Vol. 10 No. 1September 2026

ISSN : 2597-8713 (ONLINE)
ISSN : 2598-5167 (PRINT)
Agricultural Science

AGRICULTURAL SCIENCE
Journal Of Agricultural Science And Agriculture Engineering
Faculty of Agriculture, Merdeka University Surabaya,Indonesia
Available on :
https://agriculturalscience.unmerbaya.ac.id/index.php/agriscience/index

Aquaponics Development Strategy through the Empowerment of PKK Women's Groups in Palu City, Central Sulawesi

Angela Destalia Arumpone[1]*, Samliok Ndobe[1], Alimudin Laapo[1], Novalina Serdiati[1], Nasmia[1]

[1]Master of Agricultural Science Study Program, Postgraduate Program, Tadulako University, Palu, Central Sulawesi, Indonesia.

*Corresponding author E-mail: angela.arumpone.s2@gmail.com

Article History: Received: May 12, 2026; Accepted: July 06, 2026

ABSTRACT

Limited urban land and women's low technical capacity in integrated agriculture necessitate an adaptive, technology-based empowerment strategy. This study examines the level of understanding of aquaponics cultivation among members of the Dasawisma Melati PKK group in Tanamodindi Urban Village, Palu City. It identifies development constraints, opportunities, and strategic formulations. The novelty of this research lies in integrating a mixed-methods approach with SWOT-AHP analysis to empower urban PKK women's groups. This area remains under-investigated empirically in Indonesia. The study involved 13 active group members over eight weeks (October–December 2025). It used Focus Group Discussions (FGDs), Likert-scale questionnaires, in-depth interviews, field observations, and pre-tests and post-tests. Despite the small sample size (n = 13This approach is representative as it encompasses all active members directly involved in managing the Green Farm House facility. The cultivated commodities consisted of 350 African catfish (Clarias gariepinus) with a 6% feeding rate and 48 heads of lettuce (Lactuca sativa L.). The cultivation results showed that catfish biomass increased from 37 grams to 667 grams over eight weeks, with an 83.71% survival rate. The lettuce plants grew from 2 cm to 17–23 cm, with an average harvest weight of 156.3 grams per plant. Water quality remained stable at temperatures of 30–31 °C and a pH of 7. Although an increase in ammonia from 2.3 mg/L to 8.2 mg/L was observed—which theoretically approaches the toxicity threshold—it did not correlate with the high survival rate (r = 0.40; moderate positive correlation), thereby indicating potential fish adaptation or the effectiveness of the biofiltration system. Participants' understanding increased significantly from 54.02% to 85.13%. All variables, including program quality, participation, and socio-environmental benefits, shifted to the "very high" category. The Public Satisfaction Survey recorded an index of 101.25 (89.91% satisfaction level). The SWOT analysis placed the group in Quadrant I (IFAS 3.9; EFAS 3.8). Through AHP with a Consistency Ratio of 1.9%, four priority strategies were established, with routine training at the Green Farm House designated as the primary program (62% weight). This study demonstrates that aquaponics, grounded in the empowerment of PKK women, is effective at sustainably strengthening urban food security and holds potential as a replicable model for other cities. However, further research with larger sample sizes and longer observation periods is required.

Keywords: Aquaponics, development strategy, women empowerment, urban food security, PKK

1. INTRODUCTION

Food security is a strategic issue in Indonesia's national development, where agriculture and fisheries serve as the backbone for meeting the community's food demands. However, pressure on this system is intensifying alongside rapid urbanization: more than half of the global population

ISSN : 2597-8713 (ONLINE)
ISSN : 2598-5167 (PRINT)
Agricultural Science
AGRICULTURAL SCIENCE
Journal Of Agricultural Science And Agriculture Engineering
Faculty of Agriculture, Merdeka University Surabaya,Indonesia
Available on :
https://agriculturalscience.unmerbaya.ac.id/index.php/agriscience/index

currently resides in urban areas, particularly in developing countries, and the conversion of agricultural land into residential and industrial zones continues to shrink available productive space (Abdoellah et al., 2023). Consequently, cities are increasingly dependent on food supplies from rural areas, rendering them vulnerable to supply chain disruptions, price spikes, and natural disasters. This reality drives the urgent need for innovative food production systems that are adaptive to limited land while ensuring productivity and ecological sustainability.

Aquaponics is an integrated aquaculture and hydroponics system operating within a closed loop based on the principles of the nitrogen cycle: metabolic waste from fish is broken down by nitrifying bacteria into nitrates to serve as plant nutrients. In contrast, the plants purify the water before it is recirculated back into the fish pond (Panya, 2023). This symbiosis yields a system that is simultaneously productive, resource-efficient, and low-waste. Okomoda et al. (2023) emphasize that aquaponics provides clear advantages over conventional agriculture, including water conservation, enhanced productivity, minimized pollution, and low energy consumption. It holds substantial potential as a food security solution in developing countries, though in practice it still requires targeted policy interventions. These advantages are further complemented by its compatibility with renewable energy and community-based business models. However, the literature also underscores the importance of contextual research in tropical regions that accounts for local biophysical factors, such as climate, energy availability, and raw material accessibility, as primary determinants of system effectiveness before expanding production scale (Ibrahim et al., 2023).

The relevance of aquaponics grows stronger when linked to the role of women in urban food management. Women possess strategic potential as urban agricultural actors due to their high flexibility in carrying out activities in residential areas. Rahayu et al. (2026) demonstrate that entrepreneurship-oriented agricultural training for women has a tangible impact by improving technical skills, utilizing kitchen waste to produce liquid organic fertilizer, and increasing motivation to develop household enterprises. Collectively, these efforts sustainably strengthen women's empowerment, food security, and urban economic resilience.

