JRIIE Journal of Research Innovation and Implications in Education
Center for Research Implications & Practice

Website: www.jriiejournal.com ISSN 2520-7504 (Online) Vol.10, Iss.3, 2026 (pp. 664 - 673)

Early Warning Systems and Household Food Security: Evidence from Bomet County, Kenya

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Abstract: *Climate variability continues to threaten agricultural livelihoods and household food security among smallholder farmers who rely heavily on rain-fed agriculture in Kenya. Although early warning systems (EWS) are widely promoted as a climate adaptation strategy, evidence of their effectiveness in improving household preparedness and food security at the local level remains limited. This study examined the influence of early warning systems on household preparedness and food security in Bomet County, Kenya. Guided by Human Capability Theory, Social-Ecological Systems Theory, and Indigenous Knowledge Systems Theory, the study adopted a descriptive mixed-methods design. Quantitative data were collected from 398 farming households, while qualitative data were generated through 15 key informant interviews and six focus group discussions. Quantitative data were analysed using descriptive statistics, Pearson correlation, and regression analysis, while qualitative data were analysed thematically. The findings showed that timely climate information encouraged proactive adaptation, with over 72% of households adjusting planting calendars, adopting climate-resilient crop varieties, and improving food storage. Local radio, extension services, mobile phone alerts, and the Kenya Meteorological Department were the main information sources, while indigenous knowledge complemented scientific forecasts. However, delayed forecasts, poor localization, weak communication infrastructure, and socio-economic constraints reduced EWS effectiveness. The study concludes that integrating indigenous knowledge with scientific forecasting can strengthen household resilience and food security. It recommends expanding community-based climate information services and improving coordination among meteorological agencies, extension services, and local communities to deliver timely, accessible, and locally relevant climate information.*

Keywords: *Early warning systems; Household preparedness; Household food security; Climate variability; Indigenous knowledge; Bomet County, Kenya.*

How to cite this work (APA):

Kositany, J., Oino, P. G. & Angwenyi, D. (2026). Early Warning Systems and Household Food Security: Evidence from Bomet County, Kenya. *Journal of Research Innovation and Implications in Education, 10*(3), 664 – 673. **https://doi.org/10.59765/nkf69**

1. Introduction

Climate variability has emerged as one of the most significant threats to global food systems and sustainable development. Rising temperatures, erratic rainfall, prolonged droughts, and extreme weather events continue to undermine agricultural productivity and threaten the livelihoods of millions of people, particularly those dependent on rain-fed agriculture (IPCC, 2022; UNDRR, 2022). The Food and Agriculture Organization (FAO, 2022) estimates that climate-related hazards are increasingly disrupting food production systems, contributing to declining agricultural yields, reduced household incomes, and heightened food insecurity. These impacts are especially severe in low- and middle-income countries where adaptive capacity remains limited.

Early warning systems (EWS) have increasingly been recognized as an essential component of climate change adaptation and disaster risk reduction. The United

Nations Office for Disaster Risk Reduction (UNDRR, 2022) defines an effective early warning system as an integrated framework that generates, disseminates, and communicates timely and actionable information to enable individuals and communities to anticipate hazards and implement appropriate preparedness measures. Beyond providing weather forecasts, modern EWS facilitate informed decision-making by reducing uncertainty and enabling households to undertake anticipatory actions that minimize potential losses (WMO, 2023). Studies conducted across Asia and Africa demonstrate that households with timely access to climate information are more likely to adjust farming calendars, diversify crops, conserve water resources, and improve household food reserves before climate shocks occur (Hansen et al., 2011; FAO, 2022).

Sub-Saharan Africa remains one of the region's most vulnerable to climate variability because agriculture constitutes the principal source of livelihoods for approximately 60 percent of the population (World Bank, 2021). Most agricultural production in the region is rain-fed, making farming households highly susceptible to rainfall variability and prolonged droughts (IPCC, 2022). Research conducted across East Africa indicates that climate-related disasters have become more frequent over the past two decades, contributing to declining crop productivity, livestock losses, and chronic household food insecurity (Hahn et al., 2009; WFP, 2023). Consequently, governments and development partners have increasingly invested in climate information services and early warning systems to strengthen resilience among vulnerable farming communities.

