Potential and Challenges of Karst Water Resources in Sumbermanjing Wetan District of Malang Regency

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Abstract. Water is one of the primary needs of all living things. In order to figure out the potential of water resources, we need to conduct a study about water supply. This study of water resources was conducted in Sumbermanjing Wetan district located in the southern part of Malang Regency. This study is limited to the initial review of the existence of potency water resources in the study area, without including a quantitative aspect of the water resources. The first identification was collecting the data of water resources found in Sumbermanjing Wetan, and then analyze them descriptively. This step was to figure out the potential and challenges of water resources in Sumbermanjing Wetan. The result of this study showed that there were water resources in the form of spring, surface water, and subterranean river. The big volume of spring had been used by the people to fulfill their daily needs. However, the changing of the karst landscape had produced pollution around the settlement. Besides, there was volume decreasing of the spring, and so was the water supply for the people. The people could make use of other water resources such as the subterranean river that flow a whole year to overcome the problem. The most potential subterranean rivers are in Mbah Wajib Cave, Limbah Cave, Krompyang Cave, Kedung Pitu Cave, and Emas Cave.

1. Introduction

The karst landscape is unique in terms of hydrology. Hydrological characteristics in the karst region include various levels of infiltration, subsurface river flow and the outputs (seepage, springs) originating from the karst system [13]. The distribution of water flow in karst passes cracks of rock which then is connected by underground rivers. The karst function itself is as storage and source of water, whereas the epikarst zone and underground river system are reservoirs and natural underground waterways [6].

Water resources in karst will come out in springs, and some will flow to the surface and will be stored in underground rivers in cave passageways. These water resources can be utilized by the community. Utilization of water in karst can be in the form of springs for domestic needs [11], RHSs (Rainwater Harvesting System) or from underground rivers.

Some karst areas have almost the same difficulty, which is getting water resources, considering that karst landscapes are predominantly subsurface rivers than surface rivers [2],[3],[5]. This is what causes the karst areas, especially some areas in Indonesia are often experiencing drought, even though it has abundant water resources below the surface [5].

Sumbermanjing Wetan District has a karst landscape. Where caves, springs, and underground rivers [8],[10] are presented. From the description of previous results of the study, further identifications need to be done to determine the potential of karst water and the challenges that may occur in the study area related to karst water resources.
2. Method
This study was conducted in the karst landscape in Sitiarjo and Tambakrejo Village, Sumbermanjing Wetan District, Malang Regency by identifying existing karst water resources. This study is limited to the initial review of the existence of potential water resources in the study area, without including a quantitative aspect of the water resources. Furthermore, a descriptive analysis is performed to illustrate the condition of those water resources. After that, in-depth identification of the existing problems is done so that those water resources can be utilized by the community.

3. Results and Discussion
Karst water resources in Sumbermanjing Wetan sub-district are coming from springs, surface runoff (rivers, lakes) and underground rivers. The distribution of water resources can be seen in Figure 1. The existence of these water resources is mostly found in the southern part of the study area. The results of field surveys that have been carried out, a total of 36 springs have been successfully recorded and described. The springs of the Sendang Biru karst area are located in valleys, hollows, and buckling slope areas. The springs in the valley are upstream, but generally, these springs are seasonal springs or epikarst springs, which supply perennial rivers. In the northern part of the study area, there are springs with large discharges, which are located on buckling slopes on hills, such as Pasyen springs, Mbos springs, and Mbah Adjji springs. The bend section of the slope is also found in the Gambir spring downstream. Springs that flow seasonally, are generally used by residents to flow through rice fields or fields. Perennial springs that have large potential flowed to villages in the Sendang Biru Karst Area, such as Sendang Biru springs, Pasyen, and Mbos springs.

3.1 The existence of springs
The utilization of water resources in the study area has been used for daily needs. Fig 2 shows the utilization of springs in the northern part of the study area. The utilization of the springs flow is done by using gravitational. The spring that uses gravitational systems are Pasyen and Mbos spring. Pasyen spring flows towards Sendang Biru, while Mbos spring goes to Kedungbanteng Village. The springs in the northern part are also found in valleys, where the springs will flow into the Clungup river, which is used for irrigation by the surrounding community. The spring in the southern part of the study area is found in the forest and dry fields, so that the spring is still clear and clean.
Water resources in the southern part of the study area have been utilized by the community. The springs that appear on the surface are accommodated first and then taken to the village community's house. Sendang Biru spring has been utilized by the residents as PDAM (Regional Water Utility Company), where this spring is used to supply water to the people of Sendang Biru Baru village and the surrounding coastal areas.

3.2. The existence of surface runoff
In the study area, it is difficult to find any surface flow during the dry season. Rivers are commonly dry, unless by getting inputs from springs, such as Mbos and Pasyen springs. During the rainy season, many Karst surfaces have streams or puddles (Fig. 4b). At the top of the study area, there are some swamps in several study areas (Fig. 4a) which is generally used for rained rice needs. Surface run-off flows from
the overflow from the seepage of the hills, and collected on the overflow. During the dry season, this flow will disappear (Fig. 4c). Meanwhile in rivers originating from the spring recharge (Fig. 4d), it keeps flowing during the dry season in lesser debit.

