January 2026

Utilising Geospatial Data Analysis to Enhance School Meals and Regenerative Agriculture Interventions

Defining the socio-ecological landscape in four countries

Briefing Paper 1 of 2

Summary

This policy brief uses geospatial data to analyse challenges and opportunities for linking school meals programmes (SMPs) and regenerative agriculture (RA) interventions in Ghana, Nigeria, Kenya, and Rwanda. It maps key socio-ecological variables—including population density, biodiversity threats, agro-ecological zones, farm size, water risk, land degradation, poverty levels, and school attendance—to gain insights into food production demand and supply barriers.

The geospatial analysis suggests that environmental and social crises often overlap in specific "hotspot" regions and the most food-productive rural areas frequently suffer from the highest poverty. The brief concludes that identifying these hotspots is a critical first step to developing more impactful interventions. It sets the baseline for subsequent analysis which will quantify the theoretical capacity of those agricultural systems to ensure healthy diets to the local population.

Key Results

- Analysis confirms that starting points vary significantly across and within countries, demanding that interventions be tailored to specific agroecological zones, farm structures, and conservation needs.
- Environmental and social crises overlap in specific geographic hotspots where land degradation, water stress, poverty and conflict converge.
- Widespread land degradation, severe water risk, and biodiversity threats show that current farming practices are straining the natural resource base. Climate change will likely intensify these pressures, making a transition to regenerative approaches urgent.
- Rural areas that produce the most food, predominantly on smallholder farms, often suffer from the highest levels of poverty. Increasing production alone is insufficient; farmers need reliable market access and better economic returns.

Context

Geospatial analysis reveals where challenges and opportunities converge, enabling policies and plans to be tailored to place-specific realities. By identifying spatial patterns, it supports targeted interventions, more efficient resource allocation, and decisions that better respond to local needs and maximise impact. One particular intervention that can benefit from geospatial analysis is school meals programmes (SMPs).

Strategically designed SMPs have the potential to serve as a catalyst for the adoption and scaling of regenerative agriculture (RA) interventions, and these types of interventions may enhance access, quality, and diversity of school meal food. A transition to RA also presents an opportunity to improve soil health and biodiversity, increase crop productivity, enhance food security, and support sustainable livelihoods while mitigating climate risks. However, the adoption of RA practices requires careful planning, targeted investments and tailored interventions.

Understanding the potential for adoption of RA practices requires a holistic perspective of socio-ecological systems where human and environmental factors interact. Therefore, we analysed geospatial data through a set of critical, interconnected variables that represent significant environmental and social stressors that determine the resilience, sustainability, and nutritional outcomes of regional agriculture. We refer to these variables as landscape-level factors. By analysing these specific variables, we can identify key leverage points and opportunities for implementing regenerative practices that support both ecological health and improved child nutrition.

Understanding the complex and diverse realities in local country contexts can better guide collaborations, investments and interventions. In our analysis, we use high-resolution geospatial data to explore these variables across Ghana, Nigeria, Kenya, and Rwanda. These four countries were selected because they are currently investigating food systems transformation through SMPs and RA interventions. This initial policy brief outlines the findings from the first-phase of geospatial analysis with a particular focus on socio-ecological variables.

Approach

We selected the most high-quality, high-resolution, and recent (post-2015) environmental and social geospatial variables available for each country. This sourcing and selection process was guided by the need to gain insights into demand and supply barriers, as well as opportunities for scaling up SMP and RA linkages in each country.

First, to visualise the current agricultural and ecological landscape, we mapped population density against intact ecosystems and protected areas, species biodiversity threats, dominant agro-ecological zones, and farm size distribution relative to remoteness. This remoteness layer was itself a composite, created by first combining nine raster files and then calculating the minimum travel time for each pixel across all layers. This process ensured the final map accurately represents the travel time to the nearest urban area with at least 5,000 inhabitants.

