Tropentag 2025
September 10-12, 2025
Conference on International Research on Food Security, Natural Resource Management and Rural Development
organised by the University of Bonn, Bonn, Germany

Hotspots for Integrated Solutions in Kenya

Diana María Gutiérrez-Zapata[a], Chrystian Camilo Sosa[a], Hanna Ewell[a], Kelvin Shikuku[b], Ibrahim Ochenje[b], Laura Cramer[b], Janelle Sylvester[a] and Augusto Castro[a]

a Alliance of Bioversity International & CIAT
b International Livestock Research Institute (ILRI)

Abstract
As the impact of climate change increases, it is vital to implement integrated solutions to address the heightened security risks associated with it. Kenya's economy is heavily reliant on the agricultural sector, which also represents the largest source of greenhouse gas (GHG) emissions, particularly in the livestock industry. The sector's vulnerability to climate shocks and long-term changes places additional pressure on Kenya's food security, pushing already vulnerable lands into crisis. Furthermore, the vulnerable arid and semi-arid lands of Kenya are particularly susceptible to conflict, which is further exacerbated by resource constraints due to climate change. Given the finite nature of government resources, it is crucial to identify areas where integrated interventions can deliver on multiple objectives, including improving food security and reducing resource-use conflicts, while simultaneously contributing to climate change mitigation and development goals. By employing spatial analysis to map emission sources and agricultural sector conflict-related hotspots, we have identified 20 wards, primarily in Baringo, Samburu, and Elgeyo-Marakwet counties, that can be strategically prioritized to promote a harmonized approach to climate action and conflict management. By incorporating this evidence into policy frameworks, Kenya can more effectively operationalize its commitments to low-carbon development, sustainable resource management, and conflict resolution, ensuring these strategies are tailored to the unique challenges of conflict-prone and climate-vulnerable regions.

Keywords: Agriculture, climate change, conflict, peacebuilding, policy, sustainable development.

Introduction
Agriculture contributes 65% of Kenya’s export earnings and supports millions of livelihoods (Jalang’o Anyango et al., 2022). However, the sector faces significant challenges from climate change, land degradation, and resource-related conflicts (Burke et al., 2015; Nkonya et al., 2018). The Agriculture, Forestry, and Other Land Use (AFOLU) sector accounts for over 50% of Kenya’s greenhouse gas (GHG) emissions (Martius et al., 2023), and its activities are closely tied to resource-based conflicts, particularly in arid and semi-arid lands. Weak governance and shifting land tenure systems further complicate sustainable resource management (Lengoiboni et al., 2011). Integrated approaches are needed to align climate mitigation with peacebuilding. Kenya’s agricultural policies increasingly integrate climate change considerations to ensure sustainable development. This study aims to identify spatial hotspots where land use-based GHG sources and agricultural actors-related conflicts intersect, to inform targeted interventions in support of Kenya’s climate and development objectives.

Material and Methods

Five land use-related variables with GHG mitigation relevance were identified: 1) TCL: Median tree cover loss (% of ward area) (Hansen et al., 2013); 2) LUD: Percentage of area with high-very high, low-very low, and moderate level of land use degradation (RCMRD, 2023); 3) GRL: Percentage of grasslands area (Zanaga et al., 2022); 4) CRL: Percentage of croplands area (Zanaga et al., 2022); 5) LIV: Livestock units per km^2 (FAO, 2024).

Conflict events (CE) from 2011–2022 involving pastoralists, farmers, or fishers (494 events), were sourced from ACLED (Raleigh et al., 2023). Data was aggregated at the ward level (n=1442). Temporal subsets were defined for 2011-2020, 2019-2021, and 2020-2022, to align with the timeline of associated variables.

Local indicator of spatial association (LISA) was applied using the *rgeoda* (Li and Anselin, 2023) package in R with a Queen contiguity matrix and 9,999 iterations ($p < 0.01$). Eight LISA analyses were performed across variable pairs to detect overlapping spatial clusters. Wards identified more than once in clusters of interest across the LISA analyses were selected as intervention priorities.

Results and Discussion

All variable pairs exhibited weak spatial association (Moran Index from -0.112 to 0.12), with conflicts reported in only 240 of 1442 wards over the entire period.

For the TCL and CE association 11 wards were classified in the High-High cluster. Notably, five of these wards are in Narok County in southwestern Kenya. The clusters of interest for the wards where LUD (levels: high-very high and low-very low) and CE overlap are primarily in western Kenya, specifically in Baringo, Narok, and Nakuru counties. Regarding the overlap between moderate LUD level and CE, the High-High cluster comprises 12 wards, mainly in the western part of the country, with a third of them located in Baringo county.

