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CLIMATE CHANGE

ADAPTATION TO CLIMATE CHANGE IN AGRICULTURAL MUNICIPALITIES OF KIAMBU COUNTY: LOCAL STRATEGIES AND INSTITUTIONAL RESPONSES

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ABSTRACT

Climate change presents an urgent and growing challenge for agricultural communities in Kenya, particularly in Kiambu County, where farming is a primary economic activity. The region has witnessed increasingly erratic weather patterns, prolonged droughts, and a rise in agricultural pests and diseases, all of which threaten food security and livelihoods. Agricultural municipalities such as Lari, Githunguri, Limuru, and Gatundu are experiencing declining yields in maize, tea, coffee, and dairy due to shifting climate conditions. In response, communities have begun adopting adaptive strategies such as drought-resistant crops, agroforestry, water harvesting, and diversification into non-farming livelihoods. This study investigated the local adaptation strategies employed by agricultural communities in Kiambu and to examine the role of institutional actors, including the county government, NGOs, and community-based organizations. Utilizing a mixed-methods approach, the research incorporates observation and policy review of relevant county and national documents. The findings indicate a growing awareness among farmers of the need to adapt, with localized innovations and collective action emerging as key themes. However, barriers such as limited funding, poor policy implementation, and inadequate access to climate information persist. The study contributes to understanding how local adaptation can be strengthened through inclusive governance and evidence-based planning to build long-term resilience.

Keywords: *Adaptation, Climate, County, Municipality, Policy*

1. Introduction

Climate change continues to be one of the most significant threats to agricultural sustainability and food security in sub-Saharan Africa (Saleem *et al.,* 2024). In Kenya, climate variability has led to erratic rainfall, extended droughts, floods, and temperature increases that have severely impacted agricultural productivity and rural livelihoods (Ng'ang'a *et al.,* 2023). These climate disruptions have contributed to the decline in staple crop yields, increased outbreaks of pests and diseases, and exacerbated soil degradation—trends particularly evident in agriculturally intensive counties like Kiambu (Ministry of Environment, Climate Change and Forestry [MECCF], 2022).

Kiambu County, located in Kenya's Central region, plays a vital role in national food systems, producing significant quantities of dairy, tea, coffee, maize, and horticultural crops. The county's proximity to Nairobi, its fertile soils, and favorable climate have historically supported robust agricultural activity (Kiambu County, 2023). However, recent environmental changes have increasingly undermined its agricultural potential, especially in municipalities such as Lari, Githunguri, Gatundu and Limuru, which are vulnerable to soil erosion, water scarcity, and shifting crop zones (FAO, 2022, Kiambu County, 2023).

The increasing vulnerability of agricultural communities in Kiambu highlights the need for adaptive strategies at the local level. While some adaptation efforts are underway—such as crop diversification and agroforestry—the effectiveness and scalability of these initiatives depend heavily on institutional support, local governance, and policy alignment with national climate frameworks (Kuria *et al.,* 2021). Yet, there is limited empirical evidence on how local communities and institutions interact to co-develop and implement adaptation measures.

This study therefore investigated the key climate-related challenges facing agricultural municipalities in Kiambu County, assessed the adaptation strategies adopted by local communities, evaluate the effectiveness of institutional responses, and identify the barriers that hinder adaptation. The research sought to answer the following questions:

1. What are the most pressing climate-related challenges in agricultural municipalities of Kiambu County?
2. What adaptation strategies have communities adopted in response to climate change?
3. How effective are county-level policies and programs in supporting local adaptation?
4. What role do indigenous knowledge and local networks play in resilience-building?
5. What are the key institutional and socio-economic barriers to climate change adaptation?

The study adopted a mixed-methods design, combining field-based qualitative and quantitative data with policy analysis. The structure of this paper proceeds as follows: Section 2 discusses climate change impacts in Kiambu; Section 3 outlines community adaptation strategies; Section 4 explores the role of local institutions; Section 5 analyzes barriers to adaptation; Section 6 reviews policy frameworks; Section 7 explains the methodology; and Section 8 concludes with recommendations.

2. Climate Change Impacts on Agriculture in Kiambu County

With 17.4% of the county's population income coming from agriculture, it is the county's main economic activity. It is the top subsector in terms of employment, food security, income, and overall contribution to people's socioeconomic well-being. 304,449 people are employed directly or indirectly in agriculture, which provides the majority of the County's income (ASDSP II, 2020).

Among these, horticulture, banana farming, dairy farming, tea and coffee growing, and raising native chickens are important (Kiambu County Government, 2021). Agriculture in Kiambu County is increasingly vulnerable to climate change due to rising temperatures and erratic rainfall patterns. Data from the Kenya Meteorological Department show that the Central Highlands, including Kiambu, have experienced a notable rise in average annual temperatures—by approximately 1.2°C since the 1960s—with an increased frequency of hotter days (Kenya Meteorological Department [KMD], 2021). Simultaneously, rainfall has become more unpredictable, often manifesting as short, intense bursts rather than the long, evenly distributed rains that farmers rely upon. This variability has disrupted traditional planting seasons, increased post-harvest losses, and reduced the productivity of rain-fed agriculture (Kiambu County, 2023, Ogenga *et al.,* 2018).

