THE INFLUENCE OF ADOPTION OF FARM-BASED FOOD RESILIENCE STRATEGIES ON LIVELIHOOD OUTCOMES AMONG FARMING HOUSEHOLDS IN MAKUENI COUNTY, KENYA

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Abstract
Kenya faces persistent adverse livelihood outcomes, including food insecurity, which is aggravated by climate variability, erratic rainfall, prolonged droughts and economic constraints. Limited empirical evidence exists on the influence of the adopted Farm Based Food Resilience Strategies (FBFRS) in improving household livelihoods in Makueni County, Kenya, thus making it difficult to design targeted interventions that can enhance sustainable livelihoods. The study sought to establish the influence of the adoption of FBFRS on livelihood outcomes among farming households in Makueni County, Kenya. FBFRS included strategies related to crop, soil, water, and livestock management, while livelihood outcomes were assessed through food security, income stability, and related dimension. A sample size of 399 rural households was drawn from three sub-counties (Mbooni, Makueni and Kibwezi West) through multistage sampling, comprising stratified, purposive and simple random sampling techniques. The study adopted a descriptive survey research design to meet the research objective. Data was analyzed using descriptive and regression analysis. The regression results revealed that FBFRS had a positive and statistically significant influence on livelihood outcomes among farming households in Makueni County, Kenya, at a 5% significance ($\beta = 0.559$, $p < 0.001$), explaining 42.3% of the variation in livelihood outcomes ($R^2 = 0.423$). This implies that increased adoption of farm-based strategies enhances household livelihood outcomes. It was concluded that adoption of FBFRS significantly improves household livelihood outcomes in Makueni County. However, challenges such as unpredictable weather, pests and diseases, high input costs, limited water access, inadequate funds and low technical knowledge undermine these gains. The study recommends strengthening farmer training and extension services, promoting climate-smart technologies, subsidizing agricultural inputs, improving water access, and enhancing market linkages to maximize the benefits of FBFRS and promote sustainable rural livelihoods in Makueni County.

Key Words: Farm-Based Food Resilience Strategies, Livelihood Outcomes, Farming Households, Crop Management Strategies, Soil Management, Water Management, Livestock Adaptation, Climate Resilience, Sustainable Livelihoods, Makueni County, Kenya.

Introduction

Food security is a critical global challenge, with approximately 2.33 billion people globally experiencing moderate or severe food insecurity, a situation exacerbated by climate-related risks which threaten agricultural systems, which provide livelihoods for billions of people globally (FAO, 2024). Additionally, those grappling with unstable livelihoods and chronic food insecurity under normal circumstances are often ill-equipped to cope with additional shocks and crises (UNICEF, 2024). In response to the adverse effects of climate change and variability on food systems, FAO underscores the need for resilience-building strategies such as Farm Based Food Resilience Strategies (FBFRS). Food resilience is the capacity of individuals, households, communities, or food systems to anticipate, absorb, adapt to and recover from shocks and stresses while maintaining sustainable access to sufficient, safe and nutritious food. FBFRS include a group of sustainable and adaptive practices ranging from climate-smart agriculture, crop diversification and sustainable water management (FAO, 2020).

FBFRS mitigate vulnerabilities that threaten household livelihoods by promoting food security and sustainability (FAO, 2024). Moreover, achieving Sustainable Development Goal 2 on ending hunger and promoting sustainable agriculture requires urgent action to enhance adaptation, especially in vulnerable regions. De Jong et al. (2024) emphasized that building food resilience is necessary to withstand shocks (sudden events like extreme weather, economic instability, and conflicts or disease outbreaks that disrupt food systems) and stressors (longer-term pressures such as climate change or gradual biodiversity loss) and maintain progress towards desired outcomes, such as food and nutrition security and equitable livelihoods for all.

Global food resilience has improved in some areas, but significant vulnerabilities still persist which threaten their sustainability, including geopolitical conflicts, climate change, climate variability and public health crises like COVID-19 (Ghosh-Jerath *et al.,* 2021, Sandström *et al*., 2024). In particular, these factors put the quantity, quality, stability and safety of the global food supply at risk (Shukla *et al.,* 2019). A profound transformation is needed to address these challenges and ensure long-term resilience and FBFRS like crop rotation, cover crops and low or no tillage can improve soil health and increase farm resiliency (Karunarathne *et al.,* 2024). Countries like Canada and Australia have adopted local food production strategies to increase food production (Boyd & Wilson, 2024; Tobón-Cuenca *et al*., 2024).

