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A bibliometric analysis of food security and urbanization: insights and implications

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This study conducts a comprehensive bibliometric analysis of the intersection between Food Security and Urbanization (FSU), aiming to identify key themes, emerging trends, and research gaps. Using statistical analysis, co-word analysis, and social network analysis, we map the intellectual landscape and global collaboration networks in FSU research. The findings reveal the dominant contributions from the United States and China, with China's extensive international collaborations highlighting opportunities for future research. A key observation is the disconnect between urbanization and food security studies, underscoring the need for a more integrated approach to research. The study extends Sustainable Development Theory and Urban Metabolism Theory by incorporating socio-economic and environmental dimensions, demonstrating that urbanization's impact on food security differs across developed and developing countries. The research highlights emerging interdisciplinary themes, such as urban agriculture and socio-economic resilience, aligning with SDG 2 (Zero Hunger) and SDG 11 (Sustainable Cities and Communities). This study lays the foundation for future research on the synergies between urbanization and food security, promoting a more sustainable development trajectory.

KEYWORDS

food security, urbanization, bibliometric analysis, sustainable development, no poverty, responsible consumption and production

1 Introduction

Food security is a cornerstone of national stability and sustainable economic growth, serving as a pivotal assurance for global peace, development, and the vision of a shared future for humanity (Tilman et al., 2002). As depicted in Figure 1A, the food security index reveals that the top 20 nations with optimal food security are predominantly developed countries, primarily from Europe and America. In stark contrast, the 20 nations grappling with the most severe food security challenges are chiefly developing nations, with African countries being disproportionately represented (Economist Intelligence Unit, 2018).

Urbanization intricately linked to food security, acting both as a significant influencer and a catalyst for agricultural modernization. It drives national economic growth (Long et al., 2012), and symbolizes a nation's developmental trajectory (Henderson, 2003). A global perspective reveals that countries with advanced urbanization predominantly reside in Europe and North America. Moreover, the urbanization gradient is steeper in high-income nations compared to their low-income counterparts (Figures 1B,C). Empirical research underscores the profound impact of urbanization on food security (Christiansen, 2009; Wang et al., 2018). Specifically, nations with accelerated urbanization tend to exhibit enhanced food security, whereas those lagging in urbanization face exacerbated food security challenges (Masters et al.,

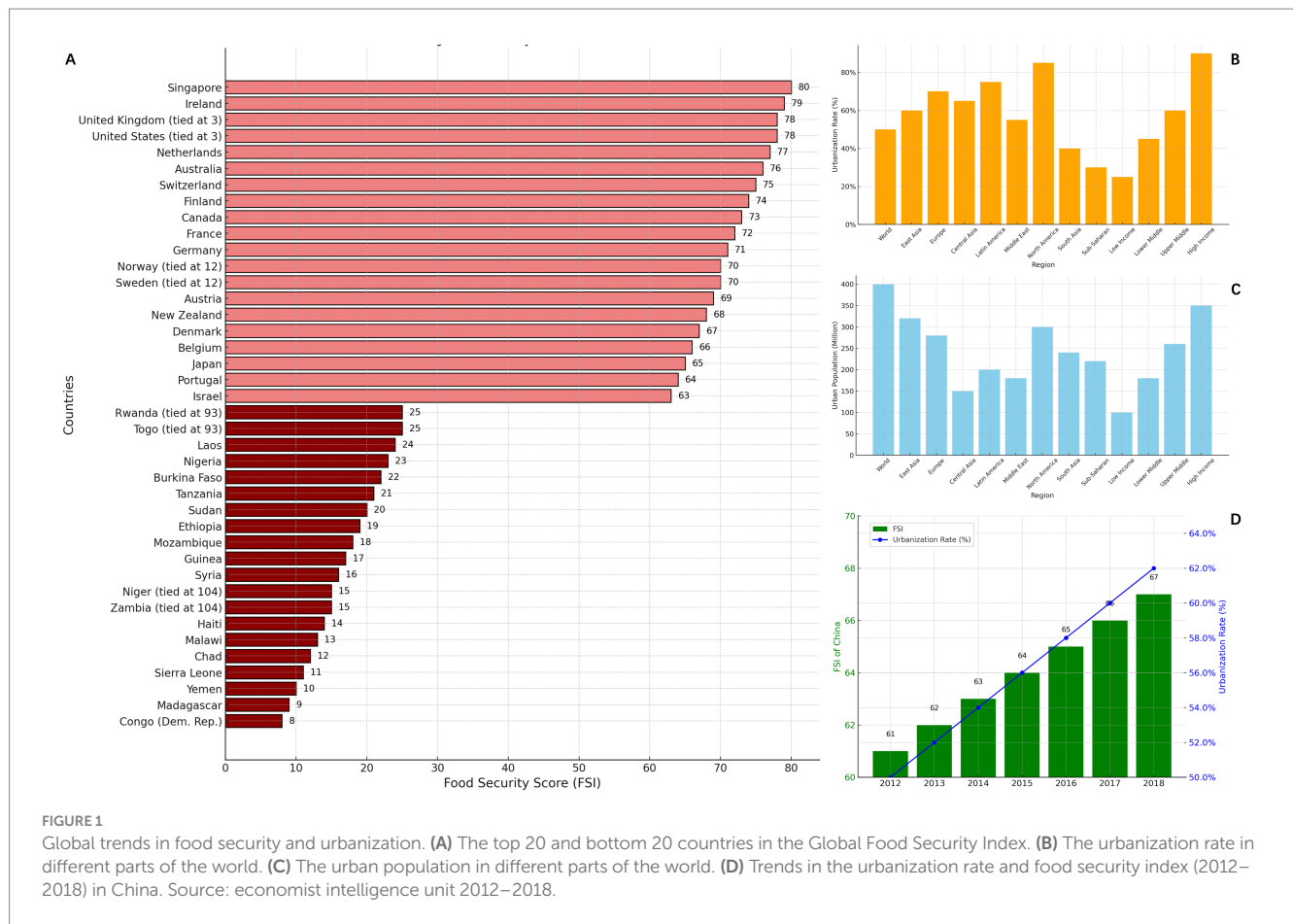


FIGURE 1 Global trends in food security and urbanization. **(A)** The top 20 and bottom 20 countries in the Global Food Security Index. **(B)** The urbanization rate in different parts of the world. **(C)** The urban population in different parts of the world. **(D)** Trends in the urbanization rate and food security index (2012–2018) in China. Source: economist intelligence unit 2012–2018.

2013; Seto and Ramankutty, 2016). China, the world’s most populous developing nation, presents a congruent trajectory of its food security index and urbanization rate (Figure 1D). The meteoric rise of urbanization carries multifaceted implications for food security (Gollin et al., 2016). Urbanization amplifies intrinsic societal demands, spanning housing, healthcare, education, and transportation (Glaeser and Maré, 2001). While technological advancements in urban areas may boost agricultural productivity, urban migration trends simultaneously create a drain on agricultural labor, leaving rural areas vulnerable and undermining food security (Zhang et al., 2016; Xiao et al., 2019).

Despite the growing body of research on food security and urbanization, there remains a significant gap in literature that integrates these two domains comprehensively. While food security studies have often focused on agricultural production, nutrition, or distributional challenges, urbanization research has primarily concentrated on its economic and social dimensions (Keith, 2015, 2016; Ji and Chen, 2017). The interdisciplinary intersection of urbanization and food security (FSU) remains underexplored, despite its potential to offer a more nuanced understanding of how these two phenomena influence each other in complex ways. Bridging this gap is crucial for developing integrated policies that address both urbanization and food security challenges, particularly in rapidly urbanizing regions. This study aims to fill this gap by providing a comprehensive analysis of how urbanization trends intersect with food security challenges globally. Our research highlights the critical role that urbanization plays in

reshaping food systems, thereby contributing to the academic discourse and informing policy decisions related to sustainable development.

To address this gap, our study explores three specific research questions:

- RQ1: What are the thematic structures and evolutionary trends in FSU research? This question aims to track the major themes and shifts in the FSU research landscape over time, mapping how the field has evolved in response to emerging challenges such as climate change and urban expansion.
- RQ2: Which countries, institutions, and funding bodies are leading contributors, and how are their collaborative networks structured? This question addresses the dynamics of global collaboration in FSU research and highlights key players shaping the direction of this interdisciplinary field.
- RQ3: What emerging themes and research directions can be identified, and how might these insights guide future studies on the interconnections between food security and urbanization in different regional contexts? This question highlights the evolving research directions and suggests how these insights could guide future studies on urbanization and food security, especially in diverse regional contexts.

