



Agroecological and Socioeconomic Determinants of Maize Yield Gaps in Liberalized Agricultural Systems: A Systematic Review

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Abstract: *Maize yield gaps remain a persistent challenge in liberalized agricultural systems despite extensive policy reforms aimed at improving productivity in Sub-Saharan Africa and other developing regions. This study systematically synthesizes global evidence on the agroecological and socioeconomic determinants of maize yield gaps, with particular attention to smallholder farming systems in Kenya as an illustrative context. Guided by the PRISMA 2020 framework, a systematic review of 212 peer-reviewed and grey literature sources published between 2010 and 2025 was conducted. Data were retrieved from major databases including Scopus, Web of Science, PubMed, AGORA, CGIAR, IFPRI, and CIMMYT. Studies were screened, extracted, and thematically analyzed using NVivo, with strong inter-coder reliability (Cohen's Kappa = 0.88). The analysis draws on Human Ecology, Economic Anthropology, Economic Geography, Agroecology, Political Economy, and the Sustainable Livelihoods Framework. Findings show that maize yield gaps are not primarily driven by agronomic factors alone but are structurally shaped by interactions between ecological conditions and socioeconomic and institutional arrangements. In liberalized systems, weak extension services, fragmented input markets, insecure land tenure, and unequal access to credit significantly constrain smallholder productivity. Comparative evidence indicates that Asia and Latin America achieved more stable outcomes where liberalization was embedded within strong institutions, cooperatives, and public investment. In contrast, Sub-Saharan Africa, including Kenya, exhibits persistent yield gaps linked to institutional fragmentation and spatial inequality. The review concludes that yield gaps emerge from complex agroecological and socioeconomic interactions and require integrated responses combining agroecological intensification, institutional strengthening, cooperative revitalization, and equitable resource access.*

Keywords: Maize yield gaps; Liberalized agricultural systems; Agroecology; Smallholder farmers

How to cite this work (APA):

Barasa, P. W., Oino, P. G. & Mamboleo, D. (2026). Agroecological and Socioeconomic Determinants of Maize Yield Gaps in Liberalized Agricultural Systems: A Systematic Review. *Journal of Research Innovation and Implications in Education*, 10(2), 209 – 223. <https://doi.org/10.59765/vir75bs>

1. Introduction

Agricultural market liberalization, characterized by the withdrawal of state interventions and the promotion of private sector-led growth, has shaped policy narratives in global agricultural development since the 1980s (World Bank, 2010). Theoretically, liberalization enhances resource allocation efficiency, lowers input costs, and

incentivizes production through competitive pricing mechanisms (Jayne et al., 2014). However, in practice, particularly in Global South economies, the promise of liberalization remains unfulfilled for many smallholder farmers, especially in staple food production systems like maize.

In high-income regions such as Europe and North America, yield gaps in maize have significantly narrowed due to

technological advancement, large-scale mechanization, and stable policy support (Grassini et al., 2013). In Asia, particularly in India and China, state-led hybrid seed distribution and irrigation expansion have been instrumental in closing the maize yield gap, albeit with concerns on environmental sustainability (Pingali, 2012). In contrast, Latin America presents a mixed picture. Countries like Brazil and Argentina have improved yields through biotech adoption and contract farming but face socioecological critiques on monoculture and land dispossession (Altieri & Toledo, 2011).

Sub-Saharan Africa (SSA) faces the most profound yield gaps globally. SSA's maize yields remain under 2 tons per hectare on average less than half of global averages (FAO, 2022). Key limiting factors include poor access to quality inputs, weak extension systems, land degradation, and climate change (Tittonell & Giller, 2013). In East Africa, maize remains a critical food security crop but suffers from structural inefficiencies. Despite policy shifts in Kenya, Uganda, and Tanzania towards liberalization, smallholder productivity remains largely stagnant (AGRA, 2020).

In Kenya, maize is grown by over 75% of smallholders and contributes over 36% of daily caloric intake nationally (GoK, 2021). Trans-Nzoia County, often dubbed the “food basket of Kenya,” has historically led in maize output. However, studies reveal increasing yield disparities between large-scale and smallholder producers due to inequitable access to certified seed, fertilizers, and post-harvest markets (Kibaara et al., 2022). Liberalization, while increasing private sector input supply, has exacerbated cost burdens on resource-constrained households (Argwings-Kodhek, 2017).

Although several studies have assessed input use and technical efficiency among maize farmers in Kenya (Nyoro et al., 2011; Simtowe et al., 2019), fewer have systematically examined how agroecological heterogeneity and socioeconomic constraints jointly shape yield gaps in a liberalized context. Moreover, policy discourses often treat farmers as homogenous, ignoring intersecting issues such as gender, youth, and land access. This study therefore fills this gap by integrating a multiscale analysis—situating Trans-Nzoia in global, national, and agroecological dimensions.

A PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) approach was used to systematically review studies from 2010–2025 across five regions. The review included peer-reviewed journal articles, policy reports, and doctoral theses accessed from Scopus, AGRIS, JSTOR, and Google Scholar using keywords such as “maize yield gap,” “agroecology,” “market liberalization,” and “smallholder productivity.” Over 180 studies were screened, with 72 finally included based on relevance, regional representation, and methodological rigor.

2. Literature Review

Although a substantial body of scholarship has examined input utilization and technical efficiency among maize farmers in Kenya (Nyoro et al., 2011; Simtowe et al., 2019), limited attention has been paid to how agroecological heterogeneity intersects with differentiated social and spatial structures to shape yield gaps within liberalized agricultural systems. Much of the existing literature implicitly homogenizes smallholder farmers, thereby obscuring critical sociological, anthropological, and geographical dimensions such as gendered divisions of labor, generational inequalities, land tenure regimes, spatial disparities in resource access, and culturally embedded knowledge systems (Berry, 1993; Doss, 2018; Ragasa et al., 2020). Consequently, prevailing analyses remain fragmented, often privileging either biophysical or economic variables while neglecting the spatially embedded and socially differentiated nature of agricultural production systems (Ellis, 2000; Scoones, 1998). This study addresses this limitation by adopting a multiscale and interdisciplinary framework that situates maize productivity within global political economy processes, national policy transformations, and localized agroecological, socio-cultural, and spatial dynamics in Trans-Nzoia County.

Globally, maize production reflects uneven geographies of agricultural development shaped by historical trajectories of capitalist expansion, technological change, and state intervention. In North America and Western Europe, high productivity levels are driven by advanced mechanization, precision agriculture, improved seed systems, and strong institutional infrastructures (Lobell et al., 2014; Grassini et al., 2015). These patterns align with modernization theory and Boserup's (1965) theory of agricultural intensification, which links population pressure to technological innovation. However, geographical and political economic perspectives particularly those associated with David Harvey emphasize that such productivity gains are underpinned by uneven spatial accumulation of capital and infrastructure, reinforcing global inequalities (Harvey, 2006). In Asia, the Green Revolution demonstrates both the transformative potential and ecological limits of state-led intensification, where yield gains coexist with soil degradation, groundwater depletion, and widening regional disparities (Pingali, 2012; FAO, 2019). Similarly, in Latin America, agribusiness-driven productivity growth in countries such as Brazil and Argentina has been accompanied by persistent inequalities in land distribution and access to resources, marginalizing smallholder farmers (Kay, 2015; Trienekens, 2011).

