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Informal food systems in food security planning: a case study of Nanjing, China

Luoman Zhao¹ · Axel Timpe² · Frank Lohrberg²

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Abstract

Continuing risks, such as economic crises, climate change, and pandemics, have raised concerns about food issues in China and worldwide. The current food planning in China, which prioritizes food security, ignores the role of the informal sector in the resilience of food systems. This study examined the role of informal food systems in enhancing food security and explored the dilemmas of informal food systems in food planning through field and literature research. Taking Nanjing as an example, individual and city-level case studies collected data through face-to-face interviews, questionnaires, observations, and secondary data sources. The data were analyzed from three perspectives: food availability, accessibility, and utilization. The results indicated that small-scale food production and food vending contribute to food diversity, affordability, allocation, and nutritional and social value. Face-to-face direct marketing and cheap prices of local food increase the competitiveness of food in informal food systems. Informal food activities still have the potential to be improved by integrating into food security planning. Food security planning should consider the contributions of informal food systems and improve the current situation by appreciating small-scale agriculture, supporting local food supply chains, and providing a formalization procedure for food bottom-up food activities.

Keywords Informal food systems · Food security · Food planning · Small-scale agriculture · Food vendors

1 Introduction

As global urbanization, natural disasters, and the pandemic threaten the availability, accessibility, and affordability of nutritious food, food security and food supply chains are gaining heightened attention (Cabannes & Marocchino, 2018). Food systems refer to food activities ranging from production to recycling. A broader definition encompasses the relationships between the ecosystem and human

communities; the results and impacts of food-related activities from food cultivation, consumption, and marketing to waste repurposing; and various factors influencing food security (Erickson, 2008). Economic growth and technological innovation have led to the development of agricultural systems that marginalize subsistence farmers. Traditional smallholders face unemployment or exit from agriculture if they cannot integrate into a commercial value chain that provides food services to cities (Serraj & Pingali, 2019).

Food security is, therefore, an important issue in food planning. The definition of food security highlights four aspects: food availability, access, utilization, and stability (FAO, 2006). Food planning integrates food-related concerns into policies, regulations, plans, and programs across diverse governmental initiatives such as planning, standards and guidelines, and public funding (Delaware Valley Regional Planning Commission, 2010). China gradually developed a dual urban-rural structure in the early twentieth century in which cities served industrial production while rural areas served agricultural output and has been striving to dismantle this model since the beginning of the twenty-first century (Ministry of Justice of the People's Republic of China, 2019). The central government's exploration of

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the socialist system transitioned from collective agricultural production to a Household Contract Responsibility System (HCRS). Although national planning has shifted from “rural areas serve cities” to “integrating urban and rural areas,” ensuring national food security has consistently remained the primary focus of rural areas (Han, 2018). China’s food planning follows a top-down approach in which the central government sets national goals and plans, and provincial governments and municipalities implement these goals within their jurisdictions (Zhong et al., 2020). At the city level, local food planning addresses urban food security by connecting local food supply chains from production to consumption.

Despite the widespread adoption of modern food systems, traditional food supply chains continue to prevail in developing countries with great significance (Lowder et al., 2016). Informal and traditional food systems may intersect and fulfill similar functions, including informal urban food production and street food vendors. The High-Level Panel of Experts on Food Security and Nutrition (HLPE-FSN) report under the Food and Agriculture Organization of the United Nations (FAO) pointed out that informal food systems in poor urban areas are crucial to food security but lack policy support. The system includes varied participants, but obtaining support regarding market intelligence, transportation logistics, and waste recycling facilities is difficult. At the same time, the lack of food system planning has led to the growth of processed foods, while local businesses that provide healthy and fresh foods have been neglected (HLPE, 2024).

Informal food production encompasses different forms, depending on the motivations of these activities and regulations over land use. Food self-provisioning at a small spatial scale is often associated with informality. For individuals, families, and communities, food self-provisioning typically involves food production, consumption, exchange, or gifting that is not oriented toward economic benefits, although these practices may alleviate the economic burden through the food supply (Suomalainen et al., 2023). For example, the concept of food self-provisioning as an informal food practice refers to non-farming households producing food with their own resources like balcony and yard and sharing it in a non-commercial manner, and the main motivation is to obtain healthy or fresh food (Jehlička et al., 2024). Guerrilla gardening in the Global North focuses on urban agriculture practices taking over spaces without land-use permission, which aims to beautify the space and cultivate food (Hardman & Larkham, 2014). In Western and Central Europe, the cultural value dominates home gardens, whereas, in Eastern Europe, these gardens not only bring food to the owners but also can be sold to tourists, local markets, and at local festivals (Ivanova et al., 2021). Informal food production for profit in China relies on informal and traditional retailing channels, and it often conflicts with local governments over land ownership and access to urban space (Zhao, 2021).

Informal food markets, including street food vendors, open-air markets, and conventional wet markets, primarily serve low-income urban dwellers (Tefft et al., 2017). In the Global North, local governments aim to boost urban vitality through street food, while in the Global South, mobile vendors provide urban populations with fresh food and a means of livelihood in an informal way (Allison et al., 2021). State-controlled and mixed-ownership fresh produce markets, such as open-air and wet markets, hold a significant share of the sales of agrifood in most African and Asian cities (Zhong et al., 2021). Informal food vendors are an important food source for most households in sub-Saharan Africa, providing low-income families a chance to achieve food security and an essential source of income for the urban poor (Giroux et al., 2021). Research on informal food provision in Bandung shows that food stalls are the most significant nutrition source for female factory workers, which provide a diverse diet at low cost (Natawidjaja et al., 2019).

While commercial informal food activities face the risk of ambiguous governance or even penalties from local governments in China, disadvantaged groups still join these activities, including urban food production and street vending for food provision and income generation (Dai et al., 2019). In rapid urbanization, a large amount of agricultural land has been converted into urban construction land in China, accompanied by an increase in landless farmers and vacant land that has not been adequately utilized, providing informal food production opportunities (Roast, 2022). Wet markets, as a traditional retail channel for fresh food, have undergone a long period of formalization through government financial support since 2007 (Zhong et al., 2019). Traditional wet markets allow local farmers to sell their goods face-to-face. Modern wet markets have achieved transformation by being involved in urban planning (Yuan et al., 2021). Formalization measures, including equipment upgrades, business licenses, and stall rental contracts, have enabled non-farming vendors to engage in wet markets rather than local small-scale farmers (Zhou, 2018).

In this study, informal food systems refer to commercial food supply chains involving informal activities, specifically, food production without land-use permission and face-to-face marketing without licenses or space-use permission. Previous research mainly examines informal urban food production and food vendors separately. This study considers that informal food activities can interconnect and influence each other in local food systems. Informal food producers and local farmers sell their fresh produce face-to-face with consumers. The informal food systems in this article are commercial food localization activities where food production is provided not only for sustenance but also for income generation. Despite specific legalization measures in China, informal food systems remain marginalized within official urban food economy analytics and encounter

restricted access to urban spaces, facilities, and services. This has caused many conflicts and made it impossible for the informal sector to improve (Boonjubun, 2017).

This study examined how informal food systems contribute to food security regarding food availability, accessibility, and utilization. These contributions highlight food producers' role in productivity, utilization of abandoned land, face-to-face and direct marketing, and other invisible benefits they can provide. Based on the food security framework, this study analyzed the dilemmas faced by informal food supply chains from production to consumption, which provide a basis for the optimization of informal food activities and possibilities of integrating informal activities into food planning.

2 Informal activities in food supply chains

Informal economic activities are pivotal in generating income and fostering social advancement in economically disadvantaged nations. The associated notion of informal employment exhibits varying characteristics across different countries.

The informal sector pertains to enterprises, whereas informal employment centers on individual jobs. Individuals are classified as holding informal employment if their job arrangements do not comply with national employment, income tax regulations, or social welfare policies (International Labour Organization, 2003). According to International Labour Organization (1993), three main attributes define the informal sector.

1. The primary objective of entities involved in industry or services is to create job opportunities and generate income.
2. Family-run businesses represent a distinctive feature within informal economic activities.
3. Informal sector activities are distinct from illicit or clandestine economic activities and are not purposely designed to avoid tax payments or social security contributions.

