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Community-Based Integrated Water Resources Conservation on Mount Penanggungan in Pasuruan, Jawa Timur

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Abstract Mount Penanggungan's watershed ecosystems, which play a crucial role in managing the water cycle, are in an alarming state right now. Community-based integrated water resources conservation efforts aim to restore the function of watersheds, particularly in terms of controlling the water cycle. The purpose of this article is to describe a variety of community-based water conservation efforts in Mount Penanggungan, Gempol District, Pasuruan, East Java. We encourage the local community to engage in integrated water resource conservation activities, such as engineering efforts, plastic waste processing, tree planting, education, and public awareness-raising. Community service students from UGM participate in these programs as live-in facilitators. Local communities now have the infrastructure necessary to engage in community-based water conservation, including both physical and non-physical infrastructure (biopore and rainwater harvester) but also non-physical infrastructure (awareness and knowledge). This activity must be continued in order to observe the growth and outcomes of the empowerment initiatives that have already been carried out.

1. INTRODUCTION

Globally, natural disasters continued to increase from 1980 to 2014, as did those in Indonesia (Badan Nasional Penanggulangan Bencana, 2020; Hoeppe, 2016). Different from other types of natural disasters, floods and drought are fairly common and have a significant impact (Dilley et al., 2005; Djalante & Garschagen, 2017; Nugroho, 2015). In the context of Pasuruan Regency, these two types of disasters occurred most frequently during the last ten years, apart from landslides and tornadoes (Badan Nasional Penanggulangan Bencana, 2020). The most recent flood occurred in early 2020 in the foothills of Mount Penanggungan, Gempol District, Pasuruan, which affected 2,950 houses and disrupted community activities (Aziz, 2020). Ironically, this phenomenon happened right after the drought in mid-2019.

Floods and droughts that occur cyclically indicate watershed ecosystems cannot control the water system, as stated by Nugroho (2015). Several previous studies have given the perspective that poor people who live in a location and conduct resource utilization activities are the main actors in watershed degradation (Chen et al., 2001; Yin & Li, 2001). Another perspective presented by (Broad, 1994) states that there is not always a negative relationship between poor people and the environment. Even in the third world, many poor people still contribute to conservation activities. This awareness may arise because they are vulnerable to natural disasters, as (Winsemius et al., 2015) expresses.

Indonesians are well known for their cooperation and local wisdom in protecting their environment. Therefore, it is not surprising that community-based water resource management can be carried out independently by the community. Unfortunately, the local wisdom of Indonesians in managing water resources is starting to wear off (Hidayati, 2017). For this reason, it is urgent to return the community to the cultural roots of 'gotong-royong' (collaborative work) and local wisdom in managing water resources. This paper aims to present various kinds

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of community-based water resource conservation activities carried out in Mount Penanggungan, Gempol District, Pasuruan, Jawa Timur. The novelty of this publication involves UGM's student community services as live-in facilitators who function as catalysts in community-based conservation activities.

2. METHOD

2.1 Location

This study was conducted on the eastern slope of Mount Penanggungan. More precisely, this area is located in Wonosunyo Village and Jeruk Purut Village, Gempol District, Pasuruan Regency, East Java, Indonesia (-7.58^o S to -7.63^o S and 112.62^o E to 112.68^o E). The study location is presented in Figure 1.

2.2 Program

This activity is an integrated program to handle water criticality on the slopes of Penanggungan Mountain. This program consists of community service, research, and mentoring of UGM's student community service. Furthermore, the results of this program will become teaching materials on community-based water resource conservation. Schematically, the program is presented in Figure 2.