We then mapped key environmental stressors and future scenarios, to identify constraints and opportunities, specifically by analysing land degradation processes, overall water risk, and projected changes in temperature and precipitation. Finally, we integrated critical socio-economic indicators selected for their ability to influence the reach of SMPs and pinpoint vulnerable populations. These included water-related conflicts, the Multidimensional Poverty Index (MPI), and gender-based disparities in school attendance. Together, these variables offer an approximation to the complex realities within and across countries, allowing for a detailed assessment of where RA can most effectively be implemented to build resilient local food systems capable of nourishing school communities.

Findings

School meals, conservation and biodiversity

The intersection of population density, cultivated land, and natural ecosystems provides the foundational context for any food system analysis. As shown in Figure 1, there is considerable variation in population density across the four countries. The geospatial data reflects that Rwanda has the highest population density, with its remaining natural habitats largely restricted to its borders. In contrast, Kenya maintains the most extensive intact ecosystems and protected areas (all IUCN categories and OMECs). Regardless of where each country lies on this spectrum, population centres and public procurement can intensify pressure on these vital ecosystems. Achieving food security and conservation goals, therefore, requires close coordination from the outset, with clear mechanisms to detect and mitigate potential negative impacts.

Recent estimates indicate that biodiversity (including amphibians, mammals, and birds) appears to face high levels of threat across all the countries (Figure 2). The highest threat levels often coincide with densely populated areas (such as the coastal regions of Kenya and the southern parts of Ghana and Nigeria). The maps also reveal corridors under high threat that connect critical ecosystems. It is, therefore, crucial that the suite of regenerative practices promoted includes biodiversity-friendly approaches at both the farm and landscape levels, to avoid worsening these threats. Agricultural landscapes can play an important role in halting biodiversity loss by providing resources and habitat for migrating species, while still producing sufficient and nutritious food.

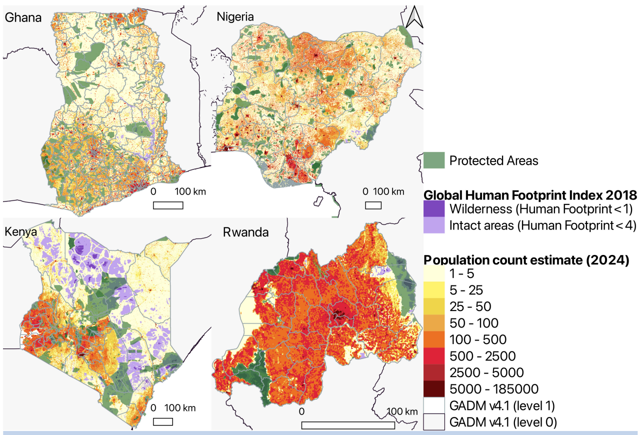

Figure 1. Overlaps between population density, intact ecosystems (low human influence) and protected areas. Source: Lebakula et al. 2024, Mu et al., 2021, and UNEP-WCMC and IUCN, 2025.

Agroecological context and smallholder realities

It appears that agricultural production in the studied countries occurs on lands with significant environmental constraints (Figure 3). The maps suggest that Rwanda is dominated by land with severe soil and terrain limitations, while Kenya appears characterized by arid and desert-like conditions; and Ghana and Nigeria by large semi-arid areas and terrain limitations. The prevalence of these challenging agroecological zones demands an agriculture that works with, not against, the existing environmental capacity. Regenerative practices that promote diversification—by using species adapted to local conditions—are essential for ensuring production stability and resilience, which can be far more important performance indicators than food production yield in such settings.

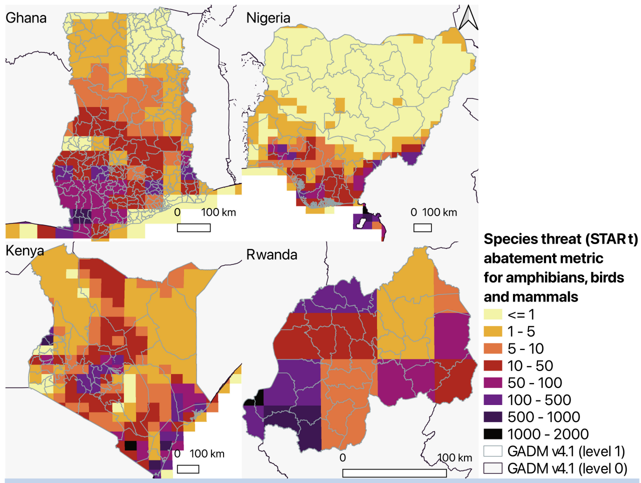

Figure 2. Species threat (STARt) abatement metric: where actions to mitigate existing threats. Threat values for amphibians, birds and mammals. Source: Mair et al. 2021.