3.3. The existence of underground streams

The karst landscape is noticeably by the existence of caves. Among those caves, some have underground rivers. This also exists in the study area, where the development of underground rivers is highly potential. Some of the examples is Mbah Wajib Cave (Fig. 5b), Limbah Cave (Fig. 5c), Krompyang Cave, Kedung Pitu Cave (Fig. 5d), and Emas Cave (Fig. 5a). The existence of the underground river flow has not been utilized by the surrounding community due to the high consideration of the cost.
The uniqueness of the karst landscape in the study area needs to be maintained because its existence is very influential on the existing of water resources. Here are some things that need to be considered in safeguarding karst water resources.

3.4. Karst landscape damage as "natural reservoir"

According to [4], karst hills act as the main reservoir in the karst region, in which the water moves very quickly and immediately to the sea as a conduit flow. This karst hill surface zone is called the epikarst zone, which is a zone where water is concentrated from the results of rainwater infiltration. The epikarst zone has permeability and porosity due to the widening of the gap from the result of dissolution compared to other layers [7]. This makes it a good storage zone because it contributes to the mainstream flowing in the underground river during the dry season.

The existence of epikarst is important, considering its function capacity to absorb, store and transmit precipitation [12]. The challenge in the water resources in the karst area is that the logging activity that will cause damage to the epikarst layer at the top of the karst hills. It is going to decrease the amount of stored water. Besides, rainwater will be difficult to absorb and disappear through the evaporation process so that it cannot be utilized. This will cause the amount of groundwater recharge decreased [5]. Changes in the morphology of the karst landscape will also affect the circulation of the water system in karst or other words, the volume of the absorbed karst groundwater component (infiltration, autogenic, allogenic, direct recharge, etc.) depends on the distribution and the number of potholes [1].

The morphological condition of Sumbermanjing Wetan District’s karst area showed some human-caused changes. Therefore, it needs to be preserved. Figure 6, shows that the karst looks like a "natural reservoir" that holds rainwater falling to the surface. This reservoir will release water on the ground or the plains (bend the slope). This is indicated by the existence of large water sources in residential areas, which are the water output from the natural reservoir. [4] explains another thing related to one of the advantages of karst springs is the long delay between the rain to come out to the spring so that some karst springs will have a large discharge during the dry season. This is why karst areas are often dubbed "giant freshwater tanks" that can be used to meet the needs of human life [4]. In addition, uncontrolled limestone mining will damage the caves around the study area. This is evident from the study of [9] who conducted studies in Albania where caves have been destroyed or severely damaged and polluted by humans due to mining.
3.5 Utilization of underground rivers in the future

The southern sub-district of Sumbermanjing Wetan has progressed in tourism and economy sectors, as well as the increasing population in the area will affect the water demand in the area. Water needs in the study area used to fulfill the domestic water needs by utilizing springs [8]. The spring is to fulfill the needs of villagers. The morphological and hydrological characteristics of the karst area in the study area are autogenic areas originates from rain water, which is subsequently deposited and flowed back into the underground river, and some karst springs are released. However, developments in the study area experienced a change in the form of land use changes that bound water resources not stored first, but went straight into the underground river and exited quickly at the spring, this was seen when the rain arrived, where springs were in the study area become turbid (Fig 6). Ford and [12] in [2] revealed that the condition of karst aquifers is still good if the karst springs have a peak discharge response about 3-4 months after the peak rain occurs. This means that the karst hills or topography on the surface are still able to become regulators and slowly grind to underground springs or rivers.

The increasing of future water demand and problems related to water shortages during the long drought need to be solved to meet the needs of the community. The potential that exists in the study area is not only the existence of springs but the existence of underground rivers that flow throughout the season in varying discharge. The underground river in the study area includes the underground river Mbah Wajib Cave, Limbah Cave, Kedung Pitu Cave, Krompyang Cave, and Emas Cave. The five underground rivers are still not utilized by the surrounding village community, considering the removal of the underground river costs a lot. The five subterranean rivers, the underground rivers in Mbah Cave should bring more benefits, due to the place is near the settlements and have high flow. Besides, SBT Gua Emas also has easy access, because it comes out of the mouth of the cave, but has not been utilized by the surrounding community.

3.6. Pollution of water resources

Mining, agriculture activities and also population pressure keeps increasing. The study area is a tourism destination and the southern way of Java Island that will be developing. The relation to the existence of water resources is the risk of pollution. The subordinate river that is dominated by cave passageways that are connected to the surface is highly at risk of pollution. [5] explains that this condition is caused by the water entering the aquifer through the conduit which does not allow soil disturbance. This causes pollutants easily contaminate groundwater in the karst region. Unlike the water that flows through infiltration, which will slowly flow through the karst hill (epikarst) which will then flow into the underground river through droplets or seepage through filtering first.

[9] provide a description of conditions in Albania with agricultural and population intensities, resulting in a decrease in karst water quality, in addition, company waste is disposed of on doline or rivers without prior action. This has been seen in the study area, with the disposal of waste that goes directly to the cave passage, where there is no more filtering and it will mix with underground rivers in Limbah Cave. Another thing that causes contamination of the underground river is the disposal of garbage at the mouth of the cave, and when it rains, the garbage will enter the underground river. The community around the cave needs socialization and understanding in order to protect the environment around the cave.
4. Conclusion
The results of the study show that there are some forms of water resources, such as springs, surface rivers, and underground rivers. Springs with large discharges have been used by the community for their daily needs. However, the change of the karst landscape pollutes the settlement and decreases the discharge of the spring. Therefore, the water that supplies the community is decreasing. To overcome this, there is another untapped water resource the flows throughout the year, which is the underground river. Some of the high potential underground rivers are located in Mbah Wajib Cave, Limbah Cave, Krompyang Cave, Kedung Pitu Cave, and Emas Cave.

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