Original Paper

Strategic mapping of food assets to enhance food security and foster Circular Economy in Semarang City: A sustainable perspective

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Abstract. *Responding to the projected 2050 global food production increase of 50%, Semarang City in Indonesia, home to 1.65 million people, is confronting the challenge of ensuring food security for its populace. To prevent the displacement of local farmers, the decline of local markets, and to avoid other social issues such as poverty and hunger, it is crucial for Semarang to become food independent. This research aims to develop a robust food information system in Semarang City by identifying and analysing urban food assets. This system will support food security, promote a circular economy, and contribute to the creation of a Food Independent City in Semarang. The study commenced with a focus group discussion involving government agencies and organizations possessing food-related data within the city. Findings reveal a diverse array of food resources, including 49 markets, 5 fruit gardens, 10 urban farms, fisheries production, rice fields, beef cattle livestock groups, and the Farmer-Owned Enterprise Lumpang Semar Sejahtera, all playing pivotal roles in shaping Semarang's food landscape. This study contributes to addressing broader food issues in Indonesia, particularly in urban settings, by highlighting the significance of strategic planning and resource mapping in achieving sustainable food systems.*

1. Introduction

Food is a fundamental need for humans that must be fulfilled every day according to its nutritional value for the body (Leandro et al., 2020; Wallace et al., 2020). Food security has long been a central concern for policymakers, evolving into a multifaceted concept addressing both immediate and long-term challenges. One dominant perspective has been the emphasis on increasing agricultural production to combat under-consumption and hunger, thereby ensuring a steady food supply (Lang & Barling, 2012). It cannot be denied that food security is very dependent on the supply of food and the availability of food (Ansar & Fathurrahman, 2018; Rusmawati et al., 2023; Santoso et al., 2021). In 2050, it is estimated that world food production must increase by around 50% in order to meet the needs arising from the increase in human population (Cervantes-Godoy et al., 2014; Food and Agriculture Organization of the United Nations (FAO),

2022). However, focusing solely on increasing agricultural production to achieve food security can lead to significant challenges, such as climate change and variability, unstable markets, and shrinking arable land resources (Hossain et al., 2020). Additionally, prioritizing large-scale industrial farming over smallholder farmers exacerbates social inequalities, deepens rural poverty, and can displace communities, leading to social unrest (Ward Anseeuw & Maria Baldinelli, 2020). Therefore, while boosting production is important, it must be balanced with environmental protection and social equity to achieve sustainable food security (Namany et al., 2020).

Achieving sustainable food security necessitates integrating practices that ensure long-term ecological balance and equitable access to resources (Berry et al., 2015; Capone et al., 2014; McKenzie & Williams, 2015). This can be effectively connected with the principles of a circular economy. The circular economy is an economic system aimed at minimizing waste and making the most of resources by reusing, recycling, and regenerating materials in a closed-loop system (Kara et al., 2022). This approach is highly relevant to food security, as it promotes sustainable practices that reduce environmental impact (Vågsholm et al., 2020). Food asset mapping complements the circular economy by identifying local food resources, strengths, and gaps, enabling communities to utilize their assets efficiently (Jensen & Orfila, 2021). Circular economy practices, including food asset mapping, reduce food waste, support local production, and enhance resource sharing (Sindhu et al., 2023). By identifying and utilizing local food assets efficiently, these practices create a more sustainable and resilient food system.

Semarang City is a metropolitan city with a population of 1.65 million people (Handayani et al., 2020; Sejati et al., 2018; Syafrudin et al., 2021). The Semarang City Government is very concerned about food availability policies for its people. This is reflected in the City Mission number 2: "Increasing the potential of a competitive local economy and stimulating industrial development, based on research and innovation based on the principles of Pancasila economic democracy", and the City Mission number 4: "Creating quality infrastructure with an environmental perspective to support the city's progress". In these two missions, the Semarang City Government really pays attention to and supports the availability and diversity of food for its people through: urban farming, hydroponic festivals, herbs and spices garden, food street festivals, vertical gardens, and others.

Despite the Semarang city government's strong commitment to achieving its food security mission, they still lack a comprehensive and representative food

map to inform their policies and regulations; whereas a Food Asset Map is crucial for integrating food production assets, supply chains, population density centres, and health and nutritional data, all of which are essential for developing a robust system of food availability and security (Alisjahbana & Busch, 2017; Saurabh & Dey, 2021). Food Assets are local food infrastructure to maintain food availability and security in communities and regions, such as: agricultural production land, agricultural input production infrastructure, agricultural product processing infrastructure, retail traders (supply chain actors), sustainable food yards and families (including urban areas). farming), markets and their integration with mapping the conditions for fulfilling community nutrition (stunting levels, nutritional adequacy rates, and Expected Food Patterns - PPH) (Caro et al., 2018). Furthermore, National Development Planning Agency/Bappenas (2021) stated that the current implementation of the Food System in Indonesia is based on Food Production and Agriculture to achieve Food Security.

This research aims to fill a critical gap in the current literature on food security by developing a comprehensive and representative Food Supply Asset Map for Semarang City. Despite strong governmental commitment, Semarang City lacks such a tool to guide its policies and regulations. This study identifies and analyses urban food assets to create this map, which will enhance the city's ability to maintain food availability and security. Unlike existing studies that often focus broadly on increasing agricultural production or addressing food security at a national or global level, this research uniquely concentrates on a metropolitan context and integrates the principles of a circular economy. By mapping local food production assets, supply chains, population density centres, and health and nutritional data, this study offers a novel approach to enhancing food security policies. The focus on Semarang City is particularly significant as it exemplifies how urban areas can incorporate sustainable practices, such as urban farming and food asset mapping, to build a resilient and equitable food system. This integration of circular economy principles not only reduces food waste but also supports local production and resource sharing, providing a model that other cities can emulate to achieve sustainable food security.