Figure 1 illustrates informal commercial activities involved in food cultivation and retail determine the composition of informal food systems. This study took commercial food supply chains with informal activities as a system, which is the informal

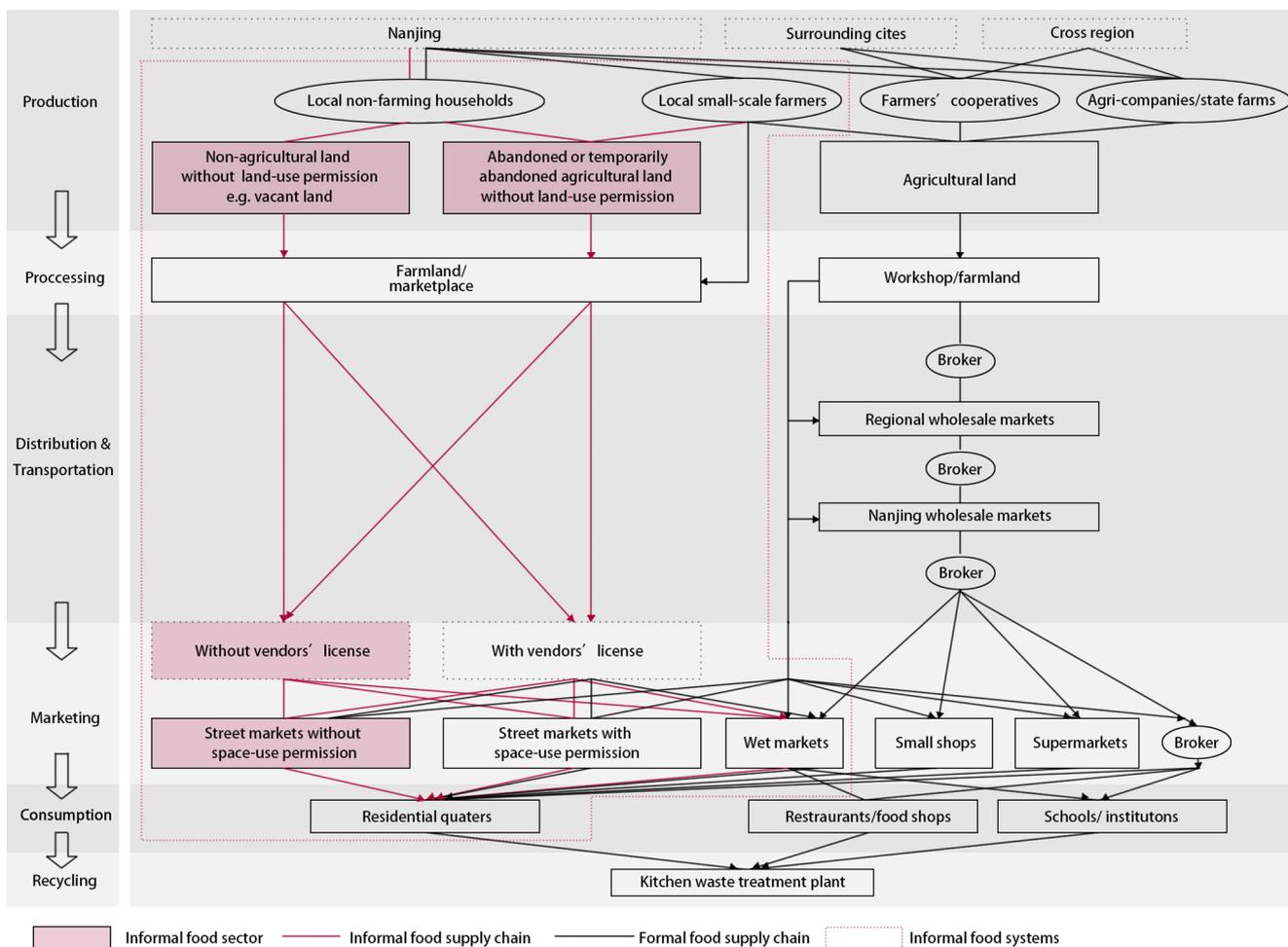


Fig. 1 Informal food supply chains in food systems in Nanjing

food system. Informal food production in this study refers to farming without land-use permission. Informality is distinct from illegality, while food production on abandoned or vacant land is a grey area in China, with local governments acquiesce if the activities do not affect the interests of others (Liu, 2021).

Informal employment groups in food direct marketing are vendors without licenses or sell in unavailable spaces according to local regulations. Nanjing set flexible and temporary street markets according to street aesthetics, transportation, and food accessibility (Nanjing City Appearance Management Regulations, 2017). Unlike small food stores, food vending is perceived as lacking standardization, regulation, and orderliness, thus serving as a temporary measure to address urban unemployment (Hanser, 2016). Wet markets, favored for purchasing vegetables, do not compete heavily with supermarkets, largely because of Chinese social norms and the cost-effectiveness offered by conventional markets (Bai et al., 2008). Manufactured and packaged foods are preferred in hypermarkets and supermarkets, whereas customers typically buy fruits and vegetables daily from street vendors or traditional wet markets (Si et al., 2016).

3 Methods and material

As shown in Fig. 2, the qualitative case study approach, including field and literature research, explored the contributions and potential of informal food systems in Nanjing

to food security and the dilemmas these activities face in food planning. Individual and city-level case studies examined three perspectives on food security: availability, accessibility, and utilization. Data were collected through face-to-face interviews, questionnaires, observations, and secondary sources. This study aimed to explore commercial informal food systems, so the interviews started at three street markets, asking the vendors whether they were also food producers. Then, six samples were selected, including three from each formal and informal food production site. Sixty consumers in street markets were selected to complete a questionnaire to obtain information on the role of food vending and direct marketing in food security.

The data were analyzed using thematic analysis within a food security framework. This study focused on freshly produced food. Small-scale producers lacked dedicated facilities for washing and preparing fresh agricultural products. Instead, they typically washed the fresh produce directly in the field to remove dirt before selling it. Many cities in China continue to face numerous risks and challenges regarding waste sorting and recycling systems. Thus, the informal food systems adopted in this study do not include food processing, distribution, and recycling.

Nanjing, a mid-sized city in China and the capital of Jiangsu province, was selected to investigate the informal food systems. As of 2023, Nanjing's urbanization rate has surpassed 87%, with a 9.547 million permanent population, of which 8.3249 million are urban residents (Nanjing Government,

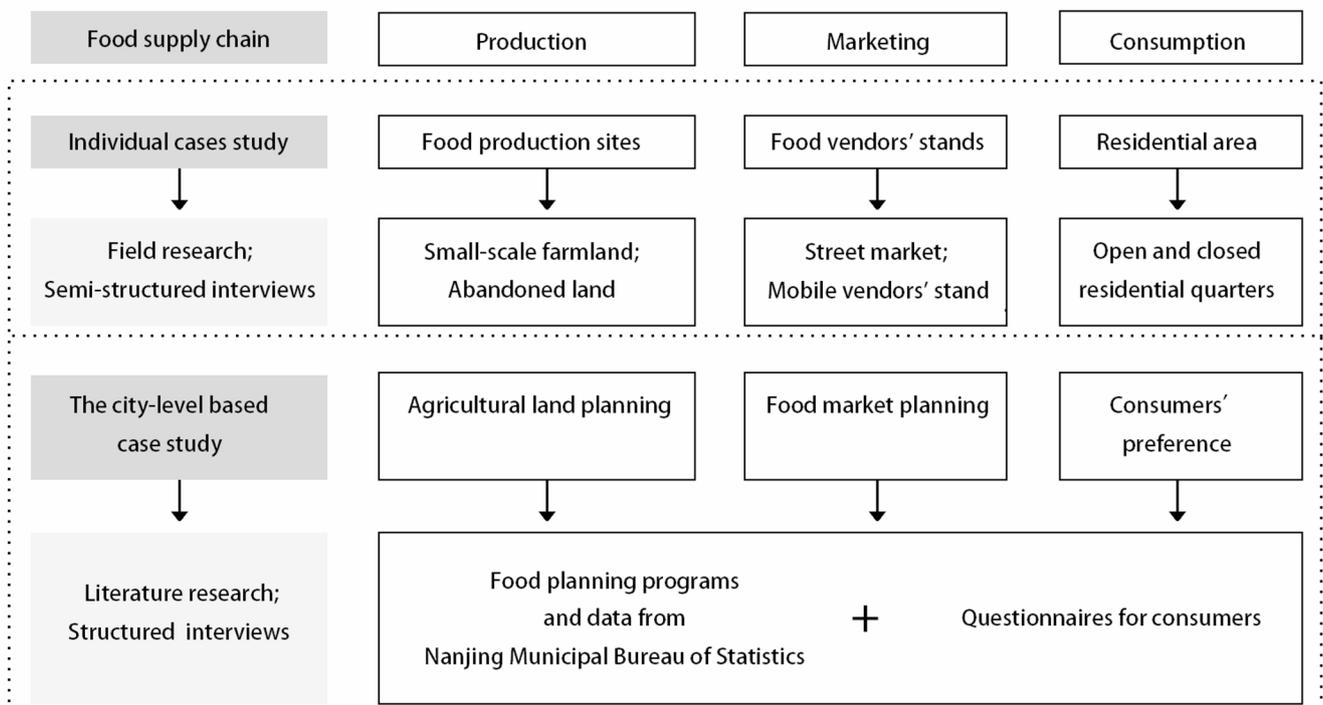


Fig. 2 Methods and material

2024). As of late 2022, Nanjing spans a total land area of 6,587.04 square kilometers, with 1,416.4 square kilometers designated as arable land and 885.73 square kilometers as built-up area (Nanjing Municipal Bureau of Statistics, 2023a). Nanjing operates at four administrative levels: municipality, district, subdistrict, and neighborhood. It comprises 11 districts, 100 subdistricts, and townships (Nanjing Government, 2019). Apart from the four central districts, the other seven districts include countryside villages and farmlands.

