INCREASING THE EFFICIENCY OF WATER USE ON AGRICULTURAL LAND THROUGH DEVELOPING RAINWATER HARVESTING SYSTEMS.

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ABSTRACT

In several rural areas, the lack of water resources during the dry season has forced farming communities living in these areas to leave their land unattended, because without sufficient irrigation it is difficult for various plant commodities to grow, and this causes farmers' income during the dry season to be greatly reduced. To overcome this problem, water conservation can be carried out by creating a rainwater harvesting (RWH) system, where rainwater is collected from the roof of the house which is then channeled into storage tanks or reservoirs, where the water is then stored. The collected water can then be used for household purposes and watering plants. In this paper we describe a prototype of the rural house that we have built in a rural area of Sumedang district, West Java. The house and yard have the capacity to collect rainwater and recirculate water through hydroponic and aquaponic systems to save water use in carrying out agricultural activities so that even during the dry season, farmers are expected to continue to cultivate food crops or vegetables.

Keywords: *constructed wetland, harvesting rainwater, aquaponic, rural areas*

1.0 INTRODUCTION

In several rural areas, the lack of water resources during the dry season has forced farming communities living in these areas to leave their land unattended, because without sufficient irrigation it is difficult for various plant commodities to grow, and this causes farmers' income during the dry season to be greatly reduced.

One of the many ways to do this for areas where the waters are dependent on rainwater is to build rainwater reservoirs, both on a small individual scale and on a large scale for the community. On a large scale, the construction of reservoirs is usually initiated and funded by the government, but because the costs required for these large scales are usually large, therefore to build small-scale reservoirs can be an alternative.

RWH collects the run-off from a structure or other impervious surface in order to store it for later use. Traditionally, this includes harvesting the rain from a roof. The rain will be collected in gutters that channel the water into downspouts and then into some form of storage

vessel. Rainwater collection systems can be as simple as collecting rain in a rain barrel or as elaborate as harvesting rainwater into large cisterns to supply an entire household demand [1].

RWH is one of the most promising alternative water sources, since rainwater can easily be collected and used without significant treatment for non-potable purposes, although the economic viability of these systems is not always assured [2].

A prototype of a pond for rainwater collection installations was made on ITB's farm land located in Haurngombong village, Pamulihan sub-district, Sumedang district, West Java, in the 2021-2022 period. By making this prototype, it is hoped that it can become an example for the surrounding community to make the same installation, so that agricultural activities can continue even in the dry season by using water from rainwater reservoirs.

2.0 CONSTRUCTION OF A POND

The pond is built to serve as a rainwater reservoir. The construction of the reservoir was motivated by limited water during the dry season in Haurngombong Village, Pamulihan District, Kab. Sumedang. Most of the Haurngombong Village area is a rain-fed agricultural area which can only be planted during the rainy season. With the construction of a rainwater reservoir, it can become a source of irrigation for the surrounding agriculture during the dry season so that it can be a solution to water shortages in the area.

