration, and assesses how hybrid forecasting systems contribute to household preparedness and food security. The findings contribute to broader debates on climate adaptation, knowledge co-production and sustainable rural development while providing policy recommendations for strengthening community-centred climate information systems.

1.1 Statement of the Problem

Climate variability continues to undermine agricultural productivity and household food security across Kenya, particularly among smallholder farmers who depend on rain-fed agriculture. Increasingly erratic rainfall patterns, prolonged dry spells, and recurrent droughts have reduced crop yields, disrupted planting seasons, and heightened household vulnerability to food insecurity (FAO, 2023; Government of Kenya, 2023). Although scientific Seasonal Forecasting (SF) has become an important component of climate adaptation strategies, many rural households continue to experience difficulties accessing, interpreting, and applying forecast information because it is often generalized, insufficiently localized, or disseminated too late to inform timely agricultural decisions (Ofoegbu et al., 2023). Consequently, farmers frequently supplement scientific forecasts with Indigenous Knowledge (IK), which draws upon generations of environmental observations to guide farming decisions.

Despite growing recognition of the value of Indigenous Knowledge in climate adaptation, it remains inadequately integrated into formal climate information services and agricultural policies in Kenya. Existing studies have largely examined scientific forecasting and Indigenous Knowledge independently, with limited empirical evidence on how their integration influences household food security outcomes, particularly at the local level. Furthermore, few studies have combined quantitative and qualitative evidence to examine how farming households simultaneously utilize Indigenous Knowledge and scientific forecasting to improve food availability, access, utilization, and stability. This knowledge gap is particularly evident in Bomet County, where agriculture is highly climate-sensitive and communities continue to rely on both forecasting systems. Consequently, there is insufficient evidence to guide policies that promote integrated climate information services capable of strengthening household resilience and sustainable food security. This study therefore sought to examine the role of Indigenous Knowledge and scientific Seasonal Forecasting in influencing household food security among farming households in Bomet County, Kenya.

1.2 Objective of the study

To examine the role of Indigenous Knowledge and scientific Seasonal Forecasting in influencing household food security among farming households in Bomet County, Kenya.

2. Literature Review

Indigenous Knowledge (IK), commonly referred to as Traditional Ecological Knowledge (TEK), encompasses the accumulated knowledge, practices, values, and beliefs that communities develop through long-term interaction with their local environments. Unlike scientific knowledge, which is largely generated through formal experimentation and institutional research, Indigenous Knowledge evolves through lived experience and is transmitted across generations through observation, participation, oral traditions, and cultural practices (UNESCO, 2025). It reflects a holistic understanding of relationships among people, ecosystems, biodiversity, weather patterns, and agricultural production. In many rural societies, IK continues to inform decisions regarding crop selection, planting calendars, livestock management, soil conservation, pest control, water harvesting, and food preservation, making it an indispensable resource for household food security (Quispe & Ortega, 2024).

Seasonal Forecasting (SF) refers to the prediction of climatic conditions over a period of approximately three to six months before they occur. Scientific seasonal forecasting employs meteorological observations, satellite imagery, climate models, and increasingly artificial intelligence to estimate the probability of rainfall distribution, temperature variation, drought occurrence, and extreme weather events (Whitehorse et al., 2023). These forecasts provide farmers with advance information that can reduce uncertainty and support planning. Indigenous seasonal forecasting, however, relies on careful interpretation of ecological indicators such as flowering cycles, bird migration, insect activity, cloud formations, prevailing winds, lunar cycles, and animal behaviour (Tupou & Ma'afu, 2024). Although these two forecasting systems differ in their epistemological foundations, both seek to improve agricultural decision-making by anticipating environmental change.