These research questions serve as the foundation for our study, guiding the exploration of the key dimensions and trends in the intersection of food security and urbanization. To empirically test and

validate the underlying relationships suggested by these research questions, we propose the following hypotheses:

- H1: Over time, the thematic structure of FSU research will exhibit greater thematic density and interconnectivity, reflecting the increasing complexity and integration of focus areas such as sustainability and socio-economic impacts, as evidenced by recent trends in the literature.
- H2: Countries with more advanced urbanization and stronger research capacities will occupy central positions in FSU collaboration networks, reflecting their significant influence on shaping research priorities and international cooperation.
- H3: FSU research hotspots are transitioning from a narrow focus on grain production toward more integrated themes encompassing nutrition, environmental sustainability, and socio-economic factors, in response to evolving global challenges.

Our study leverages the VOSviewer software to analyze literature curated from the Web of Science (WoS) database. We construct and visualize key knowledge entities, primarily encompassing institutions, nations, and funding bodies, to identify leading research contributors and elucidate the collaborative matrix within the FSU research field. Through co-word analysis and social network analysis (SNA), we conduct an exhaustive examination of FSU topics and keywords. This methodology not only illuminates prevailing research foci but also uncovers emerging trends and shifts within the field.

The motivation behind this study is to provide an integrated perspective on FSU, both to advance academic understanding and to provide practical insights for policymakers. By mapping the intellectual landscape, collaborative networks, and thematic hotspots of FSU research, we aim to guide future studies and policy interventions that address global challenges in urbanization and food systems. Theoretically, this bibliometric analysis contributes to the existing literature by offering a novel, cross-disciplinary framework that integrates urbanization and food security. It enhances our understanding of how urbanization trends intersect with food security challenges, providing a deeper, interdisciplinary perspective. Practically, this study offers valuable insights for policymakers, funding agencies, and research institutions. It helps to guide the allocation of resources, prioritize international collaborations, and formulate strategies to improve food security in urbanizing regions. This research has important implications for addressing global challenges in urbanization and food systems, making it a critical contribution to sustainable development and food security policy.

2 Literature review

The intersection of urbanization and food security (FSU) is a critical area of study, characterized by complex interdependencies and multifaceted interactions. Food security is defined by the Food and Agriculture Organization (FAO, 1996) as a condition in which all individuals have physical, social, and economic access to sufficient, safe, and nutritious food that meets their dietary needs and food preferences for an active and healthy life. This concept encompasses four main dimensions: availability, accessibility, utilization, and stability, each reflecting different aspects of food systems. Urbanization, on the other hand, refers to the increasing concentration

of populations in urban areas, driven by economic development, industrialization, and rural-to-urban migration (UN-Habitat, 2012). It involves both the spatial expansion of cities and demographic shifts that influence urban food demand, distribution, and the dynamics of food systems. Several theoretical frameworks underpin the relationship between food security and urbanization, providing valuable lenses through which these complex dynamics can be understood.

Sustainable Development Theory emphasizes the need for balancing economic growth with environmental stewardship to ensure long-term food security without depleting natural resources (Grimm et al., 2008). In the context of urbanization, this theory highlights the potential conflict between urban expansion and the sustainable use of agricultural land, resources, and ecosystem services. It underscores the importance of sustainable urban planning that accounts for both urban growth and food system resilience (Foley et al., 2011).

Systems Theory posits that urbanization and food security are integral components of a larger socio-economic system, where changes in one domain can have significant ripple effects on the other (Wang, 2019). According to this framework, urbanization alters economic structures, migration patterns, and infrastructure, which, in turn, influence food production, distribution, and consumption (Ericksen, 2008). This interconnectedness suggests that addressing food security requires a holistic approach that integrates urban and rural policies, as well as environmental and social considerations.

Urban Metabolism Theory examines the flow of resources, including food, energy, and water, into and out of urban areas, highlighting the dependencies and vulnerabilities within urban food systems (Kennedy et al., 2007). This theory offers critical insights into how cities depend on rural areas and global markets for food supply, making urban areas vulnerable to disruptions in these flows. Urban food systems are also influenced by consumption patterns, waste management, and the environmental footprint of cities, which directly affect food security outcomes (Haberl et al., 2011).

Each of these frameworks offers distinct perspectives on the relationship between urbanization and food security: Sustainable Development Theory focuses on the balance between economic growth and resource preservation, Systems Theory highlights the interdependence of urbanization and food security, and Urban Metabolism Theory emphasizes the role of resource flows in urban food systems. Together, they provide a comprehensive lens for exploring this complex interaction.

The relationship between urbanization and food security varies significantly across different regions and socio-economic contexts. Understanding these global trends is essential to recognize the broader implications of urbanization for food systems. Urbanization has been a global phenomenon, with more than half of the world's population now residing in urban areas (UN-Habitat, 2018). Over the past century, urban populations have increased at an unprecedented rate, driven by both natural population growth and rural-to-urban migration (Grimm et al., 2008). In developed countries, urbanization reached its peak in the 20th century, whereas developing nations, particularly in Asia and Africa, are experiencing rapid urbanization today (Seto et al., 2012). This transformation has profound implications for food security.

Historically, urbanization and food security have been closely intertwined. In the early stages of urbanization, the expansion of

cities often led to agricultural intensification and higher food production, particularly in regions with established infrastructure and technological advancements (Fan, 1991). However, as urban areas grow, they place increasing pressure on surrounding agricultural land, leading to land-use changes that may reduce food production capacity (Tun et al., 2015). The challenge of feeding growing urban populations is compounded by the rising demand for more diverse diets and the environmental impact of food systems (Johnston et al., 2014). Urbanization exacerbates food insecurity in regions where food systems are already fragile, stressing the need for integrated urban–rural policies to address both production and consumption needs (Fan et al., 2004). In developed countries, such as those in North America and Europe, urbanization has led to a relatively stable food security situation, largely due to advanced technological integration in agriculture and food distribution systems. In these regions, urban areas are better equipped to manage food demand through efficient global food supply chains (Szabo, 2016). In contrast, developing regions, particularly in Sub-Saharan Africa and South Asia, face significant food security challenges due to rapid urban population growth, limited agricultural innovation, and inadequate infrastructure (Harvey, 2003; FAO, 2018). In contrast, developing countries, particularly in Africa and parts of Asia, face greater food security challenges due to rapid urbanization, weak infrastructure, and insufficient rural–urban integration (Wheeler and Von Braun, 2013; Fanzo et al., 2018).

The existing literature on FSU employs a variety of research approaches, including case studies, policy analyses, and empirical quantitative studies. Many studies focus on specific regions or countries, providing in-depth analyses of how urbanization impacts food security within particular socio-economic and environmental contexts. Methodologically, studies have utilized diverse metrics to assess urbanization and food security, such as urbanization rates, food availability indices, and economic access indicators (He et al., 2017; Wu et al., 2016). However, there is a lack of standardized definitions and measurement approaches across studies, which can lead to inconsistencies in findings and hinder comparative analyses.

A significant gap in the literature is the absence of comprehensive bibliometric analyses that synthesize global research trends and collaboration networks in the FSU domain. While bibliometric methods have been effectively applied to related fields, such as agricultural research and urban studies, their application to the intersection of urbanization and food security remains limited. Notable bibliometric studies in food security include analyses of global research trajectories on specific crops (Giraldo et al., 2019), Sino-UK collaborations in food and agriculture (Zhou et al., 2013), and examinations of agroecosystems (Monasterolo et al., 2016; Liu et al., 2019). However, no such studies have specifically targeted the FSU nexus, highlighting the need for a systematic consolidation of existing research to identify patterns, emerging themes, and potential areas for future investigation.

This study fills this gap by employing a comprehensive bibliometric approach that synthesizes global FSU research trends. Our study not only covers a broader geographical and thematic scope but also integrates data-driven analysis to reveal research trajectories, network structures, and emerging topics that have been underexplored in previous literature.