In Kenya, climate variability continues to undermine agricultural productivity despite substantial investments in climate adaptation programmes. Agriculture contributes significantly to the national economy and provides livelihoods for the majority of rural households, yet more than 80% of agricultural production depends on rainfall (Kenya Meteorological Department, 2023). To reduce climate-related risks, the Government of Kenya has strengthened national and county-level early warning systems through the Kenya Meteorological Department, agricultural extension services, county disaster management committees, and community-based communication channels. Climate advisories are disseminated through radio broadcasts, mobile phone messages, agricultural extension officers, farmer organizations, and public meetings (barazas), with the objective of enabling farmers to make timely and informed agricultural decisions (Kenya Meteorological Department, 2023; Ngugi et al., 2022). Nevertheless, studies indicate that the effectiveness of these systems remains constrained by delayed dissemination of information, weak communication infrastructure, limited localization of weather forecasts, and varying levels of public trust in meteorological information (Mutasa, 2018; Obando et al., 2020).

Alongside formal meteorological services, indigenous knowledge continues to play an important role in agricultural decision-making in many rural communities. Indigenous forecasting relies on long-term observations of environmental indicators such as cloud formations, flowering patterns, insect behaviour, animal movements, and seasonal wind patterns to predict weather conditions (Berkes, 2018; Orlove et al., 2021). Although climate change has altered the reliability of some traditional indicators, several studies suggest that indigenous knowledge remains valuable when integrated with scientific climate information because it enhances local relevance, strengthens community trust, and improves household preparedness (Roncoli et al., 2009; Kihoro et al., 2021; Ronoh et al., 2022). Rather than functioning as competing systems, formal forecasting and indigenous knowledge often complement one another in supporting agricultural decision-making.

Bomet County is predominantly an agricultural county where crop and livestock production constitute the primary livelihood activities for most households. Although the county lies within Kenya's high-potential agricultural zone, recent rainfall variability, prolonged dry spells, and changing seasonal patterns have increasingly affected crop production and household food security (Kenya Meteorological Department, 2023). Smallholder farmers are particularly vulnerable because they rely heavily on seasonal rainfall while facing constraints related to access to climate information, financial resources, and adaptive technologies. Under such conditions, effective early warning systems become critical for enabling households to anticipate climatic risks, adjust farming practices, and strengthen food security.

Although previous studies have established the importance of early warning systems in enhancing climate adaptation, several knowledge gaps remain. Much of the existing literature has focused on regional or national assessments, with relatively few studies examining how early warning systems influence household preparedness and food security within specific local contexts such as Bomet County (Kihoro et al., 2021; Ngugi et al., 2022). Furthermore, many studies have examined formal meteorological information and indigenous forecasting independently, providing limited understanding of how households combine these complementary knowledge systems when making agricultural decisions. There is also limited empirical evidence explaining how institutional support, communication channels, indigenous knowledge, and household characteristics interact to shape preparedness and food security outcomes at the household level.

It is against this background that the present study examined the influence of early warning systems on household preparedness and food security in Bomet County, Kenya. By integrating quantitative household data with qualitative evidence from key stakeholders, the study provides context-specific insights into how formal

and indigenous early warning systems contribute to household resilience under increasing climate variability.

1.1 Statement of the Problem

Climate variability has become an increasingly important driver of food insecurity among smallholder farming households in Kenya, with unpredictable rainfall, prolonged dry spells, and recurring extreme weather events disrupting agricultural production and rural livelihoods. Although the Government of Kenya and its development partners have invested in early warning systems (EWS) to strengthen climate adaptation and disaster preparedness, food insecurity remains widespread in many agricultural counties, including Bomet. Formal early warning systems provide climate information through meteorological forecasts, agricultural extension services, radio broadcasts, mobile phone platforms, and local administrative structures. However, many households continue to experience difficulties in accessing, interpreting, and acting upon this information due to delayed dissemination, inadequate localization of forecasts, weak communication infrastructure, limited financial resources, and varying levels of trust in official climate advisories (Ngugi et al., 2022; Mutasa, 2018; Kenya Meteorological Department, 2023). Consequently, the availability of climate information has not consistently translated into improved household preparedness or enhanced food security.