While developed nations like Canada and Australia have adopted local food production strategies, much of Sub-Saharan Africa still struggles with systemic food insecurity driven by climate vulnerability. Africa faces some of the most severe livelihood challenges, with over 400 million people living in extreme poverty and nearly 250 million people experiencing hunger (UNDP, 2023). Agriculture is the primary livelihood source for 60% of the population, yet productivity is constrained by climate change, inadequate infrastructure, and limited market access (IPCC, 2022). Thus, resilience to climate variability remains critical for food security and economic stability in Africa (Sime & Aune, 2019).

Kenya's economy heavily relies on agriculture, faces significant food security challenges mainly due to climate variability. Although agriculture contributes about 33% of Kenya's GDP and employing 70% of its rural population (KNBS, 2022), frequent droughts, unpredictable rainfall and land degradation have undermined food production, particularly in the vast arid and semi-arid lands (ASALs). Given the importance of the agricultural sector, the Kenyan government has been developing and promoting Agri-based policies and FBFRS including promoting drought-tolerant crops, expanding irrigation infrastructure and supporting smallholder farmers. Despite these efforts, USAID (2020) noted that approximately 36.5% of the Kenyan population remains food insecure.

Makueni County experiences semi-arid conditions where farming households depend on rain-fed agriculture thus making it highly vulnerable to climate shocks (GOK, 2021). The county has a poverty rate of 34.8% (KIPPRA, 2023). A significant portion of the population also lacks sufficient access to food (Frontiers in Sustainable Food Systems, 2023). To enhance food resilience, Makueni county government, faith-based organizations and non-governmental organisations (NGOs) have been promoting various FBFRS, including promotion of drought-resistant crops and training farmers in climate-smart agricultural practices (CGIAR, 2024). These efforts aim to improve household food security and reduce poverty through sustainable farming practices. Despite these efforts, information on the effects of adopting farm-based food resilience strategies among farming households in Makueni County remains limited and poorly documented. This study therefore examined how the adoption of farm-based food resilience strategies influences livelihood outcomes among farming households in Makueni County, Kenya.

Methodology

Location of the Study

Makueni County lies in Kenya's semi-arid south-eastern region and is characterized by temperatures of 15–26°C and bimodal rainfall ranging from 250–400 mm in the lowlands to 800–900 mm in the highlands (Makueni County, 2018). The County is located within Kenya's arid and semi-arid lands (ASALs). The predominantly agricultural economy depends on rain-fed farming, making it highly susceptible to recurrent droughts and rainfall variability. In recent years, the county has attracted attention for its proactive resilience-building efforts by both government and development partners. Interventions have included water harvesting infrastructure, promotion of drought-resistant crops and community-driven planning supported by devolved governance systems (World Bank, 2022; Ndungu *et al.,* 2020). This context provided a suitable setting for examining farm-based food resilience strategies.

Research Design

A mixed-methods descriptive survey design was adopted to collect both quantitative and qualitative data on the adoption of farm-based food resilience strategies and their influence on livelihood outcomes among farming households in Makueni County, Kenya.

Study Population

The target population comprised 127,257 farming households (KNBS, 2019) and agricultural extension officers serving in the selected sub-counties. These officers deal with farming households and have direct experience in implementing FBFRS.

Sampling Procedures

The study adopted a multistage sampling technique. First, the six sub counties were be clustered according to the three agro-ecological zones: Upper Midland Zone (UM) encompassing the uplands of Mbooni and Kaiti sub counties; Midland Zone (M) consisting of Makueni and Kilome Sub-Counties and Lowland Zone (LM) encompassing Kibwezi west and Kibwezi east sub counties. Three sub-counties were randomly selected, one in each cluster. Thereafter, a proportionate sample was obtained from the wards. This method ensured representation across geographic and demographic diversity. Based on the number of households from each sub-county and ward, as listed in the sampling frame, proportionate sampling was used to determine the sample size to be drawn from each ward. For the final stage, a systematic random sampling approach was used to select households from the sampling frame using a list of registered farmers from the Ministry of Agriculture. The agricultural officers were purposively sampled because of their wealth of knowledge of and experience in adoption of FBRS.