In Lari Sub- County, known for tea farming and forestry, farmers have reported decreasing yields attributed to prolonged dry spells and the scorching of young tea shoots due to elevated temperatures (FAO, 2022). Additionally, increased soil erosion on steep slopes has washed away topsoil, degrading land quality and reducing crop viability. In Githunguri municipality, a dairy farming hub, water shortages have made it difficult to sustain pasture and clean water for cattle, leading to a decline in milk yields. Livestock are increasingly exposed to heat stress and waterborne diseases, while maize and nappier grass—commonly used for silage—is being affected by delayed rains and pest infestations (Mungai *et al.,* 2021). Certainly, adding on the above, Ikunu ward in Githunguri municipality, has long been a hub for dairy farming in Kiambu County, but climate change has deeply affected its productivity and sustainability. Traditionally reliant on rainfed agriculture, the region's dairy farmers have faced increasing climate shocks—such as erratic rainfall, prolonged droughts, and soil degradation—which have led to reduced pasture availability and strained milk production.

Limuru, another highland area transitioning into a peri-urban zone, has experienced extreme rainfall events followed by prolonged dry periods. This fluctuation has led to a decline in vegetable production, which is a major source of household income. Farmers report greater incidence of plant diseases and pests, especially fall armyworm and fungal infections that thrive in warm, moist conditions (Kuria & Njuguna, 2022). Meanwhile, in Gatundu municipality, which rely heavily on smallholder fruit and coffee production, erratic rains and unseasonal frost have significantly affected flowering and fruiting cycles. As a result, coffee berry quality has declined, and fruit yields have become inconsistent.

Water scarcity is a recurring challenge across these regions. Springs and rivers that once flowed year-round are now seasonal, sparking local disputes over access to water, particularly in Githunguri and Lari municipalities. Boreholes and shallow wells often dry up during prolonged dry seasons, impacting not just irrigation but also domestic use. Farmers have begun

to notice increased tension among neighboring households and even with wildlife, as water points become contested (NEMA, 2023).

In response, local initiatives like the Carbon Farming for Agricultural and Environmental Sustainability and Profitability (CAFAESUP) project have introduced regenerative agriculture practices to help mitigate these effects (Mumbi, 2024). By integrating tree planting for carbon sequestration, using cow dung in biodigesters to produce clean biogas and nutrient-rich bio-slurry, and adopting minimum tillage and crop intercropping methods, farmers are gradually restoring soil health and reducing reliance on synthetic inputs (Angheloiu, 2024). These practices not only support dairy production by improving fodder quality and water retention but also create opportunities for diversified income streams and enhanced resilience to climate variability.

Soil erosion has intensified on hilly terrain, especially in Lari and Limuru, due to deforestation and lack of soil conservation structures. Heavy rains combined with improper land use practices have stripped away fertile topsoil, undermining future agricultural productivity. This degradation feeds into a cycle of lower yields and reduced capacity to invest in improved farming inputs.

Local perceptions align with scientific assessments of changing climate conditions. Many farmers express concern over the unpredictability of rains, noting that "the rains no longer come when they used to" and "we cannot rely on the seasons like our parents did" (Field Interviews, 2024). These perceptions are not only accurate but also indicate a community-level awareness of climate change, though the understanding of its long-term implications remains limited.

Overall, the convergence of rising temperatures, erratic rainfall, soil erosion, pest outbreaks, and water scarcity is undermining agricultural stability in Kiambu's municipalities. These effects call for urgent and localized adaptation strategies to build community resilience and protect food security.

3. Community-Level Adaptation Strategies

In response to increasing climate variability, agricultural communities across Kiambu County have initiated a range of grassroots-level adaptation strategies. These responses, though often informal and under-resourced, reflect growing awareness of changing climate conditions and an urgent need for resilience.

One of the most widely adopted strategies is the shift to drought-resistant and early-maturing crop varieties. Farmers in Gatundu North and Limuru have increasingly planted fast-growing maize and beans that require less water and mature in shorter cycles. Organizations such as the Kenya Agricultural and Livestock Research Organization (KALRO) have supported this by distributing improved seeds and offering training on appropriate agronomic practices (KALRO, 2022). These seeds are better suited to Kiambu's shifting climate and help reduce the risk of total crop failure.

Agroforestry, terracing, and conservation farming have also gained traction. In Lari, which faces steep terrain and high erosion rates, farmers are planting trees alongside crops to stabilize soil and create microclimates. Agroforestry practices—particularly involving

grevillea, avocado, and calliandra species—not only protect soil but also provide additional sources of income through timber, fodder, and fruits (Muriuki & Gathenya, 2020). In Githunguri, the adoption of conservation farming techniques like minimum tillage and crop rotation has improved soil moisture retention and reduced pest pressure.

