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Development of Small-Scale Integrated Farming Design: towards Optimizing Agricultural Learning Media

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Abstract

Learning about integrated farming could be done by visiting site locations directly. This is a problem for universities that are located in urban areas. The distance of the integrated agricultural location from the campus often raises a significant cost burden. Therefore, providing a learning model around the university would be more efficient, and students could interact and practice directly. The design concept was compiled based on a literature review. The design was produced by direct observation at Condongcatur experimental garden, then continued SWOT analysis. The design was created using software based on the information gathered. The design development included a general description of the experimental garden, landscape biophysical aspect, concept planning, and design. The resulting design was then validated by experts descriptively using a questionnaire. Meanwhile, user acceptance was measured qualitatively through an interview. The score results obtained 4,2 of 5 based on the assessment of experts, theoretically, a small-scale integrated farming design has been successfully compiled and met the requirements to be developed as an agricultural learning model that shown from functions of land availability and site support for design, user requirements, aesthetics and budgethe design also received a good response from the management, which would then be followed up in the long-term development plan of the experimental garden.

Keyword : integrated farming, design, learning media

1. Introduction

The integrated farming system is an agricultural system that integrates the activities of the sub-sectors of agriculture, crops, livestock, and fish to increase the efficiency and productivity of resources (land, humans, and other growth factors), and also develop the independence and welfare of farmers in a sustainable manner [7]. Diversification and integration systems across production components would increase household income, reduce vulnerability to shocks, create job opportunities, enhance land productivity, and improve water use efficiency [14]. Learning about integrated farming could be done by visiting site locations directly. This is a problem for universities that are located in urban areas. The distance of the integrated agricultural location from the campus often raises a significant cost burden. Therefore, providing a learning model around the university would be more efficient, and students could interact and practice directly. The integrated farming learning model could be studied as demonstration plots in the experimental garden. It is normally located near the university and used for research and practical sites for students and lecturers. The garden is also appropriate as a learning model if managed with an arranged concept. The learning model would improve student understanding by experiencing the studied object directly.

The Condongcatur experimental garden is one of the gardens at the Faculty of Agriculture, UPN "Veteran" Yogyakarta. The garden is located in the middle of the urban. Currently, it is only used for research and practical sites, whereas it has potentially a more productive direction, such as an agricultural learning media. An initial design is needed to build a model, including a concept plan and a blocking map. A concept plan contains suitable commodity cultivation technology while blocking is required for land management. Due to limited garden land, the integrated agricultural design needed is only on a small scale. Therefore, this study aimed to produce a small-scale integrated agricultural design to optimize agricultural media learning for students.

2. Material and Methods

The design concept was compiled based on a literature review. The design was produced by direct observation at Condongcatur experimental garden, then continued SWOT analysis. Its Analysis was carried out to analyze the Strengths, Weaknesses, Opportunities, and Threats of experimental gardens as The Agricultural learning model. SWOT analysis defined Strengths factors that will be used and Weaknesses that will be anticipated. It also analyzed opportunity factors that could be exploited and threats that need to be considered.

Furthermore, the design creation used software based on the information gathered. The tools used in this study were drawing tools, meters, a digital camera, laptops, and software (such as Microsoft Word, Microsoft Excel, SketchUp, and Photoshop). The design development included a general description of the experimental garden, landscape biophysical aspect, concept planning, and design. Indicators of success are functions of land availability and site support for design, user requirements, aesthetics and budget. The resulting design was then validated by experts descriptively using a questionnaire. Meanwhile, user acceptance was measured qualitatively through an interview. User acceptance was measured qualitatively by interviewing the Head of the experimental garden and technicians.

3. Results and Discussion

3.1 General Description of Experimental Garden

The Condongcatur experimental garden is one of the Faculty of Agriculture gardens at the UPN “Veteran” Yogyakarta, Condongcatur Village, Depok sub-district, Sleman, Special Region of Yogyakarta. The experimental garden is a research and practice site for students and lecturers of the Faculty of Agriculture. Its area consists of two main buildings, a greenhouse and Office. It also has support facilities, including two nurseries and a composting station. The experimental garden is functioning well except for the greenhouse, which needs repair, especially its roof and insect barrier nets. Figure 1 shows research and practice support facilities.