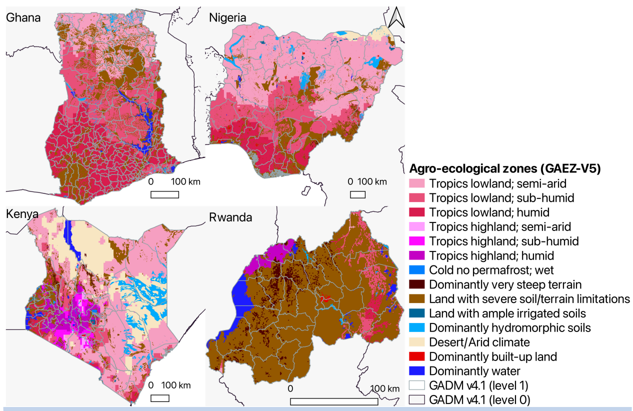

Figure 3. Food and Agriculture Organization's (FAO) Global Agro-Ecological Zones (GAEZ v5). Source: (FAO and IIASA, 2025).

Across these regions, food is predominantly produced by smallholders on farms of less than five hectares (Mehrabi and Riccardi, 2024), many of whom are in remote areas with more than one or two hours travel time from the nearest urban centre with at least 5,000 inhabitants (Nelson et al., 2019) (Figure 4).

Overlapping environmental stressors

The misalignment between current production methods and these environmental realities may put communities at risk of deepening food insecurity, resource-based conflict, and irreversible land degradation. Our analysis suggests that land degradation is widespread in the arable lands across all countries, with most areas already showing concerning signs of decline from processes like water erosion and loss of soil organic matter (Prăvălie et al., 2021) (Figure 5). Water constraints are also evident, with recent analyses showing medium-to-high overall water risk—encompassing quantity, quality, and regulatory pressures—across nearly all territories (Figure 6). The data indicates that this water stress is already manifesting as conflict, particularly in Northern Nigeria and Kenya. Beyond the immediate humanitarian tragedy and social costs, conflicts fundamentally disrupt agricultural supply chains, making the reliability of food supply a primary constraint for any SMPs operating in these zones (Figure 7).

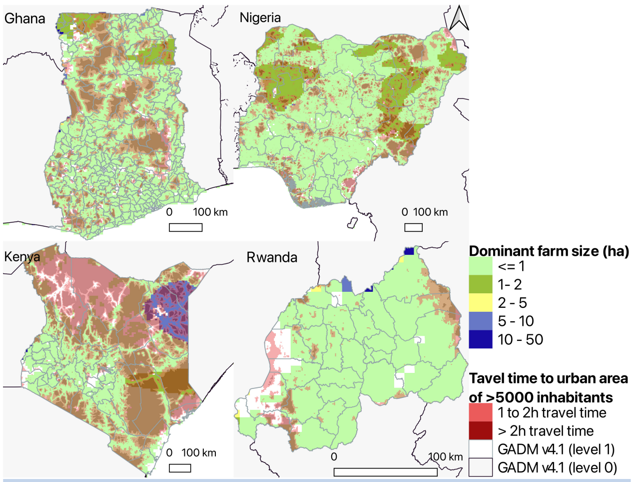

Figure 4. Dominant farm size (Mehrabi and Riccardi, 2024) and remoteness of certain areas with an estimated travel distance >1h to urban areas with >=5,000 inhabitants. Source: Nelson et al., 2019.

