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Editorial: Indigenous and local knowledge as a catalyst for sustainable agriculture and food security

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Editorial on the Research Topic
Indigenous and local knowledge as a catalyst for sustainable agriculture and food security

1 Agriculture in transition: knowledge systems—Merits, limitations, and sustainability

Global agriculture stands at a critical juncture. The twin pressures of ensuring food and nutrition security for a growing population—projected to reach nearly 9.7 billion by 2050 (UNDESA, 2024)—while addressing climate change, biodiversity loss, and land degradation is reshaping food system discourse. Despite advances, over 800 million people continue to experience extreme hunger, underscoring the urgency of systemic transformation.

Agriculture occupies nearly 40% of Earth's terrestrial surface (Ritchie and Roser, 2019), with 5 million hectares of land cleared annually between 2000 and 2020, largely driven by agricultural expansion at cost of declining forests, grasslands, and savannas particularly in tropics (Ritchie, 2021). At the same time, food systems contribute 26–34% of global greenhouse gas (GHG) emissions (Crippa et al., 2021; Ritchie et al., 2022) and impose an economic burden of USD 10–12 trillion annually due to diet-related health costs and inefficiencies (FAO, 2023). These figures highlight the interconnected food–climate–health nexus and the deep structural imbalances across this nexus and economic systems.

Modern agricultural development has largely prioritized technological intensification and monoculture production systems. While these have increased yields, they have also simplified agroecosystems, degraded soils, and contributed to biodiversity loss and dietary homogenization. For instance, from approximately 6,000 plant species historically used for food, current century lost nearly 75% of plant genetic diversity in comparison over the past century, while nine crops account for 66% of global production, with rice, wheat, and maize supplying over half of plant-derived calories (Elouafi, 2024; Ritchie, 2024; Saladino, 2021).

In contrast, Indigenous Peoples and Local Communities (IPLCs) maintain diverse, adaptive, and ecologically embedded agricultural systems. These include polycultures, agroforestry, livestock rearing, rotational farming practices, and community-based resource management developed through generations of ecological observation and experimentation (FAO, 2021, 2024). Diversified systems can yield 20–60% more than monocultures (Koohafkan and Altieri, 2010), illustrating the fundamental contrast between efficiency-driven agricultural models and resilience-oriented systems rooted in diversity-based approaches and adaptability.

Globally, Indigenous Peoples (IPs) manage around 35% of the world's land surface (IPBES, 2019) and safeguard nearly 80% of biodiversity (Vijayan et al., 2022). Their territories, including in regions like the Amazon Basin, IPLCs contribute significantly to forest conservation, carbon emission reduction, and climate mitigation (Walker et al., 2020). Indigenous People's food systems (IPFS) and their indigenous and local knowledge (ILK) also sustain diverse crops, livestock, neglected and wild edibles, reinforcing both food security and cultural identity (Matla et al., 2026; Dhyani et al., 2026).

The importance of ILK is further reflected in global crop diversity conservation. Over 7 million germplasm accessions are stored worldwide in 1,750 repositories (FAO, 2010; Zhao et al.), many derived from traditional landraces and farming systems. Examples such as the revival of the aromatic rice landrace *Kalanamak* in India demonstrate how ILK strengthens rural livelihoods, future crop resilience, and climate adaptation strategies (Nayak et al.). Likewise, traditional agroecosystems—including terraces, raised-field agriculture, polyculture, agroforestry, and indigenous multipurpose tree integration—continue to provide ecosystem services including soil fertility, microclimate regulation, and biodiversity conservation (Altieri, 2004; Dubey et al., 2020; Mpofu et al.).

Despite these contributions, ILK remains marginalized in mainstream policy and practice (Rai et al., 2024). Development models often overlook its socio-cultural and ecological dimensions, contributing to land dispossession, environmental degradation, knowledge erosion, and socio-economic exclusion (Fernández-Llamazares et al., 2021; Mishra et al., 2021). ILK is markedly under-documented and is also increasingly threatened by urbanization, land-use change, and generational shifts, leading to the erosion of intergenerational knowledge systems- also termed as shifting baseline syndrome (Swiderska et al., 2022; Knorr and Augustin, 2025; Lyver et al., 2021).