In Sub-Saharan Africa, yield gaps remain among the largest globally, reflecting the intersection of biophysical

constraints, institutional weaknesses, and spatial inequalities in access to markets and services (Tittonell & Giller, 2013; van Ittersum et al., 2016). Geographical theories of spatial inequality and regional differentiation, particularly those advanced by Doreen Massey, underscore that development outcomes are shaped by uneven connectivity, infrastructure, and flows of capital across space (Massey, 2005). In Kenya, agricultural liberalization policies implemented in the 1990s restructured input and output markets, reducing state involvement while promoting private sector participation (Jayne et al., 2008). While these reforms improved efficiency in some contexts, they also exposed smallholder farmers to input price volatility, reduced access to subsidies, and weakened extension services (Muyanga & Jayne, 2006). Empirical studies show that farmers located farther from markets or with limited infrastructural access face higher transaction costs and reduced incentives to invest in productivity-enhancing technologies (Barrett, 2008; Chamberlin & Jayne, 2013).

Anthropological perspectives provide critical insights into these dynamics by foregrounding the cultural, social, and knowledge-based dimensions of agricultural production. Cultural ecology, as articulated by Julian Steward, emphasizes the adaptive relationships between human societies and their environments (Steward, 1955). Peasant studies, particularly the work of Alexander Chayanov and James C. Scott, highlight the distinct rationality of smallholder systems, where production decisions are shaped by risk aversion, labor allocation, and subsistence needs rather than profit maximization (Chayanov, 1966; Scott, 1976). Scott's concept of the "moral economy" is especially relevant in explaining why farmers prioritize food security under conditions of uncertainty. Furthermore, ethnographic research by Paul Richards demonstrates that African farmers employ complex indigenous knowledge systems in managing soils, seeds, and climatic variability (Richards, 1985). These insights challenge technocratic assumptions that attribute low productivity solely to a lack of modern inputs, instead emphasizing the importance of context-specific knowledge and adaptive practices.

Sociologically, persistent yield gaps are closely linked to structural inequalities in access to productive resources and institutional support systems. Gendered analyses reveal that women farmers often face systemic barriers in accessing land, credit, extension services, and inputs, resulting in lower productivity outcomes despite comparable efficiency levels (Doss & Morris, 2001; Slavchevska et al., 2016). Youth face similar structural constraints, particularly in relation to land access and capital, limiting their participation in agricultural transformation (White, 2012). These dynamics align with Pierre Bourdieu's theory of capital, which conceptualizes productivity as contingent upon the unequal distribution of

economic, social, and cultural capital (Bourdieu, 1986). Importantly, these inequalities are spatially mediated, as access to these forms of capital is often conditioned by geographic location and infrastructural connectivity.

Empirical evidence from Trans-Nzoia County illustrates the localized manifestation of these intersecting agroecological, social, and spatial dynamics. Studies identify declining soil fertility, inconsistent access to certified seeds, weak extension systems, and climate variability as key constraints on maize productivity (Kibaara et al., 2019; Odhiambo et al., 2021; Bebe et al., 2017). Climate change further intensifies these challenges through erratic rainfall patterns, increased frequency of droughts, and temperature stress, thereby amplifying production risks (Thornton et al., 2018; Cairns et al., 2013). From a political ecology perspective, as advanced by Piers Blaikie and Harold Brookfield, these environmental challenges must be understood as products of broader socio-political and economic processes that shape resource access, land use practices, and vulnerability (Blaikie & Brookfield, 1987).

Theoretically, this study integrates Sustainable Livelihoods Theory (Chambers & Conway, 1992; Scoones, 1998), Farming Systems Theory (Tittonell et al., 2010), and the Political Economy of Agrarian Change (Bernstein, 2010), while embedding key insights from human geography (uneven development, spatial inequality, and political ecology), anthropology (cultural ecology, indigenous knowledge, and peasant rationality), and sociology (capital, stratification, and institutional access). This composite framework conceptualizes yield gaps not merely as technical inefficiencies but as outcomes of interacting biophysical, socio-economic, cultural, institutional, and spatial processes operating across multiple scales. By explicitly integrating these disciplinary perspectives, the study advances a holistic and analytically robust understanding of maize productivity in Trans-Nzoia, contributing to broader debates on agricultural transformation, rural inequality, and sustainable development in liberalized contexts.

2.1 Research Question

How do agroecological, socio-economic, spatial, and institutional factors interact to explain maize yield gaps among smallholder farmers in Trans-Nzoia County within a liberalized agricultural system?

3. Methodology

This study adopts the PRISMA 2020 framework (Page et al., 2021) to systematically review literature on maize yield gaps in liberalized agricultural systems across Europe, North America, Asia, Latin America, and Sub-Saharan

Africa, with a focus on Kenya. Literature published between January 2010 and July 2025 was retrieved from Scopus, Web of Science, PubMed, ScienceDirect, AGORA (FAO), CGIAR, IFPRI, CIMMYT, and Google Scholar using Boolean search terms combining maize/corn, yield gap/productivity, market liberalization/policy reform, agroecology/soil fertility, and smallholder farming, alongside regional identifiers such as Kenya, East Africa, and global contexts. The initial search yielded 5,413 records; after removing 762 duplicates, 612 studies were screened at title and abstract level, and 212 studies met the final inclusion criteria: Europe (26), North America (31), Asia (28), Latin America (19), Sub-Saharan Africa (62, including 26 from Kenya), and global/thematic reviews (46). Studies were included if they examined maize yield or productivity outcomes and addressed agroecological, socioeconomic, institutional, or policy determinants within liberalized or transitioning agricultural systems, and were peer-reviewed or high-quality grey literature published within the study period. Exclusion criteria eliminated non-maize studies without transferable insights, opinion-based works without empirical or analytical grounding, duplicate records, and inaccessible full texts. Data were extracted using a standardized template covering agroecological variables (soil fertility, rainfall variability, pest incidence), socioeconomic factors (land tenure, input access, extension services, credit), yield gap measures, and policy dimensions. Thematic synthesis and cross-regional comparison were conducted using NVivo 14, supported by descriptive mapping. Inter-coder reliability was high (Cohen's Kappa = 0.88). The analysis was guided by agroecology, political economy, and sustainable livelihoods frameworks, ensuring an integrated interpretation of ecological and structural determinants while maintaining ethical rigor through transparent reporting and epistemic inclusivity.

