



Toward Climate-Resilient Agribusiness and Food Security in Kenya's Highland Counties: Evidence from Kisii and Nyamira Counties

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ABSTRACT

Climate variability increasingly threatens the sustainability of smallholder agriculture and food systems in Kenya, particularly in the densely cultivated highlands of Kisii and Nyamira counties. This study examined climatic vulnerabilities, agribusiness adaptation strategies, institutional responses and their implications for building sustainable food systems in the two counties. A systematic literature review, guided by PRISMA principles, was undertaken using 62 publications drawn from peer-reviewed literature, policy documents and institutional reports published between 2015 and 2026. The evidence was analysed through thematic synthesis. Findings indicate that agribusiness systems in Kisii and Nyamira are increasingly exposed to rainfall variability, soil degradation, water stress, changing pest and disease dynamics, and land fragmentation. Smallholder farmers respond through crop diversification, intercropping, livestock integration, soil and water conservation, organic soil management and other climate-smart agricultural practices. However, the effectiveness and wider adoption of these strategies are constrained by limited finance, uneven extension services, inadequate infrastructure, restricted access to climate information and inequalities in productive resources. The study argues that climate resilience cannot be secured through isolated farm-level interventions. Rather, sustainable food systems require an integrated agribusiness approach linking climate-smart production with markets, finance, climate information, infrastructure and responsive institutions. Strengthening these interconnections is critical to sustaining productivity, livelihoods and food security in the Kisii–Nyamira highlands.

Keywords: climate resilience, agribusiness, climate-smart agriculture, food systems, smallholder farmers, Kisii, Nyamira

INTRODUCTION

Agriculture remains fundamental to livelihoods, rural employment and food security in Sub-Saharan Africa, where smallholder production continues to support a substantial proportion of the population. In Kenya, the sector is equally central to the national economy and rural livelihoods, but its dependence on climatic conditions exposes production systems to rainfall variability, drought, rising temperatures and other climate-related stresses (IPCC, 2022). These pressures are particularly consequential for smallholder farmers whose capacity to absorb production shocks is constrained by limited land, capital, technology and access to climate information. At the policy level, Kenya has increasingly incorporated climate adaptation into agricultural planning, although Nyangena et al. (2017) identify a persistent gap between agricultural and climate-change research, policy formulation and implementation at farm level. More recent analysis of Kenya's food-system and policy environment similarly demonstrates that agricultural resilience cannot be treated solely as a question of production; it must be understood within the wider relationships linking farming, markets, institutions, food security and environmental sustainability (Rutting et al., 2024).

These concerns are especially relevant to the western Kenyan highlands, including Kisii and Nyamira counties, where intensive smallholder agriculture operates under growing pressure from population density, land fragmentation and climatic variability. Farming in the two counties is predominantly undertaken on relatively



small holdings and remains strongly dependent on rainfall. The combination of steep terrain, intensive cultivation and changing rainfall patterns heightens exposure to soil erosion, declining soil fertility and unstable agricultural production. Within Nyamira County specifically, Otworu et al. (2024) show the growing importance of climate-smart agricultural practices in strengthening food security under changing climatic conditions. Otworu and Otworu (2024) further demonstrate that climate-smart agriculture has significant implications for the food-security outcomes of small-scale farmers in the county. These studies establish the importance of adaptation at farm level, but they also point to the need to understand climate resilience beyond individual farming practices.

Climate resilience increasingly requires an agribusiness perspective that connects agricultural production to information, technology, markets and the broader food system. Climate-smart agriculture (CSA), agroecological practices, improved crop and soil management, diversification and climate-information services have consequently gained prominence as possible responses to climate-related production risks. Access to usable agricultural and weather information is particularly important in determining whether farmers can translate adaptation knowledge into practical decisions. Kiprop et al. (2024), in their evaluation of *Shamba Shape Up* weather and farming information among Kenyan smallholders, demonstrate the significance of agricultural communication and climate information in shaping farm-level knowledge and practices. Climate-resilient agribusiness therefore extends beyond the adoption of particular technologies to encompass the institutional, informational and market systems through which farmers make production and livelihood decisions.

