Study of optimizing water utilization in Benanga reservoir for irrigation and fresh water purposes

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Abstract. Benanga dam was built in1978 an irrigation weir but currently it was developed into a multipurpose dam. However, based on the capacity curve measurement in 2015, the capacity curve measurement has been changed to get below. The runoff rate is calculated by using NRECA method, andwater reservoir volume is calculated by using penman modification method. The cropping pattern that has been implemented by the farmer of Lempake sincein Februaryis Paddy-Paddy-Fallow While the proposed cropping pattern in Benanga reservoir started on December, that proposed is based on the service ability for both raw water demands like irrigation and fresh water and if early planting is started besides these two months the elevation of benanga reservoir will not reach the normal elevation effective storage which is the condition pattern of reservoir operation.

1. Introduction

East Borneo Province is a province which has huge potential on water resources. However, this province has serious problems related to food production and decreased clean water supply day by day. based on temporary number area from BPS East Borneo Province in 2015, known that production of paddy decreased amout 4.08% ie previous in 2014 is 426.170 ton become 408.781 in 2015. one reason why it not able to reach the goal production is because there was planting area be reduced as an impact of long dry weather condition. Beside that there was also cropping delay because of time shift which is not effective.

For supporting food production in Samarinda, the government has built has some dam that has a function for irrigation and clean water supply such as Benanga dam. This dam is one of the dam which is located in Samarinda city stemmed Karangmumus River. This dam has been 30 years old, at the first time this dam was a dam that only has a main function for irrigation water needs. But more than the last 10 years this dam also functionalized for fresh water recervoir, although it's function has not optimal yet In order to fulfill it's function to serve irrigation dan raw water is necessary to review related to effectiveness of effective storage Benangan Dam. This review become really important so that this multipurpose dam could functioned according by early planning design. Therefore a study needed to optimize the water reservoir in the Benanga dam for two purposes ie for irrigation and clean water.

2. Theoretical Basic

2.1 Hidrology Concept

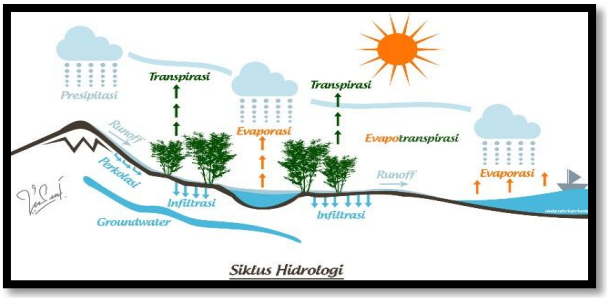

Figure 1. Hidrology Cycle
Source: *Siklus – hidrologi dan Jenis Pengairan.html*

a. Evapotranspiration

Evapotranspiration is a combination from two terms which is described physics process water transfer into the atmosphere, these are evaporation from overland flow and transpiration through the plant. The calculation evapotranspiration for irrigation is really important, because this method can give prediction total water need per day that plants need. There are a lot of method which has been developed to estimate amount of evapotranspiration such as 1) Water Balance Method, 2) Energy Balance Method, 3) Mass Transfer Method, 4) Combination of energy transfer and heat method such as Penman Method, 5) Prediction Method, 6) Method for spesific plant.

b. Defendable Rainfall

Defendable Rainfall is a rainfall that is expected to be happen in certain chance. The higher the probability of occurance that expected, the height of rainfall that occurance will be smaller and vice versa. The big probability of occurance really depends on level of need to be planned.

c. Irrigation Water Requirements

Irrigation water requirementsis the amount of water flow that is used to irrigate the land in irrigation area to know whether water that is available to irrigate existing rice field needs water balance calculation in related irrigation area. This calculation is implemented by comparing available water and existing water needs.

d. Availability Water Calculation

The availability water calculation is amout water (flow) that estimated always exist in a location (dam or other water building) with the certain amout and in certain time (period) (*Direktorat Irigasi, 1980).* Epedable flow is a minimum river flow with the certain quantities which has posibilities occurance that can be used for that needs. For irrigation needs, minimum flow that required is 80% *(Hidrologi Terapan, 2008).*

e. Water Balance Analysis

The water balance analysis can be calculated by:

$$S_t + 1 = St + lt + Rt + Et + Qt - Q_t \quad (1)$$

where :
S_{t+1} = Water storage on period to t+1
St = Water storage on period to t
lt = inflow to reservoir on period to t
Rt = rainfall which entering into reservoir storage on t periode

