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COMPARATIVE ASSESSMENT OF CLIMATE CHANGE IMPACTS ON AGRICULTURE IN KENYA AND ROMANIA

Cynthia WANJIKU[1], Francois GUYVENCHY[1], Abdelhakim Zine Eddine GANA[1], Raul PAȘCALĂU[1], Laura ȘMULEAC[1]

[1]University of Life Sciences "King Mihai I" from Timișoara, Romania
Corresponding author: raul.pascalau@usvt.ro

Abstract. *This study provides a comparative assessment of climate change impacts on the agricultural sectors of Kenya and Romania, two nations with distinct agro-ecological, economic, and socio-political contexts. Utilizing a mixed-methods approach, we analysed historical climate data (1990-2020), projected future climate scenarios (RCP 4.5 and 8.5 for 2050), and agricultural productivity statistics for key staple and cash crops. In Kenya, a predominantly arid and semi-arid country reliant on rainfed smallholder farming, climate change manifests through increased temperature extremes, prolonged droughts, and erratic rainfall. Our analysis projects potential yield reductions for maize, a primary staple, of 10-20% by 2050, exacerbating food insecurity. Conversely, Romania, a temperate European nation with a mix of subsistence and large-scale commercial farming, faces challenges from heatwaves, shifting precipitation patterns, and increased flood frequency. While some northern regions may experience a lengthened growing season, our models indicate significant yield volatility for wheat and maize, with potential short-term increases but long-term declines of 5-15% under high-emission scenarios. The comparative analysis reveals that Kenya's vulnerability is primarily driven by high exposure and sensitivity, coupled with low adaptive capacity due to economic constraints. Romania's vulnerability, while lower, is characterized by a higher sensitivity of its extensive monoculture systems and institutional challenges in adapting its post-communist agricultural sector. This study concludes that effective adaptation strategies must be context-specific: Kenya requires investments in drought-resistant crops, water harvesting, and climate-smart pastoralism, while Romania needs to focus on crop diversification, improved irrigation infrastructure, and knowledge transfer. The findings underscore that climate impacts are not uniform and that national adaptation policies must be tailored to address unique biophysical and socio-economic vulnerabilities.*

Keywords: *climate changes, agricultural productivity, adaptation strategies, climate-crop modelling, vulnerability.*

INTRODUCTION

Climate change represents a pervasive threat to global agricultural systems, yet its impacts are profoundly heterogeneous, varying significantly across different geographical, climatic, and socio-economic contexts (SMULEAC ET ALL., 2025). A comparative analysis of nations with contrasting profiles can yield valuable insights into the differential vulnerabilities and necessary adaptation pathways. This study undertakes a comparative assessment of climate change impacts on agriculture in Kenya and Romania, two countries that, while both vulnerable, embody distinct challenges (DAWSON ET. ALL, 2016). Kenya, located in East Africa, is characterized by a largely arid and semi-arid climate, with over 80% of its landmass being dryland. Its agriculture is predominantly rainfed and reliant on smallholder farmers who are highly dependent on seasonal rainfall for subsistence and livelihoods (DE TRINCHERIA ET. ALL, 2015, GOEDEGEBUURE ET ALL., 2014). Key staples like maize and beans are acutely sensitive to rainfall variability (HOTTENSIAH, 2017). In contrast, Romania, a member of the European Union in Southeastern Europe, possesses a temperate-continental climate with more reliable rainfall patterns and a significant portion of its agriculture structured around large-scale commercial farms, particularly in the fertile plains of Wallachia and Moldavia. It is a major producer of wheat, maize, and sunflower (PATRICHE ET ALL., 2024).