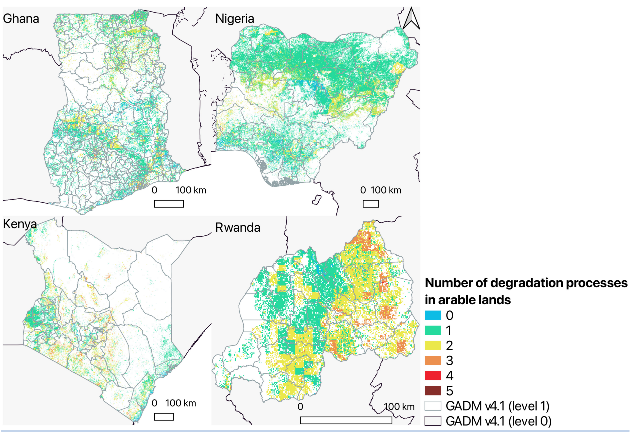

Figure 5. Overlapping degradation processes in arable land (aridity, erosion, vegetation decline, salinization, organic carbon decline). Source: (Prăvălie et al., 2021)

Regardless of their location or production system, smallholder farmers will likely face harsher, more arid climates in the near future (Figure 8). In this context, the tailored integration of SMPs and RA interventions to contrasting and environmentally stressed conditions, can contribute to wider outcomes such as peace building, resilience, and wellbeing.

However, the success of such programmes depends on factors that are invisible on a map, such as infrastructure and capacity building support. For instance, if farmers adopt agroforestry with fruit trees, then systems for drying, storage, and transport must be in place to deliver safe and nutritious products to schools. If school meals require diversified foods such as legumes which take longer to cook, then schools must be equipped with appropriate tools and slow cookers (Wang et al., 2022). If shifting to RA practices, then extension services must move away from conventional, single-crop systems, and reorient towards diverse, regenerative approaches. Local and traditional knowledge, farmer-led experimentation and learning, and peer education groups can also support these efforts and help re-designing farms that capitalize local cultivated diversity and tailored RA practices to their unique contexts.

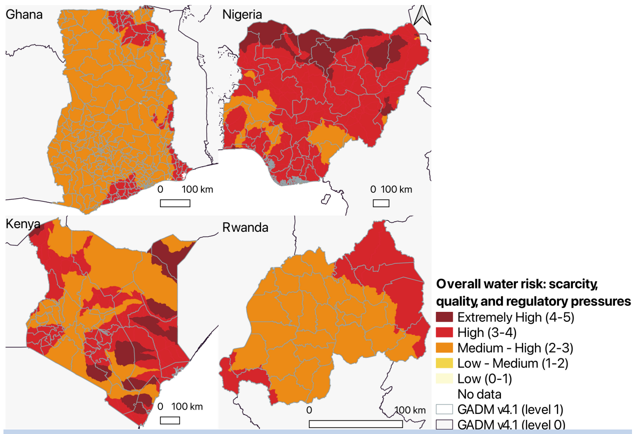

Figure 6. Overall water risk: scarcity, quality, and regulatory pressures. Source: Kuzma et al., 2023.

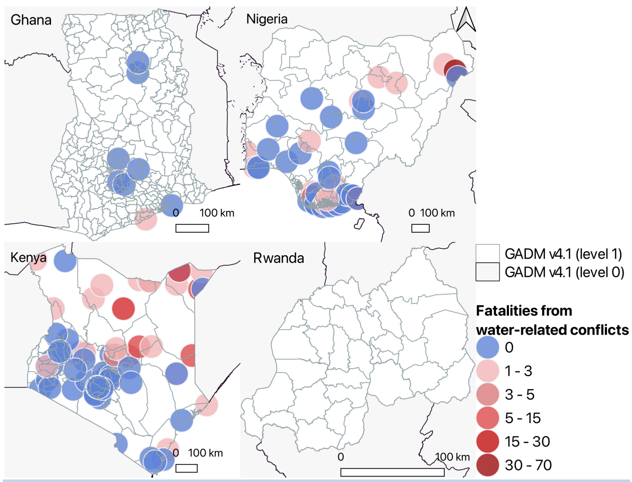

Figure 7. Locations and fatality counts of water-related conflicts (2010 – 2024). Conflict data includes resource-based, attack of water infrastructure, and protest or demonstration. Source: (Song, 2025).

