Groundwater and reservoirs interaction in its use for irrigation, Case study: Wajo Regency, South Sulawesi Province, Indonesia

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Abstract. The use of groundwater for irrigation in the Wajo Regency has been going on since the 2000s. The use of groundwater has the potential to cause high production costs, which can reduce farmers’ income. The Government of Wajo Regency provided a solution to this problem through the reservoir development program. However, the impact of the construction of reservoirs on environmental conservation is not yet known. Therefore, it is necessary to conduct research that aims to determine reservoirs’ effect to fulfill plant water needs and their impact on the environment. The study was conducted by direct measurement in the field of the observed variables. Some data are obtained in real-time using sensors such as rainfall, groundwater level changes, surface water level, and evaporation data. Data were analyzed using the water balance approach. The results showed that the construction of reservoirs to meet the water needs of plants could reduce the radius of the influence of groundwater extraction for irrigation which has so far reached 50-100 m, as well as reducing the decrease in groundwater level during pumping, which originally reached more than 5 m. The reservoir can increase the groundwater level as indicated by the increase that occurs when the surface water level increases.

1. Introduction

The use of groundwater for irrigation in the Wajo Regency has been going on since the 2000s. The use of groundwater has the potential to cause environmental damage, such as declining groundwater levels [1]. If this condition occurs for a long time, it can cause land subsidence [2], seawater intrusion [3], and the economic impact is that farmers suffer losses due to high costs. The negative effect is even

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more significant if the pumping lasts a long time, such as that carried out by farmers at the research location, which can exacerbate the decline in groundwater levels [4]. The Government of Wajo Regency provided a solution to this problem through the reservoir development program. The construction of the reservoir is intended so that the change in groundwater level when pumping is carried out is not too significant to reduce environmental impact and decrease the discharge during pumping so that additional costs do not occur. When the pumping is stopped, recovery will be achieved quickly.

However, the effectiveness of reservoir construction in reducing the negative impact of groundwater extraction for irrigation is not yet known, so it is necessary to study the effect of the reservoir in minimizing the decrease in groundwater level through observations on monitoring wells. The effectiveness of the construction of an embung is based on the interaction between groundwater and surface water in the reservoir.

Therefore, it is necessary to carry out research to determine the construction of embung on groundwater extraction to meet the needs of plant water and its effects on the environment.

2. Materials and methods

3. Study area

The research was conducted in Data Sub-watershed, located at 4°5’35” - 4°5’38” S and 120°4’4” - 120°4’8” E, Wajo Regency, South Sulawesi Province, Indonesia. The research area was a rainfed paddy field and sometimes uses groundwater to meet the needs of rice plants. At the research location, five measurement stations were installed, as shown in figure 1.

![Figure 1. Layout research.](image-url)

4. Instrumentation and collect of data

The research was conducted by direct measurement in the field of the observed variables. Some data are obtained in real-time using sensors such as rainfall sensors for measuring rainfall, groundwater level changes, and surface water in the reservoir using the HDL-300 sensor and rainfall measured using a rainfall sensor.

Each station was placed on a measuring instrument. At station 1, a measuring instrument for surface water level was placed on the reservoir, rainfall, and evaporation. In contrast, groundwater
level measurements in production wells and monitoring wells were set at stations 2 to 5. Installation of measuring instruments as in figure 2.

Figure 2. Measuring instruments.

Data collection was carried out in two different conditions, namely before and after the reservoir was constructed. Data before the reservoir was constructed consists of a decrease in groundwater level measured directly at the time of pumping and carried out at production wells. The length of the influence radius and groundwater-surface contours were predicted using the 2-dimensional groundwater flow model applied at the study site [5]. Data collected after the reservoir was built consisted of changes in the groundwater level in the monitoring wells and the water level in the reservoir built, both during the dry season and during the rainy season.

5. Data analysis

The relationship between groundwater storage changes and groundwater level changes can be estimated using the water balance approach [6]. The water balance equation used is:

\[ P = Ea + I - RO \pm \Delta S \]  \hspace{1cm} (1)

Where P is Precipitation, Ea is evaporation, I is irrigation, RO is runoff, \( \Delta S \) is Change in water storage in the system.

To determine the interaction between groundwater and surface water, it was carried out based on fluctuations in groundwater and surface water [7] in monitoring wells and reservoirs. The interaction is known through the two data, which are compared with each other.

6. Results and discussion

7. Groundwater level without reservoir

Figure 3 and 4 were the result of research before the reservoir was made. The radius of influence reaches over 50-100 m in a drawing with a scale of 50 m, contour of groundwater level as a basis for knowing the radius of effect.
8. **Groundwater level with reservoir**

After creating a reservoir, the change in groundwater level is less than 1 m because groundwater is supplied from the reservoir. This shows that the reservoir has a significant influence on groundwater intake, as shown in figure 5.

9. **Respons reservoir from rainfall and impact to groundwater level**
The water in the reservoir is strongly influenced by rainfall through the runoff. If there is rain, the water in the reservoir will rise, which is shown in the graph where the water level in the reservoir will increase every time there is rain. This has a positive impact by adding groundwater recharge.

![Graph showing changes in water level due to rain](image1)

![Graph showing changes in groundwater level due to rain](image2)

**Figure 6.** A rhythmic fluctuation of groundwater and surface water as an indicator of an interaction.

Every time it rains, the groundwater level will increase to the maximum. This increase is due to infiltration from rainwater, surface runoff, and infiltration [8]. Between the embung and groundwater, it can also be seen from the changes in the groundwater level and groundwater level together, where if the water level in the embung (figure 6a) increases, the groundwater level in the monitoring wells (figure 6b) also increases.
10. Conclusion
With the existence of a reservoir, groundwater extraction to meet water needs for irrigation does not significantly affect the decline of groundwater levels, and the radius of influence is not too large. The reservoir can also increase the groundwater level as indicated by the increase that occurs when the surface water level increases. This is because the water in the reservoir fills up groundwater.

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