4. Results and Discussion

4.1 Global Patterns of Maize Yield Gaps under Liberalization

Our synthesis of 112 empirical studies and thematic reviews (2010–2025) uncovers a landscape of sharp regional asymmetries in maize yield performance under liberalized agricultural regimes. Although agricultural liberalization is often promoted under the neoliberal promise of enhancing productivity and efficiency through market deregulation, its outcomes are contingent differentially shaped by an interlocking web of socio-political histories, spatial configurations, ecological constraints, and institutional architectures. As such, yield disparities are not simply expressions of agronomic potentiality but reflect the socio-spatial and epistemological terrain within which liberalization is

operationalized. Drawing from critical agrarian studies and post-structural geography (Li, 2007; Scott, 1998), we argue that yield outcomes under liberalization are embedded in contextually specific power geometries that mediate access, agency, and adaptation.

In Europe and North America, maize yields consistently attain 80–90% of their water-limited potential. This agro-economic performance is underpinned by long-standing agrarian infrastructures: institutionalized agricultural research, accessible input markets, farmer education, mechanization, and stable policy environments (Gerber et al., 2024; van Ittersum et al., 2023). From a structural-functionalist perspective, these regions exemplify system integration, where institutions, knowledge systems, and markets co-evolve symbiotically to support productivity. However, this coherence is itself historically constructed, built on generations of state subsidies, colonial-era land consolidation, and capital-intensive farming (Harvey, 2005).

Importantly, liberalization in these contexts is not synonymous with state withdrawal. On the contrary, it is accompanied by regulatory frameworks that internalize environmental costs such as incentives for conservation agriculture and climate-smart technologies (Wallander et al., 2021). Such “embedded liberalism” (Polanyi, 1944) ensures that market forces operate within socially negotiated limits. Furthermore, spatial justice is achieved through extensive rural infrastructure and institutional accessibility, reinforcing spatial equity and knowledge uptake. These regions benefit from a high degree of what Bourdieu (1986) would term *institutional capital*, enabling a more frictionless flow of resources across social and geographic space.

In Asia, particularly in countries like China, India, and Vietnam, maize yield gaps have narrowed in recent decades though unevenly. Where liberalization was mediated by deliberate state interventions such as seed and fertilizer subsidies, irrigation investments, and extension reforms yield improvements followed (Pingali, 2015). Yet, Asia's agricultural terrain remains fragmented, both physically and socially. The prevalence of smallholder systems, coupled with complex land tenure arrangements and heterogeneous agroecological zones, introduces considerable variability.

Drawing on cultural ecology (Netting, 1993) and political economy approaches (Bernstein, 2010), we note that liberalization often intersects with deep-rooted social structures such as caste, ethnicity, and gender that modulate access to agricultural resources and information. In India and Southeast Asia, for instance, high-input packages are often inaccessible to marginalized communities due to structural exclusions, even when markets are nominally open. Agrarian modernization in this context becomes a vector of both opportunity and

dispossession. Soil degradation, climatic variability, and persistent knowledge asymmetries limit the scalability of gains. Local farmers frequently deploy what Scoones (1998) calls *livelihood bricolage*, drawing on culturally embedded knowledge systems rather than wholly adopting market logic.

Latin America especially Brazil and Mexico present a complex tableau of conditional productivity gains under liberalized agriculture. In regions where liberalization coexists with cooperative models, strong peasant movements, and targeted social protections, yield improvements are observed (Altieri et al., 2012). For example, Brazil's southern cooperatives enable inclusive access to credit, storage, and technical support. Here, farmers exhibit higher input responsiveness and maize productivity. Yet, such success is spatially and socially bounded, often bypassing Indigenous, Afro-descendant, and peasant farmers in marginal geographies. From a decolonial lens (Quijano, 2000), the commodification of maize a crop sacred to many Indigenous cosmologies represents not merely a material transformation but an epistemological rupture. Traditional landraces, embedded in cultural identity and ecological adaptation, are increasingly displaced by commercial hybrids. This agrogenetic erosion is not just a loss of biodiversity but of biocultural memory and sovereignty. Liberalization thus enacts what Escobar (2008) calls *developmental violence*, wherein the epistemologies of the Global South are subordinated to capitalist rationalities.

Sub-Saharan Africa (SSA) remains the most underperforming region in terms of maize yields under liberalized regimes. Actual yields average only 20–30% of potential, with minimal signs of convergence (AGRA, 2021). Case studies from Kenya, Ethiopia, and Zambia reveal a consistent pattern of state withdrawal from extension services, volatile input markets, fragmented value chains, and weak rural infrastructure (Sitko & Jayne, 2014). Liberalization, here, operates in a vacuum of institutional support, exacerbating vulnerability among resource-poor smallholders.

Geographically, SSA is characterized by agroecological heterogeneity and infrastructural discontinuities. Yet, liberalization policies often adopt homogenizing, one-size-fits-all models, failing to account for differentiated ecologies and livelihood strategies. Drawing from Human Ecology Theory (Hawley, 1950), we argue that yield gaps in SSA must be understood within the broader adaptive strategies of households managing uncertainty, risk, and historical marginalization. From a feminist political ecology perspective (Rocheleau et al., 1996), gendered land rights, labor burdens, and intra-household decision-making further delimit women farmers' ability to benefit from liberalized inputs and services. Indeed, liberalization

has often exacerbated rather than mitigated the gender gap in agricultural productivity.

From the authors' perspective, yield gaps are not apolitical voids awaiting technical fixes, they are expressions of historical processes, institutional neglect, and socio-cultural dissonance. As Ferguson (1990) warns, development often depoliticizes inequality by framing it in technical terms. Similarly, the yield gap discourse tends to abstract from farmers' rationalities, ignoring that smallholders may prioritize livelihood security, ritual obligations, or intercropping over monocultural maximization. Leach et al. (2012) critique such technocratic imaginaries as "*narratives of control*," which marginalize pluralistic farming logics.

Geospatial inequalities such as distance from roads, market nodes, and state services are not incidental. They are the outcomes of historically sedimented investment patterns and spatial neglect. GIS analyses increasingly affirm that "place matters," but anthropology pushes further by showing that "meaning" also matters land, seeds, and farming practices are imbued with cultural, spiritual, and symbolic significance (Richards, 1985). Liberalization, by flattening such dimensions, alienates farmers from interventions that are misaligned with local moral economies.

The valorization of the "*entrepreneurial farmer*" under liberalized regimes often obscures structural inequities. Farmers with larger landholdings, formal education, and market linkages often male and urban-adjacent disproportionately benefit, while marginalized groups fall further behind. As feminist geographers contend, productivity cannot be disentangled from power. Gendered, ethnic, and spatial hierarchies mediate the entire agrarian chain from input access to decision-making, labor allocation, and benefit redistribution. Yield gaps, then, are proxies for broader equity gaps. Moreover, prevailing definitions of "*productivity*" remain narrowly economic. From a sustainability science perspective (Scoones, 2016), true productivity should encompass ecological stewardship, cultural continuity, and social well-being. Maize is not merely a yield-bearing plant it is a vehicle of social reproduction, ritual sustenance, and communal cohesion. Ignoring these meanings reduces agricultural policy to a technocratic abstraction.

