International Journal on Advanced Science Engineering Information Technology

Vol.13 (2023) No. 1
ISSN: 2088-5334

Urban Farming Development Strategy to Achieve Sustainable Agriculture in Magelang, Indonesia

Reismaya Wanamertan Nugroho [a,*], Kusnandar [a], Joko Sutrisno [a]

[a] *Department of Agribusiness, Faculty of Agriculture, Universitas Sebelas Maret, Surakarta, 57126, Indonesia*
Corresponding author: [*]reismayawanamertan@student.uns.ac.id

***Abstract*—The population growth every year causes an increase in land demand. This has led to conversion from agricultural land to non-agricultural land, especially in urban areas where people in rural areas migrate to cities, one of them is Magelang. The agricultural land decrease and impacts less production. The concept of urban farming provides a solution for urban areas to maintain agricultural production by utilizing residents' yard. On the other hand, urban farming practices must still pay attention to agricultural sustainability, so they are maintained in the future. This study aims to determine the priority of urban farming development strategy in Magelang by using criteria in the dimension of sustainability. This study used the Analytical Network Process (ANP) method by involving several expert respondents in conducting the assessment. Based on the analysis results, the sustainability dimension's priority is the social dimension. Meanwhile, the priorities in each economic, ecological, social, technological, and institutional dimensions are income of women farmers group members, land availability, motivation of women farmers group members, cultivation technology, and the role of agricultural extension. Based on the criteria in the dimension of sustainability, the priority of Magelang's urban farming development strategy is integrated agriculture. The results of this study can be used as a reference for further research on the development of urban farming through integrated agriculture.**

***Keywords*—ANP; strategic priority; sustainable agriculture; urban farming.**

Manuscript received 25 Jan. 2022; revised 16 Apr. 2022; accepted 23 Jul. 2022. Date of publication 28 Feb. 2023.

I. INTRODUCTION

As the main sector in meeting people's food needs, agriculture faces the threat of increasingly narrow land availability. The population increases every year, causing the conversion of agricultural land to industrial and residential needs, especially in developing countries [1]. Approximately 55% of the world's population lives in urban areas, and 80% of the world's total food production is intended to fulfill the need for food in urban areas [2]. In 2050, it is projected that more than 60% of the world population will move and stay in cities [3]. Urban areas are the main destinations for people in rural areas to live and settle to get a better life. This causes an increase in demand for land for residential areas. On the other hand, the conversion of agricultural land to non-agriculture has encouraged the government and people in urban areas to start implementing a strategy to meet food needs independently by not relying entirely on agricultural land, especially narrow land [4].

Magelang is a small city with an area of 18.12 km^2 and a population of 127,185 people. Although Magelang has the smallest area in Central Java Province, this area is quite strategic on the island of Java because it is a crossing route for transportation and trading both locally and regionally between Semarang-Magelang-Yogyakarta-Purworejo, thus giving a fairly large impact on development in this region. In the end, agricultural lands are getting narrower, and the agricultural sector is weakening as production continues to decline. According to the Central Bureau of Statistics Magelang, the area of rice fields from 2017 to 2019 decreased by 63.51 Ha, and productive agricultural land for dry fields remains at 18.51 Ha. However, the area of the yard in Magelang reaches 1,234 ha.

Moreover, the level of population consumption in Magelang increased in 2020 by 0.67 percent from 2019. Due to the increasing consumption rate and yard potential, urban farming is a solution-driven by the Magelang Government to achieve food security. Urban farming is the cultivation, processing, and distribution of food and other products through plant cultivation and livestock raising to meet local food needs [5]. Over the past 20 years, urban farming has contributed to minimizing the impact of climate change and

improving the quality of people's lives in urban areas [6]. The practice of urban farming in the yardland is a strategic step to achieve food security because it can be a source of nutritious food for families and a source of plant diversity [7].

The practice of urban farming in Magelang has started to develop since the existence of the Sustainable Food House Area program organized by the Ministry of Agriculture through the relevant agencies in each region by involving the Women Farmers Group. This program is the embodiment of Government Regulation Number 17 of 2015 concerning food and nutrition security, wherein article 26 states that one of the efforts to diversify food is through the use of yards [8]. The practice of urban farming through the Sustainable Food House Area program is expected to be an effort to achieve food security in Magelang. On the other hand, urban farming practices should be able to answer sustainability challenges, so the benefits obtained are not only felt by the current generation but also by future generations. Therefore, in maintaining its existence, it is necessary to have an urban farming development strategy while still paying attention to its sustainability aspects. Hence, this practice can make a positive contribution in the future.

II. Materials and Method

A. Logical Framework

The practice of urban farming in Magelang has been running since 2018. Several farmer groups have even carried it out before the Sustainable Food House Area Program from the Ministry of Agriculture. Parties that contributed to urban farming in Magelang were the Department of Agriculture and Food Magelang as a government, an agricultural extension that provided information from planting preparation to postharvest, and Women Farmers Group as the main actor who directly practiced urban farming activities in the yard. In its progress, urban farming in Magelang has been unstable, especially since the COVID-19 pandemic in Indonesia. Some of the Women Farmers Groups were unable to survive because of a few meetings with other members, so they lost enthusiasm for farming. This mostly happened to the group that had completed the Women Farmers Group program for approximately two years. However, some Women Farmers Groups could still survive during the COVID-19 pandemic. Efforts to maintain the existence of urban farming practices in Magelang require a development strategy by paying attention more to sustainability aspects, such as economic, ecological, social, technological, and institutional. Therefore, to determine the priority of the urban farming development strategy, the steps required are shown in Fig. 1.