2. Literature review

2.1. Urban and peri-urban food systems in Indonesia

The food system includes all actors and their involvement in interrelated value-added creation activities in the production, collection, processing, distribution, consumption and "waste" of food products originating from agriculture, forestry

or fisheries, and the food industry, as well as the economic, social and natural environment in which the process takes place (Mantino & Vanni, 2018). Food availability is the degree to which food is consistently physically obtainable in desired quantities, shaped by the production, distribution, and exchange patterns of food goods (Carson & Boege, 2020). Food availability is determined by production in the region, in this case the city of Semarang, food trade through market mechanisms in the region, stocks held by traders and government reserves as well as food assistance from the government. Figure 1 presents urban and peri-urban food systems in Indonesia.

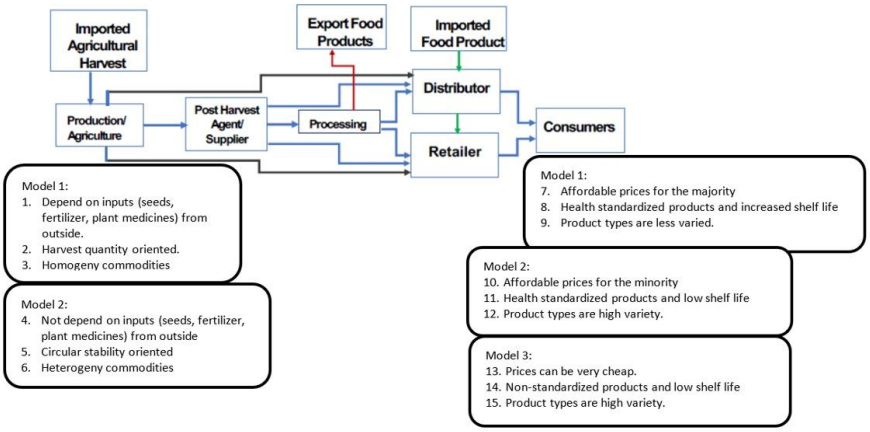

Figure 1. Urban and peri-urban food systems.

Food independence is the nation's ability to produce sufficient food to meet its needs through optimized domestic capabilities and fair international cooperation, emphasizing self-reliance and competitiveness without isolating from global partnerships (Febriani, 2023). In order to move towards a prosperous society, the focus of the development of Semarang City is contained in the Seven/*Sapta* Program, one of which is overcoming poverty and unemployment (Ahmad et al., 2019). Several poverty reduction programs in Semarang City, one of which is the food independence program (Alfisyahrin, 2021). So that in order to make Semarang City a Food Independent City, one of the ways is to support it with a food information system that can provide broad information so that each OPD has uniform data and information as a basis for preparing work programs that are oriented towards food security in Semarang City.

2.2. Food asset mapping

Asset mapping is a research tool utilized across various disciplines, particularly for supporting community capacity building and development (Kretzmann & McKnight, 1993) as cited in (Lightfoot et al., 2014). It has been employed to identify cultural assets (Jeannotte, 2016), health disparities and community health (Jakes et al., 2015), and both informal and formal community assets (Weng, 2016), as well as housing (Butterfield et al., 2009). The asset-based approach is now being applied to identify key food sites through food asset mapping. This tool is increasingly used by municipalities across Canada and is recommended by the American Planning Association (APA) (2007) in their Policy Guide on Community and Regional Food Planning. The APA (2007) advises planners to map the location of diverse "food assets" and enhance these assets. Additionally, there is a history of planners studying foodsheds—the total production area needed to feed an urban population (Donofrio, 2007). Food asset mapping helps in understanding foodsheds better.

The definition of food assets varies, and so does the purpose of food asset mapping. Currently, diverse stakeholders, including planners, public health practitioners, academics, and community organizations, conduct food asset mapping (Romses et al., 2017). There are several reasons for developing a food asset map. It is often used to keep track of the diverse food resources available in a city or region (Baker, 2018). Increasingly, online food asset maps help users find food sources in the city (Romses et al., 2017). Unlike culinary or gastronomic mapping, which focuses on promoting or attracting culinary tourism and mapping restaurants (Booysen & du Rand, 2021), asset mapping is primarily aimed at improving community food access and food security for equity-deserving community members.

3. Methodology

This research is conducted in Semarang City, the capital of Central Java Province. Geographically, the research area directly borders the Java Sea to the north (Figure 2). Data collection focuses on 16 sub-districts within Semarang City. The map below illustrates the research location.

