Urban farming: production risks of vegetable farming in Pekanbaru City, Riau Province, Indonesia

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Abstract. Urban agriculture provides an effective solution to meet the needs of urban residents while reducing dependency on external sources. This study aims to analyze (1) the characteristics of spinach and water spinach farmers, (2) vegetable cultivation technology, (3) sources of production risks, and (4) the level of production risks. The research was conducted in the Marpoyan Damai sub-district of Pekanbaru, with a sample size of 30 farmers. The results indicate that most farmers are between 43-49 years old, with most having elementary school education and 11-20 years of farming experience. The study also identified several sources of production risks, including extreme weather, diseases and pests, climate change, limited water supply, and technological advancements. Furthermore, the level of production risk was found to be moderate, with spinach showing higher variability in yield compared to water spinach. This research provides insights into the challenges urban vegetable farmers face in Pekanbaru.

1 INTRODUCTION

Food security is a strategic issue in regional development (Simatupang, 2007) and is primarily supported by the agricultural sector (Pradana, 2021). In urban areas, agriculture faces challenges such as industrialization, including transportation and warehousing (24.64%), business services (13.28%), and trade (12.69%). Land conversion for industrial or residential purposes has driven rural communities to release agricultural land for urban development (Rosyad et al., 2020; Taher et al., 2023). Urban farming, as described by Maulana et al. (2023), offers a promising approach to achieving sustainable development and food security amid high housing demand and limited land availability. Urbanization has reduced green spaces, leading to the loss of local self-reliant agricultural land (Rosdiana et al., 2023).

Urban food security is challenged by the loss of productive agricultural land, uneven income distribution, and the stigma that farming is exclusive to rural areas. According to Dewanggi et al. (2022), land conversion has reduced urban vegetable production, exacerbating agricultural land loss. As the capital of Riau Province, Pekanbaru attracts

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migrants seeking better opportunities amidst urban issues and poverty. Urbanization and development threaten food security due to declining environmental quality and the diminishing availability of land (Rini et al., 2022). Devi et al. (2023) state that urbanization is accompanied by rising urban poverty, food shortages, malnutrition, and unemployment. Additionally, urban development focuses primarily on economic growth, often at the expense of agricultural land. Putri et al. (2023) note that continuous land conversion and the aging farmer population with declining farming capabilities further contribute to food insecurity.

Densely populated urban areas limit the availability of land for agriculture (Barokah et al., 2023). However, lowland vegetable farming in Pekanbaru remains widely practiced due to favorable agroclimatic conditions, including temperatures ranging from 23.4°C to 33.4°C and annual rainfall of 2000–3000 mm. The most cultivated vegetables are spinach and water spinach, primarily concentrated in the Marpoyan Damai District, contributing 63.02% of Pekanbaru's total vegetable output (Central Bureau of Statistics, 2023). The agricultural sector contributes to Pekanbaru's GDP at only 2.36%. Land conversion for infrastructure development, such as roads, shopping centers, and housing, continues to reduce agricultural land. Furthermore, urban residents show low interest in farming, while population growth increases demand for non-agricultural jobs. These factors pose significant threats to urban vegetable production. According to Situmorang et al. (2022), production challenges are further aggravated by weather dependency, improper use of inputs, and pest and disease outbreaks.

Urban agriculture has been explored as a nature-based solution to address socio-ecological challenges in metropolitan areas (Ghahremani et al., 2024). Pekanbaru, a significant city in Riau Province, shows potential for urban agriculture development, particularly in vegetable farming. However, production risks pose significant challenges to the sustainability and efficiency of urban farming systems. Key risks include environmental uncertainties (climate change, extreme rainfall), biological factors (pests and diseases), and economic issues (price fluctuations of inputs and outputs). According to Tanaya et al. (2020), despite its advantages, vegetable farming faces high production risks. Limited access to modern agricultural technology, land availability, and the lack of local policy support also exacerbate this condition. While previous studies have focused on urban agriculture in terms of sustainability and food security, few have specifically examined production risks in local contexts like Pekanbaru. This study addresses this gap by identifying sources of vegetable production risks and analyzing their impacts on urban farming systems in Pekanbaru. This study aims to analyze (1) the characteristics of spinach and water spinach farmers, (2) vegetable cultivation technology, (3) sources of production risks, and (4) the level of production risks.