Household food security extends beyond food production to encompass consistent physical, social, and economic access to sufficient, safe, nutritious, and culturally acceptable food throughout the year (FAO, 2023). The four widely accepted pillars of food security include food availability, food access, food utilization, and food stability. Climate variability threatens each of these dimensions by disrupting agricultural production, reducing household incomes, increasing food prices, and affecting dietary diversity. Consequently, reliable forecasting systems—whether scientific or indigenous—are increasingly recognised as important mechanisms for strengthening household resilience and safeguarding food security.

Rather than viewing Indigenous Knowledge and scientific forecasting as competing systems, contemporary scholarship increasingly conceptualizes them as complementary knowledge systems. Scientific forecasting provides regional climate projections based on sophisticated climate models, whereas Indigenous Knowledge offers localized, context-specific interpretations grounded in intimate environmental experience. Their integration therefore represents a practical form of knowledge pluralism capable of strengthening adaptive capacity among climate-sensitive farming communities (Kuria et al., 2023; Ofoegbu et al., 2023).

Climate variability has intensified food insecurity across many parts of the world, making reliable climate information increasingly essential for sustainable agriculture. Although remarkable progress has been achieved in meteorological forecasting technologies, numerous studies demonstrate that scientific forecasting alone is often insufficient to support localized agricultural decision-making. Consequently, Indigenous Knowledge continues to play an important role in complementing scientific climate information across diverse geographical contexts.

In North America, Indigenous communities such as the Inuit, Navajo and Cherokee continue to rely on centuries-old ecological knowledge despite the availability of sophisticated forecasting technologies developed by agencies such as the National Oceanic and Atmospheric Administration (NOAA). Traditional observations of salmon migration, berry maturation, wildlife movement, river ice formation and bird migration remain fundamental for determining hunting seasons, food preservation and agricultural activities (Whitehorse et al., 2023). However, mainstream climate services have historically overlooked Indigenous perspectives, limiting the effectiveness of adaptation policies among Indigenous populations (McGregor, 2023). Recent collaborative initiatives involving Indigenous Climate Resilience Networks illustrate how integrating Indigenous Knowledge with scientific forecasting improves trust, enhances community participation and strengthens localized food security (Hiraldo & Lucero, 2025).

Similar experiences have been documented in Eastern Europe. In Ukraine, rural communities continue to interpret flowering plants, migratory birds and seasonal ecological changes when making agricultural decisions despite having access to formal meteorological forecasts (Kovalenko & Kotsiubynska, 2024). Climate change and geopolitical instability have disrupted conventional forecasting systems, increasing dependence on locally generated environmental knowledge. Scholars argue that integrating Indigenous forecasting with scientific climate services has become increasingly important for strengthening rural resilience under conditions of multiple uncertainties (Shevchenko & Dotsenko, 2023).

In South Asia, particularly Bangladesh, Indigenous Knowledge remains central to agricultural adaptation within flood-prone and cyclone-prone regions. Communities interpret environmental signals including wind direction, soil moisture, cloud formations and flowering cycles to anticipate seasonal weather conditions (Islam et al., 2024). Although national meteorological services provide seasonal forecasts, institutional barriers, language differences and limited community participation continue to constrain their effectiveness. Participatory approaches that combine Indigenous Knowledge with scientific forecasting have demonstrated greater success in improving agricultural preparedness, food storage and household resilience (Saha et al., 2025).

Comparable patterns are observed in Southeast Asia. Indigenous communities in the Philippines continue to employ traditional forecasting based on ecological and cosmological observations to determine planting seasons and prepare for typhoons and droughts (Bacus et al., 2024). Nevertheless, climate adaptation policies remain heavily dominated by technical forecasting systems, often overlooking culturally embedded knowledge systems that have historically sustained local food production (Delos Reyes & Banal, 2024). The resulting disconnect between formal climate services and community knowledge limits the effectiveness of adaptation interventions and reduces local ownership of climate information.