3.1 Individual case studies

This study identified informal food systems through fieldwork on individual cases in Nanjing. Fieldwork involved food activities: production, marketing, and consumption. The interviews began with vendors selling vegetables and fruits in the urban core of Nanjing, including the morning market in Xiaolingwei, which is open daily from 6 am to 8 am, and mobile street vendors in Fuzimiao and Maqun. Figure 3 shows the information on the three marketplaces. The residential areas within easy reach of food vendors are marked in yellow. Food vendors within a 0.5-mile or slightly more than 0.5-mile but less than a 1-mile radius from homes can be categorized as “high” or “medium” food access for residents (United States Department of Agriculture, 2009). The Mapbox Isochrone API helps analyze the accessibility of marketplaces to residential areas within 1000 m. Middle-aged and older people were the primary residents of Fuzimiao and Xiaolingwei, while young commuters were the primary customers of food stalls near the Maqun subway station. Initial interviews excluded middlemen and non-local food producers. Only local food producers who sell their own produce can be traced back to the locations of the food production sites. Six cases were selected: three formal and three informal food production sites. Next, semi-structured interviews were conducted to document the features of the food cultivation plots and the cultivation process. In addition, we conducted open-ended interviews with five mobile vendors in the public space of Xiaolingwei wet market, but we did not obtain permission to visit their farms. The content of the open-ended interviews was available to analyze food practitioners in wet markets. Figure 3 shows the locations of the markets and food production sites, as well as their links in Nanjing. The land-use changes and development of the selected samples were tracked using Google Earth Pro from August 2019 to December 2023.

Food producers in this study cultivated food for both household needs and income generation. They are also food vendors who sell agrifood informally. Formal food production means that producers have their farmland, whereas informal food producers cultivate food on land without permission, such as on abandoned or temporarily abandoned

land. Table 1 presents general information on formal and informal food production sites.

Mu (亩 in Chinese) is a unit of area equivalent to 666.67 square meters. Based on the referenced literature, this paper converts mu into square meters, hectares, or square kilometers for clarity.

The three formal production sites are located in peri-urban areas. Small-scale farmers grow various agricultural crops and fresh seasonal vegetables.

1. The Guxiong subdistrict, one of Nanjing’s eight significant emerging urban zones, will have its agricultural land repurposed to provide residential neighborhoods with comprehensive infrastructure, including public gardens and other recreational areas (Nanjing Natural Resources and Planning Bureau, 2012). The local food producers interviewed were uncertain about the timing of the land conversion; therefore, they did not have long-term plans for their farming business. Small farmers sell fresh agricultural food in open-air markets to support their families.
2. The Guli subdistrict is planning to develop into an idyllic travel destination with distinctive features (Nanjing Municipal Bureau of Planning and Natural Resources, 2018). While the local government intends to establish the Guli subdistrict as an area of agritourism in southern Nanjing, the emphasis is primarily on large companies and their farms. Local farmers produce food on small and fragmented farmlands.
3. The Qilin subdistrict is situated on the eastern outskirts of Nanjing. The city has highly accessible transportation. The surveyed plots in the Qilin subdistrict have dispersed farmlands that are not easily adaptable for greenhouse installation, whereas village collectives have leased other continuous land to agricultural companies owing to the land transfer policy.

The three informal food cultivation sites studied had no land-use permits. Food practitioners produce food for both income generation and self-consumption.

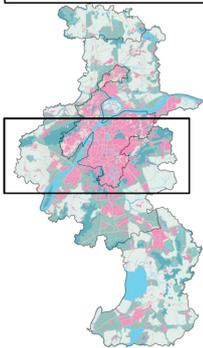
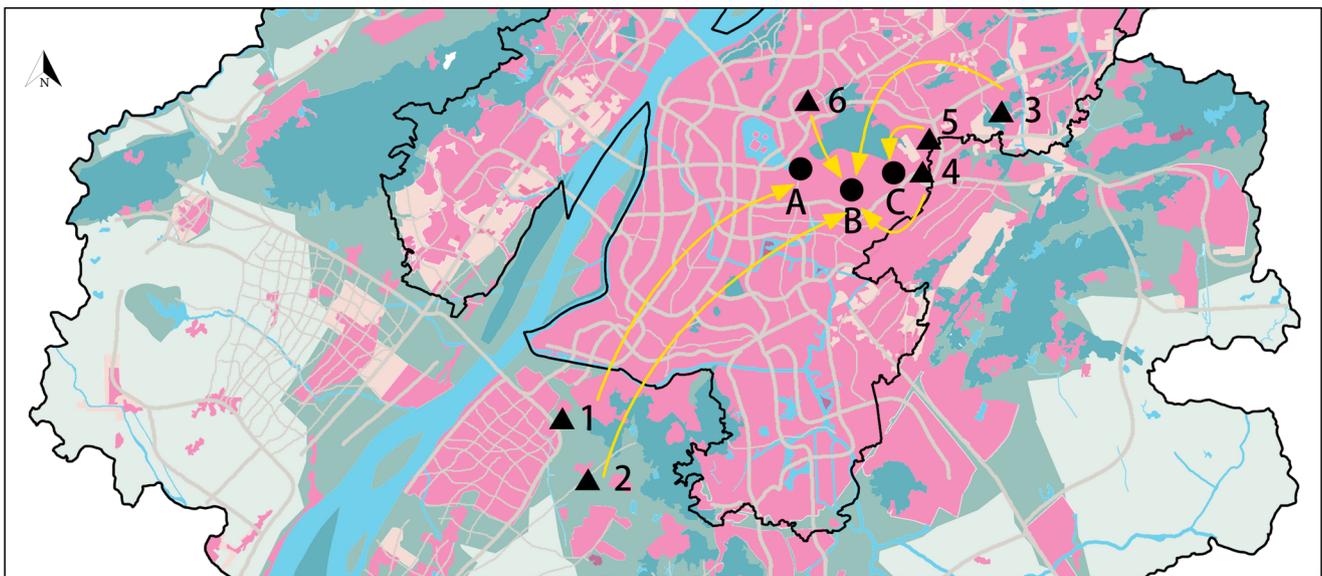
4. The Maqun subdistrict is situated near the urban core, so arable land and villages have been steadily repurposed as urban construction land because of urban expansion. The abandoned land within the Maqun community, surrounded by residential neighborhoods, was used to grow corn and vegetables.
5. In 2016, the local government expropriated Shiziba. Farmland remained abandoned until 2020. During this period, landless farmers and surrounding city dwellers cultivated food on abandoned land and sold it to vendor markets or residential quarters.



A (Jiankang street in Fuzimiao subdistrict)

B (Luohan alley in Xiaolingwei subdistrict)

C (Maqun subway station in Maqun subdistrict)



- Vendors' markets
- ▲ Food production fields
- Land for construction
- Potential construction land
- General agricultural land
- Basic farmland concentration area
- Forestry land
- Territorial waters
- ▲ 1 Site in Guxiong subdistrict
- ▲ 2 Site in Guli subdistrict
- ▲ 3 Site in Qilin subdistrict
- ▲ 4 Site in Maqun community
- ▲ 5 Site in Shiziba
- ▲ 6 Site in Huadian
- Flow from production to marketing

Fig. 3 Locations and links between production, marketing, and consumption sites

6. The Huadian community is located in the northern part of the city core near high-rise apartment complexes. The surveyed plots comprised villages demolished in 2014 for urban development. The plots were abandoned after demolition. Nearby residents cultivated on this land until it was redeveloped in 2021.

