Water resource potential at Sekaran Village, Bojonegoro Regency, Indonesia

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Abstract. Water is an essential element for agriculture, including fodder cultivation. The fodder production for School of the Community Farming (SPR) was planned to be located at Sekaran Village, Bojonegoro Regency, Indonesia. Sekaran Village always has water shortage particularly during the dry season. Sekaran Village is located in East Java and the river discharge was low. The study was conducted to evaluate the quantitative potential of water resources from both surface and groundwater. The surface water potential was analyzed based on discharge measurement at the river and rainfall potential at the village. According to river discharge and rainfall potential, several small reservoirs could be designed to collect rain water during the wet season and the location for planned reservoir was also examined. Furthermore, the groundwater potential was assessed based on a geoelectrical survey at 20 points of measurements within the study area. The discharge of the river was 1.43 L/sec and of the spring was 0.62 L/sec. The results showed that the groundwater potential was low with only less than 1 L/sec. However, this could be maximized by constructing shallow wells. To choose the reservoir and wells locations, aerial mapping was conducted to portray the topography. The research result could be used by the farmers to design their agricultural activities including developing SPR.

1. Introduction
Water has diverted functionality of needs, which is not only significant for drinking purposes but also for many developments as well [1]. Not forget to mention, water is an essential element for agriculture, including fodder cultivation. Apart from the excess of water which can lead to flooding [2], lack of water can cause drought which can impact agriculture and livestock. Besides the influence of land use changes [3], one of the solutions to reduce drought in an area is to explore the potential of water resources in the area. Therefore, water resource potential is important to be assessed prior to the fodder production plan. Several studies on the potential and management of water resources have been carried out, such as those conducted by [4]. The researches result stated that the potential of water resources can be identified by utilizing the hydrological cycle and groundwater. The research was conducted in Sekaran Village because the fodder production was planned to be located at Jar Kulon Hamlet and Jar Wetan Hamlet in Sekaran Village, Bojonegoro Regency, East Java Province. The Sekaran Village had a School of the Community Farming (SPR) and required animal fodder for the needs of the cattle in SPR. Sekaran Village always had water shortage particularly during the dry season, because the wet season was short. The low river discharge in the Sekaran Village is due to the minimum rainfall and low groundwater potential. The study was conducted to evaluate the potential of water resources to fulfill water demand in the Sekaran Village.
2. Objective
This study aimed to analyze the potential of water resources to fulfill agricultural needs and animal feed from surface water including effective rainfall and shallow groundwater.

3. Methodology
Analyses of surface water potential were conducted by calculating river discharge, runoff discharge, and effective rainfall. The runoff discharge was calculated using the rational method and the river discharge was collected by measurement. The planned rainfall was calculated using rainfall data of 10 years and several distribution methods such as log Pearson III, log normal, and Gumbel. The rainfall harvesting could be conducted by constructing small dams or embung at several locations. Therefore, one of the significant elements, the terrain model of the area, were required to be established as part of the surface water resource studies [5]. Mapping the relief of the research location was conducted using a drone and global positioning system real-time kinematic (GPS RTK). The result of measurement using the drone was processed by photogrammetry which was developed since 2013 [6]. The photogrammetry process was conducted using Agisoft Photoscan Professional 1.2.7 [7] to get an orthophoto. Groundwater potential was predicted using the geoelectrical method, an undersurface approach to explore groundwater [8]. The result of geoelectrical measurements was analyzed to get resistivity values. Keller and Frischknecht [9] and Telford et al [10] showed the resistivity values of rocks, soil, and minerals. The resistivity values were used to identify the soil layers and to predict the availability of the aquifer. By analyzing the aquifer, the potential of groundwater could be calculated.

4. Results and discussion
4.1. Surface water
Surface water resources in Ngantru Hamlet were a river and springs. The existing river was small and located around SPR Mega Jaya with a river width of ±1.5 m. The river discharge was measured using the current meter and the discharge was 1.43 L/sec. The spring Sendang Kidul was located also near SPR Mega Jaya and had a discharge of 0.62 L/sec. Runoff discharge was calculated based on the maximum rainfall at a certain return period. Using the log Pearson III distribution method, the daily rainfall of 5 years return period was 155.4 mm, and the runoff discharge at Jar Kulon Hamlet was 0.53 m$^3$/sec.