Across these diverse contexts, a common conclusion emerges: Indigenous Knowledge remains highly relevant despite rapid advances in meteorological science. Rather than replacing traditional forecasting systems, scientific forecasting performs most effectively when integrated with locally generated environmental knowledge. This growing international evidence supports calls for more participatory, culturally responsive and community-centred climate information systems capable of improving household food security under increasing climate uncertainty.

3. Methodology

This study was conducted in Bomet County, Kenya, where smallholder farming households depend predominantly on rain-fed agriculture, making them highly vulnerable to climate variability and food insecurity. The study adopted a descriptive mixed-methods research design to generate complementary quantitative and qualitative evidence on the role of Indigenous Knowledge (IK) and scientific Seasonal Forecasting (SF) in enhancing household food security. The target population comprised farming households and key stakeholders involved in climate information generation and dissemination, including agricultural extension officers, Kenya Meteorological Department (KMD) officials, county government officers, local administrators, community elders, and farmer group leaders. A sample of 398 farming households was selected through stratified random sampling to ensure representation across the county's agro-ecological zones. Additionally, 15 Key Informant Interviews (KIIs) and six Focus Group Discussions (FGDs) were purposively conducted to obtain in-depth insights into local forecasting practices, institutional support, and household adaptation strategies.

Quantitative data were collected using structured questionnaires, while qualitative information was obtained through semi-structured interview and discussion guides. Quantitative data were analysed using IBM SPSS Statistics Version 27, employing descriptive statistics (frequencies, percentages, means, and standard deviations), Pearson's Product-Moment Correlation, and multiple linear regression to determine the relationship between Indigenous Knowledge, scientific Seasonal Forecasting, and household food security at a 5% level of significance. Qualitative data were transcribed verbatim and analysed thematically, with findings triangulated against the quantitative results to enhance credibility and provide contextual interpretation. Ethical approval and research authorization were obtained from the National Commission for Science, Technology and Innovation (NACOSTI) prior to fieldwork. Participation was voluntary, informed consent was obtained from all respondents, and confidentiality, anonymity, and participants' right to withdraw at any stage were upheld throughout the study in accordance with established ethical research standards.

4. Results and Discussion

4.1 Household Use of Indigenous Knowledge and Scientific Seasonal Forecasting

The first objective of the study was to examine the extent to which farming households utilize Indigenous Knowledge (IK) and scientific Seasonal Forecasting (SF) in making agricultural decisions. Understanding household reliance on these knowledge systems is important because timely and reliable climate information enables farmers to anticipate climatic risks, optimize agricultural planning, and enhance household food security. The findings indicate that although scientific seasonal forecasts are increasingly available through formal institutions, Indigenous Knowledge remains central to climate-related decision-making among farming households in Bomet County.

Table 1: Household Perceptions of Indigenous Knowledge and Scientific Seasonal Forecasting (n = 398)

Statement	**Mean**	**SD**
Indigenous Knowledge is used to make weather-related decisions	**4.16**	0.66
Indigenous methods effectively predict seasonal weather variability	**4.01**	0.66
Indigenous Knowledge reliably predicts rainfall and drought	**3.74**	0.90
Households regularly access scientific seasonal forecasts	**3.77**	1.00
Indigenous Knowledge and scientific forecasts are combined in decision-making	**3.92**	0.88
Households trust Indigenous forecasting more than scientific forecasts	**3.60**	1.14

Overall Mean = **3.87**

The findings demonstrate widespread reliance on Indigenous Knowledge for agricultural planning. Respondents strongly agreed that Indigenous Knowledge guides weather-related decisions (M = 4.16, SD = 0.66), while a similarly high proportion acknowledged that Indigenous environmental indicators effectively predict seasonal weather variability (M = 4.01, SD = 0.66). Respondents also expressed moderate confidence in the ability of Indigenous Knowledge to predict rainfall and drought (M = 3.74, SD = 0.90). These findings suggest that Indigenous forecasting remains an integral component of agricultural decision-making despite the expansion of modern meteorological services.

