インドネシア番テン州クレンチェン貯水池の水収支分析
Water balance analysis of small reservoir in krenceng watershed, Banten province of Indonesia

サプトラ セプティアン ファウジ ドゥイ*, アティコツン フィトリヤ**, 加藤 亮**
Septian Fauzi Dwi Saputra*, Atiqotun Fitriyah**, Tasuku Kato**

1. Introduction

The effectiveness of reservoir operation and management is essential for resilience and sustainable water resource under climate change condition. The purpose of this research is to identify and analyze water resource components (inflows and outflows) in order to establish water balance of the small reservoir.

2. Study area and methods

Krenceng reservoir, as part of Krenceng watershed, is located in Cilegon City, Banten province of Indonesia with the capacity of around 5 million cubic meters (MCM) and surface area of 1.09 km^2. The watershed area is approximately 15 km^2, with two rivers that flow to recharge reservoirs. The Krenceng dam, built in 1984, is main water resource to supply water needs for domestic, industrial and agricultural sectors. A Cidanau river from the neighbor watershed, 25 km away, also provides raw water to Krenceng reservoir as an option water resource. According to Koppen's classification of climate types, the study area belongs to type of tropical rainforest and is dominated by monsoons.

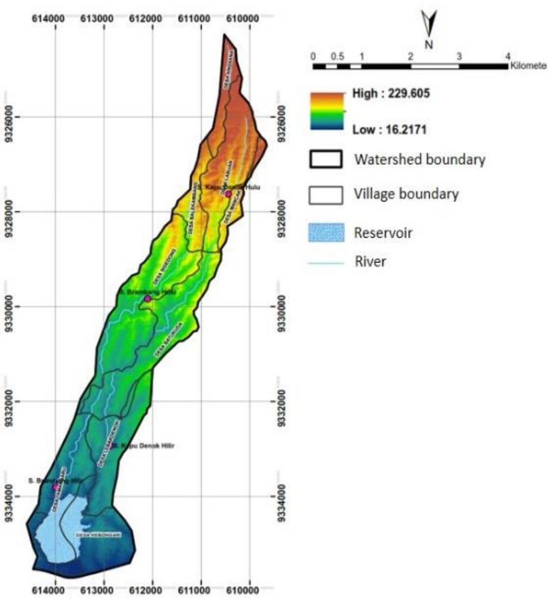

Fig.1 Location of Krenceng reservoir

The water balance was calculated using the principle of mass conservation and identified as the storage equation, in which disparity between total inflow and outflow is balanced by changes in storage over a given period of time. The following equation can be used to express the water balance for a reservoir in the study area:

$$\Delta Vs = Vin + Vpcp - Vevap - Vinf - Vsp - Vwd \qquad (1)$$

Where ΔVs is change of water storage in the reservoir (m^3) at time step; Vin is inflow into reservoir summarize both Krenceng and Cidanau rivers (m^3); $Vpcp$ is rainfall onto reservoir surface area (m^3); $Vevap$ is evaporation (m^3); $Vinf$ is infiltration loss (m^3); Vsp is spills out of the reservoir (m^3) Vwd is water withdrawal (m^3).

The evaporation loss from the reservoir was estimated by using a simplified formula for Penman evaporation model (Valiantzas, 2006) by the following equation:

$$Eo = 0.047\ \sqrt{Ta + 9.5}\ - 2.4\ \left(\frac{Rs}{Ra}\right)^2\ + 0.09\ (Ta + 20)\ \left(1 - \frac{RH}{100}\right) \qquad (2)$$

Where Eo is evaporation (m.day^{-1}); RS is global radiation (MJ.m^{-2}.day^{-1}); Ra is extraterrestrial radiation (MJ.m^{-2}.day^{-1}); Ta is average air temperature (^{o}C), RH is relative humidity (%). Then, the efficiency of water use that was expressed in terms of water application efficiency (EA) can be defined as follow:

$$EA = 100 \times \sum Vwd / \sum Vin \qquad (3)$$

3. Ongoing results and discussions

The water elevation fluctuations of Krenceng watershed were observed from 2019 to 2021, ranging from 16.79 to 20.38 m. The minimum reservoir levels were recorded at the end of November. Meanwhile, the maximum reservoir levels were recorded at beginning of July. The water withdrawal was low from April to July, so the reservoir level was increasing.

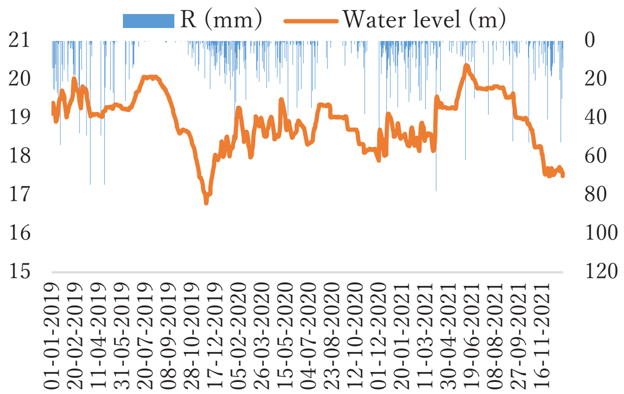

Fig.2 Rainfall and water elevation

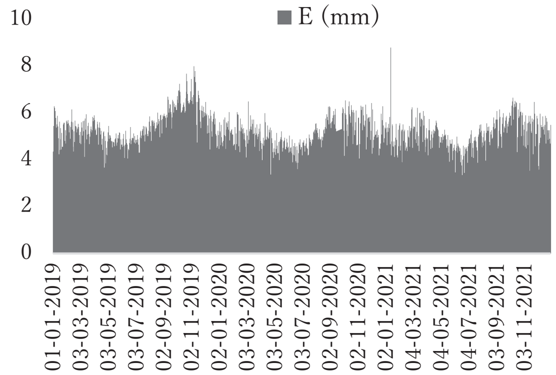

Fig.3 Daily evaporation

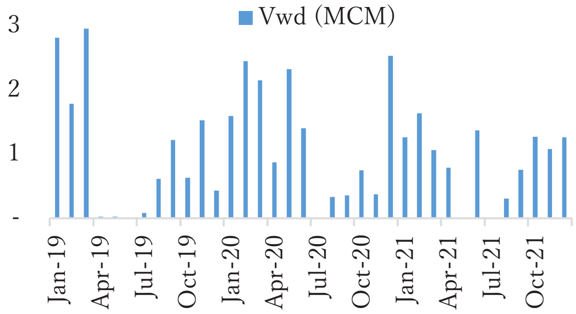

Fig.4 Water withdrawn

From 2019 to 2021, total rainfall was 1309 mm, 1465 mm and 1513 mm, while the total evaporation was 1981 mm, 1847 mm and 1849 mm, respectively. The average amount of water withdrawn as outflow was calculated 1.1 MCM.month^{-1} and maximum amount was in January in the rain season is around 2.5 MCM^{-1}, but the spill out from reservoir is none. The catchment's contribution to reservoir storage volume appears from streamflow of 2 intermittent rivers, including runoff and groundwater as base flow. In addition, inflow for reservoir comes from Cidanau river as backup to supply water needs. This research can be used to provide the data to improve water resource management for resilience in facing the climate change and land-use change in the future.

*東京農工大学連合農学研究科, United Graduate school of Agriculture, Tokyo University of Agriculture and Technology. **東京農工大学 Tokyo University of Agriculture and Technology, Keywords: resilience, small reservoir, water balance, water resource