frontiers | Frontiers in Sustainable Food Systems

TYPE Editorial
PUBLISHED 07 March 2025
DOI 10.3389/fsufs.2025.1561449

OPEN ACCESS

EDITED AND REVIEWED BY
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RECEIVED 15 January 2025
ACCEPTED 11 February 2025
PUBLISHED 07 March 2025

CITATION
Kassawmar T, Desta G, Tadesse M, Teferi E, Kaba M, Suryabhagavan KV and Shiferaw A (2025) Editorial: Evidences (states and experiences) of land management and food/nutrition (in)security in mixed farming systems: a global perspective.
Front. Sustain. Food Syst. 9:1561449.
doi: 10.3389/fsufs.2025.1561449

Editorial: Evidences (states and experiences) of land management and food/nutrition (in)security in mixed farming systems: a global perspective

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KEYWORDS

rainfed agriculture, mixed farming, land use, land management, sustainability, livelihood, food security, nutrition security

Editorial on the Research Topic
Evidences (states and experiences) of land management and food/nutrition (in)security in mixed farming systems: a global perspective

The world is not on track to meet sustainable development goals for ending hunger, food insecurity, and malnutrition by 2030, with billions still lacking access to nutritious, safe, and sufficient food (Assefa et al., 2017; Iversen et al., 2023). The need to increase agricultural productivity in response to growing population has become a global concern (Wirsenius et al., 2010). As the world faces rapid population growth, climate change, and evolving market dynamics, rainfed farming systems are under increasing pressure to meet the growing demand for food and nutrition while also addressing the urgent need for environmental sustainability (Tully and Ryals, 2017). The challenge is not only to expand cultivated land and enhance agricultural productivity but also to manage land resources in ways that promote long-term ecological health, food security, and resilience to external shocks (Wani et al., 2009). One major sustainability issue is the limited agricultural space, which has become a critical concern as it is increasingly difficult to accommodate the growing of rainfed dependent rural population (Midmore, 2010). Expanding the arable landscape has been a vital strategy, but studies show that horizontal land expansion alone will not sustainably guarantee food security (Pretty, 1999). Ontop of limited agricultural space, mismanagement and progressive degradation of cultivated landscapes have worsened food insecurity, especially for smallholder farmers in developing countries (Zerssa et al., 2021). While conventional ways of enhancing grain productivity requires context-specific, innovative land use and management systems, yet effective solutions remain unclear (Wani et al., 2009). Recent recommendations underline that financing for food security and nutrition, along with effective tracking and innovative

financing methods, is crucial for increasing investments needed to eradicate hunger and malnutrition (Iversen et al., 2023; Raj et al., 2022). The objective of the Research Topic were; (1) to explore innovative land use and management solutions to improve rural livelihoods and boost grain production, (2) to document the failures and success stories of land management strategies practiced across diverse regions of the world and finally (3) by highlighting the prevailing challenges in applying effective land use and livelihood systems, like the scalability issue, and indicating the need to co-designing of context and tailored land management solutions and (4) to identify and asses opportunities and challenges of addressing food security issues.

Aiming to understand the challenges and opportunities of sustainable land management on food security, this editorial strive to compile about 23 researches with varied in content, themes and problem addressed. The key issues and findings from these articles are grouped into four sub-themes namely; spatiotemporal dynamics of crop production, sustainable land and green water management, agricultural land management, productivity and Livelihood, and land tenure, gender and governance issues and their implications on food security. The geographic distribution of these research articles is depicted in Figure 1. This editorial systematically synthesizes key findings of research articles published on *"Land Management and Food/Nutrition (In)Security in Mixed Farming Systems*" Research Topic and presents as follows.

Spatiotemporal cropping systems dynamics and intensification strategies

Sustainable global food systems face multiple challenges, grain production declines in various parts of the world both size and productivity, although there is slight cropland area expansion in some regions. In many rainfed-dependent areas, the gap between cropland availability and grain demand remains large (Kassawmar, Tadesse et al.). Studies from Ethiopia and China indicate rainfed supporting landscapes have significant potential to boost grain production. In Ethiopia, about 60% of land is rainfed, providing an opportunity to address food insecurity and landlessness, but only 33% is cultivated due to biophysical, socio-economic, and institutional challenges (Kassawmar, Tadesse et al.).

