The effectiveness of detention basin in Soursoup (*Annona muricata* L.) farming land of Selopamioro village – Bantul, Yogyakarta

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Abstract. Soursop fruit is rich in health benefits. The soursop plants (*Annona muricata* L.) have a great potential to be cultivated in Indonesia. It requires an enough water availability in the land to optimize biomass production through photosynthesis. Soursoup farming in dry land Selopamioro Village – Bantul, Yogyakarta needs irrigation. Due to geomorphological condition, water resources for irrigation mainly from harvested rainfall in detention basin (local name “rorak’”). This study was aimed to determine the effectiveness of detention basin Soursop farming land in storing the rainfall which later used them for irrigation. The material includes the coordinates of the research location, Soursop farming land boundaries, and detention basins. Furthermore, the daily climate data in the form of rainfall, temperature, net solar radiation, wind speed, atmospheric pressure and relative humidity were used to calculate reference evapotranspiration. The reference evapotranspiration (ETo) was computed by Penman-Monteith approach. Later, it was used to determine plant evapotranspiration (ETc) using the soursop plant coefficient (Kc) from previous study. The effectiveness of detention basins was evaluated from water balance analysis. It was applied to assign annual irrigation water requirement in Soursop farming land. This study defined average ETo of Soursop farming land in Nawungan orchard was 5.0 mm/day, while the average ETc was 3.0 mm/day. There were three detention basins in Soursop farming land, laid on the upper slope and two on the middle slope. Annual irrigation water requirement was 4287 m³. During this period, three detention basins could meet the water need of plant for 84 days. So, more detention basin should be built in Soursop farming land - Nawungan orchard.

1. Introduction
Land competition is intensively due to the population growth which directly raising land demand for food, energy and housing. Dry land covers almost 40% of the world’s land area where approximately 60% of these dry lands are in developing countries [1]. Due to the land competition, the dry land is a primary land for food production in the world. In Indonesia, the dry land contribution for food production is less where solely 5% for rice production, 40% for corn, 30% for soybean, 75% for peanut, 10% for mung bean, and 15% for sweet potato. Contrary, the contribution of dry land for food
production in other country is 80% to 100% [2]. So, the food production in Indonesia would be directed to the dry land through intensification as well as extensification. However, the use and development of dry land for agriculture is more complicated [3]. Mostly of the dry lands are highly risk to drought, soil erosion, and landslides because they lay on upstream area. The soil generally is thin and low in fertility, later it is potentially eroded by rain water energy.

Nawungan orchard is located on South Mountain of Java, characterized by rough topography and geologically formed by Nglanggeran dan Wonosari formation [4]. It is characterized by hard bedrock and thin soil solum with less ability to hold the water [5]. Thus, drought is the main obstacle for plant growth in Nawungan orchard [6, 7]. To mitigate the drought, farmer harvests the rain by using detention basin called “rorak”. Furthermore, the detention basin traps the sediment produced from erosion and the farmers return back to the land as fertilizer. The water in detention basin later used to irrigate the fruit-based agroforestry land. In Nawungan orchard, five tropical fruits i.e., soursop (Annona muricata L.), durian (Durio zibethinus Murr.), rambutan (Nephelium lappaceum L.), and kelengkeng (Dimocarpus longan) were planted between wood plants Tectona grandis L. f. and D. latifolia and horticulture (peanut, chili, eggplant). The aims of this study were to evaluate the effectiveness of the detention basin in Soursop farming land for water conservation. The water balance was applied to determine the effectiveness of the detention basin. Next, it was used to evaluate the capacity of detention basin, to support the decision shall the farmers increase the number and/or dimension of detention basin.

2. Materials and Method.
The material used for this study i.e. ASTER DEM with 30 m resolution, soursop farmers data, and climate data. The ASTER DEM was overlaid with soursop farming land boundary and location of the detention basins. Due to the lack of spatial information of farming land, an interview and field work were conducted to identify boundary of the soursop farming land. The farming land boundary was tracked by using GPS. The daily climate data (rainfall, temperature, net solar radiation, wind speed, atmospheric pressure and relative humidity) from automatic weather station in Nawungan orchard were collected for determining reference evapotranspiration (ETo, mm/day). Penman-Monteith (Eq. 1) was applied to calculate ETa and ETc. The soursop plant coefficient (Kc) define by [6] was integrated to Eq. 2. The water balance (Eq. 3) was applied to assign the annual irrigation water requirement in soursop farming land.

\[
ETo = \frac{0.408\Delta (Rn-G)+\gamma \cdot \frac{900}{T+273} \cdot u_2 (e_s-e_a)}{\Delta + \gamma (1+0.3u_2)}
\]

(1)

Rn is nett radiation (MJ/m²/day), G is density of heat continously on the ground (MJ/m²/day), T is average daily temperature at a height of 2 m (°C), u2 is wind speed at a height of 2 m (m/s), e_s is saturated vapor pressure (kPa), e_a is actual vapor pressure (kPa), Δ is the slope of vapor pressure curve (kPa/°C), and γ is constant psychrometric (KPa°C).

\[
ETc = Kc \cdot ETo
\]

(2)

Where ETc is crop evapotranspiration (mm/day), Kc is crop coefficient (Annona muricata L)

\[
SRO = H - (\Delta SM + Eta + P).A_2
\]

(3)