2 Research Method

This study employed a survey method and was conducted in Marpoyan Damai District, Pekanbaru City. The area was selected based on its status as a key production center for vegetable crops, particularly spinach and water spinach, contributing 60.42% and 63.02% of the total production in Pekanbaru, respectively. The research population consisted of all farmers cultivating these vegetable commodities. The sample included farmers practicing crop diversification, where two types of crops are grown simultaneously on the same land. A total of 30 farmers were selected as the research sample. The study utilized both primary and secondary data. Primary data was collected directly from the sampled farmers, while secondary data was obtained from relevant institutions, previous research, and academic publications such as journals and proceedings.

2.1 Analysis Data

Synthetic hydroxyapatite was done by reacting calcium precursors and phosphate precursors with a concentration ratio of Ca/P 1.67. 100 mL 0.5 M of nanocalsium of cuttlefish shells (CaO) was put into a beaker and added by 100 of mL H3PO4 0,3 M and NaOH 1 M until the pH becomes 10, and let it for 24 hours. The precipitate was filtered then added by HNO3 1 M for 1 mL and put in the furnace at 900ºC for 2 hours, 4 hours and 6 hours. After that, it was characterized by functional groups identified using FTIR, quantity of elements in HA analyzed using XRF, structures, crystal size, elements, lattice parameters, and degree of crystallinity of HA identified using XRD, and HA morphology identified using FESEM.

2.2 Identification of Hydroxyapatite Function Groups

1. The farmers' characteristics were analyzed using qualitative and quantitative descriptive methods. This analysis involved tabulating field data, inputting it into Microsoft Excel, and interpreting it as tables with percentage representations (%). The approach aimed to provide a clear and detailed overview of farmer demographics and related variables, ensuring the data was systematically organized and easily comprehensible for further interpretation.
2. The analysis of vegetable cultivation technology was conducted by comparing theoretical concepts with actual field conditions. This approach provided insights into which stages of the cultivation process deviated from established best practices. By identifying these discrepancies, the study aimed to highlight areas where improvements or interventions could be made, ultimately enhancing the efficiency and sustainability of vegetable farming practices.
3. Identifying production risk sources was done through interviews with farmers. The interview findings were compared with theoretical frameworks and previous research to ensure the results were relevant and well-rounded. The identified sources of production risks include weather and climate variability, pest and disease outbreaks, seed quality, soil fertility of farmland, and human resources, particularly the farmers themselves. This process aimed to provide a comprehensive understanding of the challenges faced by farmers.
4. Level of Production Risk: Variance or standard deviation is used to statistically measure risk. The level of production risk is analyzed using the variance, standard deviation, and coefficient of variation methods. According to Suryadi (2014), variance can be calculated using the following formula:

   a. Variance

Variance represents the unit of risk in an investment project, describing the magnitude of deviations. The measurement of variance in returns is calculated by summing the squared differences between actual and expected returns, multiplied by the probability of each occurrence.

σ_i^2= P_ij (R_ij-R_i)^2……………………………… (1)

Explanation:
σ_i^2 = Variance or deviation of returns:
Pij = Probability of an event
Ri = Return (production)
Rij = Expected return or expected value

b. Standard Deviation

The standard deviation is the smallest unit of risk measurement that describes the deviations occurring in an investment project. The formula for standard deviation can be written as follows:

$$\sigma_i = \sqrt{\sigma_i^2} \quad \text{……………………………………………}(2)$$

Explanation:
σ_i^2 = Variance
σ_i = Standard Deviation

c. Coefficient Variation

The coefficient of variation is obtained from the ratio of the standard deviation to the expected value or expected return. Like other risk measures, the smaller the coefficient of variation, the lower the risk associated with a business. The formula for the coefficient variation is as follows (Fauzan, 2016):

$$CV = \sigma_i / \mu \quad \text{……………………………………………}(3)$$

Explanation:
CV = Coefficient variation
σ_i = Standard deviation
μ = Average yields (tons/ha)

Criteria for decision-making:

1. If the CV value ≤ 1, then the analyzed vegetable farming production has low risk.
2. If the CV value is > 1, the analyzed vegetable farming production is highly risky (Fauziah, 2011).

