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Design of a Zero-Waste-Based Integrated Farming System for Optimizing Home-Garden Area and Increasing Income at KWT Nur Rejeki in Tassililu Village, Sinjai Regency

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Abstract

The zero-waste-based Integrated Farming System (IFS) model was designed in response to the existing conditions at KWT Nur Rejeki, where activities are still dominated by horticultural cultivation, 35 m² of land remains unused, chicken coops and fishponds are not yet functioning optimally, vegetable production costs are high, and organic waste has not been integrated into productive resource flows. The model aims to optimize the use of home-garden land and increase the income of KWT Nur Rejeki. A research and development approach using mixed methods was applied through observation, interviews, group discussions, document review, descriptive analysis, Material Flow Analysis (MFA), waste-efficiency analysis, R/C Ratio, sales Break-Even Point (BEP), Margin of Safety (MoS), Payback Period (PP), sensitivity analysis, and Likert-scale questionnaires. A census approach with saturated sampling was used. The design integrates horticulture, laying hens, tilapia, and BSF maggot cultivation in a closed-loop system, with the potential to utilize 100% of organic waste by design. The economic analysis indicates that the conservative scenario is feasible, with an R/C Ratio of 2.18, estimated net income of Rp705,000 per month, a BEP of Rp118,644, an MoS of 90.91%, and a PP of 2.26 months. The sensitivity analysis shows that the business remains feasible despite cost increases of up to 117.50%, indicating improved economic feasibility compared with the existing conditions. Questionnaire results also show that members' understanding, acceptance, and readiness are in the very high category, with an average score of 4.58 (91.62%). In conclusion, the zero-waste-based IFS model is feasible for testing through gradual implementation at KWT Nur Rejeki.

Keywords: ***O****rganic Waste Efficiency; Integrated Farming System; KWT Nur Rejeki; Home-Garden Land; Income Increase.*

1. BACKGROUND

Developing a home-based agribusiness requires an efficient and sustainable approach that can increase productivity and support business continuity and growth. Achieving this requires a farming system that uses resources efficiently, integrates business components, and applies sustainability principles. One suitable approach is the zero-waste-based Integrated Farming System (IFS). This model can transform small home-garden areas into productive ecosystems by combining horticultural crops, livestock, and fisheries in a single interconnected cycle. Waste from one component becomes a raw material for another, potentially reducing production costs and increasing system resilience. Strong support for this approach is provided by Silvia et al. (2025), who stated that the Integrated Farming System, as a modern, sustainable, and environmentally friendly agricultural model, optimizes home-garden land, thereby increasing production yields and reducing food expenditures.

The Nur Rejeki Women's Farmers Group, which has actively cultivated organic vegetables and fruits since 2017 and has 35 members, manages a primary home-garden area of 92 m² within a total land area of 127 m². Resources that have not yet been optimized include an additional 35 m² of land and supporting facilities consisting of a chicken coop with a capacity of 10 chickens and a 1 × 1.5 m fishpond that is available but not yet operational. During the intensive mentoring period (2017–2020), the group achieved an average vegetable and fruit production of 5.7 kg per day. At a selling price of IDR 10,000/kg, gross income at that time reached IDR 1,710,000 per month. However, current production has decreased to approximately 5 kg per day, reducing monthly gross income to IDR 1,500,000.

Production costs, however, remain relatively high, reaching Rp1,340,000 per month for polybags, liquid organic fertilizer, manure, and seeds. With net income of only approximately Rp160,000 per month, KWT Nur Rejeki has a narrow profit margin and is vulnerable to economic risks. This condition results from dependence on a single commodity and the absence of integration among commodities that could reduce costs and diversify revenue sources. Without a circular system, organic waste such as horticultural crop residues and livestock manure, which could be used as fertilizer and feed, remains underutilized. In addition, existing facilities such as the additional land, chicken coop, and fishpond are not functioning optimally because an integrated system design has not yet been established.

Based on the literature review, no zero-waste-based IFS model has been identified that is specifically tailored to the resource conditions and needs of women's farmer groups. Most previous studies discuss the general technical aspects of IFS but do not provide in-depth analyses of social impacts, microeconomic feasibility, or implementation strategies relevant to the dynamics of KWT Nur Rejeki. This finding is consistent with Purnomo et al. (2025), who showed that studies integrating zero-waste principles, a gender perspective, and microeconomic analysis remain very limited in the context of women's farmer groups. Therefore, this project focuses on designing a zero-waste integrated home-garden management model that can be implemented by KWT Nur Rejeki to optimize resource utilization, increase income, and support the sustainability of the group's business.