In Indonesia, the Family Welfare Movement (Pemberdayaan Kesejahteraan Keluarga / PKK) is a women's organization with the widest reach, extending down to the neighborhood level (Rukun Tetangga / RT). PKK has the potential to become a strategic agent for disseminating urban agricultural technologies, including aquaponics, because it directly engages families as the smallest unit of food security (Fitrianti, 2025). Although the role of women in family food management is

ISSN : 2597-8713 (ONLINE)
ISSN : 2598-5167 (PRINT)
Agricultural Science
AGRICULTURAL SCIENCE
Journal Of Agricultural Science And Agriculture Engineering
Faculty of Agriculture, Merdeka University Surabaya,Indonesia
Available on :
https://agriculturalscience.unmerbaya.ac.id/index.php/agriscience/index

globally recognized, technology-based fisheries empowerment within the context of PKK groups in Indonesia remains under-examined empirically.

This study aims to address this gap. While global research on aquaponics is expanding, empirical studies specifically combining the technical aspects of aquaponics cultivation with the socio-institutional dimensions of empowering PKK groups in Indonesia remain scarce. The objectives of this study are: (1) to assess the level of understanding and involvement of PKK women in aquaponics practices; (2) to identify internal constraints and external opportunities in the development of aquaponics by the group; and (3) to formulate contextual, sustainable, and community-based aquaponics development strategies using SWOT and the Analytic Hierarchy Process (AHP). Consequently, this research not only contributes to the scientific development of aquaponics in tropical zones but also proposes a technology-based agricultural empowerment model for women that can be replicated in other Indonesian cities.

2. RESEARCH METHOD

Research Location and Time

The study was conducted at the Green Farm House, Tanamodindi Urban Village, Palu City, Central Sulawesi, over eight weeks (October–December 2025). This location was selected because it is a facility fostered by the Palu City Agriculture Department and managed by the Dasawisma Melati PKK Group.

Respondents and Data Collection Techniques

The respondents comprised 13 active members of the Dasawisma Melati PKK Group who were directly involved in aquaponics activities. Data were gathered through a Rapid Rural Appraisal (RRA) approach, which included Focus Group Discussions (FGDs), in-depth interviews, field observations, and a Likert-scale questionnaire. This was followed by the determination of development strategies using SWOT and AHP. The pre-test was conducted prior to the study, and the post-test was administered upon the completion of the mentoring program.

This study obtained formal approval from relevant stakeholders, namely the Palu City PKK Institutional Body under letter number 002/SKR/PKK/KP/2026, and the Palu City Agriculture Department—the provider of greenhouse assistance to the group—under letter number 800/418.1/DPKP/X/2025.

Vol. 10 No. 1September 2026
ISSN : 2597-8713 (ONLINE)
ISSN : 2598-5167 (PRINT)
Agricultural Science
AGRICULTURAL SCIENCE
Journal Of Agricultural Science And Agriculture Engineering
Faculty of Agriculture, Merdeka University Surabaya,Indonesia
Available on :
https://agriculturalscience.unmerbaya.ac.id/index.php/agriscience/index

Aquaponics System Design

The aquaponics system utilized a concrete tank measuring. 4 × 2 × 0.9 m integrated with six 4-inch PVC pipes (3 m long) serving as hydroponic planting channels, each with 48 planting holes. The cultivated organisms comprised 350 African catfish (Clarias gariepinus) measuring 7–8 cm and 48 lettuce plants (Lactuca sativa L.) of a local variety (Tafung brand). The feed used was commercial HI-PRO-VITE 781-2 (3 mm) pellets, administered twice daily at a feeding rate (FR) of 6% of the fish biomass per week.

Observed Parameters

Technical parameters included fish Survival Rate (SR), Specific Growth Rate (SGR), weekly biomass, plant height, lettuce harvest weight, and water quality metrics (temperature, pH, TDS, EC, salinity, ORP, ammonia, nitrite, and nitrate). Socio-institutional parameters included the level of understanding (evaluated via a Likert scale across 4 variables), the Public Satisfaction Survey (SKM), and the identification of constraints and opportunities. Water quality was measured weekly using a multifunctional water quality meter, whereas ammonia, nitrite, and nitrate levels were analyzed at the Laboratory of the Palu City Environmental Department.

Data Analysis

Data analysis employed three distinct approaches: (1) Descriptive quantitative analysis based on a Likert scale to measure changes in respondents' understanding and satisfaction; (2) Spearman's Rank Correlation to identify the association between pre-test and post-test rankings; and (3) SWOT analysis (IFAS-EFAS) followed by the Analytic Hierarchy Process (AHP) to formulate and prioritize development strategies. The AHP Consistency Ratio (CR) value was utilized as the validity threshold (≤ 10%).

In the Likert-scale analysis, 37 questions, divided into 4 variable categories, were administered to 13 respondents from the PKK group. The instrument was distributed as a questionnaire via Google Forms. The questionnaire was completed twice: at the baseline of the study (Pre-test) and following the intervention (Post-test). The four question variables are detailed in the table below:

ISSN : 2597-8713 (ONLINE)
ISSN : 2598-5167 (PRINT)
Agricultural Science
AGRICULTURAL SCIENCE
Journal Of Agricultural Science And Agriculture Engineering
Faculty of Agriculture, Merdeka University Surabaya,Indonesia
Available on :
https://agriculturalscience.unmerbaya.ac.id/index.php/agriscience/index

Table 1. Question Variables for Likert Scale Assessment

No	Variable
1	Level of understanding among PKK women regarding aquaponics, as well as access to and ease of implementation.
2	Quality of aquaponics program implementation, stakeholder roles, and program support.
3	Participation and involvement of PKK women, sustainability, and development interest.
4	The benefits of the aquaponics program, alongside its social and environmental impacts.