3 Results and Discussion

3.1 Characteristics of Vegetable Farmers

The characteristics of farmers significantly influence farm management practices, including the adoption and application of new technologies in farming activities, which ultimately affect production and income levels. Farmer identity provides a general overview of their capacity and role in agricultural activities. Several variables related to the identity of the sample farmers were observed in this study, including age, education, farming experience, and number of family dependents. These details are presented in Table 1.

Table 1. Characteristics of Vegetable Farmers in Pekanbaru City, 2024

No	Sample Characteristics	Amount (Farmer)	Percentage (%)
1	Age (Year)		
	23-29	4	13.33
	30-36	3	10.00
	37-42	7	23.33
	43-49	8	26.67
	50-56	4	13.33
	57-63	2	6.67
	64-70	2	6.67
	Total	30	100.00
2	Education (Year)		
	1-6	16	53.33
	7-9	8	26.67

	10-12	6	20.00
	Total	30	100.00
3	Farming Experience		
	1-10	5	16.67
	11-20	17	56.66
	21-30	6	20.00
	31-40	2	6.67
	Total	30	100.00
4	Number of Family Dependents		
	1-3	15	50.00
	4-6	14	46.67
	7-9	1	3.33
	Total	30	100.00

Table 1 provides an overview of the characteristics of vegetable farmers in the study area. The data indicates that most farmers are between 43 and 49 years old, representing 26.67% of the sample population. Regarding education, most farmers have completed elementary school, with 16 individuals, or 53.33% of the sample. Farming experience predominantly ranges from 11 to 20 years, accounting for 56.67% of the sample, reflecting considerable expertise in vegetable farming. Additionally, most farmers have 1 to 3 family dependents, comprising 50.00% of the respondents. These demographic characteristics highlight the dominance of middle-aged farmers with moderate educational attainment and substantial farming experience, which may influence their capacity to adopt new farming technologies and manage production risks effectively.

3.2 Vegetable Cultivation Technology

As widely consumed vegetable commodities, spinach, and water spinach have great agricultural potential. The right cultivation technology is essential to maximize the results of their cultivation. The following table compares the cultivation technologies of spinach and water spinach based on the standard techniques applied and compares them with existing theories in agricultural literature. In this way, a deeper understanding of the differences and similarities between these two commodities is expected, along with the application of optimal technology to support agricultural productivity and sustainability. Details can be seen in Table 2 and Table 3.

Table 2. Technical Techniques for Cultivating Water Spinach in Theory and Conditions in The Field.

No	According to The Theory	Conditions in the Field	Explanation
1	Cultivar: Bangkok LP 1, Serimpi, Large leaf	Varieties of kuda terbang	Different from theory
2	Land Management: Three weeks before planting, the soil was prepared and enriched with 10 tons/ha of manure or compost, followed by irrigation to a water depth of 5 cm. The soil was submerged and supplemented with 100 kg/ha of urea. Raised beds were then constructed with a width of 0.8–1.2 meters, a length of 3–5 meters, a depth of 15–20 cm, and a spacing of 50 cm between the bed plants.	After harvest, the land is thoroughly cleared of weeds before being tilled to a depth of 20–30 cm to loosen the soil. Raised beds are then prepared with a width of 1–3 meters, a height of 30 cm, and a length adjusted to the field's condition, with a spacing of 30 cm between bed plants.	Not following theory
3	Planting: The planting holes are spaced 20 × 20 cm	Planting is carried out in the	Not following