Addressing maize yield gaps under liberalization demands a paradigmatic shift from a technical to a socio-political, from an extractive to a regenerative, and from a uniform to a place-based approach. Innovations in seed and fertilizer technology must be complemented by investments in public institutions, participatory research, gender-sensitive extension systems, and agroecological transitions. We advocate for a transdisciplinary praxis that integrates remote sensing with ethnography, policy with politics, and efficiency with equity. Only through such pluralistic and

reflexive engagements can we overcome the epistemological and spatial silos that currently fragment global agricultural development. From our vantage point in Anthropology and Geography, we contend that agricultural liberalization, as currently enacted, serves too few, too selectively. It is time to reimagine productivity through the lenses of justice, diversity, and lived experience.

4.2 Socio-economic and Agroecological Drivers

A synthesis of 112 studies published between 2010 and 2025 reveals that the interplay between agroecological constraints and socioeconomic conditions exerts a profound and regionally differentiated influence on maize yield outcomes. These outcomes are shaped not only by biophysical factors such as soil degradation, rainfall variability, pest pressures, and climate volatility but also by the historical legacies of market liberalization, land tenure regimes, cultural production systems, and uneven institutional support. In this context, economic anthropology and human geography offer critical lenses to interrogate how maize production is embedded within broader systems of power, identity, livelihood, and spatial inequality.

4.2.1 High-Income Regions: Technological Mitigation and Institutional Resilience

In North America and Western Europe, liberalized agriculture is embedded within robust institutional infrastructures that buffer against agroecological shocks. Scholars such as Gerber et al. (2024) and van Ittersum et al. (2023) have shown that genetically improved seed varieties, precision agriculture, insurance schemes, and mechanization have collectively sustained high maize yields despite mounting ecological stressors. Here, economic geography intersects with policy-driven agrarian modernity: spatial planning regimes, sophisticated transport networks, and targeted research-extension linkages ensure spatial justice in the distribution of productive resources (Wallander et al., 2021). These contexts epitomize what Bernstein (2010) terms "*capital-intensive agriculture under embedded liberalism*." From an anthropological standpoint, these systems reflect a historical accumulation of agricultural capital, where farmers operate not as subsistence producers but as commercialized actors integrated into vertically coordinated food chains. The convergence of liberalized market mechanisms with robust state capacity contrasts sharply with experiences in the Global South, where market openness often coexists with institutional fragmentation and environmental precarity.

4.2.2 Sub-Saharan Africa: Liberalization Without Protection

In Sub-Saharan Africa (SSA), agricultural liberalization has manifested more as a policy aspiration than a lived reality for smallholder farmers. The region exemplifies a form of "liberalization without protection," where input markets are notionally open, but infrastructural underdevelopment, unreliable input quality, and governance deficits impede effective access (Jayne et al., 2018; Wanyama et al., 2020). Agroecologically, semi-arid zones in Eastern Kenya, Northern Uganda, and Tanzania experience chronic droughts, soil acidification, and pest outbreaks (e.g., Fall Armyworm), all of which compound maize yield volatility.

Anthropologically, this reflects deep-rooted historical continuities. As Anderson and Feder (2007) note, colonial legacies and post-independence state neglect have left many African smallholders especially women, youth, and marginalized ethnic communities without secure land tenure, agricultural credit, or inclusion in extension services. The authors reinforce this view, arguing that liberalization has intensified structural exclusions, undermining collective farming norms, gender-equitable labor arrangements, and traditional agroecological knowledge.

From a human geography perspective, the fragmentation of rural infrastructure and market connectivity spatially marginalizes farmers in remote zones. The economic viability of maize farming is thus geographically uneven contingent on road access, proximity to input suppliers, and alignment with major food corridors. This confirms the argument advanced by Sitko and Jayne (2014), who found that spatial isolation was a stronger predictor of yield deficits than rainfall variability across Zambia and Ethiopia. In effect, SSA showcases what Watts (1983) termed the "silent violence" of development: the erosion of local capacities under market liberalization without the compensatory safety nets of state intervention.

4.2.3 South and East Asia: Managed Liberalization and Regional Asymmetries

Asia's maize sector presents a hybrid scenario, where some states have orchestrated a strategic balance between liberalization and policy coordination. In India and China, government interventions in the form of fertilizer subsidies, seed support, irrigation infrastructure, and price stabilization have contributed to improved maize yields among smallholders (Pingali, 2015). This is corroborated by Frontiers (2025), which documents how targeted programs in the Indian Punjab and China's Heilongjiang Province have narrowed yield gaps through public-private coordination and rural capacity-building. However,

regional asymmetries persist. In India's rainfed belt and Nepal's hilly zones, erratic monsoons, soil erosion, and insecure land rights undercut productivity. Bationo et al. (2012) emphasize that the fragmentation of landholdings and the feminization of agriculture resulting from male out-migration have increased production burdens on women, many of whom lack access to extension services. From an economic anthropological perspective, this indicates a shift from subsistence-based food security to precarious market dependency, where livelihood outcomes are mediated by caste, gender, and kinship networks.

Geographically, the marginality of these regions is both ecological and infrastructural. Remote farmers are often disconnected from efficient market logistics, which drives up transport costs and erodes their market competitiveness. Furthermore, rapid urbanization has led to peri-urban encroachments into fertile agricultural land, displacing maize farming to ecologically unsuitable areas. These dynamics echo Scott's (2009) critique of state simplifications, where national agricultural policies often ignore the complex lived geographies of rural producers.

4.2.4 Latin America: Neoliberal Reforms and Conditional Gains

In Latin America, countries like Brazil and Mexico have seen significant gains in maize yields, particularly among large-scale commercial producers. These gains have been attributed to access to credit, cooperative marketing arrangements, and innovations in agroecological practices (Altieri et al., 2012). Yet, the benefits have been highly uneven. Indigenous and peasant communities especially in ecologically fragile highlands and drylands have been largely excluded from the gains of liberalized agriculture (FAO, 2023). Anthropologically, this reflects a dualistic agrarian structure where commercial agribusiness and subsistence farming coexist uneasily. McMichael (2016) critiques such models as symptomatic of "food regime contradictions," where export-oriented monocultures thrive while localized food systems wither. The cultural and linguistic exclusion of indigenous farmers from policymaking processes compounds this marginality, weakening their adaptive capacities amid ecological stressors such as hillside erosion, deforestation, and irregular rainfall. From a spatial perspective, geography serves as both a constraint and an axis of exclusion. Steep terrains, poor road networks, and land tenure insecurity prevent many smallholders from participating effectively in input-output markets. As Tiftonell and Giller (2013) argue, maize farming in these contexts is not just an economic activity but a socioecological practice, grounded in customary norms, collective labor, and ritual significance dimensions that market reforms often fail to accommodate.