The implementation of this research involved several stages, including primary and secondary data collection, data processing, database preparation, and data analysis using a spatial analysis approach to create thematic maps and perform

qualitative analysis of the types of food asset sources at the research location. The systematic stages of the research activities are as follows:

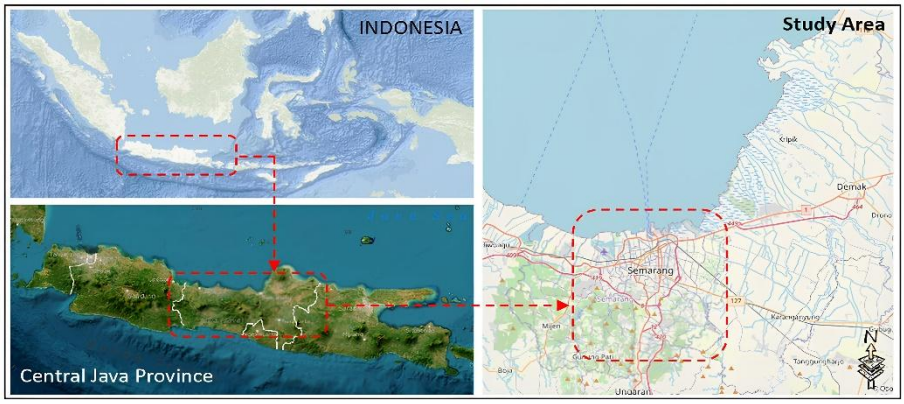

Figure 2. Research Sites

1. Focus Group Discussion (FGD)

A Focus Group Discussion (FGD) was conducted with a total of 25 participants from various affiliations, including the Regional Development Planning Agency (*Badan Perencanaan dan Pembangunan Daerah* - Bappeda), the Agriculture Department, the Food Security Department, the Trade Department, the Fisheries Department, the Cooperative and Small and Medium Enterprises Department (Dinas Koperasi dan UMKM), Farmer-Owned Enterprises, the Obor Tani Foundation, Food Bank Indonesia, PT PLN Indonesia Power Branch Semarang, lecturers from the Culinary Department of the Faculty of Engineering from a public university in Semarang- Universitas Negeri Semarang, and representatives from small and medium enterprises specializing in processed food.

The participants were divided into three groups based on their roles: government representatives from relevant agencies and universities, producers including small and medium enterprises, farmer groups, and universities, and consumers encompassing non-governmental organizations, social media practitioners, and universities. Throughout the discussion, participants focused on several key issues, including the availability of food supply data from upstream to downstream, regulations, the implementation of existing programs, and action plans for future initiatives.

2. Secondary data collection

Institutional surveys were conducted to collect secondary data related to food asset sources. Agencies involved included Bappeda, the Food Security Service, the Maritime Affairs and Fisheries Service, and other relevant bodies managing food asset data. The goal was to obtain information on food sources, land use, food source management, and additional data to support field survey activities.

3. Primary data collection

Field surveys were conducted using a participatory method, involving key personnel at each food storage site in the research location. The information collected included the name, address, and type of commodities stored. Surveyors then conducted field surveys at each food storage site using handheld Global Positioning System (GPS) equipment to obtain Universal Transverse Mercator (UTM) coordinates. Additionally, the field surveys included documentation of the food storage facilities, types and quantities of commodities, and management and production practices. The results of the field surveys were used as the database for developing the food asset information system at the research location.

4. Supporting data collection

Interviews with managers or responsible individuals for food assets were conducted to obtain detailed information about food barns in each region.

5. Database preparation

A food asset database was developed using Geographic Information System (GIS) technology, which served as the foundation for compiling thematic maps of food assets at the research location.

Data analysis in this research employed spatial analysis to prepare a spatial database and map of food assets in Semarang City. This spatial analysis identified the distribution and accessibility of food barns. Additionally, quantitative descriptive analysis was used to assess information related to each food barn, including types of food sources, land use, management practices, and other relevant data.

4. Results and Discussions

Food is one of the fundamental human needs for maintaining life. The types of food consumed by people in a region typically reflect the types of food that can

be produced or grown locally (Enthoven & Van den Broeck, 2021). This research was designed to identify the potential and capacity for food storage to support food supplies in Semarang City. To achieve this, a food supply map is necessary to provide comprehensive information regarding the food potential and conditions in Semarang City. The results of this research are as follows:

4.1. Market distribution in Semarang City

Data regarding markets, which serve as food supply providers in Semarang City, were obtained from the Semarang City Trade Office. The distribution of these markets is spread across 16 sub-districts in Semarang City. Markets in this research are categorized into three types: City Markets, Regional Markets, and Neighbourhood Markets. According to previous research, markets can be categorized based on consumer reach, physical improvements, and strategic location (Kharisma, 2014):

a. Neighbourhood Markets, serve the immediate surrounding area, selling household necessities. Semarang City has 24 neighbourhood markets.

b. Regional Markets, serve several residential areas within a sub-district, offering modern and relatively expensive commodities. Semarang City has 13 regional markets.

c. City Markets, serve the entire city and surrounding areas, offering a wider variety of goods than regional and neighbourhood markets. Semarang City has 12 city markets.

Markets are integral to the food supply chain of a region, with the buying and selling activities within them being key indicators of economic growth on local, regional, and national scales. Previous research describes market chains as networks connecting all relevant actors and transactions in the movement of agricultural goods from farms to consumers (Lundy et al., 2004). The analysis of agricultural commodity market chains includes price analysis and value addition throughout the sequence of activities from raw materials to the final product, highlighting all relevant actors and activities that directly influence the final product (Bockel & Tallec, 2016).

According to inventory data from the Semarang City Trade Office, Semarang City has 49 markets, categorized as neighbourhood, regional, and city markets. The management of these markets is divided among six regional coordinators, each managed by a respective UPTD. The regional coordinators are:

a. Johar Market Region: 5 markets

b. Karimata Market Region: 6 markets

c. Bulu Market Region: 7 markets

d. Karangayu Market Region: 9 markets

e. Jatingaleh Market Region: 9 markets

f. Pedurungan Market Region: 13 markets

The spatial distribution of markets shows that neighbourhood markets are widely spread across various sub-districts in Semarang City, whereas city and regional markets are concentrated in Central Semarang District, West Semarang District, and North Semarang District (Figure 3).