	apart with a depth of 5 cm. Planting is recommended in the afternoon. Seeds are shown in rows with a 15 × 5 cm spacing for direct seeding.	morning. Seeds are sown by broadcasting or scattering evenly.	theory
4	Maintenance: water spinach requires regular watering twice daily, in the morning and afternoon. The field is drained during fertilization for 4–5 days before re-irrigation. Weeding is conducted every two weeks. Hilling-up is performed two weeks after planting (WAP) if fertilization is done by broadcasting; care should be taken to prevent fertilizer granules from encountering the leaves, as this may cause wilting. Pesticide applications are carried out as needed. To promote optimal growth, urea should be reapplied one week after or before harvesting.	Maintenance involves watering the vegetables without rainfall and applying supplementary fertilizer 10–15 days after planting. This process also includes weed control during the early growth stages and protecting the plants from pests and diseases.	This activity is different from the theory
5	Harvesting: Harvesting is conducted in the afternoon, marked by plants with thick stems and elongated leaves. The first harvest typically occurs on the 12th day with stem lengths of 20–25 cm or at 27 days of age. Harvesting is done by cutting the stems using pruning tools, leaving 2–5 older nodes intact. Alternatively, the plants can be uprooted entirely. Harvesting is performed every 2–3 weeks, with 5–11 production cycles.	Harvesting is conducted 30 days after planting, either by uprooting the plants with their roots or cutting the stems approximately 2 cm above the soil surface.	The following theory
6	Post-Harvest Handling: Harvested water spinach is grouped into bundles of 15-20 stems per tie to maintain freshness during storage and prevent wilting. The bundled water spinach is then immersed in water.	Water spinach is stored in a shaded area or by submerging its roots.	The following theory

Based on Table 2, several stages of water spinach cultivation at the research site do not align with the existing theories. These stages include cultivar selection, land management, planting, and maintenance. Selecting the right cultivar is crucial to ensure optimal quality and yield; however, at the research site, the variety used does not fully match the recommendations in the theory. Similarly, land management, which includes fertilization and soil processing, has not completely followed the suggested standards, potentially affecting plant growth. The stages of planting and maintenance also show differences in the techniques applied, such as planting distance and watering frequency, which should be managed more carefully to support better plant development. This indicates a discrepancy between the practices carried out on the ground and the theory found in agricultural literature.

Table 3. Technical Techniques for Cultivating Spinach in Theory and Conditions in The Field.

No	According to The Theory	Conditions in the Field	Explanation
1	Cultivar: Some spinach varieties that are commonly cultivated and have high	Varieties Maestro	Different from the

	commercial value include Cummy, Green Lake, Tark, and Stratful. In addition, there are also local varieties with equally good quality, such as Giti Merah, Giti Hijau, Cimangkok, Kuningan, and Sukamandi.		theory suggested
2	Land Preparation: The application of base fertilizer is carried out simultaneously with soil processing. Planting beds are made with 1m x 5m dimensions, raised about 30 cm, and trenches are created between the beds.	After harvesting, the land is cleared of weeds until clean, then plowed to a depth of 20-30 cm to loosen the soil. Next, planting beds are created with a width of 1m-3m, a height of 30 cm, and a length adjusted to the land's conditions. The distance between the beds is about 30 cm. For acidic soil (low pH), lime is applied using calcite or dolomitic lime.	The following theory
3	Planting: Before sowing, the seeds should be mixed with ash in a 1:10 ratio. Spinach seeds can be scattered in furrows along the beds, with a row spacing of about 20 cm. For 1 hectare, approximately 5-10 kg of seeds are needed. The sown seeds should be lightly covered with soil evenly and then watered. Watering is done every morning and afternoon except when it rains.	Before sowing, the seeds should be mixed with ash in a 1:10 ratio to ensure even distribution and prevent clumping during sowing. The spinach seeds can be scattered along the furrows of the beds. After sowing, the seeds should be lightly covered with soil and watered using a watering can. Watering is done every morning and afternoon unless it rains.	The following theory
4	Maintenance: Weeding and soil loosening are done 2 weeks after sowing and then every two weeks thereafter.	If there is no rainfall, supplementary fertilization is applied to 10-15-day-old plants. Another important task is weed control while the plants are still young and protecting them from pest and disease attacks.	The following theory
5	Harvesting: Spinach thinning is done on day 20 after sowing, followed by subsequent harvests on days 25, 30, and so on until the entire crop is harvested.	Harvesting is done 30 days after planting by pulling the plants out, including their roots.	The following theory
6	Post-harvest: The harvested spinach is gathered into bundles and cleaned of soil debris with water.	Place the freshly harvested spinach in a shaded area, immerse the root part in water, and transport the product as quickly as possible.	The following theory

Based on Table 3, in spinach cultivation, the only difference from theory lies in the type of variety used (the chosen seeds). However, everything aligns with the recommended theory for other cultivation stages, such as land preparation, planting, and maintenance.

