Promoting Bamboo as Water Resources Conservation Plant in Jedong Community

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Abstract. Bamboo has been widely used for water resource conservation. The benefits of bamboo as a water resource conservation plant are not well known by the public. This paper discussed the process of promoting bamboo as a conservation plant for the people of Jedong, Wagir Subdistrict, Malang Regency. They used water from Sumber-Wangkal and Sumber-Cokro Springs to fulfill their water needs. The methods applied in this research are soil surveying and causal loop diagrams model. The soil surveying and causal loop diagrams model were done to get the spring's soil conditions and to find out the water resources conservations efforts by Jedong people in both springs, respectively. The soil samples analysis showed that the soil in both areas is suitable for bamboo plants. The causal loop diagrams (Jedong Water Resources Conservation) model showed that the village-owned water management (Pengelola Air Minum Desa/PAMDes), as the organizational system on water resources management will be able to promote the bamboo plants for conservation. Promoting bamboo plants to the Jedong community is very important to support the water resources sustainability in Jedong.

1. Introduction
Bamboo is an in-situ and ex-situ plant. They have the ability to improve land conditions (soil and water) [1], [2]. Bamboo roots can bind the soil, and reducing soil erosion [3]. Bamboo clumps along the river embankment will reduce the river cliff landslides [4]. Bamboo can improve the hydrological function on the springs area [5]. Bamboo reduces the runoff and increases the infiltration [6], and purifies the water in the subsoil system [7]. Bamboo is easy to propagate vegetatively and easy to grow anywhere [8]. Bamboo also has many benefits besides for water conservation [5]. Bamboo can be used as food [9], building materials, handicrafts, and bioenergy [10]. Bamboo is a monocotyledonous plant species of Bambusoideae and Poaceae tribes. Bamboos growing in rural Indonesia include: Dendrocalamus Asper (Bambu betung), Bambusa Blumena (Bambu Duri), Gigantochloa Apus (Bambu Apus), Gigantochloa Atter (Bambu Ater), and Schizostachyum Brachycladum (Bambu Bali). Christanty [11] explained that land will be degraded without bamboo plant.

Jedong community live on the Kawi Vulcanic slope area. The water need of the community that live on the mountainous area depend on the presence of springs [12]. The springs used by Jedong community are: 1) Sumber-Awar-awar/Urung-urung/Bidadari; 2) Sumber Cokro; 3) Sumber Wangkal, 4) Sumber-Towo, 5) Sumber-Krobyoikan, and 6) Sumber-Sawah-Pasinan seepage. Sumber-Wangkal spring is not in the Jedong village, but it is in the Dalisodo village located near to Jedong village. The community bought the land in the Dalisodo village to get the water spring access. The water availability will be lack if they used their own springs only. Water springs irrigate the field rice. It flows into the river along the valley.
Bamboo is very important for water resources conservation. Bamboo planting have been carried out around the world. The Philippines’s Government has been plant the bamboo tree for more than 52,000 hectares [13]. Bamboo cultivation in historical areas of Korea has lasted for more than 1000 years and is able to keep water resources sustainability [14]. Bamboo planting was also carried out in the BonPring Bamboo Tourism Forest, Malang. It is able to maintain the 6 water springs sustainability around the forest [15]. Although bamboo has many uses, but the bamboo ability as water conservation has not been well known by the community. Research related promoting bamboo mostly only deal with the function of bamboo as green material [16], so it requires further research regarding promoting bamboo to community. This paper aims to explain the process of the bamboo promotion as water conservation plant for Jedong Community. The process is expected to support the water resources sustainability for them.

2. Methods

This research was conducted in Jedong village, Wagir District, Malang Regency, East Java. It is 10 km southwest from the Malang City (Figure 1) [17]. The research used combination of quantitative and qualitative approach. The quantitative approach used soil surveying, while the quantitative approach used Causal Loop Diagram (CLD). Soil samples were taken from Sumber-Wangkal and Sumber-Cokro Springs. Laboratory analysis was applied to get soil properties, including permeability, porosity, soil structures, and soil textures. These information will provide the overview of soil suitability of bamboo plant [18]. CLD Models were built based on key-informant’s interview, field observation, and literature review. Key-informant interview is a qualitative approach to understand the social community condition [19]. It was proper to be implemented for limited person of the community [20], who understand the water conservation management. The key-informant involved in this research was Technical Division members of PAMDES Jedong. They were chosen as informants since they had special task to ensure water availability and water distribution in Jedong village. CLD model is widely used to understand the rural water management [12], [21]. CLD model will provide the real information of the water conservation management [22]. This research used analytical description to elaborate and to analyze land condition, bamboo promotion as water conservation plant, and water resource conservation model in Jedong.
3. Results and Discussion