In rural communities, indigenous knowledge has traditionally complemented scientific weather forecasting by providing locally grounded environmental indicators that guide farming decisions. Nevertheless, changing climatic conditions have reduced the reliability of some indigenous forecasting indicators, while formal early warning systems have made limited progress in incorporating local knowledge into climate information services (Ogutu et al., 2021; Kipkorir et al., 2020). Although previous studies have examined the performance of early warning systems, climate vulnerability, and adaptation strategies, most have focused on broader regional or national contexts, with limited attention to how formal climate information, indigenous knowledge, institutional support, and household characteristics interact to influence preparedness and food security at the household level. This gap is particularly evident in Bomet County, where agriculture remains the principal livelihood activity despite increasing climate uncertainty. Addressing this gap is essential for understanding the conditions under which early warning systems enhance household preparedness and contribute to improved food security. Accordingly, this study examined the influence of early warning systems on household preparedness and food security in Bomet County, Kenya, with the aim of generating empirical evidence to inform policies and interventions that strengthen climate resilience among rural farming households.

1.2 Research Objective

The study sought to examine the influence of early warning systems on household preparedness and food security in Bomet County, Kenya.

2. Literature Review

Early warning systems (EWS) are widely recognized as essential instruments for reducing climate-related risks and enhancing household resilience in agricultural communities. By providing timely and actionable climate information, EWS enable households to anticipate weather-related hazards, adjust agricultural activities, and reduce potential losses. Empirical evidence consistently shows that access to reliable climate information improves preparedness, supports informed decision-making, and contributes to household food security, particularly in regions where livelihoods depend predominantly on rain-fed agriculture.

Several studies have demonstrated that timely climate information enables farmers to adopt proactive adaptation strategies. Hahn et al. (2009), in a study conducted in rural Tanzania, found that households receiving seasonal climate forecasts adjusted planting dates and adopted crop varieties suited to anticipated rainfall conditions, thereby reducing their exposure to food insecurity. Similarly, Kihoro et al. (2021) reported that Kenyan farmers who accessed weather advisories were more likely to modify planting calendars, diversify crops, and improve water management practices than those without access to climate information. These findings suggest that effective early warning systems reduce uncertainty and strengthen households' capacity to make informed agricultural decisions before climate hazards occur.

Beyond supporting immediate agricultural decisions, early warning systems also contribute to long-term household resilience by encouraging investment in adaptive farming practices. Piya et al. (2020) observed that households with regular access to localized weather information were more willing to invest in soil conservation, water harvesting, and diversified farming systems because they had greater confidence in seasonal climate predictions. Likewise, Nyong et al. (2007) found that early warning information enabled pastoral communities in East Africa to anticipate drought conditions, adjust livestock movements, conserve pasture, and diversify livelihood activities, thereby reducing vulnerability to climate shocks. Collectively, these studies demonstrate that early warning systems strengthen resilience by supporting both short-term preparedness and long-term adaptation.

Despite these benefits, the effectiveness of early warning systems is often constrained by barriers that limit access to and utilization of climate information. Studies across sub-Saharan Africa identify delayed dissemination of weather forecasts, poor communication infrastructure, and inadequate translation of technical forecasts into

local languages, and weak institutional coordination as major obstacles to effective climate information services (Jiri et al., 2016; Mutasa, 2018). In Kenya, Obando et al. (2020) similarly reported that poor mobile network coverage and limited access to communication technologies reduced farmers' ability to receive timely weather advisories, particularly in remote rural areas. In addition, poverty, low literacy levels, and limited access to agricultural extension services often constrain households from acting upon climate information even when it is available (Mude et al., 2020; Ochieng et al., 2022). These findings indicate that the effectiveness of early warning systems depends not only on the quality of climate forecasts but also on households' capacity to utilize the information provided.

