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Implementation of Rainwater Harvesting Integrated Farming to realize Sustainable Development Goals (SDGs)

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Abstract

One of the SDGs elements related to the fulfillment of access to clean drinking water and sanitation must be achieved by the world community by 2030. The purpose of this research was to implement a rainwater harvesting system integrated with agriculture and livestock for alternative clean water needs in Jatikuwung Village. This research used the Research and Development (R&D) method. The model used in this research is the ADDIE model. This ADDIE model has 5 stages, namely (1) Analysis: analyzing the situation, (2) Design: designing for product design to be made, (3) Development: producing or making products, (4) Implementation: implementing of limited product testing in the field, and (5) Evaluation: evaluating the cycles and end-product. This research was conducted in Jatikuwung Village. This location experiences a water crisis during the dry season. The subject of this research was designing Rainwater Harvesting Integrated Farming by KKN-T students in Jatikuwung village. The object of this research is the process of Rainwater Harvesting Integrated Farming flow that can be utilized in life. This research was conducted in October-November 2022 and was limited to the development stage. The results of this research were rainwater harvesting integrated farming through a rainwater harvesting system that produced clean water. This system can be useful for life integrated with catfish farms that get food from maggots, and water in catfish flows to plants.

1. Introduction

Jatikuwung Village is one of 13 villages in Gondangrejo Subdistrict, Karanganyar Regency, Central Java, Indonesia. The area of Jatikuwung Village is 475,568 Ha, located in the highlands with undulating topography. Highland areas are usually defined as areas with high levels of rainfall, have fertile soil, and store many water reserves. However, in contrast to Jatikuwung Village area, although it is located in the highlands, it does not rule out the possibility of experiencing aridity and a clean water crisis.

In 2020, Jatikuwung Village was reportedly experiencing a clean water crisis and drought caused by a prolonged dry season. At least 150 families need clean water assistance on an ongoing basis. Water is a vital necessity for life. The dry season is one factor affecting the depletion of water sources. Other factors can be obtained from water use patterns that are less effective in their utilization, which impacts the availability of water in an area. These problem factors also impacts soil fertility which can cause aridity in plant quality. Based on these reasons, an idea emerged that rainwater could be utilized as a fulfillment of clean water needs in certain areas (Silvia & Safriani, 2018).

There are several problems addressed through KKN work programs related to SDGs, including Rainwater Harvesting, Urban Farming, and Trash Bank, which are three KKN work programs related to several SDGs points, namely clean water and sanitation, no poverty, decent work, and economic growth, as well as good health and well-being.

The three work programs are integrated into Rainwater Harvesting and Integrated Farming. This research was focused on rainwater harvesting and could be integrated into the Integrated Farming concept system. The agricultural integration in question is in the form of making hydroponic plants and catfish ponds. That way, villagers will feel the abundant benefits of this system. Residents will not experience a clean water crisis and plants, and catfish will be able to increase their economic value if managed properly. This system also promotes an economy based on environmentally friendly technology and optimization of all energy sources produced. Organic waste was also utilized in feeding the maggots.

Research on Rainwater Harvesting has been conducted by Huang et al., (2021) showed that Rainwater Harvesting was made through infiltration holes and small dams. Other research conducted by Odhiambo et al. (2021) stated that RWH had the potential to mitigate the adverse effects of climate change among farmers. However, proper design and implementation were critical for better performance and implementation of RWH systems in the region. These would ensure that the RWH system was reliable, technically and economically feasible, and had the desired water-saving efficiency. Other research on rainwater harvesting conducted by Zhang et al. (2021) showed the importance of integrating rainwater harvesting and drip irrigation techniques to increase water productivity, prevent land degradation and desertification, and eradicate poverty in dry areas.

The novelty of this research, with previous research, lies in the idea of a new design process integrated into agriculture. This rainwater harvesting concept can benefit living things such as catfish and plants. Magot is an additional component to be used as catfish feed and water in catfish ponds that are useful for watering plants.

From this background, the objectives of this study were to implement a rainwater harvesting system integrated with agriculture and livestock for alternative clean water needs, analyze the efficiency and savings from the application of the rainwater harvesting system and find out how influential the rainwater harvesting system integrated with agriculture on increasing economic value in Jatikuwung Village.

2. Methods of Implementation

This research used the Research and Development (R&D) method. The model used in this research was the ADDIE model. This ADDIE model had 5 stages, namely (1) Analysis: analyzing the situation, (2) Design: designing for product design to be made, (3) Development: producing or making products, (4) Implementation: implementing of limited product testing in the field, and (5) Evaluation: evaluating the cycles and end-product. This research was conducted in Jatikuwung Village. This location experiences a water crisis during the dry season. The subject of this research was designing Rainwater Harvesting Integrated Farming by KKN-T (thematic field work) students in Jatikuwung village. The object of this research was the process of Rainwater Harvesting Integrated Farming flow that could be utilized in life. This research was conducted in October-December 2022 and was limited to the development stage.