On the other hand, a study in Ethiopia's Upper Blue Nile Basin found that cropland has increased by 10% since 1985, a small change compared to the population doubling every two decades (Kassawmar, Teferi et al.). However, the impact of increased grain production from efficient cropping systems like residual farming is greater than that of cropland expansion, despite receiving little attention from the government. A study in Northern China analyzed cropland changes over 40 years, revealing about 52 thousand km^2 expansion in grain-producing areas, primarily on black cotton soils, despite significant cropland loss from urban expansion, although struggles with land aggregation and biodiversity loss (He et al.). Such scientific evidences offer opportunities to invent appropriate land management systems. They underpin the importance of policy support for land and water management strategies, especially expansion of croplands in low-elevation areas and multiple cropping systems in black cotton soils and floodplains.

Research findings compiled from 134 countries showed that sustainable intensification requires a combination of strategies tailored to local contexts and environmental conditions, rather than a single practice (Mabhaudhi et al.). In rainfed and mixed farming systems, diversified grain production strategies are essential as they have great potential to cop climate change risks while enhancing multiple ecosystem services. In Ethiopia, intensifying rainfed farming systems through multiple cropping systems can better address landlessness and food security than technological and capital intensive options like irrigation (Kassawmar, Tadesse et al.). Combining intensification strategies like multiple cropping and mixed farming, along with land management practices such as land restoration and utilizing marginal landscapes, can boost agricultural productivity and ecosystem services. However, this requires investment in extension services and farming technologies.

Given the challenges of efficiency, productivity, and political or technological barriers to expanding cropland, the focus should be on implementing multiple-harvest strategies on existing cultivated lands (Kassawmar, Tadesse et al.). A study in northwestern Ethiopia found that since the 1990s, smallholder farmers expanded eucalyptus plantations into croplands, but reverse the trend by 2017/18 due to market changes (Zeleke et al.). An interesting lesson found from this study was, clearing eucalyptus plantations led to higher yields than continuously plowed cereal fields, challenging the belief that eucalyptus harms productivity (Daba, 2016). The study found that converting cropland to eucalyptus led to significant grain losses at various scales, while also raising unexpected and controversial land tenure issues. This indicates that smallholders often prioritize short-term economic factors over long-term ecological and social concerns, highlighting the need for adaptive, context-specific land management strategies (Zeleke et al.).

Sustainable agricultural land and green water management

Managing land and water, key natural capitals in agriculture, is a critical global research focus. A major challenge in sustainable food systems is balancing land use for competing needs like food, feed, timber, and energy. This has led researchers to explore effective strategies for managing agricultural land and green water (Kassawmar, Tadesse et al.). According to Kassawmar, Tadesse et al., unlocking the potential of Ethiopia's rainfed landscapes could enhance food security and support millions more people. A study on land use strategies in Ethiopia's rainfed cropping area found that 60% of the country is rainfed, offering significant potential to combat food insecurity and landlessness. While 33% of this area is used for grain production, supporting 120 million people, the remaining 67% of uncultivated land could benefit millions more smallholders (Kassawmar, Tadesse et al.). The study revealed that 16% of the uncultivated land is suitable for crop production, but requires technological investments and addressing political challenges. The study emphasizes the need for a holistic approach to agricultural development, acknowledging the links between land, water, and food security.