Access to water remains a top concern, and communities have responded with rainwater harvesting, water storage tanks, boreholes, waterpans and small-scale irrigation systems. In Limuru, NGOs such as the African Centre for Technology Studies (ACTS) have supported farmers in installing rooftop rainwater collection systems and affordable plastic tanks to buffer against dry periods (ACTS, 2023) while Agroecology Action Group a community based organization have been advocating for regenartive agriculture in the county. In Lari and Githunguri, farmer cooperatives have pooled resources to drill boreholes and maintain gravity-fed irrigation from upland springs, increasing water access for both crops and livestock.

Climate change has also pushed households to diversify their livelihoods beyond agriculture. Youth and women, in particular, are turning to small businesses such as food vending, boda boda (motorcycle taxi) operations, tailoring, and poultry rearing. This diversification reduces reliance on farming income and spreads climate-related risks. In Gatundu South, women's groups have formed savings and loan cooperatives that help members start businesses and purchase farm inputs, enhancing household resilience.

Local communities also draw on indigenous knowledge systems and innovation. Farmers in Limuru, for example, use traditional weather indicators such as animal behavior and cloud movement to anticipate rainfall patterns. While not always scientifically precise, these methods are integrated into decision-making alongside meteorological forecasts. Additionally, farmers in Githunguri have revived the use of organic composting and natural pest repellents, recognizing their value in restoring soil health and reducing dependence on costly chemicals.

Community-Based Organizations (CBOs) and cooperatives have been instrumental in coordinating adaptation efforts. The Githunguri Dairy Cooperative Society, for instance, offers climate-smart feeding advice, veterinary services, and financial credit to over 10,000 members. In Limuru, the Karambe CBO has mobilized local youth in tree planting and environmental education campaigns. These grassroots organizations not only deliver services but also foster collective action and peer learning.

The gender dimensions of adaptation are particularly notable. Women, who play a central role in food production and household water management, are often the first to notice environmental changes. In response, women's groups have taken leadership roles in organizing savings schemes, training workshops, and community gardens. Youth, while facing high unemployment, are increasingly involved in climate-resilient agribusinesses, especially poultry farming and greenhouse cultivation (Mwangi *et al.,* 2022).

However, adaptation efforts remain uneven and constrained by limited funding, low access to information, and inadequate institutional support. While many community strategies show promise, they need to be scaled up and integrated into formal policy frameworks to be truly transformative.

In summary, Kiambu's agricultural communities are not passive victims of climate change; they are actively experimenting with diverse strategies to adapt. Supporting and scaling these efforts—particularly those led by women, youth, and local organizations—will be critical in building long-term resilience in the face of accelerating climate risks.

4. Role of County Government and Institutions

The County Government of Kiambu plays a central role in facilitating climate adaptation and agricultural resilience through policy, capacity building, and service delivery. The County Integrated Development Plan (CIDP) 2023–2027 outlines climate-resilient agriculture as a key priority area. It emphasizes enhancing extension services, promoting sustainable land use, and investing in water infrastructure to buffer against climate shocks (Kiambu County Government, 2023). However, while the plan is comprehensive on paper, implementation gaps remain due to resource constraints, lack of technical know-how and minimal institutional/departmental coordination.

Agricultural extension services have seen partial revitalization under the county's Department of Agriculture, though farmer access remains inconsistent. Extension officers help farmers adopt drought-resistant crops, practice conservation agriculture, and manage pests. Collaboration with the Ministry of Agriculture, National Environment Management Authority (NEMA), and NGOs such as SNV and World Agroforestry (ICRAF) has supported mobile-based advisory services and training on climate-smart practices (SNV Kenya, 2021). Such programs often target both individual farmers and cooperatives, enhancing knowledge transfer and uptake of new technologies. In Githunguri and Lari, for instance, county-facilitated trainings have promoted the use of early-maturing maize varieties and rainwater harvesting systems, improving food security among smallholder farmers (ICRAF, 2022).

Budgetary allocations toward climate adaptation, however, remain modest. A review of county budgets reveals that less than 5% is earmarked for climate-resilient agriculture annually (National Treasury of Kenya, 2022). This limits the scaling of successful initiatives. Nevertheless, public-private partnerships (PPPs) have offered alternative financing options. Initiatives like the Dairy Value Chain Development Program, supported by the county and private processors, have improved feed storage, reducing climate-induced milk losses in Githunguri (FAO, 2023).

A key area of innovation has been the integration of indigenous knowledge into policy dialogues. Local elders and farmer groups contribute to planning meetings, sharing observations on seasonal shifts and traditional planting calendars. This participatory approach, supported by NGOs like Vi Agroforestry, bridges scientific models and lived experience (Vi Agroforestry, 2021).