According to Sugiyono (2018), the score interpretation interval is determined by percentage ranges as the basis for categorization. The evaluation scores are converted to a scale from 0% to 100%, with 100 representing the maximum. The classification categories for the Likert Scale can be seen in the table below

Table 2. Likert Scale Categories

Scale	Category
1	Strongly Disagree
2	Disagree
3	Moderately Agree
4	Agree
5	Strongly Agree

Source: Sugiyono (2018)

Anggraini et al. (2025) note that a Score Criteria analysis is required to determine the percentage improvement in the respondents' understanding during the study. This method is designed to ensure program objectives are met while providing a measurable overview of members' comprehension throughout the research. To evaluate the achievements obtained, the score interpretation intervals are presented in the following table:

Table 3. Score Interval Interpretation Table

Score Interpretation Interval	Description
Angka 0% – 19,99%	Very Dissatisfied / Strongly Disagree / Very Low
Angka 20% – 39,99%	Dissatisfied / Disagree / Low
Angka 40% – 59,99%	Moderately Satisfied / Agree / Moderate
Angka 60% – 79,99%	Satisfied / Agree / High
Angka 80% – 100%	Very Satisfied / Strongly Agree / Very High

ISSN : 2597-8713 (ONLINE)
ISSN : 2598-5167 (PRINT)
Agricultural Science
AGRICULTURAL SCIENCE
Journal Of Agricultural Science And Agriculture Engineering
Faculty of Agriculture, Merdeka University Surabaya,Indonesia
Available on :
https://agriculturalscience.unmerbaya.ac.id/index.php/agriscience/index

Subsequently, data analysis was conducted using SWOT (Strengths, Weaknesses, Opportunities, Threats) and the Analytical Hierarchy Process (AHP). These two methods were integrated to identify strategic factors and prioritize the aquaponics development strategies based on the empowerment of the PKK women's group.

The first stage involved SWOT analysis. Data were collected using a five-tier Likert-scale questionnaire distributed to respondents. The respondents' answers were then normalized to obtain the weight of each strategic factor, and the mean scores were used to determine the ratings of internal and external factors. Next, the Internal Factor Analysis Summary (IFAS) and External Factor Analysis Summary (EFAS) matrices were constructed to plot the organization's position on the SWOT Cartesian diagram and to formulate alternative SO, WO, ST, and WT strategies.

The second stage used the Analytical Hierarchy Process (AHP) to prioritize the strategies identified in the SWOT analysis. The AHP respondents were identical to those in the SWOT analysis, specifically the women of the PKK Group who possessed direct experience and involvement in the aquaponics development activities. They were considered to thoroughly understand the internal and external conditions, as well as the program's development needs. At this stage, respondents were asked to provide evaluations through pairwise comparisons using Saaty's fundamental scale (1–9) against the alternative strategies formulated from the SWOT analysis. Utilizing the same respondents aimed to maintain perceptual consistency between the identification of strategic factors and the strategy prioritization process.

The pairwise comparison matrix was subsequently analyzed to obtain the eigenvector values as the priority weights for each alternative strategy. The consistency of the assessments was evaluated using the Consistency Index (CI) and Consistency Ratio (CR). The matrix was declared consistent if the CR value was ≤ 0.10, thereby confirming that the resulting strategy priorities could serve as a valid foundation for drafting aquaponics development recommendations.

3. RESULTS AND DISCUSSION

Respondent Characteristics

A total of 13 members of the Dasawisma Melati group were fully involved in this study. The age of the respondents ranged from 30 to 60 years (classified as productive age according to the ILO), with the majority aged 40–49 years (76.92%), followed by ages 30–39 years (15.38%), and ages 50–60 years (7.69%). The educational background was dominated by high school graduates (46.15%), followed by junior high school (23.08%), while elementary school and

ISSN : 2597-8713 (ONLINE)
ISSN : 2598-5167 (PRINT)
Agricultural Science
AGRICULTURAL SCIENCE
Journal Of Agricultural Science And Agriculture Engineering
Faculty of Agriculture, Merdeka University Surabaya,Indonesia
Available on :
https://agriculturalscience.unmerbaya.ac.id/index.php/agriscience/index

bachelor's degrees (*S1*) each accounted for 7.69%. The group members were predominantly housewives (84.62%) and civil servants (*PNS*) (15.38%). This profile indicates that the group possesses sufficient cognitive maturity to absorb new technologies, although time constraints arising from their dual roles as housewives present a distinct challenge.

Aquaponics Cultivation Performance

Biomass Growth and Survival Rate (SR) of Catfish

The catfish exhibited progressive biomass growth throughout the 8-week rearing period (Table 4). Biomass increased from 37 grams (Week 1) to 667 grams (Week 8), representing a total growth of 1,703%. The most substantial surge occurred between weeks 4 and 5 (+85%), indicating the end of the adaptation phase and the entry of the fish into an active, exponential growth phase. The SGR value of 4.82%/day falls within the optimal range for African catfish (3–6%/day), reflecting that feed management with a 6% FR and temperature conditions of 30–31 °C effectively supported metabolism (Opio et al., 2021).

Table 4. Weekly Biomass Growth of Catfish and Daily Feed Allocation (FR 6%)

Week	Biomassa (gram)	Feed/day @6% (grams)	Feed/week (grams)
1	37	2,2	15,4
2	66	4,0	27,7
3	100	6,0	42,0
4	142	8,5	59,6
5	263	15,8	110,5
6	411	24,7	172,6
7	506	30,4	212,5
8	667	40,0	280,1
Total	-	131,6	920,4

The survival rate (SR) of the catfish reached 83.71% (293 out of 350 fish). This value is considered good and is comparable to SR levels reported in biofloc catfish cultivation as well as semi-intensive aquaponics systems (82.40%–85.33%) (Ginting et al., 2022). The primary factor behind the mortality of 57 fish (16.29%) was presumed to be adaptation stress during the initial week of stocking, which is common in newly established aquaponics systems, alongside the gradual accumulation of ammonia. Nevertheless, the stability of the pH at 7 and the temperature at 30–31 °C throughout the study successfully minimized the risk of mass mortality.

ISSN : 2597-8713 (ONLINE)
ISSN : 2598-5167 (PRINT)
Agricultural Science
AGRICULTURAL SCIENCE
Journal Of Agricultural Science And Agriculture Engineering
Faculty of Agriculture, Merdeka University Surabaya,Indonesia
Available on :
https://agriculturalscience.unmerbaya.ac.id/index.php/agriscience/index

Lettuce Plant Growth

The lettuce plants (*Lactuca sativa*) demonstrated significant height growth, increasing from 2 cm to 17–23 cm (an average absolute increase of ±18 cm), with an average harvest weight of 156.3 grams per plant. The variation in final height (17–23 cm) is a common phenomenon in aquaponics systems, influenced by the distribution of nutrient flow and the positioning of the plants along the hydroponic PVC pipe channels. The primary nutrient source was nitrate derived from the nitrification of fish waste, proving the symbiotic link between increased fish biomass and nutrient availability for the plants (Goddek et al., 2020). These growth outcomes are consistent with the findings of Darmawan et al. (2020), who reported lettuce heights in catfish-integrated aquaponics systems ranging between 14 and 26 cm.