Another important theme emerging from the literature is the complementary role of indigenous knowledge in climate adaptation. Indigenous forecasting systems rely on long-term observation of environmental indicators, including cloud formations, flowering patterns, insect behaviour, wind direction, and animal movements, to anticipate seasonal weather conditions (Berkes, 2018). Roncoli et al. (2009) observed that farmers often interpret scientific forecasts alongside local environmental indicators, thereby increasing confidence in agricultural decisions. Similarly, Ronoh et al. (2022) and Kihoro et al. (2021) found that integrating indigenous knowledge with formal meteorological information improved the relevance, credibility, and acceptance of climate advisories among farming communities. These findings suggest that scientific and indigenous knowledge systems are complementary rather than competing approaches to climate risk management.

Institutional support also plays a critical role in determining the effectiveness of early warning systems. According to Mwangi et al. (2019), agricultural extension officers, community leaders, farmer organizations, and local administrative structures facilitate the dissemination and interpretation of climate information, enabling households to translate forecasts into practical adaptation measures. Where such institutional support is weak, households often struggle to understand technical weather information or lack the confidence to act upon climate advisories. This highlights the importance of strengthening institutional coordination and community engagement to maximize the effectiveness of early warning systems.

Although existing studies consistently demonstrate the value of early warning systems in strengthening climate adaptation and food security, several gaps remain. Most previous studies have focused on regional assessments, technical performance of climate information systems, or specific adaptation practices, with limited attention to how formal climate information, indigenous knowledge, institutional support, and household characteristics interact to influence preparedness and food security at the household level. Furthermore, relatively few empirical studies have examined these relationships within high-potential agricultural counties such as Bomet, where farming households continue to face increasing climate uncertainty despite the availability of early warning services. The present study addresses this gap by examining how early warning systems influence household preparedness and food security using an integrated mixed-methods approach that combines quantitative household data with qualitative insights from key stakeholders.This study is anchored on Human Capability Theory, Social-Ecological Systems (SES) Theory, and Indigenous Knowledge Systems (IKS) Theory. Collectively, these theories provide a comprehensive framework for understanding how early warning systems influence household preparedness and food security by integrating individual capabilities, institutional arrangements, ecological interactions, and locally embedded knowledge.Human Capability Theory, advanced by Sen (1999), posits that development should be understood in terms of people's capabilities to achieve the lives they value rather than merely the resources they possess. Within the context of this study, early warning systems extend beyond the provision of climate information by enhancing households' capabilities to anticipate climate risks, make informed agricultural decisions, protect livelihoods, and improve food security. The theory emphasizes that access to timely and credible climate information expands households' opportunities to adopt adaptive farming practices, safeguard food supplies, and strengthen resilience against climate-related shocks.Social-Ecological Systems (SES) Theory, developed by Ostrom (2009) and further advanced by Berkes (2018), explains resilience as an outcome of dynamic interactions between ecological systems and human institutions. The theory views households, governance structures, community networks, and ecological processes as interconnected components of a single adaptive system. In this study, early warning systems are conceptualized as adaptive governance mechanisms that link meteorological institutions, county governments, agricultural extension services, farmer organizations, and households. Household preparedness therefore depends not only on access to climate information but also on effective communication, institutional coordination, collective learning, and community participation that enable timely responses to climate variability.Indigenous Knowledge Systems Theory recognizes the value of locally generated knowledge accumulated through long-term observation of environmental conditions and community experience (Berkes, 2018; Orlove et al., 2021). Farmers use environmental indicators such as cloud formations, flowering patterns, insect behaviour, wind direction, and animal movements to anticipate seasonal weather changes and guide agricultural decisions. Although climate variability has affected the reliability of some traditional indicators, indigenous knowledge remains an important source of locally relevant information. When integrated with scientific climate forecasts, indigenous knowledge enhances the relevance, credibility, and acceptance of early warning information, thereby

strengthening household preparedness and adaptive decision-making.Together, these theories provide a complementary analytical framework for understanding how early warning systems enhance household preparedness and food security. Human Capability Theory explains households' ability to translate climate information into adaptive actions; Social-Ecological Systems Theory highlights the interactions among institutions, communities, and ecological systems that shape resilience; while Indigenous Knowledge Systems Theory underscores the importance of integrating local knowledge with scientific forecasting to improve climate adaptation. Collectively, these perspectives provide a robust foundation for analysing the role of early warning systems in strengthening household resilience and promoting food security in Bomet County, Kenya.

