

The role of urban agriculture in facing the food crisis

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Abstract. Urban agriculture has a role in dealing with climate change, one of the factors causing the food crisis that has begun to be felt by most of the world's people, including Indonesia. The role of urban agriculture is considered to be able to provide food for urban and suburban/peri-urban communities through urban agricultural technology innovations that have developed in the community. This paper aims to provide an overview of the development of urban agriculture in Jakarta, Indonesia, as well as the prospects of urban agricultural development in Indonesia. The article discusses some technologies developed to support urban agriculture, including hydroponic technology, vertical farming, aquaponics, wall gardens, vertiminaponics, foot-square, and container gardening. Urban agricultural technology that has been widely developed is also supported by advanced technology, like the cultivation of hydroponic systems based on Internet of Things (IoT) technology. Managing organic waste from agricultural products and other urban waste is very supportive in overcoming the shortage of much-needed fertilizer. Organic waste management supports circular economic activities with the five principles of refuse, reduce, reuse, recycle, and recovery. From this principle, waste generated from economic activities will always return to feedback and become raw material for other activities.

1 Introduction

The food crisis is currently hitting the world; about 300 million people are experiencing food shortages and hunger, which have begun to occur in several countries. If a solution for this condition is not found, the number of people who will be affected may increase. Risandi and Dahiri[1] states that the food problem is a crucial global issue. It must be carefully observed because 22 countries have stopped exporting various types of food to secure domestic needs amid world geopolitical turmoil. Based on United Nations observations, food prices increased by around 33 percent in 2021, and fertilizer prices increased by more than 50

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percent. [2]. The number of people affected by famine has reached around 281 million people in 59 countries by 2023 [3]. In the United States, the prices of meat, fish, and eggs have increased by 15 percent compared to the previous year, while the prices of vegetables in China, one of the most stringent countries controlling domestic food prices, increased by more than 25%. This condition is quite a fantastic number considering that China is a country that strictly controls economic statistics. Most people, especially in Indonesia, still ignore the food crisis because they think that until now, they can still eat. However, the food crisis has begun to be felt, as seen from the current increase in food prices [2].

It is time to look for a breakthrough in handling the effects of the food crisis in order to prepare for the growing impact it will have on the community. Some things that cause the food crisis include an increasingly erratic climate, a very extreme rainy season, natural disasters, high pest attacks on plants, and high conversion of agricultural land. Such conditions result in farmers failing to harvest due to flooding or drought and the explosion of pests and diseases. One solution to anticipate the impact of the food crisis is through plant cultivation in urban areas. Urban agriculture is a solution to the food crisis, especially in fulfilling the food needs of the people in urban areas because most of the food needs of the people in urban areas rely on supplies from outside the region. According to Jac Smit [4], urban agriculture is an activity of production, processing, and marketing of food and medicine sourced from plants and livestock spread throughout urban and suburban/urban peri-urban areas. According to Fauzi et al. [5], the existence of urban agriculture will provide positive value in meeting food needs; besides that, practical values can impact the ecological and economic sustainability of urban areas. Siegner [6] mentions that urban agriculture is essential as a local food movement that is currently developing. This is aimed at increasing food access for low-income people in urban areas. According to FAO [7], crop cultivation and animal husbandry in urban and suburban areas are carried out intensively supported by the reuse of natural resources and urban waste to obtain a variety of crops and livestock. The purpose of this study is to explore the evolving role of urban agriculture in addressing food shortages within urban and suburban areas.

2 Research method

The review was carried out manually, examining and synthesizing a variety of material from journals, books, and research papers. References were chosen based on their topical relevance, publication date within the last ten years, and trustworthiness as peer-reviewed sources. The analysis included categorizing the literature into major themes relevant to the study's emphasis and synthesizing data to discover patterns, trends, and gaps in the current body of research. Proper citation practices were used to assure the accuracy of the information supplied. However, limited access to particular resources may place restrictions on the review.

3 Results and discussion

3.1 Urban farming as an effort to overcome the food crisis

The food crisis is a condition of food scarcity experienced by people in certain areas. Several factors that can cause food scarcity are due to the absence of agricultural land as production land, reduced food production as a result of climate change, pest and disease attacks, natural disasters, and other causes, hampered food distribution into an area due to natural disasters, particular disease pandemic. Abu and Soom [8] state that some factors that affected food security in Benue State (Nigeria) were lack of access to credits, soil infertility, limited land,

poverty, lack of non-farm income for developing agricultural activity, and constraint of storage and processing. The increasing number of people, not matched by the availability of food leads to social conflicts due to wars in an area.