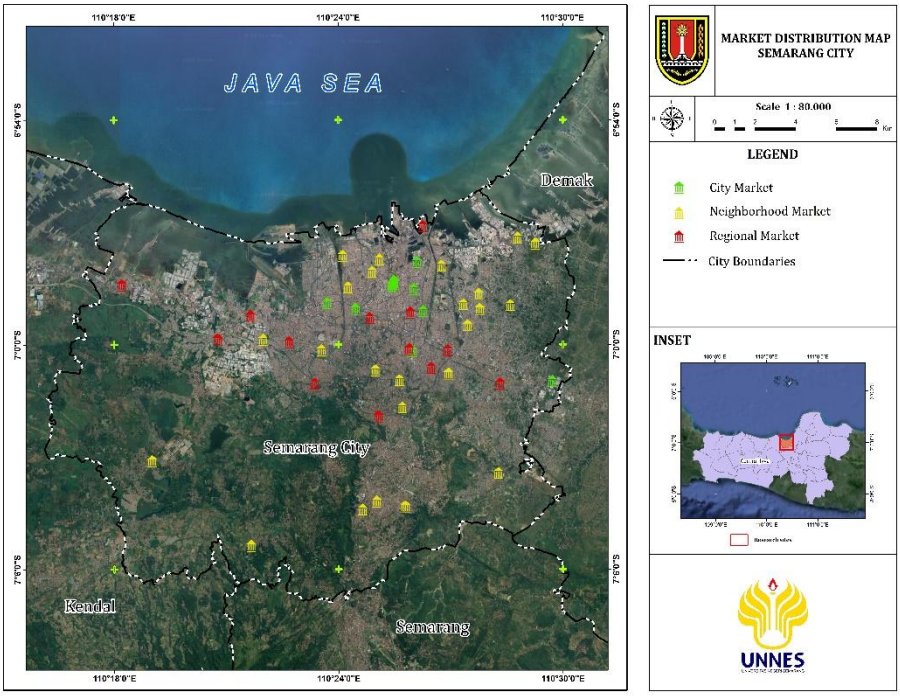

Figure 3. Market distribution map of Semarang.

4.2. Distribution of fruit gardens in Semarang City

Fruit is a vital component of the diet for many people. To meet the demand for fruit in Semarang City. The local government has established several fruit gardens. According to data from the Semarang City Agriculture Service, there are currently five fruit gardens located in the Gunungpati, Mijen, and Ngaliyan districts. Additionally, there is an Urban Farming Corner (UFC) on Jl. Menteri Supeno in the South Semarang District, which serves as a hub for agricultural activities.

Most fruit gardens in Semarang City are located in the upper areas, such as Gunungpati and Mijen districts. Developing a fruit orchard requires extensive land, which is more readily available in these upper areas. In contrast, the lower areas are too densely built-up, making orchard development impractical. Additionally, the upper Semarang area benefits from fertile soil due to its proximity to Mount Ungaran, which is highly conducive to agricultural and plantation activities, resulting in a high success rate for cultivation. Figure 4 illustrates the spatial distribution of these fruit gardens in Semarang City.

Each fruit garden in the research location has different crop commodities tailored to the natural resources and potential of each region. For instance, the Cepoko, Purwosari, and Wates fruit gardens primarily cultivate crystal guava and longan, while the Plalangan Fruit Garden focuses on durian. These gardens produce high-quality fruits that are popular among the residents of Semarang City, contributing significantly to the local fruit supply. According to (Mustikaningtyas et al., 2016), the Gunungpati District has the potential to become an agricultural center for organic fruit and vegetable gardens, underscoring the importance of these gardens in supporting the city's fruit and vegetable needs. The Cepoko, Purwosari, and Wates Fruit Gardens also serve as agrotourism destinations, offering educational and recreational opportunities for visitors. The Urban Farming Corner (UFC) further supports this initiative by acting as a meeting facility for farmers, hosting training sessions, discussions, and exhibitions organized by the Department of Agriculture.

The fruit gardens in Semarang City range in size from 3.2 to 10 hectares, utilizing land owned by the sub-districts. The Argo Plalangan Fruit Garden, covering approximately 10 hectares, is the largest, while the Agro Cepoko Fruit Garden spans about 3 hectares. The number of plants varies depending on the land area and the type of crops grown. For example, the Purwosari Agro Fruit Garden has the highest number of plants, with around 1,772 crystal guava, longan, and durian trees, managed by the Sumber Rejeki Farmers Group and the Semarang City

Agriculture Service. In contrast, despite being the largest in area, the Agro Plalangan Fruit Garden has the fewest cultivated plants (797 trees) due to the space requirements for durian trees, which need larger growing areas and wider spacing between trees.