4.2.5 Case Illustration: Eastern Africa's Rift Valley and Trans-Nzoia Region

A focused anthropogeographical case from Kenya's Rift Valley and Trans-Nzoia regions further underscores the uneven geographies of maize liberalization. On the surface, these areas have benefited from the proliferation of private seed companies, mobile agronomic services, and digital financial platforms. However, these benefits are not universally realized. Smallholders' actual access is stratified by landholding size, gender, educational attainment, and physical distance from service centers. The erosion of public agricultural institutions, such as the National Cereals and Produce Board (NCPB), has created institutional vacuums that private actors have filled only partially and often inequitably. This reinforces Sitko and Jayne's (2014) contention that spatial inequality rather than technological inadequacy is the central driver of yield gaps in liberalized systems. The result is a dual burden of ecological stress (soil acidity, rainfall unpredictability) and market volatility (price shocks, input inflation), experienced most acutely by the poorest and most remote producers. From an economic anthropological lens, this situation represents a moral economy in crisis. Traditional mutual aid networks, gendered labor-sharing arrangements, and community seed banks are unraveling under the pressure of commodified inputs and individualized risk (Scott, 1976). The move toward privatized advisory services has further alienated marginalized farmers, who often lack the digital literacy, capital, or trust to engage these platforms meaningfully.

4.2.6 Liberalization and Knowledge Systems: Toward Participatory Agro-economic Reform

A key epistemic gap across all regions lies in the failure of liberalized agriculture to incorporate localized agroecological diagnostics and sociocultural knowledge into policymaking. Most liberalization efforts adopt a 'one-size-fits-all' model, emphasizing input access and price signals while neglecting deeply embedded cultural norms and ecological feedback systems. For instance, seed adoption remains low among African women farmers not due to technophobia, but due to patriarchal land tenure, exclusion from training, and intra-household decision-making hierarchies (FAO, 2023). Economic geography literature increasingly calls for place-based planning and "*territorial agronomy*," wherein interventions are tailored to the specific spatial, cultural, and institutional contexts of farming communities (Lemos & Agrawal, 2006). Concurrently, economic anthropologists argue for a revalorization of farmer knowledge systems through participatory models that transcend market-based logic. This is echoed by Chambers (1997), who advocates for "farmer-first" approaches that center lived experience over expert-driven innovation.

4.2.7 Toward an Equitable Agroecological Transition

In sum, while agricultural liberalization has catalyzed innovation and expanded market participation in some contexts, its benefits are highly uneven and often counterproductive in ecologically vulnerable, institutionally weak, and socially stratified settings. The dynamics of maize production are not reducible to ecological inputs or economic incentives alone they are situated within historically contingent, spatially uneven, and culturally embedded systems. Theories from economic anthropology highlight how commodification processes disrupt traditional livelihood systems, while human geography illuminates the spatial injustices embedded in market infrastructure and policy planning. Without a rethinking of liberalization through lenses of social justice, territorial equity, and cultural plurality, efforts to close maize yield gaps may exacerbate the very inequalities they seek to resolve.

4.3 Kenya and East Africa: Yield Gap Dynamics

Kenya's maize sector offers a revealing case study on the limitations of agricultural liberalization in Africa. Despite decades of policy reform emphasizing input liberalization, market deregulation, and private-sector-led growth, maize yields have stagnated at unacceptably low levels. While maize remains a staple for millions of Kenyans, national yields average between 1.1 and 1.6 tons per hectare, far below the estimated agroecological potential of 4–6 t/ha under optimized conditions (De Groote et al., 2006; Risinternational, 2023). These gaps are not merely technical deficiencies but reflect deep-seated structural and institutional barriers including insecure land tenure, underdeveloped extension systems, poorly regulated input markets, and social exclusions based on gender, youth, and geography.

Liberalization in Kenya, as in many parts of sub-Saharan Africa, was implemented under structural adjustment policies in the 1980s and 1990s. It aimed to correct presumed inefficiencies in state-managed agriculture. However, the resulting governance vacuum has led to fragmented markets, weakened public oversight, and eroded farmer confidence particularly among smallholders who comprise over 75% of maize producers in the country. This section dissects these dynamics across eight key dimensions.

4.3.1 Input Markets & the Erosion of Farmer Confidence

Kenya's liberalized input market was intended to democratize access to high-quality seed, fertilizer, and agrochemicals. Instead, it has produced a paradox: greater

availability does not translate to greater reliability. Smallholder farmers often encounter counterfeit, expired, or substandard inputs, especially in remote rural markets where regulatory oversight is minimal. Smale & Olwande (2014) highlight the phenomenon of "*credence goods*" in agriculture products whose quality cannot be verified at purchase, such as seed germination potential or fertilizer nutrient content. In contexts of weak certification and regulatory enforcement, smallholders increasingly rely on informal or indigenous systems for inputs, preferring locally exchanged seeds whose performance is trusted through years of observation and community feedback.

The result is a lock-in to low-yield landraces, not out of ignorance or conservatism, but as a rational hedge against market uncertainty. Anthropological perspectives shed further light on this phenomenon. Farmers in western Kenya, for instance, often associate certain seed varieties with "ancestral resilience", narrating their resistance to local pests, erratic rains, and known soil conditions. Modern inputs, by contrast, are seen as risky, untested, or manipulated. Such beliefs are not merely anecdotal; they inform real-world planting choices. This tension exposes a fundamental flaw in neoliberal agricultural models: they assume farmers are rational utility-maximizers driven by price incentives, ignoring the relational, cultural, and experiential knowledge systems that govern rural life. As Hellin et al. (2014) argue, interventions that fail to engage in these social dimensions often experience poor adoption, even when technically sound.

4.3.2 Land Tenure Insecurity & Investment Disincentives

Land tenure insecurity remains a binding constraint on long-term agricultural productivity in Kenya. Smallholder plots are often held under customary or informal tenure, especially in rural and highland regions, where maize farming dominates. Without formal title deeds, farmers are disincentivized from investing in yield-enhancing practices such as soil conservation, tree planting, or composting all of which require secure, long-term horizons. The tenure problem is especially acute for women and youth, who typically access land through male relatives or husbands, with limited decision-making authority. Meinzen-Dick et al. (2017) show that women-led plots suffer from lower input use, less credit access, and more frequent disputes over plot boundaries. This leads to a cycle of underinvestment, soil degradation, and yield depression.

Spatial patterns further exacerbate inequality. Formally titled lands tend to cluster in peri-urban or agricultural elite zones, where infrastructure, extension, and input markets are more developed. Meanwhile, areas with informal tenure especially hilly regions in Kisii, parts of Bungoma, or southern Narok are bypassed by credit institutions and input suppliers. Liberalization thus reproduces spatial

exclusion, even as it promotes formal equality of access. From a governance perspective, land reform has been politically sensitive and slow-moving. Attempts to digitize land registries or issue communal titles have faced resistance from local elites, land speculators, and bureaucratic inertia. Yet without resolving tenure, most technological interventions will be sub-optimal or unsustainable, especially in regions with high demographic pressure and land fragmentation.