2. METHODOLOGY

2.1 Research Sample

This research was conducted at KWT Nur Rejeki, Kayutanang Environment, Tassililu Village, West Sinjai District, Sinjai Regency, South Sulawesi. The site was selected purposively because of its potential to integrate horticultural production, chicken farming, fisheries, and BSF maggot cultivation in the development of a zero-waste-based IFS. The study was conducted for approximately three months, from the second week of January to the third week of April 2026, covering initial observations, design preparation, activity implementation, data collection, and evaluation. The object of the study was the home-garden-scale agribusiness system of KWT Nur Rejeki, including land use and the integration of agriculture, livestock, and fisheries. The evaluation covered initial conditions, technical feasibility, material flow and utilization, economic feasibility, members' understanding and readiness, and design outputs in the form of a zero-waste-based IFS model, land layout, system-integration flow, managerial guide, and visual-media mock-up.

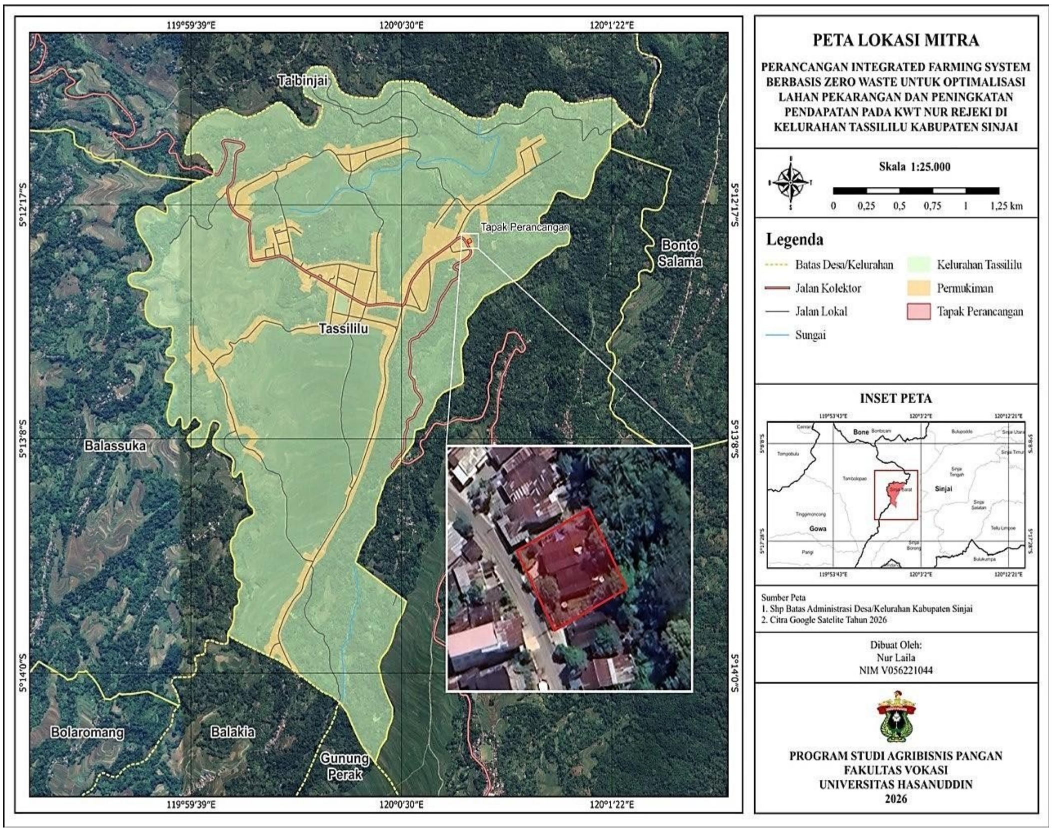

Figure 1. Study location map of KWT Nur Rejeki, Kayutanang Environment, Tassililu Village, West Sinjai District, Sinjai Regency, South Sulawesi

2.2 Method

2.2.1 Data Analysis

A feasibility analysis of the system design was conducted to assess the suitability of the zero-waste-based IFS model for full implementation. The analysis comprehensively addressed technical, economic, and social aspects, including the understanding, acceptance, and readiness of KWT Nur Rejeki members. A technical analysis was conducted to assess the operational feasibility of the zero-waste-based IFS design based on available resources. The assessed aspects included the suitability and availability of land, labor, facilities and infrastructure, and integration among business units. Land suitability was analyzed based on area, layout, accessibility, and space optimization, while labor was assessed based on the number of active members, division of tasks, and workload.