3 Materials and methods

3.1 Overall research design and methodological rationale

This study employs a bibliometric approach, supplemented by co-word analysis and social network analysis (SNA), to map the intellectual landscape, identify leading contributors, and discern thematic trends in the field of Food Security and Urbanization (FSU). *Bibliometric analysis is well-suited to our research goals because it offers a quantitative and systematic method for examining large corpora of scholarly documents, revealing structures, patterns, and collaborations that may not be readily apparent through traditional narrative or qualitative reviews (Cobo et al., 2011). While systematic narrative reviews and meta-analyses excel in providing in-depth thematic syntheses or in assessing effect sizes of well-defined interventions, they often focus on narrower scopes and may not capture the broad intellectual terrain of a rapidly evolving, multidisciplinary domain (Aria and Cuccurullo, 2017). Similarly, mixed methods approach that combine qualitative and quantitative analyses can yield richer contextual insights (Van Raan, 2014); however, our initial objective was to establish a comprehensive quantitative baseline of the FSU research landscape. Future investigations can build on this foundation, incorporating qualitative or mixed method approaches to delve deeper into specific aspects revealed by our findings.*

3.2 Data sources and retrieval strategy

To ensure authoritative and high-quality data coverage, we selected the Web of Science (WoS) Core Collection, with selected literature sourced from both Science Citation Index (SCI) and Social Sciences Citation Index (SSCI) journals, renowned for indexing leading international journals across multiple disciplines. Given the expansive scope of food security research, we instituted stringent criteria to ensure the inclusion of urbanization-centric results. The search was restricted to peer-reviewed journal articles and reviews written in English to maintain data quality and relevance. The literature search was conducted in January 2024, using the following query to encompass both urbanization and food security dimensions:

“urban*”) AND (“food safety” OR “food security” OR “grain security” OR “safety of grain”)

This query was applied to titles, abstracts, and keywords to ensure a robust capture of relevant literature.

We demarcated our publication timeframe from 1981 through 2019, extracting data on publications, affiliating institutions, geographic regions and nations, funding bodies, and research domains. This data was then collated into a structured database, primed for subsequent statistical analysis. The start year, 1981, precedes the period when food security and urbanization challenges began receiving sustained scholarly attention, allowing us to capture the field’s long-term evolution. The decision to limit the dataset to publications up to 2019 was made to ensure the analysis reflects a mature yet contemporary research period, unimpacted by the sudden global disruptions caused by the COVID-19 pandemic in 2020. The pandemic introduced significant, unforeseen shifts in research priorities and methodologies. For instance, food security and urbanization studies pivoted toward addressing immediate challenges

such as supply chain disruptions, labor shortages in agriculture due to lockdown measures, and altered consumer demand patterns focusing on essential goods. These abrupt changes likely redirected research efforts toward short-term emergency responses rather than the systematic, long-term trends and patterns our study aims to analyze.

The volume and caliber of academic literature can, to a degree, mirror disparities in scientific research prowess and influence. Direct citations of a paper epitomize one of the most salient forms of scholarly recognition, rendering citations a pivotal metric for gaging a paper's academic stature and impact (Eyrewalker and Stoletzki, 2013). Concurrently, the H-index has gained traction as a robust measure to evaluate both the volume and quality of scholarly contributions (Hirsch, 2005, 2010). In light of these considerations, we predominantly employ metrics such as paper count, cumulative citation count, average citations per paper, and the H-index to furnish a nuanced portrayal of the FSU research landscape.

FSU is inherently interdisciplinary, bridging fields such as agriculture, environmental science, economics, sociology, urban planning, and public health. This study focuses on literature that explicitly addresses the interplay between urbanization and food security, thereby isolating a critical area of study.

3.3 Analytical procedures

Following data retrieval, duplicate records were removed using the deduplication feature in WoS. Subsequently, we screened titles and abstracts to ensure that each document substantively engaged with both urbanization and food security. Documents that only marginally mentioned these concepts without meaningful integration were excluded. The final dataset comprised 1941 documents and was exported in a format compatible with VOSviewer (version 1.6.20), a leading bibliometric analysis software. This process ensured that the dataset was both relevant and manageable for subsequent analyses.

We employed VOSviewer to perform co-word analysis and generate keyword co-occurrence networks, identifying thematic clusters and research hotspots within the FSU domain. Co-word analysis quantifies the frequency of keyword pairs appearing together across documents, allowing for the detection of underlying conceptual structures. Social Network Analysis (SNA) techniques were applied to map and analyze international collaboration networks among countries. Key network metrics, including centrality and density, were computed to identify pivotal players and interconnections within the FSU research community.

Binary counting was utilized in VOSviewer, treating each keyword's appearance in a document as a single occurrence to prevent skewing results due to multiple mentions within the same paper (Van Eck and Waltman, 2023). Utilizing VOS viewer, we crafted a topic map grounded in the literature to unearth FSU's research nucleus. This topic map, rendered in density visualization, unveils research priorities and hotspots (Van Eck et al., 2010). Each graphical point is color-coded based on the surrounding element density: higher densities gravitate toward red, while lower densities lean blue. Density magnitude hinges on element occurrences and their significance. This density map offers a swift overview of FSU's research hotspots. Moreover, we assembled a keyword database encompassing all literature. Mirroring the counting approach for countries, keyword frequencies were also subjected to binary counting.

“Co-occurrence clustering” refers to the simultaneous appearance of two interconnected terms, with varying relationship strengths and orientations. Distinct clusters emerged based on the metrics defining the relationship strength and direction between co-occurring terms, thereby revealing cohesive thematic groups within the FSU research landscape. Clustering parameters, such as resolution and minimum cluster size, were based on established bibliometric standards to ensure the robustness and reproducibility of the results. Specifically, clusters were formed using VOSviewer's default resolution setting, and a minimum cluster size of 30 was established to identify significant thematic groupings. We employed VOSviewer's “clustering” functionality to generate a “co-occurrence clustering map” for keywords.

3.4 Methodological limitations and quality assurance

While the WoS database provides comprehensive coverage of high-impact journals, it may introduce regional and language biases, as not all journals or countries are equally represented. Additionally, keyword-based searches might omit relevant studies that do not explicitly mention certain terms or may inadvertently include irrelevant documents. To mitigate these issues, we employed rigorous data cleaning and screening processes, including manual verification of document relevance based on titles and abstracts. Despite the robust nature of bibliometric methods, which focus on quantitative indicators and network structures, in-depth qualitative nuances cannot be fully captured. Therefore, this study acknowledges the limitation that qualitative insights into the content and context of FSU research are beyond its scope.

4 Results

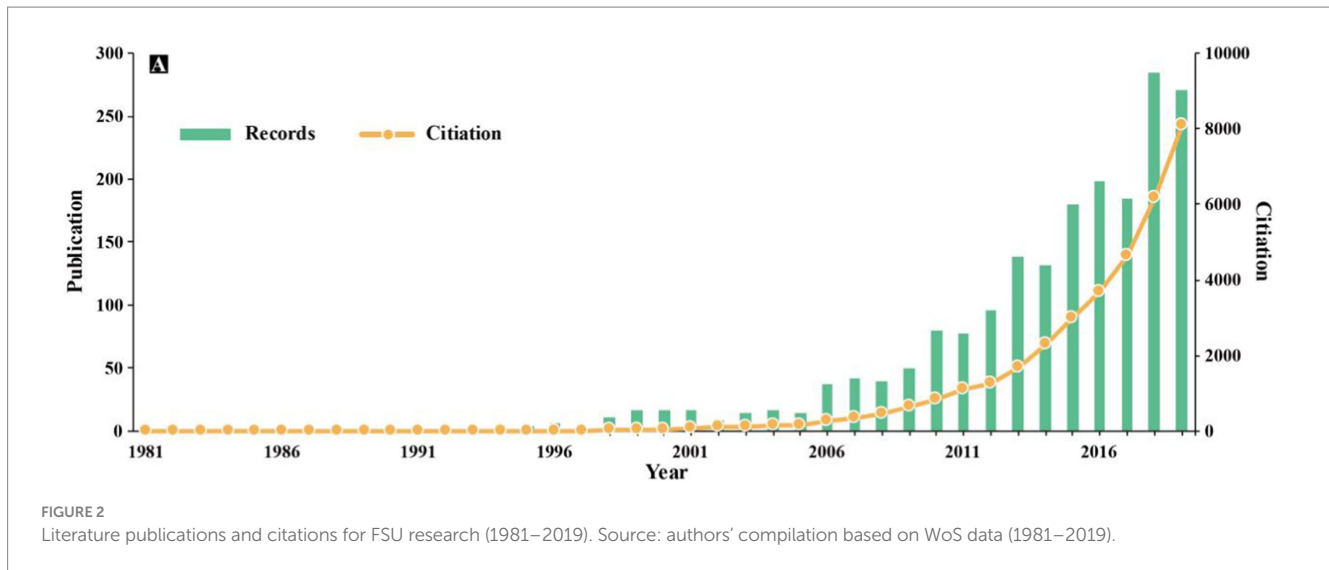
4.1 Publication and citation trends in FSU research

4.1.1 Publication trends and phases of development

The trajectory of literature publication often reflects the dynamism within a particular research domain. To address RQ1—which focuses on tracking the major themes and shifts in FSU research over time—we first examined the annual output of FSU-related publications. The timeline of publication trends is categorized into three distinct phases, as shown in Figure 2, representing the gradual growth and increasing complexity of FSU research.

