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SERMO RESERVOIR CAPABILITY TO PERFORM ITS FUNCTION

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ABSTRACT

The function of Sermo Reservoir is fulfilling drinking water, river maintenance and irrigation demand as an additional supply on irrigation area of Pengasih, Pekik Jamal, and Clereng. The Irrigation area is part of the Kalibawang Irrigation System that gets water supply from Progo River. Based on the research that has been done the supply of Progo River has been reduced. Thereby the supply of Sermo Reservoir is very necessary to meet the needs of irrigation. However, irrigation water from the Sermo Reservoir is planned only for additional supply, so it is impossible to meet all the irrigation water demand. Especially with a condition of the reservoir effective storage that has been reduced due to sedimentation. In order to avoid conflicts in serving the needs of irrigation water, it must be clearly known how large the area of irrigation area can be served from the Sermo Reservoir. In this research was being simulated operation of a reservoir with a various scenario of cropping pattern, planting area and the initial condition of reservoir storage. The aim is to obtain the area of irrigation that can be irrigated by Sermo Reservoir which the distribution of irrigation water supply in each planting season are stable. The results obtained 100% reliability in all planting seasons and various initial conditions of reservoir storage when used CPP2 planting pattern and the irrigated area is Pengasih with a service area of 0.51% (1,038 ha).

Keywords: Reservoir Performance, Reservoir Operation, Simulation

1. INTRODUCTION

Sermo Dam was built in 1996, located at Ngrancah River, Kulon Progo Region Yogyakarta Province. The function of Sermo Reservoir is fulfilling drink water, river maintenance and irrigation demand (as an additional supply on irrigation area of Pengasih, Pekik Jamal, and Clereng). Pengasih, Pekik Jamal, and Clereng Irrigation Area is part of the Kalibawang Irrigation System that gets water supply from Intake Kalibawang. In regards to the area and complexity of Kalibawang Irrigation Interconnection Network (Figure 1), there is the dependence of water flow from the downstream to suppletion in upstream water flow. In this condition, the planting area, cropping pattern and cropping scheduling must calculate the potential of water sources in the river (weir), return flow, and the operational aspect.

Budieny (2003) conducted optimization analysis of water resources management of sermo reservoir to serve the water needs of drinking water, maintenance of rivers and irrigation water in Clereng, Pengasih and Pekik Jamal with additional supplies from Serang River and Progo River. Based on the analysis result that optimum reservoir operation and planting intensity 258.2% when the initial planting started on 22-25 November. Natalia (2008) optimizes the operation of Sermo Reservoir using the Dynamic Deterministic program model. In this research, the reviewed object is Sermo Reservoir as the multipurpose dam to serve the needs of raw water, river maintenance and irrigation for Kamal Irrigation Area, Pengasih Irrigation Area, and Pekik Jamal Irrigation Area. From the obtained rule curve shows that the operation of the dam can be improved more. The Existing Rule Curve of Sermo Reservoir from 2008 shows that the release realization can be closer to the optimized Rule Curve.

Festi and Intan (2017) simulated for 25 years, when the Kalibawang intake to meet the irrigation water needs in Kalibawang, Papah, Pengasih and Pekik Jamal Irrigation Area produced an average percentage of 76.51% compliance. The percentage of average compliance in one planting season varies from 9 - 100%. And when Kalibawang intake only to meet the needs of irrigation water in Kalibawang and Papah, an average percentage of 97.77% is achieved. The percentage of average adherence in one growing season varies from 16 - 100%. Simulations performed by Festi et al. (2017) by using the discharge data at each of the weirs yielding on Pengasih and Pekik Jamal irrigation area still lack water.