3. Results and Discussion

The first stage is **Analysis**. There were several problems addressed through KKN work programs related to SDGs, including rainwater harvesting, urban farming, and Bank Sampah.

The application of the concept of rainwater harvesting to realize one of the SDGs elements (Clean water and sanitation), namely the concept of collecting rainwater that is collected in a reservoir and then the water that has been collected can be used as an alternative water source to reduce the use of groundwater and can be used for activities such as washing, drinking, watering plants (Notaro et al., 2016).

The next concept is Urban farming by cultivating plants such as chilies, tomatoes, eggplants, red ginger, and lemongrass utilizing used bottles. This activity supports food security in vegetables and medicinal plants to realize the 3 elements of SDGs: no poverty/no poverty, decent work and economic growth/decent work and economic growth, and a healthy and prosperous life/good health and well-being.

The last concept is a waste bank, which is an activity to collect waste that has been sorted and will be deposited at the waste collector by applying the 3R principle, namely Reduce (prevent waste generation), Reuse (reuse waste), and Recycle (recycle waste) through the construction of waste banks in the community. Based on data from the Ministry of Environment and Forestry (KLHK), it is stated that the main source of national waste, 36%, comes from household activities. Therefore, the waste management approach must be carried out at the source and based on community participation. Waste Bank to realize the 3 elements of SDGs: no poverty/no poverty, decent work and economic growth/decent work and economic growth, and a healthy and prosperous life/good health and well-being.

The three programs were integrated into rainwater harvesting and integrated farming. This research, not only focused on rainwater harvesting but also other innovative ideas that could be integrated into this Rainwater Harvesting concept system, namely Integrated Farming or integrated agriculture. This can also be defined as the incorporation of all agricultural components in an agricultural business system. This system also prioritizes an economy based on environmentally friendly technology and optimization of all energy sources produced. Organic waste is also utilized in feeding the maggots.

The second stage, namely, **design** was the step to designing for the product design. In the process of making Rainwater Harvesting Integrated Farming, tools and materials were needed, including RWH tubs with a capacity of 1200L, RWT pipes for household use and RWT pipes for ponds, magot breeding composter tubs, reservoir stands (estimates), magot drain pipes, plant drain pipes, catfish ponds, cotton filters, taps, paints and brushes, plastic gallons, organic waste, catfish seeds, and some plants. The product design of rainwater harvesting integrated farming is as follows:

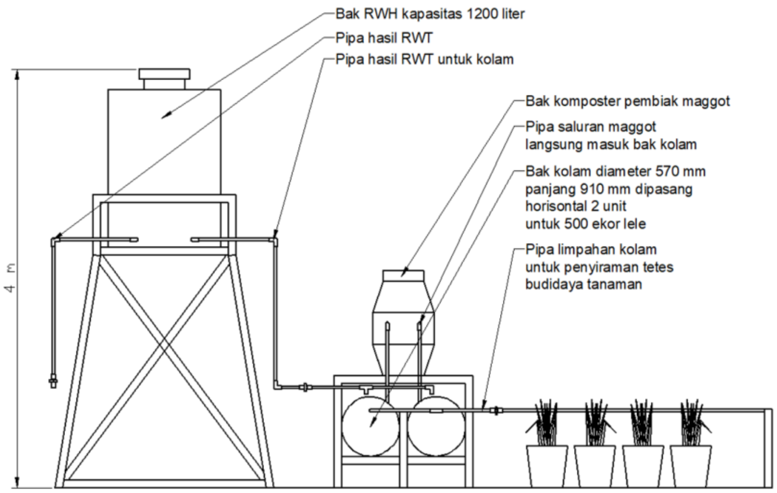

Figure 1. *Rainwater Harvesting Integrated Farming*

The third stage is development; the process of making products or the stage of producing products. After all the component materials were prepared, then this study's reconstruction process was carried out. The following was how to make it. **First**, RWH tub with a capacity of 1200 liters of reservoir mounting frame was placed on the top hole in the reservoir and was directed right under the house gutter. At the connection of the gutter pipe to the reservoir drain pipe, a cotton filter was given to filter out impurities carried by water from the house gutter. Storage capacity should be sufficient to optimize planting days after the end of adequate rainfall (FAO, 2014). The size and dimensions should be designed so that the RWH system can collect and store large amounts of water for crop production. The location of the RHW system should allow maximum collection and storage from the catchment area (Odhiambo et al., 2021).

Figure 2. *Water Line Pipe*

Second, the two ponds were placed in a horizontal position, as upward hole doors, each of which were used for catfish enlargement of about 50 catfish seedlings, so that the two ponds had a capacity of about 100 catfish seedlings. Patmawati et al. (2020) revealed that catfish could adapt to environmental conditions and had relatively fast growth and high nutritional content. The outer skin layer of the pond basin was given a hole for planting water spinach, where the roots of the water spinach would be directed into the water in the pond basin. The water spinach would be an additional intake for the catfish in the pond basin.