3.1 Soil Condition

Sumber-Cokro [23], and Sumber-Wangkal spring are the main water sources for Jedong community. They are on the mixed forest-garden land use. Most vegetation are bamboo, bushes, and trees (Figure 2b and 3b). The water springs were collected in the water storage tank (Figure 2a and 3b). Then, the water flows through the distribution pipeline to the community. The community water use is about 150 litters/house. Some of the water coming out from spring flows into the river which is at the bottom of the valley.

![Figure 2. Sumber-Wangkal Spring. (a) Red Line: Water Storage Tank, Blue Line: Springs ; (b) Vegetation around the spring (Source: field documentation)](image)

![Figure 3. Sumber-Cokro Spring. (a) Red Line: Water Storage Tank; (b) Vegetation around the spring (Source: field documentation)](image)

Laboratory analysis includes the analysis of permeability, porosity, soil structure, and soil texture (Table 1). The permeabilities of soil samples are 0.948 cm/hour in Sumber-Wangkal dan 0.776 cm/hour in the Sumber-Cokro. It means that the soil permeabilities are slightly slow. Permeability is the soil ability to release the water. Soil permeability as an indicator of water drainage rate [18]. Soil permeability related to the soil porosity. Porosity is the percentage of soil pores, and the soil ability of aeration rate [18]. The soil porosity of the springs is very bad (21% dan 31%) since of sandy clay loam texture. Meanwhile, the texture is very good for bamboo growth and it’s productivity [24]. Soil structure related to the soil stability against erosion. Soil structure of Sumber-Wangkal is better in its stability than the one of Sumber-Cokro which has slightly stable in its structure. Intensive managed soil will weaken the soil stability structure. Bamboo will reduce the erosion factor [3].

Water restoration in the degraded land can be supported by bamboo plantation [25], besides woody plants and fruits trees [26]. Bamboo roots can absorb rainwater up to 90%, and increase the groundwater...
storage [26]. Bamboo improves hydrological function, so it is very important to plant bamboo in rural areas [5], especially around the spring [26].

| No. | Characteristic Variables | Sumber-Wangkal | Indicator | Sumber-Cokro | Indicator |
|-----|--------------------------|----------------|-----------|--------------|-----------|
| 1   | Soil Permeability (cm/hour) | 0.948 | Slightly Slow | 0.776 | Slightly Slow |
| 2   | Soil Porosity (%) | 21 | Very Bad | 31 | Bad |
| 3   | Soil Structure (mm) | 0.7872 | Stable | 0.4473 | Slightly Stable |
| 4   | Soil Texture (%) | - Sand 75 | Sandy Clay Loam | 66 | Sandy Clay Loam |
|     | - Loam 0 | Loam | 0 | Loam |
|     | - Clay 25 | | | 34 |