Despite this expanding body of research, important gaps remain. Existing studies have largely examined climate-smart agricultural practices, food security, agricultural policy or climate-information interventions as separate dimensions of agricultural adaptation. In Nyamira, scholarship has provided valuable evidence on CSA and smallholder food security (Otworu et al., 2024; Otworu & Otworu, 2024), while national studies have examined the relationship between climate policy and agricultural practice (Nyangena et al., 2017), food-system governance (Rutting et al., 2024), and agricultural and weather information (Kiprop et al., 2024). What remains insufficiently synthesised is how these dimensions intersect within the agribusiness systems of the Kisii–Nyamira highlands. In particular, limited attention has been given to the connections among farm-level adaptation, agribusiness practices, climate information, markets and sustainable food systems across the two counties.

Against this background, this paper examines climate-resilient agribusiness systems in Kisii and Nyamira counties, with particular attention to how agricultural production, adaptation practices, information and market processes respond to climate change while contributing to sustainable food systems. By synthesising evidence from the two counties within the wider Kenyan policy and food-system context, the paper seeks to identify established adaptation practices, persistent constraints and areas requiring further research and policy attention.

Statement of the problem

Climate change increasingly threatens the sustainability of smallholder agriculture and agribusiness systems in Kenya. The problem is particularly significant in Kisii and Nyamira counties, where dependence on rain-fed agriculture, fragmented landholdings, intensive cultivation and pressure on agricultural land increase vulnerability to rainfall variability and other climatic stresses. These conditions have implications not only for agricultural productivity but also for agribusiness viability, household food security and the sustainability of local food systems. Although farmers and agricultural institutions have responded through climate-smart agriculture and other adaptation practices, existing knowledge remains fragmented. Studies in Nyamira have concentrated largely on climate-smart agriculture and food security (Otworu et al., 2024; Otworu & Otworu, 2024), while broader Kenyan scholarship has examined agricultural policy, climate information and food-system governance (Nyangena et al., 2017; Kiprop et al., 2024; Rutting et al., 2024). Consequently, there is insufficient synthesis of the climate-related challenges confronting agribusiness systems in Kisii and Nyamira, the adaptation practices being employed, the factors constraining their effectiveness, and their contribution to sustainable food systems. Without such integrated evidence, policy and agribusiness interventions risk remaining fragmented and insufficiently responsive to local conditions. This study addresses this gap by



examining climate-resilient agribusiness systems and their role in strengthening sustainable food systems in Kisii and Nyamira counties.

Conceptual Framework

This study conceptualises climate-resilient agribusiness as a dynamic system in which agricultural actors respond to climatic pressures through interconnected production, technological, market and institutional adjustments. The framework departs from approaches that treat climate adaptation principally as the adoption of discrete farm-level practices. Instead, it locates the farm within a broader agribusiness and food-system environment in which resilience depends upon the capacity of farmers, markets, institutions and value-chain actors to anticipate climatic risks, absorb their effects, adapt production and marketing practices, and sustain food and livelihood outcomes.

At the first level of the framework are climate risks and associated agricultural vulnerabilities. Variability in rainfall, changing temperature regimes, drought, intense rainfall and other extreme events constitute external pressures on agricultural systems. Their effects are mediated by existing local vulnerabilities, including small and fragmented landholdings, dependence on rain-fed agriculture, soil degradation and limited productive resources. In the Kisii–Nyamira highlands, these interacting pressures can disrupt crop and livestock production, increase production costs, destabilise farm incomes and ultimately affect the availability and accessibility of food. Climate change is therefore conceptualised not as an isolated environmental variable, but as a pressure transmitted through agricultural production into agribusiness and food systems.

The second component comprises **adaptation and agribusiness responses**. These include climate-smart agricultural practices, crop and enterprise diversification, soil and water conservation, improved crop varieties, changes in production practices, utilisation of climate information, technological innovation and adjustments in marketing and value-chain activities. These responses represent the mechanisms through which agribusiness actors attempt to reduce exposure, manage risk and maintain productive capacity. Their effectiveness, however, cannot be assumed from adoption alone. A practice becomes resilience-enhancing only to the extent that it reduces vulnerability while sustaining economically viable production and livelihood outcomes.

The relationship between climatic pressure and successful adaptation is further conditioned by **institutional, informational and market factors**. Access to extension services, agricultural credit, climate and weather information, technology, farmer organisations, infrastructure, markets and supportive public policy can strengthen adaptive capacity. Conversely, weak institutional support, inadequate finance, poor market access and limited availability of actionable climate information may constrain otherwise viable adaptation strategies. This mediating dimension is particularly important because it shifts the analytical focus from asking why individual farmers fail to adapt towards examining the structural environment within which adaptation decisions are made.