Research conducted by Rahmadhani et al. (2020) stated that catfish waste became a nutrient intake for the growth of water spinach.

Gambar 3. *Catfish Pond Tube*

Third, a composter tub with a capacity of 200 liters with 3 layers was made. The maggot was part of the life cycle of the Black Soldier Fly (BSF) in the form of a pupa which needed organic material intake to live (Afifah et al., 2021; Hadi et al., 2021). In the first layer, the upper part was used for the flight and reproduction of black flies by making holes for black flies to enter and exit. Then in the second layer, the placement of household organic waste became the food of the maggot. In addition, food scraps also became a container for the larval phase of the black flies. In line with Lubis et al. (2022), the maggot cultivation process must be kept moist and protected from rain and direct sunlight. Media in a place with minimal light, shade, and moisture was expected to positively impact the laying of black soldier fly eggs and the development of maggots after hatching. Black soldier flies that act as broodstock were introduced into the media, with the cultivation process taking two weeks (Hardini et al., 2021). In this layer, a hole is also made for the exit of maggots into the channel to the catfish pond basin. In the last layer, the food remnants would produce liquid waste that could be used as organic fertilizer. There was a small hose to collect the organic fertilizer called biopore.

Some studies also utilized maggot to be used as a bioconversion agent for organic waste into growing media, but what made the process in this study different was the type of organic kitchen waste used in the system. Organic waste or the rest of this easily decomposed material can be utilized to cultivate black fly maggots or BSF (Black Soldier Fly) growing media (Salman et al., 2020). There are more than two benefits of cultivating maggot, namely reducing household waste, making it in the form of feed, and becoming a feed trading ground (Rosnawati et al., 2017). Another advantage of maggot, which was relatively cultivated in small and large capacities, contains antimicrobials, was anti-fungal, did not carry diseases and its use did not compete with humans (Mokolensang et al., 2018).

Gambar 4. *Rainwater Harvesting Integrated Farming*

The results of laboratory tests related to the content of maggots were also proven to have high protein and fat content so that they could function as feed for cultivation (Irfan & Manan, 2013). The protein content in maggots is quite high, which ranging from 30-45% (Azir et al., 2017). In addition, it is also rich in AMP (antimicrobial peptides) and has a high lauric acid content of up to 49.18% of its body. Based on research by the Big Agency for the Development of Freshwater Aquaculture (BBPBAT), maggots cultured using fermented palm oil cake have a protein content of up to 45.14%. These showed that maggot was qualified to be used as an alternative feed with a considerably high protein source (Hardini et al., 2021).

In general, many catfish farmers feed catfish with fishmeal but the price is often high and fluctuated. Therefore, an alternative feed breakthrough to encourage catfish growth was to breed maggots or larvae from black soldier flies. Maggot is an organism derived from the eggs of the black soldier fly, which is one of the decomposing organisms because of its ability to consume organic materials to grow. This black soldier fly has a life cycle highly dependent on environmental conditions. Its life cycle is about 40 - 43 days. Initially, black flies produce and reproduce eggs; the eggs will be laid in leftover food sources. Then it becomes a pupa that will migrate to a more humid place and grow into an adult black fly (Fauzi & Sari, 2018).

Finally, a series of water channel piping from the RWH basin to two water flow pipelines was made. The first channel was for daily needs, and the second was to the pond basin then, the water in the pond basin flowed using a series of pipes to the plant pots in the Urban Farming program. In this piping circuit, the regulator faucet could be opened when used. When the faucet was set or turned on, the water from the reservoir would flow directly into the catfish pond drum. Then when the pond basin was filled, the water automatically flew into a series of plant pipes in which the pipe channel was given a small hole so that the water flow to the plant.

Gambar 5. *Urban farming*

The advantages of this concept were that it could integrate rainwater harvesting for daily clean water needs with agriculture and animal husbandry, which results in an abundance of benefits in terms of economy and environmentally friendly. For its shortcomings, only a few maggots moved or walked to the catfish pond, and the rainwater reservoir overflew any time if it reached the maximum load limit. The results and discussion in this research showed that the concept of Rainwater Harvesting Integrated Farming did not waste the catfish's droppings or other organic waste which can be reused by being integrated into other components.

4. Conclusion

Rainwater that was collected using the Rainwater Harvesting system was useful for clean water supply for the needs of livelihoods in Jatikuwung Village. The innovation in the form of rainwater harvesting integrated with agriculture positively impacted and provided benefits for the village area and its citizens. In addition, other innovations can be integrated into this Rainwater Harvesting concept system, namely Integrated Farming or integrated agriculture. This can be defined as the incorporation of many agricultural components in an agricultural business system. Suggestions for further research can examine the effect of maggot breeding for catfish feed on this Rainwater Harvesting Integrated Farming. This will produce clean water that is beneficial to life integrated into catfish farms. The catfish get food from maggots and water in catfish pond is good for plants.

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