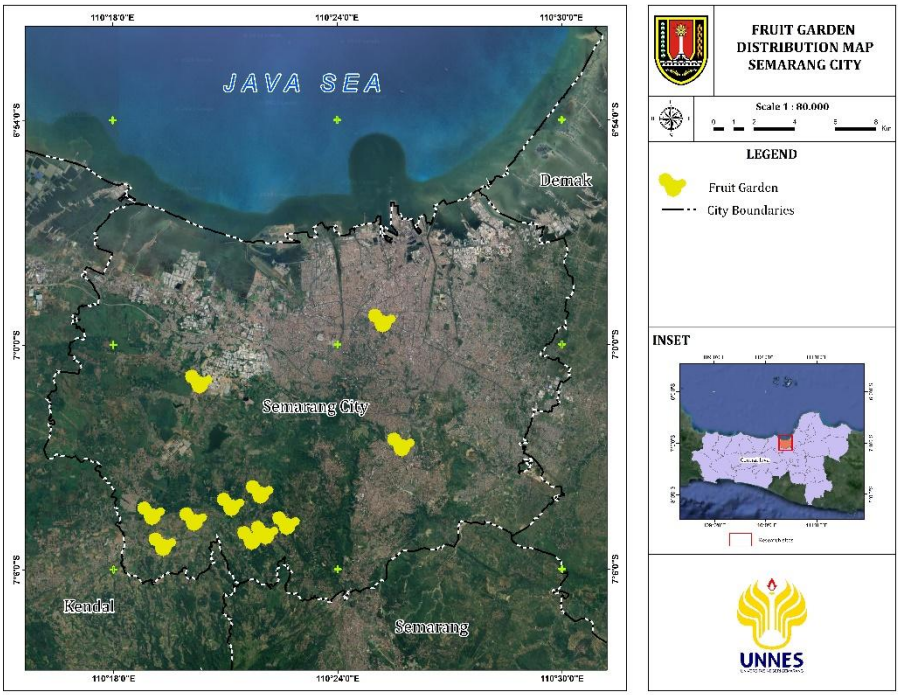

Figure 4. Fruit Garden Distribution Map of Semarang

4.3. Distribution of urban farming activities in Semarang City

Since 2019, the Semarang City Government has initiated the Urban Agriculture Movement to support the Mandiri Pangan Village program. To realize the government's goal of achieving food sovereignty, it is imperative to engage in food security activities across all sectors of society through the urban agricultural acculturation movement. This endeavour is reinforced by Semarang Mayor Regulation Number 24 of 2021, which outlines the Urban Agricultural Cultivation Movement in the city. According to this regulation, urban agriculture, also known as Urban Farming, involves the cultivation, processing, and

distribution of food and other products through intensive plant cultivation and animal husbandry in urban and peri-urban areas. It emphasizes the reuse of natural resources and urban waste to enhance crop and livestock diversity. The objectives of the Urban Agriculture acculturation movement in Semarang City include empowering communities to strengthen food and nutrition security, utilizing land and space effectively, creating a healthy environment, and enhancing greening efforts while utilizing household waste.

This urban farming movement is implemented across all sub-districts, schools, and government offices. Although all 177 sub-districts in Semarang City are mandated to execute the urban farming program, not all have been successful in their implementation. Sub-districts serve as the foundation of government at the grassroots level and play a crucial role in supporting the city government's initiatives. Farmer groups comprising local community members have been established in sub-districts to spearhead vegetable and fruit cultivation programs. Field observations have identified 10 sub-districts in Semarang City where urban farming is being effectively and sustainably practiced, with their spatial distribution depicted in Figure 5.

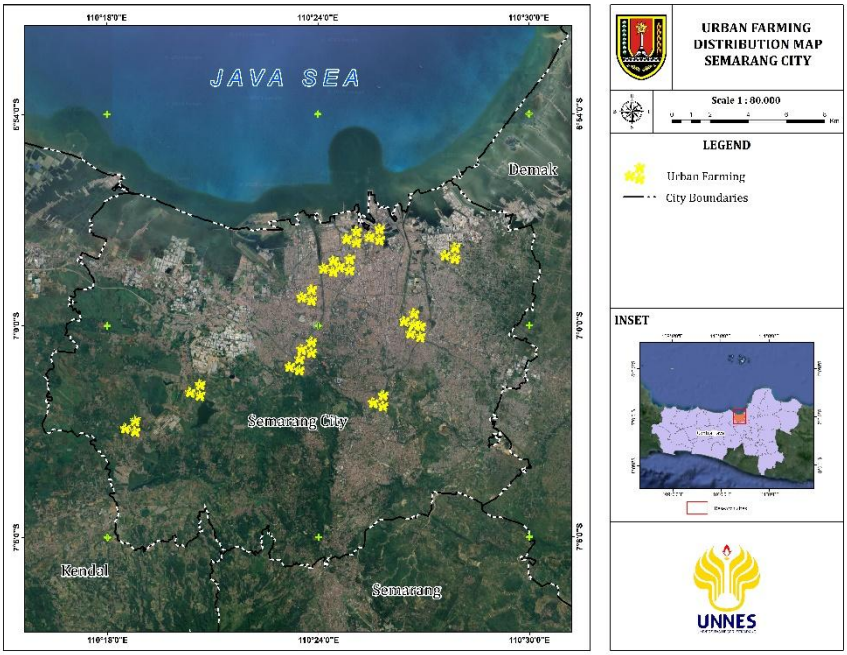

Figure 5. Urban farming activities distribution map of Semarang.

The urban farming activities that are currently continuing are mostly in the lower Semarang City area which actually has limited development space, but this is not an obstacle to the program, but rather makes the enthusiasm of KWT members to maximize the land. Based on the results of a field survey, urban farming in Tambakrejo Village has the largest development land area with an area of around 650 m², located on the banks of the Tenggang River. Urban farming in the area is managed by the Tambakrejo Farmers Group (KT) with cultivated crops in the form of vegetables and fish cultivation, where urban farming in the area is a Community Development and Empowerment (PPM) program carried out by PT Saka Energi Muria Limited (SEML) and Universitas Negeri Semarang. Next, there is Kambera urban farming with a land area of around 600 m² in Jatirejo Village with typical cultivated plants in the form of butterfly pea flowers and chilies. Furthermore, urban farming with the smallest area is in Miroto Village, Central Semarang District with a land area of around 100 m² which has cultivated plants in the form of horticultural plants.