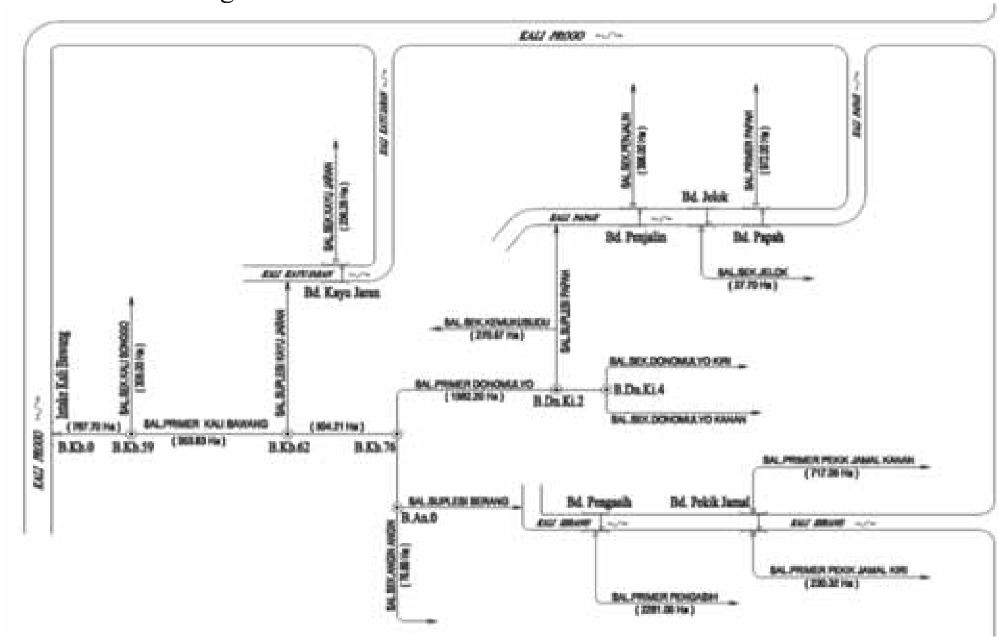


Figure 1. Kalibawang Irrigation Area Interconnection System scheme (Source: Kalibawang Draft Report Introduction Preliminary)

Based on the analysis of Budieny (2003) and Natalia (2008), it was found that water from the Sermo Reservoir in addition to the supply from Kali Serang and Kali Progo can meet the needs of irrigation water in DI (Daerah Irigasi) Pengasih and Pekik Jamal with high reliability. While based on the analysis of Festi et al. (2017) and Festi and Intan (2017) found that water from Intake Kalibawang (Progo River) is not enough to irrigate irrigation area up to DI Pengasih and Pekik Jamal. This means that the supply from the Progo River has diminished / no longer exists. So, supplies from Sermo Reservoir is very necessary to meet the needs of irrigation water in DI Pengasih and Pekik Jamal. However, irrigation water from the Sermo Reservoir is planned only for supply, so it is impossible to meet all the loving DI and Pekik Jamal, especially with the effective condensed reservoir condition that has been reduced due to sedimentation. In order to avoid conflicts in serving the needs of irrigation water, it must be clearly known how large the area of irrigation can be served from the Sermo Reservoir.

Based on the analysis of Festi and Intan (2017), the distribution of water content in one growing season varies from 9 - 100%, this will not guarantee the rice can live with the same intensity and inefficient water delivery. If at the beginning of high growth release then in the middle of the middle of the growth of low release then some rice plants will die. Then, at the end of the high back release growth, of course, the water will be wasted because the plant is already dead.

In this research will be the scenario of cropping pattern, the planting area and the initial condition of the reservoir to obtain the area of irrigation that can be irrigated by the Sermo Reservoir optimally. Optimal in terms of distribution of irrigation water supply in one stable planting season, for water-giving efficiency.

2. METHODS

Data required in this study are reserve technical data, a storage capacity of the reservoirs, hydrology, and climatology, reservoir inflow, planting pattern, reservoir operation manual guidelines (reserves operation pattern) and reports of relevant prior studies. DI Pengasih and DI Pekik Jamal is part of Kalibawang Irrigation System in Kulon Progo, Yogyakarta. The service area of the DI Pengasih is 2035 Ha and DI Pekik Jamal is 827 Ha. The source of irrigation water comes from Kalibawang Intake (Progo River), Serang River and the supply of Sermo Reservoir. In the implementation of these additional supply very dependent on the availability of water resources in each source. A simulation was developed to regulate the release of water to meet the needs of irrigation, drinking water and maintenance of the river (water demand). The water released is carried through the spillway and the intake. Release through the spillway is carried out in the case of flooding. The release to meet the water demand takes place through the intake. Water storage for the needs of irrigation, drinking water and maintenance of the river is carried out between elevations of +136.6 masl and +113.7 masl.