The manifestations of climate change in these two nations are already visible but differ in nature. Kenya is experiencing an increased frequency and intensity of droughts, leading to crop failure, livestock mortality, and heightened food insecurity (KOGO B.K ET ALL., 2021). Erratic rainfall patterns disrupt planting schedules and promote the spread of pests and diseases. Romania, meanwhile, is grappling with rising temperatures, heatwaves that cause heat stress during critical grain-filling stages, and an increase in the frequency of extreme precipitation events leading to floods and soil erosion (SMULEAC ET. ALL, 2020, 2025). While some northern regions might initially benefit from a longer growing season, the overall trend points towards increased volatility.

The central problem this research addresses is the need to move beyond generalized global or regional assessments to a more nuanced, country-specific understanding of climate impacts (PASCALAU ET ALL., 2025, 2023). By comparing Kenya and Romania, this study highlights how pre-existing conditions, such as agro-ecology, farm structure, economic development, and institutional capacity, shape vulnerability and determine adaptive potential. While Kenya's vulnerability is often linked to its economic status and reliance on climate-sensitive agriculture, Romania's vulnerability stems from the exposure of its specialized cropping systems and the legacy of its post-communist agricultural transition. This research is guided by the following questions: How have historical climate trends from 1990 to 2020 differentially affected agricultural productivity in Kenya and Romania? What are the projected impacts of future climate change (under RCP 4.5 and 8.5 scenarios) on key crops in both countries by 2050? How do the underlying socio-economic and institutional factors in Kenya and Romania influence their respective agricultural sectors' vulnerability and adaptive capacity? By answering these questions, this study aims to provide a refined framework for understanding climate-agriculture dynamics and to inform the design of targeted, context-appropriate national adaptation policies (BALAN ET ALL., 2022, SHIFERAW ET ALL, 2011).

MATERIAL AND METHODS

This study employed an integrated, mixed-methods approach to facilitate a robust comparative assessment between Kenya and Romania, combining quantitative climate and agricultural data analysis with qualitative review of socio-economic contexts (figures 1 and 2).

Data collection:

- Climate data: historical climate data (1990-2020) for both countries were obtained from the Climate Research Unit (CRU TS) and national meteorological services. This included monthly mean temperature, total precipitation, and indices for extreme events (e.g., consecutive dry days, heatwave frequency). Future climate projections for the 2050s (2041-2060 average) were sourced from the CORDEX database for two Representative Concentration Pathways (RCP 4.5 and RCP 8.5), downscaled to a resolution relevant for agricultural impact assessment.
- Agricultural data: national and sub-national yield data for key crops were collected from FAO STAT and national agricultural ministries. For Kenya, the focus was on maize, beans, and tea. For Romania, the focus was on wheat, maize, and sunflower. Data on cultivated area, irrigation coverage, and livestock numbers were also compiled.
- Socio-economic data: indicators such as the Human Development Index (HDI), GDP contribution from agriculture, rural population density, and indices of governance were collected from World Bank databases and UN reports to contextualize adaptive capacity.

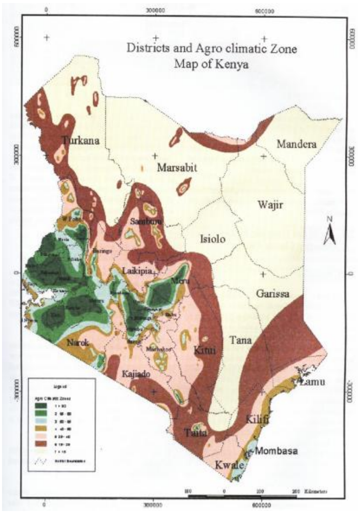

Figure 1. Agro-climatic regions in Kenya (Verplancke H et. all, 2011)

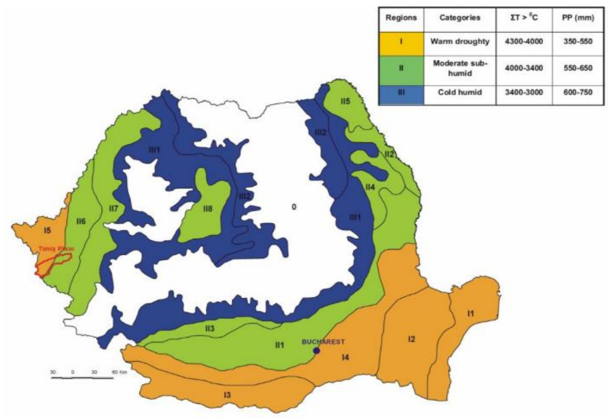

Figure 2. Agro-climatic regions in Romania (Mitrică et. all, 2015)