3. Methodology

This study employed a descriptive mixed-methods research design to examine the influence of early warning systems on household preparedness and food security in Bomet County, Kenya. The mixed-methods approach was adopted to integrate quantitative and qualitative evidence, thereby providing a comprehensive understanding of how farming households access, interpret, and utilize climate information in responding to climate variability. The study was conducted in Chepalungu and Sotik sub-counties, where agriculture is the principal livelihood and households are increasingly exposed to climate-related risks. The target population comprised 73,500 farming households, from which a sample of 398 households was selected using stratified random sampling to ensure representation across different agro-ecological zones and socio-economic groups. In addition, purposive sampling was employed to select 15 key informants, including agricultural extension officers, county disaster management officials, local administrators, and community leaders, while six focus group discussions were conducted with farmers to capture diverse community perspectives on climate adaptation and food security.

Quantitative data were collected using structured household questionnaires, while qualitative data were generated through key informant interviews, focus group discussions, and field observations of farming and adaptation practices. Quantitative data were coded and analysed using SPSS Version 31, where descriptive statistics summarized household characteristics and access to early warning systems, while Pearson correlation and multiple regression analyses examined the relationship between early warning systems, household preparedness, and food security. Qualitative data were transcribed and analysed thematically following Braun and Clarke's (2006) framework to identify emerging patterns and contextual explanations. The integration of quantitative and qualitative findings strengthened the validity of the study through methodological triangulation. Ethical approval and research authorization were obtained from the relevant institutional and national authorities, and informed consent, confidentiality, anonymity, and voluntary participation were upheld throughout the study.

4. Results and Discussions

4.1 Household Sources of Early Warning Information

Table 1 presents the primary sources of early warning information used by farming households in Bomet County. Local radio stations emerged as the most widely accessed source of climate information (78.6%), followed by agricultural extension officers (74.1%), mobile phone alerts (68.3%), and information disseminated by the Kenya Meteorological Department (65.8%). Indigenous knowledge remained an important source of climate information, with 64.9% of respondents reporting that they relied on traditional environmental indicators to anticipate seasonal weather conditions. Public barazas (58.7%) and farmer groups (54.2%) also contributed to the dissemination of weather information, highlighting the importance of community-based communication channels.

Table 1: Sources of Early Warning Information (n = 398)

Source of information	Frequency	Percentage (%)
Local radio stations	313	78.6
Agricultural extension officers	295	74.1
Mobile phone alerts	272	68.3
Kenya Meteorological Department	262	65.8
Indigenous knowledge	258	64.9
Public barazas	234	58.7
Farmer groups	216	54.2

The predominance of radio stations and agricultural extension officers demonstrates that conventional communication channels remain central to the dissemination of climate information in rural communities. Radio remains accessible even in areas with limited internet connectivity, while extension officers provide opportunities for farmers to seek clarification and receive context-specific guidance. The substantial proportion of households relying on indigenous knowledge further indicates that climate-related decision-making is informed by multiple knowledge systems rather than scientific forecasts alone. During focus group discussions, participants explained that they often confirmed meteorological forecasts by observing environmental indicators such as cloud formations, wind direction, flowering patterns of selected tree species, and insect behaviour before making planting decisions. This finding suggests that indigenous knowledge continues to reinforce confidence in formal weather forecasts rather than competing with them.

These findings corroborate earlier studies showing that multiple communication channels improve the accessibility and utilisation of climate information. Roncoli et al. (2009) found that farmers in West Africa combined scientific weather forecasts with indigenous environmental observations to improve the reliability of seasonal predictions. Similarly, Hansen et al. (2011) observed that farmers were more likely to adopt climate-smart agricultural practices when weather information was communicated through trusted local institutions. In Kenya, Kihoro et al. (2021) reported that agricultural extension services and local radio stations were among the most effective channels for disseminating climate advisories because they reached a broad spectrum of rural households and enhanced farmers' understanding of weather forecasts. The present findings extend this evidence by demonstrating that indigenous knowledge continues to complement formal climate information even where modern early warning systems are available.