4.4. Fisheries sector in Semarang

As a maritime country and the largest archipelago in the world, Indonesia has various kinds of coastal ecosystems and marine resources, including fisheries potential. Even though the potential and utilization of fisheries resources in fresh, brackish and marine waters is relatively high, eating fish has not yet become a culture in most parts of Indonesia. One food security that needs to continue to be improved is fish resources. As we know, fish contains good benefits for brain development. By consuming lots of fish, it is hoped that the nation's next generation will be a generation that is ready to compete with the outside world. Fish is universal to be used as food, fish can be accepted by all religions and all groups in Indonesia. Therefore, no restrictions on eating fish among communities in Indonesia. In addition, fish can be consumed by humans at almost any age (Nurphadilah et al., 2022). The coastal area of Semarang City has an area of 5,039.17 hectares or around 0.02 percent of the total area of Semarang City. Meanwhile, the length of the coastline is around 25 km, with details for Tugu District 3.5 km, North Semarang District 5.56 km, West Semarang District 8.94 km and Genuk District 7 km. Activities in this coastal area are increasingly heterogeneous, some of the people work as fishermen (Ridlo & Yuliani, 2018). Apart from marine fisheries commodities, freshwater fisheries are also a potential that cannot be ignored. With so many flowing freshwater sources, lakes, rivers and reservoirs, freshwater fisheries are also a potential source of excellent food.

Based on the results of inventory data from the Semarang City Fisheries Service, data was obtained for fisheries potential in Semarang City which currently consists of 4 types, namely pond aquaculture fisheries, marine capture fisheries, public water capture fisheries and pond aquaculture fisheries. The potential for fisheries in the Semarang City area can also be seen from the existence of Fish Auction Places (TPI) and fish markets. The largest results in fish production are obtained from fish cultivation through ponds in coastal areas with production in 2022 of 1,652.67 tons, while the smallest fisheries potential comes from capture fisheries in public waters with a production of 16.27 tons which is the result of freshwater aquaculture in the district Banyumanik amounting to 16.27 tons in 2022. Furthermore, there is only one TPI in Semarang City, namely TPI Tambak Lorok, while the fish market currently operating is Kobong Market which is on Jalan Raden Patah, East Semarang. Table 1 and Figure 6 present information regarding fisheries conditions and production in Semarang City.

Table 1. Fisheries sector production data in Semarang City 2022 in Mg.
Source: Fisheries Department of Semarang City, 2023

District	Aquaculture pond production	Fisheries production in marine water	Fisheries production in common water
Mijen	386.68	-	-
Gunungpati	601.23	-	-
Banyumanik	121.93	-	16.27
Gajah Mungkur	9.67	-	-
Semarang Selatan	16.59	-	-
Candisari	17.65	-	-
Tembalang	74.36	-	-
Pedurungan	70.63	-	-
Genuk	39.26	136.01	-
Gayamsari	67.22	-	-
Semarang Timur	10.64	57.41	-
Semarang Utara	5.19	1,920.59	-
Semarang Tengah	0	-	-
Semarang Barat	97.77	54.73	-
Tugu	26.32	832.92	-
Ngaliyan	107.53	-	-
Total	**1,652.67**	**3,001.66**	**16.27**

4.5. Distribution of Food Crops Commodities in Semarang

Based on data from the Semarang City Agriculture Service (2022), it shows that rice fields are classified into Sustainable Food Agriculture Land (LP2B) with a land area of around 1,625.15 hectares and ordinary rice fields with an area of 2,219.54 hectares. Most of the LP2B rice fields are in the Mijen District area with an area of 630.95 hectares, while most of the ordinary rice fields are in the

Gunungpati District with an area of around 480.88 hectares. There are three sub-districts in the Semarang City area that do not have LP2B agricultural land, but have ordinary rice fields, including Pedurungan District, Genuk District and West Semarang District, so there is still potential for existing rice fields to be converted into built-up land in line with land needs. which is increasing, especially in the lower Semarang area.