Available facilities and infrastructure included chicken coops, fishponds, planting media, BSF maggot cultivation facilities, and fertilizer-processing facilities. System integration was analyzed based on the continuity of input and output flows among business units using a simple Material Flow Analysis (MFA) approach to determine material utilization and resource efficiency. The material balance was calculated using the formula Ending Stock = Initial Stock + Input − Output, where inputs consist of materials entering the system, outputs consist of production outputs and waste leaving the system, and stock consists of materials remaining in the system. Waste-utilization efficiency was calculated as the ratio of waste diverted from disposal for productive reuse to the total waste generated by the system.

Waste Efficiency (%) = (Waste Utilized / Total Waste Generated) × 100%

Information:

1. Waste utilized: Horticultural harvest residues, kitchen waste, and livestock manure converted into compost, BSF maggot feed, and liquid fertilizer.
2. Total waste generated: The estimated total organic waste from all business units (plants, livestock, and kitchens) within a specified period.

2.2.2 Project Success Indicators

The proposed zero-waste-based IFS model is considered suitable for recommendation to the implementation stage if it meets both qualitative and quantitative indicators. Qualitative indicators include the integration and logical coherence of system flows that demonstrate effective waste utilization; a closed-loop system; the technical and operational suitability of the design for the land conditions, workforce, facilities, and capital of KWT Nur Rejeki; and members' acceptance and readiness, as demonstrated by positive responses and commitment to the design. Quantitative indicators include the utilization of approximately 3–5 kg/day of organic waste with utilization efficiency approaching 100%; economic feasibility, indicated by an R/C Ratio > 1 and the results of income, BEP, Margin of Safety, Payback Period, and sensitivity analyses; and members' understanding, acceptance, and readiness based on a Likert-scale questionnaire, with a minimum score in the high category (3.41–4.20).

3. RESULTS AND DISCUSSION

3.1 Results

3.1.1 Integration Flow Design

This stage focused on establishing reciprocal relationships among business units within an integrated zero-waste system. Crop residues and household organic waste are used for composting and as feed for BSF maggots. BSF maggots are then used as alternative feed for chickens and fish, while frass is used as organic material to improve soil fertility. Chicken manure is processed into compost, while pond wastewater is used as liquid organic fertilizer because it contains residual nutrients and nitrogen. These material flows form an interconnected and recurring cycle in which waste from one unit becomes an input for another. Thus, waste reuse can improve resource efficiency and support the implementation of zero-waste principles, as presented in Figure 2.

Figure 2. Circular flow of the zero-waste Integrated Farming System (IFS)

3.1.2 Land Layout Preparation

Land planning was carried out to accommodate the size and condition of the land managed by KWT Nur Rejeki. The design included determining the locations of the fishpond, chicken coop, plant cultivation areas, BSF maggot cultivation area, and compost-processing area. This arrangement aimed to maximize space efficiency, facilitate workflow, and minimize the distance required to move materials and waste among business units. Work comfort and environmental cleanliness were also key considerations. To clarify the layout, a site plan was prepared to illustrate the positions and integration of units within the zero-waste Integrated Farming System (IFS) model, as shown in Figure 3.