- Initiation Phase (1981–2000): A total of 69 articles were published, averaging fewer than 4 papers per year.
- Gradual Expansion Phase (2001–2010): The annual publication rate rose to over 30, accumulating 318 scholarly works.
- Exponential Growth Phase (2011–2019): Starting in 2011, a notable surge occurred, with 1,560 publications released during this period, corresponding to an average annual output exceeding 173 papers.

These phases confirm a growing complexity and diversity within FSU research, consistent with H1, which posits that the thematic



structure of FSU research will exhibit increasing density and interconnectivity over time. The gradual expansion of publications between 2001 and 2010 can be attributed to the increasing recognition of the importance of urbanization and food security in global development discourse, as well as the rise of interdisciplinary studies. The exponential growth phase, beginning in 2011, coincides with a surge in funding, international collaboration, and increased global interest in sustainability and food security, which directly influenced the volume of research output.

4.1.2 Citation trajectories and intellectual influence

Citation analyses often lag behind publication output by several years. In the case of FSU, the upturn in citations became particularly pronounced after 2006, closely following the surge in publications during the early 2000s. Altogether, FSU-related literature accumulated 37,129 citations—an average of 19.07 citations per article—resulting in an h-index of 83. This citation profile—accumulating 37,129 citations and an average of 19.07 citations per article—indicates not only growing academic interest but also the increasing intellectual influence of FSU studies across diverse fields. The calculated h-index of 83 suggests that many influential articles have been consistently cited, reinforcing the robustness and impact of FSU research within the broader scientific community.

The consistent increase in citations, particularly after 2006, aligns with our first hypothesis (H1), which posits that the thematic structure of FSU research will exhibit greater density and interconnectivity over time. This surge in citation activity not only reflects growing academic interest but also highlights the increasing scholarly integration of urbanization and food security, corroborating the evolving nature of the FSU research landscape.

4.2 Leading contributors and collaborative networks

4.2.1 Geographic and institutional contributions

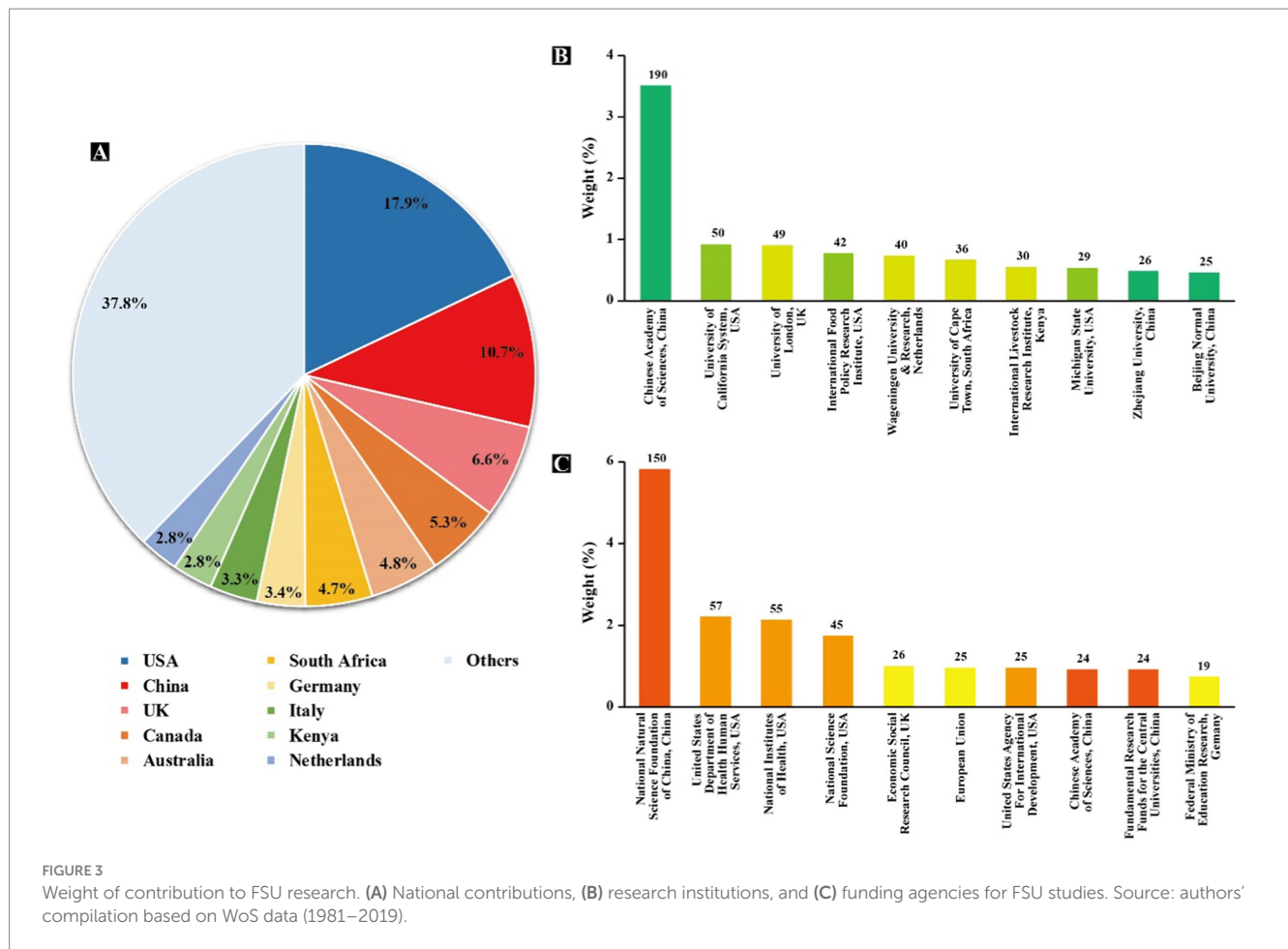
To address RQ2, this study systematically examines the contributions of key countries, institutions, and funding agencies

to the field of Food Security and Urbanization (FSU) research and investigates how their collaborative networks shape the intellectual structure of this domain. The analysis reveals that between 1981 and 2019, researchers from 125 countries (or regions), 2,137 institutions, and 1,600 funding agencies contributed to a total of 1,947 publications. These findings underscore the global and interdisciplinary nature of FSU research, highlighting its broad geographic and institutional engagement.

Figure 3A illustrates the top 10 countries by publication count, collectively accounting for 62.2% of the global FSU literature. The United States leads with 17.9%, followed by China at 10.7%, the United Kingdom at 6.6%, and Canada at 5.3%. This dominance can be attributed to significant investments in urbanization and food security research, as well as strong institutional frameworks that facilitate interdisciplinary studies. For example, China's emphasis on food security aligns with its national strategies for sustainable urban development, while the United States benefits from a well-established network of research institutions and funding agencies. Other high-contributing countries, such as South Africa, Germany, and Kenya, highlight the growing recognition of FSU challenges in both developed and developing regions. South Africa's contributions reflect its leadership in addressing food security within sub-Saharan Africa, while Kenya's presence underscores its role as a research hub in East Africa.