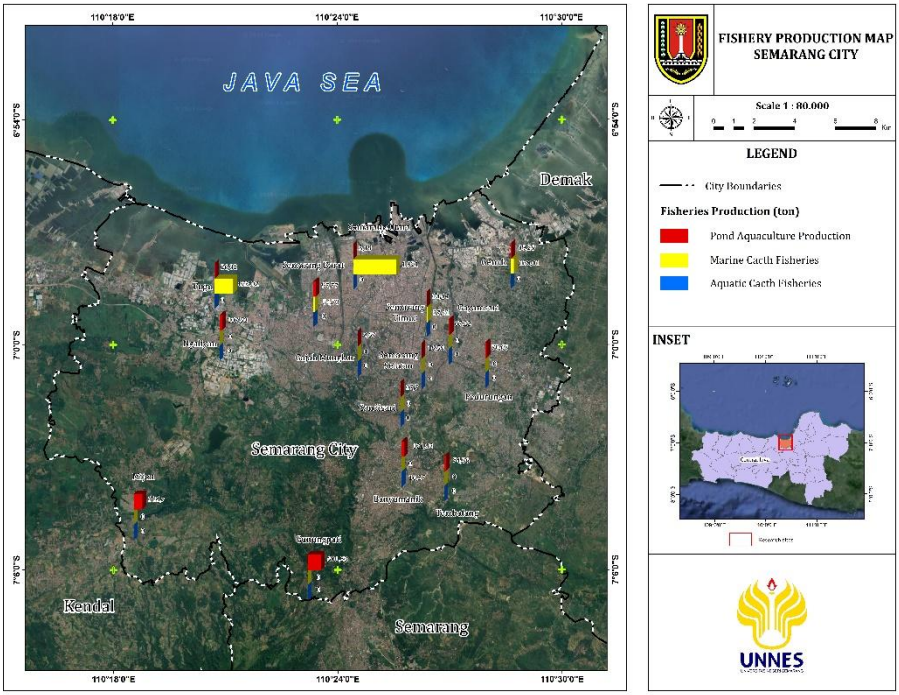

Figure 6. Fishery production map of Semarang

Food crop production in the city of Semarang is currently in 9 sub-districts out of 16 existing sub-districts. This is because some sub-districts no longer have agricultural land or plantations using built-up land, especially in the lower Semarang region. Several sub-districts that have agricultural land for cultivating food crops include: Mijen District, Gunungpati District, Banyumanik District, Tembalang District, Pedurungan District, Genuk District, West Semarang

District, Tugu District and Ngaliyan District. Figure 7 presents the spatial distribution and productivity of agricultural land in Semarang City.

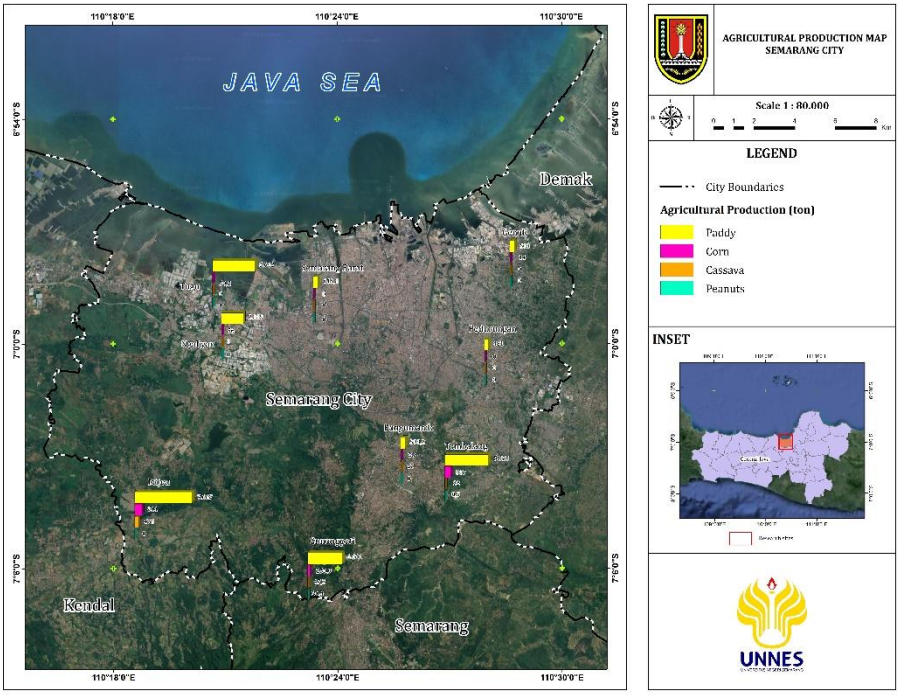

Figure 7. Agricultural production map of Semarang

Food crop commodities cultivated in Semarang City include rice, corn, peanuts, cassava, sweet potatoes, green beans, soybeans and *porang* plants with total production for all these commodities in 2022 amounting to 31,817.1 tons. The rice crop commodity has the highest production level with total production of 28,934.80 tons in 2022, with the highest production contributed by Mijen District with production of 7,666.9 tons, where Mijen District has the largest LP2B agricultural land in the Semarang City area. Furthermore, rice plants with high productivity were also produced by Tembalang District with a production of 5,828.3 tons and Tembalang District with a production of 5,641.7 tons. Furthermore, the food crop with the next highest productivity is corn with a productivity in 2022 of 2,150.24 tons, most of which is contributed by Mijen

District and Tembalang District. Table 2 presents data on agricultural land and its productivity at the research location (see Appendix A).

4.6. Research implications

The findings of this study have significant implications for policymakers, urban planners, and community leaders in Semarang City. By identifying a diverse array of food assets, including 49 markets, 5 fruit gardens, 10 urban farms, fisheries production, rice fields, beef cattle livestock groups, and the Farmer-Owned Enterprise Lumpang Semar Sejahtera, the research highlights the multifaceted and interconnected nature of the city's food supply network.

The policy recommendations emphasize the critical need for a holistic approach to food security that integrates diverse food assets and sustainable practices resources (Fitzpatrick et al., 2022; Leach et al., 2020; Savary et al., 2020). Policymakers should prioritize the protection and expansion of urban and peri-urban agricultural areas (Ahani & Dadashpoor, 2021; Spyra et al., 2021) identified in the Food Supply Asset Map, especially for the peri-urban area. This argument based on the fact that peri-urban agriculture (PUA) is more crucial in urban areas than in rural areas for food supply, ecology and biodiversity preservation, disaster mitigation, and recreation (Mulya et al., 2023). Uncontrolled urbanization has severely impacted food production in peri-urban areas of developing countries. In Ghana, agricultural land in peri-urban has drastically decreased over the last three decades due to residential and infrastructural development (Ziem Bonye et al., 2021). In Ethiopia, the continuous eviction of peri-urban farmers from their indigenous land for redevelopment projects has negatively affected the livelihoods of farming communities (Mohammed et al., 2020). In Indonesia context, the area of agricultural land in West Java experienced net losses from 2013 to 2020 being approximately 2.3 times larger than that from 2003 to 2013, amounting to about 1,850 hectares per year (Gandharum et al., 2022). The similar condition happens in Tegal (Mardiansjah et al., 2021); Malang (Adrianto & Ravetz, 2020); Yogyakarta(Nurcahyani & Marwasta, 2021) and Semarang which ost 31.85 km2 of agricultural land and 14.00 km2 of forest land and gained 20.13 km2 of urban land and 16.11 km2 of commercial/industrial land during 2006-2015 (Kelly-Fair et al., 2022).