3.2 City-level case study

Based on the elements and features of informal food systems identified by individual case studies, Nanjing was chosen as the study case. The literature research and structured interviews were conducted to explore the potential and

Table 1 Formal and informal food production sites

	Cases	Location	Size/one plot	Size/whole subdistrict	Practitioners
Formal food production	1. Site in Guxiong subdistrict	Peri-urban area	Around 1332 m ² (2 mu)	612 ha	Local farmers
	2. Site in Guli subdistrict	Peri-urban area	Around 666 m ² (1 mu)	4981 ha	Local farmers
	3. Site in Qilin subdistrict	Peri-urban area	Around 666 m ² (1 mu)	1791 ha	Local farmers
Informal food production	4. Site in Maqun community	Central urban area	Around 800 m ²	1.8 ha	Urban residents
	5. Site in Shiziba	Central urban area	Around 500 m ²	4.9 ha	Disposessed farmers
	6. Site in Huadian	Central urban area	Around 500 m ²	0.54 ha	Urban residents

limitations of informal food systems in the current planning system. The literature is based on planning documents in Nanjing. Planning programs, including HCRS, Rural Land Transfer (RLT), Permanent Basic Farmland Protection (PBFP), and Vegetable Basket Program (VBP), were analyzed in this study. Sixty questionnaires were administered to understand consumers’ preferences toward street food vendors and their fresh products.

3.3 Food security framework

Three major food security dimensions can be derived from FAO’s definition: availability, accessibility, and utilization (FAO, 2006). This study adopts a food security framework from (Ericksen, 2008), including nine sub-dimensions. Figure 4 illustrates the research materials and methodologies for each sub-dimension of food security. Availability refers to the supply of food of appropriate quality and sufficient quantity. Its production and distribution contribute to food availability. Since this study does not involve non-commercial food supply chains, food exchange is not within the research scope. Food accessibility refers to whether individuals have sufficient resources to obtain appropriate nutritious foods. The affordability and preferences of urban households and the allocation of local food define the dimension of accessibility. Food utilization is a crucial non-food input for food security, including food safety, nutrition, and social value.

This study assessed the contribution of informal food systems to food security primarily from the perspective of

producers rather than consumers. Information that cannot be obtained directly from producers was obtained from consumer questionnaires. For example, this paper assessed the area of food production in informal food systems to analyze their contribution to food availability rather than deriving how much of households’ food comes from informal food systems. This study analyzed the contribution of informal food system activities in terms of the dimensions within the food security framework and the policies and planning programs that correspond to these activities and dilemmas in food planning.

4 Results

The results of the field research identified the main food types in informal food systems, the property and size of land and labor, and the role of small-scale farmers and informal food practitioners in local food supplies. After field research, the results of the literature research showed how current food planning ignores informal food systems.

4.1 Availability

Vegetables and fruits dominate the offerings in vendor markets. Table 2 presents the results of investigation of the open-air food market in Xiaolingwei. Vegetable stands constituted 65% of the open-air market in Xiaolingwei, whereas fruit stands accounted for 14.5%. Most of these foods, particularly vegetables, are seasonal agricultural products. The surveyed vendors cultivate food by themselves, including formal and informal food production. As formal food production, local peasants cultivate food on their farmland. Due to the small size of cultivated land, they tend to sell their agrifood directly to consumers in street markets or public spaces of wet markets. Landless farmers or low-income urban residents produce food on abandoned or vacant land for profit. They sell fresh produce as mobile vendors in street markets or their residential quarters.

Formal food production implies that local rural residents have their own land. The surveyed small-scale farmers had about 666 to 1332 square meters of land for vegetable cultivation and other land for grain. On average, one hectare of land can produce 34,541 kg of vegetables in Nanjing annually (Nanjing Municipal Bureau of Statistics, 2022). According to the FAO’s healthy diet standard, each person should consume at least 0.4 kg of vegetables daily (FAO, 2021). Then, each small-scale farmer in the informal food system can supply about 16 to 32 people with vegetables per year.

Figure 5 shows the land tenure system in China. HCRS, initiated in the 1980s, is founded on land tenure laws in

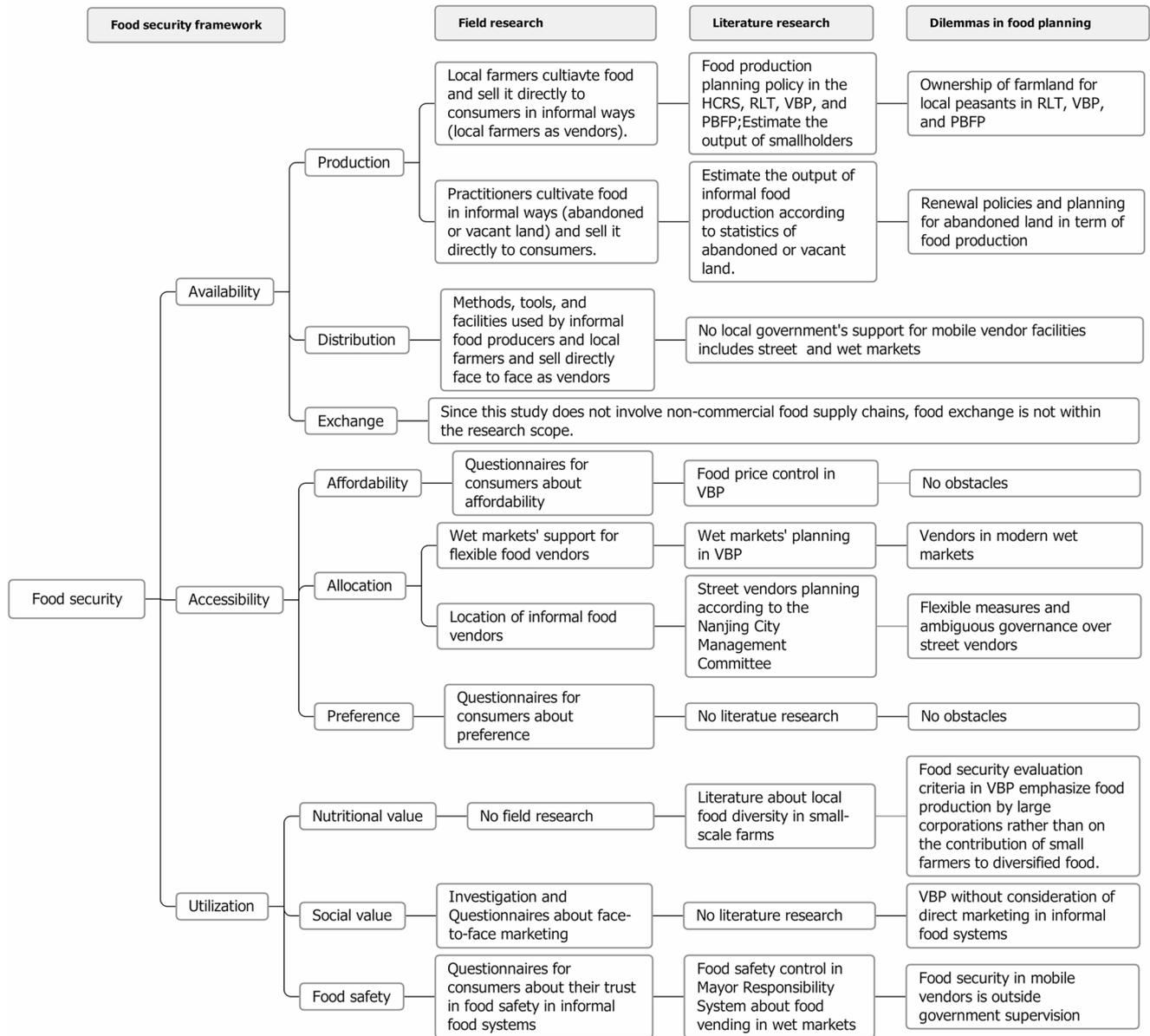


Fig. 4 Field and Literature research within the food security framework

Table 2 Investigation of the open-air food market in Xiaolingwei

Type of agrifood (number of stands)	Tools of vending stands	Sex (number of vendors)	Ages (number of vendors)
Vegetable	Shoulder pole	Male	Over 50 years old
Fruit	Bicycle		
Meat	Tricycle	Female	50 years old and below
Others	Minibus		

which states possess land in urban areas, and rural collectives own land in rural areas. Village committees periodically allocate arable land to rural households based on family size and availability of labor (Ministry of Justice of the People’s Republic of China, 2019). During the first three decades, agricultural production in the country increased by 73.4%, and the per capita income of farmers surged by

34.53 times (Ministry of Justice of the People’s Republic of China, 2019). Rural registered households are entitled to the allocated agricultural land. Residents with urban household registration cannot change to rural household registration, even if they move to the countryside.

