

## Sustainable management of Mati River

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**Abstract.** Mati river located in Denpasar City with the length of main river  $\pm$  13 km and wide of watershed  $\pm$  32,5 Km<sup>2</sup> is typical of urban river because from the upstream in Kapal Village area until estuary part in mangrove forest area Teluk Bay Benoa Forest Park its area of flow has experienced very rapid changes to urban areas. Changes into urban streams cause higher pressure on rivers such as reduced border areas, garbage disposal and waste into rivers, limited access to inspection roads on the riverbanks and law enforcement linked to river border has not maximally reduced the pressure. The analysis shows that at some point especially on the bridge construction there is a narrowing of the width of the river. This condition triggers the occurrence of floods and puddles

This research uses qualitative and quantitative method with data collection both secondary and tertiary obtained from several related institutions.

The results indicate that the existing river management has not been well coordinated. Management still emphasizes the authority of each related institution (Public Works Department of Denpasar City, Public work Department Of Badung Regency and Department River Region of Bali Penida in their respective region). In terms of budgeting, it is directed more towards financing in terms of periodic maintenance such as landslide errors, and construction of stream alignment at the estuary. While budgeting for new routine maintenance is at the stage of study made by Department River Region Of Bali Penida. The management of Eco hydraulic based management is continuously divided into three stages: short term (0-5 years) in the form of widening Resimuka bridge, Buana Raya bridge, widening West Teuku Umar bridge, spreading Umadwi weir, widening Nakula road bridge, widening Lavender hotel bridge as well as sedimentation dredging in the umadwi-estuary segment. Medium term in the form of law enforcement, planting bamboo vegetation in the upstream river channel and making the settlement in Gatot Subroto to the upstream. Long term form of local law concerning the border, construction of river inspection road, settlement arrangement along river and recommendation of making of retarding basin at downstream of Mati river around Padangsembian with wide of 15 Ha.

*Keywords: Mati river, Authority of River Management, River Management*

### I. INTRODUCTION

River management in Indonesia has been more emphasized on river management based on administrative boundaries of regency/provincial governments in each region. So the resulting solution has not been comprehensive as a unity one river one management. With this condition, the management of the river will be highly dependent on local government financial policies and capabilities. In the case of the management of Mati river the management of the river is divided into three major groups namely Denpasar City Government through the Public Works Department, Badung Regency Order through the Department of Highways and irrigation as well as the Central Government through Bali Penida river department.

So far, the management has not been coordinated with the maximum effect of the policy and ability of each agency. However, there should still be a breakthrough business that is well formulated so that the management can run well. Sustainable management of sustainable hydro-eco-based rivers requires the participation of all elements and is not limited to constructive improvements but also other activities that contribute positively to ecology.

Because it is very necessary to do a more comprehensive research so that the management of the Mati river can be done with the maximum range. From the background that can be formulated problems in Mati river as follows:

- a. What is the condition of buildings along the Mati river?
- b. What is the current management system

Meanwhile, the purpose of this study is to obtain answers to the problems presented are:

- a. Mapping the condition of buildings along the river is dead at this time
- b. Mapping of the current Dead River management system

## II METHODOLOGY

### 2.1 Components of River Operation Costs (Public Work Department, 2016)

The scope of River Operation activities consists of 7 activities, namely:

1. Provision and allocation of water.
2. Control of the use of river water.
3. Management of river water quality.
4. Control of river space utilization.
5. Flood control (high water).
6. Control of the use of space in floodplains.
7. Forecast and early warning of flood hazard.