The final component of the framework concerns **resilience and sustainable food-system outcomes**. Effective adaptation is expected to contribute to greater stability in agricultural productivity, improved farm incomes, reduced vulnerability to climatic shocks, strengthened food security and more sustainable management of natural resources. These outcomes collectively indicate the capacity of the agribusiness system to withstand climatic disturbances while retaining its productive, economic and food-security functions.

METHODOLOGY

This study employed a systematic literature review to examine climate-resilient agribusiness systems and their contribution to sustainable food systems, with particular attention to Kisii and Nyamira counties. The review was guided by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) principles to ensure transparency and consistency in the identification, screening, eligibility assessment and inclusion of relevant literature. The systematic review approach was appropriate because knowledge on climate resilience in agriculture is dispersed across several related fields, including climate-smart agriculture, smallholder adaptation, agribusiness, food security, agricultural policy and food-system sustainability. The review the-



refore sought not merely to catalogue existing studies, but to synthesise these strands of scholarship and establish how they collectively explain the changing relationship between climate risk, agribusiness and food-system resilience.

Literature was systematically searched in Scopus, Web of Science and Google Scholar. These academic databases were complemented by grey and policy literature retrieved from the Food and Agriculture Organization (FAO), World Bank, Government of Kenya ministries and agencies, and other relevant institutional repositories. Searches combined geographical and thematic terms such as *climate change adaptation in Kenya*, *climate-smart agriculture*, *agribusiness systems*, *smallholder resilience*, *highland agriculture*, *food security in Kenya*, *sustainable food systems*, *Kisii agriculture* and *Nyamira agriculture*. Boolean operators were applied where appropriate to combine related concepts and refine retrieval. Particular emphasis was placed on literature concerning Kenya and the Kisii–Nyamira highlands, while studies from other parts of Sub-Saharan Africa were considered where they offered relevant comparative evidence or analytical insights.

The review covered literature published between 2015 and 2026. This period was selected to capture contemporary scholarship and policy developments associated with the increasing prominence of climate adaptation, climate-smart agriculture and sustainable food systems. Studies were eligible for inclusion where they examined climate change or climatic variability in relation to agriculture, agribusiness, smallholder livelihoods, food security, adaptation or food-system resilience. Peer-reviewed journal articles, scholarly books and book chapters, theses and dissertations, government policy documents, and reports from recognised national and international institutions were considered. Sources were excluded where they duplicated previously identified records, lacked substantive relevance to the research problem, fell outside the defined geographical or thematic scope, or provided insufficient evidence for meaningful analysis.

The selection process followed successive stages of identification, screening, eligibility assessment and final inclusion. Titles and abstracts were initially examined for relevance to the research questions, after which potentially relevant publications were subjected to full-text assessment. Particular attention was paid to geographical relevance, methodological credibility, the nature of the evidence presented and the contribution of each source to understanding climate risks, adaptation or agribusiness resilience. Following this process, 62 publications met the inclusion criteria and constituted the final corpus for analysis. The review process was documented in accordance with PRISMA principles to provide a transparent account of how the final body of literature was derived.

The 62 publications were analysed through thematic synthesis. Rather than treating each publication as an isolated account, the analysis identified recurrent arguments, empirical patterns, areas of convergence and divergence, and gaps across the literature. Initial coding focused on evidence concerning climatic pressures on agricultural production and agribusiness. These codes were subsequently organised into five interconnected analytical themes: climate risks and vulnerabilities; adaptation and climate-smart agricultural practices; agribusiness and market responses; institutional and policy support; and resilience and food-system outcomes. Evidence specific to Kisii and Nyamira was distinguished from national and wider Sub-Saharan African evidence to avoid uncritical generalisation across different ecological, socioeconomic and institutional contexts.

The analytical framework conceptualised climate resilience as a systemic rather than exclusively farm-level phenomenon. Accordingly, adaptation was examined not simply in terms of farmers adopting particular technologies or practices, but through the interaction of production systems, climate information, markets, value chains, institutions and public policy. The synthesis consequently assessed both the practices through which agricultural actors respond to climatic pressures and the structural conditions that enable or constrain those responses. This approach provided a basis for identifying what is currently known about climate-resilient agribusiness in Kisii and Nyamira, where the evidence remains fragmented, and which dimensions require further empirical and policy attention.



