MODEL OF SURFACE WATER MANAGEMENT BASED ON THE POTENCY
OF WATER BALANCE

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ABSTRACT

Purpose: This research intends to build the simulation model of surface water management in
the Kali Lamong watershed based on each water district for maintaining in order to be able to
fulfill the sustainable water demand

Theoretical reference: Management of surface water is one of the very important issues
nowadays. By the climate and land use change, it is adding the water resources problem in the
future. Kali Lamong watershed is one of water sources for Surabaya city and the other cities.
Water availability in Lamong watershed becomes very important to be known, and how is the
condition in the future on short term (2050), medium term (2075), and long term (2100) by
using the three scenarios for facing the uncertainty.

Method: The methodology consists of developing the model of water management based on the
water district by integrating the simulation result into the solutions for developing water
management for reaching the water safety in the Kali Lamong watershed.

Result and Conclusion: The simulation result shows that on the condition of scenario A, there
is needed the reservoir capacity in short term (2050) in Lamong Hulu and Kalitemu that is 18
and 8 million m$^3$; for medium term (2075) is 35 and 19 million m$^3$; and for long term (2100) is
62 and 34 million m$^3$. For scenario B, there is needed the reservoir capacity for short term
(2050) in Lamong Hulu and Kalitemu is 23 and 10 million m$^3$, for medium term (2075) is 35 and
15 million m$^3$, and for long term (2100) is 50 and 26 million m$^3$. However, for scenario C is
needed the reservoir capacity for short term (2050) in Lamong hulu and Kalitemu is 26 and 11
million m$^3$, for medium term (2075) is 45 and 21 million m$^3$, and for long term (2100) is 80 and
38 million m$^3$.

Implication of research: Based on the prediction result of rainfall and land cover change, there
is obtained the dependable discharge (Q-80%) in each water district with 3 scenarios including
the projection of water demand. The potency of water balance in each water district produces
3 water districts which experience water deficit in Lamong Hulu, Sabeng, and Kalitemu Water
District. To fulfill the water deficit in water district, there is carried out by building reservoir

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in the watershed downstream in two locations that are Lamong Hulu and Kalitemu water districts and it is integrated in the water management model.

Originality/ value: To build a simulation model of surface water management.

Keywords: simulation, water management, dependable discharge, water balance, water allocation.

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MODELO DE GESTÃO DE ÁGUAS DE SUPERFÍCIE COM BASE NA POTÊNCIA DO BALANÇO HÍDRICO

RESUMO

Finalidade: Esta pesquisa pretende construir o modelo de simulação de gestão de águas superficiais na bacia hidrográfica de Kali Lamong, com base em cada região hidrográfica para manutenção, a fim de ser capaz de satisfazer a demanda sustentável de água

Referência teórica: Gestão das águas superficiais é uma das questões muito importantes nos dias de hoje. Pelas alterações climáticas e pelo uso do solo, está a adicionar o problema dos recursos hídricos no futuro. A bacia hidrográfica de Kali Lamong é uma das fontes de água da cidade de Surabaya e de outras cidades. A disponibilidade de água na bacia hidrográfica de Lalong torna-se muito importante para ser conhecida, e como é a condição no futuro a curto prazo (2050), médio prazo (2075) e longo prazo (2100) usando os três cenários para enfrentar a incerteza.

Método: A metodologia consiste em desenvolver o modelo de gestão da água com base no distrito da água, integrando o resultado da simulação nas soluções para o desenvolvimento da gestão da água para alcançar a segurança da água na bacia hidrográfica de Kali Lamong.