Aquaponics System Water Quality

The water quality parameters in this study were analyzed based on laboratory test results from water samples collected at each observation stage (only one water sample was tested in the laboratory per observation interval, meaning there were no independent replications). Consequently, the data presented are descriptive to characterize water quality trends during the application of the aquaponics system; thus, inferential statistical tests, such as the paired t-test or Wilcoxon test, were not performed. The interpretation of the results focuses on value changes for each parameter, their adherence to the recommended water quality ranges for fish cultivation and plant growth within aquaponics, and comparisons with prior research.

This descriptive approach provides relevant information on the performance of the aquaponics system, as the primary objective of measuring water quality was to evaluate the state of the cultivation media, the effectiveness of the circulation process, and the utilization of fish metabolic waste by the plants. The observed decrease in ammonia concentrations and changes in nitrate concentrations indicate that nitrogen transformation processes occurred within the system, allowing nitrogenous waste from fish farming to be utilized as a nutrient source for the plants. Furthermore, the physical and chemical parameters of the water remaining within the optimum range demonstrate that the system was capable of maintaining a cultivation environment that simultaneously supports both fish and plant growth.

Hence, the discussion of water quality in this study is not intended to test significant differences between pre- and post-treatment conditions statistically, but rather to evaluate trends in water quality changes based on laboratory analysis and to assess their compliance with water quality standards and relevant scientific literature.

ISSN : 2597-8713 (ONLINE)
ISSN : 2598-5167 (PRINT)
Agricultural Science
AGRICULTURAL SCIENCE
Journal Of Agricultural Science And Agriculture Engineering
Faculty of Agriculture, Merdeka University Surabaya,Indonesia
Available on :
https://agriculturalscience.unmerbaya.ac.id/index.php/agriscience/index

The water quality parameters recorded during the study are presented in Table 5. The temperature remained stable at 30–31 °C, aligning with the tolerance limits of tropical catfish and the activity requirements of nitrifying bacteria. The consistent pH value of 7 represents an optimal compromise point balancing the needs of the fish, bacteria, and plants (Wang et al., 2023). The TDS value rose from 253 ppm to 484 ppm, reflecting a progressive accumulation of nutrients alongside the expansion of fish biomass.

Table 5. Weekly Water Quality of the Aquaponics System

Week	Temp (°C)	pH	TDS (ppm)	EC (µs/cm)	ORP (mV)	Salt (ppt)
1	31	7	253	516	195	0,02
2	30	7	264	532	137	0,02
3	30	7	342	685	40	0,02
4	30	7	340	673	55	0,03
5	31	7	359	655	58	0,02
6	30	7	384	664	40	0,02
7	30	7	419	800	27	0,02
8	31	7	484	966	-17	0,04

Measurements of ammonia, nitrite, and nitrate were taken at the baseline and the conclusion of the rearing period, and subsequently analyzed at the Laboratory of the Palu City Environmental Department. The results are presented in the table below:

Table 6. Nitrogen Compound Dynamics in the Aquaponics System

Parameter (mg/L)	Before	After
Ammonia (NH_3)	2,3	8,2
Nitrite (NO_2)	0,147	0,08
Nitrate (NO_3)	1,979	1,864

Table 6 displays a substantial increase in ammonia: from 2.3 mg/L at the baseline to 8.2 mg/L at the conclusion of the study, while nitrite dropped from 0.147 mg/L to 0.08 mg/L, and nitrate remained relatively stable, shifting from 1.979 mg/L to 1.864 mg/L. This pattern indicates that nitrifying bacteria (*Nitrosomonas*) were actively converting ammonia into nitrite. However, the process was incomplete in the later stages, where the conversion of nitrite to nitrate by *Nitrobacter* was not yet optimal. The ammonia toxicity threshold of 8.2 mg/L for catfish should be avoided by optimizing the plant-to-fish ratio in subsequent cultivation cycles.

The measured free ammonia concentration (NH_3The concentration of 8.2 mg/L is considerably higher than the ranges generally recommended for catfish farming and aquaponics

ISSN : 2597-8713 (ONLINE)
ISSN : 2598-5167 (PRINT)
Agricultural Science
AGRICULTURAL SCIENCE
Journal Of Agricultural Science And Agriculture Engineering
Faculty of Agriculture, Merdeka University Surabaya,Indonesia
Available on :
https://agriculturalscience.unmerbaya.ac.id/index.php/agriscience/index

systems. NH_3 It is the most toxic form of nitrogen for fish because it can readily diffuse across the gills, disrupt acid-base balance, lower respiratory efficiency, and induce physiological stress. Research on *Clarias gariepinus* indicates that. NH_3 Concentrations in the rearing medium should be maintained below thresholds that impair growth and feed consumption, as elevated. NH_3 levels increase the risk of physiological dysfunction and mortality (Schram et al., 2010).

Nevertheless, this study achieved a fish survival rate of 83.71%. The discrepancy between the high NH_3 concentration and the high survival rate point to the need to re-verify the laboratory results, specifically concerning the exact parameter reported (NH_3, NH_3-N, or Total Ammonia Nitrogen/TAN), the analytical methods used, and the reporting units. This verification is crucial because errors in identifying parameters or units can lead to vastly different interpretations of ammonia toxicity levels.

Understanding and Involvement Levels of PKK Women

The results of the Likert scale analysis demonstrated a consistent and significant increase across all variables from the pre-test to the post-test, as detailed in Table 7. The variable tracking aquaponics understanding and ease of implementation experienced the most prominent surge, rising from 54.02% at baseline (moderate category) to 85.13% (very high category) by the end of the study. This proves that hands-on, practice-based mentoring is highly effective. All variables shifted from moderate/high categories into the very high category, reflecting a comprehensive transformation of the group's perceptions and capacities.