SRO is surface runoff (mm) that could be collected in each ponds, Eta is actual evapotranspiration (mm/day) that’s equal to ETc, H is rainfall (mm), I is irrigation (mm), ΔSM is soil moisture (mm), and P is percolation (mm). As thin soil solum, the ΔSM was neglected. The catchment area (A2) in m². The water for irrigation (KAI, liter) were required when precipitation (H) was less than ETa (Eq. 4)

\[
KAI = (H - P).A_2
\]

(4)

Where A2 is irrigation area (m²). The irrigation area was calculated by using Eq. 5.

\[
A_2 = \frac{\text{soursop farming area} \cdot m^2}{\text{planting area} \cdot m^2} \cdot \pi r^2
\]

(5)

The plant canopy was assumed circle with radius (r)

The water balance in each pond was calculated using Eq. 6

\[
v_t = v_0 + ((P.A_1) + SRO - KAI)
\]

(6)
v₀ is water volume in the pond \( t_1 \), \( A_1 \) is the pond area (m²). The irrigation discharge, \( Q \) (liter) was defined by Eq. 7.

\[ Q = KAI. A_2 \]

(7)

3. Results and Discussion

3.1. Soursop farming in Nawungan orchard

Soursop farming covers 20% of total orchard area. Biophysics condition of Nawungan orchard was described by [5, 6, 7] including soil, slope, altitude, average monthly rainfall, air humidity and temperature, as well as net solar radiation based on Barongan climate station. The previous study illustrated regional weather condition, because it was resumed from Barongan weather station which located 14 km from farming land. A weather station was installed in Nawungan orchard on February 5, 2019. It was recorded 1,710 mm precipitation (rainfall) during 5 February 2019 to 4 February 2020. There were 85 raining days. The temperature was 23°C to 30°C with average 28°C. The average solar radiation was 17.9 MJ/m²/day, wind speed was 0.5 m/s, atmosphere pressure was 98 kPa and relative air humidity was 82%.

3.2. Water balance in detention basins for irrigation design

The water balance analysis focused on water catchment in soursop farming whose area 1.63 ha. There were three detentions and one reservoir as seen in Fig. 1a). The upstream of detention basin assumed has a bring channel, so all mass of rains that transformed to the surface run off (SRO) will be collected in the pond. The catchment of each ponds was presented in Fig. 1b), while the dimension and capacity of the ponds shown in Table 1.

![Figure 1](image)

**Figure 1.** a) The catchment area in each pond, 3 ponds and a reservoir positions, b) irrigation area of soursop farming

Fig. 1a) shows the area of SRO catchment in each detention basin. While Fig. 1b) shows the irrigation area for each detention basin. The figures also show the location of three detention basins, one detention basin was on upper part of land and another ones on the middle part of land. In addition there are two reservoirs that have not been functioned.

**Table 1.** The dimension of the detention basins, irrigation area, and catchment coverage

| Detention basin (DB) | Length (m) | Width (m) | Depth (m) | Volume (m³) | Irrigation Area \( A_2 \) (m²) | Catchment Area SRO \( A_3 \) (m²) |
|----------------------|------------|-----------|-----------|-------------|-------------------------------|-------------------------------|
| 1                    | 9.2        | 3.5       | 3.0       | 96.6        | 3,785                         | 450                           |
| 2                    | 9.6        | 3.8       | 2.8       | 102.1       | 7,182                         | 1,600                         |
| 3                    | 9.3        | 3.0       | 2.7       | 75.3        | 5,828                         | 1,500                         |
Based on Eq. 6, the dynamics of water discharge in each detention basin was illustrated in Fig. 2. The water irrigation requirement was presented in Fig. 3.

Table 1 shows the characteristics of the detention basins in soursop land. Detention basin 2 was the largest ones, with capacity of water storage 102.1 m$^3$. While the detention basin 3 was the smallest with capacity 75.3 m$^3$. Regarding the SRO capture, detention basin 2 was the largest (1,600 m$^2$), while the smallest was the rorak 1.

**Figure 2.** The dynamics of potential of surface runoff (SRO) were collected in each detention basin.
Fig. 2 shows dynamic of water volume on each detention basin. It represents that the bigger capacity and the wider capture area of the SRO could store more water to fulfill the irrigation water needs. Hence, the irrigation could cover large area.

![Figure 2. Dynamic of water volume on each detention basin](image)

**Figure 3.** The water irrigation requirement for each detention basin
Detention basin was functioned to collect the surface runoff (SRO) and later they used to fulfill the needs of the irrigation water during dry season. Here, the absence of the detention basin, the irrigation water need was 6,002 m³ per year. While by detention basin, the irrigation water need decreased to 4,287 m³ per year. The water from three detention basin could irrigate the soursop farming land for 84 days. It means that the detention basin could be used to conserve water in dry land farming. [8,9] stated that the detention basin was applied to control flood or SRO, soil erosion, and water quality for agricultural watershed.

4. Conclusion
This study obtained ETo of soursop farming land in Nawungan orchard was 5.2 mm/day and the ETc was 3.0 mm/day. The annual water irrigation was 6,002 m³ and it decreased to 4,287 m³ by the presence of three detention basins. The water in the detention basins could use to fulfill water irrigation for 84 days. Further, study on spatial design of detention basin is required as adaptation of soursop farming in Nawungan orchard.

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Acknowledgement
We owe a lot to Recognisi Tugas Akhir (RTA) Grant of Universitas Gadjah Mada 2020, thank you for funding this study. We also thank Mr. Sanyoto and Mr. Eka Febuana Indra, are technician of Land and Water Resources Engineering Laboratory Faculty of Agricultural Technology - Universitas Gadjah Mada, for their assistance in the field and laboratory.