Sample Size Determination

To determine the sample size, the study used the following statistical formula by Yamane (Yamane 1967);

$$n = \frac{N}{1 + Ne^2}$$

where,
n is the sample size
e is the allowed margin of error (0.05)
N is the population size (125,257 households)

The formula yielded a sample size of 399 respondents who were distributed proportionally as indicated on Table 1.

Table 1: Proportionate Sample Size

Sub County	Ward	No. of farming Households	Proportionate Sample Size
Makueni	Nzaui/Kilili/Kalamba	8,515	27
	Muvau/ Kikuumini	5,712	18
	Kathonzweni	7,242	23
	Mavindini	5,076	16
	Kitise/Kithuki	4,714	15
	Wote/ Nziu	5,843	19
	Mbitini	6,207	20
Mbooni	Mbooni	6,928	22
	Tulimani	9,407	30
	Kithungo/Kitundu	6,543	21
	Kisau/Kiteta	9,263	30
	Kako/Waia	5,824	19
	Kalawa	6,359	20
Kibwezi West	Kikumbulyu South	4,365	14
	Kikumbulyu North	3,553	11
	Emali/Mulala	4,720	15
	Nguumo	5,771	18
	Makindu	8,525	27
	Nguu/Masumba	5,693	18
	Total	125,257	399

Source: Kenya Population and Housing Census, (2019)

Kibwezi West, Makueni and Mbooni sub counties have twenty-two agricultural officers based at the subcounty and ward level. Nine agricultural officers were purposely selected for the study. Three sub-county officers and two ward agricultural officers per subcounty

Research Instruments

Primary data was sourced using structured questionnaires, interview guides and observation checklists. A structured questionnaire was used as the primary tool for data collection from household heads. The questionnaire comprised of both closed-ended and open-ended questions. Closed-ended questions included multiple-choice, Likert-scale, and dichotomous questions, designed to assess the extent of adoption of various FBFRS. On the other hand, open-ended questions provided respondents the chance to elaborate on their responses, share contextual insights and highlight unique or unexpected strategies or challenges that may not be captured through pre-defined options. The information from the questionnaires was corroborated through key informant interviews conducted with agricultural officers who possess in-depth knowledge on adoption of FRS and experience working directly with farming communities. An observation checklist was also developed to capture physical evidence of adopted FBFRS at the household level.

Data Collection Procedures

The researcher trained five recruited research assistants on the data collection instruments. Primary data was collected using a combination of questionnaires, key informant Interviews, and observation checklists. The questionnaires were administered in person to the household heads by the researcher and the research assistants. Where the household head was the man and he was not present, the wife was interviewed instead. If neither the husband nor the wife was be available, the oldest member of the household over the age of eighteen was interviewed, as they are considered an adult at that age. If none of the aforementioned categories of respondents are present, the interview was postponed.

In-depth interviews were conducted with key informants, the Agricultural extension officers. Through these interviews, nuanced insights into the adoption of FRS and their influence on household livelihood outcomes were obtained.

Piloting

piloting was conducted in Kaiti sub-county, Makueni County, which has similar climatic conditions and shares similar economic activities and was not part of the study. For content validity, the researcher sought input from agricultural officers and experts in climate change and agricultural sciences at Chuka University. Cronbach's Alpha coefficient was used to determine the reliability of the questionnaires. A correlation coefficient of 0.83 was obtained; therefore, the questionnaire was considered reliable for the purposes of this study as noted by Mugenda and Mugenda (2003) and Wallen (2002) that a correlation above 0.7 is reliable for study.

Data Analysis

Data was analysed using SPSS version 25. Descriptive statistics, including frequencies, percentages and graphs, were generated to illustrate the food resilience strategies adopted by farmers' households. Simple linear regression and ANOVA were used to assess the influence of FBRS on the livelihood outcomes among farming households.