Indigenous farming communities possess nuanced and place-based understandings of climatic variability, seasonal indicators, and ecological signals that inform agricultural decision-making (Rodríguez-Díaz et al.). In several states of India, for instance, local communities have developed innovative practices such as double transplantation to sustain and enhance rice production under changing climatic conditions (Dubey et al., 2023). Similarly, tribal farmers cultivating traditional millet varieties have evolved climate-responsive practices and drought-tolerant crops—such as finger millet (*Eleusine coracana* L.) and pearl millet (*Pennisetum glaucum* L.)—that enhance resilience to rainfall variability and temperature fluctuations while also providing important nutritional benefits (Chapke, Satyavathi, Babu et al.; Chapke, Satyavathi, King et al.). However, the simplification of food systems and loss of traditional crops have contributed to nutritional decline and cultural erosion (Wood et al., 2023). Furthermore, ILK systems face growing challenges from socio-economic change, land-use shifts, urbanization, infrastructure expansion, and youth migration, leading to erosion of intergenerational knowledge (Sangha et al.).

These challenges call for a shift toward pluralistic knowledge systems that integrate scientific and Indigenous approaches. Rather than viewing them as dichotomous, scholarship increasingly emphasizes their complementarity and co-production (Agrawal, 1995; Lam et al., 2020). Integrated landscape and seascape approach in eastern coastal Taiwan further demonstrate how biodiversity conservation, food production, and community livelihoods can be aligned through participatory planning and frameworks and knowledge co-production (Karim and Lee).

This editorial synthesizes 27 contributions from diverse geographies, highlighting three key insights: (i) ILK enhances resilience through diversification and ecological adaptation; (ii) ILK is deeply embedded within socio-cultural and institutional contexts shaping how communities respond to environmental and economic changes; and (iii) ILK integration with scientific knowledge offers promising pathways for sustainable, just, and inclusive food system transformation as illustrated in Figure 1. Such integration is critical to tackling interconnected, cascading challenges across food, biodiversity, climate, soil, water, and health systems, while accelerating progress toward global goals and targets for 2030 and beyond (IPBES, 2024).

2 Indigenous and local knowledge pathways for resilient food systems across diverse global landscape

Across regions, IPLCs continue to adapt agricultural practices in response to environmental and socio-economic changes. These adaptations combine traditional ecological knowledge with emerging opportunities for innovation, strengthening livelihood resilience and food security.

Studies of rural households highlight how livelihood assets, social networks, and adaptive capacity shape resilience to food insecurity and environmental shocks (Abebe et al.). Diversification strategies—including mixed cropping, livestock rearing, and supplementary income sources—enhance farming households' resilience to shocks (Munyoro). In some regions, Strong linkages between livelihood strategies and farmland efficiency further illustrate the integration of ILK within socio-ecological systems, and livelihood choices (Liu et al.). Importantly,