Data analysis:

- Trend analysis: Mann-Kendall trend tests and Sen's slope estimator were applied to the historical climate and crop yield data to identify statistically significant trends over the 1990-2020 period.
- Climate-crop modelling: a statistical modelling approach was used to quantify the relationship between climate variables and crop yields. Multiple regression models were developed for each key crop in both countries, using de-trended yield data as the dependent variable and growing season temperature and precipitation as independent variables. These models were then forced with the future climate projection data to simulate yield changes under RCP 4.5 and RCP 8.5 scenarios for 2050.
- Vulnerability assessment: a simplified vulnerability framework was applied, conceptualizing vulnerability = f (exposure, sensitivity, adaptive capacity). Exposure was derived from the magnitude of projected climate changes. Sensitivity was assessed based on the dependence of the agricultural sector on climate-sensitive resources and the modelled crop response. Adaptive capacity was qualitatively assessed based on socio-economic indicators, institutional strength, and access to technology and finance.

Comparative synthesis:

The quantitative results from the trend analysis and crop modelling, along with the qualitative vulnerability assessment, were synthesized in a comparative table to juxtapose the key impacts, vulnerabilities, and challenges for Kenya and Romania. This synthesis identified commonalities (yield volatility) and critical differences (primary climate stressors, adaptive capacity) to draw overarching conclusions about context-specific resilience.

RESULTS AND DISCUSSIONS

Historical trends and projected impacts in Kenya

The historical analysis for Kenya showed a significant warming trend (+0.3°C per decade) and high precipitation variability, with a notable increase in the frequency of dry spells. The climate-crop model revealed a strong negative correlation between maize yields and temperature increases, with a 1°C rise associated with a ~5% yield decline under rainfed conditions. Projections for 2050 indicate further warming of 1.5-2.0°C under RCP 4.5 and 2.0-2.5°C under RCP 8.5. This translates to potential maize yield reductions of 10-20% by 2050, threatening national food security. The high-value tea sector in the highlands also faces stress from increased temperatures, potentially reducing quality and shifting suitable growing zones.

Historical trends and projected impacts in Romania

In Romania, the historical data indicated a pronounced warming trend (+0.4°C per decade) and an increase in heavy precipitation events, particularly in the summer. The statistical models for wheat showed a significant negative yield response to high temperatures during the flowering and grain-filling period. Projections for 2050 suggest warming comparable to Kenya (1.5-2.5°C). The impact on wheat and maize is more complex; while CO2 fertilization and a longer growing season in the north may offer transient benefits, the increasing frequency of heatwaves and drought stress in the southern plains is projected to lead to greater yield volatility and long-term declines of 5-15% for wheat under RCP 8.5.

Comparative vulnerability

The vulnerability assessment highlighted stark contrasts:

- Kenya: exhibits high exposure to droughts, high sensitivity due to rainfed dependence, and low adaptive capacity constrained by poverty, limited irrigation, and weak safety nets.
- Romania: exhibits moderate exposure, high sensitivity due to specialized, input-intensive monocultures, and moderate adaptive capacity due to EU membership and stronger institutions, though hampered by rural infrastructure gaps and an aging farmer population.

Divergent primary stressors and systemic vulnerabilities

The discussion centres on the divergent primary climate stressors. For Kenya, the paramount threat is hydro-climatic variability-the failure of seasonal rains. This directly impacts the foundation of its smallholder-based food system. For Romania, the primary threat is thermal stress-heatwaves during critical phenological stages-which disrupts the productivity of its large-scale, mechanized grain production. This difference underscores that vulnerability is not a single metric but a syndrome arising from the interaction of a specific climate hazard with a specific agricultural system.