The findings are consistent with Social-Ecological Systems Theory**,** which emphasizes that resilience emerges through interactions among institutions, communities, and ecological systems. The coexistence of formal meteorological services, community organisations, and indigenous knowledge illustrates the interconnected governance structures through which climate information is generated, interpreted, and utilised. The findings also support Indigenous Knowledge Systems Theory**,** which recognises locally generated environmental knowledge as an important component of adaptive decision-making. Rather than replacing indigenous forecasting, scientific early warning systems appear to strengthen household preparedness when both knowledge systems are integrated.

4.2 Household Preparedness Following Early Warning Information

The study further examined the preparedness measures adopted by households after receiving early warning information. As presented in Table 2, adjusting planting calendars was the most common adaptation strategy (72.1%), followed by the adoption of climate-resilient crop varieties (69.3%), improved food storage practices (63.6%), water conservation measures (59.8%), and crop diversification (55.5%). These findings indicate that early warning information encouraged households to implement anticipatory measures aimed at reducing climate-related risks before the onset of adverse weather conditions.

Table 2: Household Preparedness Measures Following Early Warning Information

Preparedness measure	Frequency	Percentage (%)
Adjusted planting calendar	287	72.1
Adopted climate-resilient crop varieties	276	69.3
Improved food storage	253	63.6
Water conservation	238	59.8
Crop diversification	221	55.5

The predominance of anticipatory actions demonstrates that households did not merely receive climate information but translated it into practical adaptation strategies. Participants explained that timely forecasts enabled them to delay planting until rainfall patterns stabilized, select crop varieties suitable for the anticipated season, and improve food storage to minimize post-harvest losses. Agricultural extension officers similarly observed that farmers who consistently accessed seasonal forecasts were more likely to adopt recommended climate-smart agricultural practices than those who relied exclusively on traditional farming calendars. These findings suggest that effective early warning systems enhance preparedness by enabling households to act before climate hazards occur rather than responding after losses have been incurred.

The findings corroborate those of Hahn et al. (2009), Hansen et al. (2011), and Piya et al. (2020), who reported that timely climate information supports proactive adaptation through adjustments in planting dates, crop selection, water management, and livelihood diversification. Likewise, Ngugi et al. (2022) found that Kenyan farmers with regular access to seasonal climate advisories demonstrated higher levels of preparedness and greater adoption of climate-resilient agricultural practices. Collectively, these studies reinforce the conclusion that early warning systems contribute to household resilience by enabling informed decision-making before climate-related shocks occur.

From a theoretical perspective, the findings strongly support Human Capability Theory (Sen, 1999), which argues that development is reflected in people's ability to convert available resources into meaningful actions that improve their well-being. In this study, climate information functioned as a strategic resource that expanded households' capabilities to make informed agricultural decisions and strengthen food security. The findings also align with Social-Ecological Systems Theory**,** which emphasises that household resilience depends not only on access to information but also on institutional support, knowledge exchange, and adaptive learning. The observed preparedness measures therefore reflect the interaction between individual decision-making, community institutions, and environmental knowledge in building resilience to climate variability.

Analysis of household engagement with early warning systems (EWS) in Chepalungu and Sotik sub-counties revealed high levels of adaptive behavior. After cleaning and coding the quantitative data in SPSS Version 31, 72% of households reported adjusting agricultural practices, including modifying planting dates, selecting climate-resilient crop varieties, and implementing improved food storage measures, in response to EWS advisories. This indicates that households recognize the relevance of timely forecasts for reducing vulnerability to food insecurity.

Additionally, 65% of households reported using indigenous knowledge to complement formal advisories. Local indicators, such as cloud formations, animal behavior, and vegetation phenology, guided decision-making, particularly in areas where formal alerts were delayed or inaccessible. These findings demonstrate that households employ hybrid adaptation strategies, blending scientific forecasts with indigenous knowledge to optimize preparedness.