Table 7. Results of Likert Scale Analysis: Pre-test vs. Post-test

Variable	Pre-test (%)	Category	Post-test (%)	Category
Understanding and ease of implementation	54,02	Moderate	85,13	Very High
Program quality and stakeholder roles	64,62	High	87,54	Very High
Participation and development interest	66,92	High	87,69	Very High
Benefits and socio-environmental impacts	58,97	Moderate	89,40	Very High

Public Satisfaction Level

The Public Satisfaction Survey (SKM) was conducted to evaluate the effectiveness and quality of the mentoring provided during the aquaponics activities, drawing directly from the perceptions of the PKK women as beneficiaries. Ismiyati (2023) explains that the SKM serves as an instrument for evaluation, accountability, and a foundation for program improvement and sustainability. Consequently, measuring satisfaction not only outlines the program's success rate but also forms the basis for formulating recommendations for community-empowerment-based

ISSN : 2597-8713 (ONLINE)
ISSN : 2598-5167 (PRINT)
Agricultural Science
AGRICULTURAL SCIENCE
Journal Of Agricultural Science And Agriculture Engineering
Faculty of Agriculture, Merdeka University Surabaya,Indonesia
Available on :
https://agriculturalscience.unmerbaya.ac.id/index.php/agriscience/index

aquaponics initiatives. The scoring breakdown for the Public Satisfaction Survey is presented in the table below:

Table 8. Public Satisfaction Scoring among Respondents regarding Aquaponics Implementation

Question Code	**Respondent Score**														
	1	2	3	4	5	6	7	8	9	10	11	12	13	Total	Max
P1	5	5	4	5	5	5	4	5	5	4	4	4	4	59	65
P2	5	5	4	5	5	5	4	5	4	4	4	4	4	58	65
P3	5	5	4	5	4	5	4	4	4	5	5	4	4	58	65
P4	5	5	4	5	5	5	4	5	4	4	4	4	4	58	65
P5	5	5	4	5	4	4	4	4	4	5	5	4	4	57	65
P6	5	5	4	5	4	5	5	4	4	4	4	4	4	57	65
P7	5	5	4	5	5	5	4	5	5	5	5	4	4	61	65
P8	5	5	4	5	5	5	5	5	5	4	4	4	4	60	65
P9	5	4	4	5	4	5	4	4	5	4	4	4	4	56	65
P10	5	5	4	5	4	5	5	5	5	5	5	4	4	61	65
TOTAL	45	44	36	45	40	44	39	41	40	40	40	36	36	526	585
SKM Score Interpretation:	Total max score/ Y x 100% = (526 / 585) x 100 % = **89,91%** Average Element Value / Number of Elements x 25 = 40,5 / 10 x 25 = **101,25**														

With an index value of 101.25 (satisfied category), the SKM score reached 89.91%, demonstrating that the respondents not only acquired new knowledge but also felt tangible benefits from the implemented program for themselves and others.

Strategic Development Formulation Analysis

SWOT analysis was applied as a strategic tool to identify internal strengths and weaknesses, alongside external opportunities and threats affecting the development of the aquaponics system by the Dasawisma Melati PKK Group in Palu City, thereby addressing the third research objective. These strategic factors were compiled through observations, interviews, and questionnaires, forming the basis for formulating realistic, contextual aquaponics development strategies tailored to the target group's capacity. The variables for each factor are presented in the tables below:

Table 9. Strength Variables (S)

No	Variable
1	High motivation and interest
2	Strong institutional support from the PKK
3	Awareness of aquaponics benefits
4	Availability of a greenhouse as a shared facility

ISSN : 2597-8713 (ONLINE)
ISSN : 2598-5167 (PRINT)
Agricultural Science
AGRICULTURAL SCIENCE
Journal Of Agricultural Science And Agriculture Engineering
Faculty of Agriculture, Merdeka University Surabaya,Indonesia
Available on :
https://agriculturalscience.unmerbaya.ac.id/index.php/agriscience/index

Table 10. Weakness Variables (W)

No	Variable
1	Low technical knowledge and skills
2	Uneven participation among members
3	Limited facilities and initial internal capital within the group
4	Limited time availability of members
5	Unorganized bookkeeping system (inventory and finance)
6	Presence of social jealousy among group members

Table 11. Opportunity Variables (O)

No	Variable
1	Support from the government and external agencies
2	Open local market opportunities
3	Increasing public interest in healthy and organic food
4	Potential for urban agricultural edutourism within the greenhouse

Table 12. Threat Variables (T)

No	Variable
1	Extreme weather conditions in Palu City
2	Rising food and seed prices are difficult to afford
3	Unsustainable technical assistance
4	Minimal interest from the younger generation in aquaponics
5	Low security checks and high safety risks for the aquaponics facilities and greenhouse
6	Competition from other agricultural businesses

Determination of IFAS and EFAS Values

The IFAS (Internal Factor Analysis Summary) and EFAS (External Factor Analysis Summary) values are quantitative analytical tools within the SWOT method used to systematically evaluate strategic factors, enabling a more objective and measurable strategy formulation process. According to Natalya et al. (2024), IFAS is employed to identify and assess internal factors encompassing strengths and weaknesses, while EFAS analyzes external opportunities and threats stemming from the environment outside the organization.

In this study, the IFAS analysis assessed the PKK women's group's internal capacity to develop aquaponics. In contrast, the EFAS analysis assessed external factors, including policy support, market conditions, and socio-economic factors that could support or hinder the program. The resulting IFAS and EFAS values determined the group's strategic position and shaped the

ISSN : 2597-8713 (ONLINE)
ISSN : 2598-5167 (PRINT)
Agricultural Science
AGRICULTURAL SCIENCE
Journal Of Agricultural Science And Agriculture Engineering
Faculty of Agriculture, Merdeka University Surabaya,Indonesia
Available on :
https://agriculturalscience.unmerbaya.ac.id/index.php/agriscience/index

aquaponics development strategies. The detailed calculations for the IFAS and EFAS matrices are summarized in the tables below.

