Concept of agroedutourism based on smart farming in integrated farming systems

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Abstract. The implementation of smart farming is a solution to increase yields and simultaneously reduce production costs in agribusiness operations. This is achieved by optimizing the use of water, fertilizers in cultivation activities, feed in livestock/fisheries activities, and being able to predict the real-time conditions of livestock/fisheries. The concept of sustainable, integrated, and modern (digital) agriculture becomes a solution in agroedutourism with integrated farming systems. This study aims to develop the concept of smart farming-based agroedutourism in integrated farming systems to support sustainable agriculture and create efficient added value in the use of technology for agricultural and livestock activities as an effort to improve the welfare of farmers. The research was conducted at Attaqie Farm Agroedutourism, Tuban, East Java, Indonesia from June 2021 to December 2023. The research began with Focus Group Discussions (FGDs), which involved collecting data through structured discussions related to the problems faced in agroedutourism in general, thus formulating a concept in the form of solutions offered to address these problems. Next, the development of an artificial intelligence system was carried out and implemented on a scale of agroedutourism in vegetable crops in greenhouses, compost fertilizer from the cultivation of star fruit commodities, and biofloc fisheries systems. The results showed that smart farming can be effectively and efficiently used in various activities to monitor and predict the growth and increase in fish yields in biofloc, support the increase in compost production according to SNI standards, increase the growth and harvest of vegetables in greenhouses, and monitor the growth of goat livestock.

1 INTRODUCTION

The environmental issues of land degradation and land availability, as well as food security, will always be serious problems in Indonesia and even globally. Most communities in Indonesia, especially in rural areas, heavily rely on the use of chemical fertilizers. The concept of sustainable, integrated, and modern (digital) agriculture needs to be implemented in various regions, villages, and even urban areas. Integrated farming can eventually be applied throughout Indonesia, supported by a digital farming system that is developed based on current conditions, facilitating agricultural development.

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An integrated farming system that incorporates sustainable agriculture by utilizing starfruit waste as compost fertilizer, biofloc aquaculture by using waste from starfruit cultivation, and livestock farming integrated with plant cultivation is being developed. Optimizing this integrated farming system with an Artificial Intelligence-based system will be an appropriate solution to face the challenges of the Industrial Revolution 4.0.

Artificial Intelligence systems can assist farmers, traders, research centers, and agricultural startups in achieving optimal quality and quantity of yields through best cultivation practices. This research aims to develop the concept of agroedutourism based on smart farming within an integrated farming system to support sustainable agriculture and create efficient added value through the use of technology for agricultural and livestock activities as an effort to improve farmers' welfare.

2 MATERIALS AND METHODS

2.1 Time and Place

This research was conducted from July 2021 to November 2023. The location of the research was at Agroeduwisata Attaqie Farm, Panyuran Village, Palang District, Tuban Regency, East Java. Geographically, it is located at Astronomical Position 111.30' - 112.35 East Longitude (BT) and 6.40' - 7.18' South Latitude (LS).

2.2 Research Methods

The research began with conducting a Focus Group Discussion (FGD), which involved collecting data through structured discussions related to common problems faced in agroedutourism. This FGD then formulated a solution concept to address these issues. Following this, the development and implementation of an artificial intelligence system were carried out on an agroedutourism scale involving vegetable crops in greenhouses, compost fertilizers from starfruit cultivation, and biofloc system aquaculture.

2.3 Research Stages

2.3.1 Artificial Intelligence System in Biofloc

There were two types of concepts designed to address the issues using an artificial intelligence system: the growing pond biofloc and the yield of catfish.

2.3.2 Designing Biofloc Pond for the Internet of Things

1. The pond was a cylindrical tarpaulin pool with a diameter of 1.5 meters, and a height of 1 meter, supported by a wiremesh ring.
2. The water inlet pipe height was 110 cm, with a stop valve installed near the end of the pipe, and the pipe size was 0.5 cm.
3. The water outlet height was 80 cm from the bottom of the pond with a pipe size of 2.5 inches.
4. The floor underneath the round pond was made of concrete with a size of 4.5 x 4.5 meters with a pond drainage channel.
5. The air installation consisted of 4 aeration points.

2.3.3 The activities carried out in the preparation of the biofloc pond system include:

1. Land leveling at the biofloc pond site.
2. Construction of the pond base and installation of the water drainage system.
3. Installation of the pond frame and fish tarpaulin, air installation, and electrical installation.
4. Testing the pond using Internet of Things sensors.