At the institutional level (Figure 3B), the Chinese Academy of Sciences, University of California System, and University of London rank among the top contributors, reflecting their interdisciplinary research capacities and sustained investments in FSU-related topics. Institutions such as the International Food Policy Research Institute and Wageningen University and Research specialize in agricultural policy and food systems, emphasizing the importance of integrating global perspectives in addressing FSU challenges. These institutions play a critical role in advancing collaborative research and informing policy interventions on a global scale.

A total of 2,578 records were attributed to 1,600 funding agencies, emphasizing the diverse financial support behind FSU research (Figure 3C). The National Natural Science Foundation of China accounts for 5.82% of these mentions—approximately 92 times the average of 0.063%. This reflects China's prioritization of



food security and urbanization in its national research agenda. Similarly, major U.S.-based funders, such as the Department of Health and Human Services and the National Institutes of Health, highlight their focus on interdisciplinary studies that bridge public health, urban planning, and environmental science. These dominant funding agencies shape the research trajectory by directing resources toward high-impact, policy-relevant topics, fostering both national and international collaborations.

4.2.2 International collaboration patterns

Figure 4A illustrates the international collaboration network in Food Security and Urbanization (FSU) research, where nodes represent countries (or regions), and links symbolize co-authorships. The size of a node corresponds to the volume of collaborations, while the thickness of the links reflects the strength of these relationships. This network analysis highlights the United States as the central hub, establishing robust collaborative ties with prolific paper-producing nations, including China, the United Kingdom, Australia, Canada, Germany, and Kenya. The U.S. also serves as a key connector, bridging countries that otherwise lack direct collaboration. China, positioned near the network's core, plays a quasi-central role, actively collaborating with other high-output nations such as the United States, the United Kingdom, and Australia. Other significant contributors, including South Africa, Germany, Italy, the Netherlands, and

Kenya, also facilitate regional and global collaborations, underscoring the diverse and interdisciplinary nature of FSU research.

Figure 4B provides a more detailed view of collaborative relationships involving the U.S. and China. The U.S.-China partnership emerges as the most significant, reflecting their shared leadership in FSU research. Both countries also maintain strong ties with Australia, Canada, the U.K., and Germany, forming a highly interconnected network of major contributors. In East Asia, China's collaboration with Japan is particularly notable, highlighting regional research synergies. In contrast, the U.S. exhibits strong collaborations with Brazil, South Africa, and India, demonstrating its influence in both developed and emerging economies. Additionally, the U.S.-Kenya partnership exemplifies the growing importance of addressing FSU challenges in sub-Saharan Africa.

The centrality of the U.S. and China in the network highlights their pivotal roles in shaping the global research agenda on FSU. The robust links between high-output nations suggest a well-established collaborative framework, which facilitates knowledge exchange and the dissemination of innovative methodologies. However, the relatively limited direct collaborations between certain regions, such as Africa and East Asia, indicate potential gaps that future research networks could address. Strengthening these connections may enhance the global capacity to tackle FSU challenges, particularly in underrepresented regions.

4.3 Emerging themes and future research directions

4.3.1 Research foci and academic disciplines

In addressing RQ3, this section identifies emerging themes and research directions within the FSU domain, analyzing the disciplinary distribution and thematic foci. Figure 5 highlights the multidisciplinary nature of FSU research, dominated by fields such as Environmental Sciences and Ecology (562 articles), Agriculture (342 articles), and Food Science and Technology (249 articles). These fields underline the environmental, agricultural, and technological dimensions central to FSU studies. Additionally, Nutrition and Dietetics (216 articles) and Public, Environmental and Occupational Health (203 articles) emphasize the socio-economic and health-related challenges of food security in urban contexts.

The disciplines represented in FSU research can be grouped into five primary categories:

- **Economic and Policy Analysis:** Studies under Business Economics, Public Administration, and Sociology investigate the socio-economic dynamics shaping food security and urbanization, focusing on governance, resource allocation, and policy interventions.
- **Spatial and Territorial Dynamics:** Disciplines like Geography, Urban Studies, and Physical Geography analyze spatial interactions between urban expansion and food systems, providing insights into distribution networks and land-use changes.
- **Resource Management:** Research in Water Resources, Geology, and Engineering emphasizes sustainable resource utilization to address challenges in food production and environmental conservation.
- **Health and Nutrition:** Fields like Nutrition and Dietetics and Public Health examine the nutritional and health disparities arising from urbanization, focusing on malnutrition, hunger, and food accessibility.
- **Agricultural and Ecological Foundations:** Agriculture, Biodiversity Conservation, and Plant Sciences explore ecosystem services, crop diversity, and sustainable food production as fundamental elements of food security.

These categories highlight the broad academic interest in FSU and its alignment with global challenges, including climate change, urban sustainability, and public health disparities.

4.3.2 Clusters of research hotspots

A keyword co-occurrence analysis, visualized in Figure 6, identified eight primary research clusters, reflecting the evolution of FSU research toward increasingly integrated themes. These clusters reveal the broadening scope of the field, transitioning from a narrow focus on grain production to a holistic consideration of sustainability, nutrition, socio-economic disparities, and environmental resilience. This finding corroborates H3, which posits that FSU research is progressively adopting multidisciplinary approaches to address complex global challenges. The identified research clusters are summarized as follows (Table 1).

- **Technological Innovations in Food Security:** This cluster explores resource-efficient and technology-driven solutions,

such as urban agriculture and smart farming practices, to address food system challenges. Topics include precision agriculture, vertical farming, and innovative waste management strategies, which aim to enhance the sustainability of urban food production systems.

- **Urbanization and Land-Use Dynamics:** Studies in this cluster focus on the interplay between urban sprawl, rural development, and land-use changes, with particular emphasis on rapidly urbanizing regions, such as China and India. These studies address the conflicts between urban expansion and agricultural land preservation, highlighting the role of policy interventions and urban planning in mitigating these tensions.
- **Socio-Economic Challenges in Food Security:** This cluster examines the socio-economic dimensions of food security, including poverty alleviation, affordability of food, and gender disparities. Research emphasizes the vulnerability of women and children to food insecurity, with particular focus on developing regions like Sub-Saharan Africa and South Asia.
- **Nutrition and Ecosystem Services:** Research in this cluster investigates the interconnections between dietary diversity, ecosystem health, and sustainable food systems. Topics include the role of ecosystem services in supporting agricultural productivity and the integration of nutrition-sensitive agricultural policies.
- **Agricultural Practices and System Resilience:** This cluster highlights irrigation practices, crop management strategies, and the resilience of food systems to environmental and economic stressors. Studies address the adaptation of agricultural systems to climate change, with examples from regions experiencing heightened vulnerability, such as East Africa and South Asia.
- **Food Policy and Consumption Patterns:** Research addresses disparities in food access, shifts in consumption behaviors, and the socio-economic drivers of dietary preferences. This cluster includes studies on food deserts, the impact of urbanization on local food markets, and policy frameworks to ensure equitable food distribution.
- **Health and Nutrition Outcomes:** This cluster focuses on public health issues such as stunting, malnutrition, and nutritional transitions, with an emphasis on vulnerable populations. Case studies frequently highlight regions experiencing rapid urbanization and demographic shifts, such as South Africa and Ethiopia.
- **Environmental Sustainability and Food Systems:** Studies in this cluster examine pollution control, natural resource management, and urban planning strategies that link environmental health with food security outcomes. Topics include the mitigation of heavy metal contamination in agricultural soils and the role of green infrastructure in urban food systems.