Table 13. IFAS Matrix

Factor		Rating (mean)	Weight	Score
S1	High motivation and interest	4,538	0,156915	0,71215
S2	Strong institutional support from the PKK	5,000	0,172872	0,86436
S3	Awareness of aquaponics benefits	5,000	0,172872	0,86436
S4	Availability of a greenhouse as a shared facility	5,000	0,172872	0,86436
W1	Low technical knowledge and skills	1,000	0,034574	0,03457
W2	Uneven participation among members	2,000	0,069149	0,1383
W3	Limited facilities and initial internal capital	1,000	0,034574	0,03457
W4	Limited time availability of members	1,000	0,034574	0,03457
W5	Unorganized bookkeeping system	2,000	0,069149	0,1383
W6	Presence of social jealousy among members	2,385	0,082447	0,1966
Total		**28,923077**	**1**	**3,88216**

Table 14. EFAS Matrix

Factor		Rating (mean)	Weight	Score
O1	Support from the government and external agencies	5,000	0,146396	0,731982
O2	Open local market opportunities	5,000	0,146396	0,731982
O3	Increasing public interest in healthy/organic food	4,000	0,117117	0,468468
O4	Potential for urban agricultural edutourism	5,000	0,146396	0,731982
T1	Extreme weather conditions in Palu City	1,462	0,042793	0,062543
T2	Rising food and seed prices	1,769	0,051802	0,091649
T3	Unsustainable technical assistance	2,154	0,063063	0,135828
T4	Minimal interest from the younger generation	2,000	0,058559	0,117117
T5	Low security checks and high safety risks	4,000	0,117117	0,468468
T6	Competition from other agricultural businesses	3,769	0,11036	0,415974
Total		**34,15385**	**1**	**3,955994**

ISSN : 2597-8713 (ONLINE)
ISSN : 2598-5167 (PRINT)
Agricultural Science
AGRICULTURAL SCIENCE
Journal Of Agricultural Science And Agriculture Engineering
Faculty of Agriculture, Merdeka University Surabaya,Indonesia
Available on :
https://agriculturalscience.unmerbaya.ac.id/index.php/agriscience/index

Based on the calculation results of the IFAS and EFAS values, conclusions regarding the strategic direction can be mapped onto a Cartesian SWOT Diagram (Graph 1).

Chart

1. Cartesian SWOT Diagram

SWOT Matrix

The IFAS and EFAS analyses revealed that the Dasawisma Melati PKK Group achieved an IFAS score of 3.8 and an EFAS score of 3.9, positioning the group squarely within Quadrant I of the Cartesian SWOT diagram. This quadrant designates a highly advantageous state, indicating that the group is supported by strong internal strengths and substantial external opportunities to scale up the aquaponics system.

The core strengths include high member motivation, solid PKK institutional backing, deep awareness of aquaponics benefits, and the presence of a greenhouse for production and learning. Meanwhile, primary opportunities stem from government and partner institutional aid, expanding demand for healthy foods, and the potential to build aquaponics-based edutourism. On the other hand, certain weaknesses require attention, including uneven technical skills, capital limitations, sub-optimal group administration, and potential social friction among members. The group also faces threats such as commercial competition, erratic technical mentoring continuity, facility security vulnerabilities, and low youth interest. Given these conditions, the most appropriate direction is an SO (Strengths–Opportunities) Strategy or an aggressive strategy. This involves optimizing internal strengths to leverage external opportunities via group capacity building,

ISSN : 2597-8713 (ONLINE)
ISSN : 2598-5167 (PRINT)
Agricultural Science
AGRICULTURAL SCIENCE
Journal Of Agricultural Science And Agriculture Engineering
Faculty of Agriculture, Merdeka University Surabaya,Indonesia
Available on :
https://agriculturalscience.unmerbaya.ac.id/index.php/agriscience/index

expanding partnerships, developing healthy-food and edutourism ventures, and strengthening institutional ties to cement program sustainability and establish the group as a model for women's empowerment in Palu City. The strategic formulation is outlined in the matrix table below:

Table 15. SWOT Matrix Table

	Opportunities (O)	*Threats* (T)
Strength (S)	**SO Strategy**	**ST Strategy**
1	Leverage government and stakeholder support to expand PKK-based aquaponics programs.	Harness the PKK's institutional strength to maintain program continuity when external mentoring decreases.
2	Develop the greenhouse as a hub for aquaponics training and edutourism in Palu City.	Enhance product quality and differentiation to counter competition from other agricultural ventures.
3	Utilize high member motivation to capture market demand for healthy fish and vegetables.	Optimize greenhouse structures to cushion the impacts of extreme weather.
4	Build group enterprises anchored on organic products and healthy foods.	Deploy organizational solidarity to safeguard group facilities and assets.
Weaknesses (W)	**WO Strategy**	**WT Strategy**
1	Elevate members' technical skills through sustained training and mentoring.	Draft cultivation SOPs and group management guidelines to reduce external dependence.
2	Tap into government initiatives to secure capital grants and production inputs.	Revamp administrative and financial accounting systems to bolster business readiness.
3	Foster partnerships with universities and technical agencies to build group capacity.	Enhance group cohesion to neutralize internal conflicts and social jealousy.
4	Capitalize on the edutourism potential as an additional revenue stream for the group.	Drive member regeneration by involving the younger generation in aquaponics operations.

Formulation and Prioritization of Development Strategies

Following the derivation of primary strategies via SWOT analysis, the next step was to establish a clear hierarchy of priorities using the Analytic Hierarchy Process (AHP). Developed by Thomas L. Saaty, AHP is a multi-criteria decision-making method that structures problems hierarchically and executes pairwise comparisons to generate priority weights for each alternative. This method effectively translates qualitative judgements into quantitative values, yielding rational, consistent, and scientifically sound decisions (Zhao et al., 2020). In this study, calculations were processed through an online AHP calculator (AHP Google Tools) to analyze the pairwise comparison matrices between strategies. The AHP method was applied to determine the priority

ISSN : 2597-8713 (ONLINE)
ISSN : 2598-5167 (PRINT)
Agricultural Science
AGRICULTURAL SCIENCE
Journal Of Agricultural Science And Agriculture Engineering
Faculty of Agriculture, Merdeka University Surabaya,Indonesia
Available on :
https://agriculturalscience.unmerbaya.ac.id/index.php/agriscience/index

aquaponics development strategies by integrating technical, social, institutional, and economic aspects.