A simulation is done with some scenario as follows:

a. Fulfilling the need for drinking water 150 liters/s and river maintenance 50 liters/s fulfilled 100%.
b. The crop's planting pattern (CPP) applied in this study is those practiced in the field, i.e., paddy-paddy-palawija (palawija such as corn, sugarcane, cabbage, and etc.). In every irrigation area will be divided into 2 (two) golongan (groups) and the starting of the planting is as follows:
   1) Scenario 1: CPP1
      Group 1: MT 1 starts on Oct. II, MT 2 starts on Feb II and MT 3 starts on June II
      Group 2: MT 1 starts on Nov I, MT 2 starts on March I and MT 3 starts on July I.
   2) Scenario 2: CPP2
      Group 1: MT 1 starts on Nov I, MT 2 starts on March I and MT 3 starts on July I
      Group 2: MT 1 starts on Nov II, MT 2 starts on March II and MT 3 starts on July II
   3) Scenario 3: CPP3
      Group 1: MT 1 starts on Nov II, MT 2 starts on Mar II and MT 3 starts on July II
      Group 2: MT 1 starts on Des I, MT 2 starts on Apr I and MT 3 starts on Aug I
c. According to Sermo Reservoir operation manual made by CV. HARA Consultant in order to improve planting efficiency, water reservoir fluctuation in the final period of filling the dam reaches minimum water level elevation at the elevation as follows:
   a) During Dry Year + 114.89 masl, reservoir volume of 1.89 million m^3
   b) During Normal Year + 128.88 masl, reservoir volume of 9.6 million m^3
   c) During Wet Year + 136.60 masl, reservoir volume of 20.2 million m^3

   So that the initial condition of the reservoir in the first year of operation is made in three scenarios as mentioned above.
d. Irrigation area is simulated from existing area up to a certain area where water can be fulfilled with 100% reliability for each planting season.

Flowchart of research can be seen in Figure 2.

3. RESULT AND DISCUSSION

3.1 Water Availability

The availability of water is obtained from the inflow data of the Sermo reservoir, the recorded data from Sermo reservoir available from 2009 to 2014. Generally, the data used for the analysis is data with a data length of 10-20 years, but the data available is only 5 years so it must be done data generation to provide an overview of the real data (Marhendi, 2006). To obtain a longer data, there is some theory to generate the flow data such as Thomas-Fiering Method or Box-Jenkins method. In principle, the generation of longer data is to seek all possible flows sequences in each area which are still having statistical behavior similar to those of historical. The generated data can then be used to analyze the behavior of the system in longer (wider) variations of flows possibilities. The Sermo discharge data is then generated bi-weekly for 25 years and used the last 10 years of generated data for further analysis (Figure 3).

To justify whether the generated data has similar statistical parameters to those of historical data, comparison on statistical parameters between generated and historical data is performed for each of data generation these comparisons are shown in Figure 4. The comparison is performed for average, standard deviation, serial correlation, and inter-month correlation, as well as its variation coefficient. From these comparisons, it is shown that the generated and historical data have good similarity. It indicates that the generated data can mimic the statistical behavior of historical data and thus can be used for further analysis.