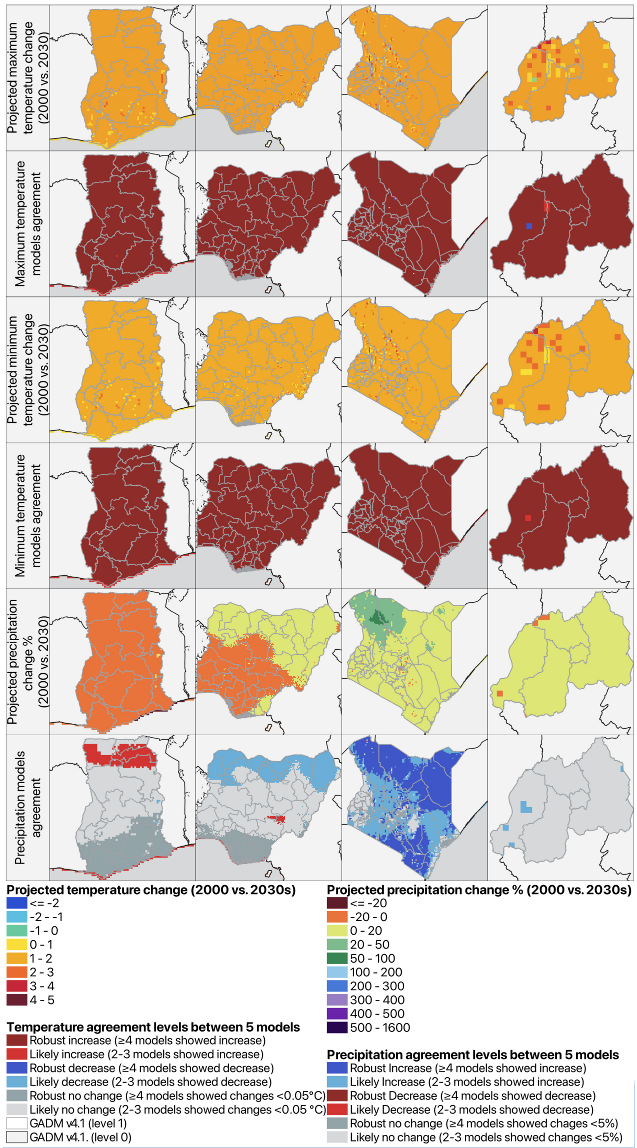

Figure 8. Projection of temperature precipitation change percentage (2000-2030) under scenario A2; level of agreement between assessed models. Source: (Navarro-Racines, 2020).

The socio-economic landscape: poverty and education

The maps reflect that the regions producing the most food often have the highest levels of multidimensional poverty (MPI) (United Nations Development Programme, 2024) (Figure 9). Figure 9 highlights distinct regional disparities in poverty that are critical for targeting SMP interventions:

Nigeria and Ghana appear to exhibit a sharp North-South divide. The northern regions show the highest intensity of deprivation (indicated by darker red/orange hues). When viewed alongside Figure 4, it is evident that these high-poverty zones overlap with remote landscapes dominated by smallholder farming. This suggests that, for agrarian communities, current agricultural livelihoods are not automatically translating to economic prosperity.

In Kenya, poverty appears to be most concentrated in the arid and semi-arid northern and eastern lowlands (Figure 3), contrasting with lower poverty rates in the central highlands.

While Rwanda shows lower overall intensity of poverty on this regional scale, localised pockets of poverty appear to persist. This suggests that broad regional interventions may miss vulnerable groups—requiring more precise, community-led approaches.