Et =water loss because evaporation in reservoir on t periode
Ot = Reservoir outflow t periode
Qst = Reservoir spill out t periode

3. Analysis and Discussion

Dam Location can be seen in the following picture :

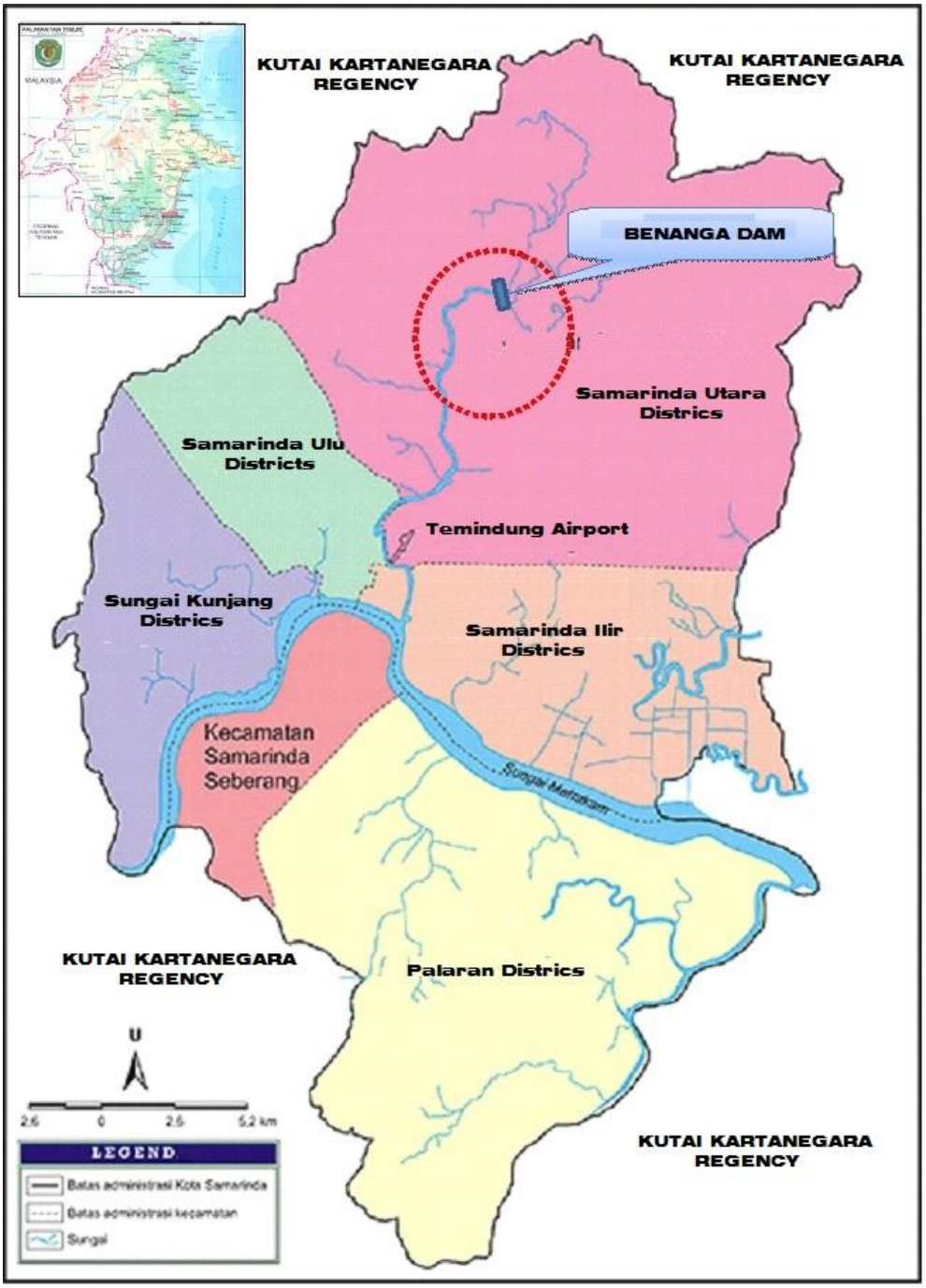

Figure 2. Location of Benanga Dam

This dam planned to fulfill irrigation water needs about 350 Ha and 210 l/seconds for clean water need. But nowdays, this dam is also utilized to accommodate water from upstream Karang mumus watershed before entering Samarinda city. So that, in data analysis the steps will btaken are :