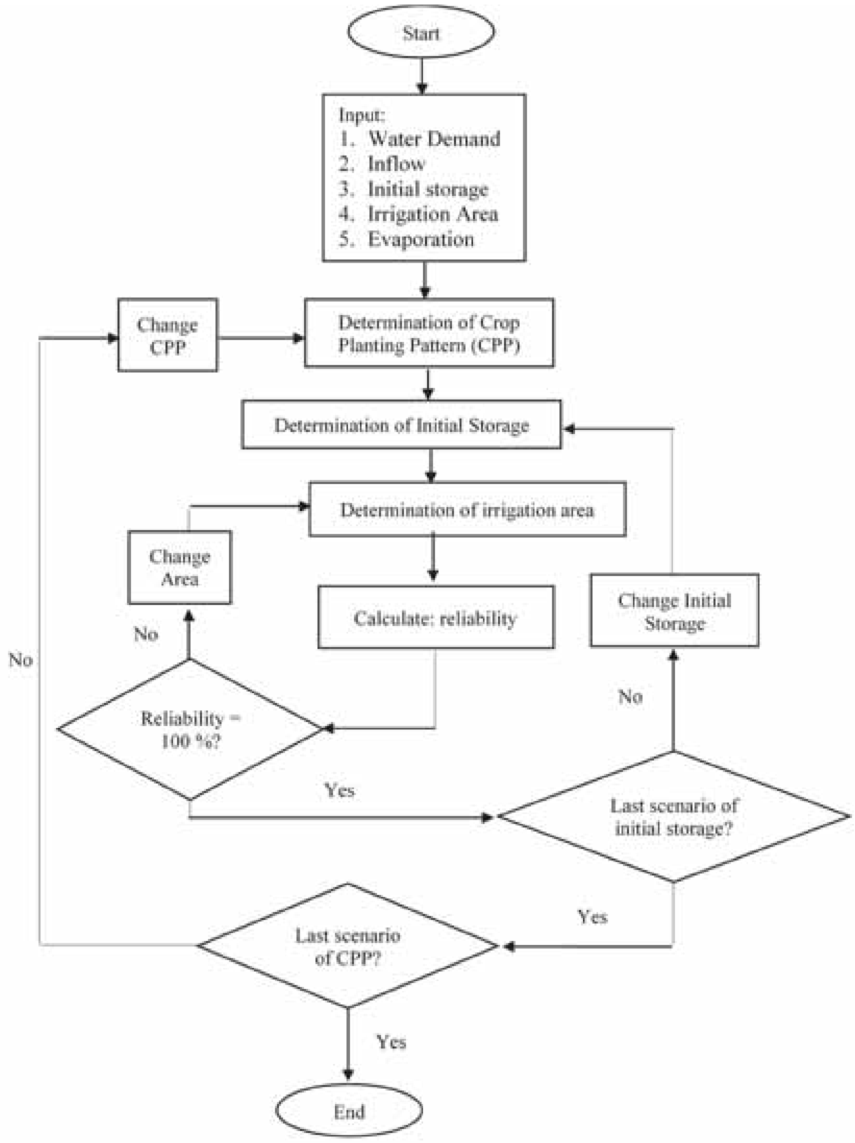


Figure 2. Flow Chart

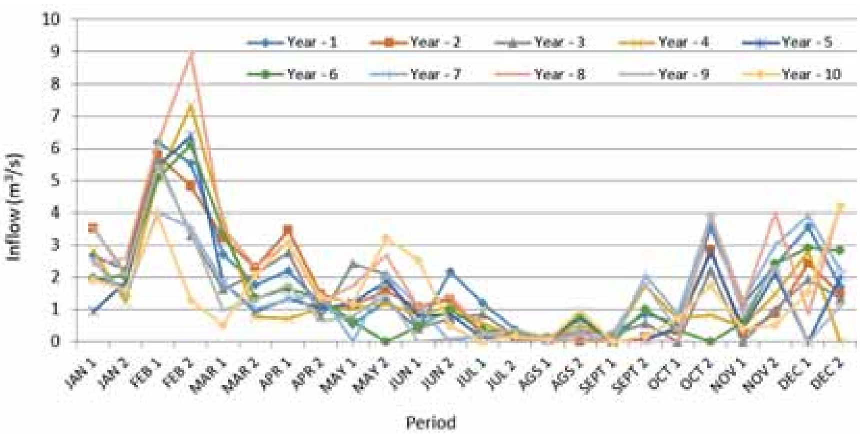
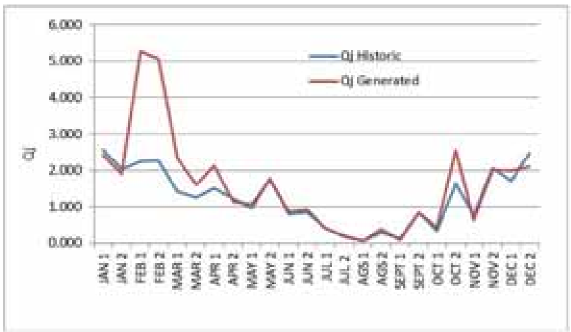
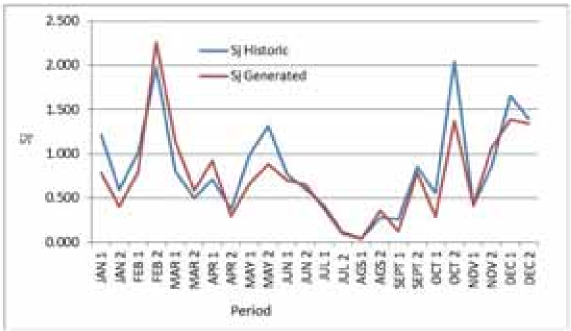