Although this system protects the land-use rights and interests of registered rural residents and prevents wealthy

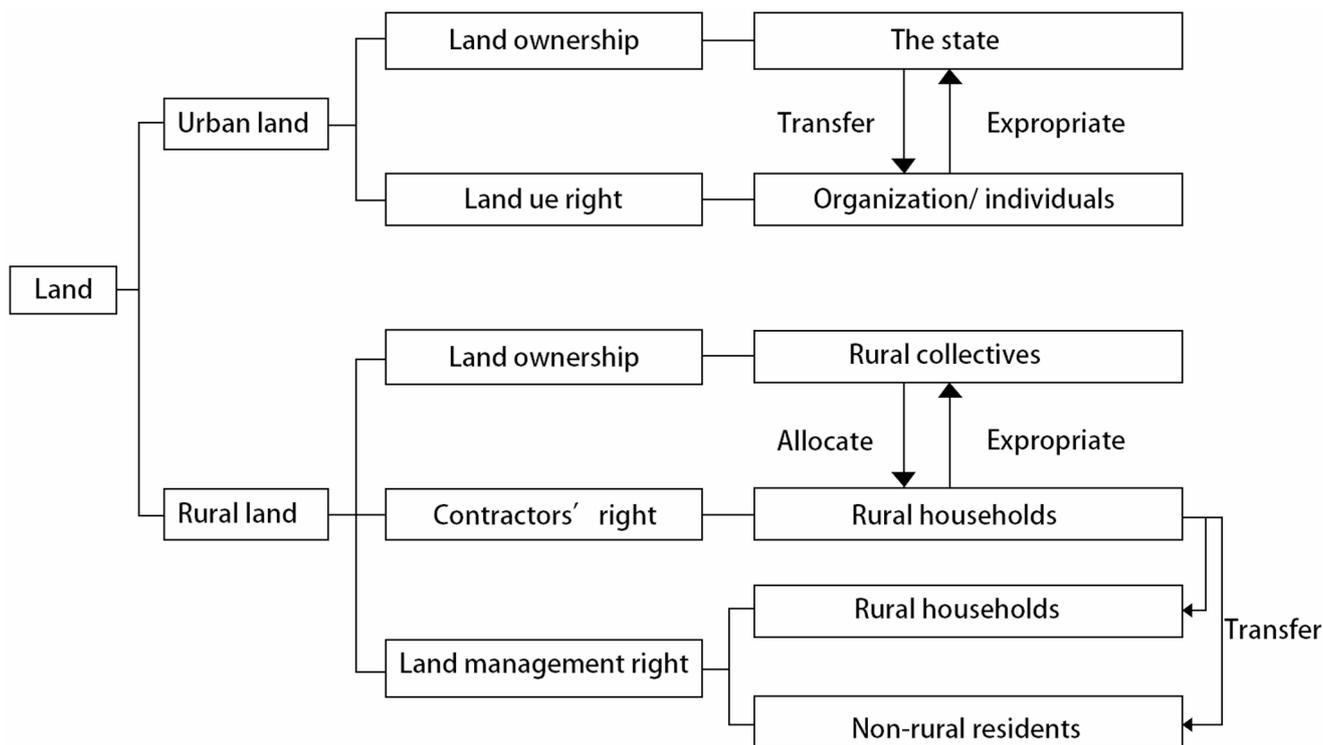


Fig. 5 Land tenure system in China (Zhao, 2023)

individuals in the city from seizing rural land, the local government considers the fragmented and small-scale farmland backwards and challenging to create high value (Krusekopf, 2002). According to the Third National Agricultural Census of Nanjing, Figs. 6 and 7, and 8 show that despite the larger number of local smallholders, there is no significant difference in the composition of sex, education level, and age among local smallholders, large-scale agricultural households, and agricultural enterprises (Nanjing Municipal Bureau of Statistics, 2018). Local smallholders aged above 55 are slightly more than those aged 36–54. Most agricultural practitioners have primary and junior high school education. The average arable land size in China is approximately 0.5 hectares (Ministry of Agriculture and Rural Affairs of the People’s Republic of China, 2014). There are 515,500 rural households registered in Nanjing, with approximately 1.23 million people, and 417,100 households engaged in agriculture, of which 333,300 are local smallholders (Nanjing Municipal Bureau of Statistics, 2018).

RLT encourages rural households to lease their land to agricultural companies, promoting intensive and modern agriculture. At the beginning of the implementation of HCRS, the policy prohibited the transfer of rural farmland contracting and management rights until 1984, when the government allowed local rural households to transfer the contract rights (Han, 2018). Transferred rural land in Jiangsu province exceeds 20,000 square kilometers, and among the administrative districts of

Nanjing, Lishui district has the largest land circulation area, reaching 168.66 square kilometers (Ministry of Agriculture and Rural Affairs of the People’s Republic of China, 2021). Among the rural households that have carried out rural land transfer, 79.91% of the villagers are voluntary, while 7.94%, 7.94%, and 2.34% of the villagers have been mobilized by the local government, village cadres, and other organizations, and 1.87% have been forcibly accepted for the transfer (Qian et al., 2021).

VBP is a planning strategy that ensures a local supply of fresh food but ignores support for smallholder farmers. It plays a crucial role in establishing regional food systems, reflecting agricultural industrialization’s tendency toward strong top-down features (Geoffrey Luehr, 2019). VBP is committed to supporting large-scale and standardization of agricultural production bases. The program established 16 permanent standardized vegetable production bases covering a total area of 133.3 square kilometers and over 100 regular bases, with an area exceeding 6.7 hectares, from 2013 to 2017 (Ministry of Agriculture and Rural Affairs of the People’s Republic of China, 2013).

PBFP aims to ensure food security by protecting arable land based on a comprehensive land-use plan and agricultural product demand for population growth and socio-economic development (Nanjing Natural Resources and Planning Bureau, 2006). This system considers two major factors for farmland protection: quantity and quality of arable land:

(Ten thousand person)

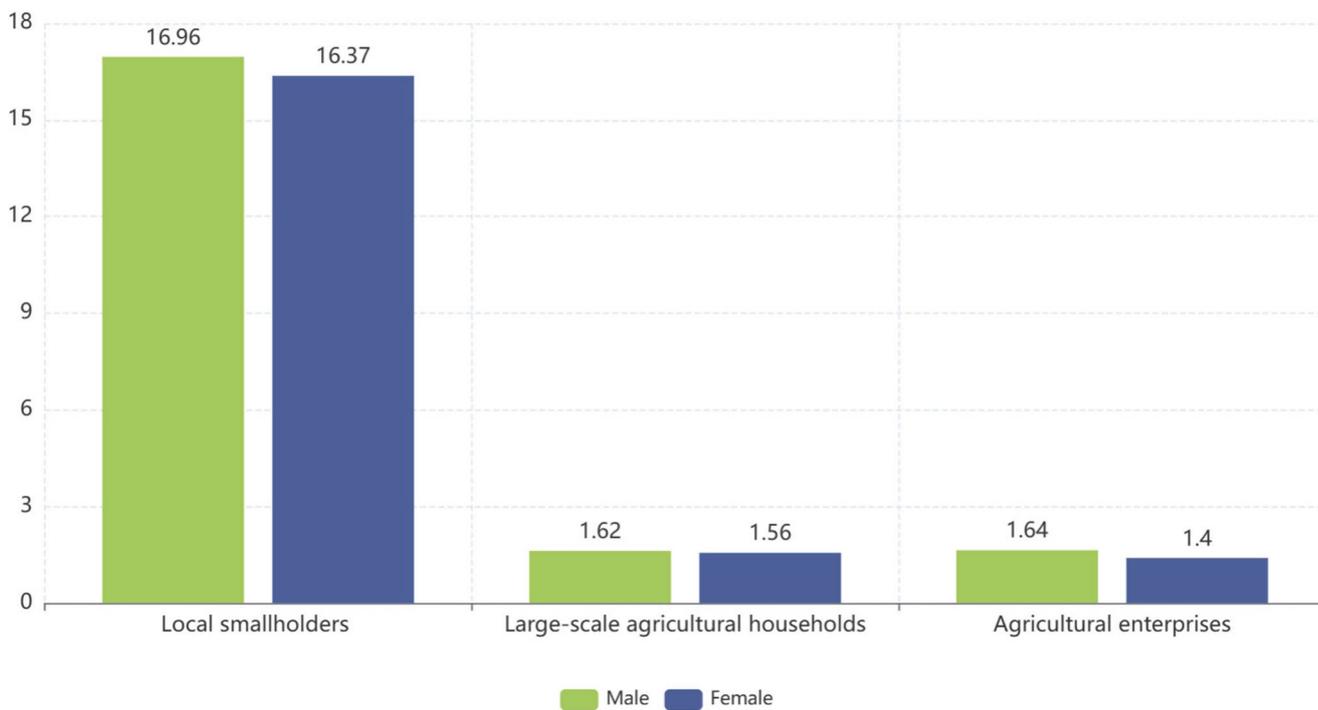


Fig. 6 Sex and number of agricultural practitioners in Nanjing

(Ten thousand person)