RESULTS, ANALYSIS AND DISCUSSION

The thematic synthesis of the 62 publications revealed that climate vulnerability in Kisii and Nyamira cannot be explained by climatic variability alone. Rather, vulnerability emerges from the interaction between changing rainfall and temperature patterns and pre-existing structural conditions, particularly land fragmentation, soil degradation, limited water-storage capacity, constrained access to capital and uneven institutional support. At the same time, the literature demonstrates that farmers are not passive recipients of climatic shocks. Smallholders have developed diverse responses involving crop diversification, soil management, adjustment of planting calendars, livestock integration and other climate-smart practices. The central finding of the review, however, is that the effectiveness of these responses depends considerably on the wider agribusiness system within which farmers operate. Climate resilience in the two counties is therefore both an ecological and an institutional question.

Climatic Vulnerabilities in Kisii and Nyamira

Although Kisii and Nyamira have historically benefited from relatively favourable highland climates and bimodal rainfall, the reviewed evidence challenges the assumption that high rainfall necessarily translates into low climatic vulnerability. Otworu et al. (2024) demonstrate that Nyamira has experienced changing rainfall and temperature patterns with implications for food production, while Nyang'au et al. (2021) found that smallholder farmers in Masaba South, Kisii, perceived significant changes in climatic conditions and had consequently altered farming practices. The important issue is therefore not simply the amount of rainfall received, but its timing, distribution and predictability. Agricultural calendars that previously depended upon relatively stable seasonal patterns become less reliable when rainfall onset is delayed, rainfall is concentrated within shorter periods, or dry spells occur during critical stages of crop development. The Nyamira County Climate Change Action Plan similarly identifies erratic rainfall, prolonged dry periods and extreme rainfall as significant threats to agricultural productivity and food security.

Soil Degradation and Erosion

Soil degradation emerged as one of the most consequential manifestations of climate vulnerability in the two counties. The problem is particularly acute because climatic pressure interacts with the physical geography and intensity of land use. Heavy rainfall falling on steep and continuously cultivated slopes accelerates the removal of topsoil, while repeated cultivation on increasingly small parcels reduces opportunities for fallowing and natural soil regeneration. The consequence is not merely physical soil loss but the gradual erosion of the productive capital upon which smallholder agribusiness depends.

Evidence from Kisii corroborates this relationship. Nyang'au et al. (2021) found considerable adoption of soil-conservation practices, including mulching and terracing, among farmers responding to changing climatic conditions. The prevalence of these responses itself indicates the significance farmers attach to soil and moisture conservation. The Kisii County climate planning documents likewise identify soil erosion among the consequences of climatic change and prioritise soil conservation within agricultural adaptation. In Nyamira, county climate assessments similarly associate extreme rainfall with accelerated erosion, land degradation and sediment movement.

The synthesis therefore suggests that soil degradation should not be treated as an environmental problem separate from agribusiness performance. Loss of fertile topsoil increases dependence on purchased fertiliser and other soil amendments, raises production costs and potentially reduces the profitability of small farms. In this sense, climate-induced soil degradation can produce a reinforcing cycle in which declining soil productivity reduces household income while reduced income simultaneously constrains investment in soil conservation. Climate resilience consequently requires both ecological restoration and economically accessible mechanisms for maintaining soil fertility.

Pest and Disease Dynamics

A second vulnerability concerns the changing ecology of agricultural pests and diseases. Climatic variability



can alter the conditions under which pests, pathogens and invasive species survive, reproduce and spread. This creates an additional layer of uncertainty because farmers must respond simultaneously to changes in rainfall and temperature and to biological threats whose distribution may themselves be climate-sensitive.

The Nyamira Participatory Climate Risk Assessment identifies pests and diseases among the county's prevailing climate-related hazards and records increasing concern about armyworms and invasive species. It further reports that changing temperature and rainfall conditions are expected to influence pest and disease incidence. Comparable evidence is found in Kisii's banana sector. Research on banana production in Kisii documented substantial prevalence of Fusarium wilt and Black Sigatoka alongside pests such as weevils and nematodes, demonstrating the importance of biological stresses within one of the region's major food and commercial crops. Wahome et al. (2021) similarly identified pests and diseases as major constraints on banana production in Kisii, Nyamira and other producing areas.

These findings require a cautious interpretation. The existence of a pest or disease cannot automatically be attributed to climate change. What the reviewed evidence supports more strongly is that climatic variability can modify the ecological conditions within which existing and emerging biological threats operate. The agribusiness consequence extends beyond yield loss: greater pest pressure can increase expenditure on pesticides, disease-free planting material and crop management while simultaneously reducing the quantity and quality of produce entering local markets and value chains.