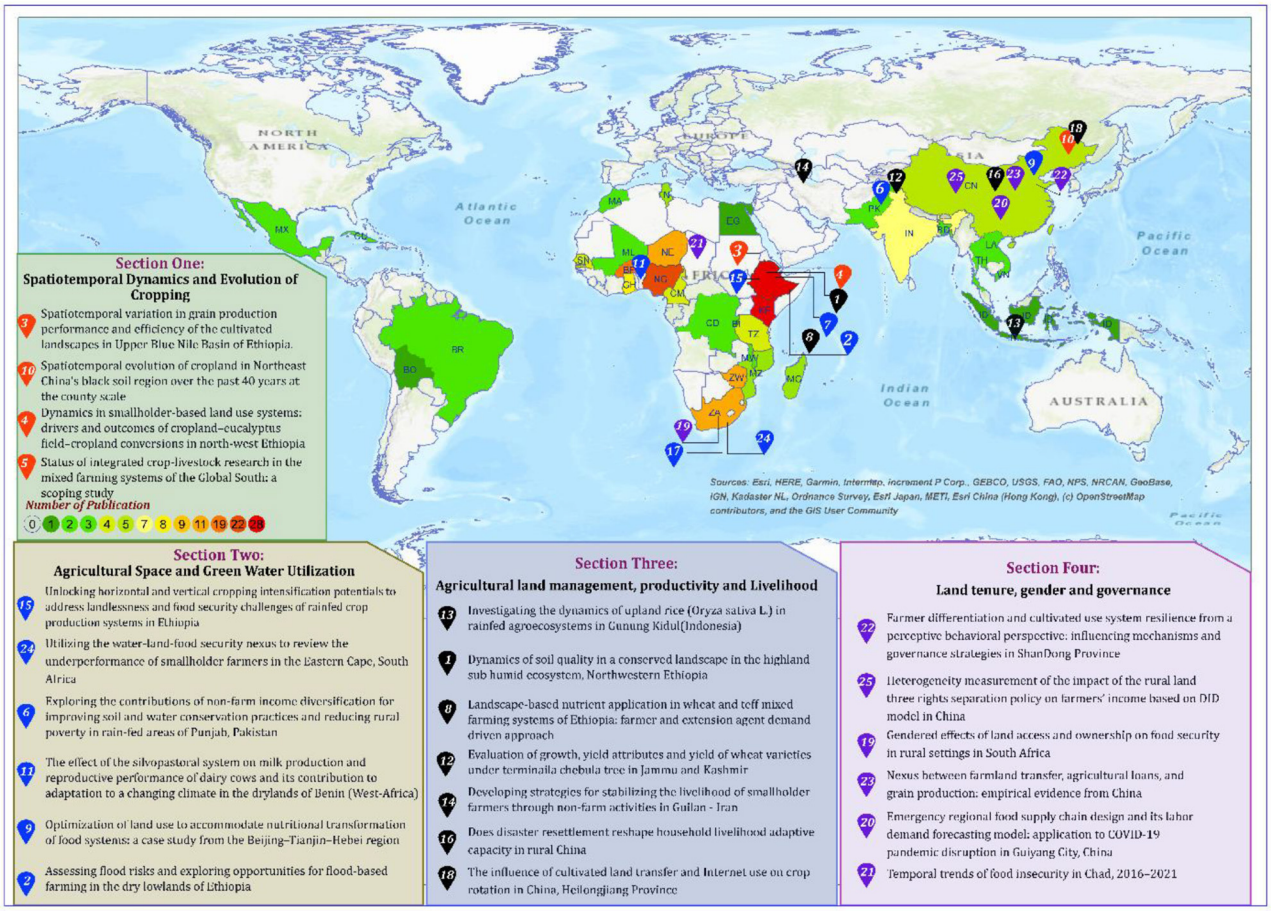

FIGURE 1
Spatial distribution and global representation of the research articles included in this Research Topic.

Another study in Eastern Cape, South Africa, found that inadequate adaptation strategies by smallholder farmers resulted in poor land use performance, limiting resource optimization for food security (Tantoh and McKay). A study from Ethiopia highlights the potential for expanding cropland through efficient systems like residual farming. However, it suggests that producing more grain is more achievable through efficient multiple cropping practices than by simply expanding agricultural land. Smallholders can benefit more by utilizing marginal areas through soil and water conservation measures and adopting multiple cropping systems such as residual moisture farming, flood farming, short rainy season farming, agroforestry, and mixed cropping (Kassawmar, Teferi et al.; Desta, Legesse, Ahmed et al.). Non-crop farming systems, such as livestock farming and eco-tourism, are also have untapped potentials to ensure resilient livelihood systems. A study from Benin, West Africa, found that agroforestry, combining trees with livestock, is an effective strategy for optimizing land and green water (Assani Seidou et al.).

