Assessing the Potential of Tambakboyo Retention Basin for Raw Water Supply in the City of Yogyakarta Indonesia

Edy Sriyono[1], Agung Purwanto[1], Sardi[1], Nindyo Cahyo Kresnanto[1], Tania Edna Bhakty[1] and Muhammad Kunta Biddinika[1]

[1]*Civil Engineering Master's Degree Program, Janabadra University, Jalan Tentara Rakyat Mataram 55-57 Yogyakarta,*

Keywords: Water resources, retention basin, water potential.

Abstract: This paper presents an assessment of the potential of Tambakboyo basin as one of the potential new water sources due to the water shortage in some areas of the city of Yogyakarta. It is a retention basin located in the Sleman Regency, Special Province of Yogyakarta, Indonesia. The basin has overflow elevation of +147,00 m and retrieval pipe elevation of +141,00 m. This assessment includes an analysis of the inflow, rain fall on the surface of the reservoir, outflow for water requirements, water loss from evaporation and seepage. By using the scales of water balance and simulation of water retrieval, we are able to determine water potential of the basin for clean water.

1 INTRODUCTION

Some areas in Yogyakarta City have experienced water crisis. The region consists of 5 (five) subdistricts, namely District Gondokusuman, Mergangsan, Mantrijeron, Jetis and Umbulharjo. To overcome the problem, water sources that can be utilized for water daily usage should be reduced.

The increasing demand for water causes some areas in Yogyakarta to experience water shortages. These short comings can be met by utilizing the potential of existing water resources. In Kabupaten Sleman there is a potential source of water that is likely to be used to meet water shortages. The source is Embung Tambakboyo which until now has not been utilized up to its potential. In addition to the overflow, the embung location is also higher than areas that require water, making it possible to stream the water using gravity.

Embung Tambakboyo is one of water retention basin that was built from 2003 until 2008 in Tambakboyo River upstream or in the meeting between Klanduan River and the downstream of Sembung River. The embung location is in Condongcatur Village, Depok District, Sleman Regency, Special Region of Yogyakarta. According to the interviews with local residents around the embung, in the dry season Tambakboyo Embung pond is always fully charged and water always overflowed through the spillway. The condition gives an illustration that Embung Tambakboyo has water potential that can be utilized for raw water usage (Pengairan, 1986) (Kamiana, 2011).

For that we need a study of how much potential water Embung Tambakboyo can be utilized to meet the lack of water in the city of Yogyakarta. The study will be conducted by simulating water retrieval based on the water balance of embung which is the relationship between inflow, outflow and the number of containers (Gustian, 2014).

2 LITERATURE REVIEW

2.1 Water Resources Development

According to (Triatmodjo and Terapan, 2008), water resources development can be grouped into two activities, namely water utilization and water management (Figure 1). Water utilization activities include the provision of water for irrigation water needs,households, offices, hospitals, education, houses of worship, hotels, river maintenance/raiding, fisheries, livestock, industry and so on. These various needs can be served by available water which can be either surface water or ground water with certain reliability. Water regulation activities include flood control, drainage and waste management. These activities are conducted to

Sriyono, E., Purwanto, A., Sardi, ., Kresnanto, N., Bhakty, T. and Biddinika, M.
Assessing the Potential of Tambakboyo Retention Basin for RawWater Supply in the City of Yogyakarta Indonesia.
DOI: 10.5220/0009878900960100
In *Proceedings of the 2nd International Conference on Applied Science, Engineering and Social Sciences (ICASESS 2019)*, pages 96-100
ISBN: 978-989-758-452-7

overcome the existence of excessive water in the form of floods that can cause harm to the community.

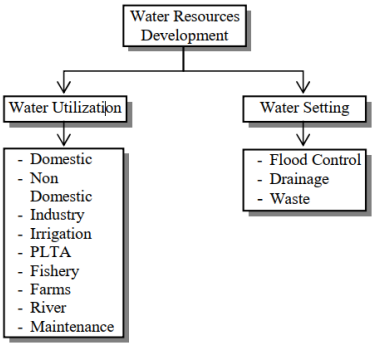

Figure 1: Water Resources Development Activities.

The relationship between the two activities is in the rainy season the water will be abundant so that should be thrown into the sea so as not to cause flood. But in the dry season the availability of water is significantly reduced, making itdifficult to meet the needs of water that is relatively fixed and even increases along with the increase of population. To that end, it takes facilities such as embung to accommodate excess water in the rainy season and use it in the dry season.