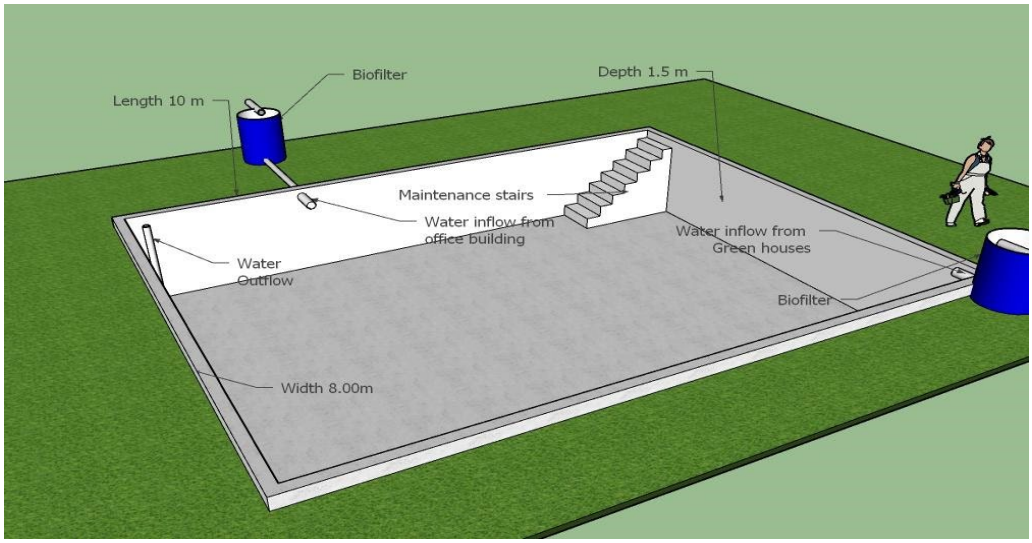

Figure 1: Technical design of rain water collector pond

The prototype of the reservoir building that we made was built from bricks and cement. The dimensions of the rainwater reservoir are 10 m long, 8 m wide and 1.5 m deep as shown in Figure 1. The capacity of the volume of water that can be accommodated is 100 m3. The pond is equipped with a ladder for maintenance, an output channel to remove excess water when it is full, and an input channel equipped with a biofilter to filter incoming rainwater (Figure 2). When it rains, the water that collects in the pond comes from run-off and rainwater

that is caught on the roofs of the surrounding buildings which is channeled using a network of gutters.

Figure 2: Pond for collecting rain water

Aside from being a source of irrigation for agricultural land, the stored water can also be used for fisheries. The fish that has been cultivated at this time is Nirvana tilapia. The tilapia that have been released into the pond are juveniles measuring 5-10 cm in length. Fish are ready to be harvested when they are of ready-to-consume size (5-8 fish per kg) which will be reached after 4-6 months.

The costs incurred for the construction of this reservoir are around IDR 11,085,000 (eleven million eighty five thousand rupiah) which includes the purchase of building materials: bricks, sand, cement, and the cost of manufacturing services. The following is a table of expenses (Table 1).

Table 1: Cost for creating a pond

NO	ITEMS	UNIT	AMOUNT	PRICE PER UNIT	TOTAL
1	Brick	pcs	150	Rp 3,000	Rp 450,000
2	Sands	truck	1	Rp 1,350,000	Rp 1,350,000
3	Cement	bag of 40 kg	35	Rp 65,000	Rp 2,275,000
4	Bucket	pcs	2	Rp 5,000	Rp 10,000
5	Plaster (roskam)	pcs	1	Rp 10,000	Rp 10,000
6	Wooden 2 m	pcs	6	Rp 10,000	Rp 60,000
7	Nail	Kg	0.5	Rp 20,000	Rp 10,000
8	Brick	pcs	3000	Rp 700	Rp 2,100,000
9	Pipe PPC 3in	pcs	2	Rp 70,000	Rp 140,000
10	Pipe junction 3in	pcs	1	Rp 10,000	Rp 10,000
11	Water sealer (Dop)	pcs	2	Rp 10,000	Rp 20,000

12	Field preparation	Man days	2	Rp 100,000	Rp 200,000
13	Const worker services	Man days	13	Rp 150,000	Rp 1,950,000
14	Assist services	Man days	25	Rp 100,000	Rp 2,500,000
				Total Cost	**Rp 11,085,000**

3.0 INSTALLING RAINWATER TANKS AND FILTERS

The reservoir gets its water supply from rainwater that falls on the roofs of the surrounding buildings, namely office roofs (100 m2), green house-1 roofs (160 m2), and green house-2 roofs (30 m2). The total cross-sectional area of the roof which becomes a rainwater catchment area is 290 m2 (Figure 3).

Captured rainwater is channeled through a network of gutters and pipes with a total length of 84 m to the reservoir. Before entering the reservoir, rainwater goes through a biofilter for the filtering process. The filter used starts from the bottom layer, namely gravel, zeolite sand, and palm fiber with a thickness of 20 cm each.

