Analysis of Nusa Dua Estuary Dam Operations for Clean Water Supply South Badung Tourism Area

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Abstract: The southern part of Badung is a very rapidly developing tourist area. Several areas have become world tourism icons such as Kuta Beach, Nusa Dua Area and other supporting areas such as Seminyak and Legian Beaches, Benoa Water sports area, Pandawa Beach, Jimbaran area, Uluwatu Temple and several other beaches in Pecatu, Kutuh and Ungasan. . With such rapid development causing an increase in the need for clean water Various breakthroughs have been made to support the availability of sufficient water in this area, one of which is through the construction of the Nusa Dua Estuary Dam in 1994 with capacity 350 liters/second. This capacity is enlarged to 500 liters/second. To maintain water supply by the reservoir in 2019, new buildings have been added in the form of pneumatic crest gates, diversion channels and trash racks. With the new building, of course there will be changes in the operating system, but until now there is no operating system guide. Therefore, it is necessary to analyze the operating system according to the current building. This research was conducted by observing and analyzing the operating system of the Muara Nusa Dua Dam which has been running so far after the addition of new buildings as well. The problem to be conveyed in this research is the need for a new operating system according to the current building conditions. The results showed that the operating system was distinguished in three conditions, namely normal water, flood water and low water with the operation of the trash rack, radial gate, pneumatic crest gate and rubber dam set by taking into account the normal water elevation at 1.7 sea above level.

1 INTRODUCTION

The development of tourism in Bali, especially in the southern part, greatly affects the increase in the amount of water needed. The increase in water demand is seen from its quality, quantity and continuity (Yamamoto at al 2021),(Sunarta, Rahman, and Syakur 2015). Therefore, a good arrangement is needed so that the availability of water and the carrying capacity of the environment can be maintained. It is necessary to regulate the existing clean water infrastructure so that it produces water as expected (Cole 2012)

Nusa Dua Dam is a single purpose reservoir in the form of providing clean water for the South Badung area, this reservoir utilizes water in the Badung River estuary in Benoa Bay. At the beginning of its construction, this reservoir provided water of 300 liters/second but at this time the capacity has been increased to 500 liters/second (Bali river council 2020). Judging from the initial construction in 1994, the Nusa Dua Estuary Dam has undergone changes and additions to buildings. In 2019-2020, additional buildings in the form of diversion channels equipped pneumatic crest gates and a trash rack located to the west of the reservoir.

The development of the Nusa Dua Estuary Dam with several new buildings aims to provide greater raw water in the southern area of Badung Regency which has experienced very rapid development. The rapid development of tourism in southern Badung cannot be separated from well-known tourism destinations both nationally and internationally which are the center of tourism activities such as the Nusa Dua area, Kuta Beach, Tanjung Benoa water sport area, Uluwatu Temple and several supporting tourist areas in the vicinity such as Legian Beach, Seminyak Beach, Pandawa Beach, Dream Land and other areas (Badung Tourism Board 2020)

The increase in water demand is related to the systematic operation of the reservoir system. The reservoir operating system is closely related to several factors, namely: sedimentation that enters the reservoir, water needs, water conservation needs,

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flood control and as a water quality controller (Wulandari. at al 2014) (Fang et al. 2014).With a very vital role as a provider of clean water and the addition of several new buildings, it requires a good operating system so that the water supply can still be maintained at 500 liters/second. However, until now the latest operating and maintenance patterns do not exist, so an analysis is needed that can be a guide in the operation and maintenance system for water supply. This research aims to design the right operating system according to the current building conditions

2 METHOD

2.1 Research Design

This research was conducted for six months by conducting in-depth observations related to the operation and maintenance activities of the Nusa Dua estuary Dam. The data were taken based on interviews and direct measurements in the field as well as by conducting an audience at the Bali Penida River Council. The activity begins with an analysis of the discharge of the Badung river to obtain reservoir inflow, continued with population projections to obtain water needs and finally an analysis of current operations is carried out to determine operating system policies in accordance with the latest existing buildings. In more detail the research methods carried out can be seen in figure 1.

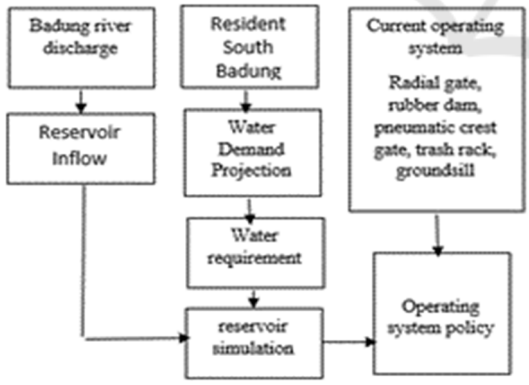

Figure 1: Research flow.