B. Data Collection

The technique of collecting data was done by conducting interviews through two stages. The first stage was to determine alternative strategies, and the second stage used a questionnaire to assess the dependencies between elements that had been prepared previously. Interviews were conducted with experts consisting of one person from the Department of Agriculture and Food Magelang, one from the Agricultural Extension Officer, and one from the Women Farmers Group representative.

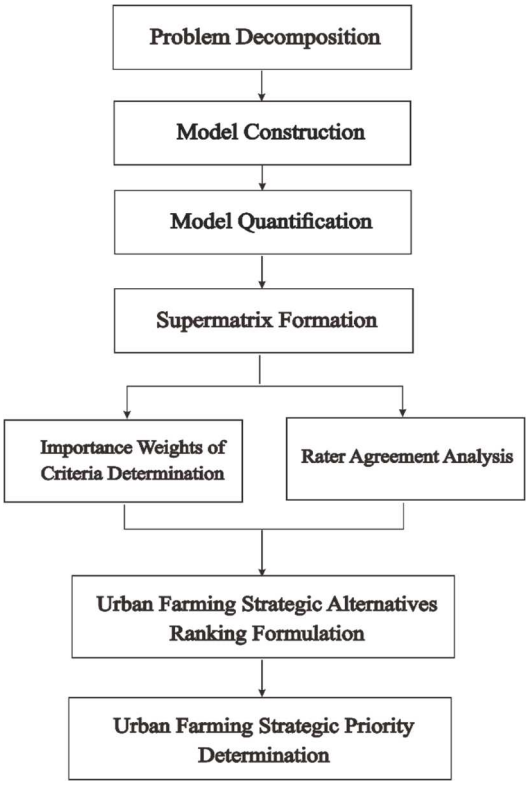

Fig. 1 Logical framework

C. Data Analysis Method

The collected data were analyzed using the Analytical Network Process (ANP) method. ANP is the development of the Analytical Hierarchy Process (AHP) method. This method is a mathematical theory that can analyze the influence with an assumption approach to solve complex problems through synthesis decomposition accompanied by a priority scale that produces the greatest priority effect [9]. ANP allows interaction and feedback from elements (nodes) in each cluster (group), known as inner dependence, and inter-cluster (between groups known as outer dependence [10]. The main reason for using the ANP method to analyze the strategic priorities of urban farming development in Magelang was its ability to provide a comprehensive framework of thinking in producing decisions that policymakers can use [11]. The steps in conducting the analysis using the ANP method [12], [13] are as follows :

1) Problem Decomposition: Breaking the problem into several clusters and nodes in each cluster by building dependencies, either interaction, and feedback from nodes in each cluster or inter-cluster interaction and feedback [14].

2) Model Construction: Making model construction with literature study, brainstorming, and focus group discussions with the experts [15].

3) Model Quantification: Carrying out the model quantification using questions in the ANP questionnaire in the form of pairwise comparisons between elements (nodes) in *Groups* (clusters) or between clusters to find out which of them has the greater influence and how much the difference is through a numerical scale of 1-9 [16]. Pairwise comparison scale is shown in Table 1.

TABLE I
PAIRWISE COMPARISON SCALE

Importance	Definition
1	The two elements are equally important, the two elements have the same effect.
3	One element is slightly more important than the other, experience and judgment slightly support one element over the other.
5	One element is more important than the other elements, experience and judgment strongly support one element over the other elements.
7	One element is more absolutely important than the other elements, one element is strongly supported and dominant over the other elements.
9	One element is absolutely important than the other elements, the evidence that supports one element against another has the highest possible level of affirmation to corroborate.
2,4,6,8	Values between two values for adjacent considerations, this value is given if there are two compromises between two choices.
Reciprocals of the above non-zero numbers	If activity i get one point compared to activity j, then j has the opposite value compared to activity i.

The data that have been collected using the ANP questionnaire was then inputted and processed through Super Decision 3.2 software. The assessment obtained from the expert must be checked for its consistency by calculating the Consistency Index (CI) of a matrix with calculations in equation 1:

$$CI = \frac{\lambda \max - n}{n-1} \quad (1)$$

After the CI value was obtained, the next step was to calculate the consistency ratio (CR) by calculating the equation 2.

$$CR = \frac{CI}{RI} \quad (2)$$

RI values were obtained through Table 2 Random Index values according to [17].

TABLE II
RANDOM INDEX (RI) VALUE

n	0	2	3	4	5	6	7	8
RI	0	0	0.58	0.90	1.12	1.24	1.32	1.41

If the CR is less than 0.1 then the expert's assessment is consistent, but if the CR value is more than 0.1 then it is necessary to ask the expert again to provide consistent results [18].