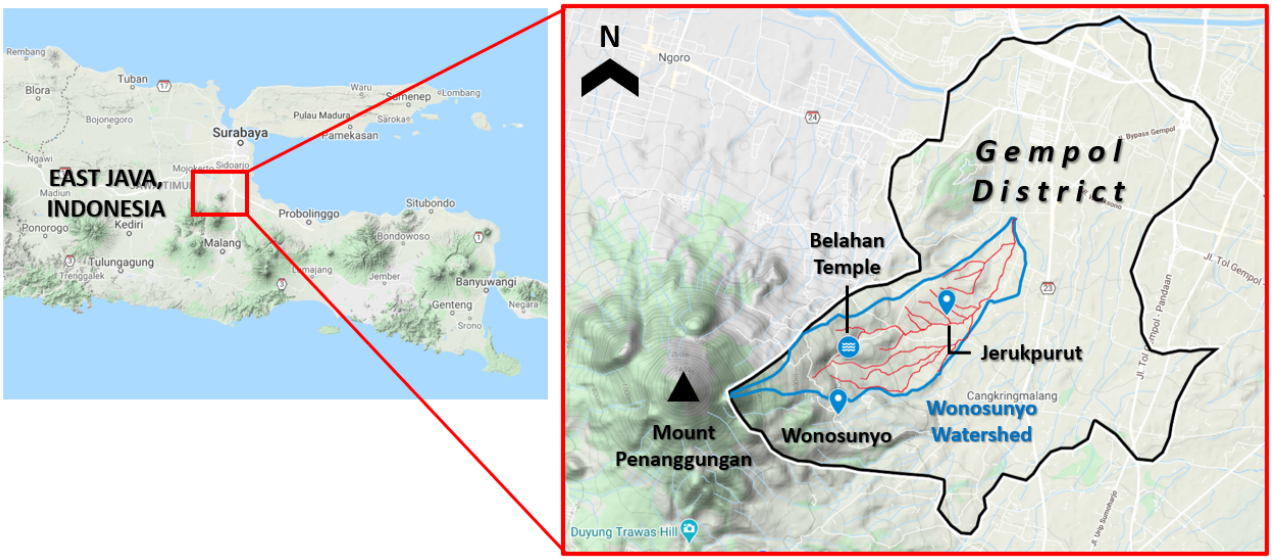

Figure 1 . Study location

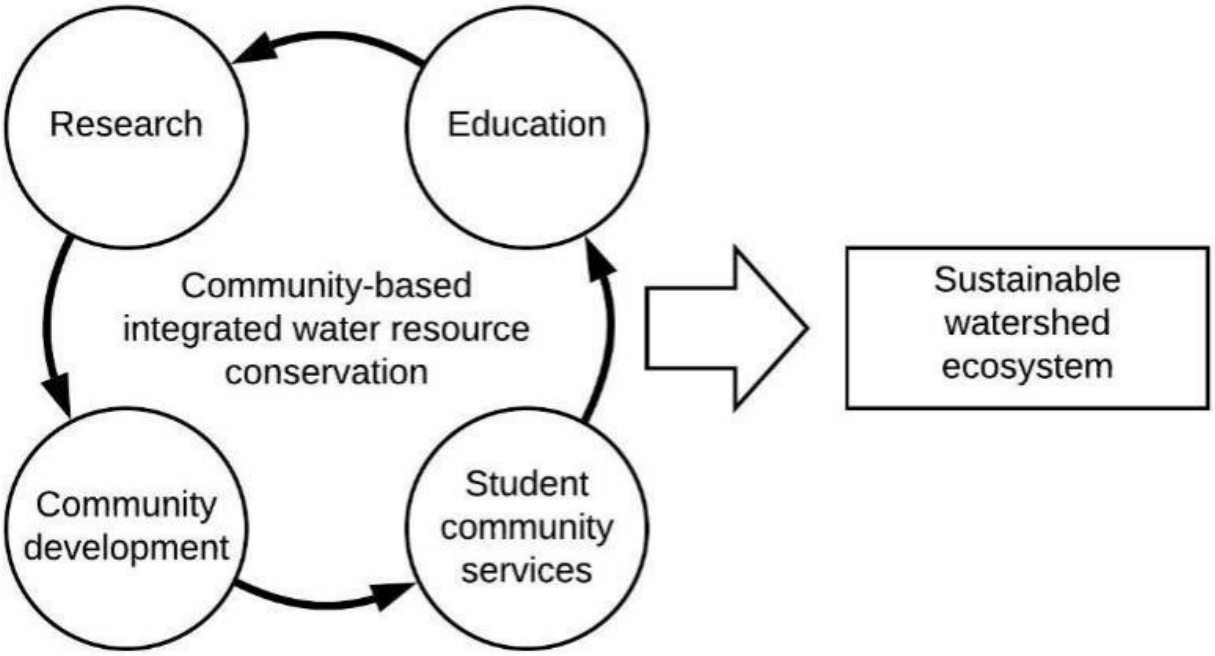

Figure 2 . Community-based integrated water resource conservation in Mount Penanggungan

3. RESULT AND DISCUSSION

3.1 Short-term and long-term mitigation efforts

Based on the existing conditions, the problem is not the amount of rain but how rain can be held longer in the region. Relatively thin soil in the upstream area and the reduction in the area of forest cover is the primary cause of this phenomenon. These problems cause a continuous imbalance of water balance: drought in the dry season and flooding downstream in the rainy season. This problem needs to be addressed immediately so that these events do not recur continuously in the future.