Water Stress amid Relative Rainfall Abundance

An important paradox emerging from the review is the coexistence of relatively high annual rainfall with periodic agricultural water stress. Water vulnerability in Kisii and Nyamira is therefore less a simple question of annual precipitation than one of rainfall distribution, storage capacity and water-management infrastructure. Periods of intense rainfall can generate substantial runoff, yet the same farming households may experience water shortages during subsequent dry spells if that water has not been captured and stored.

Nyang'au et al. (2021) found that water harvesting was among the less widely adopted climate adaptation practices in Masaba South, with only 18.4 per cent of adopters reporting the practice; investment costs and knowledge requirements were identified as constraints. Kisii County's climate-risk assessment consequently prioritises irrigation expansion and rainwater harvesting as adaptation measures. Nyamira presents a comparable pattern: its climate action planning identifies declining water quantity, prolonged dry spells and pressure on springs as significant climate risks and places water harnessing among priority resilience investments.

Water stress is thus partly infrastructural. The inability to retain rainfall during wet periods converts climatic variability into production instability during dry periods. Investment in farm ponds, roof catchments, storage tanks, spring protection and efficient small-scale irrigation could therefore perform a dual function: reducing vulnerability to rainfall irregularity while permitting production beyond conventional rain-fed seasons.

Land Fragmentation and the Intensification of Climate Risk

The review further indicates that climate vulnerability is inseparable from the political economy of land. Kisii and Nyamira are characterised by intensive smallholder agriculture under considerable population pressure. In Kisii, official county information places typical holdings at approximately 0.5–4.5 acres and directly associates small farm sizes with subdivision and fragmentation. Kiprop et al. (2021) similarly associate land fragmentation with smallholder farm income and the challenges confronting agricultural production in Kisii.

Land fragmentation matters for climate resilience because it reduces the physical space within which adaptation can occur. Very small farms limit possibilities for mechanisation, extensive agroforestry, water-storage structures, rotational systems and enterprise expansion. Farmers may consequently intensify cultivation on the same parcels, potentially accelerating soil nutrient depletion. Yet fragmentation can also encourage crop diversification as households allocate limited land among food and cash crops. Its effects are therefore not uniformly negative. The central problem is that increasingly small holdings reduce farmers' margin for



experimentation and failure. A climatic shock affecting a two-acre diversified farm may have fundamentally different livelihood consequences from the same shock on a larger farm with greater productive and financial reserves.

AGRIBUSINESS PRACTICES AND RESILIENCE STRATEGIES

The literature reveals considerable adaptive agency among farmers in both counties. Smallholder production systems combine food crops, cash crops and livestock, with tea, maize, beans, bananas and horticultural crops forming important components of local agricultural economies. Rather than relying on a single adaptation strategy, farmers frequently combine practices to distribute production and livelihood risks.

Crop diversification and intercropping emerged particularly strongly. Nyang'au et al. (2021) reported crop diversification, altered planting dates, crop rotation, mixed cropping and manure application among important adaptation strategies in Masaba South. These findings closely correspond with Otworì et al. (2024), who found mixed cropping, crop rotation, organic farming and cover cropping to have significant relationships with food security among small-scale farmers in Nyamira. The convergence between evidence from the two counties is important: resilience appears to be generated not through wholesale replacement of local farming systems but through their incremental diversification and ecological intensification.

Diversification performs several functions simultaneously. Intercropping and mixed farming distribute climatic and market risks across enterprises, while livestock provides manure, food and alternative income. Organic manure and crop residues can improve soil structure and moisture retention while reducing complete dependence on purchased fertilisers. This creates a form of resilience based upon functional complementarity between farm enterprises. However, diversification should not be romanticised as inherently resilient. On very small and fragmented holdings, excessive diversification can produce enterprises below commercially viable scale. The resilience question is therefore not whether farmers diversify, but whether diversification creates economically productive combinations capable of supporting household consumption and market participation.

Agribusiness resilience also extends beyond production. Cooperative organisation, access to markets and agricultural information influence whether increased production translates into stable livelihoods. Kenya's Agricultural Sector Transformation and Growth Strategy recognises smallholder income growth and agricultural commercialisation as central to agricultural transformation, while the Kenya Climate Smart Agriculture Implementation Framework places value-chain actors alongside producers within resilience planning. This broader perspective is critical for Kisii and Nyamira: a climate-resilient farm cannot produce a resilient livelihood where market access, storage, transport and price conditions remain unstable.