For the LISA analyses that involved GRL, CRL, and LIV, the highest number of wards in the High-High cluster is found for the analysis between GRL and CE (23 wards), with most of them located in the northern part of the country. Laikipia, Samburu and Turkana counties have the highest number of wards (six for the first and five for the other two) in this cluster. Conversely, only four wards were classified in the High-High cluster for CRL and CE analysis and two for LIV and CE analysis, mainly in Laikipia and Narok, respectively.

From 47 wards in relevant clusters, 20 were prioritized (Figure 1). Olorropil (Narok) appeared in six analyses, while Kapedo/Napeitom (Turkana), Mau Narok and Mauche (Nakuru), and Melelo (Narok) appeared in four. These overlaps, though weak spatially correlated, highlight localized opportunities for integrated responses that potentially deliver in multiple objectives.

Identified hotspots align with counties highlighted in a prior consultative workshop (Shikuku et al., 2023). These regions are particularly vulnerable to recurrent and severe droughts and floods, which create conditions conducive to various forms of conflict. These tensions can escalate into violent clashes, sometimes evolving into politically charged conflicts (Raleigh et al., 2010; Song et al., 2024)

The complexity of these conflicts is further exacerbated by economic disparities, historical grievances over land ownership and access, and competition for arable land. Cultural and political factors also contribute to conflict (Schilling et al., 2012; Shikuku et al., 2023). Conflicts also disrupt informal mechanisms for resource management and dispute resolution (Lengoiboni et al., 2011), while climate mitigation and conservation efforts also influence resource access and control.

Localized and integrated interventions show promise in addressing these intertwined challenges. For instance, training programs in Baringo and community conservancies in Laikipia and Samburu, engage local stakeholders in sustainable resource management while promoting economic benefits through conservation and eco-tourism, fostering peacebuilding and conflict

prevention. Capacity-building programs in Turkana and Wajir have improved rangeland management, alleviating resource pressures and reducing conflicts. Similarly, the introduction of climate-resilient livestock breeds in Narok and Kajiado has enhanced community adaptation to changing environmental conditions (Shikuku et al., 2023). These localized interventions, when supported by robust and inclusive policy frameworks, can strengthen Kenya's ability to meet its NDC targets while fostering long-term peace and resilience

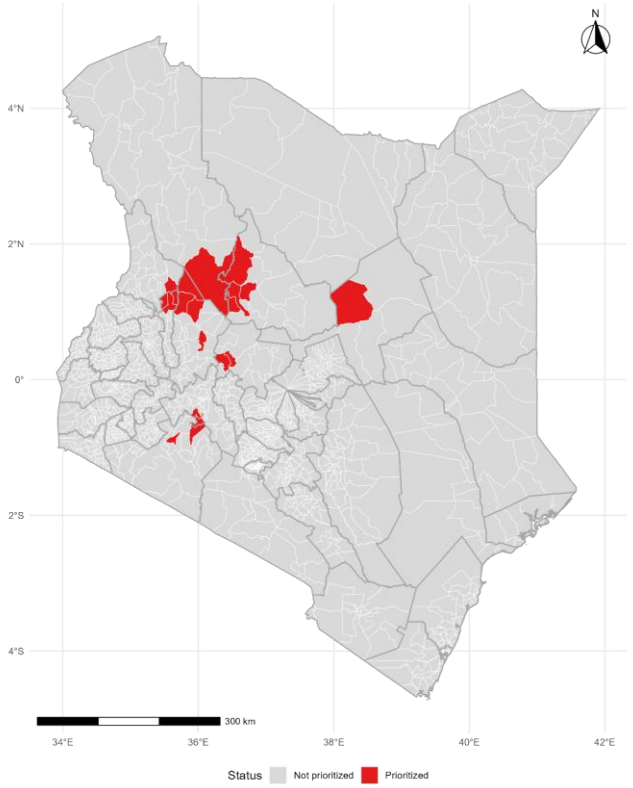

Figure 1. Kenyan ward-level priorities to promote a harmonized approach to climate action and conflict management

Conclusions and Outlook

Strategic areas to promote a harmonized approach to climate action and conflict management can be localized in counties such as Baringo, Samburu, Elgeyo-Marakwet, Laikipia, Nakuru and Narok. However, further understanding is needed regarding the underlying motivations driving conflicts in these areas, especially as ACLED data suitability for representing resource-based conflicts remains unclear.

A diverse range of conflicts exists in Kenya, many of which are not directly linked to the agricultural sector. Gaining a deeper understanding of these conflicts is essential to comprehending their dynamics within the broader context of climate change and sustainable development. Although some conflicts may not explicitly stem from resource disputes, they can still influence resource management practices and decision-making processes. Enhanced knowledge of these interactions can support the development of targeted intervention strategies that simultaneously address mitigation, adaptation, and development challenges, fostering more integrated and sustainable outcomes.