The Adaptive capacity divide

The chasm in adaptive capacity is the most significant differentiator. Kenya’s low adaptive capacity means that even a moderate climate shock can lead to a humanitarian crisis, as farmers have limited savings, insurance, or alternative livelihoods. Romania’s access to the EU Common Agricultural Policy (CAP) provides financial resources for adaptation, such as subsidies for irrigation or crop insurance. However, its adaptive capacity is not fully realized due to bureaucratic hurdles and a lack of targeted knowledge transfer, preventing a swift systemic response.

Implications for adaptation policy

The findings dictate fundamentally different adaptation priorities. In Kenya, policy must focus on risk management and building foundational resilience. This includes promoting drought-tolerant crops, decentralized water harvesting, index-based livestock insurance, and strengthening early warning systems. In Romania, policy should focus on systemic adjustment and modernization. Key strategies include incentivizing crop diversification away from water-intensive maize, investing in precision irrigation to cope with drought, and developing heat-resistant crop varieties. For both, enhancing climate information services and fostering knowledge exchange are universal needs. This comparative analysis demonstrates that a one-size-fits-all approach to climate adaptation is futile; effective strategies must be deeply contextual, addressing the unique blend of exposure, sensitivity, and capacity that defines each nation's agricultural vulnerability.

CONCLUSIONS

This comparative assessment yields the definitive conclusion that the impacts of climate change on agriculture, while universally challenging, are deeply contextual and mediated by a nation's specific agro-ecological, economic, and institutional fabric. Kenya and Romania, though both vulnerable, face distinct threats and possess markedly different capacities to respond. Kenya's agricultural system is critically threatened by increasing aridity and rainfall unpredictability, which directly undermine its rainfed, smallholder-dominated subsistence base. The projected significant declines in maize production underscore an urgent need to address food security at its core. In contrast, Romania's more technologically advanced sector is primarily vulnerable to extreme heat and its cascading effects on major commodity crops, presenting a threat to economic stability and its role as a regional breadbasket.

A paramount conclusion is that the concept of vulnerability must be deconstructed into its constituent parts-exposure, sensitivity, and adaptive capacity-to be meaningful. Kenya's plight is a story of high exposure and sensitivity colliding with critically low adaptive capacity, where climate impacts directly translate into human suffering. Romania's situation illustrates how moderate exposure and high sensitivity can be partially offset by a higher, though imperfect, adaptive capacity, leading to economic rather than humanitarian crises. This distinction is crucial for international climate finance and policy, directing resources to where they are most desperately needed for basic resilience versus where they can catalyse efficiency and modernization.

The study also highlights that a nation's development pathway and agricultural history are key determinants of its climate vulnerability. Kenya's challenges are intertwined with poverty and underdevelopment, while Romania's are linked to the legacy of its post-communist transition and its integration into a complex supranational policy framework like the EU's CAP. Therefore, climate adaptation cannot be siloed as an environmental or agricultural issue alone; it is intrinsically linked to broader goals of poverty reduction, economic development, and institutional strengthening.

Based on these findings, we recommend prioritized, context-specific actions. For Kenya, immediate support should focus on building community, level resilience through water harvesting infrastructure, dissemination of drought-tolerant seeds, pastoralist support programs, and scaling up social safety nets. For Romania, efforts should centre on modernizing irrigation infrastructure, reforming CAP subsidies to explicitly reward climate-resilient practices, investing in R&D for heat-tolerant varieties, and improving the coordination of national adaptation efforts. In conclusion, the contrasting cases of Kenya and Romania serve as a powerful reminder that the global response to climate change in agriculture must be nuanced and differentiated. Tailoring strategies to the specific vulnerability profile of each country is not just a matter of efficiency, but of equity and effectiveness in safeguarding global food security for all.

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