### 2.2 The concept of eco-hydraulics

The development of the waters, especially rivers in the world today, mostly still use the partial approach of civil engineering of hydro engineering so that the result of this engineering is very very impressed and sometimes even contrary to the interests of ecological or environmental sustainability. The pure hydraulic engineering pattern means that in solving the problems in the waters area, especially the river is based solely on the hydraulic function alone, without considering the negative impact and its relation to the existing ecological component. For example, the function of a river according to the pure hydraulic concept is only seen as a hydraulic channel discharging excess water into the sea at the estuary. So with this concept all the rivers should be straightened and on the wall with the hope that the water flows to the quickly downstream. With a partial concept like this the ecological stream will automatically be totally destroyed (Arthington,2002, Linsley,1995)

The concept of eco hydraulic is an integral approach in river basin development that incorporates synergistic elements and hydrolic and ecological considerations. This concept can actually produce synergistic mutualism to produce engineering that beneficial both hydraulic and environmental ecology. In the river eco-hydraulic concept is no longer only defined as a flow in the earth that is flowed by water and sediment, but the river is defined as a unity of open water ecosystems between upstream and downstream that have biotic and abiotic components interconnected with each other. Abiotic components are characteristic of river morphology, water flow and sediment along with fluctuations in quality and quantity. While the biotic component is a component of plant and animal as well as people living along the watershed. Based on this concept, every activity in the basin should pay attention to all components of the existing river ecosystem. (Barrow, 1998, Cui,1999)

The concept of eco hydraulic directs flood handling by taking into account the ecology around the watershed. In this concept, the river is directed to a condition as natural as possible so that the river has a sloping cross section on its right side with biodiversity interacting with each other. The existence of vegetation on the groove and river banks will have resistance when the flood occurs so that the flood speed can be reduced. With this condition the overflow of water will overflows on the banks of the river and will provide a dynamic inundation with the natural duration of vegetation along the river. Likewise, the lower water velocity and abundance on the riverbed will contribute to the increase of the downward recharge which becomes a positive value for groundwater filling. The concept of eco-hydraulics is in harmony with environmentally sustainable development that is a concept based on

conscious and planned efforts that integrate the environment, including resources into the development process to ensure the capability, welfare and quality of life of present generation with future generations (Cui,2003)

### 2.3 River Functions As Main Drainage In Urban

The development of urban areas has brought about the effect of the greater land conversion from agricultural land to other uses such as housing, offices and other designations. This condition puts greater pressure on the river's natural state of reduced capacity, decreased water quality, recharge and soil conservation of thinning water which in total gives a bad effect on the function of the river as a whole. (Linsley 1995, Liu S,1999, Nillsson 1991)

### 2.4 Analysis

#### ➤ Hydrological Analysis

Hydrological analysis is an analysis that aims to calculate the potential of existing water in certain regions / regions, to be utilized, developed and controlled water potential for the benefit of the people around the area (Sharin,1990, Central research,2000, Chow,1987, BMKG, 2016)

Rainfall Design.

1. Gumbel Method

2. Pearson Log Method

To calculate the design rainfall by the Log Pearson type III method, the data must first be converted into a logarithmic form, then calculate the statistical

$\text{Log Ri} = \text{Log R} - K \cdot S$

Where :

R: average rain

K: frequency factor

S: standard deviation

#### ➤ Design Flood

Flood design is needed to calculate the magnitude of the flood that passes through the river  
Method of Hydrograph of Nakayasu Method

$$QP = \frac{C \times A \times R_o}{3.6 (0.3 T_p + T 0.3)}$$

Where :

Qp = flood peak discharge (m s)

R<sub>o</sub> = rain unit (mm)

T<sub>p</sub> = the grace period from the beginning of the rain to the peak of the flood (hour)

T<sub>0,3</sub> = The time required by the peak discharge decrease to 30% of peak discharge

#### ➤ River Capacity Analysis

This analysis is conducted to determine the capacity of each river or channel associated with the existing flood discharge. Analsis in channel capacity uses the Manning equation (Sukarno, 2009; Chow, 1987) as follows:

$$Q = A V$$

$$V = R^{2/3} S^{1/2} / n$$

With:

A = square (m<sup>2</sup>)

V = velocity (m/s)

n = roughness of the channel

R = hydraulic radius

S = slope of the channel

n = number of roughness of the wall of the channel

### III. RESULT AND DISCUSSION

#### 3.1 Current River Management

From some results of observations made in the field as well as auditing with related agencies can be in the management of the current River Mati is as follows:

1. Public Works Office of Denpasar has management authority on:

- a. Lange weir
- b. Dadas weir
- c. Free Intake Mergaya
- d. Tebad Channel

2. Public work office of Badung has the authority to:

- a. Trash rack road Sun Set road
- b. Automatic water level recorder behind the trash rack sun set road
- c. Estuary area
- d. Blambangan Flood Pump
- e. Dewi Sri flood pump

3. Central government has the authority:

- a. Flood embankment (Segment Patas sari-trash rack)
- b. Flood embankment (Trash rack segment - Umadwi weir)
- c. Flood embankment (Umadwi-bendung Dadas dam)
- d. Flood dike (Dadas- Bendung Lange Dam Square)
- e. Flood embankment (Bendung Lange-Gatot Subroto)
- f. River channel (Gatot Subroto - upriver river area)

#### 3.2 River Management Issues

The problem of river management that often arises is in some cases still need to increase the coordination of the existing agencies in budgeting operating and maintenance costs. What happens nowadays in some budget Operation and maintenance costs are not all agencies budgeted. Operation and maintenance activities include:

a. Planning

In the case of planning still occurs some obstacles such as planning is not done simultaneously in all related agencies is caused by the ability of budgeting is not the same among all agencies.

b. Implementation

In terms of coordination implementation also still needs to be improved

c. Supervision

#### 3.3 Waste Management

Until now there is no clear scheme associated with waste management in the river, although in general the waste in Mati river is not too large. Anticipation is done by performing regular monitoring and routine to building of filter of garbage (trash rack) that exist in Mati river that is in Legian area.

#### 3.4 Organization Management

The Mati river management organization is a collaboration between the Government, the private and community institutions. This can be proven from several conditions that exist in the field are:

1. In terms of financing construction, construction is more emphasized to the government element

2. The maintenance side of the river, especially in the case of the ban on garbage disposal into the river is strongly supported by the Denpasar City Government Regulation and the institutional rules of the community through the rules (*awig-awig*) that exist in each adat village
3. Private participates in spontaneity activities in the form of net program activities financed by private companies.

### 3.5 Cost Analysis of Real Need Task Force Operation and Maintenance of Mati River

An analysis of operating and maintenance costs is needed to find out how much it costs to keep the river functioning properly. The need for river operating and maintenance costs is closely linked to the type of river that is the natural river, the river develops and the urban river. The more natural the river the cost of operation in terms of inspection becomes more expensive compared to urban streams that already have access. From result of analysis of operation cost and maintenance cost to Tukad Mnati is Rp. 66.198.000

In addition to the cost requirements for routine inspections, other operating and maintenance costs required in the river is Rp. 3.224.839.000

### 3.6 The Concept of Handling Mati River Based on Sustainable Eco-Hydraulic

In the case of Mati river handling with sustainable eco-hydraulic concept, it is necessary to do work continuously by involving all elements. The concept of handling can be divided into three stages of handling that is short-term, medium and long term.

#### ➤ Short term concept (0-5 years)

This short term concept is closely related to the Mati river flood handling which can rapidly lower the flood waters.

1. Widening of several bridges in the middle and downstream of the river. From the results of the research phase 1, it can be concluded that some bridges in the middle of the river need widening, more bridges need to be widened: *Resimuka* bridge, *Buana Raya* Bridge, *Teuku Umar Barat* Bridge and *Umadwi* dam, *Nakula S* bridge and *Lavender Hotel* Bridge downstream section of the Mati river. The proposed new width of the bridge to be able to overcome the flood in Mati river is the width of the *Resimuka* Bridge proposed 10 to 15 m wide. *Buana* bridge from the width of 11 m to 15 m, *Teuku Umar West* bridge height from 1.5 m to 2.5 m, *Umadwi* weir from 18 m width to 24 m, *Nakula r* bridge from 13 m to 18 m and the *Lavender hotel* bridge from 13 meters to 20 m
  - a. The current condition of the bridge *Resimuka* case is shown in the picture that the width is only 10 meters. When compared with the *Gatot Subroto* bridge that is in the upstream it will be very visible if the bridge on this bridge occurs narrowing (bottle neck). This segment becomes the first segment of the flood point that is difficult to overcome in the *Munang-Maning* area. If the current 10 meters can be spread to 15 meters it will contribute significantly to eliminate flooding in the *Munang-Maning* and surrounding areas. The problem with the widening of this bridge is that the right and left rivers are full of settlements which result in land acquisition becoming very difficult to do