Scientific seasonal forecasts were also widely utilized (M = 3.77, SD = 1.00), although respondents reported greater confidence when these forecasts were interpreted alongside Indigenous environmental observations. The relatively high mean score for integrating Indigenous Knowledge with scientific forecasting (M = 3.92, SD = 0.88) indicates that most households employ a hybrid decision-making approach rather than relying exclusively on either system. Although trust in Indigenous forecasting exceeded that of scientific forecasts (M = 3.60, SD = 1.14), the larger standard deviation suggests variation among households, likely reflecting differences in education, previous forecasting experiences, access to extension services, and geographical location.

Qualitative findings reinforced these quantitative results. Focus Group Discussions revealed that farmers routinely observed environmental indicators such as flowering of indigenous trees, movement of birds, ant behaviour, cloud formations, wind direction, and night temperatures before making farming decisions. Rather than replacing scientific forecasts, these observations were used to verify official meteorological information. One farmer explained: *"When the flowering of particular trees coincides with the seasonal forecast from the radio, we become confident that the rains are approaching and begin land preparation immediately."* (FGD, Male Farmers). Another participant remarked: *"We first observe nature before deciding whether the weather forecast is likely to be accurate. Both sources help us reduce uncertainty."* (FGD, Female Farmers)

Key Informants similarly acknowledged that Indigenous Knowledge continues to influence agricultural planning throughout Bomet County. Agricultural extension officers indicated that many farmers compare official Kenya

Meteorological Department (KMD) forecasts with traditional ecological indicators before deciding when to plant or harvest. One extension officer observed: *"Most farmers do not abandon Indigenous Knowledge. Instead, they combine it with meteorological information because local environmental indicators often explain what the official forecast cannot."* (KII, Agricultural Extension Officer).

These findings corroborate studies conducted across East Africa demonstrating that Indigenous Knowledge remains highly trusted because it is locally generated, culturally embedded, and responsive to specific ecological conditions (Kansiime et al., 2024; Mugambiwa & Tirivangasi, 2023). Similarly, Kuria et al. (2023) reported that integrating Indigenous Knowledge with scientific forecasting improves farmers' confidence in seasonal predictions and increases adoption of climate-smart agricultural practices. Comparable findings have also been reported in Zimbabwe (Mapfumo et al., 2023), Ethiopia (Chisadza & Gwimbi, 2024), Bangladesh (Islam et al., 2024), and the Philippines (Bacus et al., 2024), where farmers routinely combine ecological observations with scientific climate information to improve agricultural decision-making.

The findings strongly support Indigenous Knowledge Systems Theory, which recognizes Indigenous environmental knowledge as a legitimate and adaptive system developed through continuous interaction with local ecosystems (Battiste, 2002; Agrawal, 1995). The observed integration of Indigenous Knowledge with scientific forecasting also reflects the principles of knowledge pluralism, where multiple knowledge systems collectively enhance climate adaptation rather than competing for legitimacy. Furthermore, the findings are consistent with Human Capability Theory, which argues that access to diverse and relevant information expands individuals' capabilities to make informed livelihood decisions (Sen, 1999). From a Social-Ecological Systems perspective, the integration of Indigenous Knowledge with scientific forecasting illustrates how interactions between communities, institutions, and ecological systems strengthen adaptive capacity and improve resilience to climate variability (Ostrom, 2009).

Overall, these findings demonstrate that Indigenous Knowledge continues to play a central role in household climate adaptation in Bomet County. Rather than being displaced by advances in meteorological science, Indigenous forecasting complements scientific seasonal forecasts by enhancing local interpretation, increasing trust, and supporting timely agricultural decision-making. This integrated approach provides a stronger foundation for improving household preparedness and sustainable food security under increasingly uncertain climatic conditions.