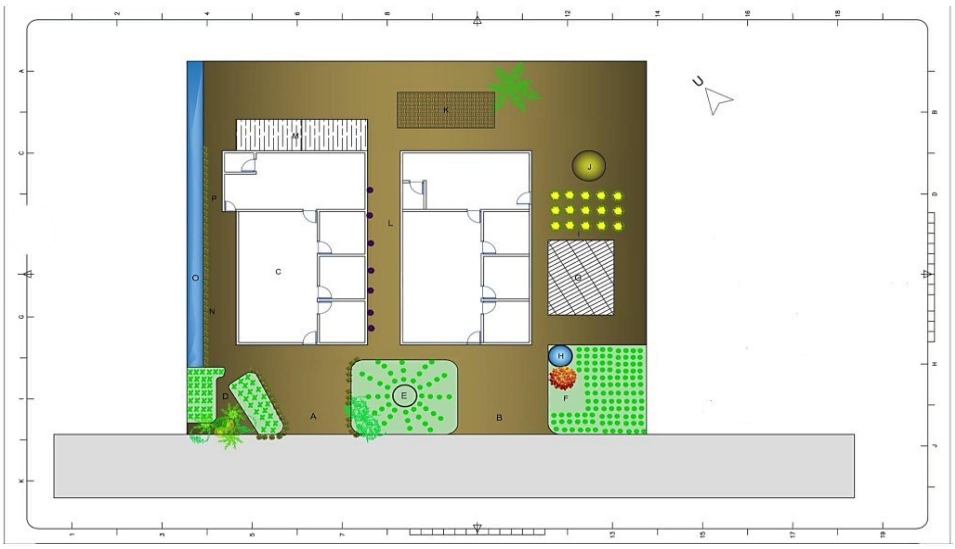

Figure 3. Layout plan of the zero-waste Integrated Farming System (IFS) at KWT Nur Rejeki, scale 1:350

Information:

A. Entry Area

B. Exit Area
C. Nur Rejeki Secretariat Building, 8 × 12 m (96 m²)
O. Drainage
P. Equipment Storage and Production Weighing Area, 3 × 4 m (12 m²)

Agriculture
D. Vegetable Plants (Chayote, Water Spinach, Green Mustard, Spring Onion, and Celery) and Medicinal Plants (Ginger and Binahong), 4 × 5 m (20 m²)
E. Fruit Plants (Dragon Fruit, Tomatoes, and Strawberries), 5 × 5 m (25 m²)
F. Cucumber Plants, 4 × 5 m (20 m²)
G. Greenhouse (Nursery), 4 × 5 m (20 m²)
I. Pumpkin Plants, 3 × 4 m (12 m²)
K. Chili Plants, 5 × 7 m (35 m²) (Unused)
L. Eggplant Plants, 1 × 9 m (9 m²)
N. Refugia Plants (Plant Pest Control)
J. Composting Area (Plant Nutrient Source), 2 × 3 m (6 m²)

Fisheries (Source of Plant Nutrition)
H. Fishpond, 1 × 1.5 m (Unused)

Livestock (Source of Fertilizer and Feed)
M. Chicken Coop and B*SF Maggo*t Cultivation Area, 4 × 5 m (20 m²) (Unused)