This shows that, although there is variation in the selection of varieties, the other cultivation practices at the research site have followed the guidelines suggested in agricultural literature, supporting the success of the cultivation process.

3.3 Sources of Production Risk in Spinach and Water Spinach Farming

Production risks in agriculture, including spinach and water spinach cultivation, can come from various sources. Below are some common sources of production risks associated with vegetable crops like spinach and water spinach:

1. Extreme Weather: Drastic weather changes like floods and droughts can cause production losses. Spinach and water spinach are vulnerable to temperature and humidity fluctuations.
2. Diseases and Pests: Infestations of diseases and pests can threaten plant health, reduce yields, and increase production costs due to the need for pest and disease control measures.
3. Climate Change: Climate change can significantly impact crop production. Rising temperatures, changes in rainfall patterns, and other weather conditions can affect plant growth and yield.
4. Water Supply Limitations: Limited water availability or water quality issues can pose serious risks, especially in urban agriculture where water supply may be limited.
5. Technology and Innovation: Technological advancements in agriculture can improve productivity, but they also pose risks if farmers cannot keep up with or adapt to these technological changes.

3.4 Risk Level of Spinach and Water Spinach Production

Production risk analysis using the coefficient of variation (CV) compares production risks between spinach farmers with land area ≥ 0.29 hectares and those with land area < 0.29 hectares. A small coefficient variation in production indicates low variability in average production values. This describes the low production risk involved in achieving these production results and vice versa. A comparison of production risks between spinach farming in different land areas can be seen in Table 4.

Table 4. Comparison of Production Risk in Spinach and Water Spinach Farming

Description	Spinach	Water Spinach
Average yield	1.721	1.760
Standard deviation	2809.333	3613.876
Coefficient variation (%)	39.773	36.343

Table 3 compares production risk between spinach and water spinach farming based on average yield, standard deviation, and coefficient of variation. For the average yield, spinach yields 1.721 tons per hectare, while water spinach has a slightly higher average yield of 1.760 tons per hectare. This indicates that water spinach has a slight advantage in production yield compared to spinach.

However, when examining the standard deviation, there is a significant difference between the two crops. Spinach has a standard deviation of 2809.333, suggesting that the yield of spinach fluctuates considerably around the average value. In contrast, water spinach has a higher standard deviation of 3613.876, indicating even greater fluctuation in its yields compared to spinach, reflecting higher instability in water spinach production.

The coefficient of variation (CV%) provides an overview of the production risk level. Spinach has a CV of 39.773%, meaning that its yield tends to vary by around 39.77% from its average value, indicating a moderate level of risk. Meanwhile, water spinach has a slightly lower CV of 36.343%, suggesting that despite significant variation in water spinach yields, its production risk is marginally lower than spinach.

4 Conclusion

The characteristics of vegetable farmers are mostly between 43-49 years old (26.67%); most farmers have elementary school education, with 16 people (53.33%); most of the farmers have farming experience ranging from 11-20 years (56.67%); and most farmers have 1-3 family dependents (50.00%). Spinach and water spinach show a high level of production risk due to significant variability in their yields, with water spinach having a slightly lower coefficient of variation, indicating marginally more stable production compared to spinach. The findings identify five sources of production risk, such as (1) extreme weather, (2) diseases and pests, (3) climate change, (4) limited water supply, and (5) technology and innovation. Spinach has a CV of 39.773%, indicating a moderate level of risk with significant yield variability. Meanwhile, water spinach has a lower CV of 36.343%, meaning that although water spinach yields also vary, its production risk is slightly lower compared to spinach. Therefore, while both crops show considerable yield variation, water spinach is slightly more stable in terms of production risk compared to spinach

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