The carrying capacity of the plantation could be assessed through the Carrying Capacity Ratio (CCR) value. In the experimental garden, its calculations couldn’t be carried out because of its function as a research location. As a result, several parameters such as the frequency of harvests, the number of household heads, and the current population couldn’t be calculated. Although, based on the experience of researchers, most plants can thrive, except for plants that require cool and cold climates. Considering the conversion of its function as a learning model, plants and livestock that are kept in a small area could be a good example of integrated agriculture.

Figure 1. A) Nursery station B) Office, warehouse, and composting station C) Experimental field D) Greenhouse

Facilities and infrastructure through their functions and roles support the concept of integrated agriculture that will be developed. The office building could serve as a place for discussion and planning. Then, the warehouse could be used as storage for tools and fertilizers. Meanwhile, the composting station (Figure 1B) could process livestock manure, both solid and liquid, into fertilizer to support plants' nutrition and soil health. The nursery station (Figure 1A) could function as a nursery for plants which are then transferred to the experimental field (Figure 1C). To supply feed, the land is prepared for crops needed by livestock.

3.2 Biophysical Landscape Aspects

Biophysical aspects are the important things in a landscape**.** The interactions of the biophysical landscape are biotic and abiotic interactions processes in the landscape that influence development and landscape evolution. An example is land heterogeneity's influence in promoting microbial life's coexistence [10] and climate and vegetation-related effects [16]; [17]. Landscape sites are 3031.7 m^2. The climatic conditions of a landscape will affect the vegetation and the animals living in a landscape. The water source comes from drilled wells. The average temperature is 27.79 C, and the rainfall is 204.73 mm. The research site is in the lowlands at an altitude of 113 meters above sea level [1]. Vegetations are identified as bamboo (*Bambusoideae*), mango (*Mangifera indica*), water apple (*Syzygium aqueum*), lime (*Citrus aurantiifolia*), banana *(Musa paradisiaca*), citronella grass (*Cymbopogon nardus*), sansevieria (*Sansevieria masoniana*) and bushes. The animals are wild in general, often found in the surrounding garden, both in urban areas and natural habitats, namely dragonflies (*Anisoptera*), squirrels (*Scadentia*), grasshoppers (*Dissosteira carolina*), garden lizards (*Eutropis multifasciata*), bee (*Anthophila*) and sparrows (*Passer montanus*).

The vegetation and animals on the site are rich in quite a lot of local fruit plants so that they can be used to cultivate useful plant commodities for integrated agricultural purposes. Some trees are used as additional shade plants such as mangoes, bamboo. Bees can function as pollinators for plants. Dragonflies function as bio-indicators of clean water, so they can be indicators of water cleanliness around integrated agricultural land.

3.3 SWOT Analysis

SWOT analysis is a classic strategic planning tool that provides a simple way to estimate the best way to define a strategy [5]. The results of the SWOT analysis of the Condongcatur experimental garden are as follows in Table 1. Based on the SWOT analysis, it could be formulated mapping strategies that could be implemented in the Condongcatur Gardens by referring to the strengths and weaknesses. The garden might seize opportunities and remove obstacles or constraints hindering development. The above strategy could be implemented through activities in the Condongcatur garden stimulated by the small-scale integrated farming system development program. It shows that small-scale integrated farming could be built considering its strengths, such as high accessibility and the presence of competent human resources. ever, adequate funding is needed because Condongcatur garden can be the only campus that has an integrated concept. small-scale farming as a learning medium.