The keyword co-occurrence analysis highlights significant interconnections among the clusters, demonstrating the interdisciplinary nature of FSU research. For instance, Clusters 1 (Technological Innovations) and 4 (Nutrition and Ecosystem Services) share a focus on urban agriculture and ecosystem sustainability, emphasizing resource-efficient and environmentally conscious solutions. Clusters 3 (Socio-Economic Challenges) and 7 (Health and Nutrition Outcomes) converge on themes related to poverty alleviation and health equity, underscoring the socio-economic underpinnings of

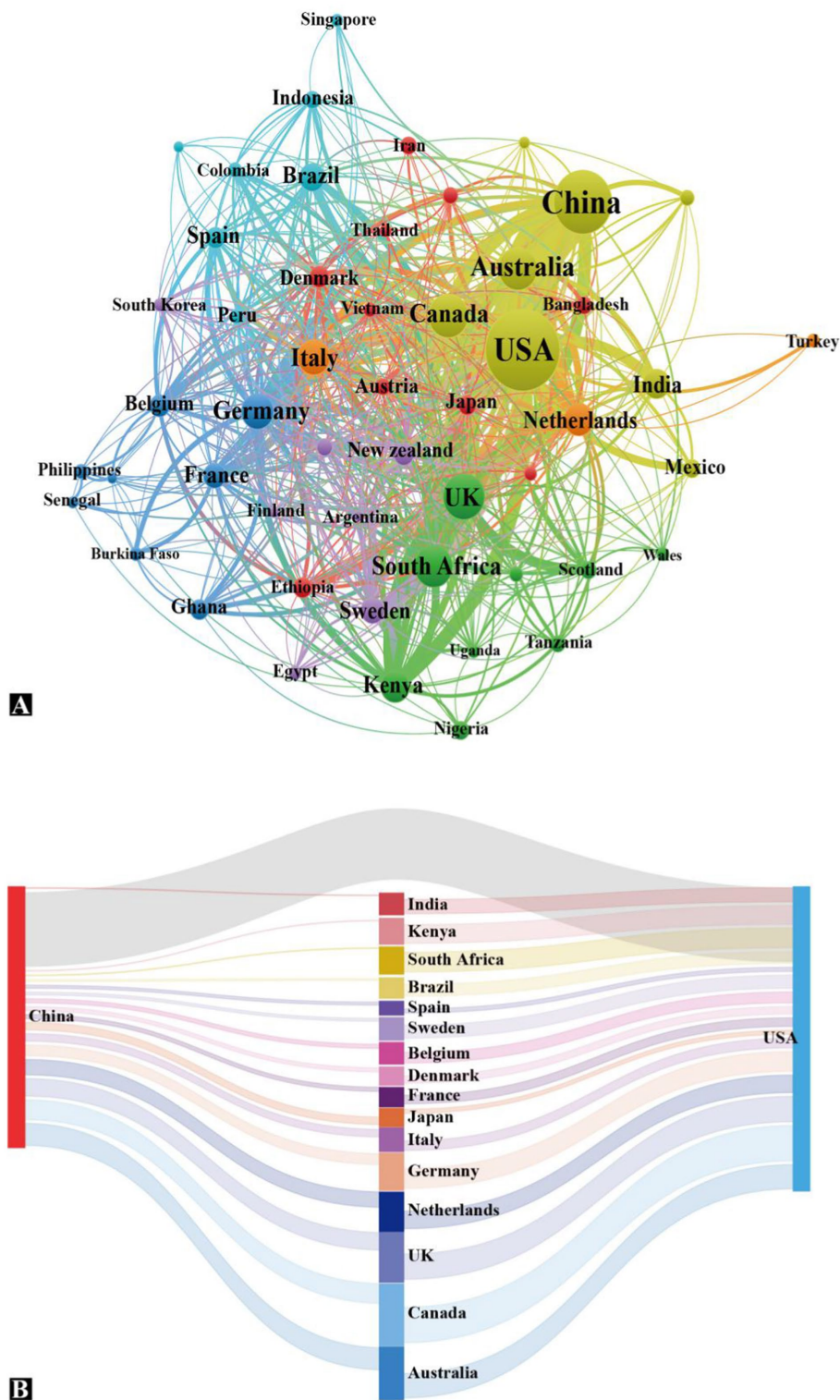


FIGURE 4 International collaboration in the research of FSU. **(A)** National collaboration network on FSU. **(B)** Major countries cooperating with China and the United States. Source: authors' compilation based on WoS data (1981–2019).

food security. These interrelationships reflect a broader trend in FSU research, transitioning from single-discipline studies to integrated approaches that address urbanization, sustainability, and public health

holistically. This trend aligns with global initiatives, such as the United Nations Sustainable Development Goals (SDGs), particularly SDG 2 (Zero Hunger) and SDG 11 (Sustainable Cities and Communities).

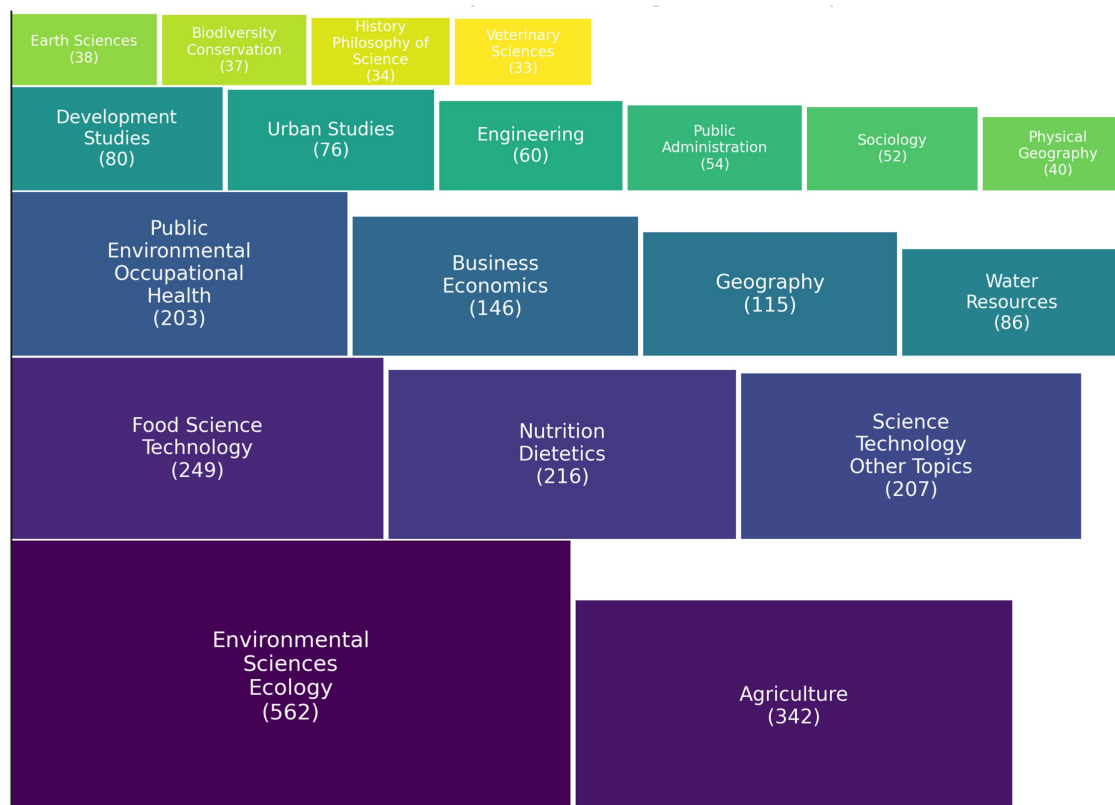


FIGURE 5
Research areas related to FSU Source: authors' compilation based on WoS data (1981–2019).

5 Discussion

5.1 Research development and shifts

Our analysis reveals a significant upward trajectory in Food Security and Urbanization (FSU) research from 1981 to 2019, segmented into three distinct phases: Initiation (1981–2000), Gradual Expansion (2001–2010), and Exponential Growth (2011–2019). These phases reflect the growing complexity and interdisciplinary nature of FSU research, which has evolved in response to global challenges and policy frameworks.

In the Initiation Phase (1981–2000), research in FSU was relatively limited, with only 69 publications, averaging fewer than four articles per year. This period was foundational, with scholars beginning to explore the relationship between urbanization and food security. Early studies focused primarily on defining key concepts and establishing the theoretical framework that would guide future investigations into the interactions between urban growth and food systems (Serageldin, 1999). The research in this phase was largely conceptual, setting the stage for more empirical studies in later years.

The Gradual Expansion Phase (2001–2010) saw a marked increase in research output, with 318 publications produced, reflecting both a rise in the volume of research and greater interdisciplinary engagement. This period coincided with the growing recognition of urbanization and food security as global challenges, further catalyzed by policy frameworks such as the Millennium Development Goals

(MDGs). Researchers adopted a more integrated approach, emphasizing the complexities of urbanization's impact on food systems (Erickson, 2008; Christiansen, 2009). In addition, global research collaborations expanded, broadening the scope of FSU studies and enriching the field with diverse perspectives and expertise from multiple disciplines.