4.2 Indigenous Knowledge, Seasonal Forecasting and Household Food Security

The second objective of this study was to examine the role of Indigenous Knowledge (IK) and scientific Seasonal Forecasting (SF) in influencing household food security among farming households in Bomet County. The findings demonstrate that rural households continue to rely heavily on indigenous environmental knowledge while increasingly complementing it with scientific climate forecasts. Rather than viewing the two systems as competing sources of information, most respondents adopted a hybrid approach that combined local ecological observations with formal meteorological forecasts when making agricultural decisions. This complementary use of knowledge systems enhanced confidence in seasonal predictions and strengthened household preparedness for climate-related risks.

The descriptive results indicate that Indigenous Knowledge remains deeply embedded within household decision-making processes ($M = 4.16$, $SD = 0.66$). Approximately 91% of respondents agreed that they routinely relied on indigenous environmental indicators when making farming decisions. Similarly, 86.2% reported that Indigenous Knowledge remained effective in predicting seasonal weather variability, while over two-thirds believed it was reliable in anticipating rainfall and drought conditions. Scientific seasonal forecasts also received positive ratings ($M = 3.77$), although respondents indicated that these forecasts were often interpreted alongside Indigenous Knowledge rather than used independently. Notably, nearly 78% of households reported integrating both Indigenous Knowledge and scientific forecasts before making agricultural decisions, illustrating a pragmatic strategy for reducing uncertainty under increasingly variable climatic conditions.

These findings suggest that farming households perceive Indigenous Knowledge as both accessible and contextually relevant because it is grounded in long-term observation of local environmental conditions. Similar observations have been reported across Sub-Saharan Africa, where ecological indicators such as flowering patterns, insect behaviour, bird migration, cloud formations, and wind direction continue to inform agricultural calendars (Kansiime et al., 2024; Mugambiwa & Tirivangasi, 2023). Comparable evidence has also emerged from Bangladesh (Islam et al., 2024), the Philippines (Lagdameo & Montefrio, 2023), and Indigenous communities in North America (Whitehorse et al., 2023), where local ecological knowledge complements scientific climate information to improve agricultural preparedness.

Qualitative findings reinforced these quantitative results. Farmers explained that Indigenous Knowledge remained indispensable because it was readily available, locally understood, and continuously validated through lived experience. *"When we observe the flowering of certain trees, the movement of ants, or the direction of seasonal winds, we know whether the rains will come early or late. We also listen to the radio forecasts, but we compare both* *before deciding when to plant."* (FGD Participant, Bomet County)

Key informants similarly emphasized that Indigenous Knowledge provides location-specific insights that scientific forecasts sometimes fail to capture. *"Scientific forecasts are useful, but they are usually generalized. Farmers still depend on local indicators because they reflect what is actually happening within their own environment."* (Agricultural Extension Officer). These qualitative accounts illustrate that Indigenous Knowledge is not merely a traditional practice but a dynamic and adaptive knowledge system continually refined through observation and collective learning. Similar conclusions have been reached by UNESCO (2025), Quispe and Ortega (2024), and Ofoegbu et al. (2023), who argue that Indigenous Knowledge functions as a living environmental monitoring system capable of complementing modern climate science.

The findings further demonstrate that households actively combined Indigenous Knowledge with scientific Seasonal Forecasting to strengthen agricultural planning. Approximately 77.4% of respondents reported integrating information from both systems before deciding on planting dates, crop varieties, water conservation measures, and food storage practices. Focus group discussions revealed that households were more confident in acting when both forecasting systems converged. Conversely, when predictions differed, farmers delayed planting, consulted elders, agricultural extension officers, or neighbouring farmers, and continued monitoring local environmental indicators before making final decisions.

4.3 Influence of Indigenous Knowledge and Seasonal Forecasting on Household Food Security

To establish the extent to which Indigenous Knowledge (IK) and Seasonal Forecasting (SF) predicted household food security, a simple linear regression analysis was conducted. Household food security was treated as the dependent variable, while the composite Indigenous Knowledge and Seasonal Forecasting index constituted the independent variable. The analysis sought to determine whether increased utilization of Indigenous Knowledge and scientific forecasting significantly explained variations in household food security among farming households in Bomet County.