Table 1. SWOT analysis of the Condongcatur experimental garden

	Helpful	Harmful
Internal	**Strengths (S):** the experimental garden is located in an urban area and at the university, so it has high accessibility for students or visitors, fertile soil provides plants growth, high trustability to Faculty of Agriculture about human resource capacity development of agriculture.	**Weaknesses (W):** a management system considers old fashion management that the garden does not need changement and financial support.
External	**Opportunities (O):** Other universities do not yet have a small-scale integrated farming model in urban areas. With the growing popularity of eco-friendly integrated agriculture, gardens could be used as agricultural learning media.	**Threats (T):** campus access is closed when a pandemic occurs, making it difficult to manage the garden.

3.4 Integrated Farming System Development Concept - Crop and Livestock

The integrated farming system model is an agricultural concept that can be developed for limited and large agricultural land. A crops and livestock concept is proposed for this garden. Crop-livestock diversification refers to combining the production of one or more crops and livestock with the available resources [8]. This concept is appropriate for development on narrow land, such as in the Condongcatur garden, designed with a land intensification pattern.

Functional biodiversity could be achieved by combining crop and livestock species that have complementary properties and relate in synergistic and positive interactions so that stability could be improved and the productivity of agricultural systems had lower inputs. The composition and production of crops in the integrated farming system differ based on the ecological characteristics of each location. The arrangement and crop production influence the differences in each site's livestock varieties [24].

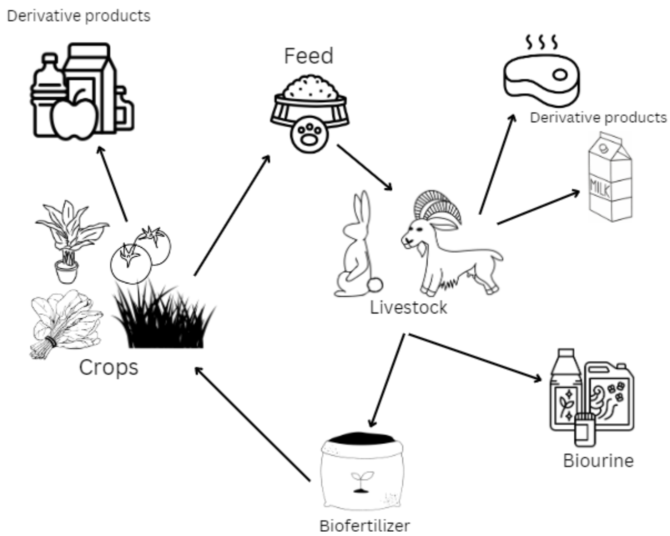

Figure 2. Small-scale integrated farming system model - crop and livestock

Besides the needs of farmers or garden owners, food crops could also be used as feed for livestock. In this garden, goats (*Aegagrus hircus*) and rabbits (*Oryctolagus cuniculus)* are kept for livestock. Goat farms are different from other livestock, which have simple maintenance, for instance, the need for capital, a maintenance system, and disease management. Compared to cattle, rabbit and goat farms require less capital. A fairly simple maintenance system and goat livestock are disease-resistant [15]. [23] Mentioned that rabbits do not need houses and complicated equipment like other animals and only require low costs to start maintenance [6]. Their feces and urine are for biofertilizer. Composted rabbit manure was reported to replace peat effectively in manufacturing horticultural growing media. Its application resulted in more than 90% seedling emergence and good seedling qualities (including enhanced root length, seedling height, and chlorophyll content) [9].

In addition, there is the cultivation of ornamental plants and plants in pots ("Pot-in-Pot gardening"), which have the potential to be developed and commercialized. "Pot-in-Pot" gardening is a method where plants are grown in a pot placed inside another larger pot filled with soil. This technique is often used for urban gardening as it saves space and allows easier maintenance. In addition, cultivated plants with "Pot-in-Pot" gardening can bear fruit quickly. Commonly used plants in "Pot-in-Pot" gardening is a type of fruit [20].

There is a nursery station that could provide seeds growth that will be used in cultivation in the garden. Its location met the requirements because it is close to a water source and has a flat topography. A location far from water sources would incur a high cost for technology input. Meanwhile, Uneven topography would complicate technical work and require specific building construction.