Several things have been done to deal with these problems, both short-term solutions and long-term solutions. Short-term solutions that have been carried out in this activity are engineering efforts (i.e. biopore and rainwater harvester installation) and plastic waste processing. Long-term efforts have been made, such as tree planting, education, and raising public awareness. These solutions will be discussed more in the next section.

3.2 Biopore and rain water harvesters installation

Biopore and rainwater harvesters have different characteristics and requirements. Biopore and rainwater harvesters are engineering efforts that are expected to be able to help hold water longer in the study area. While a rainwater harvester can be installed anywhere, biopore can only be installed in an area with sufficiently deep soil.

Biopore technology has been widely adopted globally as well as in Indonesia. This technology has been adopted by communities in many places in Indonesia. In several previous biopore installation activities, the site selection mainly was based on administrational boundaries, i.e. biopore installation done by (Verasta et al., 2021) in Citereup Bandung and (Sumardjo et al., 2022). While in this activity, biopore installation locations were selected based on a hydrological system which consists of upstream and downstream areas.

The purpose of biopore installation is to increase groundwater recharge and reduce surface runoff, which can cause inundation. The biopore installation in the upstream area carried out in the Belahan Nangka, Badud, and Wonosunyo 1 hamlets were 12 points. Biopore installation location was determined in a participatory manner between the UGM team and the community members (Figure 3 (a)). In the downstream area of biopore, there were 8 points in Taruna Bhakti Vocational School in Gempol District and 24 points in Trisakti Vocational School in Beji District Figure 3 (b) and Figure 3 (c).

Figure 3 . (a) Biopore installation in the Wonosunyo Village, (b) Biopore installation and training at Taruna Bhakti Vocational School (c) Biopore installation and training at Trisakti Vocational School (d) Rainwater harvester installation

Rainwater harvester is not a new technology and has often been used in various regions across the world. The working principle is to collect rainwater that falls on the roof, filter it, collect it in reservoirs, and regularly use it to meet the community's water needs. The rainwater harvesting technology used in this activity adopts the Gama Rain Filter rainwater harvesting technology invented by (Maryono, 2017).

Due to limited resources, this activity can only provide a set of rainwater harvesters to be installed at the study site. Therefore, choosing the most representative location is necessary and provides the highest benefit. Although installing a rainwater harvester can be done anywhere, in this activity, Wonosunyo Village was considered the first priority because it had the problem of lack of water in the dry season. Based on deliberations between the UGM team and the community, a pilot rainwater harvester was installed at the Wonosunyo village hall with the consideration that it could be used together. It could also be used as a pilot if people were interested in adopting this technology for their respective homes.

Rainwater harvester technology is very appropriate to be used in this region considering the enormous potential of rain Table 1, and so far, it only flows as surface runoff. The rain that was captured from the roof of the village hall office with an area of 100 m^2 of roof cover is 2,130 L per day. A reservoir installed with a capacity of 3,000 L can only hold rainwater for 1.5 days. Ideally, more than one reservoir is needed to load more water and be able to be used to meet domestic needs for a longer duration. Even so, this condition alone has two advantages: reducing the amount of surface runoff and obtaining water reserves to support domestic needs. If in the future this technology can be adopted by most of the residents of Wonosunyo Village, they can minimize the impact of the imbalance of water that have occurred in recent years.

Table 1 . Rainfall potential estimation

No	Parameter	Value	Unit
[1]	Average annual rainfall*	2,807.34	mm
[2]	The average number of rainy days in a year*	131.4	day
[3]	Average daily rainfall [1]/[2]	21.3	mm
[4]	The roof area of the village hall	100	m^2
[5]	Daily rainfall volume [3]x[4]	2,130	L

*Data source: Badan Meteorologi, Klimatologi, dan Geofisika (n.d.)