Capacity-building efforts are increasingly digitally enabled. Platforms like Kenya Agricultural Observatory Platform (KAOP) offer real-time climate data and market information via SMS, though digital literacy and access remain uneven (KALRO, 2022).

Lastly, the relationship between county and national institutions is both a strength and a challenge. While national bodies provide technical guidance and funding frameworks, overlaps and poor coordination often lead to duplicated efforts. For example, conflicting

guidelines from the Ministry of Environment and Kiambu's local policies have delayed some community-based water projects (NEMA, 2022). Strengthening institutional synergy is vital for coherent climate adaptation governance.

5. Barriers to Effective Adaptation

Despite efforts at both community and institutional levels, multiple barriers continue to constrain effective climate change adaptation in Kiambu's agricultural municipalities.

A primary constraint is limited funding and technical support. County budget allocations for climate-resilient agriculture are insufficient, and many rural farmers lack access to subsidies, improved seeds, or technical equipment (National Treasury of Kenya, 2022). Extension officers to the farming population ratio is low, leaving knowledge gaps on adaptive practices (KALRO, 2022).

Low climate literacy and limited access to accurate weather forecasts further hinder decision-making. While tools like KAOP exist, many farmers in Lari and Gatundu South report relying on intuition or outdated weather patterns due to a lack of trust or understanding of modern forecasting systems (ICRAF, 2022). Women and elderly farmers, in particular, face information exclusion due to digital illiteracy and infrastructural barriers.

Another major barrier is fragmented governance and bureaucracy. Overlapping mandates between county departments, parastatals, and NGOs create confusion and inefficiencies. For instance, community groups in Limuru have struggled to secure permits for irrigation projects due to contradictory policies between the Ministry of Water and Kiambu's land authorities (NEMA, 2022).

Unclear land tenure further discourages long-term investments. Many smallholder farmers operate on ancestral or informal land with no title deeds, reducing their ability to secure credit or invest in infrastructure like terraces or irrigation (FAO, 2023).

Finally, gender and generational exclusion from decision-making limits adaptation outcomes. Women—despite being key agricultural laborers—often lack representation in cooperatives or farmer associations. Youth, who bring innovation potential, are frequently sidelined due to cultural hierarchies or migration to urban areas (Vi Agroforestry, 2021).

Addressing these barriers will require inclusive, well-funded, and coordinated adaptation planning that recognizes the socio-economic realities and diverse capacities within Kiambu's agricultural communities.

6. Policy and Planning Frameworks Supporting Adaptation

Climate adaptation efforts in Kiambu County are framed by both county-level strategies and national policies. While Kiambu County lacks a finalized standalone Climate Change Action Plan as of 2024, climate adaptation is embedded in the County Integrated Development Plan (CIDP) 2023–2027, which outlines priorities such as agroecological resilience, irrigation infrastructure, and value chain development (Kiambu County Government, 2023). However, the absence of a specific and enforceable county-level adaptation roadmap creates coordination gaps.

At the national level, Kenya's Climate Change Act (2016) serves as the primary legislative instrument mandating climate-responsive planning across all levels of government. It establishes institutional frameworks, such as the Climate Change Council and the Directorate of Climate Change, and compels counties to establish climate change units and mainstream adaptation into their development plans (Republic of Kenya, 2016).

Complementing the Act is the National Adaptation Plan (NAP) 2015–2030, which sets sectoral priorities, including climate-resilient agriculture, water management, and risk reduction systems (Ministry of Environment and Forestry, 2018). Moreover, the Kenya Climate Smart Agriculture Strategy (KCSAS) 2017–2026 provides a comprehensive guide to promote sustainable, productive, and adaptive farming systems (Ministry of Agriculture, 2017).

An analysis of Kiambu's CIDP reveals alignment with national priorities, especially regarding sustainable water management, training programs, and agro-processing. However, implementation gaps persist due to low funding, unclear performance indicators, and limited public awareness of these frameworks (National Treasury, 2022). For instance, while the KCSAS emphasizes early warning systems and insurance for farmers, few such services are functional at the grassroots level in Lari or Gatundu North.

Accountability mechanisms remain low. Monitoring and evaluation are often donor-driven or NGO-led rather than institutionalized within county departments. Citizen participation in planning processes, though legally required, is inconsistently applied, with women and youth frequently underrepresented in public forums (Vi Agroforestry, 2021).

To enhance policy effectiveness, counties like Kiambu must develop tailored Climate Change Action Plans, build cross-departmental coordination structures, and foster community-based monitoring. Alignment with national frameworks requires both technical guidance and budgetary support from the central government.

7. Methodology

A policy review was conducted, analyzing government documents such as the CIDP, the Climate Change Act, NAP, and Kenya Climate Smart Agriculture Strategy, alongside NGO reports (e.g., Vi Agroforestry, SNV Kenya, ICRAF) for implementation insights.