Resultado e Conclusão: O resultado da simulação mostra que, na condição do cenário A, é necessária a capacidade do reservatório a curto prazo (2050) em Lamong Hulu e Kalitemu, que é de 18 e 8 milhões de m3; a médio prazo (2075) é de 35 e 19 milhões de m3; e a longo prazo (2100) é de 62 e 34 milhões de m3. Para o cenário B, é necessária capacidade de reservatório para curto prazo (2050) em Lamong Hulu e Kalitemu é de 23 e 10 milhões de m3, para médio prazo (2075) é de 35 e 15 milhões de m3, e para longo prazo (2100) é de 50 e 26 milhões de m3. No entanto, para o cenário C é necessária a capacidade de reservatório a curto prazo (2050) em Lamong hulu e Kalitemu é de 26 e 11 milhões m3, para médio prazo (2075) é de 45 e 21 milhões m3, e para longo prazo (2100) é de 80 e 38 milhões m3.

Implicação da pesquisa: Com base no resultado da previsão de chuvas e mudança da cobertura do solo, obtém-se a descarga confiável (Q≥80%) em cada distrito hídrico com 3 cenários incluindo a projeção da demanda de água. A potência do equilíbrio hídrico em cada distrito hídrico produz 3 distritos hídricos que experimentam déficit hídrico em Lamong Hulu, Sabeng, e Kalitemu Distrito Hídrico. Para cumprir o déficit de água no distrito de água, há realizado pela construção de reservatório na bacia hidrográfica a jusante em dois locais que são Lamong Hulu e Kalitemu distritos de água e está integrado no modelo de gestão de água.

Originalidade / valor: Para construir um modelo de simulação de gestão de águas superficiais.

1 INTRODUCTION

The accurate selection of model needs the consideration to some criteria in the context of problem solving in the field. Several key factors involve the depth understanding related to the context of problem, time that is needed to develop model, water resources that is needed, transferability, and maintenance need. The effective maintenance reflects the thinking and understanding way that is simplified through the mathematical formulation that intends to obtain the accurate representation to the real condition. Modeling has to be able to give contribution in finding the solution to the problem, to moderate the thinking process, and to give the overall illustration related to the problem for understanding and fulfilling. To facilitate the development, interpretation, and communication of model, it is important the simplicity in the structure of model. Although the issue that is faced is often complex, the use of model that has more complexity is necessary to be avoided, and has to focus in the effort to decrease the non-essential complexity (Lund et.al, 2010).

Some research related with the climate change in Indonesia, have been carried out, like the research by Manton et.al (2001) that made effort to analyze the increasing trend of extreme case in the Asia-Pacific region. The research result did not show the clear trend related with temperature and rainfall change in Indonesia, although the main constraint that is faced is the limitation of data mainly for temperature data. In the other side, the research by Boer and Faqih (2004) used the rainfall data from 210 stations for comparing the yearly rainfall between 1931 until 1969 and 1961 until 1990. This study recorded the decreasing trend of rainfall in some areas like Java, Lampung, Sumatera Selatan, Sulawesi Selatan, and Nusa Tenggara, while some other area like Kalimantan and Sulawesi Utara experienced the increasing of rainfall. Aldrian (2006) also found the significant decreasing trend in yearly rainfall mainly in Kalimantan. The research result of Nurlatifah et.al (2023) gave the projection which showed that the increasing of monthly rainfall in Java Island is from 2021 until 2050. Although the increasing is not overall significant (is about 1.7-5.3 mm), however, the East Java experiences the highest increasing that is reaching 15.1-22.4 mm. The uncertainty and difference of research result indicates the difficulty in formulating the comprehensive illustration about the trend of climate change in Indonesia. It shows that how difficult to predict the water availability in the future in the scheme for water management.
The water supply reduced in amount of 20% can give the impact on PDB decreasing until 10%, while the increasing of water deficit can decrease the employer demand until 12% and it causes the significant change in land use including the missing of worth hydrology service. It shows the negative impact to the prospect of regional economy and the potency of natural damage (Taheripour et.al, 2020). The 9 main innovations are applied by Israel in water management for fulfilling the water scarcity that are 1) to correlate all of water infrastructure for regulation of water distribution system; 2) to treat waste water for irrigation; 3) big scale desalination for water drinking independence; 4) the utilization of aquifer as reservoir; 5) interception of surface water run-off; 6) promotion of vegetation selection and import of air virtual; 7) application of irrigation technology efficiently; 8) management of demand and public communication; and 9) to create environment (Smakhtin et.al, 2004) that supports the innovation (Marin et.al, 2017).