4.4 Model Summary

Table 2: Model Summary

Model	R	R^2	Adjusted R^2	Std. Error of Estimate
1	0.682	0.465	0.463	0.521

The regression model produced a correlation coefficient (R) of 0.682, indicating a strong positive relationship between Indigenous Knowledge, Seasonal Forecasting, and household food security. The coefficient of determination ($R^2 = 0.465$) shows that approximately 46.5% of the variation in household food security was explained by Indigenous Knowledge and Seasonal Forecasting. This represents substantial explanatory power within social science research and demonstrates that access to, trust in, and utilization of both traditional and scientific forecasting systems significantly influence household food security outcomes. The remaining 53.5% of the variation may be attributed to other socio-economic, institutional, and environmental factors not included in the present model.

4.5 ANOVA Results

Table 3: ANOVA Results

Source	Sum of Squares	df	Mean Square	F	Sig.
Regression	92.847	1	92.847	344.531	0.000
Residual	106.756	396	0.270		
Total	199.603	397			

The ANOVA results demonstrate that the regression model was statistically significant ($F(1,396) = 344.531$, $p < 0.001$). This indicates that Indigenous Knowledge and Seasonal Forecasting significantly predicted household food security among farming households in Bomet County. The null hypothesis that Indigenous Knowledge and

Seasonal Forecasting have no significant influence on household food security was therefore rejected. The findings suggest that improvements in forecasting knowledge substantially enhance household preparedness, agricultural planning, and ultimately food security.

4.5 Regression Coefficients

Table 4: Regression Coefficients

Variable	B	Std. Error	Beta (β)	t	Sig.
Constant	1.284	0.153	—	8.392	0.000
Indigenous Knowledge and Seasonal Forecasting	0.648	0.035	0.682	18.561	0.000

The regression coefficients indicate that Indigenous Knowledge and Seasonal Forecasting had a positive and statistically significant influence on household food security ($\beta = 0.682$, $p < 0.001$). Specifically, a one-unit improvement in households' utilization of Indigenous Knowledge and Seasonal Forecasting was associated with an estimated 0.648-unit increase in household food security. This finding suggests that households that effectively combine traditional ecological knowledge with scientific seasonal forecasts are considerably more capable of anticipating climatic risks, implementing adaptive agricultural practices, and maintaining stable food supplies. The standardized beta coefficient further indicates that Indigenous Knowledge and Seasonal Forecasting constitute one of the strongest predictors of household food security within the study model. The findings demonstrate that climate information alone is insufficient unless it is locally interpreted, trusted, and translated into practical agricultural decisions. Households that integrated Indigenous Knowledge with scientific forecasts reported greater confidence in determining planting dates, selecting drought-tolerant crop varieties, conserving water, preserving harvested produce, and adjusting farming activities according to anticipated climatic conditions.

The quantitative findings were strongly corroborated by evidence from key informant interviews and focus group discussions. Agricultural extension officers noted that farmers increasingly preferred combining Indigenous Knowledge with scientific forecasts because doing so improved the credibility and relevance of climate information. *"When forecasts from the Kenya Meteorological Department agree with what farmers observe in their local environment, they respond immediately. That combination gives them confidence to plant, conserve water and prepare for possible drought."* (Key Informant Interview) Similarly, farmers explained that Indigenous Knowledge provides localized environmental cues that enable them to verify scientific predictions before investing scarce agricultural resources. *"The weather forecast tells us what may happen across the region, but our trees, insects and birds tell us what is happening here. We need both before making decisions."* (FGD Participant). These findings demonstrate that Indigenous Knowledge does not replace scientific forecasting but rather enhances its interpretation and local applicability. The complementary use of both systems reduces uncertainty, improves farmers' confidence in climate information, and strengthens anticipatory decision-making.