2.2 Data Collections Activities

Data collection was carried out by taking secondary data from the Bali Penida River Council, Badung statistic agency and primary data through direct measurements.

2.3 Analysis

The analytical work carried out includes: discharge analysis, water demand analysis, simulation analysis of water in reservoirs, analysis of building functions in reservoirs, analysis of current operating systems, analysis of operating development systems.

The hypothesis that can be conveyed in this study is that the addition of new buildings, especially in the diversion channel equipped with pneumatic crest gates and trash racks, has an effect on the operation and maintenance system that is easier to divert water from the reservoir during the rainy season.

3 DISCUSSION

3.1 General Description

Nusa Dua Estuary Dam is located at the Badung River estuary, precisely at the downstream of the By Pass Ngurah Rai road bridge, Suwung is the border between Denpasar City and Badung Regency which is the main road to the Sanur–Kuta–Nusa Dua tourist area. The area of the Nusa Dua Estuary Dam area is 35 Ha, with an inundation/reservoir area of 3 km^2 (Bali river council 2020). The watersheds that affect the flow conditions of the Nusa Dua Estuary Dam are the Badung river watershed and the Ayung river tributary. The Badung river stream originates in Cemenggaon Village which flows through the heart of Denpasar City to the south with a total length of 22 km. The Ayung river drainage area from the Oongan Weir until its meeting with Badung river on Dipenogoro street is a 3.20 km long urban drainage. General technical data as follows: catchment area Badung river: 37.70 km^2, reservoir inundation area: 35 Ha, deposition zone area: 1.6 Ha, total reservoir storage: 770,000 m^3, Total effective reservoir reservoir : 595,000 m^3, Normal water level elevation (NWL): 1.70 m, Elevation minimum water level (LWL): 0.50 m, maximum water level (HWL): 2.10 m, rubber dam lighthouse elevation: 1.70 m, reservoir embankment elevation: +2.85 Installed capacity of raw water supply: 500 litres/second, Output average discharge of raw water drawn: 500 litres/second, length of dam: 3.10 km, maximum tidal elevation: 0.90 m Design flood discharge (Q50): 234 m^3/second.

In 2019, new buildings were added to the Nusa Dua estuary Dam in the form of making a 20 m wide diversion channel equipped with a pneumatic crest gate and trash rack, adding a pneumatic crest gate to the active reservoir section, adding a bar screen and structuring the area in some parts of the estuary dam.

The addition of this new building of course creates a new operation system that must be made to suit the existing building.

3.2 Hydrological Analysis

Hydrological analysis is carried out to obtain the amount of water that enters the reservoir as inflow (Fang et al. 2014) (Iqbal et al. 2020). Hydrological analysis was carried out downstream of Badung river because the water became inflow into the Nusa Dua estuary dam. Inflow and outflow data of 500 litres/second that enters the Nusa Dua estuary dam with 50% reliability is then seen in Figure 2.

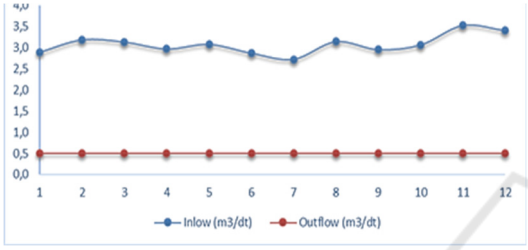

Figure 2: Fluctuations inflow and outflow the nusa dua estuary dam with 50% reliability.

On the other hand, the calculation of water reliability in reservoirs for drinking water is calculated with 90% reliability in accordance with the provisions of the minister of public works where this discharge has a 90% chance of occurring. Simulation of inflow and outflow the reservoir with 90% reliability shows that there are 10 months with inflow discharge conditions below the outflow taken at 500 liters/second. Of the existing 10 months, there are four months with very small inflows that cause the reservoir elevation below 1 m, namely in June, July, August, September. More details can be seen in Figure 3 and Table 1 below.