Effective land and water use can be achieved through evidence-based planning aligned with food security and environmental goals. A study in China's Beijing-Tianjin-Hebei region shows that a balanced land allocation strategy, emphasizing crop diversity for better nutrition, reduces land fragmentation and enhances food security (Wang et al.). Another study from Ethiopia show that integrated, data-driven approaches—through landscape segmented flood risk management and flood farming techniques can strengthen smallholder farming systems under drought conditions (Desta, Legesse, Ahmed et al.). These research findings emphasize the importance of smart agriculture and land use planning in optimizing inputs like fertilizers, pesticides, and water, boost productivity while ensuring environmental sustainability. Sustainable agriculture requires balancing economic, social, and environmental goals, focusing on local contexts, and empowering farmers to integrate adaptive farming with food and environmental objectives. This requires huge investment on innovations and strengthening spatial technology applications.

Soil health management and innovations for improved productivity and livelihood: opportunities and challenges

In the pursuit of resilient livelihoods and sustainable farming, studies in India, Ethiopia, China, and Pakistan have

highlighted the importance of innovative farming practices. Effective land management, including soil health management, conservation practices, and agroforestry, can enhance soil health and productivity, contributing to sustainable livelihoods. In Pakistan, using biochar, organic fertilizers, and targeted soil amendments on upland rice helped to narrow down yield gaps and boosting production on nutrient-deficient soils (Santosa et al.). A study from Ethiopia shows that, compared to conventional farms, soil and water conservation practices have greatly improved soil quality in degraded landscapes (Tebeje et al.). However, the overall benefits remain limited, mainly due to lack of integration with other technologies. To ensure long-term benefits of soil and water managements, rainfed based mixed farming needs context-specific strategies. In smallholder mixed farming systems, farmers often face losses from blanket applications of costly fertilizers, as they cannot match fertilizer use with crop nutrient needs. Challenges such as extreme soil variability, lack of spatial evidences, and inadequate knowledge and poor government support hinder effective nutrient management. A study from Ethiopia showed that applying landscape-specific fertilizer at different slope positions significantly increased yield, offering higher profits than blanket applications (Desta, Legesse, Agegnehu et al.). Such and similar approaches help reduce yield gaps and improve nutrient use efficiency, with potential for scaling through further innovations. In contrast, studies from Northeast China highlight the negative impacts of cropland aggregation on soil health, emphasizing the need for better management. A study from India's Jammu region stressed that agroforestry systems provide valuable ecosystem services and enhance rural incomes compared to other cropping systems (Kumar et al.). Despite its benefits, agroforestry is underused due to limited awareness and support, with key technical challenges in optimizing crop-tree spatial arrangements and balancing tree canopies with crops.

While land management efforts focus on boosting grain production and resilient food systems, non-farm activities, limited attention and advocacy given to them is very limited while they are crucial for resilient livelihoods (Baghernejad et al.). Land management approaches, such as integrated farming in Benin and land use optimization in China, show that smallholder mixed farming prioritizes productivity resilience over food security and livelihood resilience. Scholars stress that, to effectively enhance livelihood resilience, exploring non-agricultural income diversification and integrating with agricultural sustainability is critical. Given smallholder based agriculture sector has limited employment opportunities, non-farm livelihoods should be considered although a successful livelihood stabilization is not trivial. As there is a risk of shifting entirely from agriculture to non-farm activities like tourism, a study from Benin highlights the need for careful integration of agricultural with non-agricultural systems and prevent sudden decline of grain production.