Source: Primary Data

3.2 Water Resources Conservation

Sustainability concepts of the water resources conservation have 3 pillars: social, economic, and environment [27]. Each pillar will influence each other to support the sustainability. Key-informant was interviewed to identify the Water resources conservation efforts of Jedong community. The interview was focused on the sustainability efforts of PAMDes related to water resources conservation. PAMDES is under the Village-Owned Enterprise (Badan Usaha Milik Desa/BUMDes) management. BUMDES is an autonomous [28], and dynamic [29] village organization. PAMDes is a community empowerment manifestation [30]–[32]. It has responsibility to manage the water drinking of the Jedong community. There are 2 important things regarding to water management for the Jedong community. They are the role of PAMDes for drinking water management, and spring conservation efforts. PAMDes chose bamboo as a conservation plant because it was multipurpose plant and could grow easily. Water resources conservation efforts cannot be separated partially from the dynamics relationship between water and humans [12]. Figure 4 shows the Jedong Water Resource Conservation (JWRC) Model. JWRC Model using Causal Loop Diagram (CLD). CLD is a System Dynamic approach to provide an overview among the variables that works in the real system [33]. Hirijanto [22] explained that CLD is a basic model that very close to the real world. Ganjidoost [34] used CLD to describe the Integrated Asset Management of Water Distribution. CLD also be used by Neely [21] to model a rural water services in Timor Leste. Masitoh [12] used CLD for understanding the spring conservation through people beliefs and their ritual. JWRC model in this research have 2 subsystems. They are Social Subsystem (SS) and Water Subsystem (WS). Social subsystem includes Water Prices, Population, Water Distribution, PAMDes Water Management, and Conservation Education. WS includes Groundwater Storage, Springs Discharges, Water Consumption, Water Infiltration, Run-Off, Bamboo Plants, and Land Suitability. JWRC model and the Neely model [21], showed the best scheme of the community-based management for a sustainable rural water services.
Rural drinking water management have been widely applied [30], [31]. PAMDes Jedong is the main agent to manage the Jedong water resources. PAMDes served water distribution and maintained its infrastructure. Water springs was distributed to people's houses (Figure 5a and 5b). Water Consumption will increase if Water Distribution increase (Figure 4). Jedong community must pay the price for water that they used. The water prices were determined by PAMDes and village apparatus. Every month, the community will receive the water use cost receipt to be paid. The average water use cost of Jedong community was ranging from 8,000 – 15,000 rupiahs for each house per month. The paid cost was used for water infrastructure maintenance. Water price impacted to Water Consumption. If PAMDes increases the water price, so the Water Consumption will decrease. The increased number of people using the water will increase Water Consumption (Figure 4). PAMDes also collaborated with many universities related to the conservation education projects. Their collaboration included promotion of bamboo as a conservation plant (Figure 6a), and bamboo planting projects (Figure 6b).
Figure 6. Conservation Education, (a) Bamboo Plants Socialization by university, (b) Bamboo planting project (Source: field documentation)

JWRC Model have 3 loops: Loop B1, B2, dan B3 (Figure 4). Loop B1 showed the interrelationship among Groundwater Storage, Groundwater Wells, dan Water Consumption. The interview results stated that the high availability of groundwater will increase the groundwater wells use. This condition is similar to Pophare's research [35] about the high use of groundwater for irrigation in Nigeria. Loop B2 is the interrelationship among Groundwater Storage, Springs Discharges, dan Water Consumption. The key-informant stated that information about the potency of groundwater coming out from springs and wells will be able to improve the water services. High water services increased the water consumption. Wang’s research [36] mentioned that a lot of people activity would more increase the water consumption. The water consumption would decrease groundwater storage, then [37].

Loop B3 of JWRC model is an interrelationship among Groundwater Storage, Environmental Carrying Capacity, Bamboo Plants, Run-off, Water Infiltration. Water resources condition would influence the Environmental Carrying Capacity/ECC [38]. Good ECC conditions and the high motivation of PAMDes in water resources conservation efforts, will help promoting bamboo as a water resource conservation plant (Figure 4). The growing bamboo reached more than 60% in a month after bamboo planting project. The bamboo growth was indicated by the growth of new leaves and stems (Figure 6b). The planted bamboo will be able to reduce run-off [7], so it is good for water resources restoration [2]. Ato’s research [39] showed that bamboo is a multipurpose plant. Conservation of water resources using bamboo takes a long time. It is based on the experience of water conservation in BonPring Turen by BUMDES since 2015 [40]. The planted bamboo is able to conserve water resources for the village community besides to be as a bamboo ecotourism [41]. Ben-zhi’s research [42] also proved that bamboo forests have important role in water conservation. If PAMDes implements water conservation using bamboo, so groundwater storage will able to be increased [43]. Bamboo can be the recommended plant for water resource conservation in Jedong Village.

4. Conclusion

Water resources sustainability is very important to be noticed by the community. The Jedong community have been using springs as the main water source to fulfil their water needs. Sumber-Wangkal and Sumber-Cokro have low soil quality based on the soil samples analysis. Low soil quality can be improved by bamboo planting. Jedong Water Resources Conservation Model showed the water resources management by Jedong community. PAMDes is the village-owned organization to manage the water management. Water resources conservation is important for PAMDes to assure water availability for the community. Bamboo planting projects can be a natural way to conserve water resources. Appropriate soil condition and high motivation of PAMDes in water conservation effort will improve successfulness of bamboo planting project. Water resources conservation means ensuring the water sustainability of water availability for Jedong community. The further research is expected to use...
this research findings for more promoting and planting bamboo analysis to ensure water resource sustainability in Jedong.

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