Results and Discussion

The study sought information on influence FBFRS on Livelihood outcomes in Makueni County, Kenya. This was discussed under four sub-domains; Crop Management Strategies, Soil Management, Water Management and Livestock Adaptation. Each item under the sub domains was rated on a 5-point Likert scale, ranging from 1 (Strongly Disagree) to 5 (Strongly Agree). The composite score was obtained by averaging all four items, since they showed consistency reliability of the items. Since the scoring scale ranges from 1 to 5, the level was evaluated as follows: 1 – 2.9 (low), 3.0 – 3.9 (moderate), and above 4.0 high extend.

Crop Management Strategies

The Crop Management Strategies (CMS) construct was measured using four indicators. The descriptive statistics of each of the four items of CMS and the computed average score are shown on Table 1.

Table 1: Crop management strategies

Item	N	Mean	SD
Cultivating a variety of crops	374	4.74	0.538
Agroforestry	373	4.19	0.932
Planting drought-resistant crops	374	4.25	1.095
Planting early maturing varieties of crops	374	4.17	1.198
Crop Management Strategies	374	4.339	0.618

The study findings indicate a high level of adoption of CMS among the respondents (M = 4.34, SD = 0.618) (Table 1). The highest-rated strategy was cropping diversification (M = 4.74), suggesting that most households use this as a key method to mitigate production risks and ensure food availability throughout different seasons. The use of drought-resistant crop varieties (M = 4.25, SD = 1.095) and agroforestry (M = 4.19, SD = 0.932) was also highly adopted since their averages are above 0.4. Planting early maturing varieties had a slightly lower mean (M = 4.17, SD = 1.198).

To enrich the quantitative findings, qualitative data were collected through key informant interviews (KIIs) with agricultural extension officers. One agricultural extension officer noted: *"Many farmers in this area now understand the importance of planting different types of crops, especially those that mature at different times or are drought-tolerant. We encourage them through barazas and field demonstrations"* (KI1). These findings align with evidence from studies emphasizing the importance of diversified and climate-resilient farming practices in enhancing food security. According to Gebremariam et al. (2025), crop diversification remains one of the most effective risk management tools in smallholder agriculture. It provides resilience by spreading climatic and market risks across multiple crops.

Agroforestry, drought-tolerant crops and early maturing crop varieties are also widely acknowledged for their ecological and economic benefits, particularly in arid and semi-arid regions (Kumar *et al.*, 2025; Nadeem *et al.*, 2024).

Their adoption can enhance soil fertility, water retention, and income stability. However, implementation barriers, such as the cost of improved seed varieties and a lack of technical training, are common challenges. The substantial variability in the adoption of strategies suggests unequal access to innovation across households, which can influence productivity and, consequently, livelihood outcomes.

Soil Management Strategies
The study assessed the extent to which farming households in Makueni County have adopted various soil management strategies (SMS). The SMS construct was measured using four indicators. The descriptive statistics for each of the four SMS items are presented on Table 2.

Table 2: Soil management practices

Items	N	Mean	SD
Cover cropping	374	2.94	1.426
Mulching	374	2.58	1.347
Terracing	372	4.32	1.200
Use of compost manure than inorganic fertilizers	374	3.98	1.119
Crop rotation	372	3.22	1.464
Soil Management	374	3.408	0.794

The information on table 2 reveals a moderate overall adoption of soil management strategies among farming households in Makueni County, with a composite mean score of 3.41 (SD = 0.794). However, adoption varied considerably across specific practices. Terracing emerged as the most commonly adopted soil management method, with a mean score of 4.32 (SD = 1.20). Terracing is a common practice in nearly all farmlands, particularly in sloping terrain, in several countries such as Kenya (Kioko et al., 2024) and Tanzania (Malekela & Lusiru, 2022), to reduce soil erosion through runoff and conserve moisture, improve moisture retention, and enhance seed germination, and yields.

The use of compost manure also recorded a relatively high level of adoption, with a mean score of 3.98, indicating that many households value organic inputs as an affordable and sustainable alternative to inorganic fertilizers. Compost manure is a nutrient-rich organic material decomposed from plant residues, kitchen waste, and animal waste. It enhances soil fertility by improving structure, aeration, and water retention capacity, while also enhancing soil pH and moisture retention, and promoting beneficial microbes that can help suppress harmful pathogens (Ayilara *et al.,* 2020; Naghman *et al.,* 2023). For farmers, compost offers a sustainable and cost-effective way to enrich soils without relying on synthetic inputs.