Figure 1. Determination of Priority Criteria in AHP

Figure 2. Pairwise Comparison

The pairwise comparisons in this study yielded a Consistency Ratio (CR) of 1.9%. The CR is a quantitative measure derived from the ratio of the Consistency Index (CI) to the Random Index (RI), used to assess logical consistency in pairwise evaluations (CR < 0.10). The level of consistency is considered acceptable, and the derived priority weights are validated; conversely, a CR > 0.10 points to inconsistencies requiring revision. With a CR of 1.9% falling well below this threshold, all priority weights generated in this study are confirmed as valid and scientifically reliable.

Vol. 10 No. 1September 2026
ISSN : 2597-8713 (ONLINE)
ISSN : 2598-5167 (PRINT)
Agricultural Science
AGRICULTURAL SCIENCE
Journal Of Agricultural Science And Agriculture Engineering
Faculty of Agriculture, Merdeka University Surabaya,Indonesia
Available on :
https://agriculturalscience.unmerbaya.ac.id/index.php/agriscience/index

AHP Resulting Priorities

The calculation results provided priority weights for the four alternative aquaponics development strategies based on the empowerment of the WWT (*Kelompok Wanita Tani*) and PKK group. Within the AHP framework, priority weights are extracted from the principal eigenvector generated from the pairwise comparison matrix, thereby reflecting the relative importance of each alternative toward the ultimate objective. The panel under *Priorities* lists the four alternative strategies evaluated against each other. These strategies represent the formulation of Strength–Opportunity (SO) strategies from Quadrant I of the SWOT analysis, prioritized to identify the most effective aquaponics development strategy.


Resulting Priorities

Priorities

These are the resulting weights for the criteria based on your pairwise comparisons:

Cat		Priority	Rank	(+)	(-)
1	Memanfaatkan dukungan pemerintah dan stakehol	62.0%	1	12.3%	12.3%
2	Mengembangkan Green House sebagai pusat pelat	15.0%	3	0.7%	0.7%
3	Memanfaatkan tingginya motivasi anggota untuk	15.9%	2	3.7%	3.7%
4	Mengembangkan usaha kelompok berbasis produk	7.1%	4	1.4%	1.4%

Decision Matrix

The resulting weights are based on the principal eigenvector of the decision matrix:

	1	2	3	4
1	1	4.00	5.00	7.00
2	0.25	1	1.00	2.00
3	0.20	1.00	1	3.00
4	0.14	0.50	0.33	1

Figure 3. AHP Priority Results

Based on these weighting results, the strategy with the highest priority value is identified as the most viable alternative to be implemented for aquaponics development led by the Dasawisma Melati PKK Group in Palu City:

Table 16. AHP Priority Results

No	Variabel	Priority (%)	Rank
1	Leveraging government and stakeholder support	62.0%	1
2	Utilizing high member motivation to meet market demands	15.9%	2
3	Developing the greenhouse as a training and edutourism hub	15.0%	3
4	Developing group enterprises based on healthy products	7.1%	4

ISSN : 2597-8713 (ONLINE)
ISSN : 2598-5167 (PRINT)
Agricultural Science
AGRICULTURAL SCIENCE
Journal Of Agricultural Science And Agriculture Engineering
Faculty of Agriculture, Merdeka University Surabaya,Indonesia
Available on :
https://agriculturalscience.unmerbaya.ac.id/index.php/agriscience/index

Correlation Between Constraints and Opportunities Factors in Aquaponics Development Strategy

Correlation analysis in aquaponics development strategies aims to measure the strength and direction of associations between internal variables (human resource capacity, institutional backing, and technological readiness) and external variables (policy support, market potential, and environmental resource availability), rather than establishing causal relationships (Akoglu, 2018). Linking these two dimensions is crucial to understanding strategy synergy, specifically whether the strengthening of internal factors occurs in tandem with the optimization of external opportunities. As emphasized by Wang et al. (2023), integrating both components is an essential element in strategy formulation derived from SWOT and AHP analyses. Therefore, variables were ranked based on their pre-test and post-test scores, as compared in the tables below:

Table 16. Pre-Test Rank (X)

No	Variable	Percentage (%)	Category	Rank
1	Participation, involvement, sustainability, and interest	66,92	High	1
2	Program implementation quality and stakeholder roles	64,62	High	2
3	Program benefits and socio-environmental impacts	58,97	Moderate	3
4	Level of understanding and ease of implementation	54,02	Moderate	4

Table 17. Post-Test Rankings (Y)

No	Variabel	Persentase (%)	Kategori	Rank
1	Program benefits and socio-environmental impacts	89,4	Very High	1
2	Participation, involvement, sustainability, and interest	87,69	Very High	2
3	Program implementation quality and stakeholder roles	87,54	Very High	3
4	Level of understanding and ease of implementation	85,13	Very High	4

ISSN : 2597-8713 (ONLINE)
ISSN : 2598-5167 (PRINT)
Agricultural Science
AGRICULTURAL SCIENCE
Journal Of Agricultural Science And Agriculture Engineering
Faculty of Agriculture, Merdeka University Surabaya,Indonesia
Available on :
https://agriculturalscience.unmerbaya.ac.id/index.php/agriscience/index

With an *R* With a value of 0.40 (denoting a moderate positive relationship), the Spearman's Rank correlation between the pre-test and post-test rankings indicates that the program successfully drove a significant shift in perception without distorting the respondents' original cognitive baseline. This reflects a learning approach that is both progressive and adaptive to the group's baseline capacity.

4. CONCLUSIONS

The findings of this study demonstrate that the aquaponics development strategy based on the empowerment of the Dasawisma Melati PKK Group is highly prospective (IFAS: 3.88; EFAS: 3.96; SWOT Quadrant I), indicating that the group's internal capacity is well positioned to exploit external opportunities optimally. Departing from earlier research that largely focused on technical productivity and efficiency, the core strength highlighted here stems from member motivation, organizational support, and the role of the greenhouse as a learning-production hub. This confirms that social capital is just as critical as technological innovation in community-based aquaponics ventures.