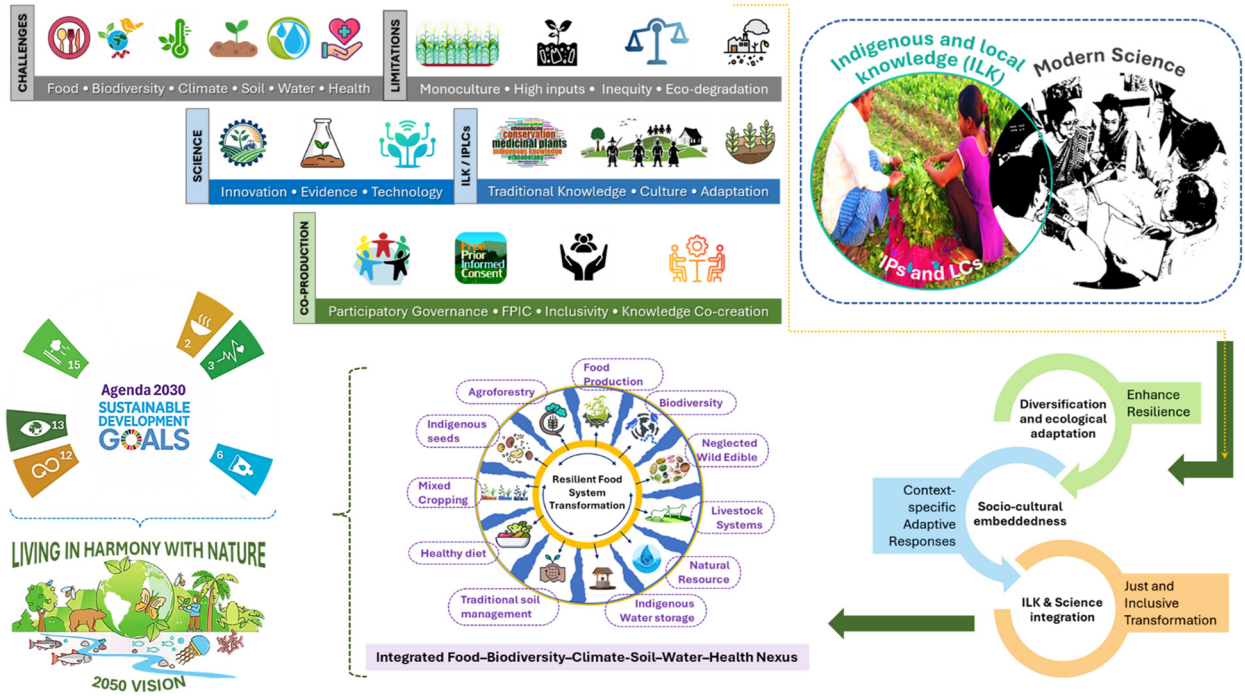


FIGURE 1
Conceptual framework illustrating how integrating Indigenous and Local Knowledge (ILK), embedded within Indigenous Peoples and Local Communities (IPLCs), with scientific knowledge fosters resilient and inclusive food system transformation, addresses interconnected challenges, and directly contributes to the United Nations Sustainable Development Goals–particularly SDGs 2 (Zero Hunger), 3 (Good Health and Wellbeing), 6 (Clean Water and Sanitation), 12 (Responsible Consumption and Production), 13 (Climate Action), and 15 (Life on Land), while indirectly supporting other goals, in line with the 2050 vision of living in harmony with nature (Sekar, 2025).

such resilience is increasingly understood within globally interconnected food systems influenced by trade, climate, and market forces, highlighting the need for systems-based approaches that recognize interdependencies across scales (Wood et al., 2023).

Policy frameworks also shape adaptive livelihood transitions within local communities (LCs). In China's Yangtze River basin, fishing bans have encouraged shifts toward alternative livelihoods such as ecological agriculture, supported by insurance schemes, training programs and institutional mechanisms (Wang et al.). Such examples highlight sustainable livelihood transformations is not solely determined by economic assets but also by governance and policy interventions which are closely linked to social capital, knowledge systems, adaptive capacities embedded within ILK.

Climate variability remains a major challenge, yet ILK offers locally grounded adaptation strategies. In southern Chile, for instance smallholder farmers employ drought-resilient practices such as crop diversification, soil moisture and water management rooted in traditional knowledge and community-based learning systems (Kaulen et al.). These approaches are increasingly critical as increasing frequency of climate shocks disrupt food systems, supply chain, affect prices and exacerbate vulnerabilities across food–water–health linkages (Haynes et al., 2025).

ILK also informs soil management practices, including organic amendments and nutrient cycling, supporting long-term soil fertility and productivity (Setsoafia et al.). These practices reflect a deep understanding of biodiversity, soil health, nutrient cycling, and climate resilience within everyday farming systems agricultural decision-making across IPLCs.

Indigenous agricultural systems play a crucial role in conserving biodiversity. Traditional landscapes in the Yucatán Peninsula maintained by Maya communities support significantly higher biodiversity than modern monocultures (Rosado-May et al.), while Indigenous stewardship contributes significantly (nearly 80%) to global biodiversity conservation (Vijayan et al., 2022). In a similar context, the cultivation of Bambara groundnut in Namibia has been demonstrated to be largely gender-neutral in terms of production, although specific roles and responsibilities for men and women persist, reflecting the social organization and knowledge transmission embedded within ILK systems (Pasipanodya et al.). Likewise, historical agricultural knowledge and traditional crop varieties continue to play a critical role in maintaining genetic diversity within global food systems (Zhao et al.). Such diversity is particularly important considering global dietary simplification given the global reliance on a narrow set of crops, and it highlights IPLCs central role in maintaining food–biodiversity–climate linkages.

Livestock systems further illustrate ILK's contributions. Studies among small-scale livestock farmers demonstrate how indigenous breeds of cattle, goats, sheep, and poultry support food security, cultural identity, and income resilience under harsh conditions (Kone et al.; Nontu et al.). Such systems highlight the importance of biocultural diversity, where livestock, landscapes, and cultural practices co-evolve, supporting resilience across food, health, and livelihood dimensions. Pastoral practices such as seasonal

transhumance and rotational farming practiced historically by Yörük pastoralists in Türkiye further illustrate how ILK sustain ecosystems and livelihoods, though they face increasing pressures due to socio-economic changes and land-use transformations (Per et al.). These systems underline the importance of locally adapted breeds and mobility-based practices in sustaining livelihoods under environmental stress. Similarly, Indigenous communities in the Andean region continue to cultivate native potato varieties within rotational farming systems that sustain soil fertility while preserving crop diversity (Potter et al.).