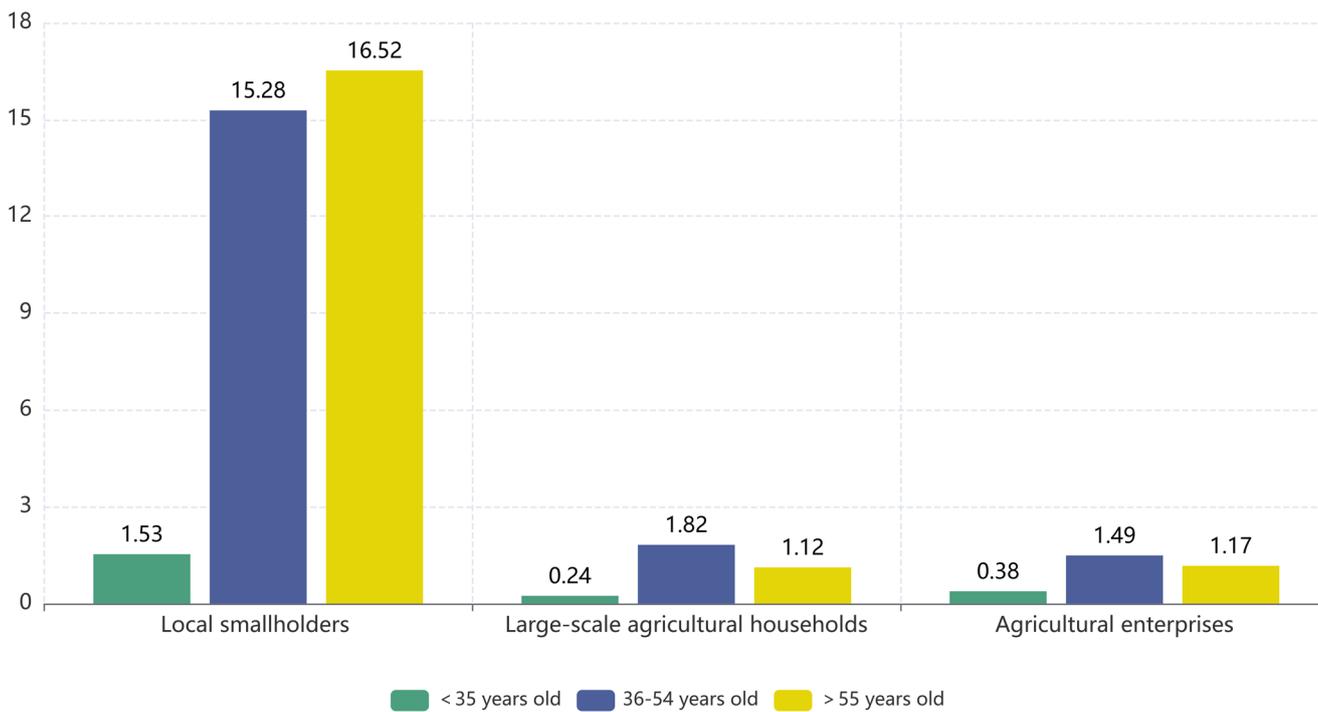


Fig. 7 Age of agricultural practitioners in Nanjing

(Ten thousand person)

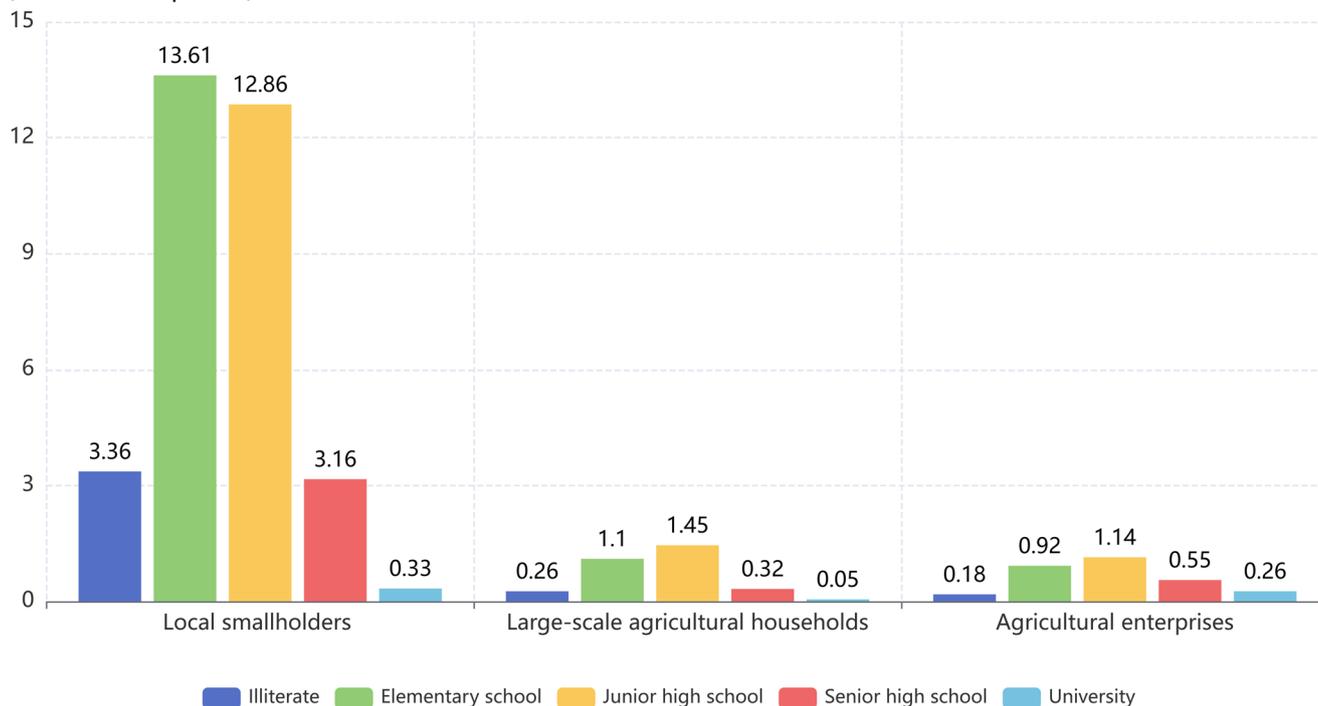


Fig. 8 Educational level of agricultural practitioners in Nanjing

“Article 8: When formulating the overall land use plan, governments at all levels shall include the protection of basic farmland as a part of the plan, and clarify the layout, quantity indicators and quality requirements of basic farmland protection.” (Nanjing Natural Resources and Planning Bureau, 2006).

In addition, land designated as permanent basic farmland is prohibited from being converted into other land types without approval from the State Council. For necessary land transformation, the local government must request approval from the State Council to revise the land-use plan. When utilizing arable land, the equivalent amount and quality of farmland must be restored or compensated.

Under informal food production, practitioners cultivate land without permission. Approximately 5.8% of China’s existing urban construction land is abandoned, covering 16,187 square kilometers (Qu et al., 2020). If calculated according to China’s 2024 food production per unit area of land at 5,921.1 kg/ha and the FAO “food security line of 400 kg per capita per year”, China’s abandoned land can guarantee more than 23.96 million people a year of basic food supply (The State Council, 2024). Reports by the Ministry of Land and Resources indicate that enterprises cause 46% of abandoned land, whereas 54% stems from misconduct by the local government, such as challenges in the acquisition of land and planning modifications (Wang, 2010).

The informal food supply chains investigated were both direct and face-to-face. In informal food systems, farmers

wash agri-products on their farms, such as for soil removal, before selling them. While being sold, vegetables and fruits that require peeling or cutting are prepared according to customer specifications. People use simple tools to transport agricultural products, the most common of which are shoulder poles, bicycles, and tricycles. In the Xiaolin-gwei open-air market, these three tools account for 23%, 17%, and 28%, respectively. Vendor markets are held in the morning and located near residential areas. As vendors do not have refrigerated storage facilities, food prices change depending on the freshness. In addition to open-air markets, mobile vendors also prefer open spaces near wet markets. Traditional wet markets provide space for mobile vendors to charge daily management fees.