4) Supermatrix Formation: Supermatrix is a matrix consisting of a sub-matrix composed of a set of relationships between the two levels contained in the model [19]. Supermatrix formation is carried out to obtain priorities through the derivation of the pairwise comparison matrix which is described in horizontal and vertical forms [20]

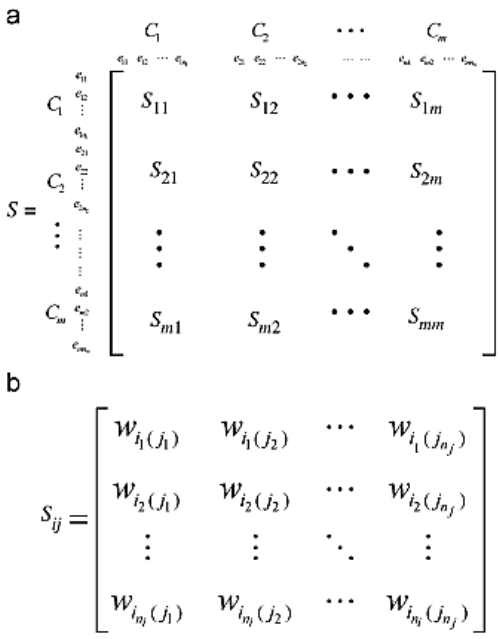

Fig. 2 The general representation of a supermatrix (a). The general representation of a sub-matrix (b).

Supermatrix (fig. 2a) is a matrix that consists of a set of relationships between nodes or elements of each cluster according to the dependency relationship. The supermatrix consists of m ($C_1, C_2, \ldots, C_m$,) and the node in C_k consists of nodes n_k which are denoted as $e_{k1}, e_{k2}, \ldots, e_{knk}$. Sub-matrix (fig. 2b) consists of columns with priority vectors representing the effect of all nodes in cluster i on each node in cluster j, and some priority vectors can be zero if there is an effect between nodes [12]. Three stages of the supermatrix must be completed. The first stage (unweighted supermatrix) is formed by a pairwise comparison matrix and produces a supermatrix containing local priority vectors [21]. The second stage (weighted supermatrix) is obtained by multiplying the contents of the unweighted supermatrix by the weight of each cluster. The last stage (limit supermatrix) is obtained by raising the weighted supermatrix until it gives stable results [22].

5) Importance Weights of Criteria Determination: The determination of importance weight uses the results of the normalized supermatrix limit from the ANP model [20]. The overall priority of each alternative is calculated through a synthesis process by calculating the Geometric Mean value of all respondents [23]. The Geometric Mean value is obtained through calculations in equation 3

$$GM\bar{y} = \sqrt[n]{y_1 y_2 y_3 y_4 y_5 \ldots\ldots\ y_n} \quad (3)$$

6) Rater Agreement Analysis: Rater Agreement analysis is a measure that shows the level of conformity (agreement) of the respondents to problems in one cluster. This analysis uses Kendall's Coefficient of Concordance (W) with a value of 0 (no agreement) to 1 (perfect agreement) [24]. If the W value is close to or equal to 1, then the assessment or opinion of the experts is close to an agreement, but on the contrary, if the W value is close to 0 or equal to 0, then the results show disagreement or the response of the experts varies [25]. The value of Kendall's Coefficient of Concordance (W) gives

different interpretation results according to the criteria in Table 3 [26].

TABLE III
CRITERIA OF RATER AGREEMENT

W	Criteria
0.00	No agreement
0.10	Weak agreement
0.30	Moderate agreement
0.60	Strong agreement
1.00	Perfect agreement

7) Strategic Alternative Ranking Formulation: After obtaining a value for each element by calculating the weight of importance, it needs to be sorted, where the highest weight is the main priority, and the lowest weight is the last priority [27].

8) Strategic Priority Determination: Strategy's priority is determined using the highest weighted value, which indicates a higher level of importance and effectiveness than other alternatives [28].

III. RESULTS AND DISCUSSION

The decision to prioritize the urban farming development strategy began with conducting a literature study, brainstorming, and discussions with experts to determine clusters and nodes which were formulated in a network structure of ANP (Fig. 3). The analysis aims to determine the priority of urban farming development strategies in Magelang. The development of an urban farming strategy requires the involvement of sustainability dimensions, including economic, ecological, social, technological, and institutional. Clusters in the network structure consist of sustainability aspects groups, economy, ecology, social, technology, institutional, and alternative urban farming development strategies in Magelang, Indonesia. Each cluster consists of connected nodes, both between nodes in one cluster and between nodes in different clusters. All data inputted into the Super Decision 3.2 software show that the consistency ratio (CR) value in each pairwise comparison matrix is less than 0.1, which means that the assessments of all experts provide consistent results.