For example, urban areas with limited land to produce their food needs have a very high food dependence on rural areas as producer areas. The high population growth also causes the food needs of urban communities to increase. Jakarta as the Special Capital Region, for example, with an average population growth of 0.85% per year from 2019-2021, the population in the capital city has increased from 10,557,800 people in 2019 to 10,609,700 people in 2021 [9]. The consumption of calories per capita of the Jakarta population on food raw materials also increased from 1493.29 calories per capita in 2019 to 1,617.87 calories per capita in 2021. This means the population's need for food ingredients increased from 15,765,857.2 kcal in 2019 to 17,165,115.3 kcal in 2021 [10]. This condition causes the urban community's need for food to increase yearly, and it is not impossible that one day, the rural area as a producer cannot fulfill it, resulting in a food crisis in urban areas.

One of the efforts that can be performed is "urban farming" by planting vegetables such as spinach, kale, *pakcoy*, chilies, tomatoes, etc., and fruits such as melons to overcome the food crisis, especially in urban areas. Urban farming can be established on limited land and not always be conducted on land but can be done by planting without soil (hydroponics), combining fish and vegetable cultivation (*vertiminaponics*), vertical cultivation using gutters/*paralon* (verticulture), and planting with using the wall as a place to put the planting module (wall gardening). This planting system does not require a large area because it can be done on rooftops, house walls, fences, and narrow yards. Even planting with a hydroponic system produces healthier vegetables or fruits because they do not use pesticides during planting. Smart et al. [11] stated that urban farming is a survival strategy for people in rapidly growing urban areas.

Meanwhile, according to Opitz [12], the direction of urban agriculture is still to meet food needs, especially at the household level. According to Atmaja et al. [13], the benefit of urban farming is not only for feeding potential but also for nutrient sufficiency, especially for the population with the highest health risk. According to Opitz et al. [12], urban farming is not only an agricultural activity but also a system adapted to specific and distinct spatial, ecological, social, and economic conditions in The Global North.

To contribute to the implementation of urban farming in the Special Capital Region of Jakarta, together with various parties, i.e., central government, business entities, non-governmental organizations (NGOs), universities, and community groups), the provincial government of Jakarta compiled the 2018-2030 Grand Design of Urban Agriculture. It contains the current condition of urban farming and policies and regulations regarding implementing urban farming in Jakarta [14]. The Jakarta Regional Government, through the Department of Food Security, Maritime Affairs and Agriculture, not only makes plans listed in the grand design of urban agriculture in Jakarta but also acts proactively in the field by providing hydroponic equipment, seeds, fertilizers, as well as technical guidance of hydroponics and other urban farming. The implementation of urban farming in Jakarta was strengthened by Governor's Instruction No. 14 of 2018 concerning implementing Urban Agriculture [15]. One of success story are Haryati and the Women Farmers Group D'Shafa in Malaka Sari, East Jakarta that have been pioneering urban farming initiatives since 2017. Their consistent efforts have led their communities to have sustainable vegetable production locally, with Haryati being nominated for the Provincial Award for Outstanding Women in Agriculture by the local government in 2024 [41].

Although until now, the products produced from urban farming are still small, so most of the urban farming activities are still limited to meeting the food needs of the family, little by little, it has been able to meet the needs of the community around the location of urban farming. Marketing of urban farming products is still limited to the community around the

planting location, with prices adjusted to market prices, except for hydroponic vegetables, which are sold slightly above the market price. With the frequent shortage of supplies of several types of food lately, which causes prices to soar, urban communities are starting to realize the benefits of urban farming. People began to grow chilies, shallots, and other types of vegetables in pots or hydroponically to meet their needs or those of a limited group. Farmer Groups in Jakarta and other urban areas, such as Bandung, Semarang, and Surabaya, have begun organizing groups to actively plant vegetables and fruit in their residential locations by utilizing unused or limited land in their respective neighborhoods. Suppose the urban farming program goes well, with more and more people doing urban farming. In that case, it is estimated that by 2030, urban farming can meet 5% of the community's need for vegetables and fruit in Jakarta [42].

3.2 Urban agricultural technology innovation

The practice of urban agriculture through the use of land in urban areas for agricultural activities is generally carried out in idle land, house yards, rooftops, or vertical cultivation. According to Sastro [16], urban agriculture provides many benefits, including providing food for family members and contributing to increasing the proportion of urban green open space (GOS). Urban agriculture is characterized by limited supporting resources for cultivation, including limited land, fertilizer, water, labor, and other resources that affect plant cultivation. To deal with some of the characteristics of urban agriculture, many studies have been carried out on technological innovations that can support plant cultivation in urban areas with all the existing limitations.

Many technologies that have been developed to support urban agriculture include:

3.2.1 Hydroponic Technology

The hydroponic system is a cultivation technology without soil and applies a nutrient solution with supporting media as support for plants [24]. Although it requires special skills and a fairly high initial investment when compared to soil-based plant cultivation, this hydroponic system has many advantages, including high performance, not requiring much labor, and is practical in processing [25]. Research that supports IoT-based hydroponic systems is the use of software to control water pH and monitor the hydroponic plant environment. Through the use of this system, it can be useful for ordinary people to garden without worrying about the need for large land and the complexity of plant care, this will stimulate the community in realizing food independence at the household level through the provision of food crops for family consumption [23].