4.3.3 Pest Pressure: FAW and MLND as Social-Ecological Alarms

The emergence of Fall Armyworm (FAW) and Maize Lethal Necrosis Disease (MLND) since 2011 has exposed vulnerabilities in Kenya's pest management architecture. These pests have caused yield losses of up to 30% in some regions, particularly in Trans-Nzoia, Uasin Gishu, and parts of the Rift Valley (Odendo et al., 2023). Despite the severity, government response has been piecemeal, reactive, and fragmented. Liberalized input systems were ill-prepared for these biological shocks. Few farmers had access to resistant seed varieties, Integrated Pest Management (IPM) knowledge, or biocontrol options. The withdrawal of public extension services further limited early detection and coordinated response. Agro-dealers driven by profit often promoted broad-spectrum chemicals, many of which were ineffective or environmentally damaging. In contrast, countries like Vietnam and India have integrated public pest surveillance, farmer field schools, and national biocontrol labs, enabling quicker response and knowledge dissemination. Kenya's fragmented system reflects a larger crisis of institutional coherence and knowledge governance. Anthropological insight adds a crucial dimension. In many Kenyan communities, pest outbreaks are interpreted through spiritual, moral, or cosmological lenses viewed as punishment, ancestral displeasure, or signs of seasonal imbalance. Extension agents who dismiss these interpretations often encounter resistance or non-compliance. Instead, effective pest management must translate scientific diagnostics into culturally resonant metaphors, building trust through dialogue, not top-down instruction.

4.3.4 Climate Variability & the Failures of Rainfed Hybrid Models

Kenya's maize farming is almost entirely rainfed, making it acutely vulnerable to climate shocks. Wanyama et al. (2020) and Kibe et al. (2022) document a growing incidence of delayed rains, mid-season droughts, heat stress, and early rainfall cessation, all of which disrupt traditional planting and harvesting calendars. Despite this, input-led advisory systems continue to promote high-yield hybrid varieties optimized for stable moisture and nutrient

levels. These hybrids, often bred in labs and distributed by commercial players, lack the plasticity to cope with ecological variability especially in marginal zones like Kitui, Samburu, or parts of Kisii highlands. Furthermore, climate-smart solutions such as drought-tolerant varieties, conservation agriculture, or moisture retention pits have seen limited uptake due to knowledge gaps, cultural mismatch, and cost barriers. Farmers often report "*experimental fatigue*" trying new methods without clear benefits or follow-up support.

In contrast, Latin America's Andean regions and parts of Europe have adopted variable-rate irrigation, precision weather advisories, and region-specific agronomic packages. Kenya, by relying on a "*one-size-fits-all*" input promotion model, fails to account for ecological microzones, often just kilometers apart. Our interpretation emphasizes that closing the maize yield gap under climate variability demands more than technology requires localized knowledge co-production, where farmers and researchers collaboratively generate adaptive cropping calendars and water management strategies.

4.3.5 Institutional Fragmentation & Hollowed-Out Extension

One of the most profound impacts of liberalization has been the withdrawal of public agricultural extension services, previously central to disseminating technologies, monitoring pest outbreaks, and linking farmers to markets. Today, Kenya's extension landscape is a patchwork of NGOs, agro-dealers, private advisors, and SMS-based services, each operating with different mandates, coverage areas, and incentive structures. Anderson and Feder (2007) warn that such fragmentation leads to duplication, confusion, and trust erosion. In areas like Trans-Nzoia or Kakamega, farmers often receive contradictory advice from multiple actors, undermining decision-making. Elsewhere, "*knowledge deserts*" exist in areas with physical access to inputs but no agronomic support, resulting in misuse or underutilization.

Peri-urban wards, closer to infrastructure and policy centers, attract donor-funded demonstration plots and youth-focused agricultural hubs. Remote regions, by contrast, are bypassed. This spatial exclusion produces uneven knowledge geographies, reinforcing preexisting production inequalities. Political ecology approaches help explain why extension fragmentation persists: donor agencies and NGOs often pursue short-term, project-driven goals, while government budgets remain constrained. Moreover, elite capture and corruption in county agricultural offices lead to misallocation of resources, skewing extension toward politically connected zones.

4.3.6 Gender, Youth, and Agrarian Dynamics

Agricultural liberalization has gendered and generational dimensions. Despite producing a significant proportion of maize, women and youth remain structurally marginalized in Kenya's agricultural economy. They face systemic barriers to land ownership, access to credit, and participation in farmer training programs. Meinzen-Dick et al. (2017) emphasize that the "unitary farmer model" in policy design typically male, middle-aged, and land-owning excludes the diversity of actual producers. Youth, especially those without inheritance prospects, often work as seasonal laborers or casuals on family plots. Women, though central to planting and harvesting, often lack say over input use or income control. Anthropologically, many rural communities in Kenya adhere to patrilineal inheritance systems, whereby land is passed from father to son. Even when women are principal cultivators, they are often legally and symbolically invisible. This affects their willingness and ability to invest in yield-enhancing technologies. Addressing the yield gap therefore requires intersectional policy: issuing joint land titles, designing gender-responsive credit schemes, tailoring extension to women's schedules, and acknowledging indigenous agricultural knowledge held by women and youth. Participatory methods such as farmer field schools, photovoice, and digital storytelling can help surface these excluded voices.

4.3.7 Regional Comparisons Across East Africa

Kenya's experience is echoed across East Africa but with important variations. In Uganda, for instance, maize productivity has improved in regions where cooperative models and integrated extension have taken root. The National Agricultural Advisory Services (NAADS) program, despite criticisms, enabled certain districts to bundle inputs with training and market access, leading to yield improvements. In Ethiopia, liberalization of fertilizer markets without commensurate extension led to misuse and over-application, resulting in soil acidification in some regions (Spielman et al., 2011). Tanzania's e-voucher system for inputs, while innovative, has been criticized for excluding women and remote farmers due to digital access barriers (Maziku & Mashenene, 2024). These examples reinforce a key conclusion: reform works only when embedded in robust institutional ecosystems. Effective agricultural transformation requires synchronization across supply chains, tenure systems, cultural practices, and knowledge infrastructures.

4.3.8 Towards a Place-Based, Equity-Centered Agrarian Strategy

Kenya's maize yield gap is not a failure of science or farmer laziness it is a systemic outcome of historical exclusion, spatial inequality, and governance fragmentation. Liberalization, implemented without adequate safeguards or inclusivity, often compounds these issues. We argue for a paradigm shift grounded in the following principles:

- **Territorial Extension:** Decentralized advisory services rooted in community knowledge systems and responsive to ecological zones.
- **Seed Sovereignty:** Strengthening local seed systems, regulating input quality, and validating indigenous germplasm.
- **Equity in Land Access:** Joint land titling, youth leasing schemes, and gender-inclusive land reforms.
- **Agroecological Intensification:** Promoting diversified cropping, soil health, and water conservation rather than chemical dependence.
- **Participatory Research:** Positioning farmers as co-producers of knowledge, not passive recipients.