Site selection was guided by ecological and economic diversity. Lari and Limuru municipalities represents forested highland systems vulnerable to erosion and rainfall variability, while Gatundu and Githunguri municiplalities reflect drier zones with high dairy and maize production pressures. The rainfall availability, land slope and topography and heat stress levels in Kiambu County maps are shown in figure 1-3. This diversity enabled a nuanced analysis of adaptation strategies across different risk profiles.

4. Results of Documents and Policy Review

Policy and Strategy Alignment Review for Climate Adaptation in Kiambu County's Agricultural Sector

This review assessed the coherence, relevance, and implementation readiness of key national and county policy documents in supporting climate adaptation within Kiambu County's agricultural regions. The focus was on evaluating how well these policies address climate vulnerabilities, particularly in areas like Lari, Gatundu, Githunguri, and Limuru municipalities. The analysis centered on the alignment between national strategies and the Kiambu County Integrated Development Plan (CIDP) 2023–2027.

The review covered the Climate Change Act (2016), the National Adaptation Plan (NAP) 2015–2030, and the Kenya Climate-Smart Agriculture Strategy (2017–2026), alongside the CIDP and reports from development partners such as Vi Agroforestry, SNV Kenya, and ICRAF. These documents were analyzed in terms of their strategic objectives, adaptation measures, and local implementation potential.

The methodology involved policy document review approach, identifying strengths, gaps, and opportunities for better integration of national climate strategies into county-level planning and agricultural resilience efforts.

Policy Review: Kiambu County Integrated Development Plan (CIDP) 2023–2027

The Kiambu County Integrated Development Plan (CIDP) 2023–2027 provides a well-structured overview of the county's physiographic, climatic, and ecological conditions, which are essential for informing climate-resilient agricultural strategies. Kiambu's division into four broad agro-ecological zones — Upper Highland, Lower Highland, Upper Midland, and Lower Midland — sets the stage for region-specific interventions (Kamau et al., 2022, Kiambu County Government, 2023). These zones align directly with key agricultural sub-counties such as Lari, Gatundu North and South, Githunguri, Limuru, Juja, and Thika, which were also focal in the research.

Lari, located in the Upper Highland zone, is particularly important due to its high rainfall and forest cover (Kieni and Kinale forests), which make it a critical water catchment area and a high-potential zone for agroforestry and moisture-sensitive crops (ASDSP II, 2020, MoALFC, 2021). Githunguri, Gatundu North, and Limuru fall largely within the Lower Highland zone, where tea, dairy, maize, and horticultural farming dominate. These regions benefit from fertile upland volcanic soils and relatively high rainfall (over 1000 mm annually), making them suitable for intensive agriculture, though climate variability is increasingly a concern (Kioko, 2024, MoALFC, 2021).

Juja, Thika, and parts of Ruiru in the Upper and Lower Midland zones face semi-arid conditions, low soil fertility, and shallow drainage. These characteristics present unique challenges for agriculture, but also opportunities for expanding drought-resistant crops and livestock rearing under climate-smart strategies (MoALFC, 2021).

The CIDP presents valuable climatic data — such as bimodal rainfall distribution, average annual temperatures (15–23°C), and spatial patterns of rainfall and humidity — that

can inform seasonal planning and resource allocation. However, the document falls short in aligning this data with specific climate resilience frameworks (Kioko, 2024). It lacks explicit mention of vulnerability assessments, risk reduction measures, or integration with national climate policies and tools such as the Kenya Climate-Smart Agriculture Strategy (Kiambu County Government, 2023).

In summary, while the CIDP provides a strong ecological and climatic foundation, it requires a more deliberate link between agro-ecological zoning and actionable CSA planning to enhance resilience in key agricultural sub-counties like Lari, Githunguri, Gatundu, and Juja.

Review of the Climate Change Act, 2016 in the Context of Kiambu County

The Climate Change Act, 2016 serves as Kenya's principal legal framework for coordinating climate change responses at both national and county levels. Its enactment established mechanisms for mainstreaming climate resilience and low-carbon development across all sectors, including agriculture, which is central to Kiambu County's economy (The climate change act, 2016).

In line with the Act, the County Government of Kiambu enacted the Kiambu County Climate Change Act, 2021, which institutionalizes climate action at the local level. The 2016 Act mandates the integration of climate change into development planning, budgeting, and policy implementation, thus reinforcing the county's efforts to align with the National Climate Change Action Plan (NCCCAP). Through this legal alignment, Kiambu has prioritized the formulation of a County Climate Change Action Plan (CCCAP) to guide climate interventions based on local vulnerabilities (Kevins, 2022, Kiambu County Acts, 2021).

This framework is particularly relevant to Kiambu's agricultural regions such as Githunguri, Lari, Gatundu North and South, and Limuru, where climate change has led to erratic rainfall, flooding, prolonged droughts, and declining agricultural yields (Kevins, 2022). These impacts directly affect smallholder farmers, informal settlements, and marginalized populations such as PWDs, the elderly, youth, orphans, and the economically disadvantaged—groups whose vulnerabilities are compounded by poor infrastructure, food insecurity, and limited access to healthcare or emergency response systems.