3.2.2 Aquaponics/Vertiminaponics Technology

Hydroponic systems combined with fish farming have also been developed in urban farming businesses. According to Sastro (2013) [16] aquaponics/vertiminaponics is a combination of aquaculture (fish farming) cultivation systems with hydroponics for plant/vegetable cultivation without soil media. The Aquaponics system refers to an ecological system in a natural environment, where there is a symbiotic relationship of mutualism between fish and plants. Some of the advantages of applying aquaponic system cultivation include that it can be applied in narrow yards, does not require planting media, fertilizers, watering, saves water, is healthy, has high aesthetic value, and is free of contaminants. Thus, aquaponics/vertiminaponics technology has the prospect to be developed in places with limited supporting resources such as urban areas.

3.2.3 Vertical Cultivation

The vertical cultivation technique is a planting solution for people who do not have land at all, with this system can produce high yields of biomass even though with limited land, the most important thing is getting enough sunlight. Vertical cultivation is not only dominated by leaf vegetable plants but has now also penetrated the cultivation of shallots. This will certainly help people who are affected by the increase in food prices, especially shallots when there are uncontrolled price fluctuations. Vertical cultivation can be implemented using either soil-based or hydroponic systems. Vertical cultivation of crops carried out on wheels in India offers flexibility to serve the needs of agricultural products at the customer's doorstep [17]. Vertical farming that is done indoors can be done with the help of LED lights. The results of the research of Atmadja et al (2022) [18], the use of IoT-based LEDs in indoor hydroponics can affect plant growth by adjusting the light intensity of each spectrum. Implementation of the Internet of things in vertical and indoor agriculture to build smart cultivation methods ([19]; [20]; [21]). IoT-based hydroponic cultivation can ease the maintenance of plants because the system is regulated through sensors controlled by lighting, automatic irrigation, nutrition, etc., so plants can still produce even indoors. Kagalangan et al (2022) [22] stated that the vertical cultivation system with outdoor and indoor systems did not have a significant difference. This shows that without sufficient land and sunlight, people can cultivate indoor plants with yields equivalent to outdoor cultivation. Wall Garden technology is a type of vertical plant cultivation. According to Diwanti (2018) [26] the wall garden cultivation system is urban agricultural cultivation that is not much different from conventional cultivation methods, the difference is only that the placement is made vertically. Bria et al (2021) [27] the wall garden system is more efficient in land use because there are more plants planted than conventional systems, besides that it can also save on the use of fertilizers and pesticides, the possibility of grass and weeds growing is smaller and is mobile because it can be moved easily and makes monitoring/maintenance easier. In the wall garden system, the most widely grown commodities are leaf vegetables and medicinal plants. The wall garden system can also be combined with the cultivation of the aquaponic system to become wall aquaponics, with the same area, more vegetable crops will be obtained.

3.2.4 Composting Technology Using Household Waste

The cultivation technology in question is to deal with the limitations of land, water, and sunlight. Supporting technologies to deal with the limitations of planting media and fertilizers include composting technology using worms/vermicompost, maggot/kasgot, and which is currently being widely developed is the manufacture of eco-enzymes. Composting technology and the manufacture of eco-enzymes will reduce urban waste because the existing waste will be processed and reused to support urban agricultural businesses.

The cultivation technology in question is to deal with the limitations of land, water, and sunlight. Hydroponic-based plant cultivation technology innovations in urban areas are needed to anticipate the problem of the food crisis which has already begun to be felt. According to Gashgari et al (2018) [28] hydroponic-based plant cultivation is better than traditional system cultivation because the hydroponic system provides faster plant growth. Magdalena & Santoso (2021) [29] by looking at the criteria for the superiority of hydroponics, it encourages the Pangkalpinang community to choose plant cultivation with a hydroponic system.

3.3 Utilization of urban waste

The relatively large number of residents in urban areas causes much waste to be generated, not only organic waste that can be recycled but also non-organic waste that cannot be

recycled, such as plastic, iron, glass, bottles/cans used for drinks, etc. can still be used, and some cannot be used. This condition is exacerbated by the increasing flow of urbanization, thus causing an increasing pile of garbage in urban areas [30]. A new paradigm has emerged regarding waste management: waste can be used as a new economic source. In a circular economy, there are five waste management principles: refuse, reduce, reuse, recycle, and recover. Waste produced with good management has economic value and will always return to the feedback loop as raw material for other economic and energy activities. As a "by-product," waste can be recycled or reused [31]. The above waste management principles are based on Presidential Regulation No. 97 of 2017 concerning National Policies and Strategies for Managing Household Waste and Types of Household Waste, Chapter 2, article 3 [32]. In Indonesia, in the field of agriculture, the principle of circular economy has also been carried out in integrated agricultural activities with the principle of zero waste, meaning that there is no more agricultural and livestock waste left, all of which is used to become organic fertilizers to increase agricultural production.