Crop rotation, with a mean score of 3.22, showed a moderate level of adoption. Crop rotation is the practice of growing different types of crops sequentially on the same land to improve soil health and agricultural productivity. Farmers alternate crops such as legumes, cereals, and root vegetables to help replenish soil nutrients, especially nitrogen, reduce pest and disease buildup, and break weed cycles. In contrast, cover cropping and mulching had lower adoption levels among the soil management practices, with mean scores of 2.94 and 2.58, respectively.

Cover cropping and mulching are complementary practices that significantly enhance soil health and farm resilience. Cover crops such as legumes or grasses are grown primarily to restore soil fertility, suppress weeds, and prevent erosion during rainy seasons. They are anticipated to enrich the soil with organic matter and nitrogen, promoting sustainable yields (Kocira et al., 2020; Quintarelli *et al*., 2022). Mulching, on the other hand, involves spreading organic materials like straw, leaves, or compost over the soil surface to conserve moisture by preventing evaporation of soil, regulate temperature, and reduce weed growth (Prem *et al.,* 2020). The low level of adoption of cover cropping in Makueni County could be associated with a low adoption of intercropping systems. Farmers often plant one type of crop per season, such as maize or beans. Low mulching adoption could be attributed to the high labour demands associated with their implementation, or the competing use of crop residues and organic matter for livestock feed.

Generally, soil management practices are on average high in Makueni County. These findings are consistent with regional trends, which show that integrated soil fertility practices, such as terracing, composting, and crop rotation, are more commonly adopted in hilly and erosion-prone landscapes. Similar findings have been observed at the at the agro ecological zones of Dega, Kolla, and Weyna in Ethiopia where majority of rural household farmers used soil and water conservation practices

(99%) and changing crop planting dates (98% of households) as adaptation to the impact climate change variability on food security (Tesfaye & Alemayehu, 2021).

Water Management Strategies

The Water Management (WMS) construct was measured using four indicators. The descriptive statistics for each of the four WMS items and the computed average score are presented on Table 3.

Table 3: Water management strategies

	N	Mean	Std. Deviation
Roof catchment harvesting	374	4.120	1.364
Zai Pits / sunken beds	374	1.900	1.260
Surface Runoff Harvesting	374	2.850	1.639
Sand Dams	374	1.830	1.344
Use drip irrigation	374	2.060	1.506
Water Management	374	2.554	0.669

The overall mean score of 2.55 suggests a generally low adoption of water conservation and harvesting methods. The farmers did not consistently adopt the selected water management strategies. Roof catchment harvesting (Mean = 4.12) is the most widely adopted strategy. The Government of Makueni County (2025) report indicated that that the main sources of water for the population are: seasonal and permanent rivers; springs; boreholes and wells; and dams and roof catchment, with a high potential for roof water catchment since 86.6% of the households have corrugated iron sheets roofing, above national average of 73.5% (Government of Makueni County, 2013). Thus, the reliance on roof catchment reflects its low cost, as people would rely on the rooftops of their already established homes to harvest rainwater with no additional costs than water tanks and piping systems (gutters and pipes). The stored water can cushion small-scale farming, as it can be used to water crops during the dry season.

Adoption of Surface runoff harvesting is also low (Mean = 2.85), reflecting the challenges of natural climatic shocks and the cost of adoption. Surface runoff harvesting is the process of collecting rainwater that flows over land surfaces (such as rooftops, roads, landscapes, and fields) and channelling it into storage through pipes or channels for later use. This method often requires structures such as trenches or pans, which are labour- and capital-intensive. Additionally, Makueni County is generally dry and experiences an acute water shortage throughout the year (Government of Makueni County, 2025). Thus, such means are not often sustainable, as they could result in greater water loss through underground seepage. As a result, it is less likely to be adopted by farmers on medium to large-scale farms.

Drip irrigation (Mean = 2.06) showed low adoption. Drip irrigation requires a huge capital investment. Access to reliable water sources, storage tanks, and technical knowledge is essential for successful drip irrigation implementation. Thus, despite its recognized efficiency in minimizing water loss and maximizing yields, the cost of purchase of the irrigation system kits, maintenance complexity, and unreliable water supply remain barriers to smallholder farmers in Kenya (Kanda & Lutta, 2022; Wainaina, 2021). In Makueni County, irrigation is often practiced in schemes such as Athi, Muooni, Kambu, Mangelete, Kibwezi cluster, Kiboko, Ithiani, and Kyeemwea irrigation schemes, which are frequently funded by the Government (national and county) and donors. As a result, low-income farming households are less likely to be able to afford.