Figure 4. Top View

Figure 5. Right-Side View

Figure 6. Left-Side View

Figure 7. Rear View

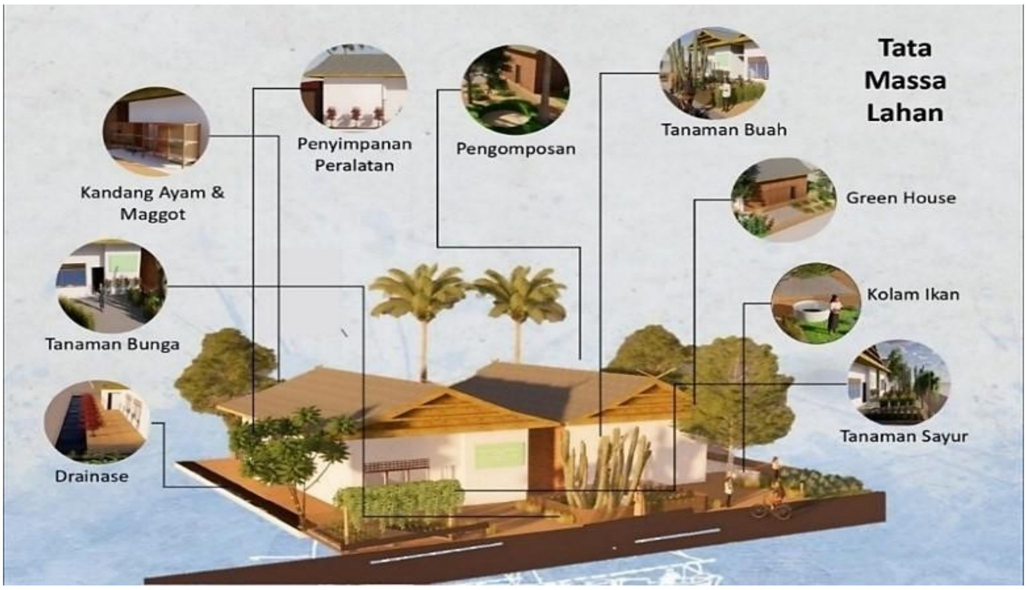

Figure 8. Land-Use Zoning

The land and facilities of KWT Nur Rejeki were functionally arranged to support IFS implementation. The front zone is used for refugia plants as part of pest control, as well as food and medicinal plants, to facilitate monitoring and harvesting. The middle zone focuses on economically valuable crops such as dragon fruit, strawberries, tomatoes, and eggplant, with consideration of lighting requirements, monitoring, and space optimization. The right-side zone serves as an integrated agro-complex area that includes a fishpond, greenhouse, cucumber plants, and composting and pumpkin areas, allowing pond wastewater and compost products to be reused as sources of plant nutrients.

The rear zone is used for chili cultivation and the integration of chicken coops with BSF maggot cultivation. Chicken manure and organic waste are used in the BSF bioconversion process; frass and decomposition residues are used as organic fertilizer, while maggot biomass is used as supplementary feed for chickens and fish. Placing the livestock and maggot units adjacent to each other also supports efficient material distribution and the implementation of sanitation and biosecurity measures. The left-side zone is used for equipment storage, production weighing, and drainage, with flowering plants in polybags serving as both a boundary and a supporting element for environmental management. Overall, the zoning is designed to optimize land use, simplify operations, and strengthen material flows among business units within the zero-waste system.

3.1.3 Development of a Zero-Waste-Based Integrated Farming System (IFS) Model

This visualization and educational medium, a 1:150-scale model of a zero-waste Integrated Farming System (IFS), illustrates the relationships among business units, waste-utilization flows, and the locations of production facilities within the designed land layout. The model is expected to help KWT Nur Rejeki members understand the integration concept more easily and to serve as an effective learning tool before the system is implemented in the field. The model is presented in Figures 9–12.

Figure 9. Front View

Figure 10. Rear View

Figure 11. Right-Side View

Figure 12. Left-Side View

3.1.4 Socialization of the Zero Waste-Based Integrated Farming System (IFS) Model Design

Socialization of the zero-waste-based Integrated Farming System (IFS) model design at KWT Nur Rejeki was conducted to comprehensively introduce the concept, system flow, and management mechanisms of each integrated business unit. The activity was held on April 17, 2026, from 1:30 PM to 3:30 PM WITA at the KWT Nur Rejeki Secretariat. The material was delivered through educational videos, a system-model mock-up, and a managerial guidebook that had been prepared to help members understand the design more clearly and systematically.

Educational videos were used to explain the basic concepts of the zero-waste-based Integrated Farming System (IFS) and the interrelationships among business units, while the mock-up helped members visualize the layout and integration flow of the designed system. The managerial guidebook served as a technical guide for operational management, role allocation, and the steps required to implement the system model. In addition, demonstrations of the tools and materials used for BSF maggot cultivation were conducted to reduce the psychological distance associated with adopting new technology, drawing on one month of experience by female students in processing organic waste using BSF maggots. After the socialization materials were presented, members of KWT Nur Rejeki were invited to ask questions and were then asked to complete a questionnaire. The questionnaire served as an evaluation instrument to assess their understanding, acceptance, and readiness for the system-model design before implementation. This process provided a more objective picture of the social and participatory feasibility of the proposed model.

3.2 Discussion

3.2.1 Technical Feasibility Analysis and Material Flow Analysis (MFA)

A technical feasibility analysis was conducted to assess the suitability of the design for the resources, technology, and capacities of KWT Nur Rejeki members. The assessment focused on technological suitability, availability of physical assets, member capabilities, operational risks, and the coherence of material flows within the system. A synthesis of the technical feasibility of the zero-waste Integrated Farming System (IFS) model is presented in Table 1.