1. Availability Water Analysis by Nreca Method
2. Irrigation Water Needs Analysis
3. Analysis of Waduk Benanga Inundation Map by reservoir capacity curve
4. Simulation of Benangan Reservoir

3.1. Evapotranspiration calculation Result

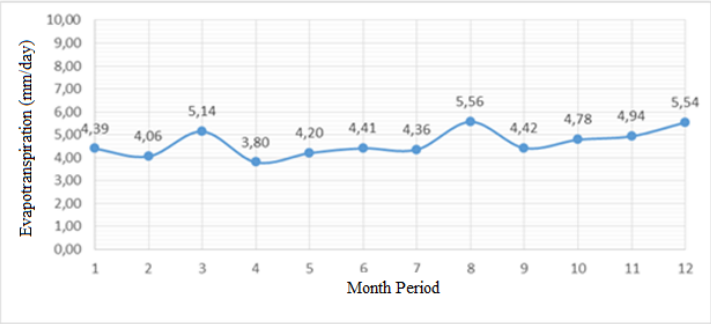

Figure 3. Evapotranspiration in Benanga Reservoir

From chart above can be seen that highess evapotranspiration in Benanga reservoir theoccurance in month 8 (August) where the value of evapotranspiration of reference plant (ETo) reaches value about 5.56 mm/days. This thing show that the biggest evaporation occurance on that month that is because of air speed about 2.06 m/dtk. *Dependable Rainfall Calculation Result 80% and 50%.*

In dependable rainfall calculation that occurance in Benangan Reservoir used the data of monthly rainfall that obtained from Badan Meteorologi Klimatalogi dan Geofisika (BMKG)that occurance between this 15 years since 2000 until 2015. This is the chart of dependable rainfall 80%:

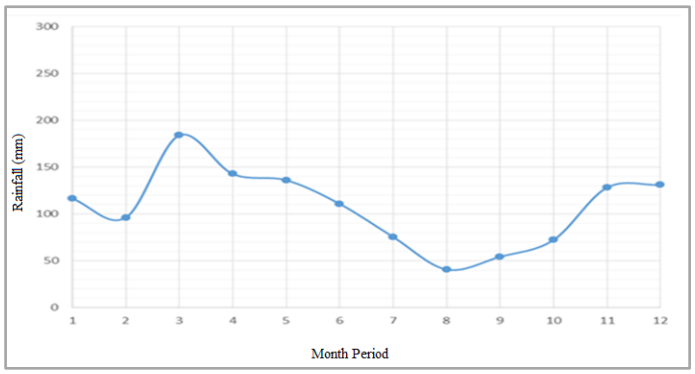

Figure 4. Dependable Rainfall Characteristics 80%

From that chart can be seen that dependable rainfall 50% characteristics which is occurance in Benanga reservoir where the highess dependable rainfall occurance on month 3 (March) which is about 183.9 mm.

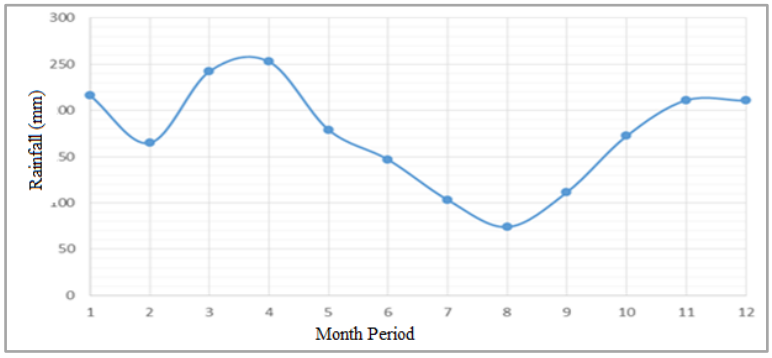

Figure 5. Dependable Rainfall Characteristic 50%

3.2. Calculation of Irrigation Water Requirements

Most of Irrigation water needs be fulfilled by overland flow. Irrgation water needs affected some factors such as climatology, soil condition, plant coefficient, cropping pattern, water supply, group system, cropping schedule, and ect. Some field condition related to water needs to agriculture varies towards time and space as mentioned in these following factors:

1. Types and varieties of cropping by farmer
2. Coeffisien varieties plants, depends on type and plants growing steps
3. When the preparation of land started (group)
4. Cropping schedule that is used by farmers, incluiding water supply related on land preparation, nurseries, and fertilization.
5. Irrigation system status and irrigation efficiency
6. Type of soil and agroclimatology factors

Des		Jan		Feb		Mar		Apr
I	II	I	II	I	II	I	II	I
LP	PD-I	PD-I	PD-I	PD-I	PD-I	PD-I	LP	LP
LP	LP	PD-I	PD-I	PD-I	PD-I	PD-I	PD-I	LP

Apr	Mei		Jun		Jul		Agust		Sep		Okt	
II	I	II	I	II	I	II	I	II	I	II	I	II
PD-II	PD-II	PD-II	PD-II	PD-II	PD-II	PLW	PLW	PLW	PLW	PLW	PLW	LP
LP	PD-II	PD-II	PD-II	PD-II	PD-II	PD-II	PLW	PLW	PLW	PLW	PLW	

Figure 6. December Cropping Pattern Planning

Legend :

LP = Land Preparation
PD-I = First Cropping Pattern
PD-II =Second Cropping Pattern
PLW = Cropping Palawija

3.3. Simulation Reservoir

To determine step that must be taken so need to besimulated with 3 alternatives such as:

1. Arrange cropping pattern for farmer only
2. Do dredging as deep 1.2 m
3. increasethe height of spilways of the dam

a. Alternative 1 (without dredging and increase spillways)
In this alternative the result of reservation simulation can be shown, as follows:

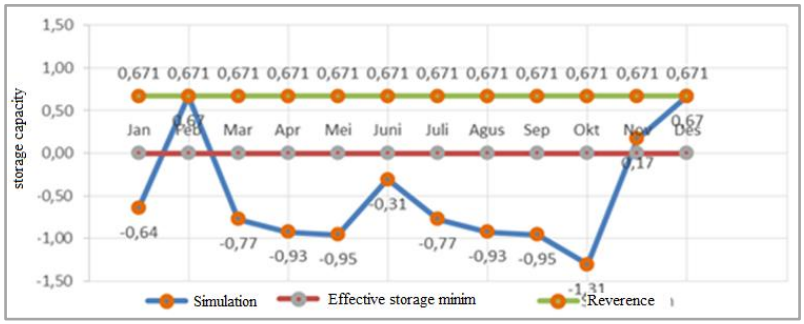

Figure 7. Result of Water Balance Simulation RTT

In chart above shows that December is the month which can be selected forthe farmers in Benanga reservoir in order to start planting period. Advantages of cropping pattern Alternative Simulation in December until January are irrigation area which can be served is larger, more raw water needs which can be fulfilled, abundant amount of water less.

b. Alternative 2 (dredged reservoir as deep 1.2 m)
In this alternative, the simulation will dredged as deep 1.2 m appropriate with the height of the main Benanga's spillway.