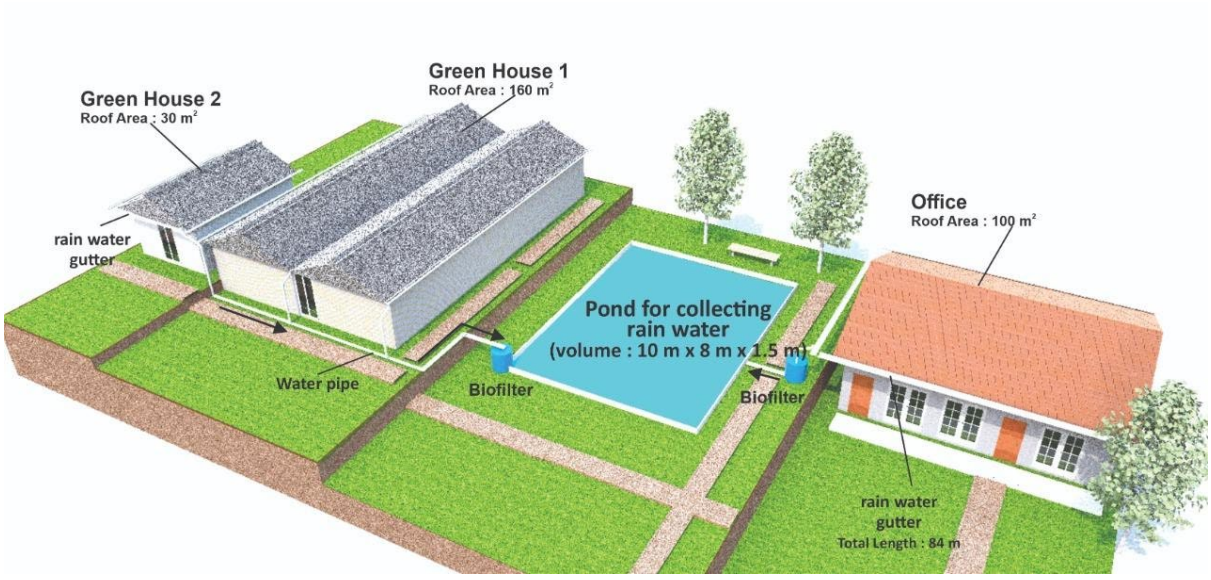

Figure 3: Technical design for rain water collecting system

Maintenance is carried out periodically, namely cleaning the roof, guttering network, filtering system, and cleaning the pond. The roof is cleaned of leaf litter because it can prevent water from falling from the roof into the gutters. The gutter network must be cleaned periodically from leaf debris that drifts into it so that it does not clog the water flow. The filter system also needs to be checked or cleaned regularly once every 1 month or replaced once every 1 year or after the rainy season is over.

The pond also needs to be kept clean from leaf litter. Often the reservoirs are used as breeding grounds for mosquitoes and frogs. Cultivating fish in ponds can be a solution to dealing with mosquito larvae. Meanwhile, to deal with frogs is done by catching frogs that enter the reservoir, removing eggs or tadpoles that appear with a net (Figure 4).

The costs that have been incurred for the manufacture of this rainwater storage installation are around Rp. 3,761,500 (three million seven hundred and sixty one thousand five hundred rupiah), which includes the purchase of gutters and the cost of their installation services. The following is a table of expenses that have been incurred (Table 2).

Table 2: Cost for installing rain water collector

NO	ITEMS	UNIT	AMOUNT	PRICE PER UNITPIPE	TOTAL
	Pipe 0,5 in	Pcs	3	Rp 25,000.00	Rp 75,000.00
2	Connector pipe 0,5 in	Pcs	10	Rp 3,000.00	Rp 30,000.00
3	T connector pipe 0,5 in	pcs	10	Rp 3,000.00	Rp 30,000.00
4	Gutter Kt AB	pcs	20	Rp 65,000.00	Rp 1,300,000.00
5	Gutter cover	pcs	12	Rp 5,000.00	Rp 60,000.00
6	Gutter connector	pcs	14	Rp 5,000.00	Rp 70,000.00
7	Gutter funnel	pcs	7	Rp 15,000.00	Rp 105,000.00
8	connector 2 in	pcs	4	Rp 5,000.00	Rp 20,000.00
9	Connector 2.5 in	pcs	11	Rp 7,500.00	Rp 82,500.00
10	Connector T 2 in	pcs	2	Rp 5,000.00	Rp 10,000.00
11	Connector T 2.5 in	pcs	4	Rp 7,500.00	Rp 30,000.00
12	Gutter holder	pcs	70	Rp 6,000.00	Rp 420,000.00
13	Pipe 2 in	pcs	4	Rp 40,000.00	Rp 160,000.00
14	Pipe 2.5 in	pcs	7	Rp 50,000.00	Rp 350,000.00
15	Pipe Glue	pcs	1	Rp 40,000.00	Rp 40,000.00
16	Wire	pcs	2	Rp 40,000.00	Rp 80,000.00
17	Nile	pcs	40	Rp 500.00	Rp 20,000.00
21	Palm fibre (5kg)	bag	1	Rp 83,000.00	Rp 83,000.00
22	Ziolite	bag	2	Rp 23,000.00	Rp 46,000.00
23	Service const worker	Man day	3	Rp 150,000.00	Rp 450,000.00
24	Service assistant	Man day	3	Rp 100,000.00	Rp 300,000.00
				Total cost	**Rp 3,761,500.00**