CLIMATE-SMART AGRICULTURE AND LOCAL INNOVATION

Climate-smart agriculture emerged from the review as the principal policy and practical framework through which agricultural adaptation is currently articulated. Yet the evidence suggests that CSA in Kisii and Nyamira is not a single technology. It comprises combinations of crop diversification, soil and water conservation, agroforestry, organic soil management, altered planting calendars, improved varieties and water-management practices.

The evidence from Masaba South is particularly instructive. Nyang'au et al. (2021) found high levels of adoption for crop diversification, changing planting dates and mixed cropping, whereas more capital-intensive practices such as irrigation and water harvesting were much less common. In Nyamira, Otworì et al. (2024) similarly found that CSA practices collectively had a statistically significant relationship with food security, but individual practices did not produce uniform outcomes. Mixed cropping, crop rotation, organic farming and cover cropping showed significant effects, whereas the results for agroforestry, drought-resistant crops, water harvesting and integrated soil-fertility management were not individually statistically significant in that study.

This variation is analytically significant. It demonstrates that CSA should not be presented as a universally



transferable package whose adoption automatically produces resilience. The effectiveness of particular practices depends upon farm size, capital requirements, labour availability, local ecology, farmer knowledge and the period over which benefits become visible. Practices requiring relatively modest financial investment may diffuse more readily than solar irrigation, substantial water-storage infrastructure or other capital-intensive technologies. Thus, the critical policy question is not simply how to increase the number of farmers classified as CSA adopters, but how to match particular technologies to local ecological and socioeconomic conditions.

The national Kenya Climate Smart Agriculture Strategy reinforces this multidimensional interpretation by linking productivity, adaptation and mitigation rather than treating them as separate agricultural objectives. For Kisii and Nyamira, however, the reviewed evidence suggests that the adaptation and livelihood dimensions are especially immediate. CSA becomes meaningful to smallholders when it stabilises production, protects soil and water resources, reduces exposure to crop failure and produces tangible household benefits.

INSTITUTIONAL AND POLICY SUPPORT

The review found a comparatively elaborate policy architecture for climate-resilient agriculture in Kenya. At national level, the Kenya Climate Smart Agriculture Strategy 2017–2026 establishes the strategic basis for integrating productivity, resilience and mitigation, while the Kenya Climate Smart Agriculture Implementation Framework 2018–2027 translates this orientation into implementation options for counties and value-chain actors. The Agricultural Sector Transformation and Growth Strategy 2019–2029 further places smallholder incomes, agricultural commercialisation and food security within the wider transformation of Kenyan agriculture.

County-level frameworks indicate increasing localisation of this policy agenda. Nyamira's Climate Change Action Plan 2023–2028 identifies agriculture, water, infrastructure and environmental management as priority areas and explicitly recognises climate finance, technology, capacity development and knowledge management as enabling conditions for resilience. Kisii's climate planning similarly prioritises crop diversification, small-scale irrigation, farmer capacity-building and improved weather information.

The analytical issue emerging from the literature is therefore less the absence of policy than the relationship between policy commitments and implementation capacity. This observation echoes Nyangena et al. (2017), who draw attention to the nexus between agricultural-sector policy, climate-change research and practice in Kenya. A sophisticated national policy framework cannot by itself create resilience if extension officers, county departments, financial institutions and farmer organisations lack the resources to translate policy into accessible services. The institutional challenge is consequently one of vertical integration: national climate objectives must become locally usable information, finance, technologies and extension support at farm level.

BARRIERS TO RESILIENCE BUILDING

The synthesis identified financial, informational, institutional and structural barriers that explain why technically viable adaptation measures remain unevenly adopted. Finance is particularly important because adaptation frequently involves costs incurred before benefits are realised. Irrigation equipment, water tanks, improved planting materials, terraces, agroforestry and other investments compete with immediate household needs for limited resources. Nyang'au et al. (2021), for example, associate the low uptake of water harvesting with investment and knowledge requirements. Nyamira's climate planning likewise identifies climate finance, resource mobilisation and technological capacity as enabling requirements for effective adaptation.