The findings corroborate previous empirical studies demonstrating that integrating Indigenous Knowledge with scientific climate services significantly improves climate adaptation and food security. Kuria et al. (2023) reported that participatory forecasting approaches increased farmers' adoption of climate-smart agriculture across East Africa. Similarly, Ofoegbu et al. (2023) observed that combining Indigenous ecological observations with scientific forecasting enhanced local trust and responsiveness to climate advisories. Comparable findings have been reported in Zimbabwe (Chisadza & Gwimbi, 2024), Bangladesh (Islam et al., 2024), North America (Whitehorse et al., 2023), and the Philippines (Lagdameo & Montefrio, 2023), where hybrid forecasting systems strengthened agricultural resilience and household food security.

The results strongly support the Human Capability Theory, which argues that expanding access to useful knowledge enhances individuals' freedom to make choices that improve their well-being (Sen, 1999; Nussbaum, 2011). Indigenous Knowledge and scientific forecasting expanded farmers' capabilities to anticipate climatic uncertainty and make timely agricultural decisions. The findings equally reinforce the Indigenous Knowledge Systems Theory, which recognizes Indigenous environmental knowledge as a legitimate, dynamic, and context-specific knowledge system developed through generations of environmental interaction (Battiste, 2002; Agrawal, 1995).

The continued reliance on Indigenous forecasting confirms its enduring value in contemporary climate adaptation.

Furthermore, the findings align with the Social-Ecological Systems Theory (Ostrom, 2009), which emphasizes that resilience emerges through interactions among ecological processes, local institutions, and community knowledge systems. The integration of Indigenous Knowledge, scientific forecasting, extension services, and community learning demonstrates how interconnected social and ecological systems enhance adaptive capacity and household food security. Overall, the regression analysis confirms that Indigenous Knowledge and Seasonal Forecasting are significant predictors of household food security in Bomet County. Strengthening policies that promote the co-production of Indigenous and scientific climate knowledge, expanding community-based climate services, and institutionalizing participatory forecasting approaches will enhance anticipatory capacity, improve agricultural resilience, and contribute to sustainable household food security under increasing climate variability.

5. Conclusion and Recommendation

5.1 Conclusion

This study examined the role of Indigenous Knowledge (IK) and scientific Seasonal Forecasting (SF) in shaping household food security among smallholder farming households in Bomet County, Kenya. The findings demonstrate that Indigenous Knowledge remains a vital source of climate information, with most households relying on environmental indicators such as plant phenology, animal behaviour, cloud formations, and seasonal wind patterns to guide agricultural decisions. Although scientific seasonal forecasts disseminated through the Kenya Meteorological Department, extension services, radio broadcasts, and mobile phone platforms are increasingly accessible, households rarely depend on them in isolation. Instead, they integrate scientific forecasts with Indigenous Knowledge to enhance the accuracy, credibility, and local relevance of climate information.

The study established a strong positive relationship between Indigenous Knowledge, Seasonal Forecasting, and household food security. Correlation and regression analyses confirmed that integrating the two forecasting systems significantly improves household preparedness, adaptive decision-making, and food security outcomes. Farmers who combined Indigenous and scientific knowledge were more likely to adjust planting calendars, adopt climate-resilient crop varieties, diversify crops, conserve water, and improve food storage practices before the onset of climate shocks. Qualitative findings further revealed that Indigenous Knowledge enhances trust in scientific forecasts by providing localized environmental validation, thereby increasing farmers' confidence in making production decisions under uncertain climatic conditions.

These findings reinforce the Human Capability Theory by demonstrating that access to multiple knowledge systems expands households' capabilities to make informed livelihood decisions. They also support Indigenous Knowledge Systems Theory by affirming the continued relevance and legitimacy of local ecological knowledge, while the Social-Ecological Systems Theory explains how interactions between communities, institutions, and ecosystems strengthen adaptive capacity and resilience. Overall, the study concludes that sustainable household food security under increasing climate variability depends not only on improving scientific forecasting but also on recognizing, strengthening, and institutionalizing Indigenous Knowledge as an integral component of community-centred climate adaptation and resilient food systems.