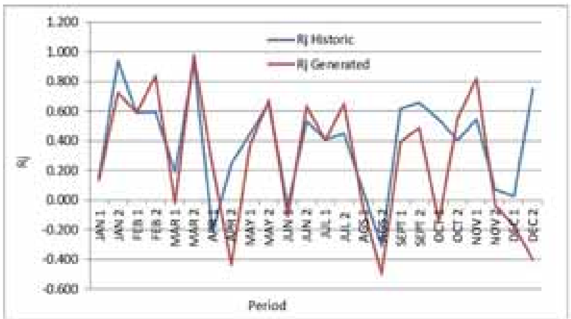
Figure 3. The last 10 years of generated data for inflow to Sermo Reservoir



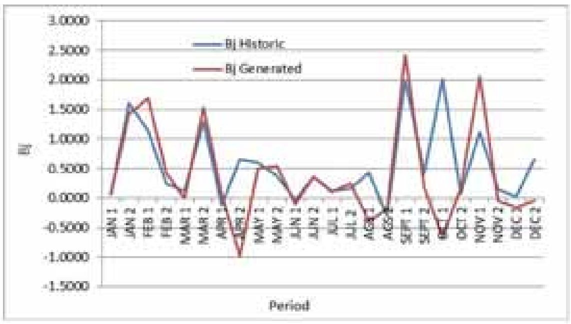
(a) Comparison of Average (Qj)



(b) Comparison of Standard Deviation (Sj)



(c) Comparison of Correlation (Rj)



(d) Comparison of Inter-Month Correlation (Bj)

Figure 4. Statistical Comparison between Historical and Generated data at Sermo Reservoir

3.2 Irrigation Water Demand

The analysis for irrigation water requirements, therefore, uses data about rainfall, climatology, as well as planned planting pattern (pola tanam). The climatological data include data on air temperature (°C), relative air humidity (%), wind velocity (m/s) and relative sunshine duration (%). The crop's planting pattern (CPP) applied in this study is those practiced in the field, i.e., paddy-paddy-palawija, as the scenario above. The results of the irrigation water requirements at Pengasih and Pekik Jamal Irrigation Area are shown in Figure 5 and Figure 6. The basic irrigation water requirements in the Figures are in litter/second/Hectares. The basic irrigation water requirements as shown those figures will then be used in the calculation of irrigation water requirements by multiplying the basic irrigation requirements to the respective planting area and planted the crop. Based on Figure 5 and Figure 6, irrigation water requirement has almost the same pattern.

3.3 Simulation

Based on the simulation results obtained things as follows:

1) When the Sermo Reservoir is used to irrigate the Pengasih and Pekik Jamal, Irrigation Area (DI) the average reliability is between 43 - 47%, with a range between 0 - 100% (Table 1). This means that in one growing season the water supply is unstable to meet the water needs. When the reliability of 0% there will be death in plants because there is no water supply, so the water supply in the period before or after is wasted. There is no excess water that runs through the spillway.
2) If the Sermo Reservoir is used to irrigate the Pekik Jamal irrigation area then the average reliability is 100% in all planting seasons (Table 2). The excess water that spills passes between 85.97 - 114.98 million m3. Sermo Reservoir is able to serve irrigation area Pekik Jamal and there is still excess water. Excess water only occurs in some periods alone so it cannot be used to irrigate other irrigation areas.