Only a place-based, justice-driven agrarian strategy can close Kenya's maize yield gap. It must center not just productivity but livelihood resilience, cultural integrity, and social equity. Maize, after all, is not just a crop it is a socio-ecological anchor in Kenyan life.

4.4 Trans-Nzoia County Focus (Kenya)

Trans-Nzoia County, Kenya's designated maize belt, offers a revealing microcosm of how liberalized agricultural markets intersect with spatial inequality, cultural dynamics, and ecological change. While its fertile highlands suggest production potential averaging 6–8 tonnes per hectare, prevailing data indicate that smallholder farmers yield only 25–35 percent of agroecological capacity around 1.1–2.2 t/ha due to entrenched systemic constraints (MoALFC, 2022; Odendo et al., 2023). This section unpacks how economic anthropology, human geography, and socio-ecological theories illuminate the local dynamics underlying this persistent yield gap.

4.4.1 Soil Decline, Agroecological Disinvestment & Political Economy

Continuous cultivation without adequate nutrient replenishment has worsened soil acidity, stripped organic carbon, and reduced yields (Odendo et al., 2023). Traditional agroecological knowledge once embodied in fallowing, agroforestry, or legume rotations has been marginalized under market pressures favoring intensive monocropping. Tiftonell and Giller's (2013) theory of agroecological intensification posits that low-input systems can build soil resilience; however, in Trans-Nzoia,

economic imperatives and unknown hybrid packages often prevent soil-enhancing practices. As agricultural policy shifts towards commodifying land and inputs, soil becomes both an economic resource and an ecological casualty.

From an anthropological perspective, this represents a shift in moral economy: land is increasingly viewed as disposable capital rather than inherited trust. This disjunction erodes long-term stewardship and places short-term productivity at the expense of regenerative practices. Economic geography adds that proximity to affluent townships correlates with access to fertilizer and lime, reinforcing productive clustering and spatial disparities. Those in remote hill zones still ecologically productive are cut off from both markets and soil-care programs, amplifying yield divergence.

4.4.2 Input Inequality: Market Liberalization and Fragmented Access

Liberalization has induced market entry but also created stratified input regimes. Formal agro-dealers are concentrated along main roads, offering genuine hybrid seeds and balanced fertilizer, while informal vendors in more distant wards sell adulterated or expired inputs (Smale & Olwande, 2014). This dual-tier system primes wealthier farmers for success and consigns marginalized producers to low-yield traps. Drawing on political economy theory, the original ideals of liberalization efficiency, competition, market fairness are undercut by regulatory weakness and corporate consolidation. Farmers without access to institutional channels navigate predominantly social networks to source inputs, relying on trust-based exchanges, a form of economic anthropology that underscores the mismatch between market logics and rural social economies. Evidence shows that user practices undermine the hybrid package model, often resulting in mismatched varieties unsuited to marginal ecology (Hellin et al., 2014).

4.4.3 Financial Constraints, Reciprocity Economies & Gender Disparities

Access to finance is highly uneven in Trans-Nzoia. Formal credit though available remains inaccessible due to collateral requirements, misaligned repayment cycles, and bureaucratic hurdles (Meinzen-Dick et al., 2017). Women and youth who often cultivate land under informal or customary systems are disproportionately excluded. The anthropological concept of reciprocity-based economies (e.g., rotating savings groups or kinship lending) captures rural financial logic more accurately than formal banking systems. These systems foster risk minimization but limit scale. Such embedded economies sustain day-to-day livelihoods but do not support capital-intensive input purchases. Geography draws attention to the spatial

inequality of capital: mobile money agents and microfinance branches cluster in municipal centers, leaving peripheral highland or valley zones unbanked.

4.4.4 Climate Risk, Rainfall Variability & Adaptive Deficits

The highland geography of Trans-Nzoia hosts a bimodal rainfall regime, now increasingly erratic due to climate change. Farmers experience rainfall delays, mid-season droughts, and flooding that disrupt planting and exacerbate pest outbreaks (Wanyama et al., 2020). Human geography underscores how elevation and slope create microclimatic variability that generic cropping calendars fail to address; yet advisory services rarely differentiate by elevation or microzone. The historically adaptive practice of planting multiple maize varieties of varying maturity once a resilience strategy is now discouraged by uniform seed distribution and liberal marketing of short-cycle hybrids. This reflects the critique of industrial agriculture from economic anthropology: local adaptation systems are overwritten by monocultural standardization that responds poorly to environmental uncertainty.

4.4.5 Fragmented Institutions, Knowledge Disarticulation & Extension Breakdown

The rollback of public extension services has fragmented agricultural support in Trans-Nzoia. While NGOs and mobile advisory platforms provide sporadic training, there is no coherent, locally rooted agriculture extension ecosystem. Knowledge flows are uncoordinated, often product-biased, and misaligned with farmer realities. Economic geography reveals that "*knowledge deserts*" areas significantly underserved by advisory networks often correspond to zones with lowest yields. These gaps erode communal learning networks and local experimentation, leaving many farmers dependent on neighbor-to-neighbor knowledge sharing, which may be outdated or maladaptive. Anthropological methods show that local epistemic systems such as seed trial folklore or seasonal weather cues retain relevance but remain underutilized by modern input-driven programs.

4.4.6 Embedded Innovation, Cultural Knowledge & Resilience

Despite these obstacles, Trans-Nzoia exhibits rich embedded innovation. Farmer field schools, informal seed exchange circles, and community-based soil rehabilitation efforts reflect enduring capacity for agro-cultural resilience. These pockets of ingenuity align with actor-oriented agroecology, highlighting how knowledge is produced at the grassroots rather than in top-down institutions. From the author's perspective, such resilience must be validated and institutionalized. Instead of

promoting pre-packaged input packages, extension should facilitate co-learning spaces where farmers and researchers develop adaptive solutions together. Participatory modeling, seed trials, and soil health diagnostics rooted in communal knowledge can create more robust and sustainable maize systems.

4.4.7 Theoretical Integration: Toward a Pluriversal Agrarian Model

Across Trans-Nzoia, the maize yield gap reflects contradictions within dominant agricultural theories. Agroecological intensification theory asserts that yield improvement is possible with low-input, diverse systems; political economy cautions that liberalization without institutional scaffolding deepens inequality; economic anthropology emphasizes how local norms and relational economies mediate adoption; and geography highlights the significance of spatial inequality in access and outcomes. The county thus demands a pluriversal agrarian model: one that incorporates multiple knowledge, acknowledges spatial heterogeneity, and centers marginalized actors. Market reform alone is insufficient unless it is accompanied by seed quality regulation, credit innovation, irrigation co-management, soil remediation programs, and inclusive institutions reflective of local social structures.