From 2011 to 2019, the field experienced an unprecedented surge in research activity, with 1,560 publications produced, an average of over 173 papers per year. This exponential growth was driven by several factors, including increased funding, accelerated international collaborations, and the growing urgency of addressing global challenges such as climate change, sustainable urbanization, and food security (Fanzo et al., 2018; Wheeler and Von Braun, 2013). The rapid expansion of both research topics and methodologies during this period reflects the maturation of the field, with FSU studies becoming increasingly interdisciplinary. This phase supports the hypothesis that the thematic structure of FSU research has become denser and more interconnected over time.

Citation analysis indicates that FSU research has garnered considerable academic attention, accumulating a total of 37,129 citations and achieving an h-index of 83. Citation activity began to rise sharply after 2006, following the surge in publications during the Gradual Expansion Phase. This delay between publication and citation accrual is consistent with the typical citation lag observed in bibliometric studies and reflects the growing intellectual influence of FSU research across multiple disciplines (Van Eck and Waltman, 2023). The sustained increase in citations signifies not only the

5.2 Dominance and dynamics of FSU research contributions and collaboration networks

5.2.1 Dominance and geographical disparities

The results of our analysis clearly demonstrate the leading roles played by the United States and China in shaping the Food Security and Urbanization (FSU) research landscape. The dominance of these two nations, accounting for 17.9 and 10.7% of total publications respectively, highlights their strategic investments in both urbanization and food security research. This finding aligns with existing literature emphasizing the importance of robust research infrastructures and national policies aimed at addressing complex global challenges such as urbanization and food security (Hawkes, 2006; Tendall et al., 2015). These countries' research agendas are heavily influenced by national priorities related to sustainable development, making their research output pivotal in setting the global FSU agenda (Habert et al., 2011). While the United States and China dominate the field, the concentration of research within a small group of countries points to significant geographical disparities in FSU research capacity and funding. The top 10 countries contribute over 60% of total publications, underscoring the concentration of resources in key research hubs. This geographic concentration is not merely a reflection of research output but also an indicator of unequal access to funding and the lack of research infrastructure in less-represented regions. The dominance of food-producing and exporting nations like the U.S. and China, which are also major grain producers, further accentuates this disparity (Siciliano, 2012). These nations, being top global grain producers, have established pronounced dominance within the FSU domain, largely due to substantial financial backing from entities like the National Natural Science Foundation of China (NSFC) and the Chinese Academy of Sciences. This concentration, verging on a monopoly, not only facilitates robust international collaborations but also perpetuates the dominance of these nations in setting research priorities and agendas (Harvey, 1989).

The significant contributions from institutions such as the Chinese Academy of Sciences and the University of California System reflect the interdisciplinary research capabilities within these institutions, facilitating high-impact publications and fostering global collaborations. As major players in FSU research, these institutions not only lead in terms of publications but also shape research directions by integrating insights from various fields such as urban planning, agriculture, and public health. This trend indicates a broadening of the interdisciplinary nature of FSU research, aligning with broader global research trends that prioritize systems thinking in addressing complex societal challenges (International Food Policy Research Institute; Wageningen University and Research).

The role of funding agencies cannot be understated in shaping FSU research trajectories. Agencies like the National Natural Science Foundation of China (NSFC) and U.S. agencies, including the Department of Health and Human Services and the National Institutes of Health, play a crucial role in directing research priorities. These funding bodies prioritize high-impact, interdisciplinary projects, influencing the direction of research in ways that may reflect national interests as well as broader global priorities. The influence of these agencies highlights the interconnections between research funding

and global policy agendas, which significantly affect the development and focus of FSU research (Zhan, 2017).

5.2.2 International collaboration networks and regional gaps

In line with our second hypothesis (H2), the findings illustrate that countries with strong urbanization processes and advanced research capacities are more likely to occupy central positions in global FSU collaboration networks. The dense collaborative ties between leading nations, especially the United States and China, create a robust network of knowledge exchange and resource sharing. However, this interconnectedness also exposes gaps, particularly in regions that remain underrepresented in FSU research, such as parts of Africa and Latin America. These gaps suggest that regional disparities in research collaboration and funding might hinder the global capacity to address localized FSU challenges, particularly in areas with unique socio-economic or environmental factors.

The international collaboration network reveals that while the United States serves as a central hub, China's role in the Asia-Pacific region further emphasizes the strategic partnerships emerging within these regions. China's quasi-central position reflects its leadership in addressing regional FSU issues, but it also highlights the need for further strengthening of regional collaborations to fully address the diverse and pressing challenges related to urbanization and food security. The strong U.S.-China bilateral collaboration further underscores their shared leadership, demonstrating mutual interests in advancing knowledge and addressing global sustainability challenges.

Ultimately, the patterns of collaboration in FSU research highlight a robust yet uneven global network. Strengthening regional partnerships and increasing support for underrepresented areas could enhance the global capacity to tackle the multifaceted challenges of food security in rapidly urbanizing contexts. These findings suggest that fostering more inclusive research networks will be critical for creating global solutions to urbanization and food security issues, ensuring that all regions have access to the knowledge and resources necessary to address these challenges effectively.

5.3 Interdisciplinary shifts and research keys

Our analysis highlights a significant shift in the nature of Food Security and Urbanization (FSU) research, as emerging themes reflect the growing complexity of the field. These shifts suggest that FSU research is increasingly characterized by interdisciplinary approaches, integrating environmental, social, and economic perspectives to address the interlinked challenges posed by urbanization and food security. These findings support our third hypothesis (H3), which posits that FSU research will increasingly adopt integrated, multidimensional solutions to address complex food security challenges.

5.3.1 Macro-level and micro-level perspectives in FSU research

FSU research continues to bifurcate into two primary perspectives: macro and micro. The macro perspective addresses the broad, systemic impacts of urbanization on food systems, including elements such as technological advancements, urban agriculture, soil and water

management, and waste management. Research in this domain prominently features countries like China, where urbanization's effects on agricultural productivity and resource distribution are explored through case studies in provinces like Sichuan and Jiangsu (Qi et al., 2015; Su et al., 2016). These studies align with systems-based approaches, focusing on the interdependencies between urban growth and food systems.

In contrast, the micro perspective zooms in on individual food security, particularly the impact of urbanization on household food security and nutritional status (Fanzo, 2019). Research in regions such as Ethiopia (Regassa and Stoecker, 2012) and South Africa (Dodd, 2016) underscores the vulnerability of marginalized populations, particularly women and children, to food insecurity. These studies emphasize socio-economic dimensions and the need for targeted interventions at the household level, incorporating factors like economic access, health assessments, and demographic shifts.

5.3.2 The interdisciplinary nature of emerging themes

FSU research is increasingly defined by an interdisciplinary approach that combines insights from diverse fields such as environmental sciences, public health, agriculture, urban studies, and socioeconomics (Mohammadi et al., 2012; Wei and Ye, 2014). This shift away from isolated studies on agricultural productivity or grain yield reflects the broader recognition that food security and urbanization are complex, interconnected systems that must be understood holistically. Emerging themes point to a growing recognition that sustainability, nutrition, socio-economic equity, and environmental resilience are central to addressing food security challenges. The integration of social sciences with hard sciences indicates a broader acceptance of systems thinking, where the interconnections between urban growth, food systems, and environmental health are central to developing sustainable solutions. This interdisciplinary trend aligns with Sustainable Development Theory, which emphasizes the need for strategies that integrate economic development, social inclusion, and environmental sustainability (Tilman et al., 2002). As FSU research matures, it is clear that the challenges of urbanization and food security are interdependent, requiring collaborative solutions that bring together insights from multiple academic disciplines and research sectors.

5.3.3 Research keys and challenges in the FSU domain

FSU research is shaped by a myriad of factors across different scales, ranging from individual and household decisions to agri-food systems, environmental systems, and policy mechanisms (Glaeser et al., 2004; Gillespie and van den Bold, 2017). One of the primary challenges arising from rapid urbanization is the competition for resources such as land, water, and energy between urban areas and agricultural systems. This competition diminishes food production capacities, exacerbating food insecurity. The growing global population amplifies these pressures, highlighting the importance of integrating sustainability and ecological considerations within the urbanization–food security nexus.