2.3.4 Data Collection from Biofloc using Internet of Things Sensors

This data collection captures the environmental conditions within the biofloc pond, consisting of:

1. Measurements of water temperature, pH, total dissolved solids, electrical conductivity, turbidity, external temperature, and relative humidity. These measurements were taken three times a day to ensure a comprehensive and dynamic depiction of the biofloc conditions.
2. Measurements of catfish growth include the weight and number of live and dead catfish, and feed weight. These data were collected weekly to monitor the growth progress of catfish over time. However, this data has not yet been analyzed.

2.3.5 Compost Fertilizer from Starfruit Cultivation:

The materials used in the production of compost fertilizer for sustainable farming systems are leaves and twigs pruned from trees, as well as young fruits thinned from the trees at the agrotourism site. The procedure for making compost was as follows:

1. Materials were chopped using a chopper machine to a total of 50 kg.
2. Preparation of a solution using 5 liters of water, 3 liters of molasses, and 50 ml of EM- 4, that were mixed.
3. The mixture was then fermented for 1x24 hours.
4. Stored for 4 weeks.
5. The mixture was stirred twice a day during storage, and pH measurements were taken.
6. The obtained compost was used for cultivating butternut squash, pak choi, and tomatoes in the greenhouse.

2.3.6 Internet of Things Sensors Installed in the Goat Pen:

This data captured the environmental conditions within the goat pen, such as temperature. These temperature measurements were intended to ensure the goat pen did not become too hot, as the research site has high temperatures of around 39°C, thereby providing an alternative to achieve optimal temperatures for the goats. In addition to these activities, this research also employs a zero-waste system (integrated farming), ensuring that waste from goat manure is utilized as manure for vegetable cultivation in the greenhouse, supporting sustainable agriculture.

3 RESULTS AND DISCUSSION

3.1 Information on Agroedutourism Potential

Based on the official website of the Tuban government (2024), the research location is situated at Astronomical Position of 111.30' - 112.35' East Longitude (BT) and 6.40' - 7.18' South Latitude (LS). The land area is 1,839.94 km², with a sea area of 22,608 km². The coastline is estimated to be 65 km long. The topography of Tuban Regency ranges from 5 to 182 meters above sea level (asl). The research location is part of the lowland area with an elevation of 0 to 15 meters asl. Various marine and agro-tourism spots are of high interest to tourists visiting Tuban, East Java (Figure 1).

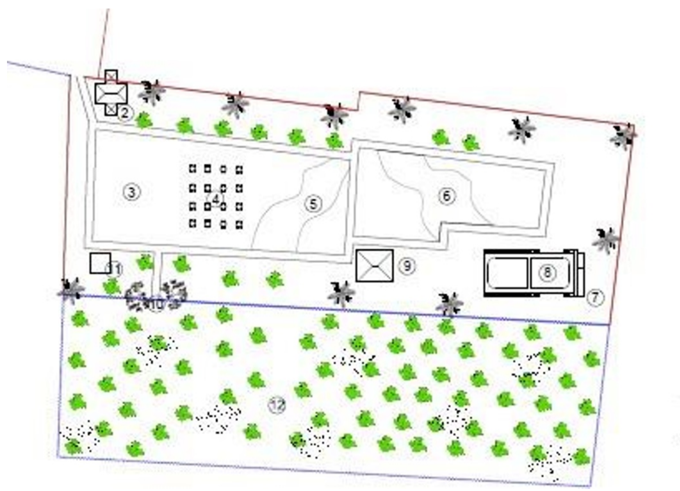

Fig. 1. Site plan of Starfruit orchard Attaqie Farm Agroedutourism, Sumiasih & Ichniarsyah, (2021).

The selected research location was Attaqie Farm Agroedutourism, with a public tourism area of 2 hectares and a fruit production area of 13 hectares. The main commodity of this place was Tasikmadu variety Starfruit, which had been a superior horticultural commodity since 2005 with the best quality in East Java. Integrated farming developed at Attaqie Farm has conventionally planted vegetables, greenhouse vegetables, a garden (ornamental plants for education; purposes), grass-fed goats, catfish biofloc, a compost house, and a liquid organic fertilizer house. The following facilities are available at Agroeduwisata Attaqie Farm, which can be seen in Table 1.

Table 1. Facilities available at Attaqie Farm [1].

No	Available for	Activities	Facilities
1	General visitors	Relaxing at gazebo, water and land recreation, eating at the café, visiting the garden	Water recreation facility (swimming pool), land recreation facility, café, prayer room, gazebo
2	Educational tourism and outbound visitors	Agricultural education, learning about organic vegetable cultivation, composting, liquid organic fertilizer, nursery in the greenhouse, picking starfruit, starfruit propagation, swimming	Swimming pool, café, educational garden, prayer room, gazebo, playground

3.2 Tourist Visit Potential in Tuban, East Java:

Farm-based tourism is a good diversification strategy for farms located or close to central districts and located near scenic attractions with several outdoor activities to enjoy [2]. Tuban is a well-known tourist destination famous for its natural attractions such as marine tourism (beach tourism) and religious tourism (Sunan Bonang). Its proximity to marine tourism at Pantai Kelapa and religious tourism has led to an increase in the number of tourists. This presents both opportunities and challenges for the development of rural agro-tourism.