The Act's emphasis on public participation, transparency, and devolution of climate governance empowers counties like Kiambu to tailor mitigation and adaptation strategies to local realities. However, implementation challenges persist, including limited technical capacity, financial constraints, and data gaps.

Overall, the Climate Change Act, 2016 provides a robust foundation for climate resilience in Kiambu. Yet, realizing its full potential demands sustained investment, institutional coordination, and inclusive participation to protect the county's most vulnerable and safeguard its agricultural productivity.

Review of the National Adaptation Plan (NAP 2015–2030)

The National Adaptation Plan (NAP 2015–2030) provides Kenya's overarching strategy for adapting to climate change, supporting the implementation of the Climate Change Act, 2016, and guiding sectoral and county-level climate actions. It identifies agriculture and

water resources as priority sectors for climate resilience due to their vulnerability to climate variability and their centrality to Kenya's food and economic security (Government of Kenya, 2016).

Agriculture sector targets in the NAP include enhancing food security through the promotion of climate-smart agriculture (CSA), improving early warning systems, and increasing the resilience of smallholder farmers (Shammugam *et al.,* 2024). For water resources, the NAP emphasizes integrated water resource management, increasing water harvesting and storage capacity, and rehabilitating degraded watersheds.

For counties like Kiambu, the NAP outlines the need for devolved adaptation planning. Strategic actions such as promoting CSA technologies, improving access to drought- and flood-resistant seed varieties, supporting rainwater harvesting, and integrating adaptation in land-use planning are emphasized.

However, gaps remain in local alignment. While Kiambu's CIDP references climate adaptation, the integration of NAP targets is often broad and lacks detailed localization. For example, the vulnerability of agricultural zones like Githunguri, Lari, and Gatundu—frequently impacted by erratic rainfall, flooding, and drought—is not matched with clearly defined adaptation interventions (Shammugam *et al.,* 2024). Additionally, institutional coordination between national and county structures is limited, and the financial planning necessary for NAP implementation is not fully embedded in the CIDP.

In summary, the NAP provides a strong national framework, but its impact in Kiambu depends on greater localization, financing, and capacity building to match sectoral targets to on-the-ground realities.

Review of the Kenya Climate-Smart Agriculture Strategy (KCSAS) 2017–2026

The Kenya Climate-Smart Agriculture Strategy (KCSAS) 2017–2026 outlines a transformative approach to agriculture by integrating climate change adaptation, mitigation, and development goals. Its vision is to build a resilient and food-secure agricultural sector in the face of increasing climate stress, especially for vulnerable smallholder farmers (Ministry of Agriculture, Livestock and Fisheries, 2017).

KCSAS emphasizes five action areas: enhancing productivity, building resilience, mitigating emissions, strengthening coordination, and financing CSA. The strategy promotes regionally relevant interventions, such as the use of drought-tolerant crops, agroforestry, soil health improvement, efficient irrigation systems, and improved post-harvest technologies (Anyango *et al.,* 2022).

In Kiambu County, the relevance of KCSAS is clear, given the county's ecological diversity—ranging from highland tea and coffee zones in Limuru and Lari, to mixed farming systems in Githunguri and Gatundu. Climate-smart solutions such as soil fertility restoration, terracing to prevent erosion in sloped areas, and crop diversification are well aligned with the region's needs (Anyango *et al.,* 2022). The county's livestock subsector, particularly dairy farming, would benefit from CSA practices like climate-resilient fodder crops and water-saving techniques.

Despite this alignment, Kiambu's CIDP lacks specificity in terms of KCSAS implementation. CSA is referenced conceptually, but county-level CSA action plans tailored to local agroecological zones and vulnerable populations (such as smallholder farmers and informal settlements) are missing. Furthermore, linkages to county agricultural extension services, farmer education on CSA practices, and climate risk insurance remain underdeveloped.

To fully leverage the KCSAS framework, Kiambu must develop localized CSA investment plans, strengthen farmer cooperatives' climate resilience, and collaborate with research institutions to scale regionally appropriate technologies.

Summary of Gaps and Areas of Focus

A critical review of the NAP 2015–2030, KCSAS 2017–2026, and Kiambu's CIDP reveals key gaps in coordination, localization, and implementation. While national frameworks provide comprehensive strategies, county integration remains low. The CIDP lacks detailed alignment with sectoral targets, particularly in agriculture and water. Strategic actions like CSA promotion or water harvesting are acknowledged, but without corresponding resource allocation or implementation roadmaps.

There's also minimal evidence of harmonized monitoring systems, making it difficult to track adaptation progress at the local level. Vulnerable zones and populations identified in Kiambu (e.g., Lari informal settlements, drought-affected farmers in Gatundu) are not adequately matched with tailored interventions.