The water resources scarcity that has become as the inhibitor factor of socio-economy development during the last decades is as a serious challenge in many world areas including Indonesia (Wang et.al, 2017 and United Nations Environment Programme, 2011). The increasing of water demand as the impact of population growth, industrialization, and less effective strategy of water management becomes as the focus of global attention (Kondili et.al, 2010). The population growth in the city/ regency like Gresik, Lamongan, Mojokerto, ans Surabaya increases the demand of water resource from Kali Lamong. Therefore Kali Lamong is very important for ecosystem and society demand fulfilling. The quantitative study that integrates the water supply and demand in every water district in Kali Lamong watershed has been carried out (Purnomo et.al, 2023). The further analysis about the water condition in the future is needed to be carried out through the projection of further demand (Purnomo et.al, 2023a and Ciampittiello et.al, 2021). As the anticipative step, simulation from some scenarios is needed to be carried out for seeing how far the impact that is faced and how to fulfill the water scarcity in the future. This process can be carried out through the model development of water management based on the water district, by integrating the simulation result into solutions for developing the surface water management for reaching the water safety in Kali Lamong watershed.
2 MATERIALS AND METHOD

The model simulation of water management is carried out in the water district of Kali Lamong watershed. Kali Lamong watershed consists of 6 water district areas that cover the regency administration areas of Lamongan, Mojokerto, Gresik, and Surabaya, as presented in the Figure 1.

![Figure 1 Boundary of water district in the Kali Lamong watershed](source: Purnomo (2023a))

2.1 DATA

Data that are used in this study consists of population, technical irrigation area, and industry that come from Statistical Center Institution (BPS) in district level in the regencies of Lamongan, Gresik, Mojokerto, and Surabaya city. There is information available starting from village level in the district BPS. The other data like hydrology data for analysis water availability is using the study result data from the topic of Surface water balance based on water district analysis in Lamong Watershed, East Java Province, Indonesia (Purnomo et.al, 2023), while for assessing the projection in the future with the water scarcity in each water district has been presented with the title of potential analysis of surface water balance in the water district of the Kali Lamong watershed, Indonesia (Purnomo, 2023a).

2.2 METHOD

The method that is used in this research is by carrying out the simulation due to the model scenario of surface water management that is used. The simulation is for seeing the surface water management through the water balance result in the future (2050, 2075, and 2100) in each water district that experience water safety (surplus). Model of surface water management is carried out integrated and simultaneously from water district in the upstream until downstream. This model is following the stage of analysis scheme as presented in the Figure 2.
2.3 MODEL OF SURFACE WATER MANAGEMENT

Model of effective surface water management has to be able to cover the long-term design that involves stakeholders from some sectors, so the solution that is produced can give the sustainable impact. Gleick (2003) presented the comprehensive illustration about water use by integrating the technical and social aspect in water resources management and also described the complexity of water use from some perspective and gave overall illustration about the challenge that is faced in making sure the sustainability of water resources utilization. To detail the simulation of management in the future, the model structure that is used can be seen in the Figure 3.
2.4 SCENARIO MODEL OF SURFACE WATER MANAGEMENT

The change of scenario in the future that can be adapted for a certain area is as follow:

2.4.1 Variability of rainfall

This study conducted in two locations: a) the rainfall change is increasing about 0.2% every year, and b) the rainfall change experiences the decreasing in amount of 0.2%
every year. In addition, the temperature change is also analyzed due to the influence on water availability through the increasing of evaporation that is directly influencing the model of rainfall-run-off in Kali Lamong watershed.

2.4.2 Land use change:

The land use change significant influences the water availability. Therefore, the scenario of land use change is carried out by modifying the parameter related with land cover like PSUB and GWF parameters in NRECA model (Crawford, 1986).

2.5 MODEL SIMULATION OF SURFACE WATER MANAGEMENT

In model simulation of surface water management, some scenarios has been identified for anticipating and managing the potency of water scarcity in the future, to be possible the decision maker for developing the most effective and sustainable management strategy.