Fig 1 *Resimuka* Bridge

b. Condition of Buana R Bridge

Condition of Buana Raya road bridge its position is behind the Bridge Resimuka. In addition to the narrow bridge width the position of Jalan *Buana Raya* bridge is located in the bend area so that it implies the decrease of water speed. With a width of only 11 meters and is located in the bend area then this position becomes a contributor to the flood point in Mati river. The suggestion that can be submitted is the widening of the bridge from the width of all 11 meters to a width of 15 meters. Problems in the widening of this bridge is constrained by the surrounding land is already full of buildings and surrounding temples stand. With conditions like this then the land acquisition becomes difficult to do.



Fig 2 *Buana Raya* bridge

c. *Teuku Umar Barat* Bridge

This bridge is located in the upper reaches of Dadas dam with a crossover position on *Teuku Umar Barat* street. The width of the existing bridge is actually quite adequate with a width of 23 m. But the problem arises because the height (clearance) that there is very limited that is 1.5 m. In this area there is a very high sedimentation due to the dam at the downstream of the bridge. With this limited height this segment can not immediately drain the water in case of flooding. Floods in this area will soak the existing settlement area on the road *Pura Demak*. Clearance required at this point is 2-2.5 meters



Fig 3 *Teuku Umar Barat* bridge

d. Umadwi Dam

Currently Umadwi dam have a width of 18 meters and is a weir motion of the previous is a fixed dam with the construction of stone pairs. With the construction of a weir of motion, it gives more flexibility in the water regulation especially when there is a large discharge that requires rapid elevation. From the observation and analysis done then the ideal width required for umadwi weir is about 24 meters.



Fig 4 Umadwi dam

e. Nakula Road Bridge

Nakula street bridge is located in the area of *Legian* located in the international tourism area of Kuta. This bridge became a contributor to the flood and puddles that flooded the region. The current width of the *Nakula* bridge is 13 m. The location of this bridge is in the downstream part of the Mati river so it has a very flat slope so that the water speed becomes low. Low water speed coupled with a short bridge width then the rainy season when this section becomes one of the flood points that exist in Mati river.



Fig 6 Nakula bridge

f. Bridge Hotel Lavender

The bridge that is around the hotel Lavender width 18 m with the position of the bridge is already close to the estuary. The analysis shows that the width of the existing bridge should be widened from the current 13 meters to 20 meters.



Fig 7 Lavender bridge

2. Sediment dredging is an effort to increase river capacity in accordance with river design. From the observation downstream section of the river toll segment starting from the Umadwi dam to the estuary has a very flat slope of the river (0.002-004), causing this area to be a very high place of sedimentation flow. The average sedimentation that occurs has reached 0.3 meters in the middle of the groove up to 0.6 meters on the left side and right side of the existing river channel. If dredging regularly every year can be done then the opportunity to reduce the flood to be very significant can reduce the flooding that occurred.