The application of advanced technologies like mobile apps and remote sensing have become crucial to promote effective land management practices and improve land productivity. In Ethiopia, a mobile app providing landscape-specific fertilizer recommendations helps optimize input use, increase yields, and enhance farmer profitability (Desta, Legesse, Ahmed et al.). Another study from China demonstrated that, digital technologies have become vital in facilitating agricultural supply and boosting sustainable land use (Liang et al.). Although both land transfer and internet use promote crop rotation, the former has stronger effect in specifically benefiting older farmers, the latter benefits more the younger ones. Promoting crop rotation through stable land rights and incentivized land transfer can boost sustainable livelihoods and productivity.

Inclusive land tenure, gender and governance on land investment, food and nutrition security

Global studies emphasize the role of land governance, tenure systems, and gender in improving agricultural productivity. Adaptive land management is crucial for sustainable development, especially in influencing farmers' behaviors. A case study from China evaluated farmers' perception on the resilience of the cultivated land use system (Wang and Wang) and found that farmers' cultivated land use systems exhibit uneven resilience, generally labeled as low production resilience. Poor production efficiency and limited ecological protection indicate weak functioning of the cultivated land use system. Thus highlights strategic needs to improve production resilience, encourage investment in land resources, promote ecological protection, and enhance willingness for land transfer.

The three rights policy in China's land system reform, has positively impacted rural livelihoods and incomes although the effects vary across farmers group (Hu et al.). Since the inception of the reform, farmers who got more training, have larger croplands, and those growing food crops benefit the most by the policy. Although further research is needed to fully understand the direct impacts of the policy, the findings unveiled directly linkage of income with investment, credit access, and non-agricultural employment opportunities. A study using provincial data from China found that farmland transfer and agricultural loans positively correlate with grain production, though agricultural loans have a negative effect (Ding et al.). This suggests that financial access enhance farmland efficiency and grain production, emphasizing the need for government support in land reforms and agricultural finance.

Another study in South Africa, where there is critical gender related land issues, rural women's have limited access to land, hindering their economic opportunities (Masuku et al.). Gender disparities in land access remain a significant challenge in rural South Africa, as customary law challenges women in acquiring equal land ownership. Land reform for equal access is essential for reducing food insecurity and promoting gender equality in agriculture (Ding et al.). Evidences from a case study in China, support the importance of land transfer, which promotes crop rotation and improved land use, while addressing land ownership issues. These findings urge developing countries like South Africa to create land policies that address gender disparities in land access and ownership, as they negatively affect food security. Lessons learned during COVID-19 pandemic highlights that the disruption of global food supply chains during global shocks can only be addressed by building food supply systems proactively (Tian and Mei). A study from Chad showed that while food insecurity had been rising before the pandemic, food security improved after the

shock, indicating the impact of increased awareness and knowledge gained from the pandemic's effects (Kang et al.).

In summary, an important concluding remark from the synthesized scientific evidences is that appropriate land use systems and efficient agricultural water management strategies alone cannot enhance incomes and ensure sustainable food system. Rather access to land, markets, financial resources, and extension services are also essential, especially empowering women, are key to sustainability. Besides, to promoting regenerative agriculture and multiple cropping systems authors underline the importance of promoting non-farm activities as they can play crucial role in stabilizing livelihoods and boosting resilience of food systems. Technologies like remote sensing, GIS, and mobile tools can leverage precision farming, and further enhance crop yields and environmental sustainability. Promoting agricultural technology and digital literacy, specifically rural digitalization, help young farmers adopt sustainable practices and further improve productivity and safeguard food supply chains.