Crop-livestock integration technology usually applies the concept of cleaner production, which aims to produce zero-waste farming because livestock waste is used as a source of organic fertilizer for agricultural businesses. In addition, livestock integrated with crops utilize by-products from plants (plant residues/wastes) for animal feed. On the other hand, livestock provides raw materials for organic fertilizers (solid and liquid) as a source of nutrients plants need continuously. Waste or manure of goats and rabbits could be used as a source of organic fertilizer that is a more eco-friendly product. Organic fertilizers are the best fertilizers for increasing crop yield than chemical fertilizers by improving soil fertility [11]. Organic fertilizer sources improve soil fertility and crop productivity [2].

3.5 Design of Small-scale Integrated Farming

This design was designed to suit the needs of an integrated agricultural system. Not many changes were made to the building or land in this design. Changes were only limited to the relocation of space functions. The northern part is a building consisting of several divisions of space.

Figure 3. Site plan of small-scale integrated farming A) garden office, B) warehouse, C) composting station, D) organic waste counter, E) goats barn, F) rabbit barn, G) nursery station, H) ornamental plants station I) open field, J) greenhouse

Figure 3A is a garden office that functions as a meeting place or anything related to administrative affairs. Warehouse space for farming equipment and as a workspace for a garden manager or staff is shown in Figure 3B. Figure 3C is a composting station where the composting material could be from organic plant litter or livestock manure. Figure 3D is a chopping chamber for chopping large organic waste before composting. Figure 3E is a goat farm with male and female goats; Figure 3F is a rabbit barn. Manure from goats and rabbits will be used as fertilizer, and goat and rabbit urine could be processed into bio urine. The bio-urine processing area is between the goat and rabbit colony cages.

The garden's center is a semi-permanent building consisting of *paranet* houses for the nursery (Figure 3G) and ornamental plants (Figure 3H). The nursery station is used to prepare seedlings that would be planted in the field (figure 3I). The ornamental plant's station is used to cultivate ornamental plants such as aglaonema, which has a unique variety of leaf patterns and has the potential to be developed and commercialized. An open field (Figure 3I) is used to plant horticultural crops or as a research location for lecturers or students. Its harvests could be used as a food source or feed livestock apart from plants on the garden's edge. The products could also be marketed targeting the academic community of the Faculty of Agriculture and the university level. Greenhouse (Figure 3J) is used to research or cultivate hydroponically.