Water utilization includes the study of water availability and water requirements as well as planning facilities/buildings that can meet these needs from available water availability. For that we need to know the amount of water available and the current water needs and predictions of future needs. From both analysis, we can calculate water balance in a watershed, by comparing the availability and the need for water.

2.2 Water Balance

Embung is a water retention structure that serves to store water while at the time of excess water and released in the event of water shortage. The water balance of the embung is based on the continuity equation which is the relationship between inlet water, outlet water and the number of containers. Figure 2 shows the water balance in the embung, which can be mathematically expressed in terms of the following equation (Asdak, 2018), (Brotowiryatmo, 1993)(Hadisusanto, 2010):

$$Q + P = O + E + I + \Delta S \quad (1)$$

where Q is inlow from the river, rainfall that falls on the surface of the reservoir, O is outflow for irrigation water needs; raw water and so on, E is evaporated, I is water loss from seepage, and ΔS is the water reservoir in the reservoir.

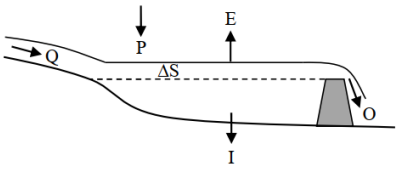

Figure 2: Embung's water balance.

3 METHODOLOGY

3.1 Location

The research was conducted at Embung Tambakboyo in Tambak Bayan River, Condongcatur Village, Depok District, Sleman Regency, Yogyakarta Special Region as presented in Figure 3.

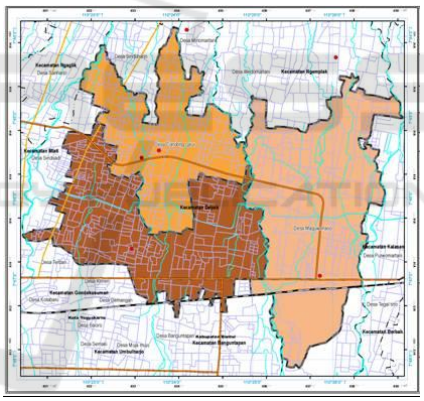

Figure 3: The location of Embung Tambakboyo.

3.2 Inflow

The inflow water discharges consists of the flow of streams and rain falling on the surface of the embung. River flow discharge in question is the result of Mock simulation that has been calibrated with debit data . While the rain falling on the surface of the embung multiplied by the surface area of the embung.

3.3 Outflow

The outflow water discharges consist of water requirements for various purposes (water requirements for irrigation and fisheries), and water loss from evaporation and seepage.

3.4 Water Balance Simulation of Water Retrieval

The availability of Tambakboyo water pond comes from the inflow and outflow. Analysis of water availability is estimated based on the water balance of the reservoir calculated using equation (1), then the simulation of water harvesting was conducted to determine the maximum limit of water retention ponds.

4 RESULT AND DISCUSSION

4.1 Inflow

The inflow of Embung Tambakboyo consists of 90% (Q90) mainstay discharge of Mock simulation result and 90% rainfall (R90) result of area rainfall analysis multiplied by embung pond area of 60,542.4 m2 as presented in Figure 4. The table shows that the largest inflow was in February, which was 1989.29 lt/sec while the smallest inflow was in December, which was 36.12 lt/sec.

Month	Q_{90} (lt/sec)	R_{90} x pond area (lt/sec)	Inflow (lt/sec)
January	1522.93	10.70	1533.63
February	1978.06	11.23	1989.29
March	1204.29	6.21	1210.50
April	557.40	2.00	559.40
May	563.73	2.67	566.39
June	315.78	0.08	315.85
July	213.91	0.00	213.91
August	149.74	0.00	149.74
September	108.31	0.00	108.31
October	73.37	0.00	73.37
November	53.07	0.00	53.07
December	35.95	0.16	36.12

Figure 4: Inflow (Q + P).

4.2 Water Loss due to Evaporation

Water loss due to evaporation above the water surface of the embung is calculated from the evaporation value of modified Penman method multiplied by the surface area of the pond. In full conditions, the water level elevation is at + 147.00 m elevation with a surface area of 60,542.4 m2. The results of Embung Tambakboyo evaporation calculations are presented in Figure 5.