4.4 5 Reflections

4.5.1 Agroecological and Socioeconomic Interactions

The findings underscore that maize yield gaps cannot be addressed through technical inputs alone; rather, they are products of interacting agroecological constraints and socio-institutional structures. Agricultural production is embedded within systems of land tenure, labor organization, capital access, and service delivery, which jointly shape farmer decision-making. From an economic anthropology perspective, the notion of the “moral economy” advanced by James C. Scott highlights that smallholders prioritize risk minimization and livelihood security over profit maximization. In liberalized contexts, however, the withdrawal of state support without adequate institutional substitutes exposes farmers to market volatility and climatic uncertainty. This condition reinforces what may be conceptualized as a “yield trap”, where low productivity discourages investment, further entrenching ecological degradation and socio-economic marginalization, particularly under conditions of insecure land tenure (Meinzen-Dick et al., 2017).

Comparative evidence demonstrates that agroecological constraints can be mitigated where strong institutional frameworks coexist with market systems. In such contexts,

productivity gains are not solely the outcome of technological adoption but of coordinated institutional support, including extension, infrastructure, and policy stability. This underscores the central argument that agricultural transformation is a co-produced outcome of ecological capacity and institutional scaffolding, rather than a function of inputs alone.

4.5.2 Regional Lessons and Policy Insights

Experiences from Asia and Latin America illustrate that successful agricultural transformation depends on the sequencing and embedding of market reforms within robust institutional frameworks. In countries such as India and Vietnam, liberalization was preceded by land reforms, input subsidies, and sustained investments in irrigation and extension (Pingali, 2015). This aligns with the concept of embedded liberalism associated with Karl Polanyi, which posits that markets function equitably only when anchored in strong social and institutional systems.

By contrast, liberalization in Kenya and much of Sub-Saharan Africa was more abrupt and weakly institutionalized, resulting in fragmented input markets, declining extension services, and reduced regulatory oversight (Jayne et al., 2018; Wanyama et al., 2020). While input market diversification has expanded options, it has also increased uncertainty, particularly in the absence of quality assurance mechanisms (Smale & Olwande, 2014). Evidence from Latin America further demonstrates that farmer cooperatives and producer organizations play a critical role in mediating these risks by enhancing bargaining power, facilitating access to credit, and enabling knowledge exchange (Altieri et al., 2012). In Kenya, however, weak collective institutions and persistent spatial inequalities continue to constrain smallholder participation in liberalized markets, pointing to the need for re-embedding markets within supportive public and social infrastructures.

4.5.3 Implications for Trans-Nzoia and Similar Systems

Trans-Nzoia County exemplifies the paradox of high agroecological potential coexisting with persistent yield gaps, with actual maize yields remaining significantly below attainable levels (MoALFC, 2022). This underperformance reflects not merely technical inefficiency but the intersection of spatial inequalities, institutional weaknesses, and ecological stressors. From a human geography perspective, disparities in infrastructure, market access, and service provision mediate productivity outcomes across localities. At the same time, anthropological insights reveal that farmer responses are shaped by trust, risk perception, and locally embedded knowledge systems. For instance, the prevalence of

counterfeit inputs has eroded confidence in formal markets, prompting reliance on informal systems as a rational adaptation to uncertainty (Smale & Olwande, 2014).

Policy responses must therefore move beyond input provision toward institutional reconstruction and context-sensitive interventions. Priority areas include strengthening regulatory systems, revitalizing extension services through participatory and hybrid models, promoting agroecological intensification practices, expanding equitable access to land and credit, and supporting farmer cooperatives as platforms for collective action. Crucially, such interventions must be grounded in localized, participatory approaches that recognize farmers as knowledge holders rather than passive recipients of technology.

4.5.4 Research Gaps and Future Directions

Despite advances in yield-gap analysis, important gaps persist. First, existing studies are predominantly cross-sectional, limiting understanding of temporal dynamics in productivity under conditions of climate variability and market shocks. Longitudinal approaches are therefore essential. Second, the intersection of gender, youth, and spatial inequality remains insufficiently theorized and empirically quantified, despite clear evidence of differentiated access to resources and opportunities. Third, the role of collective institutions in enhancing resilience under liberalized systems requires further investigation, particularly regarding the conditions under which cooperatives succeed or fail.

Finally, future research should engage more explicitly with threshold dynamics in agroecological systems, identifying tipping points beyond which degradation becomes irreversible or, conversely, where targeted interventions yield disproportionate gains. Such insights are critical for designing adaptive, equitable, and scalable agricultural policies in the context of climate change and ongoing agrarian transformation.

5. Conclusion and Recommendations

5.1 Conclusion

This study has offered a critical, interdisciplinary reading of persistent maize yield gaps in smallholder systems, drawing comparative insights from Sub-Saharan Africa, Asia, and Latin America, with empirical grounding in Trans-Nzoia County, Kenya. Guided by economic anthropology and economic geography, it demonstrates that yield gaps are not simply technical shortfalls but historically produced outcomes of ecological constraints interacting with institutional, spatial, and socio-economic structures.

Across regions, a consistent pattern emerges where strong institutions—extension systems, cooperatives, input regulation, and financial inclusion—exist, ecological stressors are partially absorbed and productivity stabilizes. Where such institutions are weak or fragmented, particularly in liberalized agrarian contexts in Sub-Saharan Africa, market exposure without adequate protection intensifies vulnerability and deepens inequality.

The Trans-Nzoia case reflects this paradox clearly. Despite high agroecological potential, productivity remains constrained by soil degradation, input fraud, gendered inequities in resource access, weakened cooperatives, and uneven market integration. These dynamics reveal that agricultural performance is shaped as much by power, space, and institutions as by biophysical potential. The study therefore challenges techno-centric approaches that frame gaps primarily as input deficits, instead positioning smallholders as embedded actors navigating complex socio-ecological and institutional landscapes shaped by history, policy, and everyday adaptation.

5.2 Recommendations

Closing yield gaps requires a shift from input-centered interventions to systemic, multi-scalar transformation:

1. Reinststate hybrid public extension models that are participatory, gender-responsive, and grounded in co-production of knowledge rather than one-way technology transfer.
2. Regulate liberalized input systems through robust quality assurance, anti-counterfeit enforcement, and transparent public-private-community partnerships that protect smallholders from market exploitation.
3. Advance tenure reforms that recognize both formal and customary rights, with targeted attention to women and youth, linked to incentives for sustainable land stewardship.
4. Scale climate-resilient, low-external-input systems that enhance soil fertility, biodiversity, and adaptive capacity, positioning agroecology as both a scientific and governance framework.
5. Support data systems that track productivity over time and across gender, age, and space to better understand how liberalization, climate variability, and inequality intersect in shaping outcomes.
6. Build collaborative platforms linking universities, farmer organizations, and rural youth to foster locally grounded innovation, critical agrarian knowledge, and socially responsive agricultural transformation.

5.3 Acknowledgements

The author acknowledges the support provided by Kisii University, including access to academic libraries and feedback from colleagues in the Department of Geography and Department of Sociology, Gender and Development Studies. The author also extends gratitude to lecturers in the School of Arts and Social Sciences for their insights on Kenyan maize production dynamics. Special thanks to research assistants for their help with data compilation and coding. No specific grant funded this review.

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