Table 1. Technical Feasibility Synthesis of the Zer*o-Waste-Based Integrated F*arming System (*IFS) Model*

Technical Aspects	Condition of KWT Nur Rejeki	Assessment and Mitigation
Member capacity	Members are accustomed to cultivating horticultural crops, but not all of them are accustomed to cultivating BSF maggots, chicken and fish farming, or maintaining business records.	Feasible, provided that hands-on training is conducted. SOPs should be concise, illustrated, and divided into daily/weekly tasks.

Technical Aspects	Condition of KWT Nur Rejeki	Assessment and Mitigation
Physical assets	Land, pens, ponds, and a greenhouse are available.	This is highly supportive because the design uses existing assets and requires only limited facility improvements.
Technical Aspects	Condition of KWT Nur Rejeki	Assessment and Mitigation
Waste processing technology	Simple composting is already understood, but BSF maggot cultivation is a new skill.	It is feasible because the technology is low-tech, but initial assistance is needed for humidity control, feed type, and BSF maggot harvesting.
Fisheries management	The pond is only approximately 1 × 1.5 m, so production capacity is limited.	Stocking densities and harvest targets should be conservative. High targets are only feasible if aeration, water quality control, and consistent feed management are provided.
Operational consistency	Group activities depend on the active participation of members and the division of tasks.	The main risks are irregular waste sorting, feeding, and record-keeping. Mitigation is a duty schedule. notebooks, and monthly evaluations.

Source: Primary data after processing, 2026

Based on Table 1, the zero-waste IFS model is technically feasible because the technology is relatively simple and raw materials are available. The new skills required include BSF maggot cultivation, chicken and fish management, and record-keeping. Therefore, the model's technical feasibility is strongly influenced by the quality of initial training and the consistency of task allocation.

In addition, Material Flow Analysis (MFA) was used to examine material flows within the design and ensure a logical balance. Because the system has not yet been fully implemented, the MFA at this stage represents a design projection. The basic formula used is total input = total output + change in stock. In the monthly design, changes in stock are assumed to be small or are recorded as compost-material reserves.

Table 2. Material Flow Analysis of the Zero-Waste-Based Integrated Farming System (IFS)

Flow Components	Quantity Estimation	Direction of Utilization	Analytical Notes
Horticultural plant waste and household organic waste	±150 kg/month	±90 kg for BSF maggot cultivation; ±60 kg for compost.	It is necessary to sort organic waste so that it is not mixed with plastic and oil. excessive, or strong-smelling materials.
Wet chicken droppings	±30 kg/month	Enter the composting process	Direct application is not recommended

Table 3. Estimated Material Flows and Utilization Pathways in the Zero-Waste-Based Integrated Farming System (IFS)

Flow Components	**Quantity Estimation**	**Direction of Utilization**	**Analytical Notes**
		with carbon materials such as husks or dry leaves.	directly on the plants because it requires a decomposition process to be safer.
Total organic input	±180 kg/month	All inputs have a processing path.	Design utilization efficiency can approach 100%, but actual achievement must be demonstrated. through recording.
Maggot BSF	±9-18 kg/month from 90 kg of BSF maggot feed ingredients	As additional feed for chickens and fish, and some is set aside to maintain the production cycle.	A range of 10–20% is used as a conservative estimate. Economic calculations use a minimum of 9 kg/month to avoid overly optimistic assumptions.
Frass and compost	±70-100 kg/month	As a fertilizer for 127 m² of land; excess can be stored or tested as a by-product.	The need for active fertilizer is around 20 kg/month so there is reserve space, but the quality of the compost must be tested.
Nutrient-rich pool water	Not yet weighed	Can be used in limited quantities for irrigation, subject to odor and water-quality considerations.	Not yet counted as economic income because it requires further observation carry on.