3 RESULTS AND DISCUSSION

3.1 WATER AVAILABILITY IN THE FUTURE

This research uses 2 scenarios of rainfall change that are increasing and decreasing as the base analysis. In addition, land use change in the future is associated with the related parameter in the model, reflects the degradation that is possible happened. By combining the aspects, this research intends to give further understanding related with water availability in the future.

3.2 THE PREDICTION OF RAINFALL IN THE FUTURE

To determine the trend of rainfall change in the future, there is used the Monte-Carlo method based on the characteristic of rainfall data that is monitored. The prediction of rainfall analyses two scenarios that are increasing trend about 2% and decreasing trend about 0.2%. By using this data, it can be produced the illustration of monthly rainfall in the Lamong-Baboh watershed beginning from 2024 until 2100 as presented in the Figure 4.
3.3 PREDICTION OF FLOW DISCHARGE IN THE FUTURE

After analyzing monthly rainfall data, then, there is carried out the simulation by using NRECA model for obtaining the flow discharge in Kali Lamong-Baboh watershed. The simulation covers 2 scenarios that are rainfall with increasing trend and rainfall with decreasing trend. The prediction result of flow discharge then it is used for analyzing the dependable discharge (Q80%) for every water district in some periods in the future that are 2025 until 2050, 2051 until 2075, and 2076 until 2100.

Based on the discharge that is produced, the water availability in every future period experiences change regarding to the rainfall condition that is used. The discharge that is listed is come from the rainfall condition that experiences increasing trend, so the discharge that is produced is bigger than the dependable discharge that is produced from observation data now (Purnomo, 2023a).

In Figure 5, it is seen that dependable discharge (Q80%) from every water district shows that the significant increasing during the rainy season, while on the dry season experiences the increasing of dependable discharge value which is little. By the change of dependable discharge in every water district, water balance in each water district maintains the same pattern with the existing water balance condition, however, the volume of surplus discharge is increasing than the existing dependable discharge condition. The increasing of volume on the surplus season is a possibility for fulfilling the water scarcity on the dry season.
In the rainfall condition that experiences decreasing, it is seen that there is difference in future dependable discharge that is produced. This dependable discharge shows the similar pattern with the existing one, but in the rainy season, the future dependable discharge is generally higher than the existing condition. On the contrary, in the dry season is seen that the future dependable discharge tend lower than the existing condition. The difference is clearly presented in the Figure 6.

Based on the dependable discharge analysis that has been carried out, by the assumption that rainfall experiences the decreasing trend and the land cover condition experiences degradation including the increasing of evaporation data, there is predicted that water discharge that is produced will experience reducing in the future. Therefore,
the water availability is likely to decrease, it causes the challenge in water management in the future for determining in order to be remained to have surplus. This scenario can assume as the worst condition that has to be faced in the future. If the water management model that is proposed is able to fulfill this challenge, so it can be predicted that the surface water management will be remained to produce the surplus in the future, as long as the water demand is fitted with the projection that is produced in this research.

Figure 6 dependable discharges (Q80%) in the future for the decreasing trend of rainfall

![Figure 6](image)

Source: own study

3.4 WATER DEMAND IN THE FUTURE

Water demand in each water district in the future has been projected for each sector. The water demand that is significantly influencing the water demand total is in the sectors of agriculture, domestic, and industry. From each sector, there has been projected
the demand until 2100 (Purnomo, 2023a). However, the water demand total for each water district on every period can be seen in the Table 1.

Table 1 Total of water demand in each water district

<table>
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Source: own study

3.5 POTENCY OF WATER BALANCE IN THE FUTURE WATER

Analysis of water balance in each water district in Kali Lamong watershed in the future (2050, 2075, and 2100) will be analyzed. The potency of water balance for existing condition has been produced and it experience water deficit in certain month period. Water deficit is only happened in 3 water districts that are Lamong Hulu, Sabeng, and Kalitemu (Purnomo et al., 2023a). The potency of water balance in the future is necessary to be known so the design in the future can be anticipated how the surface water management in the future will be remained surplus dan it does not experience the water scarcity due to the ecosystem change happenning. To anticipate the problem, so there is carried out the analysis with some assumption of change in the future through some scenarios that is described in section below.