Agroforestry is another domain in which Indigenous land management practices demonstrate strong ecological and economic benefits. In the Peruvian Amazon, for instance, cocoa cultivation with native shade trees such as *Amburana cearensis* L. and *Cedrela odorata* L. enhance productivity, biodiversity, and income diversification (Gurbillón et al.). Forest-dependent communities also demonstrate how Indigenous ecological knowledge informs resource stewardship. Among the Suku Anak Dalam community in Indonesia, traditional practices such as selective harvesting, sustainable hunting, and forest resource regeneration reflect a deep understanding of ecosystem dynamics and contribute to both food security and biodiversity conservation (Ginting et al.). These systems reflect principles of reciprocity and stewardship embedded in Indigenous worldviews where sustainable resource use is guided by spiritual dimensions and cultural norms of stewardship, sharing, and respect for nature offering insights often absent in reductionist scientific frameworks (Teixidor-Toneu et al., 2023).

Although ILK is increasingly recognized as a legitimate knowledge system, its effective integration depends on participatory governance, knowledge co-production, and inclusive decision-making among communities, researchers, and policymakers as demonstrated through landscape level initiative (Karim and Lee). At the same time, hybrid frameworks that combine ILK with analytical tools are emerging as promising approaches for evaluating development interventions in culturally appropriate ways (García-Vázquez et al.). Such collaborative approaches are essential for addressing global food system challenges, which currently impose significant economic, health, and environmental costs, including diet-related diseases and ecosystem degradation (FAO, 2023). However, challenges such as land-use change, infrastructure expansion, and human–wildlife conflict caused by elephants, wild boars, and deer continue to threaten Indigenous livelihoods (Manikandan et al.). While hybrid solutions that integrate traditional practices with modern technologies—such as solar fencing, sensor-based alarms, and remote monitoring—can strengthen wildlife management, rapid infrastructure development may reshape community–environment relationships and influence conservation attitudes (Musa et al.).

Technological interventions can enhance productivity when aligned with local knowledge systems (Liao et al.), emphasizing the importance of context-specific solutions. At the same time, ILK remains under documented, despite its vast biodiversity knowledge—evident in the recognition of over 1,000 edible plant species in Türkiye compared to number recorded in global repositories such as Kew's global database (300–500 species) (Nguyen et al.). This reinforces the need for more inclusive knowledge systems and documentation approaches (Teixidor-Toneu et al., 2023).

3 From tradition to transformation: ILK in future food systems

Evidence across contexts and diverse agricultural landscapes demonstrates that IPLCs and their ILK systems is central to building resilient, sustainable, and equitable food systems. These knowledge systems reflect long-standing relationships between communities and ecosystems, supporting practices such as seed conservation, water management, and livestock integration.

At a global scale, ILK is critical for addressing interconnected challenges including food insecurity, biodiversity loss, climate change, and human health. Its dynamic and adaptive nature—evolving through intergenerational learning and experimentation—enhances its relevance for future food system innovation (Teixidor-Toneu et al., 2023).

Safeguarding ILK requires more than documentation; it demands recognition of Indigenous rights, cultures, and governance systems, in alignment with frameworks such as the United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP), including adherence to the principle of free, prior, and informed consent (FPIC), ensuring IPLCs approve decisions affecting their lands, territories, and resources (Mitchell et al., 2019). Strengthening collaboration among communities, researchers, and policymakers is essential for enabling inclusive and context-specific innovation. Integration should move beyond simplistic dichotomies and instead promote co-produced knowledge systems that enhance decision-making across scales. Insights from tropical and subtropical case studies in this research topic highlight ILK's role in inclusive agricultural transitions, with further research from the Global North needed to strengthen comparative understanding.

As current food systems continue to generate environmental and economic costs while failing to ensure equitable nutrition, transformative change is imperative. Reframing agricultural innovation systems to incorporate ILK involves strengthening land rights, supporting participatory research, and embedding ILK within policy frameworks.

Equally important is adopting rights-based and participatory approaches that position IPLCs as active agents in decision-making processes (Gunn, 2021). Efforts to document, share and support ILK must balance preservation with lived practice and approaches, ensuring that knowledge transmission remains rooted in relationships with ecosystems while enabling broader learning and collaboration (Benyei et al., 2020).

Ultimately, sustainable food system transformation will depend not only on technological advancement but on the meaningful integration of diverse knowledge systems. Re-centering ILK offers a pathway to reconnect food, biodiversity, climate, soil, water, and health systems, enabling more resilient, inclusive, just, and sustainable futures.

Author contributions

PKD: Conceptualization, Investigation, Validation, Visualization, Writing – original draft, Writing – review & editing. AM: Validation, Writing – original draft, Writing – review & editing. DS: Validation, Writing – original draft, Writing – review & editing. MKU: Validation, Writing – original draft, Writing – review & editing. PKJ: Validation, Writing – original draft, Writing – review & editing. RS: Validation, Writing – original draft, Writing – review & editing.

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Conflict of interest

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