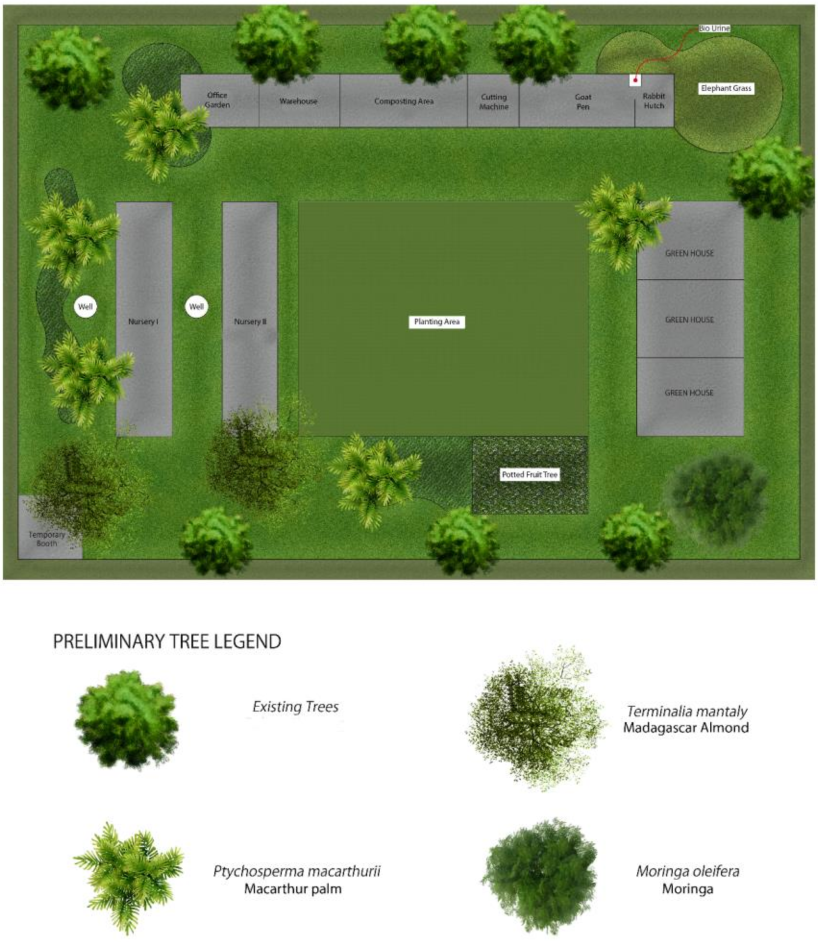

Figure 4. Master plan with tree of small-scale integrated farming system design in Condongcatur garden

This design accommodates trees, in which in this design, the replacement and addition of the trees and plants needed to support the concept of the Integrated Farming System are carried out. Existing trees are maintained as side plants and shade trees. The species of Kencana ketapang (*Terminalia mantaly*) is proposed to be near the nursery station and ornamental plants as shading plants because of the cool atmosphere needed. Ketapang Kencana has a shady and beautiful canopy, which is good for planting in the yard or along the roadside [13]. Besides, it could reduce campus pollution [12]. Meanwhile, Palem macarthur (*Ptychosperma macarthurii*) is proposed as the garden's aesthetics. The northeastern area of the garden is planted with dwarf elephant grass (*Pennisetum purpureum*) as feed for goats and rabbits (chopped needed). Dwarf elephant grass (*Pennisetum purpureum* cv. Mott) is a superior type of grass with high productivity and nutritional value. It had high palatability [22] and alternatively provided forage [21]. Ruminants highly preferred this grass because it had a leaf texture and soft stems. Furthermore, it resisted high-intensity sunlight and adapted highly in tropical countries [19]. It is proper for goats' and rabbits' feeds. *Moringa oleifera* is a tree that functions as a shade around the stable area and its surroundings, as well as a medicinal plant.