3.6 POTENCY OF WATER BALANCE IN THE WATER DISTRICT FOR SOME SCENARIOS

The potency of water balance in the future is analyzed by using some approach scenarios. The scenario that is used for analyzing the potency of water balance is regarding to the method that has been presented before. The classification of scenarios to the water availability in the future can be categorized into 3 that are: i) scenario-A is the water availability condition in the future is assumed the same with the existing condition, ii) scenario-B is the water availability in the future is predicted based on the increasing rainfall trend, and iii) scenario-C is water availability in the future is predicted based on...
the decreasing rainfall trend. The analysis result that is clearly related with the potency of water balance from the scenarios are described below.

3.7 THE POTENCY OF WATER BALANCE IN WATER DISTRICT FOR SCENARIO-A

Scenario-A is the scenario by using dependable discharge (Q80%) based on the discharge that is monitored until now. The dependable discharge has been used for analysis of water balance potency in each water district. There are still some water deficit due to the potency of water balance in each water district. The water district with the water deficit in the upstream is Kali Lamong watershed so it is needed an effort how can improve the water deficit on dry season in the model of surface water management can be fulfilled. There are three water districts experience water deficit that are Lamong Hulu, Subeng, and Kalitemu water districts (Purnomo et.al, 2023). The analysis result of water balance potency in each water district can be seen in the Figure 7.
Figure 7 Potency of water balance in the water district on the water availability condition now

Source: own study

3.8 POTENCY OF WATER BALANCE IN WATER DISTRICT FOR SCENARIO-B

The scenario-B involves the use of dependable discharge (Q80%) based on the discharge data that has been analyzed by using the rainfall data which have the increasing of change trend. The dependable discharge that has been produced has been applied for analyzing the potency of water balance in some water districts. However, the analysis result shows that some water districts still experience water deficit although the dependable discharge is increasing. The water deficit is happened on the dry season month and the area that experience water deficit is in the same water district for scenario-A which is Lamong Hulu, Sabeng, and Kalitemu. The scenario-B can’t fulfill water deficit on dry season because the dependable discharge that is produced on the scenario-B has not still given the significant increasing value in this month. However, it only gives the increasing of water volume on the rainy season which on this month the surface water management also experiences the water surplus. Therefore, it is needed an effort to
improve the model of surface water management and to fulfill the water deficit mainly during the dry season. The analysis result of water balance potency in every water district can be seen in the Figure 8.

Figure 8 Potency of water balance in the water district on the water availability condition based on the increasing trend of rainfall

3.9 POTENCY OF WATER BALANCE IN THE WATER DISTRICT FOR SCENARIO-C

Scenario-C applies the utilization of dependable discharge (Q80%) based on the analysis of discharge data by attending the rainfall decreasing trend. The dependable discharge that is produced is used for analyzing the potency of water balance in some water districts. The analysis result shows that some areas experience the water deficit mainly during the dry season. The areas that are impacted the water deficit in scenario-C
is really the same with that is identified in the scenario-A and B that are Lamong Hulu, Sabeng, and Kalitemu. In the scenario-C, the dependable discharge that is produced mainly for dry season is smaller than in the scenario-A, so the potency of water balance in the water district that experiences water deficit will be increasing. On rainy season, the potency of water balance for all of water districts still experience surplus. Therefore, it is needed an effort to complete the model of surface water management and to fulfill the water deficit mainly during dry season. The detail of analysis result for potency of water balance in every water district can be accessed in the Figure 9.

3.10 MODEL SIMULATION OF SURFACE WATER MANAGEMENT

From the 3 scenarios that have been analyzed for determining the dependable discharge in the future, there is identified that water deficit on dry season in the three
water districts show the similar pattern. Therefore, every management model that will be implemented in water district that experiences water deficit will be simulated for all water district. The main aim of this simulation is for understanding and measuring the influence that may be happened in the other water district due to the implementation of the model.