The AHP results (Consistency Ratio of 1.9%, indicating high consistency) reinforce these insights: the highest priority lies in leveraging government and stakeholder support to expand the program, rather than focusing solely on advancing technical parameters. This stands in contrast to other aquaculture AHP studies that routinely prioritize production efficiency above institutional factors.

The transformation in respondents' perceptions (shifting from moderate-high categories to very high in the pre- vs. post-test assessments, with a Spearman's Rank correlation of 0.40) proves that training and mentoring effectively built self-reliance among members without abruptly fracturing their initial priority frameworks. This reflects a gradual and adaptive empowerment process.

In conclusion, ensuring the long-term sustainability of aquaponics programs requires a balanced integration of social, institutional, economic, and technical dimensions, rather than a narrow focus on harvest yields alone. The novelty of this research lies in its systematic framework, which integrates a Likert-scale SWOT analysis with AHP into a single analytical loop. In contrast, previous studies generally deployed these methods in isolation. This integrated approach yields prioritized strategies rooted in group consensus while providing a structured decision-making

ISSN : 2597-8713 (ONLINE)
ISSN : 2598-5167 (PRINT)
Agricultural Science
AGRICULTURAL SCIENCE
Journal Of Agricultural Science And Agriculture Engineering
Faculty of Agriculture, Merdeka University Surabaya,Indonesia
Available on :
https://agriculturalscience.unmerbaya.ac.id/index.php/agriscience/index

framework that can be replicated in other urban agriculture-based community empowerment initiatives.

REFERENCES

Abdoellah, O. S., Suparman, Y., Safitri, K. I., Mubarak, A. Z., Milani, M., & Surya, L. (2023). Food security of urban agricultural households in North Bandung, West Java, Indonesia. Sustainability, 15(24), 16683. https://doi.org/10.3390/su152416683

Akoglu, H. (2018). User's guide to correlation coefficients. Turkish Journal of Emergency Medicine, 18(3), 91–93. https://doi.org/10.1016/j.tjem.2018.08.001

Darmawan, M., Irmawati, & Asmuliani, R. (2020). Growth and production of lettuce (Lactuca sativa) and catfish (Clarias) in an aquaponic system. AGRIUM: Journal of Agricultural Sciences, 22(3), 157–161. https://doi.org/10.30596/agrium.v22i3.4687

Fitrianti, R. (2025). The role of the Family Welfare Movement (PKK) in community-based family economic empowerment. Journal of Social and Development Sciences, 8(2), 112–128.

Ginting, D. K., Julyantoro, P. G. S., & Wijayanti, N. P. P. (2022). Growth rate and survival of African catfish with different stocking densities in a biofloc system. Current Trends in Aquatic Science, 5(1), 40–47.

Goddek, S., Joyce, A., Kotzen, B., & Burnell, G. M. (Eds.). (2020). Aquaponics food production systems: Combined aquaculture and hydroponic production technologies for the future. Springer. https://doi.org/10.1007/978-3-030-15943-6

Hao, Y., Ding, K., Xu, Y., Tang, Y., Liu, D., & Li, G. (2020). Economic viability and environmental sustainability of aquaponic systems: A review. Sustainability, 12(21), 8899.

Ibrahim, A., [other author's name]. (2023). Life cycle assessment and sustainability of aquaponics: A systematic review—Journal of Cleaner Production, 387, 135751.

Ismiyati, T. (2023). Analysis of public satisfaction with public services. Ideguru: Jurnal Karya Ilmiah Guru, 8(3), 460–469. https://doi.org/10.51169/ideguru.v8i3.512

Muralidharan, C., Anantharaman, N., & Deshmukh, S. G. (2003). Confidence-interval approach to the consistency ratio rule in applications of the analytic hierarchy process. West Indian Journal of Engineering, 26(1), 17–28.

Natalya, D. A. K., & Sudarmawan, I. W. E. (2024). Analysis of alternative business strategies based on SWOT analysis. Journal of Tourism and Business, 3(5), 779–788. https://doi.org/10.22334/paris.v3i5

Okomoda, V. T., Oladimeji, S. A., Solomon, S. G., Olufeagba, S. O., Ogah, S. I., & Ikhwanuddin, M. (2023). Aquaponics production system: A review of historical perspective, opportunities,

ISSN : 2597-8713 (ONLINE)
ISSN : 2598-5167 (PRINT)
Agricultural Science
AGRICULTURAL SCIENCE
Journal Of Agricultural Science And Agriculture Engineering
Faculty of Agriculture, Merdeka University Surabaya,Indonesia
Available on :
https://agriculturalscience.unmerbaya.ac.id/index.php/agriscience/index

and challenges of its adoption. Food Science & Nutrition, 11(3), 1157–1165. https://doi.org/10.1002/fsn3.3154

Opio, L. G., Abdelfattah, E. M., Terry, J., Odongo, S., & Okello, E. (2021). Specific growth rate as an indicator of feed efficiency in tropical aquaculture: A review: Aquaculture Reports, 21, 100823.

Panya, L. (2023). The potential of aquaponics in sustainable urban agricultural systems. Agrotechnology, 12, 352. https://doi.org/10.35248/2168-9891.23.12.352

Pattillo, D. A. (2017). An overview of aquaponic systems: Hydroponic components (NCRAC Technical Bulletins Series #005). North Central Regional Aquaculture Center.

Sugiyono. (2018). Quantitative research methods. Alphabet.

Wang, W., Elahi, E., Sun, S., Tong, X., Zhang, Z., & Abro, M. I. (2022). Optimizing temperature and pH in aquaponic systems for leafy greens. Horticulturae, 8(3), 225. https://doi.org/10.3390/horticulturae8030225

Zhao, Y., Wang, L., Li, H., Zhu, Y., Wang, Q., Jiang, S., Zhai, J., & Hu, P. (2020). Evaluation of groundwater overdraft governance measures in Hengshui City, China. Sustainability, 12(9), Article 3564. https://doi.org/10.3390/su12093564