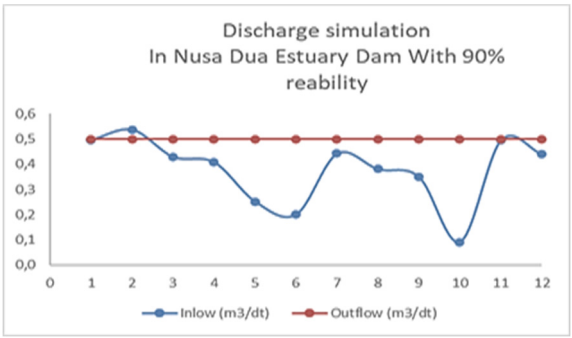

Figure 3: Discharge simulation with 90% reability.

Table 1: Inflow and outflow Nusa Dua Estuary Dam with reability 90%.

No.	Month	Inflow (m^3/second)	Outflow (m^3/second)	Elevation (m)
1	January	0,50	0,50	1,70
2	February	0,54	0,50	1,70
3	March	0,43	0,50	1,65
4	April	0,41	0,50	1,61
5	May	0,25	0,50	1,13
6	June	0,20	0,50	0,41
7	July	0,44	0,50	0,35
8	August	0,38	0,50	0,28
9	September	0,35	0,50	0,01
10	October	0,09	0,50	1,23
11	November	0,50	0,50	1,22
12	December	0,44	0,50	1,25

Source: analysis, 2021

3.3 South Bali Area Water Needs

The need for clean water is closely related to population growth and other non-domestic needs. For the South Badung area (South Kuta Sub District) the largest non-domestic water needs are needed for tourism purposes where in this area there are many tourist destinations that are spread evenly in almost all areas. Based on data analysis in 2020, the population in South Kuta District is 176,950 people. Based on the projected population and the increase in the amount of water demand, in 2030 the need for clean water has reached 514.02 litres/second, exceeding the 500 liters per second that can be prepared by the Nusa Dua estuary dam. Completely projected population and water needs in South Kuta District can be seen in Table 2 below.

Table 3: Projection of water demand in the south Badung area.

No.	Year	Population	Domestic use	Non domestic use	Total Use
		People	liters/second	liters/second	liters/second
1	2020	176.950	245.76	61.44	307.20
2	2025	206.905	287.37	71.84	359.21
3	2030	236.860	411.22	102.80	514.02
4	2035	266.815	463.22	115.81	579.03
5	2040	296.770	515.23	128.81	644.03

Source: analysis, 2021

3.4 Operating System

The addition of new buildings in the Nusa Dua Estuary Dam makes it necessary to change the new operating pattern which is emphasized on three conditions, namely low water conditions, normal water conditions and high/flood water conditions. (Vincenzo and Molino 2013)(Navas et al. 2009)(Iqbal et al. 2020)(Vugteveen and Lenders 2009). The

operating system on the estuary Nusa Dua dam is as follows:

a. Equipment Operating System.

The radial gate is operated open when there is a flood and closed when the water is normal level and the water is low. This is done because the radial gate has a very large influence in reducing water. There are 7 radial gates located in the southern part of the reservoir. Rubber dam are opened when there is a flood and closed when the water is normal level and the water is low. The pneumatic crest gate in the bar screen is closed when there is a flood but is opened when the water is normal water level and the water is low. The bar screen is always closed at various water conditions to prevent debris from entering the reservoir. More details equipment and new operating system proposalof Nusa Dua estuary dam can be seen in figure 4 table 4 below:

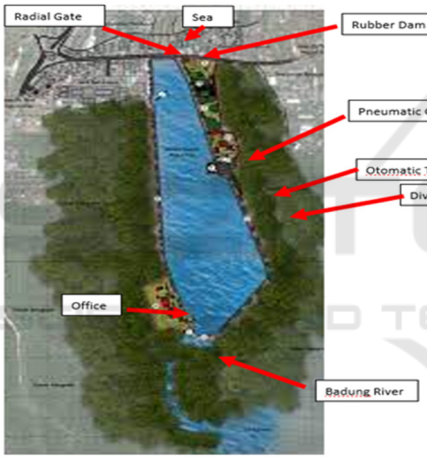

Figure 4: Equipment of Nusa Dua Estuary Dam.

Table 4: Operating System.

No.	Condition / Equipment	high water level	normal water level	low water level
1	Radial Gate	Open	Close	Close
2	Rubber dam	Open	Close	Close
3	Penumatic crest gate di *groudsill*	Close	Open	Open
4	*Bar Screen* pada groundsill	Close	Close	Close

Source: analysis, 2021

The gate radial and rubber dam operating systems are operated as before. Door opening can be done manually or automatically. The complete condition of the gate radial, rubber, and pneumatic crest gate and bar screen can be seen in figure 5 and figure 6.