Simulation of Surface Water Management on 2050

From this simulation result, it will be seen how the three scenarios and some storage capacity are influencing the fulfilling of water demand in Lamong Hulu water district. The curve will visualize the relation between supply and demand, to help the decision taking related with the further steps in managing water in this area. The initial simulation is important as the base for seeing the previous condition of water storage structure implementation, at a time to help designing the optimal solution for fulfilling the water deficit that is faced in the future.

Table 2 Simulation result of some reservoir capacities that is used for 3 scenarios of water availability on 2050

<table>
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<th>Reservoir capacity of Kalitemu (million m$^3$)</th>
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<th>Year</th>
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</table>

Source: own study

If on 2050 is happened like there is assumed on the scenario-C, so there is needed the storage capacity that is getting increasing for fulfilling the demand from some sector in each water district. It is due to the dependable discharge that is predicted on this scenario experiences the decreasing from scenario-A mainly on dry season. However, the simulation result shows that the storage capacity in Lamong Hulu water district is needed.
about 26 million m$^3$, while the storage capacity demand in Kalitemu water district is 11 million m$^3$.

3.10.1 The condition of dependable discharge for scenario-a (existing)

The criteria that is used for determining the storage capacity has fitted if the curve of water demand can be given for supply (fitted). On the condition of scenario-A on 2050, there has been carried out the simulation by using the zero storage capacity, so the curve of demand and supply for each water district is presented as in the Figure 10. Figure 10 shows that the curve of demand and supply has not yet fulfilled the demand in each water district. If the storage capacity is followed in analysis by adding the value of storage capacity, it is seen that the curve change as in the Figure 10. The curve result that is seen in Figure 11 is as the simulation by adding the storage capacity in Lamong Hulu is about 18 million m$^3$ and in Kalitemu is about 5 million m$^3$. From Figure 11 is seen that there some water districts that have fulfilled the demand as being shown in the curve of demand-supply is handled together. If the curve of demand-supply is not handled together, so there is water deficit on this month. In this case, for Kalitemu and Lamong Hilir water district still experience water deficit. Therefore, it is needed to increase the reservoir storage capacity in Kalitemu so it can fulfill in this area.

Figure 10 Curve of demand and supply by reservoir storage (Lamong Hulu: 18 million m$^3$ and Kalitemu: 5 million m$^3$)

Source: own study
3.10.2 The condition of dependable discharge scenario-B (increasing)

Simulation has been carried out for determining the storage capacity that is needed for fulfilling the water demand on 2050, by the scenario-B indicates that the zero storage capacity cannot completely fulfill water demand in some water districts. It can be seen from the simulation result as presented in the Figure 12. From Figure 12, it is seen that the curve of demand-supply has not still experienced the balance.

The simulation result that is reflected in the Figure 13 illustrates that the additional storage capacity in Lamong Hulu is in amount of 20 million m$^3$ and in Kalitemu is in amount of 5 million m$^3$ produces the change on the curve of demand-supply. A number of water districts has reached the balance between water demand and water supply, as being reflected from the parallel of demand-supply curve. However, there is still deficit water in the certain water district like Sabeng, Lamong Tengah, Ngrembeng, Kalitemu, and Lamong Hilir. Therefore, it is recommended to increase the storage capacity in Lamong Hulu and Kalitemu for determining the fulfilling water demand in this area. If the curve of demand-supply does not reach the balance, it reflects water deficit on the certain months. Therefore, it is suggested to carry out the further adjustment through the increasing of storage capacity.
3.10.3 The condition of dependable discharge for scenario-C (decreasing)