Rainwater harvesters have been adopted worldwide to combat water scarcity. Several studies mention that the utilization of rainwater harvesters similar to the one that has been done in this research and others in another location has proven successful in addressing the lack of water problems due to its low cost and its participatory approach (De Melo Branco et al., 2005; Kim et al., 2016).

The installation of biopore and rainwater harvesters is not only intended to conserve water resources practically, but to educate the public as well. Around a hundred local people are involved in this activity to educate them. The installation of biopore and rainwater harvesters in the village of Wonosunyo involves the village community, especially the farmer cadets who are targeted to be the leading persons of water conservation in this area. The installation of biopore in vocational schools mainly aimed to teach and train vocational students to be able to do the making and installation of biopore and water conservation techniques in other locations.

3.3 Plastic waste management

Integrated water resources conservation takes into account all aspects of water resources, not only quantity but also quality aspects. The results of the field observations found that there were still problems with solid waste in the study area, especially plastic waste. The issue of plastic waste is a global problem that needs to seek immediately.

In order to overcome this problem, a plastic waste management program was conducted in the study area. This program targets an early-age population: students at Jeruk Purut I elementary school, as many as 180 students. The plastic waste management program is carried out by training in manufacturing useful items from plastic bottles, such as decorative plant pots Figure 4. Furthermore, this activity also includes education and awareness to care for the environment, especially water resources, and the concept of 3R (reduce, reduce, recycle).

Figure 4 . (a) Training on plastic bottle processing, (b) Plastic pots

3.4 Planting water conserving plants

It is well-known that plants as communities, so-called forest areas, have an essential role in conserving water resources. Forests have sponge effects: reducing the water's destructive power, retaining excess water during the rainy season, and releasing water gradually during the dry season. The problem encountered in the study area is that the ecosystem has shown symptoms of a decline in function due to land conversion. Tree planting is expected to gradually restore and restore the ecosystem functions of the upstream watershed.

Table 2 . The role of water conserving plants

Tree Species	Role in Conservation	Source
Albizia (*Falcataria moluccana*)	- Suitable for land rehabilitation - Fast-growing species - Increase soil fertility	(Irawanti et al., 2012)
Rain tree (*Samanea saman*)	-Very high CO_2 absorption capacity (28.5 tons/stem/year) - High evapotranspiration ability	(Dahlan, 2010)
Breadfruit (*Artocarpus altilis*)	- Canopy functions in rain interception -Other functions: food, medicine, building materials	(Adinugraha & Kartikawati, 2012; Supriyati, 2010)
Guava (*Psidium guajava*)	- Having high absorption capacity of lead (Pb)	(Dahlan et al., 1989))
Tamarind (*Tamarindus indica*)	- Low CO2 absorbing capacity - Supporting roots are able to grip the soil - Tree canopy is a good windbreaker	(Dahlan, 2008; Kidaha et al., 2017)
Longan (*Dimocarpus longan*)	- Vegetative landslide control - Plant canopies intercept rain - Has a relatively high economic value	(Bahari et al., 2015; Muharam, 2011)
Soursop (*Annona muricata*)	- Medium CO2 absorption capacity - Other functions: medicinal plants for anti-cancer drugs	(Dahlan, 2008)

Figure 5 . (a) Preparatory activities (b) seedlings from the BPDASHL Sampean (c) ploughing land (d) seedlings planting

In the study area, seven trees were planted: Albizia, rain tree, breadfruit, guava, tamarind, longan, and soursop. In addition to having an essential role in water conservation, these types are also expected to have socioeconomic contributions to the local community. For example, fruits with high economic value and aesthetic functions support tourist objects. The role of each tree type is presented in Table 2.

The plant seeds of the seven tree species totalling hundreds of stems are a collaboration with Sampean BPDASHL, which is one of the partners of UGM's student community services. These trees were planted in the source of the Sunyo Spring Belahan Temple in January 2020, which was still in the rainy season (Figure 5). The tree planting location was chosen in a participatory manner by the UGM team and community representatives (village committee, farmer cadets, youth clubs, Alfaz Kabajo studio).

Tree planting is one of the conservation activities that has been done in many places worldwide for various goals. Compared to what has been done in this activity, several tree planting activities are not aiming for soil and water conservation goals, i.e. tree planting activity in Ethiopia (Worku et al., 2018) and in Nepal (Bajracharya et al., 2005) for fuel wood supply. Due to different goals, the trees planted were different in types.