Weak or uneven access to extension services compounds financial limitations. Farmers require more than awareness that the climate is changing; they require specific knowledge concerning planting dates, crop varieties, pest management, soil conservation, water management and market conditions. The Kenya Climate Smart Agriculture Implementation Framework recognises this need for transformative initiatives and context-specific implementation, while Kisii's climate-risk assessment explicitly prioritises farmer training and weather



information. Resilience therefore depends upon the quality, timeliness and usability of information rather than its mere availability.

Land tenure and gender introduce a further distributive dimension. Access to land, credit, technologies and decision-making authority is not necessarily equal within rural households or communities. Climate adaptation interventions that assume a homogeneous category of "the farmer" risk obscuring differences in control over productive assets. Similarly, poor roads, inadequate storage and weak market infrastructure can erode the economic returns from successful adaptation by increasing transaction costs and post-harvest losses. The barriers are therefore mutually reinforcing: limited land can restrict collateral and investment; limited finance constrains technology adoption; weak extension reduces the effective use of technologies; and inadequate market infrastructure lowers the returns from whatever productivity gains are achieved.

OPPORTUNITIES AND POLICY IMPLICATIONS

The evidence points first to the need to strengthen research–extension–farmer linkages. Climate research acquires practical value only when scientific information is translated into locally intelligible and timely farm decisions. Otwori et al. (2024) emphasise continued monitoring of local climate conditions and collaboration among meteorological agencies, researchers, policymakers and communities, while Kisii's climate-risk assessment identifies improved early-warning and weather-information systems as adaptation priorities. Farmer field schools, demonstration farms and digitally supported extension should therefore function as sites of reciprocal learning rather than simply channels through which experts transfer predetermined technologies to farmers.

Second, climate-smart innovations should be scaled selectively rather than uniformly. The evidence from Nyamira shows that mixed cropping, crop rotation, organic farming and cover cropping were associated with improved food-security outcomes, while the Kisii evidence demonstrates substantial farmer use of diversification, manure, adjusted planting dates and soil conservation. Scaling should consequently begin with locally demonstrated practices while simultaneously addressing the financial and technical barriers that suppress adoption of potentially valuable but capital-intensive measures such as water harvesting and irrigation.

Third, agricultural finance should be reconceptualised as part of climate adaptation infrastructure. Credit products, insurance, savings mechanisms and green financing need to reflect the production cycles and risk profiles of smallholders rather than conventional lending assumptions. Nyamira's current planning already identifies green financing and increased CSA adoption as connected development priorities, while national CSA policy recognises finance as integral to agricultural transformation. Inclusive finance would allow households to invest before climatic shocks rather than depending principally upon coping mechanisms after losses occur.

Fourth, investment in water, roads, storage and market infrastructure should be understood as climate-resilience investment. Water harvesting reduces dependence on rainfall timing; roads preserve market access during extreme weather; storage reduces post-harvest losses; and functional markets strengthen incentives for investment in adaptation. The national agricultural transformation strategy explicitly places counties at the centre of building a food system capable of withstanding climatic, pest and market shocks. Nyamira's climate plan similarly integrates water, agriculture and rural infrastructure within its resilience agenda.

Resilience policy must be socially differentiated and gender responsive. Expanding technology without addressing unequal access to land, finance, information and decision-making risks reproducing existing inequalities within ostensibly climate-smart interventions. Gender responsiveness should therefore extend beyond the numerical inclusion of women in training programmes to their effective access to productive assets, finance, markets and institutional decision-making.

Taken together, the findings demonstrate that the transition towards climate-resilient agribusiness in Kisii and Nyamira is already underway but remains uneven and structurally constrained. Farmers are adapting through



diversification, soil management, altered production practices and other locally accessible strategies, while national and county governments have progressively constructed policy frameworks supportive of climate-smart agriculture. The unresolved challenge lies in connecting these two levels. Resilience will not be secured through farm-level adaptation alone, nor through policy formulation in isolation. It requires an agribusiness system in which ecological adaptation is reinforced by functioning markets, climate information, finance, infrastructure, extension services and inclusive institutions. The central implication of the review is therefore that sustainable food systems in the Kisii–Nyamira highlands depend upon moving from isolated climate-smart practices towards an integrated climate-resilient agribusiness system capable of absorbing climatic shocks, sustaining production and maintaining viable rural livelihoods.