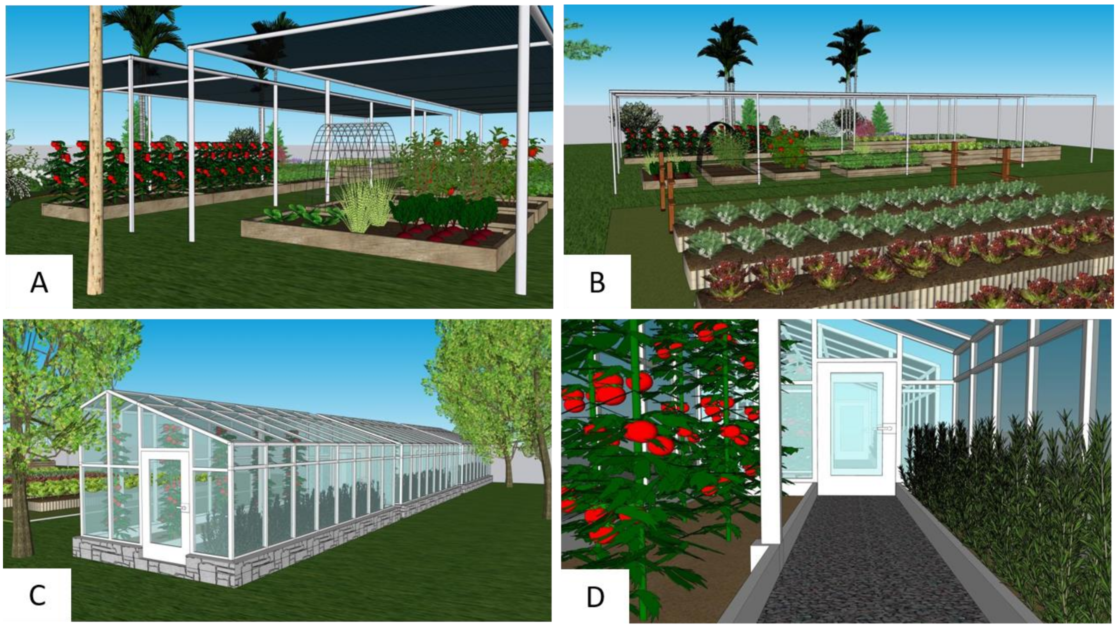

Figure 5. 3D design of small-scale integrated farming A) Nursery station B) Planting block C) apparition of Greenhouse D) Greenhouse's inside

A nursery station propagates and develops trees, shrubs, ground cover plants, vines, and other herbaceous plants [3]. Horticultural plant nurseries such as seasonal vegetables, fruit, and ornamental plants are needed to be cultivated through well nursery management. One of the functions of the nursery is to provide plant materials that are in accordance with the planting schedule [25]. Figure 5A is a detail of the plant nursery station block. It was designed to prepare horticultural seeds such as seasonal vegetables, fruits, and ornamental plants.

Figure 5B is a field planting seasonal crops and research land for students and lecturers. Flat and open areas have a lot of potential to be developed, one of which is as a research and trial area on a land.

The design of the greenhouse is shown in Figure 5C, and Figure 5D is the greenhouse's inside. Greenhouse design has a major influence on the microenvironment in it. One of the parameters of the plant microenvironment is temperature. High temperatures accelerate plant evapotranspiration, accelerating the loss of water and energy. One way to control the micro-environment of plants in a greenhouse, especially the temperature, is through natural ventilation [4].

Ventilation on the walls and roof of the greenhouse plays an important role in creating an optimal microclimate for plants without increasing operational costs [18]. The advantage of using natural ventilation is that it is inexpensive and does not require maintenance. The placement and width of the ventilation openings will determine the air movement inside the greenhouse, which will help reduce the temperature. The ventilation's location and the greenhouse's shape will affect the air movement inside. It moves hot air from inside the Green House. The hotter air that is released will help lower the air temperature.

The costs that would be needed to run this plan were divided into 3 groups including equipment and material expenditure, investment costs, and operational costs. Expenditures for tools and materials were predicted to require Rp.21.902.000. Investment costs (greenhouse repair and nursery construction) would require 80,000,000 funds while operational costs would require 2,500,000 per month (honorary and other necessities).

The design in the plan has fulfilled the requirements in terms of location. It would obtain high light intensity, water and electricity sources, flat topography, close to supporting facilities (office and laboratory), easy road access, and far from sources of contamination. The design was then presented and assessed by the Head of the experimental garden, staff, and experts. The results of the descriptive assessment are shown in Table 1.

Based on the criteria that have been assessed by experts, a total score of 4.2 out of 5 was obtained. This value indicated that the design offered met the criteria for small-scale integrated farming. Even so, this assessment was still in the early stages of planning development into an agricultural learning model. In general, the design was well received by the management and will be included in the long-term plan to develop the garden that shown by the direct assessment by the head of the experimental garden.

Table 2. Summary results of the small-scale integrated farming design's descriptive assessment.

No	Criteria	Percentage (%)	score (1 – 5)	Values (percentage x score)
1.	The substance of the garden layout (contents of material and knowledge); the layout is complete, especially regarding the distribution of blocks	20	5	1.0
2.	The overall layout contains a small-scale development plan for an Integrated Farming System	20	4	0.8
3.	Layout originality	20	4	0.8
4.	Suitability of the layout with the function of each building	40	4	1.6
	Total	100	17 of 20	4.2 of 5

4. Conclusion

Based on the results obtained, theoretically, a small-scale integrated farming design has been successfully compiled and met the requirements to be developed as an agricultural learning model. The design also received a good response from the management, which would then be followed up in the long-term development plan of the experimental garden.

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