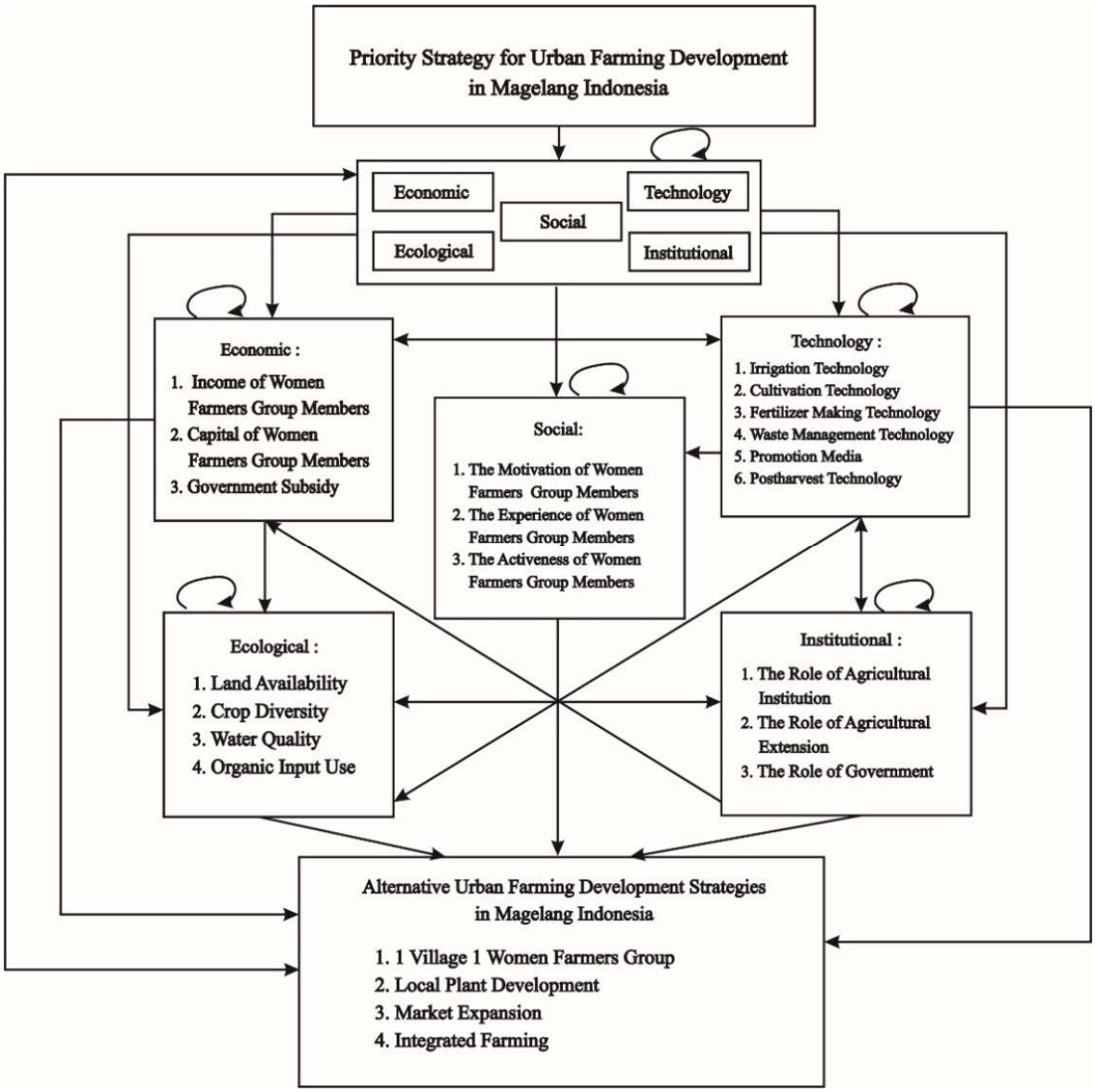

Fig. 3 The network structure of ANP

After the consistency analysis was performed, an unweighted supermatrix was formed. Furthermore, multiplying the unweighted supermatrix with the weights of each cluster obtained the weighted supermatrix. After obtaining the results of the weighted supermatrix, then it raised to the power to obtain a stable result to produce the limit matrix and the normalized result (normalized by cluster) as the weight of importance [29].

TABLE IV
WEIGHT OF SUSTAINABILITY DIMENSIONS

No	Sustainability Dimensions	Normalized by Cluster	Limiting
1	Economic	0.177963	0.051290
2	Ecological	0.190302	0.054847
3	Social	0.221783	0.063920
4	Technology	0.166094	0.047869
5	Institutional	0.174437	0.050274

Based on Table 4, the synthesis results show that the node in the sustainability dimension that has the most priority in the development of urban farming in Magelang is the social dimension with a value of 0.221783. The ecological dimension (0.190302), the economic dimension (0.177963), the institutional dimension (0.174437), and the last is the technology dimension (0.166094). Based on Kendall's Coefficient of Concordance, the rater agreement value is 0.10, which means a weak agreement among the experts. The social dimension plays an important role in the practice of urban farming. Urban farming requires a good collaboration built from each individual or Women Farmers Group member as a pioneer involved. Activities in each urban farming activity invite the surrounding community to participate by utilizing the potential of the yard in each house to foster public interest in the practice of urban farming directly [30]. Moreover, urban farming impacts social life, such as reducing poverty and crime [31], and create meaningful job opportunities [32].

TABLE V
WEIGHT OF ECONOMIC DIMENSION

No	Economic	Normalized by Cluster	Limiting
1	Income of Women Farmers Group Members	0.502102	0.035198
2	Capital of Women Farmers Group Members	0.210058	0.014725
3	Government Subsidy	0.211395	0.014819

The results of the synthesis based on Table 5 show that the income of Women Farmers Group members is the most prioritized node in the economic dimension for urban farming development in Magelang. The priority value of Women Farmers Group members' income is 0.50210, then government subsidy (0.211395), and the last is the capital of Women Farmers Group members (0.210058). Based on Kendall's Coefficient of Concordance, the rater agreement value is 0.44, which means moderate agreement among the experts. The income of Women Farmers Group members is the most important thing in the economic dimension. This is because the purpose of urban farming activities is food self-sufficiency in each household, which impacts increasing income. Additional household income with the practice of urban farming comes from reducing the cost of spending on food consumption and selling the surplus production of crops [33].