This aligns with research conducted in Sri Lanka by [3] [4], which states that agro-tourism must be developed with community participation and government support. In developing the concept of agricultural village tourism, various factors need to be considered, including physical factors, community, and socio-cultural aspects, economic factors, technology, legal and policy aspects, the level of supply and demand for agricultural tourism, tourists, and the experiences gained during visits to the agricultural tourism area.

Farm tourism is often considered a form of tourism whose main characteristic is sustainability [5]. In developing agricultural tourism (agroedutourism), modern technology should be adopted as a form of agricultural modernization. Furthermore, environmentally friendly farming practices (integrated farming concept) should be implemented to ensure ecosystem sustainability. Therefore, the use of smart farming with the integrated farming concept in various activities is expected to optimally support yield agriculture from upstream to downstream. This aligns with research conducted in Filipina by [6], which Farm tourism as a farm diversification strategy to supplement income in rural communities.

3.3 Artificial Intelligence System in Biofloc

Agroedutourism that manages fish farming using biofloc currently faces various issues in fish cultivation, primarily because control and monitoring are still done manually. This monitoring is essential as water quality is crucial for fish farming using biofloc technology. Several parameters continuously monitored by fish farmers include water nutrient levels, temperature, pH, and total dissolved substances. This makes the work inefficient and time-consuming. Therefore, the developed system can monitor water nutrient levels, temperature, pH, and dissolved substance content, and also control the water quality.

With this system, monitoring and control can be easily carried out via a mobile application that can be integrated with a computer, so fish farmers do not need to visit and check the pond so often. This aligns with the research by [7], which explains that several physical and chemical factors that are water quality parameters in freshwater fish farming include temperature, pH, DO (Dissolved Oxygen), ammonia, and nitrite.

The use of biofloc farming systems can be done in several types of containers, including concrete ponds, fiber ponds, and round-shaped tarpaulin ponds according to [8]. The research conducted indicated that fish farming with the biofloc system could run well until harvest. Wastewater from the biofloc system was used for irrigation for grass planted beside the biofloc. The grass is then used as feed for goats at the Agroeduwisata. The biofloc and sensor images can be seen in Figure 2.

Fig. 2. The Biofloc system and the Internet of Things sensor.

Below is the workflow diagram of the Internet of Things in biofloc (Figure 3), and the yield of catfish can be seen o Figure 4.

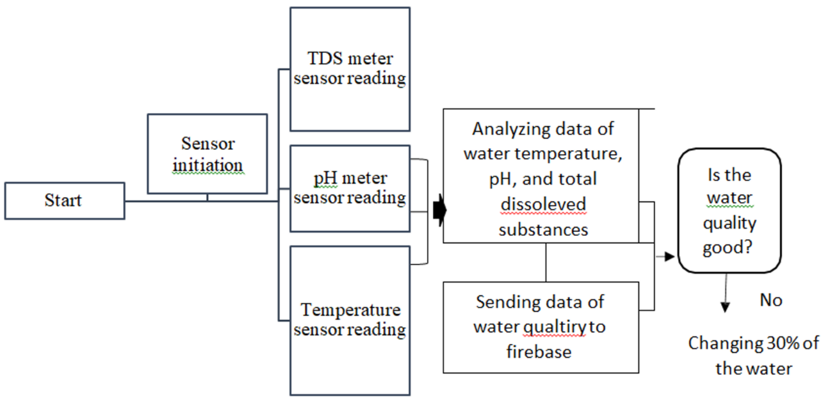

Fig. 3. Workflow diagram of the Internet of Things in biofloc.

Fig. 4. Catfish yield.

The web hosting for this research is smart.attaqiefarm.com, with the URL address https://smart.attaqiefarm.com/, which can be accessed through user authentication. Once successfully logged in, the main page display is as shown in Figure 5. The web page built in this research is not only used to monitor biofloc but can also be used to monitor the CCTV around the biofloc, compost house, and goat pen (Figure 6).