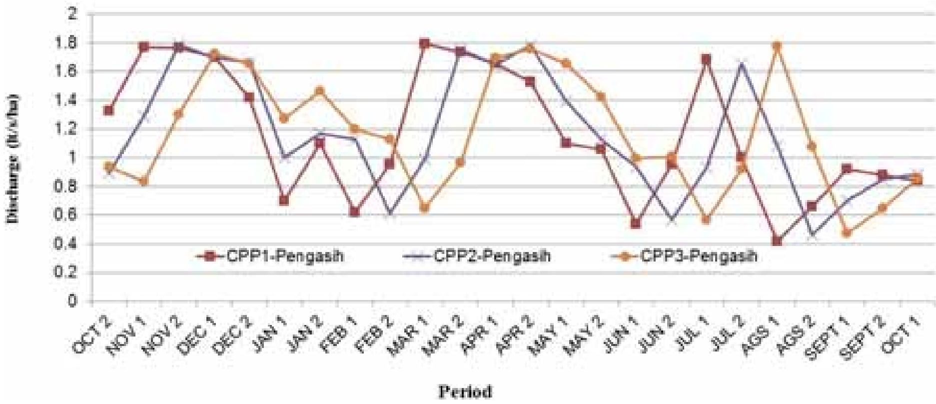


Figure 5. Basic irrigation water requirements for Pengasih irrigation area

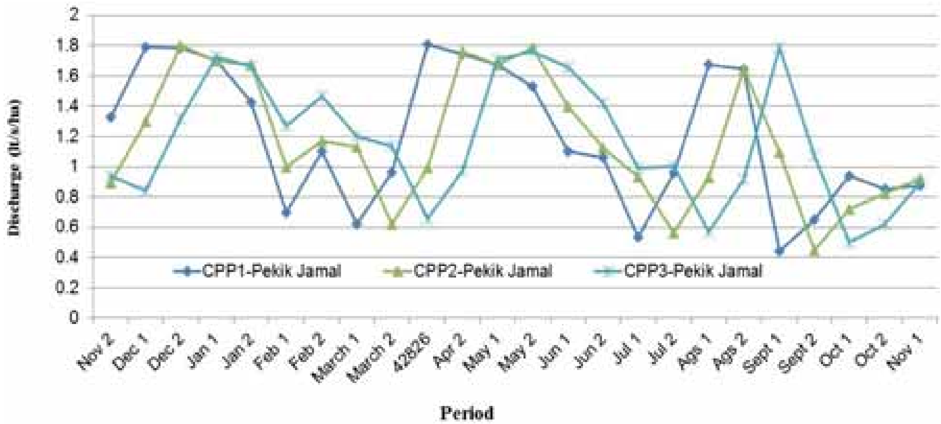


Figure 6. Basic irrigation water requirements for Pekik Jamal irrigation area

Table 1. Result of simulation for Pengasih and Pekik Jamal with existing irrigation area

No.	Planting Pattern	Initial storage (million m^3)	Area of Services (ha)	Reliability (%)		Water Spill (m^3)
				Average	Range	
1	CPP1	20.2	2,862	44.22	0 - 100	0
2	CPP2	20.2	2,862	46.00	0 - 100	0
3	CPP3	20.2	2,862	45.00	0 - 100	0
4	CPP1	9.60	2,862	44.72	0 - 100	0
5	CPP2	9.60	2,862	46.00	0 - 100	0
6	CPP3	9.60	2,862	44.00	0 - 100	0
7	CPP1	1.89	2,862	43.07	0 - 100	0
8	CPP2	1.89	2,862	45.00	0 - 100	0
9	CPP3	1.89	2,862	44.00	0 - 100	0