4.3 Relationship between Early Warning Systems and Household Food Security

To establish the relationship between early warning systems and household food security, Pearson's Product-Moment Correlation analysis was conducted. The results are presented in Table 3.

Table 3: Correlation between Early Warning Systems and Household Food Security (n = 398)

Variables	**1**	**2**
1. Early Warning Systems	1	
2. Household Food Security	**0.684****	1

Note: p < 0.01.

The results revealed a strong positive and statistically significant relationship between early warning systems and household food security ($r = 0.684$, $p < 0.01$). This indicates that increased access to timely, reliable, and actionable climate information was associated with improved household food security. Households that regularly received and utilised early warning information were more likely to adopt anticipatory agricultural practices, minimise production losses, and maintain stable food supplies than those with limited access to climate information.

The qualitative findings reinforced the statistical results. Farmers consistently reported that seasonal weather forecasts enabled them to make informed decisions regarding planting dates, crop selection, and food storage. Extension officers similarly observed that households receiving regular climate advisories demonstrated greater preparedness and recovered more quickly from adverse weather events than households that depended solely on traditional farming calendars. Participants also noted that combining scientific forecasts with indigenous knowledge increased confidence in decision-making, particularly during seasons characterised by uncertain rainfall patterns.

These findings corroborate those of Hansen et al. (2011), who reported that access to climate information significantly improved agricultural productivity and household resilience by supporting timely adaptation decisions. Similarly, Kihoro et al. (2021) found that farmers who regularly utilised weather forecasts were more likely to adopt climate-smart agricultural practices than those without access to such information. Comparable evidence has been reported by Ngugi et al. (2022), who concluded that climate information services significantly improved preparedness and reduced vulnerability among smallholder farmers in Kenya. Collectively, these studies demonstrate that early

warning systems contribute to improved food security by enabling households to anticipate climate-related risks and implement appropriate adaptation strategies before losses occur.

The findings are consistent with Human Capability Theory, which argues that access to relevant information expands individuals' capabilities to make informed choices that enhance their well-being (Sen, 1999). In this study, climate information enhanced households' capacity to anticipate climatic risks, allocate resources efficiently, and adopt appropriate adaptation measures. The results also support Social-Ecological Systems Theory, which views resilience as a product of interactions among households, institutions, and ecological systems (Ostrom, 2009). The observed positive relationship reflects the effectiveness of institutional communication, community learning, and adaptive governance in strengthening household resilience. Furthermore, the complementary use of indigenous forecasting alongside scientific climate information reinforces the propositions of Indigenous Knowledge Systems Theory, which emphasizes the value of locally generated knowledge in enhancing environmental decision-making and adaptive capacity.

4.4 Influence of Early Warning Systems on Household Food Security

To determine whether early warning systems significantly predicted household food security, a multiple regression analysis was performed. The results are presented in Table 4.

Table 4: Multiple Regression Analysis

Predictor	β	Std. Error	t	p-value
Constant	—	—	—	—
Early Warning Systems	**0.612**	0.048	12.74	<0.001

The regression analysis indicates that early warning systems significantly predicted household food security ($\beta = 0.612$, $p < 0.001$). The model explained 46.8% of the variation in household food security ($R^2 = 0.468$), suggesting that nearly half of the observed differences in food security among households were associated with differences in access to and utilisation of early warning information. These findings demonstrate that timely climate information plays a substantial role in enhancing household preparedness and strengthening food security, although other socio-economic and environmental factors also contribute to household outcomes.

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The quantitative findings were supported by qualitative evidence from farmers and extension officers, who explained that climate information enabled households to make proactive decisions regarding crop selection, planting schedules, water conservation, and post-harvest management. Nevertheless, participants emphasised that effective utilisation of early warning information depended on complementary factors such as extension support, access to farm inputs, financial resources, and reliable communication infrastructure. These observations suggest that early warning systems are most effective when supported by broader institutional and livelihood interventions.