Figure 5: Radian Gate and Rubber Dam.

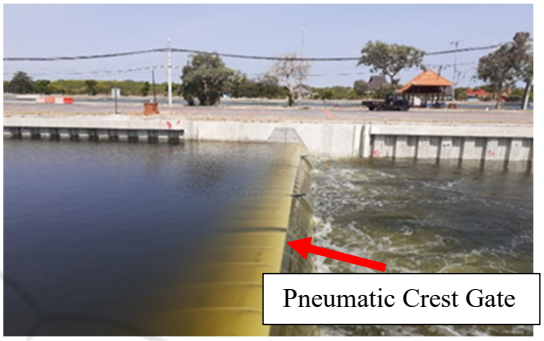

Figure 6: Pneumatic Crest Gate.

Figure 7: Bar Screen and Groundsill.

b. Trash Rack and Pneumatic Crest Gate Operation

The trash rack operating system is carried out on the diversion channel which aims to control waste and maintain water elevation in the reservoir. Trash racks are always operated under various conditions to prevent waste from entering the reservoir. The pneumatic crest gate is opened when there is a flood but is closed when the water is normal level and the low water level. More details can be seen in table 5.

Table 5: Trash rack and pneumatic crest gate operation.

No.	Condition / Equipment	high water level	normal water level	low water level
1	*Trashrack*	Operation	Operation	Operation
2	*Penumatic crest gate*	Open	Close	Close

Source: analysis, 2021

c. Flow System and Sediment Dredging

Flow system and sediment dredging are very important, especially during floods condition. (Wulandari, Legono, and Darsono 2014) (Heydari, Othman, and Qaderi 2015) (Fang et al. 2014) At the time of flood water, the flow system is directed to the diversion channel, when normal water is directed to the diversion channel and utilization zone and at low water level flow is directed to the utilization zone. Sediment dredging is an effort to prevent sediment from entering the reservoir. In the reservoir operating system, dredging is carried out only when low water conditions are carried out in the deposition zone area. The deposition zone is in the downstream of the Badung River where mechanical dredging is carried out which is operated periodically. More details can be seen in table 6.

Table 6: Flow System and Sediment Dredging.

No.	Kondisi / Operation	high water level	normal water level	low water level
1	Flow System	Directed ti diversion channel	Directed to utilization zone and diversion channel	Directed to utilization zone
2	Sediment Dredging	No operation	No operation	Operation

3.5 Flood Problems in the Badung River

The problem of flooding in the Badung river downstream often causes inundation problems in the southern Denpasar area around the estuary reservoir. The flooding that occurred was caused by the blockage of garbage that clogs the equipment on the trash rack of the estuary reservoir, causing the water level to rise which could potentially inundate the surrounding area. So that the most important operation of the estuary reservoir during the rainy season is controlling waste so that it does not enter the reservoir. Waste management must be carried out with various approaches, both technically through building infrastructure and non-technically through guidance to the community. The people around the river are mostly Balinese who are very obedient to the values of nature conservation through traditional and cultural approaches. Therefore, in the waste management system, it is very effective to approach the community through the customary and cultural systems that already exist in the study area. Customary and cultural regulations in the form of customary regulations can be adopted to encourage the community to actively participate in handling waste. Three approaches that are very familiar in Bali are environmental conservation systems with the concept of a harmonious relationship between humans and God, humans and humans and humans and their natural surroundings. This concept is widely known as the Tri Hita Karana concept. (Kristinayanti et al. 2020)(Sukarma 2016)

4 CONCLUSION

Based on what was described in the previous section, it can be concluded several things as follows:

1. The addition of a new building in the Nusa Dua estuary dam creates a new operating system
2. The results of the hydrological analysis show that with 90% reliability there is an inflow that is 10 months smaller than the outflow. Based on this, it is recommended that at the peak of the dry months, namely June, July, August and September does not take 500 liters/second.
3. Based on the projected water demand in the South Kuta District in 2040, there is an excess of demand compared to the discharge provided by the Nusa Dua estuary dam. Therefore, it is necessary to take steps to develop raw water sources through development from other sources
4. The operating system of the estuary dam is regulated in three conditions, namely flood water conditions, normal water conditions and low water conditions.

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