Limitations

LISA is effective for detecting spatial clustering, but it does not model causal relationships. Furthermore, the GHG sources variables and conflict events were analyzed in predefined time

periods, which may not fully capture dynamic interactions or time-lag effects between climate and conflict emergences.
Aggregating both land use-related and conflict data at the ward level may obscure intra-ward variations or localized dynamics. Some conflicts are highly localized and may not align precisely with administrative boundaries.

References

1. Burke, M., Hsiang, S.M., Miguel, E., 2015. Climate and Conflict. Annu. Rev. Econ. 7, 577–617. https://doi.org/10.1146/annurev-economics-080614-115430
2. Food and Agriculture Organization of the United Nations (FAO), 2024. GLW 4: Gridded Livestock Density (Global - 2020 - 10 km).
3. Hansen, M.C., Potapov, P.V., Moore, R., Hancher, M., Turubanova, S.A., Tyukavina, A., Thau, D., Stehman, S.V., Goetz, S.J., Loveland, T.R., Kommareddy, A., Egorov, A., Chini, L., Justice, C.O., Townshend, J.R.G., 2013. High-Resolution Global Maps of 21st-Century Forest Cover Change. Science 342, 850–853. https://doi.org/10.1126/science.1244693
4. Jalang'o Anyango, D., Mugo, V., Vyas, S., Schiek, B., Wamicwe, P., Binge, B., Nowak, A.C., Karanja, S., Magambo, G., Nekesa, T., Jaquet, S., 2022. Climate Smart Agriculture Investment Plan for Kenya. Accelerating Impacts of CGIAR Climate Research for Africa.
5. Lengoiboni, M., van der Molen, P., Bregt, A.K., 2011. Pastoralism within the cadastral system: Seasonal interactions and access agreements between pastoralists and non-pastoralists in Northern Kenya. J. Arid Environ. 75, 477–486. https://doi.org/10.1016/j.jaridenv.2010.12.011
6. Li, X., Anselin, L., 2023. rgeoda: R Library for Spatial Data Analysis.
7. Martius, C., Guérin, L., Pingault, N., Mwambo, F.M., Wassmann, R., Cramer, L.K., Shikuku, K.M., 2023. Food systems emissions in Kenya and their reduction potential: A country profile.
8. Nkonya, E., Minnick, Nganga, E., Woelcke, J., 2018. Land and natural resources degradation in the Arid and Semi-Arid Lands, Kenya (Text/HTML). World Bank Group.
9. Raleigh, C., Kishi, R., Linke, A., 2023. Political instability patterns are obscured by conflict dataset scope conditions, sources, and coding choices. Humanit. Soc. Sci. Commun. 10, 1–17. https://doi.org/10.1057/s41599-023-01559-4
10. Raleigh, C., Linke, A., Hegre, H., Karlsen, J., 2010. Introducing ACLED: An Armed Conflict Location and Event Dataset. J. Peace Res. 47, 651–660.
11. Regional Centre for Mapping of Resource for Development (RCMRD), 2023. Kenya Land Degradation Monitoring and Assessment 2020.
12. Schilling, J., Opiyo, F.E., Scheffran, J., 2012. Raiding pastoral livelihoods: motives and effects of violent conflict in north-western Kenya. Pastor. Res. Policy Pract. 2, 25. https://doi.org/10.1186/2041-7136-2-25
13. Shikuku, K.M., Laichena, J., Ochenje, I., Kaloi, F., Wakhungu, H., Omosa, E.B., Musyoka, K., Ayuko, W., Anomat, J., Njenga, R., 2023. Climate change mitigation and peace building in Kenya: Report of a stakeholders consultation workshop. ILRI.
14. Song, C., Petsakos, A., Gotor, E., 2024. Linguistic diversity, climate shock, and farmers-herder conflicts: Implications for inclusive innovations for agro-pastoralism systems. Agric. Syst. 216, 103883. https://doi.org/10.1016/j.agsy.2024.103883
15. Zanaga, D., Van De Kerchove, R., Daems, D., De Keersmaecker, W., Brockmann, C., Kirches, G., Wevers, J., Cartus, O., Santoro, M., Fritz, S., Lesiv, M., Herold, M., Tsendbazar, N.-E., Xu, P., Ramoino, F., Arino, O., 2022. ESA WorldCover 10 m 2021 v200. https://doi.org/10.5281/zenodo.7254221

The complete version of this study is available at https://hdl.handle.net/10568/169236.