The table shows that the largest water loss due to evaporation was in October, which was 3.37 lt/sec while the smallest water loss due to evaporation was in July, which was 2.49 lt/sec.

Month	Evaporation (lt/sec)
January	2.62
February	2.69
March	2.68
April	2.79
May	2.47
June	2.45
July	2.49
August	2.99
September	3.28
October	3.37
November	2.94
December	2.52

Figure 5: The evaporation of Embung Tambakboyo.

4.3 Water Loss from Seepage (I)

The flow-net projection (Hardiyatmo, 2012), resulting in 8 (eight) flow lines (Nf) and 30 (thirty) equipotential lines (Nd). If the water level is at + 147.00 m elevation, there is a high energy difference (h) between the beginning and end (9,89 m) equipotential energy line (Nd). From the depiction presented in Figure 6, water loss from seepage that occurred in Embung Tambakboyo is 0.073 lt/sec, the full calculation is presented in Figure 7. The table shows that the largest water loss from seepage (I) is at + 147.00 m elevation, which was 0.075 lt/sec while the smallest water loss from seepage (I) is at + 141.00 m elevation, which was 0.028 lt/sec.

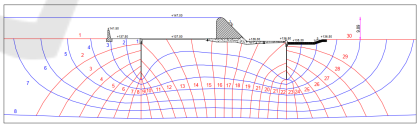

Figure 6: Flownet of Embung Tambakboyo.

Elv.	k=1.1x10^{-4} (cm/sec)	k=1.1x10^{-6} (m/sec)	h (m)	Nf	Nd	n (m)	q (m^3/sec/m)	(lt/sec/m)	Q (lt/sec)
147	0.00011	0.0000011	9.5	8	28	25	0.0000030	0.003	0.075
146	0.00011	0.0000011	8.5	8	28	25	0.0000027	0.003	0.067
145	0.00011	0.0000011	7.5	8	28	25	0.0000024	0.002	0.059
144	0.00011	0.0000011	6.5	8	28	25	0.0000020	0.002	0.051
143	0.00011	0.0000011	5.5	8	28	25	0.0000017	0.002	0.043
142	0.00011	0.0000011	4.5	8	28	25	0.0000014	0.001	0.035
141	0.00011	0.0000011	3.5	8	28	25	0.0000011	0.001	0.028

Figure 7: Calculating the seepage of Embung Tambakboyo.

4.4 Water Balance and Simulation of Water Retrieval

The water scale of Embung Tambakboyo Watershed is the ratio between the inflow and the outflow. The difference from the comparison provides information

on water availability from January to December. In the case of a water surplus (+) or water deficit (-), the pond retention pond remains fully charged at 387,947.47 m3 at +147.00 m elevation. The water balance of the Tambakboyo Embung Watershed is presented in Figure 8.

Elv.	k=1.1x10^{-4} (cm/sec)	k=1.1x10^{-6} (m/sec)	h (m)	Nf	Nd	n (m)	q (m^3/sec/m)	(lt/sec/m)	Q (lt/sec)
147	0.00011	0.0000011	9.5	8	28	25	0.0000030	0.003	0.075
146	0.00011	0.0000011	8.5	8	28	25	0.0000027	0.003	0.067
145	0.00011	0.0000011	7.5	8	28	25	0.0000024	0.002	0.059
144	0.00011	0.0000011	6.5	8	28	25	0.0000020	0.002	0.051
143	0.00011	0.0000011	5.5	8	28	25	0.0000017	0.002	0.043
142	0.00011	0.0000011	4.5	8	28	25	0.0000014	0.001	0.035
141	0.00011	0.0000011	3.5	8	28	25	0.0000011	0.001	0.028

Figure 8: Water balance of Embung Tambakboyo.

In the case of surplus water (excess water), the fulfillment of water needs for various purposes (outflow) using the inflow of water (inflow). If there is still any residual from the inflow, the water is considered to be melted.

In the state of water deficit (lack of water), the fulfillment of water needs for various purposes (outflow) using water reservoir embung. This situation resulted in decreasing embung volume and decreasing of surface water level. Change of embung water storage is calculated based on water balance of embung.

In Embung Tambakboyo at the rear of the drain door, there is a 16-inch galvanized tube at + 141.00 m elevation. The pipe is fitted with the purpose can be utilized if there is a plan of utilization of Tambakboyo water pond for raw water.