TABLE VI
WEIGHT OF ECOLOGICAL DIMENSION

No	Ecological	Normalized by Cluster	Limiting
1	Land Availability	0.330107	0.029386
2	Crop Diversity	0.194916	0.017351
3	Water Quality	0.092857	0.008266
4	Organic Input Use	0.293515	0.026128

The synthesis results based on Table 6 show that land availability is the most prioritized node in the ecological dimension for developing urban farming in Magelang. The priority value of land availability is 0.330107, then organic input use (0.293515), crop diversity (0.194916), and the last is water quality (0.092857). Based on Kendall's Coefficient of Concordance, the rater agreement value is 0.64, which means a strong agreement among the experts. The availability of land is the most important aspect of the ecological dimension. Land is an important resource for urban farming. The practice of urban farming requires an area of land, regardless of whether the agricultural system applied is land-based or not. Although land is an important component, the availability of land for urban farming activities is still limited. Women Farmers Group, the pioneer of urban farming practice, has problems providing land. Collective urban farming activities in a demonstration plots known as “demplot” are still tied to one landowner who cannot last long. According to Martin-moreau and Ménascé [34], many urban areas still do not have a special area for urban farming activities. This is due to high industrial, housing, and institutional demand. Although urban farming has been recognized to contribute to food security, urban greening, and productive job, it still has a large gap between the perception of activities by decision-makers and urban farming practitioners. Land use activities for urban farming are still considered not a priority by urban authorities [35].

TABLE VII
WEIGHT OF SOCIAL DIMENSION

No	Social	Normalized by Cluster	Limiting
1	The Motivation of Women Farmers Group Members	0.360859	0.030520
2	The Experience of Women Farmers Group Members	0.241398	0.020417
3	The Activeness of Women Farmers Group Members	0.351235	0.029707

The results of the synthesis based on Table 7 show that the motivation of Women Farmers Group members is the most prioritized node in the social dimension for the development of urban farming in Magelang. The priority value of Women Farmers Group members' motivation is 0.360859, then in the next sequence is the activeness of Women Farmers Group members (0.351235), and the last is the experience of Women Farmers Group members (0.241398). Based on Kendall's Coefficient of Concordance, the rater agreement value is 0.44, which means a moderate agreement among the experts. Motivation encourages each individual to achieve their goal

in carrying out an activity [36]. The motivation of Women Farmers Group members in carrying out urban farming is supported by their desire to fulfill their daily food needs efficiently, the need for environmental health around the house, and as an activity to fill their spare time by utilizing the potential of the existing yard. Some respondents' practice of urban farming can also save spending money, increase skills in agriculture, and serve as a medium for exchanging information with other Women Farmers Group members. Motivation in carrying out urban farming practices is very important for Women Farmers Group members because it can positively impact their quality of life [37].

TABLE VIII
WEIGHT OF TECHNOLOGY DIMENSION

No	Technology	Normalized by Cluster	Limiting
1	Irrigation Technology	0.135425	0.010052
2	Cultivation Technology	0.241708	0.017941
3	Fertilizer Making Technology	0.110225	0.008182
4	Waste Management Technology	0.103237	0.007663
5	Promotion Media	0.156425	0.011611
6	Postharvest Technology	0.165529	0.012286

The results of the synthesis based on Table 8 show that cultivation technology is the most prioritized node in the technology dimension for the development of urban farming in Magelang. The priority value of cultivation technology is 0.241708, then in the next sequence is postharvest technology (0.165529), promotion media (0.156425), irrigation technology (0.135425), fertilizer manufacturing technology (0.110225), and waste management technology (0.103237). Based on Kendall's Coefficient of Concordance, the rater agreement value is 0.37, which means moderate agreement among the experts. Cultivation technology is a unified process that greatly determines the quality of crop products because it can overcome biotic and abiotic factors that inhibit plant growth and development. Technology development in cultivation provides quality differences compared to conventional processes, such as reducing loss of fitness and increasing genetic diversity [38].

TABLE IX
WEIGHT OF INSTITUTIONAL DIMENSION

No	Institutional	Normalized by Cluster	Limiting
1	The Role of Agricultural Institution	0.184540	0.016441
2	The Role of Agricultural Extension	0.575296	0.051255
3	The Role of Government	0.196085	0.017470

The synthesis results based on Table 9 show that the role of agricultural extension is the most prioritized node in the institutional dimension for developing urban farming in Magelang. The priority value of the role of agricultural extension is 0.575296, then in the next sequence is the role of the government (0.196085), and the last is the role of agricultural institutions (0.184540). Based on Kendall's Coefficient of Concordance, the rater agreement value is 0.78, which means a strong agreement among the experts. Agricultural extension plays an important role in the success of urban farming practices. Adequate capabilities of extension workers, both in terms of insight or expertise in conveying information, will increase farmer's ability to manage urban farming practices and increase public awareness about the importance of urban farming in urban areas [39]. Agricultural extension as a medium to Women Farmers Group members provides technical assistance through information distribution to direct practice, manage agricultural and institutional activities, and open opportunities for urban farming actors to sell their harvests [40].