4.2. Geographical condition
Sekaran Village is located in Kasiman Subdistrict, Bojonegoro Regency (Figure 1). The village has three hamlets, i.e. Jar Kulon Hamlet, Jar Wetan Hamlet, and Ngantru Hamlet. This village was a village of farmers and breeders where most of the population worked as farmers/ranchers. The area was 1632 ha with a rice field of 518 ha, dry land of 370 ha, plantation of 10 ha, settlement, and public facilities of 42 ha, forest of 692 ha.

4.3. Mapping
Mapping in this study aimed to evaluate the relief of the research location and was conducted using a drone and global positioning system real-time kinematic (GPS RTK). The topographic map was showed in Figure 2 and was used to choose the suitable location of embung.

4.4. Location of embung for rainfall harvesting
After obtaining a topographical map, the location of the reservoir (embung) for rainwater harvesting could be analyzed. The location of the embung was shown in Figure 3. Based on topography and basin analysis, the location of the reservoir as a rainwater harvesting was in the north of Jar Kulon Hamlet at coordinates of 7°6′33.102″ S and 111°38′46.122″ E and at an elevation of 48.5 masl.
At this location, there is a sloping empty land so that it can be used for the reservoir with a square shape of 41 x 41 m and a depth of 2 m. The surface area for *embung* was 1681 m² and a storage volume of 2894 m³.

**Figure 1.** Location of Sekaran Village

**Figure 2.** Topographic map in Jar Wetan and Jar Kulon Hamlet
Figure 3. Location of embung as rainharvesting

Figure 4. Location points of geoelectric measurement (the red point)
4.5. Shallow groundwater potential

The potential for shallow groundwater was surveyed using the geoelectric method. The measurements were conducted at 20 location points and were processed with 3D cross-sectional modeling based on the resistivity of the rock. The locations were divided into sections A-B, C-D, E-F, G-H, and I-J. The A-B, C-D, E-F, and G-H sections were given in Figure 5.

![Figure 5](image)

After analyzing data of 20 points and dimensioning the cross-section, it can be seen that the potential for shallow groundwater is in the G-H and I-J sections. The G-H section was presented in Figure 6 and the I-J section was shown in Figure 7.

The GH cross-section has geoelectric sample points BJ.6, BJ.7, and BJ.8 with a relatively elongated groundwater content in the sand layer in areas up to a depth of 5-35 m. There was a confined aquifer layer in the clay layer where the sand was inserted, but the presence of water was small to insignificant.

The cross-section of I-J was in the hilly area of Sekaran village. In the cross-sectional area of I-J, there are geoelectric sampling points for BJ.18, BJ.19, and BJ.20. The results showed relatively good groundwater potential and two layers of sand could be classified as free aquifers and confined aquifers. It had long distribution (wide distribution) with a depth in the free aquifer of 5-10 m and in the confined aquifer of 15-35 m, such as was shown from the IJ driver (figure 7). Based on the analysis result of 20 location points of the geoelectric survey, the groundwater potential was found at a shallow depth of up to 20 m (free aquifer).
Figure 6. Cross-section G-H based on resistivity value

Figure 7. Cross-section I-J based on resistivity value
5. Conclusion
The results showed that the groundwater potential was low with only less than 1 L/sec. However, this could be maximized by constructing numerous shallow wells, since the sand layer was indicated near the surface. The reservoirs and wells locations were chosen based on the topography map and were plotted on the map. The river discharge was 1.43 L/sec and the spring Sendang Kidul had a discharge of 0.62 L/sec. Based on the rainfall with 5 years return period of 155.4 mm, the runoff discharge at Jar Kulon Hamlet was 0.53 m³/sec. The research result could be used by the farmers to design their agricultural activities including developing School of the Community Farming (SPR).

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