Table 2. Result of simulation for Pekik Jamal with existing irrigation area

No.	Planting Pattern	Initial storage (million m^3)	Area of Services (ha)	Reliability (%)		Water Spill (m^3)
				Average	Range	
1	CPP1	20.2	827	100	100	101,279,392
2	CPP2	20.2	827	100	100	392,287,376
3	CPP3	20.2	827	100	100	108,912,621
4	CPP1	9.60	827	100	100	93,386,489
5	CPP2	9.60	827	100	100	114,984,423
6	CPP3	9.60	827	100	100	98,317,202
7	CPP1	1.89	827	100	100	85,968,680
8	CPP2	1.89	827	100	100	111,102,690
9	CPP3	1.89	827	100	100	91,748,156

3) If the Sermo Reservoir is used to irrigate the Pengasih irrigation area only, the average reliability is between 57 - 62%, with a range between 0 - 100% (Table 3). This means that in one growing season the water supply is unstable to meet the water needs. When the reliability of 0% there will be death in plants because there is no

water supply, so the water supply in the period before or after is wasted. There is no excess water that spills through the spillway.

Table 3. Result of simulation for Pengasih with existing irrigation area

No.	Planting Pattern	Initial storage (million m^3)	Area of Services (ha)	Reliability (%)		Water Spill (m^3)
				Average	Range	
1	CPP1	20.2	2,035	59.00	0 - 100	0
2	CPP2	20.2	2,035	62.00	0 - 100	0
3	CPP3	20.2	2,035	60.00	0 - 100	0
4	CPP1	9.60	2,035	58.67	0 - 100	0
5	CPP2	9.60	2,035	61.00	0 - 100	0
6	CPP3	9.60	2,035	59.00	0 - 100	0
7	CPP1	1.89	2,035	57.15	0 - 100	0
8	CPP2	1.89	2,035	60.00	0 - 100	0
9	CPP3	1.89	2,035	58.00	0 - 100	0

4) Sermo Reservoir is used to irrigate the Pengasih irrigation area with the reduced irrigated area so that the average reliability is 100% (Table 4). After the trial error obtained the most optimal results with 100% average reliability in all growing seasons is when used CPP2 planting pattern. The area of irrigation can be irrigated 1,037.85 ha (0.51% of the existing area). Except for the initial dry period, the area of irrigation that can be served on MT I is only 427.35 ha. In all initial reservoir conditions and cropping patterns, the excess of water that passes through the spillway is relatively smaller compared to when the Sermo reservoir is used only to irrigate the area of Pekik Jamal. The reservoir water level can be kept high enough to store the water reserves to be given in the previous year (Figure 7).

Table 4. Result of simulation for Pengasih with simulating irrigation area

No.	**Planting Pattern**	**Initial storage (million m^3)**	**Area of Services (ha)**	**Reliability (%)**		**Water Spill (m^3)**
				Average	**Range**	
1	CPP1	20.2	997.15	100	100	55,310,380
2	CPP2	20.2	1,037.85	100	100	59,387,869
3	CPP3	20.2	976.80	100	100	61,613,828
4	CPP1	9.60	976.80	100	100	50,114,437
5	CPP2	9.60	1,037.85	100	100	48,793,837
6	CPP3	9.60	976.80	100	100	51,018,709
7	CPP1	1.89	MT 1 year 1 : 610.5 915.75	100	100	64,649,513
8	CPP2	1.89	MT 1 : 427.35 MT 2, MT 3 : 1,037.85	100	100	98,694,934
9	CPP3	1.89	976.80	100	100	45,339,790