TABLE X
WEIGHT OF STRATEGIC ALTERNATIVES

No	Strategic Alternatives	Normalized by Cluster	Limiting
1	1 Village 1 Women Farmers Group	0.050093	0.014196
2	Local Plant Development	0.219249	0.062135
3	Market Expansion	0.235518	0.066745
4	Integrated Farming	0.460889	0.130616

The synthesis results based on Table 10 show that integrated farming is the most prioritized node as an alternative strategy for urban farming development in Magelang. The priority value of integrated farming is 0.460889. This concept integrates the agricultural, livestock, and fisheries sectors. The livestock sector can produce products in the form of meat and animal manure as fertilizer, and the fisheries sector produces products in the form of meat for consumption and fish manure that can be used as natural fertilizers for plants in aquaponic farming systems. Meanwhile, the plant production process produces food for humans and organic waste for animal feed and compost. Integrated farming contributes to overall urban circularity metabolism and urban aesthetics [41]. Furthermore, it also positively impacts household income because the products come from not only one sector but several sectors that are integrated into an agricultural system [42].

Market expansion is the second priority, with a value of 0.235518. Most of the urban farming products that come from home gardens are subsistence and have not been widely marketed. This is because the yields produced are still limited, so they cannot meet market demand. In addition, market information is still limited. Therefore, some Women Farmers Group members sell their harvest around the area where they live. Market expansion can be done by using social media to sell harvested products that are already widely used by members of the Women Farmers Group [43].

The development of local plants is the third priority, with a value of 0.219249. The development of local crops is intended to make the community more focused on cultivating certain plants. Thus, inter-regional cooperation will be established to complement each other's needs for agricultural commodities that are not planted in their area. In addition, the cultivated plants are adapted to soil conditions and air temperatures that can provide optimal yields [44].

The establishment of 1 village 1 Women Farmers Group is the fourth priority with a value of 0.050093. Women Farmers Group as an agricultural institution plays an important role in the development of urban farming. This is because the

Women Farmers Group is a pioneer that can invite the community to contribute to the practice of urban farming [45]. The rater agreement value for the alternative cluster strategy based on Kendall's Coefficient of Concordance is 0.91, which means a strong agreement among the experts.

IV. Conclusions

The analysis results on the cluster of sustainability dimensions produce a priority order: social, ecological, economic, institutional, and technological. Based on the analysis of the economic, ecological, social, technological, and institutional dimensions sequentially, it shows that the income of Women Farmers Group members, land availability, motivation of Women Farmers Group members, cultivation technology, and the role of agricultural extension are the priority criteria in the development of urban farming. Meanwhile, the priority of the urban farming development strategy in Magelang shows that integrated agriculture is in the first place, then in the next sequence is market expansion, local crop development, and the establishment of 1 village 1 Women Farmers Group. The results of this study can be used as an alternative policy for the government and related parties in developing urban farming in the lack of agricultural land for food production by integrating the agricultural, livestock, and fishery sectors. In addition, the methods and criteria used in this study can be applied to related research in the future.

Acknowledgment

The authors thank the Department of Agriculture and Food Magelang, the Coordinator of Agricultural Extension Officers Magelang, and the Women Farmers Group, who have provided information and support for this research.

References

[1] Y. Ren, Z. Li, J. Li, Y. Ding, and X. Miao, "Analysis of Land Use/Cover Change and Driving Forces in the Selenga River Basin," *Sensors*, vol. 22, no. 3, pp. 1–23, 2022, doi: 10.3390/s22031041.

[2] FAO, *Framework for the Urban Food Agenda*. Rome, Italy: FAO, pp. 1-39, 2020. doi: 10.4060/ca3151en.

[3] D. Kumar Singh and R. Sobti, "Long-range real-time monitoring strategy for Precision Irrigation in urban and rural farming in society 5.0," *Comput. Ind. Eng.*, vol. 167, no. 2022, pp. 1-9, 2022, doi: 10.1016/j.cie.2022.107997.

[4] J. E. Jansma and S. C. O. Wertheim-Heck, "Feeding the city: A social practice perspective on planning for agriculture in peri-urban Oosterwold, Almere, the Netherlands," *Land use policy*, vol. 117, no. 2022, pp. 1-10, 2022, doi: 10.1016/j.landusepol.2022.106104.

[5] M. Hardman, A. Clark, and G. Sherriff, "Mainstreaming Urban Agriculture: Opportunities and Barriers to Upscaling City Farming," *Agronomy*, vol. 12, no. 3, 2022, doi: 10.3390/agronomy12030601.

[6] S. A. Salim, S. H. Salim, and F. Mohd Razali, "Structured Literature Reviews (SLR) of Urban Farming for Improving Economic Status of Urban Residents," *Int. J. Sustain. Constr. Eng. Technol.*, vol. 12, no. 5, pp. 271–273, 2021, doi: 10.30880/ijscet.2021.12.05.027.

[7] I. Goodfellow and V. Prahalad, "Barriers and enablers for private residential urban food gardening: The case of the City of Hobart, Australia," *Cities*, vol. 126, no. 2022, pp. 1-18, 2022, doi: 10.1016/j.cities.2022.103689.

[8] Ministry of Agriculture, "Technical Guidelines for Government Assistance in Sustainable Food House Area Activities in 2019," Jakarta: Ministry of Agriculture, 2019, pp. 1-57.

[9] M. Usak, M. Y. Hsieh, and Y. K. Chan, "A concretizing research on making higher-education sustainability count," *Sustain.*, vol. 13, no. 5, pp. 1–14, 2021, doi: 10.3390/su13052724.

[10] L. P. Fernandez, M. A. Sebastian, and C. Gonz, "Methodology to optimize quality costs in manufacturing based on multi-criteria analysis and lean strategies," *Applied Science,* vol. 12, no. 2022, pp. 1-17, 2022, doi: 10.3390/app12073295.