Areas of focus include:

- Developing county-specific CSA action plans linked to local agroecological zones.
- Strengthening intergovernmental coordination between national agencies and county departments.
- Establishing climate finance mechanisms and investment pipelines to support local adaptation.
- Embedding community-driven adaptation tools to empower grassroots resilience.

These efforts will enhance the responsiveness and effectiveness of climate strategies in Kiambu.

5. Conclusion and Recommendations

This study examined climate change adaptation in the agricultural municipalities of Kiambu County, revealing a complex interplay of climatic threats, local innovation, institutional roles, and policy challenges.

Findings indicate that climate variability, particularly erratic rainfall and rising temperatures, has significantly affected maize, tea, coffee, and dairy production. Water shortages, soil erosion, and increased pests have further compounded agricultural risks. Yet, local communities have responded with diverse strategies, including drought-tolerant crops, agroforestry, rainwater harvesting, and economic diversification into poultry and transport.

Community-based organizations and cooperatives in Githunguri and Limuru have emerged as key adaptation actors, though they face challenges related to funding and technical capacity. The county government supports adaptation through extension services and partnerships, but these efforts are constrained by low budgets and poor coordination with national institutions.

Policy analysis showed partial alignment between national adaptation frameworks and county development plans. However, gaps in implementation, limited accountability, and exclusion of marginalized groups—particularly women and youth—persist.

To enhance adaptation effectiveness, the following recommendations are proposed:

1. Strengthen extension services by recruiting more officers and incorporating digital platforms for training and forecasting.
2. Increase financial support, including microcredit schemes, insurance products, and public-private partnerships tailored for smallholders.
3. Invest in early warning systems and integrate local forecasting with scientific data to improve preparedness.
4. Reform land tenure systems to provide security for long-term investments in adaptive infrastructure.
5. Promote youth and women inclusion in adaptation planning through targeted capacity-building and leadership roles.
6. Institutionalize indigenous knowledge within formal policy and planning frameworks to enhance local relevance.

Future research should explore the long-term economic impacts of adaptation strategies and assess the role of climate finance mechanisms at the sub-national level. Overall, the study underscores the necessity of inclusive governance, sustained investment, and community empowerment to build climate resilience in Kenya's agricultural heartlands.

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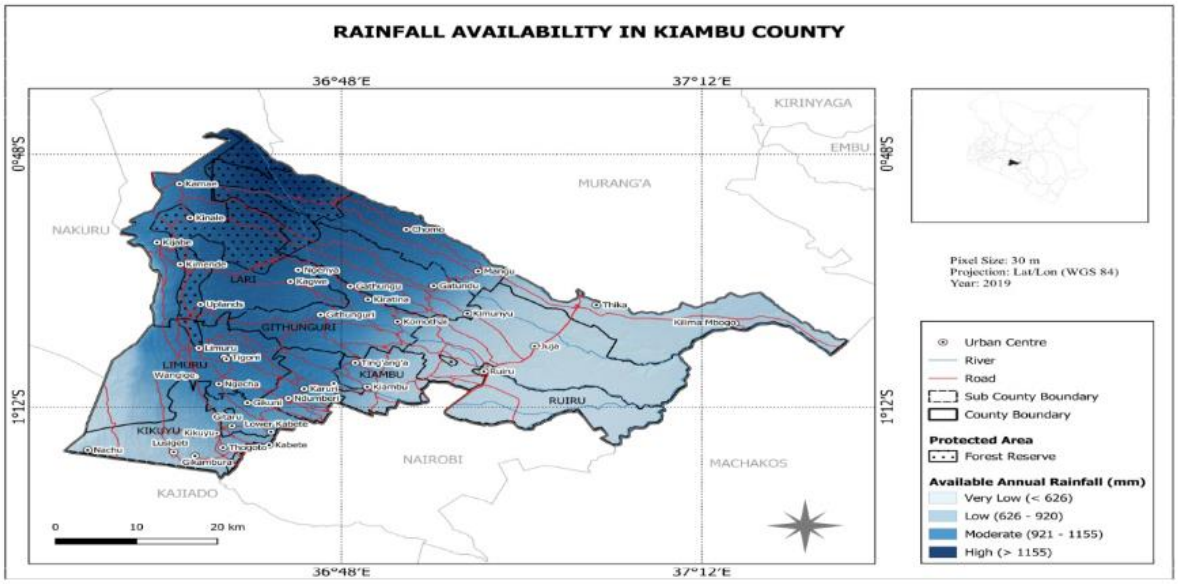