Urban agriculture, when integrated with urban ecology, offers a promising solution to urban food security. Initiatives that promote the use of green spaces for food production and resource management can enhance food availability and support sustainable urban development

(Karthika and Karthikeyan, 2016). However, unsustainable agricultural practices—such as overuse of water resources or intensive monocultures—can damage local ecosystems, threatening food security by compromising water quality and biodiversity (Alavaisha et al., 2019). Furthermore, climate change poses a serious threat to food security, particularly in climate-sensitive regions where agricultural systems are already under stress (Fanzo et al., 2018). Climate-induced changes in agricultural environments further jeopardize food security in impoverished regions (Casillas and Kammen, 2010).

The impact of climate change exacerbates vulnerabilities in food systems, leading to food crises resulting from natural disasters or economic shocks (Tendall et al., 2015). While agricultural diversification can help buffer the impact of these crises, it does not always translate into improved food security for individuals, particularly in marginalized communities. Increased agricultural diversity, although beneficial for ecological resilience, may not always improve nutritional outcomes or child nutrition in specific contexts (Rosenberg et al., 2018). Therefore, it is critical to integrate diversified strategies for food security that balance production, access, and nutritional needs.

5.3.4 Implications for policy and practice

The emerging interdisciplinary clusters in FSU research have profound implications for policy and practice. Technological innovations in food security, including smart farming and precision agriculture, offer potential pathways for improving food production in urban environments. However, their success hinges on policy frameworks that facilitate access to technology while ensuring environmental sustainability and equitable access to resources. Urban agriculture, in particular, holds promise for enhancing urban food security, but it must be supported by policies that integrate urban planning with sustainable land use and green infrastructure.

In addition, the growing awareness of socio-economic disparities in food access demands targeted policies aimed at improving the economic accessibility of food, especially for vulnerable populations. Policies must address the root causes of food insecurity, such as poverty, income inequality, and health disparities. Incorporating public health strategies into food security research will be essential to achieving nutritional equity across urban populations.

5.4 Theoretical insights and implications

5.4.1 Theoretical implications

The findings of this study are consistent with and extend existing literature on FSU research, highlighting both the evolution and broadening scope of the field. The increase in thematic density and interconnectivity within the research landscape supports the relevance of Sustainable Development Theory and Urban Metabolism Theory, both of which advocate for integrated and sustainable approaches to urban and food system challenges (Christiansen, 2009). Specifically, the emphasis on technological innovations, socio-economic challenges, and environmental sustainability corroborates prior studies that highlight the multifaceted nature of FSU research (Zhang et al., 2016; Fanzo et al., 2018).

The centrality of countries such as the United States and China in collaborative networks aligns with global trends that highlight the

critical role of leading nations in shaping interdisciplinary research agendas (Monasterolo et al., 2016; Liu et al., 2019). These nations, with their advanced research infrastructures and national strategies focused on food security and urbanization, are pivotal in advancing global FSU discussions.

Our bifurcation of FSU research into macro and micro perspectives also aligns with existing literature, which acknowledges the need for both systemic analyses of urban food systems and individual-level studies on food security, especially for vulnerable populations (Guitart et al., 2012; Dodd, 2016). This dual approach enhances our understanding of the interconnectedness between urbanization and food security, underscoring the importance of multi-dimensional frameworks in addressing these challenges.

5.4.2 Methodological considerations

This study employed a bibliometric approach to map the FSU research landscape, offering valuable quantitative insights into research trends, key contributors, and collaborative networks. However, the methodology is subject to several limitations. For instance, the reliance on the Web of Science (WoS) Core Collection introduces potential regional and language biases. Furthermore, keyword-based searches may exclude studies that do not explicitly mention the selected keywords, potentially overlooking significant contributions in areas such as policy interventions or local case studies. To mitigate these limitations, future research could enhance comprehensiveness by incorporating additional databases such as Scopus and Google Scholar, as well as multilingual sources. This would provide a more inclusive view of FSU research, especially in non-English speaking regions.

While bibliometric tools such as VOSviewer and Social Network Analysis (SNA) are valuable for identifying research clusters and collaborative networks, they have limitations in capturing qualitative nuances or contextual factors that influence research dynamics. Complementary qualitative analyses are recommended to better understand the cultural, policy, and environmental factors shaping FSU research trajectories.

5.4.3 Research strategy and future directions

Future FSU research should build on the strengths of both macro-level and micro-level perspectives, which together provide a comprehensive understanding of food security in urbanizing contexts.

- **Macro-level research:** There is a need for further investigation into the systemic effects of urbanization on food systems, with a focus on how urbanization influences resource management, urban agriculture, and sustainable food production. Case studies from China, such as those from Sichuan and Jiangsu provinces (Qi et al., 2015; Su et al., 2016), offer valuable insights into the impacts of urban expansion on food systems. Future studies should continue to explore technological innovations, climate adaptation, and resource management strategies within the urbanization–food security nexus.
- **Micro-level research:** On the individual and household level, there is a growing need for research focused on food security vulnerabilities within low-income and marginalized populations, especially in rapidly urbanizing regions. Studies from regions such as Ethiopia and South Africa (Regassa and Stoecker, 2012; Dodd, 2016) highlight the socio-economic factors influencing

household food security. Future research should explore the effectiveness of targeted interventions addressing food access, health outcomes, and economic resilience, particularly for women and children.

Despite advancements in both macro and micro-level research, there is still a significant gap in adopting a holistic, systems-based approach to FSU. Much of the existing research focuses on isolated factors such as grain yield, soil health, and water quality, but it often overlooks the intricate web of interdependencies that define urban food systems. Future research should focus on integrating environmental, socio-economic, and policy dimensions to provide a more nuanced, comprehensive understanding of the urbanization–food security nexus.

To bridge this gap, future studies should adopt a systems-based approach that incorporates multiple levels of analysis, from macro-level urban planning to micro-level household surveys. This will allow researchers to capture the full spectrum of factors influencing food security in urbanizing regions and provide robust, universally applicable insights into the challenges of food security.

6 Conclusion

This study explores the complex relationship between urbanization and food security within the context of contemporary global challenges. Our findings highlight two key perspectives: the macro-level impacts of urbanization on food systems, such as technological advancements, urban agriculture, and resource management, and the micro-level implications for household food security, particularly for vulnerable groups like women and children. These insights challenge the conventional narrative that urbanization uniformly leads to greater food insecurity, instead suggesting that the drivers of urbanization—rural-to-urban migration in developing nations versus industrialization in high-income countries—have different outcomes for food security. This divergence underscores the importance of considering context-specific approaches to urban food systems.

Theoretical contributions of this study include a deeper understanding of how Sustainable Development Theory and Urban Metabolism Theory can be applied to the dynamic relationship between urban growth and food security. This study extends these theories by integrating socio-economic and environmental dimensions, demonstrating that food security in urban contexts is shaped not only by economic and environmental factors but also by political will and policy interventions. Our findings align with prior studies on urbanization and food security, confirming the growing need for interdisciplinary solutions that integrate these fields into a cohesive framework.

In practical terms, this study contributes to the growing body of literature on sustainable urban food systems and policy solutions for food security. It highlights the need for integrated urban planning, resource-efficient agricultural technologies, and inclusive food policies that address the unique challenges faced by both high-income and low-income countries. Policymakers must account for the regional disparities in urbanization patterns and the socio-economic characteristics of urban populations to design effective food security interventions.

While this study provides valuable insights, there are several limitations. First, the reliance on secondary data and survey-based research may not capture the full diversity of experiences in urban food security across different regions. Future research should focus on longitudinal studies that track the impacts of urbanization on food security over time and in more diverse geographical contexts. Additionally, incorporating qualitative methods to complement the quantitative bibliometric approach would allow for a deeper understanding of the local nuances in urban food systems.

In conclusion, this study addresses key gaps in the global literature on urbanization and food security by providing a comprehensive bibliometric analysis that maps global research trends and collaboration networks. It contributes new insights into how urbanization impacts food security differently across regions, emphasizing the need for contextualized policy solutions that consider the unique challenges of both high-income and low-income countries. We recommend future studies adopt a holistic, systems-based approach to better understand the complex dynamics of urban food systems and improve global food security outcomes.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Author contributions

YW: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Software, Visualization,

Writing – original draft, Writing – review & editing. XW: Formal analysis, Software, Validation, Visualization, Writing – original draft, Writing – review & editing. ZY: Project administration, Resources, Supervision, Writing – original draft, Writing – review & editing. JF: Project administration, Resources, Supervision, Writing – original draft, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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