Journal of Integrative Agriculture 2026, 25(2): 399–401

Available online at ScienceDirect

Journal of Integrative Agriculture



EDITORIAL

Ecosystem management and agricultural green development in subtropical regions

The United Nations Sustainable Development Goal (SDG) 2 aims to achieve Zero Hunger by 2030. However, global hunger and food insecurity have continued to rise at an alarming rate (UN 2023). Subtropical regions are home to more than 30% of the world's population, predominantly in developing countries where per capita farmland and food supply are only 40% of those in developed nations (FAO 2018). Meeting the Zero Hunger target amid ongoing population growth in these regions requires a substantial increase in agricultural production while minimizing soil degradation and adverse ecological impacts. This challenge is shared by many countries across South Asia, Africa, and Central and South America.

Against this background, the 4th International Symposium on Sustainable Agriculture for Subtropical Regions (ISSASR-4) was held from June 21 to 24, 2024, in Changsha, China, hosted by the Institute of Subtropical Agriculture, Chinese Academy of Sciences. The symposium brought together over 300 experts and scholars from nearly 30 countries. Under the theme "Ecosystem Management and Agricultural Green Development in Subtropical Regions", discussions focused on four key topics: (i) regional resources and ecosystem management for enhancing agricultural productivity, (ii) green crop and animal production, (iii) minimizing adverse environmental impacts of agricultural production, and (iv) the growing role of big data, artificial intelligence (AI), and smart farming. Participants exchanged the latest research advances, identified major challenges, and explored countermeasures for agriculture and ecological sustainability in subtropical regions worldwide.

This Special Focus of the *Journal of Integrative Agriculture* (JIA) addresses these pressing issues by presenting empirical evidence and innovative solutions for agricultural green development. It comprises 13 papers covering a wide range of topics related to carbon, nitrogen, and phosphorus pathways in natural and agricultural ecosystems, with attention to microbial processes, land-use change, production management, and their effects on nutrient cycling and grain yield. We hope this collection enhances understanding of ecosystem management and green agricultural development, offering actionable insights for policymakers, researchers, and practitioners.

Section 1: Regional resources and ecosystem management

This section examines three key areas: agricultural bio-resources, soil carbon and nutrient dynamics across ecosystems, and regional grain supply–demand matching. Studies provide insights into bioinput-based agricultural frameworks, soil nutrient responses to climate change and anthropogenic influences, and the dynamic, heterogeneous patterns of grain matching. Vermelho *et al.* (2026) reviewed microbial bioinputs, outlining their categories, mechanisms, global challenges, and Brazil's production infrastructure and regulatory context. Wang M M *et al.* (2026) reported moderate spatial variation with positive autocorrelation in soil organic carbon (SOC), total nitrogen (TN), total phosphorus (TP), and total potassium (TK), noting greater vulnerability to phosphorus and potassium limitation than to nitrogen, with soil properties outweighing spatial or environmental factors in explaining nutrient variation. Another study by Wang L Y *et al.* (2026) identified climate and hydrological changes as key drivers of SOC loss in Dongting Lake, with accelerated loss occurring above 21.4 m elevation, suggesting that managed water levels during droughts could enhance carbon sequestration. Wan *et al.* (2026) showed that plantations can mitigate climate change by increasing carbon storage at the aggregate scale in alpine regions. Miao *et al.* (2026) demonstrated a scale-dependent mismatch in grain supply and demand, highlighting how interregional flows from 1980 to 2020 reduced deficit areas. Together, these studies advance frameworks for sustainable ecosystem management.

Section 2: Green crop production in subtropical regions

Enhancing green crop production in subtropical regions requires practices that improve soil health and carbon sequestration while sustaining yields. Given the vulnerability of subtropical croplands, effective strategies for maintaining SOC are critical. Hua *et al.* (2026) found that long-term

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doi: 10.1016/j.jia.2025.12.026

livestock manure substitution improves soil aggregate stability and reduces water erosion but increases lateral loss of labile organic carbon, revealing a trade-off. Kautsar *et al.* (2026) reported that terrace reconstruction altered rice yields between field sides and modified SOC, TN, and decomposition dynamics in the 15–30 cm layer, with subsoil fertility determining productivity. Wang J *et al.* (2026) demonstrated that massive granulated straw incorporation boosts SOC and crop yield in infertile soils, with accumulation efficiency ranging from 30.8 to 60.0%, primarily from plant residues. These studies highlight practical pathways for sustainable soil management.

Section 3: Environmental impacts of agricultural production

Assessing and mitigating agriculture's environmental footprint requires a multiscale understanding of soil ecological processes. Pan *et al.* (2026) found that natural restoration enhances karst soil phosphorus-cycle multifunctionality more than artificial restoration or cropping, driven by increased SOC and bacterial network complexity, with rare *phoD*-harboring taxa playing a critical role. Wang Y *et al.* (2026) reported that niche outweighs genotype in shaping pea fungal communities, with β-diversity driven by species replacement and deterministic assembly in niche-based groups. Zhu *et al.* (2026) showed that SOC is higher in brown and yellow-brown soils and that spring irrigation significantly increases farmland SOC, supporting carbon sequestration. Zheng *et al.* (2026) demonstrated that spatial factors govern carbon-cycling gene abundances in uplands, while biotic and substrate factors dominate in paddy soils, revealing an integrated "microbial carbon pump" in trace-gas cycling at a continental scale. Collectively, these studies advance understanding of the mechanisms underlying soil functionality and greenhouse gas modulation.

Section 4: Big data, artificial intelligence and smart farming in agriculture

The integration of big data, AI, and smart technologies is pivotal for the digital transformation of agriculture. This section presents a study on their practical application to environmental challenges. Wang M H *et al.* (2026) developed an Android-based decision support system (CNPDSS) to control non-point source nitrogen (N) and phosphorus (P) pollution. Integrating GIS, a Bayesian predictive model, an optimization algorithm, and a smartphone interface, the system identified solutions that minimize both pollutant loadings and engineering costs in the Tuojia catchment, China. Its adaptive design demonstrates potential for broader application, offering a scalable tool for sustainable water quality management.

This Special Focus underscores the critical intersection of ecosystem management and agricultural development in subtropical regions. Through 13 studies organized across four themes — resource management, green production, environmental impact mitigation, and smart technology — the collection provides a science-based framework for enhancing productivity while preserving ecological integrity. It offers concrete insights for achieving sustainable food systems and advancing the UN Zero Hunger goal in some of the world's most vulnerable and vital agricultural landscapes.

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Declaration of competing interest

The authors declare that they have no conflict of interest.

Declaration of generative AI and AI-assisted technologies in the writing process

The authors declare that they did not use AI in the preparation and writing of this manuscript.

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