The condition of scenario-C has been carried out the simulation for obtaining the result how much the value of storage capacity that is needed. The simulation is carried out by using some storage capacity for obtaining the result which water demand on this year can be fulfilled. The criteria for assessing that the storage capacity that is used has been fitted if the curve of demand-supply has been balanced. It can be seen from the simulation result in the Figure 14. The curve that is presented in the Figure 14 is as the simulation result which is seen that the curve of demand-supply has not been to experience the balance because there still uses the zero storage capacity. If the storage
capacity is following in the simulation, so the change of demand-supply curve experiences the change. The simulation result in the Figure 14 is as the simulation result by adding the storage capacity in Lamong Hulu in amount of 25 million m$^3$ and in Kalitemu is in amount of 5 million m$^3$. A number of water districts have reached the balance between water demand and water supply, as which being reflected from the parallel curve of demand-supply. However, there is still water deficit in the certain water district like Kalitemu and Lamong Hilir. Therefore, it is recommended for carrying out the increasing of storage capacity in Lamong Hulu and Kalitemu for determining the fulfilling of water demand in this area. If the curve of demand-supply does not reach the balance, it reflects the water deficit on certain month. Therefore, it is suggested to carry out the further adjustment through the increasing of storage capacity.

Figure 14 Curve of demand and supply if the reservoir storage is zero for scenario C

Source: own study
3.11 SIMULATION OF SURFACE WATER MANAGEMENT ON 2075

Simulation of surface water management is carried out for detailing the overall dynamics between demand and supply in Lamong Hulu and Kalitemu water districts and the other district area. In this context, the reservoir capacity is expanded regarding to the demand at projection on 2075 and fulfilling the water supply for every district area. Table 3 presents the summary of simulation result on 2075, to consider several storage capacities that are applied in the three scenarios which have been proposed before. This data gives depth illustration about the effective strategy of water management that implement in anticipating the water demand in the future.
Table 3 Simulation result of some reservoir capacity that is used for 3 scenarios of water availability on 2075.

<table>
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<tr>
<th>No</th>
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</table>

Source: own study

Based on the simulation result on 2075 for the three scenarios of dependable discharge that is used there is seen that the reservoir capacity in two water districts is able to fulfill the water demand in all of water districts. In the existing condition, the reservoir capacity in Lamong Hulu water district is estimated reaching about 35 million m³, however, in Kalitemu water district is about 19 million m³, and it is used as the anticipated step to the water deficit potency on the dependable discharge condition now.

In the context of assumption about the rainfall change in the scenario-B, there is seen that although the water discharge experiences increasing, but the reservoir capacity that is needed is also tend to increase. The reservoir capacity that is needed for Lamong Hulu water district is reaching 35 million m³, while for Kalitemu water district is about 15 million m³. The increasing of reservoir capacity demand is caused by the decreasing of dependable discharge on dry season, although it experiences increasing in rainy season. If seeing the scenario-C on 2075 that is assumed to experience the decreasing of dependable discharge from scenario-A, so it is needed the reservoir capacity that is getting increasing for fulfilling the water demand from several sectors. The simulation result shows that the reservoir capacity in Lamong Hulu water district is needed about 45 million m³, while for Kalitemu water district is needed about 21 million m³.
3.12 SIMULATION OF SURFACE WATER MANAGEMENT ON 2100

This approach involves the infrastructure development of water storing in district area in the upstream part of watershed, it is hoped can be contributed in fulfilling water deficit in three main district areas that experience water deficit. The concept simulation of water management that is presented for 2100 is applied in each water district in Kali Lamong watershed, using the three scenarios that have been discussed before. This simulation result is presented through the curve that illustrates the relation between water demand in the year projection and the fulfilling of water supply for every water district. Table 4 presents the summary of simulation result for the three scenarios that are applied on 2100 by considering some different storage capacity.