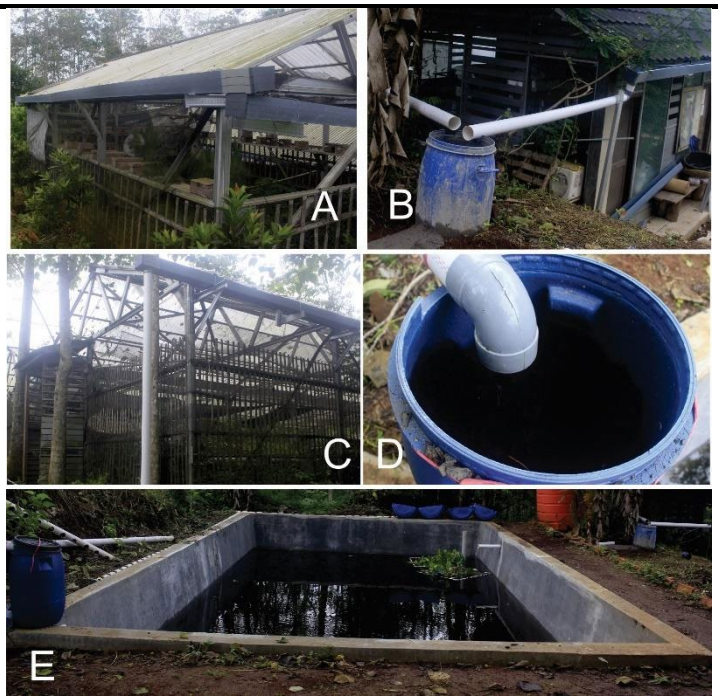

Figure 4: Rainwater Storage System. (A) Rainwater is collected from the roof of the bee house. (B) Rainwater is collected from the roof of the office. (C) Rainwater is collected from the roof of the green house. (D) Rainwater through the filtering process on the biofilter. (E) Rainwater enters the reservoir after going through filtering.

4.0 DISCUSSION

In our rainwater collection system we have not installed a first-flush diverter to help prevent the first flush of contaminated rainwater from entering the tank. To replace it, we installed a simple biofilter to minimize the pollutant content in rainwater. Thus, before entering the pond, rainwater will undergo a filtering process.

In a closed system with a tank, a screen filter is used to keep insects such as mosquitoes out of the system. In an open system like a pond, to keep mosquitoes out of the system, we put some fishes i.e. Tilapia mossambica, to eat mosquito eggs or larvae. This is a type of fish with relatively easy maintenance but still has high economic value. In relation to fish farming, the role of the biofilter is very important. In line with what was stated by Nurhidayat and Ginanjar [6], biofilters play a role in improving water quality and have an impact on increasing fish growth.

A complete rainwater collecting system (Figure 5) usually installed a pump system for rainwater distribution, however in our case we mainly collect the water using gravitational force so there is no need for a pump system. A pump is needed if we are going to distribute the water in relatively remote areas from the pond.

Moreover, a complete rainwater collection system usually incorporates a pumping system for rainwater distribution. Different things happen to the rainwater collection system that we have implemented. Ponds used to collect rainwater have a relatively higher location than agricultural land. The stored water is channeled using gravity to reach lower land so that a pump system is not needed. Pumps will be needed if we are going to distribute water to areas that are relatively higher and far from the holding ponds.