Urban waste that can be recycled is organic waste from household kitchens in the form of vegetable, fruit, processed food waste, agricultural, livestock, and fishery waste, as well as inorganic waste such as used bottles, paint cans, used buckets, etc. Organic waste can be processed into solid and liquid organic fertilizers that can enrich the soil for agriculture [31]. As solid organic fertilizer, municipal waste is processed into compost using various processing techniques, such as vermicompost, composting heap system, and MOL system. Vermicompost is a composting process that utilizes various types of worms as composting agents; heap system composting, which is a composting method with a stack system; and composting with the MOL system that utilizes kitchen waste (vegetables and fruit) mixed with water and an activator. Among the three systems, stacking composting is the easiest and cheapest, so many farmers use this system to make compost. Urban waste processing with the composting system is also carried out by urban communities in Addis Ababa [33].

In addition to the above, inorganic waste bottles, cans, and used buckets can be used as hydroponic plant pots or plants using soil. Homemakers have done this for a long time by using these used goods to grow various types of plants, such as chili, leaf vegetables, tomatoes, leeks, celery, and other plants. The production of these plants can reduce household spending on buying various types of vegetables for household needs. The development of urban agriculture is not only for food security and reducing spending but also for recreation. This condition also occurs in the urban communities of India, especially in Nepal [34].

3.4 Fulfillment of food through urban agriculture

Currently, urban agriculture has begun to be developed in urban areas and in suburbs/peri-urban areas, both in Indonesia and other region such as America, Africa, Europe, and Asia. The role of urban agriculture in meeting the food needs of the people in an area was initially similar to what was done in Cuba. According to [35], urban agriculture in Cuba is rapidly playing a role in providing significant fresh produce for urban and suburban communities. This is because a large amount of land in Havana and other large cities began to emerge to deal with the crisis due to the loss of trade with the collapse of the socialist groups in 1989. The use of gardens/land in urban areas helped stabilize the supply of fresh produce to the centers of downtown Cuba. The urban farming system implemented in Cuba utilizes 8000 national gardens developed and managed based on agroecological principles without pesticides or inorganic fertilizers, emphasizing diversification, recycling, and the use of local resources. The success of urban agriculture in Cuba is achieved through the integration of various achievement strategies covering social, economic, and environmental issues by raising the issue of food security.

Food fulfillment for urban and suburban communities through urban agriculture can shorten the food supply chain in urban areas so that the freshness of food ingredients can be maintained. So, through urban agriculture, people in urban areas can consume foodstuffs of better quality. According to [36], urban agriculture focuses on agricultural production that can produce food independently. Foodstuffs in urban areas can be produced through space-based plant cultivation techniques, including using a hydroponic system, both cultivated outdoors and indoors, by utilizing LED lights as a substitute for sunlight, vital for photosynthesis. Thus, in this case, urban agriculture has a function in dealing with climate change, one of the factors causing the food crisis that is starting to be felt now. Vertical planting can help overcome the constraints of the land now available in urban settings to increase crop production. [37] In Mexico, vertical hydroponic cultivation can help overcome the looming problem of food shortage/food crisis due to limited soil and water to support crop cultivation, exacerbated by climate change problems. In Nigeria, urban agriculture can potentially increase food availability for urban communities [38].

Urban farming produces vegetables (leaf vegetables and fruit vegetables), seasonal and annual fruits, fish, and livestock. The potential of urban agriculture in supporting the fulfillment of household food for people in urban and suburban areas is starting to be felt. Food fulfillment through urban agriculture can be fulfilled through community empowerment in urban and suburban areas, as has been done in several cities in Indonesia [16,39,40].

4 Conclusion and recommendation

The food crisis that has begun to be felt by most people, including Indonesia, needs special attention because the impact will affect the level of food availability, which will affect the high selling price of food products. In dealing with the food crisis, it is time to find a solution so that the impact does not affect the fulfillment of the community's food needs, especially in urban and suburban areas, which rely a lot on food needs from outside the region. One of the vertical garden technology innovations with an IoT-based hydroponic system can ease the maintenance of plants because the system is regulated through sensors controlled for lighting, automatic irrigation, and nutrition. So that plants can still produce even indoors. The role of urban agriculture considered to be able to provide food for urban and suburban/peri-urban communities through urban agricultural technology innovations that have developed in the community. People in urban and suburban areas can access food more efficiently to obtain better quality and more affordable food through urban agriculture.

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