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Source: own study

Based on the simulation result that is carried out on 2100 for the three scenarios of dependable discharge that is used, it can be produced that the reservoir capacity in two water districts has fulfilled the water demand in all of water districts in Kali Lamong watershed. In the existing condition, there is obtained the reservoir capacity in Lamong Hulu watershed that is estimated about 62 million m³, and the reservoir capacity in Kalitemu water district is about 34 million m³ that is used for anticipating the water deficit in the dependable discharge condition of scenario-A. If there is assumed the rainfall change is happened as the scenario-B, so the reservoir capacity that is used will be
different with before. The reservoir capacity that is needed for Lamong Hulu water district is about 50 million m$^3$, while the reservoir capacity for Kalitemu water district is about 36 million m$^3$. If there is attended from dependable discharge result that is obtained from the scenario-B, the discharge experiences increasing, but the reservoir capacity that is needed tend to experience increasing. The increasing of reservoir capacity demand is due to that on dry season, the dependable discharge in this condition experiences decreasing if it is compared with the scenario-A, however, it experiences increasing on rainy season. If on 2100 the water availability is assumed the same as the scenario-C, it is needed the reservoir capacity is getting increasing for fulfilling the demand from some sectors. It is due to the dependable discharge that is predicted in this condition experiences decreasing. However, the simulation result shows that the reservoir capacity in Lamong Hulu water district that is needed is about 80 million m$^3$, while the demand of reservoir capacity in Kalitemu water district is about 38 million m$^3$. Although the value of reservoir capacity in this analysis is only a number that has to be fitted, however, it is needed the further evaluation for determining that the water surplus on rainy season can fulfill the available reservoir capacity.

3.13 ANALYSIS OF WATER INFLOW VOLUME IN RESERVOIR PLAN

The simulation of surface water management in the future has been carried out by some scenarios. The result that is obtained for facing the water scarcity in the future is by building the water storage and saving water when there is happened the surplus water. Plan of storage capacity from some scenarios that are used have been produced and it can be seen in the Table 5 as the summary of the whole simulation that is used.

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Source: own study
From the value of reservoir capacity that is needed for facing the water demand in the future, it is necessary to be determined the volume of water availability that enters into the reservoir plan. Because the reservoir plan is in the Lamong Hulu and Kalitemu water districts, so the inflow that is used is only the water availability for each water district. The inflow volume of water availability that has been analyzed are presented in the Table 5 is as the volume during one year.

The analysis result that is seen in the Table 5 shows that there is the scenario which produces the value of reservoir capacity that is proposed more than the inflow volume of water availability in this location, because the source that is used is only in the water district and has not considered the rest of water availability that is produced from each water district.

4 CONCLUSIONS

Based on the simulation result of water management that has been discussed in this research, it can be concluded as follow:

The dependable discharge for each water district for some change scenarios have been carried out and the generation of discharge in the future (2024 until 2100) has been carried out. The potency of water balance in each water district in the future and by using the three scenarios have been carried out and the result shows that there is some water districts experience the water deficit. The water deficit in the future will be happened in Lamong Hulu, Sabeng, and Kalitemu water districts, while in the other water districts, the water surplus still have longer period and the water deficit is still very little.

The Lamong Hulu and Kalitemu water districts are as the water district that are located in the upstream of watershed and have the very significant pressure to the water resources demand in the future. The surface water management in Lamong watershed that is carried out based on the water district has produced the value of reservoir capacity for anticipating the water scarcity in the future. The value of reservoir capacity that is produced is depended on the condition that will be happened regarding to the scenario that is used. The reservoir capacity that is needed for long term (2100) with the scenario-A needs the reservoir capacity of Lamong Hulu in amount of 62 million m$^3$ and in Kalitemu is about 32 million m$^3$. If the condition is based on the scenario-B, so it is needed the reservoir capacity in Lamong Hulu in amount of 50 million m$^3$ and in Kalitemu is
about 26 million m$^3$. If following the scenario-C, so the reservoir capacity that is needed in Lamong Hulu is about 80 million m$^3$ and in Kalitemu is about 38 million m$^3$. 
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Taheripour, Farzad; Tyner, Wallace E.; Sajedinia, Ehsanreza; Aguiar, Angel; Chepeliev, Maksym; Corong, Erwin; de Lima, Cicero Z.; Haqiqi, Iman. 2020. Water in the Balance: The Economic Impacts of Climate Change and Water Scarcity in the Middle East. © World Bank, Washington, DC. http://hdl.handle.net/10986/34498