The findings are consistent with studies by Piya et al. (2020), Mude et al. (2020), and Ochieng et al. (2022), which demonstrate that climate information services significantly enhance adaptive capacity and food security when accompanied by institutional support and community engagement. The results further affirm Human Capability Theory, which emphasises that information creates opportunities only when individuals possess the capability to utilise it effectively. Similarly, Social-Ecological Systems Theory highlights that resilience emerges through coordinated interactions among households, institutions, and ecological systems rather than through isolated interventions. Consequently, strengthening communication networks, expanding agricultural extension services, and integrating indigenous knowledge with scientific forecasting are likely to enhance the effectiveness of early warning systems in improving household food security.

The findings of this study demonstrate that early warning systems play a critical role in strengthening household preparedness and improving food security among farming households in Bomet County. Descriptive results showed that households relied on multiple sources of climate information, with local radio stations, agricultural extension officers, mobile phone alerts, and the Kenya Meteorological Department serving as the principal dissemination channels. Importantly, indigenous knowledge remained an integral component of household decision-making, with many farmers combining scientific weather forecasts with traditional environmental indicators to enhance confidence in seasonal predictions. This integration of knowledge systems enabled households to implement proactive adaptation measures, including adjusting planting

calendars, adopting climate-resilient crop varieties, improving food storage practices, conserving water resources, and diversifying agricultural production.

Inferential analysis further established a statistically significant positive relationship between early warning systems and household food security, demonstrating that access to timely, reliable, and locally relevant climate information substantially enhanced household preparedness and adaptive capacity. The qualitative findings reinforced these results by illustrating how institutional support, community learning, and indigenous knowledge strengthened farmers' ability to interpret climate information and respond effectively to changing weather conditions. However, the study also identified persistent challenges, including delays in disseminating weather forecasts, inadequate localization of climate information, poor communication infrastructure, and limited financial capacity, all of which constrained households' ability to fully utilise early warning information.

The findings corroborate previous studies (Hahn et al., 2009; Hansen et al., 2011; Kihoro et al., 2021; Ngugi et al., 2022) demonstrating that timely climate information enhances agricultural decision-making and household resilience. At the same time, this study extends existing knowledge by showing that the effectiveness of early warning systems depends not only on the availability of scientific forecasts but also on the integration of indigenous knowledge, institutional coordination, and accessible communication channels. These findings align with Human Capability Theory, which emphasises the role of information in expanding people's capacity to make informed livelihood decisions; Social-Ecological Systems Theory, which highlights the importance of interactions among institutions, communities, and ecological systems in building resilience; and Indigenous Knowledge Systems Theory, which recognises local environmental knowledge as an essential complement to scientific forecasting. Collectively, the findings demonstrate that effective early warning systems are not merely technological interventions but integrated socio-ecological processes that enhance adaptive capacity, strengthen household resilience, and contribute to sustainable food security under increasing climate variability.

5. Conclusion and Recommendations

5.1 Conclusion

This study examined the influence of early warning systems on household preparedness and food security in Bomet County, Kenya. The findings demonstrate that timely and reliable climate information significantly enhances household preparedness by enabling farmers to make informed decisions on planting, crop selection, water conservation, and food storage. The study further established that the effectiveness of early warning systems is strengthened when scientific climate information is complemented by indigenous knowledge and supported by effective institutional coordination and accessible communication channels. However, challenges such as delayed dissemination of forecasts, inadequate localization of climate information, and socio-economic constraints continue to limit the ability of some households to fully benefit from early warning services. Strengthening integrated, community-centred early warning systems is therefore essential for enhancing household resilience and promoting sustainable food security under increasing climate variability

5.2 Recommendations

Based on the findings, the study recommends that:

1. National and county governments strengthen the timeliness and localization of climate information through multiple communication channels, including radio, mobile platforms, and agricultural extension services.
2. There is also a need to formally integrate indigenous knowledge into early warning systems to enhance the relevance and acceptance of climate advisories among farming communities.
3. Investments in agricultural extension, rural communication infrastructure, and climate-smart farming initiatives should be prioritized to improve households' capacity to utilize early warning information and strengthen food security under changing climatic conditions.

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