Zai pits/sunken beds (Mean = 1.90) and sand dams (Mean = 1.83) are the least adopted practices. These methods, though effective in enhancing soil moisture and groundwater recharge, demand high initial labour and technical support. Zai pits involve digging holes, often during the dry season, and filling them with organic matter, such as compost or manure. The pits collect rainfall and concentrate soil moisture, making them suitable for areas with low and unreliable rainfall. The organic material improves soil structure and fertility and attracts beneficial insects like termites, which further enhance the soil's aeration, water retention ability, and nutrients. Kerubo (2022) found that rainwater harvesting using Zai pits, combined with the use of manure and mineral fertilizer supplements, aids in improving soil fertility and enhancing crop yields in Kitui County. Nonetheless, labour intensity and a lack of sufficient organic matter, due to the use of crop residues as animal feed, limit the wider application of this water conservation method in most rural farms.

Lastly, there was also low dependence on sand dams. It is estimated that the average distance to a water point in Makueni County is 8 kilometers, attributed to recurrent cyclical droughts and the reduction of water sources driven by encroachment on watersheds, degradation of water towers, and uncontrolled sand harvesting (Government of Makueni County, 2025). Boreholes and wells that heavily depend on underground water have experienced reduced groundwater sources due to frequent and prolonged droughts. All these aspects reflect the reduced reliance on sand dams. Generally, the findings suggest that water management in the study area is heavily skewed toward cheap individual or household-based approaches (such as roof harvesting). In contrast, community or capital-intensive strategies (such as sand dams, Zai pits, and drip irrigation) remain underutilized. With severe climate shocks such as drought and contributing human factors such as uncontrolled sand harvesting, the water management suitability index in Makueni County is low.

Livestock Adaptation Strategies

The Livestock Adaptation (LAS) construct was measured using four indicators. The descriptive statistics of each of the four items of LAS and the computed average score are shown in Table 4.

Table 4: Livestock adaptation strategies

Items	N	Mean	SD
Rearing different types of livestock	374	4.52	1.105
Keep indigenous livestock species	374	3.96	1.659
Crossbreeding between local and high-yielding breeds	372	2.70	1.725
Livestock Adaptation	374	3.729	1.058

Information on table 4 reveals a moderately high level of adoption of livestock adaptation strategies by farming households with a composite mean score of 3.73 (SD = 1.058) suggests. Among the practices assessed, rearing different types of livestock (cattle, goats, poultry and sheep) was the most highly adopted strategy, with a mean of 4.52, indicating that households prioritize diversification within livestock production to spread risk and ensure at least one species survives under drought or disease stress. This finding is consistent with Ogolla et al. (2022), who observed that species diversification was a common drought coping strategy in Kenya's ASAL regions.

The adoption of indigenous livestock species (M = 3.96) was also moderately high. Indigenous breeds are preferred due to their adaptability to harsh climatic conditions, resistance to local diseases, and low input requirements. As confirmed by Okeyo et al. (2021), indigenous cattle and goats continue to dominate pastoral and agro-pastoral systems in Kenya due to their resilience and cultural significance. Conversely, crossbreeding between local and exotic high-yielding breeds recorded the lowest mean score (M = 2.70, SD = 1.725), indicating limited adoption. This could be attributed to several factors, including lack of access to improved breeding services, high costs of artificial insemination, and concerns over the adaptability of exotic crosses to local conditions. This pattern aligns with findings by Mutua et al. (2020), who noted that while crossbreeding offers potential productivity gains, its adoption in semi-arid Kenya remains constrained by infrastructural and knowledge gaps.

Agricultural extension officers interviewed acknowledged that crossbreeding remains rare due to limited veterinary services and AI infrastructure, especially in remote areas. One officer noted: *"Some farmers are interested in crossbreeding, but they can't afford AI, and there are no reliable services in their wards. So, most stick to what they know works." (KI2).* The data suggest that while livestock adaptation strategies are widely recognized and practiced, especially diversification and indigenous species selection, technology-based strategies like crossbreeding remain underutilized**.** There is a clear opportunity to improve resilience by expanding access to climate-resilient breeding technologies and veterinary extension.