Based on the water balance of the embung, the volume of the containment and the presence of the pipe, a simulation of water harvesting to determine the maximum limit of water retention ponds from elevation +147,00 m to elevation + 141,00 m. The simulation uses alternate picking, 10 lt/sec, 20 lt/sec, 30 lt/sec, 40 lt/sec, 45 lt/sec and 48 lt/sec. The calculation of the complete water-taking simulation is presented in Figure 9.

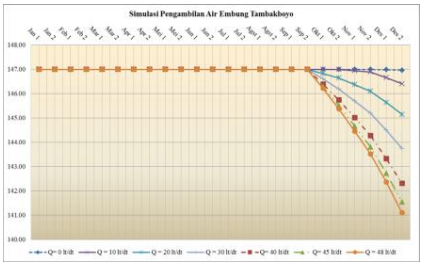

Figure 9: Graphical simulations of water retrieval at Embung Tambakboyo.

Figure 9 provides information on the influence of each of the water-taking alternatives. The information will be explained as follows:

1. Take water of discharge 0 lt/sec The utilization of the catchment water occurred in December when Embung Tambakboyo was ina state of water deviation. When uses 0 liters/second of water retrieval, leaving a volume of 385,928.30 m3 of contained water at an elevation of + 146.97 m.
2. Take water of discharge 10 lt/sec The utilization of shelter water occurs from November to December at the time of Embung Tambakboyo in a state of water deviation. When a 10 liters/second water discharge is used, it will leave the volume of water in the reservoir 352,676.69 m3 at elevation + 146.41 m.
3. Take water of discharge 20 lt/sec The utilization of shelter water occurs from October to December when Embung Tambakboyo is in a state of water deviation. When a 20 liters/second liquefaction discharge is used, it will leave a water volume in the reservoir of 278,698.03 m3 at an elevation of + 145.15 m.
4. Take water of discharge 30 lt/sec The utilization of shelter water occurs from October to December when Embung Tambakboyo is in a state of water devisit. When a 30 liters/second water discharge is used, the volume of water in the container will be 199.210.03 m3 at elevation + 143,74 m.
5. Take water of discharge 40 lt/sec The utilization of shelter water occurs from October to December when Embung Tambakboyo is in a state of water deviation. When a 40 liters/second water discharge is used, it will leave a water volume in container of 119.722.03 m3 at elevation + 142.31 m.
6. Take water of discharge 45 lt/sec The utilization of shelter water occurs from October to December when Embung Tambakboyo is in a state of water deviation. When a 45 lt/sec water discharge is used, it will leave a volume of 79,978.03 m3 of water in storage at + 141.54 m elevation.
7. Take water of discharge 48 lt/sec The utilization of shelter water occurs from October to December when Embung Tambakboyo is in a state of water deviation. When a water harvesting rate of 48 lt/dt is used, it will leave a volume of water in the reservoir of 56,131.63 m3 at elevation + 141.09 m.

5 CONCLUSIONS

1. Embung Tambakboyo is a very strategic water source that can be used to help overcome the lack of water in some areas in Yogyakarta city. This is because the location is higher than the area in the city of Yogyakarta that requires the water.

2. By utilizing the volume of the embung embankment to reach the dead storage elevation (+141.00), then dry season with 90% reliability, the water in Tambakboyo embung can be collected by 48 lt/sec without disrupting the utilization of exsisting water, such as for Irrigation and fish ponds.

REFERENCES

Asdak, C. (2018). *Hidrologi dan pengelolaan daerah aliran sungai*. Gadjah Mada University Press.

Brotowiryatmo, S. (1993). Analisis hidrologi.

Gustian, M. (2014). Optimasi parameter model dr. mock untuk pengelolaan daerah aliran sungai. *ETD Unsyiah*.

Hadisusanto, N. (2010). Aplikasi hidrologi, jogja mediautama.

Hardiyatmo, H. (2012). Mekanika tanah i.

Kamiana, I. M. (2011). Teknik perhitungan debit rencana bangunan air. *Graha Ilmu, Yogyakarta*.

Pengairan, D. P. U. (1986). Standar perencanaan irigasi kp–01. *Bandung: CV Galang Persada*.

Triatmodjo, B. and Terapan, H. (2008). Beta offset.