Figure 1: Rainfall availability in Kiambu County

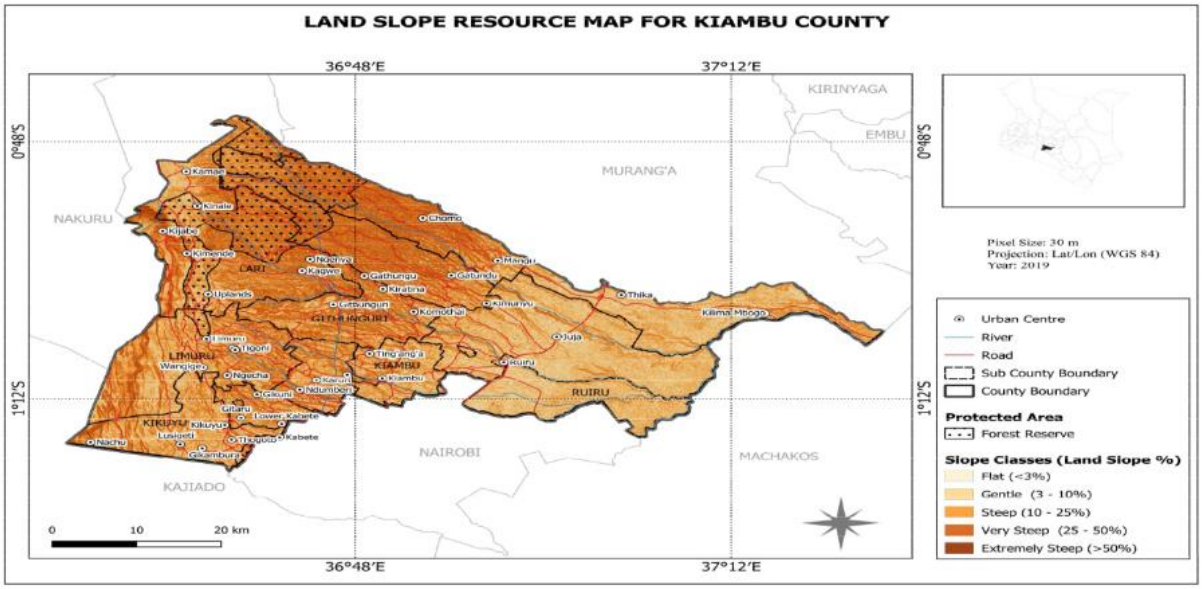

Figure 2: Land slope resource map for Kiambu County

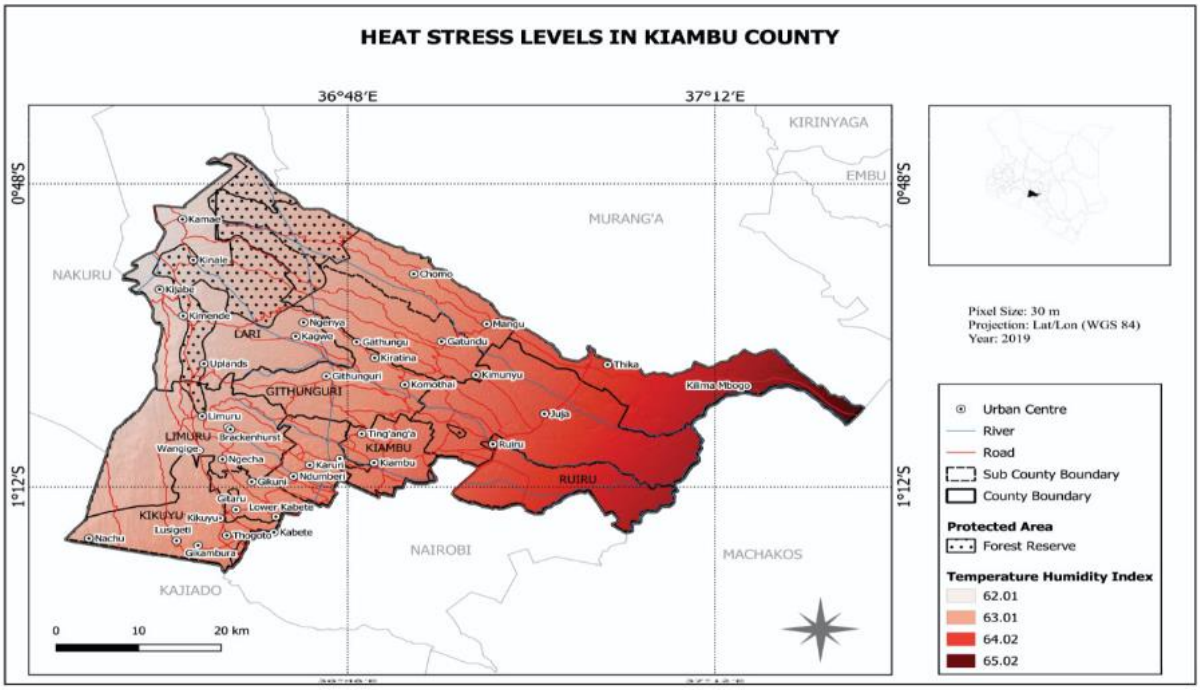

Figure 3: Heat stress levels in Kiambu County

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