[11] A. Popa, S. Hadad, R. Paiusan, and M. Nastase, "A new method for agricultural market share assessment," *Sustain.*, vol. 11, no. 1, pp. 1–13, 2019, doi: 10.3390/su11010088.

[12] D. Rodrigues, R. Godina, and P. E. Cruz, "Key Performance Indicators Selection through an Analytic Network Process Model for Tooling and Die Industry," *Sustainability,* vol. 13, no. 2021, pp. 1-20, 2021,doi: 10.3390/su132413777.

[13] S. Kumar, R. D. Raut, M. M. Queiroz, and B. E. Narkhede, "Mapping the barriers of AI implementations in the public distribution system : The Indian experience," *Technol. Soc.*, vol. 67, no. 2021, pp. 1-9, 2021, doi: 10.1016/j.techsoc.2021.101737.

[14] L. A. Ocampo, "Decision modeling for manufacturing sustainability with fuzzy analytic hierarchy process," *Global Business Review,* vol. 20, no. 1, pp: 25-41, 2019, doi: 10.1177/0972150917736990.

[15] N. Wibowo, J. K. Piton, R. Nurcahyo, D. S. Gabriel, F. Farizal, and A. F. Madsuha, "Strategies for improving the e-waste management supply chain sustainability in Indonesia (Jakarta)," *Sustain.*, vol. 13, no. 24, pp. 1–15, 2021, doi: 10.3390/su132413955.

[16] S. Lin *et al.*, "Socio-Economic Planning Sciences An evaluation framework for developing green infrastructure by using a new hybrid multiple attribute decision-making model for promoting environmental sustainability," *Socioecon. Plann. Sci.*, vol. 75, no. 2021, pp. 1-16, 2021, doi: 10.1016/j.seps.2020.100909.

[17] M. Polo-castañeda, J. Gómez-rojas, and J. Linero-cueto, "Application of AHP and GIS for determination of suitable wireless sensor network zones for oceanographic monitoring in the South Caribbean Sea upwelling zone," *International Journal on Advanced Science Engineering Information Technology,* vol. 11, no. 5, pp. 1696-1703, 2021.

[18] M. C. Kurian, S. P.R, and P. V.R, "Maintenance strategy selection in a cement industry using analytic network process," *J. Qual. Maint. Eng.*, vol. 26, no. 4, pp. 509–525, 2020, doi: 10.1108/JQME-07-2017-0048.

[19] A. Keyvanfar, A. Shafaghat, N. Ismail, S. Mohamad, and H. Ahmad, "Multifunctional retention pond for stormwater management: A decision-support model using Analytical Network Process (ANP) and Global Sensitivity Analysis (GSA)," *Ecol. Indic.*, vol. 124, no. 2021, pp. 1-22, 2021, doi: 10.1016/j.ecolind.2020.107317.

[20] M. Giannakis, R. Dubey, I. Vlachos, and Y. Ju, "Supplier sustainability performance evaluation using the analytic network process," *J. Clean. Prod.*, vol. 247, no. 2020, pp. 1-12, 2020, doi: 10.1016/j.jclepro.2019.119439.

[21] M. A. Arjomandi, F. Dinmohammadi, B. Mosallanezhad, and M. Shafiee, "A fuzzy DEMATEL-ANP-VIKOR analytical model for maintenance strategy selection of safety critical assets," *Adv. Mech. Eng.*, vol. 13, no. 4, pp. 1–21, 2021, doi: 10.1177/1687814021994965.

[22] A. Haruna, N. Shafiq, O. A. Montasir, S. Haruna, and M. Mohammed, "Design, Material Selection and Manufacturing for Sustainable Construction: An Analytical Network Process Approach," *IOP Conf. Ser. Earth Environ. Sci.*, vol. 476, no. 1, 2020, doi: 10.1088/1755-1315/476/1/012006.

[23] V. Sharma, B. D. Gidwani, V. Sharma, and M. L. Meena, "Implementation model for cellular manufacturing system using AHP and ANP approach," *Benchmarking*, vol. 26, no. 5, pp. 1605–1630, 2019, doi: 10.1108/BIJ-08-2018-0253.

[24] Taryono, A. Mashar, and S. Aryasa, "Management policy of invasive species red claw crayfish (Cherax quadricarinatus) at Lido Lake, Bogor Regency," *IOP Conf. Ser. Earth Environ. Sci.*, vol. 744, no. 1, pp. 0–10, 2021, doi: 10.1088/1755-1315/744/1/012090.

[25] A. M. Alfuraih, F. N. Almutairi, S. B. Alotaibi, and A. A. Alshmrani, "Semi-quantitative scoring of imaging modalities in detecting soft tissue foreign bodies: an in vitro study," *Acta radiol.*, vol. 63, no. 4, pp. 474–480, 2022, doi: 10.1177/0284185121999654.

[26] T. Widiastuti, E. F. Cahyono, S. Zulaikha, I. Mawardi, and M. U. Al Mustofa, "Optimizing zakat governance in East Java using analytical network process (ANP): the role of zakat technology (ZakaTech)," *J. Islam. Account. Bus. Res.*, vol. 12, no. 3, pp. 301–319, 2021, doi: 10.1108/JIABR-09-2020-0307.