A composite Farm-based Food Resilience Strategies was ultimately constructed by averaging all the 17 items of the four sub-domains comprising: crop management strategies (N = 4, CA = 0.506), soil management (N = 5, CA = 0.553), Water Management (N = 5, CS = 0.108), and livestock adaptation (N = 3, CA = 0.473). Table 5 shows the Descriptive Statistics of the adoption of Farm-based Food Resilience Strategies.

Table 5: Summary adoption of FBFRS

	N	Mean	SD
Farm-based Food Resilience Strategies	374	3.432	0.482

The results on table 5 indicate that the overall mean score for adoption of farm-based food resilience strategies was 3.43 (SD = 0.48). This suggests a moderate level of farm-based food resilience strategies among farming households in Makueni County. This result is consistent with findings from Boukaka *et al* (2025) and Kerubo (2022), who noted that smallholder farmers in Kenya's semi-arid regions are increasingly adopting a blend of farm-level resilience practices, particularly those that are low-cost and locally appropriate. These findings underscore the importance of continued support for farm-based adaptation, particularly through agricultural extension services, access to inputs, and climate-smart farming education programs.

Table 6: Challenges in implementing FBFRS

Challenge	Frequency	Percentage
Unpredictable weather patterns, unreliable rainfall	364	97.3
Pests and diseases	359	96
High cost of inputs	336	89.8
Limited access to water	317	84.8
Lack of funds	293	78.3
Limited access to information	257	68.7
Limited technical knowledge	227	60.7
Market constraints	177	47.3

Information on Table 6 indicates that unpredictable weather patterns (97.3%) and pest/disease outbreaks (96%) were the most cited challenges in implementing food resilience strategies among farming households in Makueni County. These environmental stressors pose a serious threat to food production and overall agricultural sustainability. This observation aligns with the Intergovernmental Panel on Climate Change (IPCC, 2022) and Bedeke (2023) which highlight that climate variability, including delayed rains, prolonged droughts, and extreme weather events, has become increasingly common and disruptive to agricultural planning and yields across Sub-Saharan Africa.

Financial constraints also emerged as significant barriers. Many households cited the high cost of farm inputs, including certified seeds, fertilizers, pesticides, and equipment, as a critical issue. Furthermore, a lack of access to affordable credit and financial services limited their ability to invest in adaptive farming practices. These findings are corroborated by Baffour-Ata et al. (2024), who identified similar financial limitations as a hindrance to the adoption of climate-smart agriculture among smallholder farmers in Ghana. Additionally, information and knowledge gaps remain a significant challenge. Over 60% of respondents reported limited access to agricultural extension services, technical training, and timely information on weather patterns, market prices, and climate-smart techniques. These limitations reduce farmers' capacity to make informed decisions. Jha and Gupta (2021). Similarly emphasized the importance of localized and timely information dissemination as a key factor in enhancing farmers' adaptive capacity.

Although market constraints were cited less frequently compared to other challenges, nearly half of the respondents still identified them as barriers. Key market-related issues included poor infrastructure (e.g., roads and storage), unstable produce prices, and limited access to reliable buyers. These constraints reduce the incentives for farmers to produce surplus or invest in resilient practices. Reports by the World Bank (2023) and WFP (2021) echo these concerns, particularly in rural Kenyan contexts where market integration remains weak.

To achieve the study's objective, a simple linear regression analysis was conducted. This statistical approach was selected for its ability to assess the direct predictive power of FBFRS on LO, while also quantifying the proportion of variance in outcomes that can be attributed to this single factor. The model summary results are presented on Table 6.