CONCLUSION

This study examined climate-resilient agribusiness systems in Kisii and Nyamira counties and their contribution to sustainable food systems. Regarding the climatic vulnerabilities affecting agribusiness, the review established that rainfall variability, soil degradation, water stress, changing pest and disease dynamics, and land fragmentation increasingly undermine agricultural productivity and smallholder livelihoods. These vulnerabilities are intensified by the dependence on rain-fed agriculture and the limited productive resources available to many smallholder farmers. In relation to adaptation and resilience strategies, the study found that farmers employ crop diversification, intercropping, livestock integration, organic soil management, water conservation and other climate-smart agricultural practices. However, their effectiveness and adoption vary according to local socioeconomic and ecological conditions. The assessment of institutional support further revealed that, despite relatively comprehensive national and county policy frameworks, implementation is constrained by inadequate finance, weak extension services, infrastructure deficits, limited access to climate information and inequalities in productive resources. The study therefore concludes that sustainable food systems in Kisii and Nyamira cannot be secured through farm-level adaptation alone. Climate resilience requires an integrated agribusiness approach linking climate-smart production with effective extension, accessible finance, reliable climate information, functional markets and supportive infrastructure. Strengthening these interconnections is essential for sustaining agricultural productivity, improving smallholder livelihoods and enhancing long-term food-system resilience.

REFERENCES

1. County Government of Nyamira. (2023). *County climate change action plan 2023–2028*. Department of Environment. [Nyamira Climate Change](#)
2. Government of Kenya. (2017). *Kenya climate smart agriculture strategy 2017–2026*. Ministry of Agriculture, Livestock and Fisheries. [Springer](#)
3. Government of Kenya. (2018). *Kenya climate smart agriculture implementation framework 2018–2027*. Ministry of Agriculture, Livestock, Fisheries and Irrigation. [UNDP](#)
4. Kiprop, C., Kirwa, L., Ngotho, E., Mwungu, C., Wanjau, A., Otieno, F., Gamoyo, M., Koech, G., & Ghosh, A. (2024). *Impact evaluation of Shamba Shape Up weather and farming news on smallholder farmers in Kenya*. Accelerating Impacts of CGIAR Climate Research for Africa (AICCRA). [Alliance Bioversity-CIAT](#)
5. Kiprop, I. N., Ngugi, J. K., & Kosgei, G. K. (2021). Effects of land fragmentation and crop diversity on smallholders' farm income: Case of Kisii County, Kenya. In D. K. Isutsa (Ed.), *Proceedings of the 7th International Research Conference held at Chuka University, 3–4 December 2020* (pp. 1–7). Chuka University. [Chuka University Repository](#)
6. Nyang'au, J. O., Mohamed, J. H., Mango, N., Makate, C., & Wangeci, A. N. (2021). Smallholder farmers' perception of climate change and adoption of climate smart agriculture practices in Masaba South Sub-county, Kisii, Kenya. *Heliyon*, 7(4), e06789. <https://doi.org/10.1016/j.heliyon.2021.e06789> [ScienceDirect](#)
7. Nyangena, W., Guthiga, P. M., Ogada, M., & Sikei, G. (2017). *An assessment of agricultural sector policies and climate change in Kenya: Nexus between climate change related policies, research and practice* (Working Paper No. 20). Kenya Institute for Public Policy Research and Analysis. [Agris](#)



8. Otwor, D. O. (2024). *Climate-smart agriculture and its implications on food security among small-scale farmers in Nyamira County, Kenya* [Doctoral dissertation, Masinde Muliro University of Science and Technology]. MMUST Institutional Repository. [MMUST IR Library](#)
9. Otwor, D. O., Mugalavai, E. M., & China, S. S. (2024). Assessing climate-smart agriculture practices for enhanced food security in Nyamira County, Kenya: A scientific perspective. *Journal of the Kenya National Commission for UNESCO*, 5(1). <https://doi.org/10.62049/jkncu.v5i1.161> [Journal of UNESCO Kenya](#)
10. Rutting, L., Njoroge Kimani, M., Veeger, M., & von Breymann, R. (2024). *A contextual analysis of Kenya's food system and policy environment*. CGIAR Initiative on Climate Resilience. [CGSpace](#)
11. Wahome, C. N., Maingi, J. M., Ombori, O., Kimiti, J. M., & Njeru, E. M. (2021). Banana production trends, cultivar diversity, and tissue culture technologies uptake in Kenya. *International Journal of Agronomy*, 2021, 6634046. <https://doi.org/10.1155/2021/6634046> [Wiley Online Library](#)