4.2 Accessibility

Table 3 shows sixty questionnaires that surveyed consumers’ attitudes toward vendors and their produce. The random interviews took place near open-air markets. Most of the customers in open-air markets are women, so a large proportion of interviewees are also women. Fresh and healthy food, low prices, and convenient location are the main reasons consumers choose street vendors. Consumers are skeptical about the safety of agricultural products such as pesticides and preservatives in long food chains. They are more likely to visit vendors with whom they already have

Table 3 Results of customers' questionnaires

1. What is your sex?			
Male	20%	Female	80%
2. How old are you?			
< 30 years old	26.67%	30–40 years old	0%
40–50 years old	13.33%	> 50 years old	60%
3. What is your level of education?			
Elementary school	13.33%	Junior high school	40%
Senior high school	6.67%	University	40%
4. How often do you visit vendors?			
Everyday	40%	3–5 times per week	20%
1–2 times per week	33.33%	Less than 1 time	6.67%
5. What type of vendors do you visit regularly? (Multiple choice question)			
Wet markets	53.33%	Open-air markets in the morning or evening	66.67%
Mobile vendors	66.67%	Others	6.67%
6. What time of day do you typically visit vendors? (Multiple choice question)			
Before 6 am	46.67%	6 am – 8 am	26.67%
8 am – 12 am	20%	12 noon – 6 pm	13.33%
6 pm – 10 pm	40%	After 10 pm	0
7. What locations do you frequently visit vendors? (Multiple choice question)			
Roadsides	53.33%	Squares	26.67%
Alleys	20%	Around subway entrance	20%
Wet markets	46.67%	Near the place of residence or workplace	60%
8. What do you think are the advantages of buying food from vendors? (Multiple choice question)			
Convenient location	66.67%	Cheap price	53.33%
Fresh and healthy food	73.33%	Variety	0
As a leisure activity	20%	Others	0
9. What do you think are the disadvantages of buying food from vendors? (Multiple choice question)			
Food safety issue	46.67%	Give short weight	46.67%
Chaotic order	33.33%	Occupy public spaces and affect traffic	26.67%
Street vendors are unsightly in the city	20%		
10. Where do you tend to source your food?			
Locally produced and directed marketing	86.67%	Locally produced and through wholesale market	6.67%
Domestic imported and through wholesale market	6.67%	Imported from abroad	0
11. Why do you care about where your food comes from? (Multiple choice question)			
Freshness and health (transit time, etc.)	100%	Variety and quality	53.33%
Impact of carbon emissions on the environment	0	Difference in price caused by the middleman	6.67%
Others	0		

a familiar relationship. Food from street vendors is cheaper than wet markets and supermarkets. Roadside and wet markets are where customers often visit vendors. People often visit vendors in squares, alleys, and subway entrances. Consumers visit vendors frequently. 40% of people buy fresh products from vendors every day. People are more likely to buy fresh food before 6 am and between 6 pm and 10 pm, accounting for 46.67% and 40%, respectively. Most consumers choose vendors close to where they live or work.

86.67% of people prefer locally produced food and directed marketing. All interviewees agreed that fresh and healthy food was important, but they were not concerned about carbon emissions in the food chain.

Nanjing's food planning shifted from a focus on food production to food accessibility, developing a mixed public-private wholesale market ownership system to ensure food availability and affordability (Zhong et al., 2023). VBP works to renovate and build wet markets to improve urban

food accessibility. The local government is formalizing and modernizing traditional wet markets that were used to provide space for informal food vendors with low fees and are now being leased to middlemen. In Nanjing, the government has stipulated that each community should have an average of four “Vegetable Basket” outlets (Nanjing Government, 2017). It ensures the operation of two non-profit wholesale markets in Nanjing and plans to complete the renovation of 101 wet markets between 2016 and 2030 (Nanjing Government, 2018). New wet markets should have a construction area of at least 2,000 square meters, a service radius spanning 500–600 m, and an area of 50–75 square meters per 1,000 people. They must also have essential amenities, including freight-handling zones and parking facilities (Ministry of Justice of the People’s Republic of China, 2016).

Local governments adopt flexible measures for mobile vendors. To maintain the city’s cleanliness and beauty, street vendors are frequently arranged on its outskirts. However, this has caused some sellers who are unable to support themselves to return to the city center as informal and mobile vendors (Huang et al., 2012). The Nanjing City Management Committee designates ten scenic roads and 70 strictly regulated roads where stalls are strictly prohibited (Provisions of Nanjing Municipality on the Administration of Temporary Booth Establishment, 2009). This emphasizes the importance of maintaining urban traffic flows and enhancing urban aesthetics. A legal street market can be established in urban streets, alleys, residential neighborhoods, squares, and other public spaces, except in prohibited areas. To boost consumption and support low-income individuals, the Urban Management and Law Enforcement Bureau set up an additional 1,410 temporary booths in response to the COVID-19 pandemic. By May 2020, Nanjing had 134 legal locations for mobile vendors (Nanjing Government, 2020).

4.3 Utilization

The six surveyed sites demonstrated the benefits of small-scale food production in that farmers grow a variety of regional farming varieties and supply seasonal harvests. Modern wet markets emphasize distribution and retail and are gradually replacing traditional wet markets and street markets. This is accompanied by the marginalization of informal employment groups in food systems. Mobile vendors sell fresh and perishable local vegetables and fruits at lower prices than modern markets do. As a result, small-holder farmers, low-income urban residents, and rural migrants can survive.

According to observation and interviews with vendors, traditional vendors’ markets facilitate direct interactions between local farmers and consumers, offering low-cost

rental spaces and basic amenities. During the harvest season, local farmers rent open spaces in these markets daily to sell their produce. At the morning market in Xiaolingwei, each vendor stand pays 1 RMB per day, equivalent to about 0.14 dollars. However, as wet markets modernize, the high rental fees for stands often exclude local farmers from participating in these modernized venues (Yuan et al., 2021). According to interviews with vendors in Xiaolingwei, vegetables in modern wet markets originate mainly from Zhongcai wholesale market which is the biggest wholesale market in Nanjing.

Ensuring the local food supply is the primary goal of VBP. It is committed to improving its food self-sufficiency. There are 50–60 vegetable varieties growing in Nanjing each year. Nanjing’s vegetable self-sufficiency rate reached 40%, whereas the self-sufficiency rate of leafy vegetables under the Vegetable Basket Program was 80% (Ministry of Agriculture and Rural Affairs of the People’s Republic of China, 2013).

The mayor’s political achievements were related to the outcomes of VBP. It is based on the Mayor Responsibility System (MRS). In addition to food production, this system is responsible for the variety, price, and safety of the food. City mayors are responsible for the program as part of officials’ performance evaluation. A two-year assessment of the program was conducted, which included five categories: regulation capacity, accounting for 24%; production capacity, also 24%; quality supervision capacity, 24%; citizen satisfaction, 8%; and market circulation capacity, 20% (Ministry of Agriculture and Rural Affairs of the People’s Republic of China, 2017). Food prices were assessed using the annual consumer price index (CPI). Nanjing’s CPI by 2023 is 100.6%, which is higher than the national CPI of 100.2% (Nanjing Municipal Bureau of Statistics, 2023b). Measures to ensure food safety in the VBP include building and updating facilities to provide fresh food, conducting random food inspections, and building food traceability systems.

Nanjing has taken a number of measures to ensure food safety, including increasing the coverage of food production certification, developing and improving food safety monitoring and testing systems, improving the sanitation of wet markets, and strengthening the enforcement of food quality and safety regulations (Zhong et al., 2019). However, informal food vendors are not included in this supervision system. According to interviews with vendors and questionnaires with consumers, supervising food safety among mobile vendors depends on their familiarity with consumers. During the interviews, consumers demonstrated trust in the vendors they frequently visited. Consumers believe high prices do not necessarily ensure food safety. Especially for older residents, their knowledge of local farmlands and informal food production sites allows them to contact farmers face-to-face.

5 Discussion

Diverse food systems play a positive role in the stability of food security, which refers to long-term food availability, accessibility, and utilization. Recognizing these contributions can help informal food systems gain policy and financial support. Food systems involve diverse spheres, and the intersection of these spheres requires a multi-scale approach to food system planning that considers more activities, actors, and multiple spaces (Cabannes & Marocchino, 2018).

5.1 Appreciation of small-scale agriculture

Small-scale farms deserve appreciation because they can promote biodiversity, ecological sustainability, and social justice (Altieri, 2009). Peasants, landless farmers, migrant laborers, and low-income city dwellers earn their livelihoods by engaging in small-scale food cultivation and informal food vending. Although the HCRS, which protects the rights of peasants being allocated farmland, increased national agricultural output in the first three decades after the collective economic system because of the shift toward industrialization and modernization, the local government considers fragmented farmland and small-scale farms that are difficult to mechanize as threats to productivity (Han, 2018). PBFP responds to the ongoing occupation of farmland by urbanization and industrialization and is allocated based on the national population and socioeconomic demand for agricultural products (State Council Information Office, 2019).

Narrow food security objectives that prioritize solutions based on the market for productivity and achieve self-reliance on a national scale have led to food planning programs that ignore the contributions of local and small-scale agriculture systems (Kirwan & Maye, 2013). The National Food Security Report in China outlines several key criteria, including agricultural production output, levels of self-reliance, storage capabilities, food availability, and hunger prevalence (The State Council Information Office of the People's Republic of China, 2019). Thus, food planning aims to enhance farmland productivity and ensure that residents have access to food. Consequently, RLT is a measure to achieve these goals by promoting large-scale farms, thereby fostering agricultural modernization and intensification (The State Council, 2014).