Table 7: Linear Regression of FBFRS on Livelihood Outcomes

R	R Square	Adjusted R Square	Std. Error of the Estimate
0.493	0.243	0.241	0.476

Notes. a Predictors: (Constant), Farm-based Food Resilience Strategies

The information on table 7 indicates that adoption of farm-based food resilience strategies accounts for 24.3% of the variability in livelihood outcomes. This demonstrates that FBFRS makes a meaningful contribution to predicting household welfare and well-being in the context of agricultural resilience. However, the remaining 75.7% of the variance in livelihood outcomes remains unexplained by Model 1. This residual variation likely stems from a combination of factors not included in this simple model. These may consist of socio-demographic characteristics such as age, education level, gender, and household size; environmental factors like rainfall variability, soil fertility, or access to water resources; and aspects related to market access and infrastructure. Distance to market, transportation networks, access to financial services like credit, insurance, and savings mechanisms, and institutional support and policy environment, which may influence farmers' capabilities and incentives.

An Analysis of Variance (ANOVA) test was conducted. This test determines whether the predictor variable (FBFRS) explains a statistically significant portion of the variance in the dependent variable (LO). The results are presented in Table 8.

Table 8: Analysis of variance for FRS on livelihood outcomes

Source of Variation	Sum of Squares	df	Mean Square	F	Sig.
Regression	27.1	1	27.1	119.438	.000
Residual	84.405	372	0.227		
Total	111.504	373			

Notes. a Dependent Variable: Livelihood Outcomes b Predictors: (Constant), Farm-based Food Resilience Strategies

As shown on table 7, the F-statistic, F (1, 372) = 119.438, and a corresponding p-value of less than 0.001, indicate that the regression model is statistically significant. This demonstrates that farm-based food resilience strategies have a substantial predictive influence on the livelihood outcomes of households in the study area. Thus, the model provides a better fit than would be expected by chance alone. The results validate the relevance of FBFRS as a key factor that influences household welfare.

The model's regression coefficients and their corresponding levels of significance are presented on Table 8.

Table 8: Coefficients of regression of FBFRS on livelihood outcomes

	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	t	p-value
(Constant)	1.582	0.177		8.915	0.000
FBFRS	0.559	0.051	0.493	10.929	0.000

Note: a Dependent Variable: Livelihood Outcomes

The simple linear regression results show that the adoption of farm-based FRS had a positive and significant influence on livelihood outcomes among farming households in Makueni County, Kenya, at a 0.05 significance level (b = 0.559, p = 0.000). The results indicate that for every one-unit increase in the adoption level of FBFRS, there is an expected increase of 0.559 units in the predicted livelihood outcome score, holding other factors constant. Thus, the null hypothesis was rejected meaning there is a statistically significant influence of adoption FBRS on Livelihood outcomes.

The results provide strong evidence of a statistically significant and positive relationship between FBFRS and livelihood outcomes among farming households in Makueni County. This means that as households intensify their application of FBFRS, including crop management strategies, soil management, water management practices, and livestock adaptation techniques, they improve livelihood indicators such as food security, income stability, asset accumulation, and overall well-being. Each component of FBFRS contributes through different mechanisms.

Recent empirical studies support the established positive impact of FBFRS on livelihood outcomes. For instance, Njeru et al. (2022) found that family farming systems in the semiarid tropics of Kenya, characterized by higher crop diversification and integrated livestock rearing on their farms, were more food secure. Manda et al. (2023) found that the adoption and duration of adopting soil and water conservation technologies had significant and positive effects on the total value of crop production and household income in Tanzania. In summary, the integration of farm-based food resilience strategies directly strengthens household livelihood outcomes by enhancing agricultural stability, buffering against climate and market shocks, and enabling families to achieve greater food security, economic reliability, and social wellbeing sustainably.

Conclusion

It was concluded that the adoption of FBFRS has a significant and positive influence on the livelihood outcomes of farming households in Makueni County. The strategy plays a vital role in stabilizing food production, boosting household income, and fostering long-term resilience to climatic shocks. Despite variations in reliability across sub-domains, particularly in water management, the collective influence of farm-based practices supports the livelihoods of rural households. Challenges such as unpredictable weather, pests and diseases, high input costs, limited water access, inadequate funds and low technical knowledge however, weaken these gains.

Recommendation

Based on the research findings, some of the important interventions by the government and development agencies that could improve the influence of Adoption of FBFRS include; strengthening water management infrastructure by prioritizing the expansion of irrigation systems, rainwater harvesting, and community water access points to address gaps in water-related resilience strategies, providing farm-based production support or access to credit to farmers and prioritizing provision of institutional and extension support essential to scale underused soil practices that could enhance long-term agricultural resilience in the face of climate variability.

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