We hope this Research Topic of articles on emerging agricultural practices and ways to sustain food production will be useful to scientists, agricultural educators, government regulators, and other relevant stakeholders of food production. We also hope that they will serve as a good course on a global scale to help mitigate improper land use and management, especially on crop production. Authors believed that these published articles are going to impact to a wide range of readers with an insight into practical sustainable agricultural land and water management and technologies among the smallholder farming systems. Authors recommended more in-depth, systematic assessment that spans local, continental, and global scales is crucial because:

1. **Local Scale**: The conditions and challenges at the local level often differ significantly, so it's essential to tailor strategies to local needs. For example, water availability, soil fertility, and access to energy resources vary from region to region and need to be considered in food systems.
2. **Continental Scale**: At the continental level, broader patterns such as climate variability, population growth, and economic trends come into play. Continental policies and infrastructure can also impact resource use and distribution, and solutions need to consider trade, policy coordination, and regional cooperation.
3. **Global Scale**: Global factors such as climate change, international trade agreements, and global supply chains influence resource availability and food security across regions. Policies that consider these interconnected global challenges can help in fostering a more equitable and sustainable food system.

By looking at the land-water-food-energy nexus across all these scales, we can identify trade-offs, synergies, and solutions that balance the demand for food, water, energy, and the health of ecosystems. It requires interdisciplinary efforts combining agricultural, environmental, and socio-economic perspectives, as well as robust data collection, monitoring, and modeling to ensure long-term sustainability.

Author contributions

TK: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. GD: Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. MT: Conceptualization, Investigation, Supervision, Visualization, Writing – original draft, Writing – review & editing. ET: Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. MK: Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. KS: Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. AS: Supervision, Visualization, Writing – original draft, Writing – review & editing.

Acknowledgments

The authors thank the contributors of the Research Topic that pinpoint global evidences highlighting the land management opportunities and constraints for food and nutrition security.

Conflict of interest

The authors declare that this editorial article is developed in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

References

Assefa, Y., Van Damme, W., Williams, O. D., and Hill, P. S. (2017). Successes and challenges of the millennium development goals in Ethiopia: Lessons for the sustainable development goals. *BMJ Global Health* 2:2. doi: 10.1136/bmjgh-2017-000318

Daba, M. (2016). The Eucalyptus dilemma : the pursuit for socio-economic benefit versus environmental impacts of eucalyptus in Ethiopia. *J. Nat. Sci. Res.* 6:19. doi: 10.4172/2157-7617.1000366

Iversen, T. O., Westengen, O., and Jerven, M. (2023). Measuring the end of hunger: Knowledge politics in the selection of SDG food security indicators. *Agricult. Hum. Values* 40:3. doi: 10.1007/s10460-023-10418-6

Midmore, D. (2010). "Rainfed agriculture: unlocking the potential," in *Comprehensive Assessment of Water Management in Agriculture Series 7*, eds. S. P. Wani, J. Rockstrom and T. Owels (Wallingford: CABI), 310.

Pretty, J. (1999). Can sustainable agriculture feed africa? New evidence on progress, processes and impacts. *Environm. Dev. Sustainab.* 1, 3–4. doi: 10.1023/A:1010039224868

Raj, S., Roodbar, S., Brinkley, C., and Wolfe, D. W. (2022). Food security and climate change: differences in impacts and adaptation strategies for rural communities in the global South and North. *Front. Sustain. Food Syst.* 5:691191. doi: 10.3389/fsufs.2021.691191

Tully, K., and Ryals, R. (2017). Agroecology and sustainable food systems nutrient cycling in agroecosystems: balancing food and environmental objectives. *Agroecol. Sustain. Food Syst.* 41:1336149. doi: 10.1080/21683565.2017.1336149

Wani, S. P., Rockström, J., and Oweis, T. (eds.) (2009). "Rainfed agriculture: unlocking the potential," in *Rainfed Agriculture: Unlocking the Potential* (Wallingford: CABI), 310. Available at: https://www.mendeley.com/catalogue/381b1033-3699-3868-b1cb-7272d8ad4686

Wirsenius, S., Azar, C., and Berndes, G. (2010). How much land is needed for global food production under scenarios of dietary changes and livestock productivity increases in 2030? *Agricult. Syst.* 103:5. doi: 10.1016/j.agsy.2010.07.005

Zerssa, G., Feyssa, D., Kim, D. G., and Eichler-Löbermann, B. (2021). Challenges of smallholder farming in Ethiopia and opportunities by adopting climate-smart agriculture. *Agriculture* 11:192. doi: 10.3390/agriculture11030192