Source: Primary data after processing, 2026

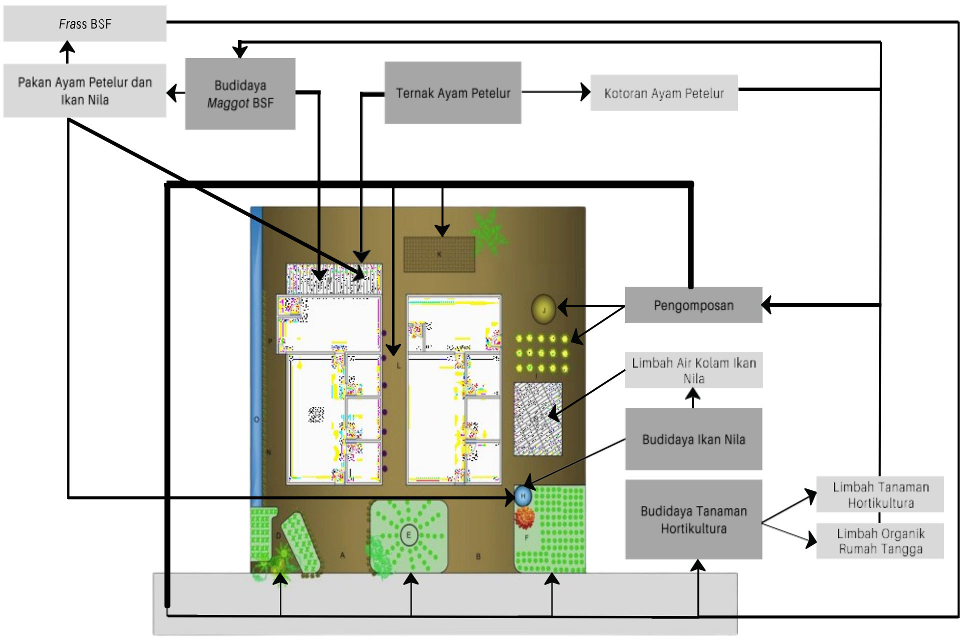

Figure 13. Material Flow Design o*f the Zero-Waste-Based Inte*grated Farming S*ystem (IFS)*

The MFA results in Table 2 and Figure 13 show that the zero-waste Integrated Farming System (IFS) model provides a utilization pathway for all major organic waste streams. This means that the zero-waste principle can be operationalized through waste sorting, BSF maggot cultivation, and composting. Waste-utilization efficiency is calculated by comparing the amount of waste diverted from disposal to productive use with the total organic waste generated in the system. A total of 180 kg of organic waste per month, consisting of 150 kg of horticultural and kitchen waste from KWT Nur Rejeki members and 30 kg of wet chicken manure, is allocated to BSF maggot cultivation (90 kg), composting of horticultural and kitchen waste (60 kg), and composting of wet chicken manure (30 kg). Thus, waste-utilization efficiency in the system is calculated at 100% because all 180 kg of organic waste generated is utilized as designed.

This 100% value indicates that all primary organic waste, including members' horticultural and kitchen waste and chicken manure, has been allocated to productive uses such as BSF maggot cultivation, composting, and organic fertilizer production. Therefore, the Integrated Farming System (IFS) model has the potential to implement the zero-waste principle by design, as no primary organic waste is allocated for disposal. However, the 100% value represents a potential or design target rather than an actual field achievement. The realization of waste-utilization efficiency depends greatly on consistent organic-waste sorting, successful BSF maggot cultivation, composting quality, and regular recording of waste flows. Therefore, the term "zero waste" in this system design is more accurately interpreted as the potential for near-complete waste utilization rather than a guarantee that the system will operate without any residue during implementation.

4 CONCLUSION AND SUGGESTIONS

Based on the results and discussion, the zero-waste Integrated Farming System (IFS) design at KWT Nur Rejeki is considered conceptually, technically, economically, and socially feasible for gradual implementation. The model integrates horticulture, laying-hen farming, tilapia production, and organic-waste processing so that plant waste, kitchen waste, and chicken manure can be converted into compost, BSF maggots, and frass as production inputs. The system has the potential to process approximately 180 kg of waste per month. Under the conservative economic scenario, it is projected to generate net income of IDR 705,000 per month, with a sales BEP of IDR 118,644, an MoS of 90.91%, and a Payback Period of 2.26 months. From the social perspective, members' understanding, acceptance, and readiness are classified as very high, with a score of 4.58 (91.62%). To support sustainable implementation, mentoring by PPL, relevant agencies, academics, and practitioners, as well as the preparation of simple SOPs and regular recording and documentation of activities, are required. Implementation should also be evaluated using actual data, including waste-utilization efficiency, BSF maggot productivity, compost quality, fish and egg production, and changes in income. Further analysis is recommended to account for equipment depreciation and member consistency in waste sorting and production recording, thereby supporting effective and sustainable implementation of the zero-waste system.

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