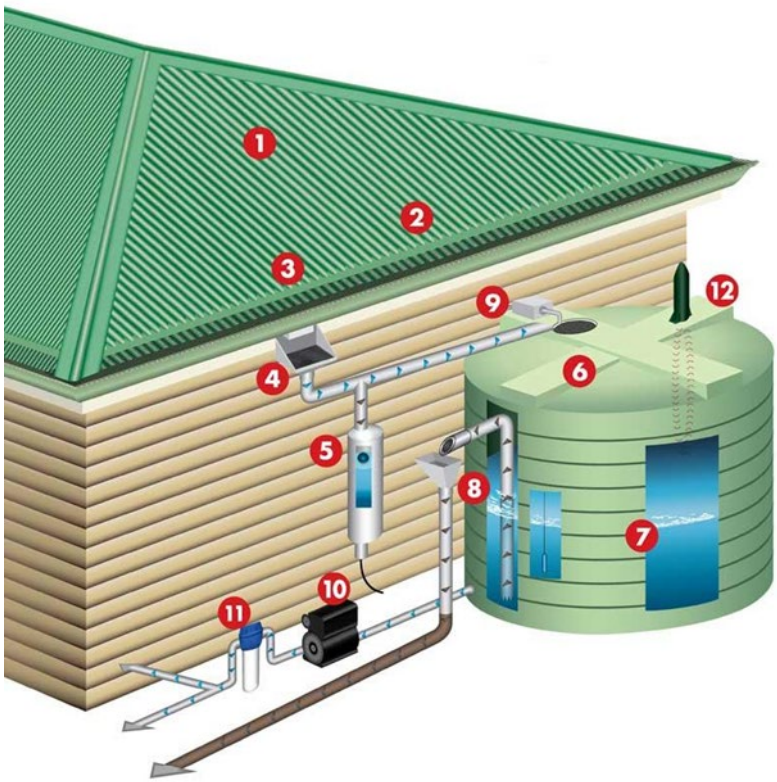

Figure 5: A complete rainwater collection system (1). notes: 1) roof surface. 2) gutter protection screening, 3) gutter, 4) rain head (downspout filter), 5) a first-flush diverter, 6) a tank screen, 7) rainwater, 8) an insect proof flap valve, 9) an auto-fill system, 10) a pump system, 11) irrigation filter,12) water level indicator.

RWH can save water from the range of 8.6% to 45% for green roof type. It has also been proven that RWH can be a potential source of water. In some areas, RWH can be used as a source of drinking water and even as water for washing cars. That means, RWH has a big potential to be used as a source of water for agriculture [4]. Collected rainwater can be used as a source of agricultural spring water because rainwater is usually free of all pollutants and toxins caused by human activities. Salt accumulations can also be rinsed from plants and soil by the collected water. In addition, rain is also free of chlorine [7].

In making the pond, due to limited funds, we did not reinforce the bottom of the pond with iron rod reinforcement so that the strength of the bottom of the pool is not strong enough to withstand the weight of incoming water when the pond is fully filled with water, resulting in cracks in several parts due to subsidence of the soil in the middle. which causes pool leaks.

This happens because it turns out that the soil structure is less dense because the texture in some parts are rocky and sandy.

The degree of RWH systems implementation and the technology selection are strongly influenced by economic constraints and local regulations [2]. Moreover, despite design protocols having been set up in many countries, recommendations are still often organized only with the objective of conserving water without considering other potential benefits associated with the multiple-purpose nature of RWH. However, the most determining factor for water catchment is rainfall in the region [5].

Furthermore, Campisano et al [3] suggested that future work on RWH addresses three priority challenges, namely: more empirical data on system operation is needed to allow improved modelling by taking into account multiple objectives of RWH systems. Secondly, maintenance aspects and how they may impact the quality of collected rainwater should be explored in the future as a way to increase confidence on rainwater use. Finally, research should be devoted to the understanding of how institutional and socio-political support can be best targeted to improve system efficacy and community acceptance [3].

5.0 CONCLUSION

From the project that we carried out in the ITB garden in Haurngombong village, Sumedang for making ponds and installing rainwater harvesting on a small scale and at a relatively low cost, it is very possible for the community to apply and become capital to be used not only for water reserves for crop irrigation agriculture but also for fish farming, gray water wastewater treatment and can be integrated with hydroponic systems. It would be better if for the construction of this installation the community could be assisted with financing by the government, universities in community service programs or social institutions.

Acknowledgement

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