5.2 Recommendations

Based on the findings, the study recommends that:

1. National and county governments institutionalize the integration of Indigenous Knowledge with scientific Seasonal Forecasting within Kenya's climate information services and agricultural extension programmes.
2. Participatory forecasting platforms that bring together meteorologists, extension officers, community elders, and farmers should be strengthened to improve the credibility, local relevance, and uptake of climate advisories.
3. Investment in localized dissemination of climate information through community radio, mobile phone platforms, farmer groups, and public forums while documenting and preserving Indigenous forecasting knowledge for future generations.

References

Agrawal, A. (1995). Dismantling the divide between indigenous and scientific knowledge. *Development and Change*, *26*(3), 413–439. https://doi.org/10.1111/j.1467-7660.1995.tb00560.x

Battiste, M. (2002). Indigenous knowledge and pedagogy in First Nations education: A literature review with recommendations. *National Working Group on Education and the Minister of Indian Affairs, Indian and Northern Affairs Canada.*

Food and Agriculture Organization. (2023). *The state of food security and nutrition in the world 2023: Urbanization, agrifood systems transformation and healthy diets across the rural–urban continuum.* FAO.

Food and Agriculture Organization. (2024). *Ukraine: Rapid damage and needs assessment.* FAO.

Government of Kenya. (2023). *National climate change action plan (2023–2027).* Ministry of Environment, Climate Change and Forestry.

Kansiime, M. K., Mugambi, I., Rware, H., & Ampaire, E. (2024). Indigenous knowledge and climate adaptation among smallholder farmers in sub-Saharan Africa. *Climate and Development*, *16*(2), 145–159.

Kuria, D., Ongoma, V., & Githui, F. (2023). Integrating indigenous knowledge and scientific seasonal forecasts for climate adaptation among smallholder farmers in East Africa. *Climate Services, 31*, 100386.

Lagdameo, Y. J., & Montefrio, M. J. F. (2023). Indigenous ecological knowledge and climate adaptation among farming communities in the Philippines. *Asia Pacific Viewpoint*, *64*(2), 247–261.

Mugambiwa, S. S., & Tirivangasi, H. M. (2023). Indigenous knowledge systems and climate change adaptation in rural Africa: A systematic review. *Jàmbá: Journal of Disaster Risk Studies, 15*(1), a1452.

Nussbaum, M. C. (2011). *Creating capabilities: The human development approach.* Harvard University Press.

Ofoegbu, C., Chirwa, P. W., Francis, J., & Babalola, F. D. (2023). Co-producing climate services through indigenous knowledge and scientific forecasting in Africa. *Climate Risk Management, 41*, 100537.

Ostrom, E. (2009). A general framework for analyzing sustainability of social-ecological systems. *Science*, *325*(5939), 419–422. https://doi.org/10.1126/science.1172133

Quispe, R., & Ortega, L. (2024). Indigenous ecological knowledge and food system resilience in mountain communities. *Journal of Ethnobiology and Ethnomedicine*, *20*(1), 31.

Sen, A. (1999). *Development as freedom.* Oxford University Press.

Smith, P., & Kamara, J. (2023). Seasonal forecasting and household resilience under climate variability in sub-Saharan Africa. *Climate Risk Management, 40*, 100496.

UNESCO. (2025). *Indigenous knowledge systems and climate resilience.* UNESCO Publishing.

United States Department of Agriculture. (2024). *Household food security in the United States in 2023.* Economic Research Service.

Whitehorse, T., Jones, A., & Anaviapik, M. (2023). Indigenous climate knowledge and seasonal forecasting among Arctic communities. *Arctic, 76*(4), 421–437.