The six surveyed production sites and three marketplaces improved food availability and accessibility in urban residential areas. According to study results, affordable, fresh, and healthy food with high accessibility is the main reason why consumers choose local food producers. The third agricultural census indicates that small-scale farmers operate on

70% of China's arable land (National Bureau of Statistics, 2017). Conventional small family farms can also achieve high productivity if the evaluation criteria focus on the comprehensive output of diverse agrifood products rather than a monoculture (Altieri et al., 2012). A diverse mix of vegetables, fruits, animal products, and grains can mitigate the risk of disruption in food markets. Food security planning should consider many small-scale farms. Concepts of food security have changed over the past three decades. It initially focused on ensuring food availability and stable prices but now encompasses broader considerations, including ethical and human rights dimensions (FAO, 2006).

Food planning also needs to consider informal food production practitioners, who play a positive role in local economic development and food security. Numerous literary works have viewed urban planning as a potential hindrance to urban food cultivation. The reluctance of urban administrators to adopt policies supporting urban food production is a recurring theme in the literature dating back to 2000 (Bryld, 2003). In developing and developed nations, vibrant cities face significant challenges owing to the high cost of urban land, which hinders planning programs that promote intra-urban agriculture (Zeeuw & Drechsel, 2015). Urban policymakers and planners are growing more cognizant of the positive outcomes of urban farming in fostering food security and resilience. Food production in urban areas should be adopted in various formats and sizes, allowing designers and planners to strategize and develop diverse food production initiatives that enhance social, economic, and ecological sustainability.

5.2 Supporting local food supply chains

The trend of localizing food systems to diminish environmental impacts associated with food transportation and disposal, bolster food accessibility, and local economic development is gaining popularity (Benedek et al., 2020). Informal food systems, including small-scale farming, urban food production, and local open-air and wet markets, bolster the local agrifood supply chains. Surveyed farmers and informal food producers took advantage of the proximity of the city by selling fresh agrifood at street markets. Familiarity between local food producers and customers can foster trust in food safety and fair pricing, even in the absence of official market supervision.

Although the VBP promotes food self-sufficiency, its support for food localization and farmer-to-consumer sales is limited. The extensive distribution and transportation systems of large-scale food operations hinder direct connections between small-scale farmers and large wet markets. Consequently, vegetables often pass through four to five intermediary stages from farmland to fresh food outlets

(Wang & Chen, 2013). While the assessment standards of the MRS consider the ability to cultivate local food, there is no distinction between local and non-local food distribution and marketing processes. Both types of food are transported to wholesale markets, and, subsequently, to food outlets. Approximately 80% of the agricultural products from neighboring cities are directed to centralized distribution hubs in Nanjing before being distributed to various local wholesale markets and then transported to retail outlets, such as open-air markets, small shops, wet markets, and supermarkets (Si et al., 2016).

The results of the questionnaires showed that customers who visit vendor markets do not care about the effect of carbon emissions on the environment in food supply chains. Low-income residents pay more attention to food freshness and price. This poses a challenge for upgrading small farms. Upgrading small farms as a form of a Participatory Guarantee System, which underscores the engagement of local farmers, customers, rural advisors, and municipal officials, can bring more added value to local farmers (FAO, 2018), but it also means that their production may not be affordable for low-income residents. A major advantage of this business model is that it achieves quality assurance through farm visits and collaboration to ensure that farmers adhere to organic standards. Successful farmers' markets currently operate with the involvement of large farms in China; however, they still provide experience for small farms and informal open-air markets that claim financial support and urban public spaces (He, 2020).

5.3 Formalization of bottom-up initiatives

Compare with the clean-up plan that treats informal activities as a problem (Boonjubun, 2017) and ambiguous governance that expresses empathy for informal practitioners (Weller, 2012), transforming the adverse impacts of informality into advantages through urban planning and policies is a better approach. Formalizing bottom-up food initiatives facilitate cooperation among a broad range of stakeholders to optimize informal activities. It optimizes the utilization of abandoned or underutilized land, conserves environmental resources, and beautifies public spaces (Hardman et al., 2018). It also provides a means for the unemployed, elderly, and dispossessed farmers to supplement their food supply and income. Conversely, a lack of formality implies these activities occur without government oversight. This is problematic because abandoned construction sites may have polluted soil and water, and individual cultivators typically lack the resources to detect and remediate the pollution.

In China's dual land structure of urban and rural areas, contemporary industrial production prevails in the urban economy, whereas food production dominates in the rural

economy (Chen & Long, 2019). This land tenure system separates urban and rural land, giving urban residents no right to obtain farmland. In planning documents, urban agriculture, known in Chinese as *du shi nong ye*, typically refers to farming or gardening on agricultural land around urban areas rather than non-agricultural land within the built-up area. Although urban areas lack officially designated agricultural land, informal food production frequently occurs at urban sites. By inclusion of urban land in food, planning can formalize informal food production activities into recognized urban agriculture. Urban food production activities can be sustainably and positively affected by integrating urban agriculture into legislation concerning urban and rural planning (Cai & Luo, 2004).

In Nanjing cases, city managers disregard informal food production without supervision and policy support. Individuals either passively or actively engage in informal activities because of the absence of formalization procedures. In the Global North, urban food production, as a traditional activity, has been undergoing formalization and legislative processes (Hardman & Larkham, 2014). Numerous formal urban agriculture initiatives originate from the practice of guerrilla gardening, where individuals initially occupy spaces and subsequently engage with local authorities to advocate for legislative adjustments (Hardman & Larkham, 2014).

Informal food production and marketing play a pivotal role in the informal food supply chain. Establishing a formalization pathway for informal food production initiatives could facilitate the oversight of food systems and amplify their beneficial impacts. Formalizing urban food production enables citizens to conduct urban agricultural activities within a secure framework. Converting unused land into urban agricultural plots necessitates specific regulations and approval processes. Unsuitable land, due to factors such as soil quality or pollution, sunlight exposure, water availability, and agricultural infrastructure, can adversely affect the success of farming endeavors.

Systematic regulations and reasonable planning are necessary to issue vendor licenses and supervise and manage vending activities. Since 2009, street vendors have become eligible for registration as individual industrial and commercial entities in China; and many cities have endeavored to formalize their presence (Management And Law Enforcement Bureau, 2009). Street vendors are often relocated to the city outskirts to maintain cleanliness and aesthetics. However, this has resulted in some vendors being unable to maintain their means of living and returning to the downtown area as informal vendors (Huang et al., 2012). Legislation and formalization processes for street vendors must focus on mitigating the negative impacts of informal activities and ensuring adequate space and support, especially for vulnerable groups.

6 Conclusions

This study explored the contribution of informal food systems to food security through field and literature research, including city- and individual-level case studies. Owing to China's urban-rural dual land and HCRS, small farmers still account for a large proportion of the country's population. Smallholders contribute to the diversity and local food supply. Informal urban food production utilizes large amounts of unused land and is at risk of expulsion owing to the lack of land-use permits. Disadvantaged groups engaged in small-scale agriculture and informal food production, including local farmers, landless farmers, and economically disadvantaged groups, choose food vending as their marketing channel. Informal food marketing improves food accessibility and provides consumers with affordable fresh food. The limitation of this study is that the contribution of informal food systems to food security is only analyzed from the perspective of producers in the food supply chain from production to consumption, and there is no systematic assessment of consumers' dietary composition and consumption habits.

Current food planning in China considers food self-sufficiency to be top priorities. However, as the concept of food security expands, planners must focus on the diverse stakeholders and activities within the food system. Small-scale farming and informal urban food production should be promoted to contribute to diverse food systems. As a channel for the local food supply, vendor markets can build direct connections and trust with consumers. Food security planning should support local food by optimizing informal food systems. Formalizing bottom-up food activities require support not only from food planning policies and regulations but also from urban spatial planning.

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Declarations

Consent to participate and publish Verbal informed consent was obtained prior to the interview.

Ethics approval Approval was obtained from the ethics committee of Nanjing University of Aeronautics and Astronautics. The procedures used in this study adhere to the tenets of the Declaration of Helsinki.

Competing interests The authors have no competing interests to declare that are relevant to the content of this article.

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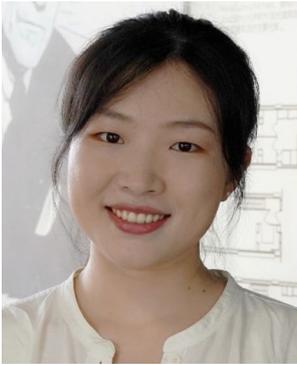
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