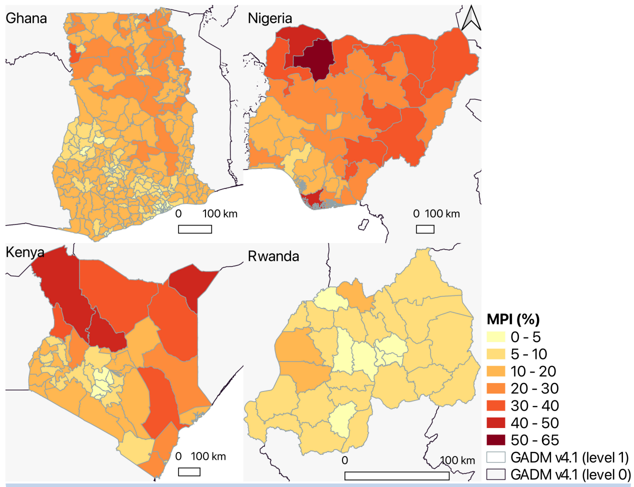

Figure 9. Multidimensional Poverty Index (MPI) by subnational boundaries.

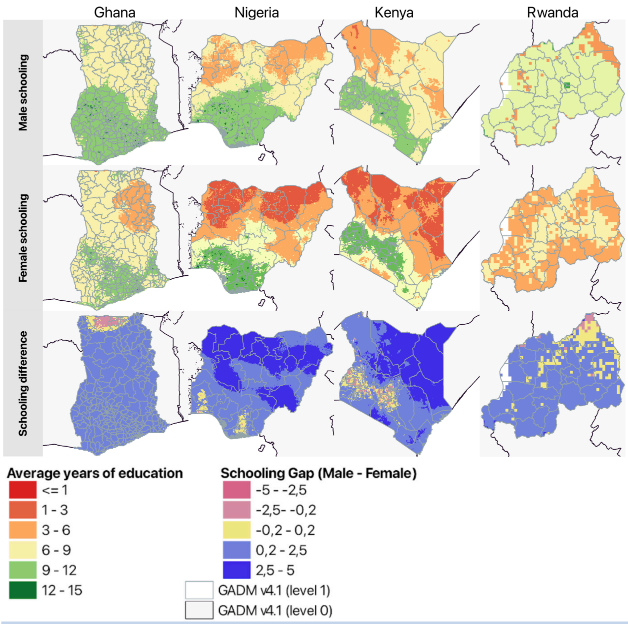

Figure 10. Sub-national and gender-based disparities in years of school attendance for males and females of 20-24 years old in 2017. Source: Local Burden of Disease Educational Attainment Collaborators, 2020.

Discussion

This geospatial analysis indicates that SMPs, if well designed, can be a promising entry point for fostering rural development and ensuring nutritious diets for children, especially when paired with RA interventions. However, the results of geospatial data do not reflect the social influencing factors at play. Therefore, regional differences can guide discussions for tailoring interventions, yet these interventions can greatly benefit from participatory and inclusive processes to determine important but more invisible factors hindering the goal of planet-friendly meals. For instance, food choices are heavily influenced by prices, media, cultural norms, traditional knowledge regarding nutritious local species, and many other factors. Holistic interventions could also connect food availability and quality with educational campaigns. Local knowledge on practices, cultivated diversity and traditional recipes is critical for redesign production systems that meet cultural, environmental and nutritional requirements. Local engagement and active contribution in redesigning farms and integrating farmers with schools is central to ensure interventions are locally grounded and globally relevant contributing to global commitments on land degradation, water security, and biodiversity.

The maps and analyses presented here, rather than an exact diagnostic, aim to stimulate discussion, reflection, and collaboration, fostering the multi-sectoral and multi-stakeholder engagement required to design and implement strategies that deliver planet-friendly SMPs.

In particular, these maps show that any agriculture interventions should not take place in a vacuum. Instead, agriculture can be seen as a solution space for:

- Restoring soil
- Retaining and enhancing water resources
- Improving water quality
- Delivering culturally relevant, nutrient-rich food
- Respecting and enhancing biodiversity
- Supporting peace building, prosperity, & social cohesion
- Enabling communities to adapt to climate change

About this policy brief

This project brief is part of a series aiming to convey the results and progress of the Food Systems Transformation Through School Feeding Project, funded by the International Development Research Centre (IDRC) and the Rockefeller Foundation. The full series can be found at www.regenerativefoodsystemsalliance.org.

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