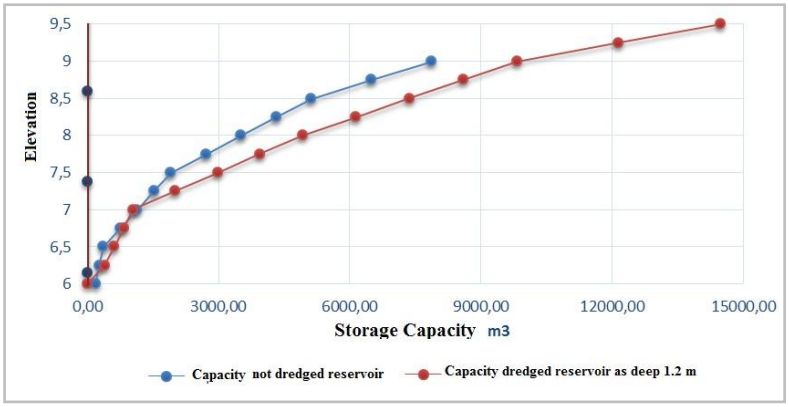

Figure 8. Simulation Result of Capacity Curve

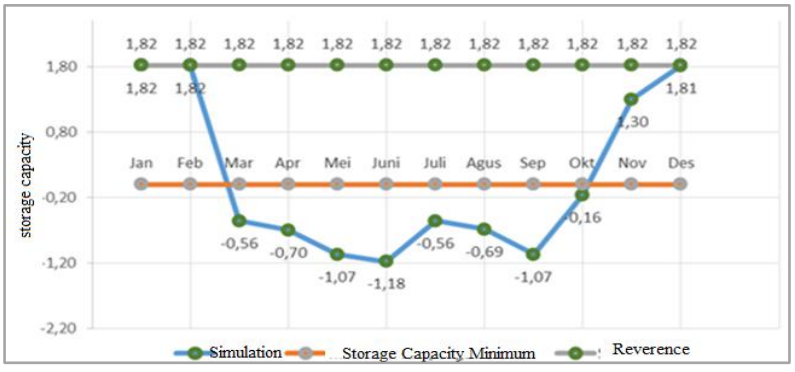

Figure 9. Dredging Simulation Result of Benanga

Figure 9 shows that if the reservoir dredged for 1.2 m. There are 3 alternative for early planting that can be used such January, February, and December and among these 3 months early planting in December month is the most profitable cropping pattern alternative where in this early planting Benanga reservoir can serve irrigation needs about 350 Ha, clean water about 210 l/second, and mantaining river about 50 l/second.

c. Alternative 3 (increase the height of Reservoir's Spilways)

Benanga's spilways nowdays is in +7.20 elevation based on water balace simulation result shows with the elevation position in +7.20 Benanga Reservoir can only serve raw water needs (irrigation water and clean water) if early cropping pattern start from February month and December with the maximum service in December month where in December month, it can serve irrigation needs about 350 Ha, Clean water 133 l/second, and mantaining river about 50 l/seconds. So elevation increasing for it's elevation which aim to waduk Benanga can fulfill raw water needs just like in it's planning 2014. Based on simulation result for increasing top elevation spilway there is in elevation +7.75 with the recaptulation of water balance values as follows :

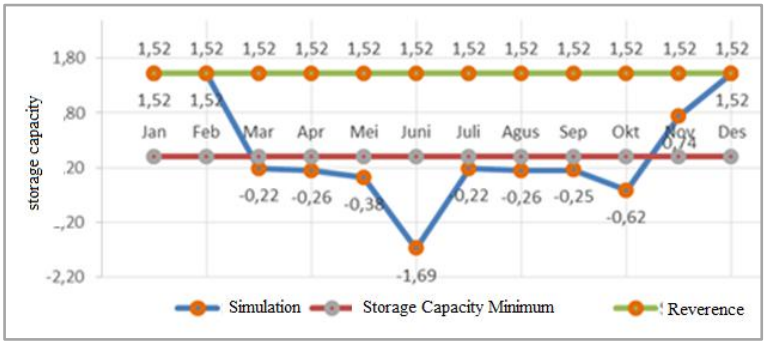

Figure 10. Simulation Result of increasing spilway

In chart above shows that if increasing the spilway has done until in 7.75 elevation then there are 3 alternative early cropping that can be used such as January, February, and December and among these three months early cropping in December month is the most profitable early cropping pattern alternative where in elevation +7.75 Benanga Reservoir able to fulfill irrigatin needs about 350 Ha, clean water about 210 l/second, for river mantaining about 50 l/second.

4. Conclusion

1. From the result known that simulation of reservoir besides February and December can not be choose because it can not reached back +7.20 elevation the storage capacity is under minimum elevation of effective storage (<6.00) so simulation of early cropping pattern should be implemented appropriate with the requirement of reservoir operation system that has done in February and December.
2. Based on simulation of water balance that appropriate with the requirement of reservoir operation system are obtained 2 alternative that fulfill the requirement there are in February and December.

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