3.5 Focus group discussion (FGD)

Figure 6 . (a) Integrated community-based water resources conservation socialization (b) Focus group discussion with the people of Wonosunyo Village

Focus group discussion activities were focused on disseminating knowledge and a forum for discussion between the community and the research team regarding the implementation of water resources conservation activities in the field. Thirty participants were community members consisting of village officials, farmer cadets, BUMDes, BPD, and youth clubs (Figure 6).

The results of this activity show that most people still did not know the role of forests in the conservation of water resources before the FGD and counseling activity; nevertheless, they gained knowledge after the event (Figure 7). Furthermore, the community also did not fully understand various techniques for conserving water resources. Nevertheless, an exciting finding in this FGD is that the community felt a gradual degradation of water resources in terms of both quantity and quality. Some FGD participants alleged that one of the causes of degradation was due to the presence of sand mining, which has increased in recent years. Filling the pot with soil, (b) Planting seedlings into pots

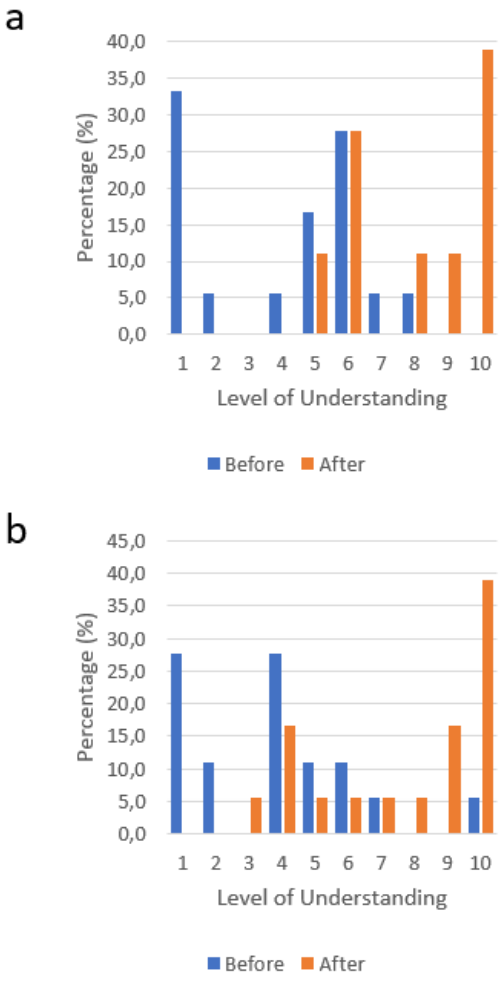

Figure 7 . (a) Soil and water conservation knowledge and (b) biopore technology knowledge; before and after FGD, 1 is the lowest

3.6 Water resource education for youth

Early-age residents are the next generation who are expected to be able to carry out environmental activities on the slopes of Mount Penanggungan in a sustainable way, including the water resources aspect. For this

reason, it is crucial to plant awareness early on about the importance of maintaining harmony between humans and the environment. Water resource conservation education for youth was carried out at Wonosunyo I elementary school. One of the activities was to plant seeds of several types of tree crops (Gmelina) and fruit plants (tamarind, soursop, guava, and longan) in a pot (Figure 8). UGM's student community services accompanied these elementary students in doing these activities. These activities ranged from filling the container with soil media, adding seedlings, and covering it again with soil to how to care for the seeds, from watering to fertilizer application.

Figure 8 . Filling the pot with soil, (b) Planting seedlings into pots

4. CONCLUSION

Community-based integrated water resources conservation activities seek to restore the function of watersheds, especially in regulating the water cycle, with the community as the main actor. Many activities of water resource conservation start from the grass root worldwide, resulting in better results compared to top-down activities. Nevertheless, the bottom-up conservation model requires extra time to see the results, and this is not yet able to be achieved in this article. Nevertheless, this article has been able to show that the community can carry out conservation efforts with the support of academics and live-in facilitators as catalysts. In the future, we hope that both the quantity and quality of the water in Mount Penanggungan will improve so that it can continue to be used sustainably for current and future generations.

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CONFLICT OF INTERESTS

This study doesn't have conflict of interest.

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