The protection and expansion of urban and peri-urban agricultural areas can be achieved through zoning regulations that designate these areas for agricultural use, thereby safeguarding them from urban sprawl and developmental pressures. Simulations conducted by Domingo et al (2021) in Spain highlight the importance of zoning regulations, showing that directing growth to areas

designated for urbanization projects could preserve nearly 4,200 hectares of grassland and cropland from overdevelopment and shifting growth to zones without urbanization projects could save another 3,800 hectares (Domingo et al., 2021). Additionally, offering tax incentives or subsidies for sustainable farming practices, such as organic farming and agroecological methods, can incentivize producers to adopt environmentally friendly techniques while enhancing the resilience of local food production systems (Piñeiro et al., 2020). This strategy has been proved as effective strategy in China (Bai et al., 2022) and European Union (Scown et al., 2020).

Furthermore, the study underscores the importance of fostering local food markets (González-Azcárate et al., 2023) and cooperatives that connect producers directly with consumers. Policymakers can support this by creating infrastructure and policies that facilitate the establishment and growth of farmers' markets, such as developing e-commerce for agricultural products (Muñoz et al., 2021), supporting community-supported agriculture (CSA) programs in terms of legal and regulation issues (Martinez et al., 2022), and creating local food hubs (Moragues-Faus, 2021). These initiatives not only promote economic opportunities for local farmers but also ensure access to fresh, nutritious food for urban residents. Integrating circular economy principles into these initiatives can further enhance resource efficiency by promoting practices such as food waste reduction, recycling of organic materials, and sustainable packaging solutions.

In terms of urban planning, policymakers should integrate food asset mapping data into land use planning processes. Urban planners can leverage food asset mapping data to create more effective land use plans that protect and expand urban and peri-urban agricultural spaces. By understanding the strategic value of different food assets, planners can prioritize the allocation of land and resources to areas that maximize food production and accessibility. This involves integrating food asset mapping into urban development plans (Giroux et al., 2021; González-Azcárate et al., 2023), ensuring that agricultural activities are not only preserved but also promoted in urban settings (Diehl et al., 2020). This can lead to the creation of green belts, community gardens, and urban farms that serve as vital sources of fresh produce and contribute to the city's environmental health. By incorporating green infrastructure into urban development plans, such as green roofs and vertical gardens, cities can mitigate the urban heat island effect, improve air quality, and provide additional space for food cultivation

Community leaders and local organizations can use these insights to strengthen community-based initiatives and support local food production. By fostering

collaborations between different stakeholders, including small-scale farmers, local markets, and educational institutions, communities can enhance their food self-sufficiency and resilience (Guell et al., 2022). Initiatives such as urban farming projects (Clerino et al., 2023; Mabon et al., 2023), community-supported agriculture (CSA) programs (Egli et al., 2023; Tay et al., 2024), and local food cooperatives (Bijman & Höhler, 2023) can be bolstered using the data from this study. These efforts not only improve food access and nutrition but also promote social cohesion and community empowerment. Moreover, enhancing food security policies requires collaboration across government departments, community organizations, educational institutions, and private sector stakeholders. Policymakers should promote multi-stakeholder partnerships that facilitate knowledge sharing, capacity building, and collective action towards sustainable food systems. This collaborative approach can foster innovation in urban agriculture, improve food distribution networks, and strengthen community resilience in the face of climate change and economic uncertainties.

This study calls for policymakers in Semarang City to adopt an integrated and proactive approach to food security that embraces the city's diverse food assets and promotes sustainable practices. Implementing the outlined recommendations will enable policymakers to ensure a resilient and equitable food system that meets the needs of current and future generations while safeguarding the environment and enhancing community well-being. By continuously updating and refining food asset maps, researchers and policymakers can ensure that Semarang City remains well-prepared to meet the food security needs of its growing population.

5. Conclusions

The study concludes that Semarang City's food supply is supported by a diverse array of assets. These findings were obtained through a comprehensive focus group discussion with government agencies and organizations that manage food data in the city. Despite the valuable insights provided, the study has certain limitations. One major limitation is the reliance on available secondary data, which may not capture the full scope of smaller or informal food sources that also contribute to the city's food supply. Additionally, the study's methodology could be expanded to include more detailed field surveys, allowing for a more granular understanding of the food supply landscape. Future research should aim to address these limitations by employing more diverse data collection methods. Engaging a broader range of stakeholders, including small-scale farmers, local

market vendors, and community organizations, can provide a more comprehensive view of the food supply network. Furthermore, future studies should investigate the resilience of these food assets to environmental and economic changes, such as climate change and market fluctuations. This would provide a more robust understanding of the sustainability and adaptability of Semarang City's food security framework. By addressing these areas, future research can contribute to the development of more effective policies and strategies for enhancing food security and sustainability in Semarang City.

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