[27] J. Liu, K. M. Kamarudin, Y. Liu, and J. Zou, "Developing pandemic prevention and control by ANP-QFD approach : a case study on urban furniture design in China Communities," *International Journal of Environmental Research and Public Health,* vol. 18, no. 5, pp. 1-26, 2021, doi: 10.3390/ijerph18052653.

[28] K. Kasutjianingati, A. Wahyono, A. Brilliantina, and E. K. Novitasari, "SWOT and Analytical Network Process (ANP) Analysis for Robusta

Coffee Bean Development Strategy in Panti District, Jember Regency," *IOP Conf. Ser. Earth Environ. Sci.*, vol. 411, no. 1, 2020, doi: 10.1088/1755-1315/411/1/012019.

[29] L. Xiong, G. Sheng, Z. M. Fan, H. Yang, F. J. Hwang, and B. W. Zhu, "Environmental Design Strategies to Decrease the Risk of Nosocomial Infection in Medical Buildings Using a Hybrid MCDM Model," *J. Healthc. Eng.*, vol. 2021, no. 2021, pp. 1-17, 2021, doi: 10.1155/2021/5534607.

[30] R. Wulandari, R. Witjaksono, and R. Inekewati, "Community Participation in the Development of Urban Farming in Yogyakarta City," *E3S Web Conf.*, vol. 232, pp. 1–11, 2021, doi: 10.1051/e3sconf/202123201024.

[31] S. Wuyep, "The role of urban vegetable production in Jos (Nigeria) as a source of livelihood," *Afr. J. Food. Agric. Nutr. Dev.,* vol. 21, no. 8, pp. 18533–18551, 2021, doi: 10.18697/ajfand.103.20300.

[32] M. H. M. Saad, N. M. Hamdan, and M. R. Sarker, "State of the art of urban smart vertical farming automation system: Advanced topologies, issues and recommendations," *Electron.*, vol. 10, no. 12, pp. 1–40, 2021, doi: 10.3390/electronics10121422.

[33] M. Mupeta, E. Kuntashula, and T. Kalinda, "Impact of urban agriculture on household income in zambia: An economic analysis," *Asian J. Agric. Rural Dev.*, vol. 10, no. 2, pp. 550–562, 2020, doi: 10.18488/journal.ajard.2020.102.550.562.

[34] M. Martin-moreau and D. Ménascé, *The journal of fi eld actions Urban Agriculture : Another Way to Feed Cities*. Aubervilliers, France: Institute Veolia, 2019, pp. 12-17.

[35] A. Halloran and J. Magid, "Planning the unplanned: Incorporating agriculture as an urban land use into the Dar es Salaam master plan and beyond," *Environ. Urban.*, vol. 25, no. 2, pp. 541–558, 2013, doi: 10.1177/0956247813500903.

[36] N. Othman, R. A. Latip, and M. H. Ariffin, "Motivations for sustaining urban farming participation," *Int. J. Agric. Resour. Gov. Ecol.*, vol. 15, no. 1, p. 45, 2019, doi: 10.1504/ijarge.2019.10021353.

[37] C. K. Kirby *et al.*, "Differences in motivations and social impacts across urban agriculture types: Case studies in Europe and the US," *Landsc. Urban Plan.*, vol. 212, no. 2021, pp. 1-11, 2021, doi: 10.1016/j.landurbplan.2021.104110.

[38] T. Wang, H. Zhang, and H. Zhu, "CRISPR technology is revolutionizing the improvement of tomato and other fruit crops," *Hortic. Res.*, vol. 6, no. 1, pp. 1-13, 2019, doi: 10.1038/s41438-019-0159-x.

[39] A. I. Al-Ansari and A. M. A. Hasan, "The Role of Extension Farms in Developing the Knowledge, Skills, and Attitudes of Farmers in the Provinces of Central Iraq," *IOP Conf. Ser. Earth Environ. Sci.*, vol. 761, no. 1, pp. 1-17, 2021, doi: 10.1088/1755-1315/761/1/012135.

[40] Y. Girma and B. Kuma, "A meta analysis on the effect of agricultural extension on farmers' market participation in Ethiopia," *J. Agric. Food Res.*, vol. 7, no. 2022, pp. 1-6, 2022, doi: 10.1016/j.jafr.2021.100253.

[41] F. Orsini, "Innovation and sustainability in urban agriculture: the path forward," *J. fur Verbraucherschutz und Leb.*, vol. 15, no. 3, pp. 203–204, 2020, doi: 10.1007/s00003-020-01293-y.

[42] S. Oosting *et al.*, "Farmed animal production in tropical circular food systems," *Food Secur.*, vol. 14, no. 1, pp. 273–292, 2022, doi: 10.1007/s12571-021-01205-4.

[43] S. Mohseni, K. Baghizadeh, and J. Pahl, "Evaluating Barriers and Drivers to Sustainable Food Supply Chains," *Math. Probl. Eng.*, vol. 2022, pp. 1-24, 2022, doi: 10.1155/2022/4486132.

[44] N. Belinda and D. Rahmawati, "Development of urban farming based on the preferences of the people of Semampir District, Surabaya," *J. Tek. ITS*, vol. 6, no. 2, 2017, doi: 10.12962/j23373539.v6i2.25008.

[45] I. Indarwati, D. Retna, J. Herawati, T. Tojibus, "Empowerment of urban women farmers in supporting the improvement of the family economy by using yardland," vol. 1, no. 3, pp. 180–189, 2021, doi: 10.53067/ijecsed.