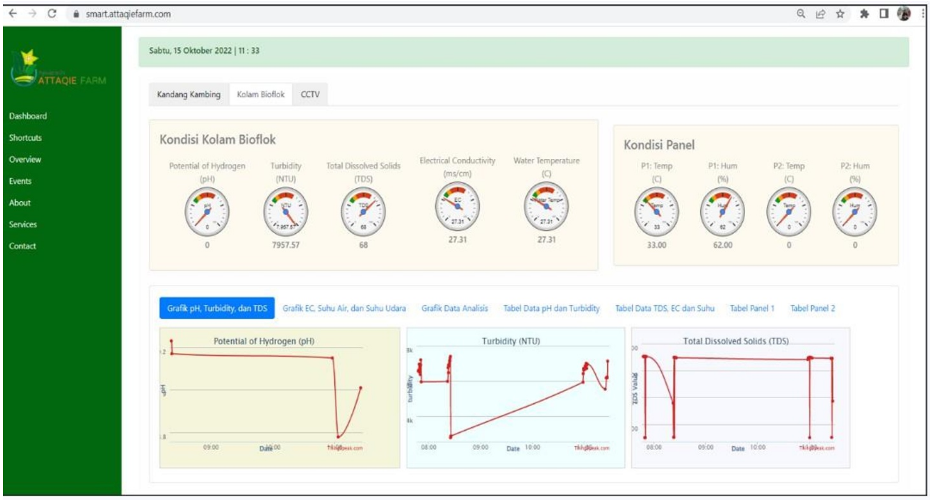

Fig. 5. The main page display.

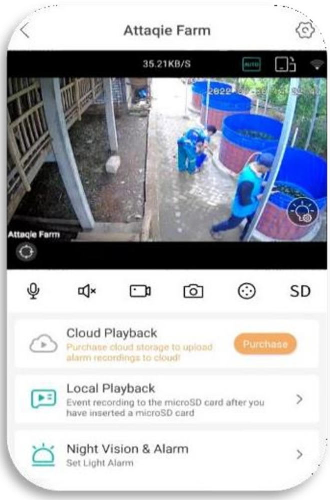

Fig. 6. CCTV in agrotourism location.

3.4 Compost Fertilizer from Starfruit Cultivation

The compost materials used were pruned leaves and starfruit waste found at Attaqie Farm. This concept could be applied to various tourist villages that adopt an integrated agroedutourism concept. Based on the research by [9], the analysis test results of the compost conducted at Attaqie Farm indicate that the nutrient content available in the tested compost is sufficient for the growth and yield of pak choi. This is because the nutrients in the compost are formed from the decomposition or weathering of organic materials (Table 2).

Table 2. Compost Analysis.

Compost Parameter	Starfruit Compost Content	Compost Parameter	Minimum SNI compost content
C-Organic	51.53	C-Organic	27
C/N	19	C/N	20
Water content	68.8 %	Water content	50 %
pH H2O	9.1	pH H2O	7.49
Macronutrient : N	2.78 %*	Macronutrient: N	0.40 %
P_2O_3	0.88 %*	P_2O_3	0.10 %
K_2O	2.70 %*	K_2O	32 %
Ca	2.65 %*	Ca	25.50 %
Mg	1.34 %*	Mg	0.60 %
S	0.01 %	S	-
Micronutrient : B Total	186	Micronutrient : B Total	-

Note: *Content value in accordance with SNI. Attaqie Farm starfruit compost content result was published by Soil Research Institute (2021) Siregar *et al.* 2022.

Based on the research by [10], regarding compost for pak choi cultivation conducted at Attaqie Farm, it is stated that the nutrient content in starfruit waste compost showed good results according to the compost criteria standards of SNI 19-7030-2004. Starfruit compost is ready to use and effective by the third month. The results of the observation on the potential use of starfruit waste as compost for pak choi indicated an effective dosage of 20 tons/ha (equivalent to 40 g/polybag). Below were the packaged compost (Figure 7) and various vegetables cultivated using starfruit waste compost at Attaqie Farm (Figure 8).

Fig. 7. Starfruit compost with good nutrient content according to SNI.

Fig. 8. Several vegetables cultivated using starfruit compost at Attaqie Farm.

3.5 Internet of Things Sensors Installed in the Goat Pen:

The agroedutourism concept, which implements an integrated farming system using smart farming, is very well-suited for application in various regions. At the research location, goats were fed odot grass irrigated with water from biofloc waste, ensuring that water from the biofloc is not wasted. Meanwhile, waste from the goats produced manure that was used as fertilizer for vegetable cultivation. The goat pen's maintenance was also monitored using sensors to observe the temperature and conditions of the goats (Figure 9). If the pen became too hot, a blower would activate to lower the temperature, ensuring the pen maintains a suitable temperature for goat growth.

Fig. 9. Goat pen and fertilizer dashboard.

4 Conclusion

The research results indicated that smart farming can be used effectively and efficiently in various activities to monitor and predict the growth and yield of fish in biofloc, support the production of compost according to SNI standards, enhance the growth and harvest of pak choi, butternut squash, and tomatoes grown in the greenhouse, and monitor the growth of goats.

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