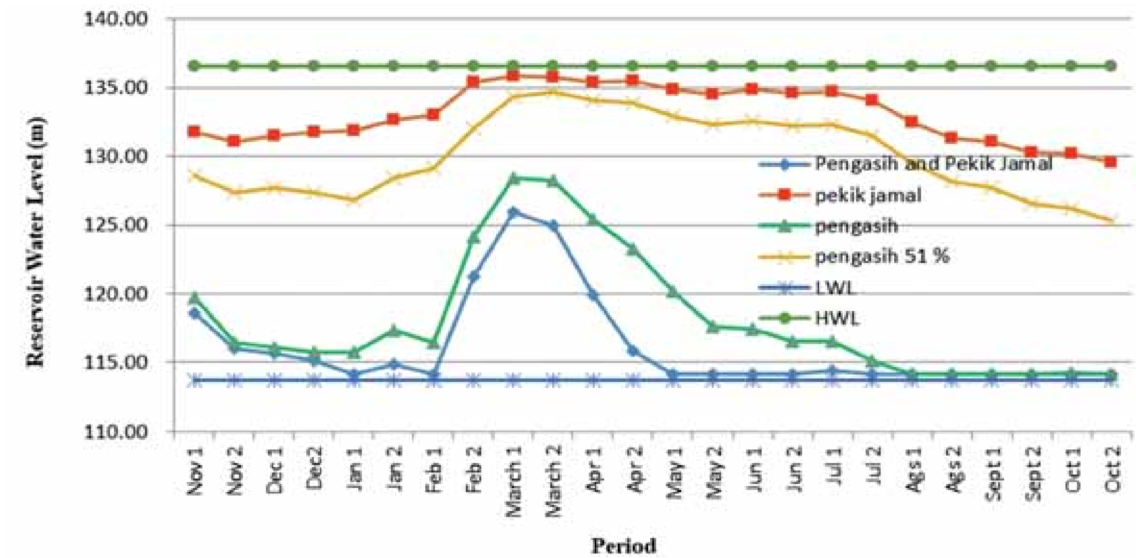


Figure 7. Reservoir water level at CPP2

4. CONCLUSIONS

The most optimum result with 100% average reliability in all growing seasons is when the CPP2 cropping pattern is used. The area of irrigation can be irrigated 1,037.85 ha (0.51% of the existing area). Area of irrigation area during dry year MT1 427.35 ha.

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REFERENCES

Aris, Sunantyo Tarsisius dan Suryolelolo Kabul Basah. (2012). Design and Installation for Dam Monitoring Using Multi Sensors: A Case Study at Sermo Dam, Yogyakarta, Province, Indonesia, Universitas Gadjah Mada, Yogyakarta.

Ariyanti, Vicky, Rani Sjamsinarsi dan Andie Arif Wicaksono. (2015). The Sermo Dam Experience, Indonesia Community Development as Key Success for Dam Project Implementation and Operation, Universitas Teknologi Yogyakarta, Yogyakarta.

Budieny, Hary. (2003). Analisis Optimasi Sumberdaya Air Waduk Sermo. *Jurnal dan Pengembangan Keairan,* No. 1 Tahun 10, pp. 32-40

Fauzan, Rifly Agesta. (2009). Evaluasi Pelaksanaan Tata Pengaturan Air Waduk Sermo pada Sistem Irigasi di Kabupaten Kulon Progo, Universitas Atmajaya, Yogyakarta.

Gunawan, S. (2006). Kajian Panjang Data Historis yang Representatif pada Model Stokastik. Tesis, Fakultas Teknik Universitas Diponegoro, Semarang.

Haz, Zainullah. (2000). Laporan Tugas Akhir, Analisis Imbangan Air pada Lahan Pantai di Daerah Irigasi Bendung Pekik Jamal, Universitas Muhammadiyah Yogyakarta, Yogyakarta.

Kementrian Pekerjaan Umum dan Perumahan Rakyat. (2015). Laporan Akhir Review Manual OP Bendungan Sermo, Yogyakarta.

Kementrian Pekerjaan Umum dan Perumahan Rakyat. (2016). Pekerjaan Detail Desain Rehabilitasi Sistem DI Kalibawang, Yogyakarta.

Muhyidin, Endin. (2000). Laporan Tugas Akhir, Perencanaan Kebutuhan Air Irigasi untuk Tanaman Padi dan Palawija pada Daerah Irigasi Pekik Jamal, Universitas Muhammadiyah, Yogyakarta.

Marhendi,Teguh. (2006). Keandalan Debit Intake Kalibawang Sungai Progo. *Media Komunikasi Teknik Sipil*, 14(1):56-62.

Natalia, Karni, P.R. (2008). Penyusunan Rule Curve Waduk Menggunakan Model Program Dinamik Deterministik. *Jurnal Teknik Sipil* 8(3):225-236.