Fig 8 Sedimentation

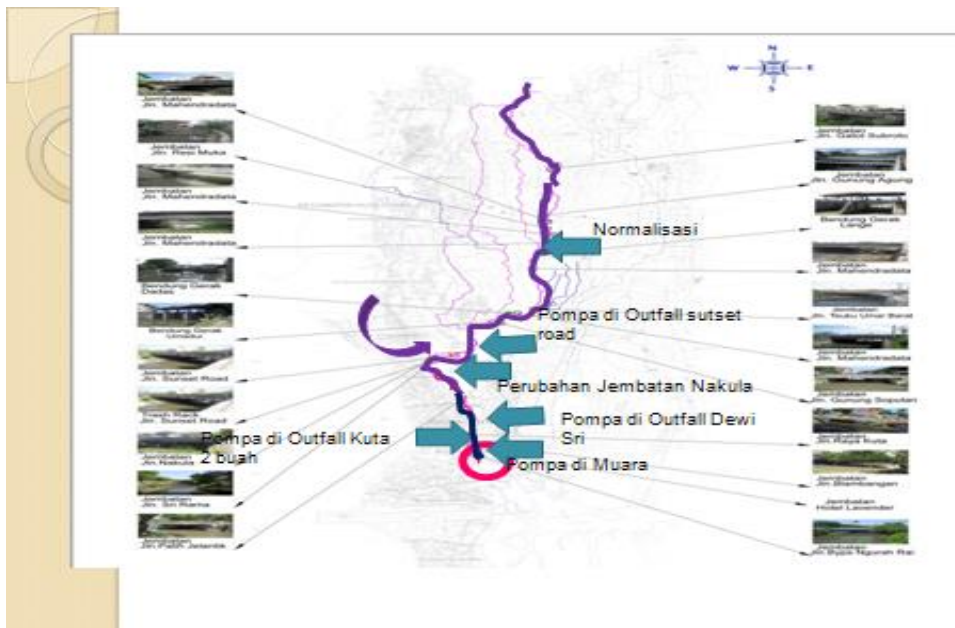


Fig 9 Short Term Concept

➤ Medium-term handling (5-10 Years)

In this medium term handling there are several things that need to be done both in construction and non construction. More things to do are as follows;

- a. Enforcement of rules which will serve as a guideline for areas that may be built and areas that should not be built. During this time often violations of some areas should not be awakened utilized for other purposes



- b. Cultivation of bamboo vegetation along the river bank in the Upper (around *Sempidi* and surrounding areas). The existence of bamboo trees can withstand the landslide of the cliff and maintain the safety of the river slopes from the Gatot Subroto to the upstream to *Sempidi*.
- c. Construction of temporary water reservoir building. This building is built in a river with a height of about 3 m and width following the width of the river. The existence of this building will be able to reduce the peak flood in the middle and downstream Mati river.

➤ Long Term Handling (over 10 years)

In the long-term handling of this need to be done several things to keep the condition of Mati river remain ideal can accommodate the flow of water is as follows:

a. Enforcement of regulation governing river border.

On several occasions many Mati river have no borders. The absence of river borders causes excess water during the rainy season to easily enter the surrounding settlements.

b. Inspection road construction along the river

Inspection road construction along the river is necessary for the operation and maintenance of the river. Especially when it will bring the material for the improvement of the river. In the absence of this inspection road, the value of the river improvement project will increase due to difficulties in working methods.

c. Settlement along the river

Settlements along the river is necessary to make the river as a water rod that gives beauty to the surrounding environment. There are still many houses built back to the river. This condition makes the river become on clean and dirty because not a few of these settlements throw drainage into the river. Not only drainage of some garbage appears to be disposed of by the people to the river body. This condition causes the river is not good scenery and potentially reduce the capacity of the river.

d. Making a temporary flood reservoir (retarding basin)

Making basin retarding is an innovation step that can be done to reduce the amount of flood peak discharge that occurred in the area of *Dewi Sri* road until downstream. Hydrolic and hydrological analysis indicates that the presence of retarding basin will be able to reduce the peak discharge of the Mati river flood to 20%. This will certainly be very profitable seen from the desire to free the area of Kuta and surrounding areas free from flooding. From the results of field surveillance and observation of several possible places is the area that lies to the west of Dadas dam. Current land condition is paddy field with area reach 15 Ha. If simulated area of 15 Ha with a depth of 4 m then the retarding basin is able to accommodate water as much as 600 m<sup>3</sup>.

## V Conclusion

From the analysis conducted on the technical study of the management of Mati river based on eco-hydraulic can be concluded several things, namely:

1. The existing Mati river management is still partial in the sense that in one river segment is managed by several agencies namely the Public Works Department of Denpasar, the Public Works Department of Badung Regency and Central government.. In the case of budgeting for operation and maintenance is also very minimal budget allocated by each agency. During this time the budget is more directed to the periodic financing. More detailed description of Mati river management tasks by each agency can be mentioned as follows;
  - a. Public Works Department of Denpasar in charge of managing buildings along the Mati river in the city of Denpasar such as Lange dam, Umadwi dam and Bendung Dadas
  - b. Public work of Badung are in charge of managing waste filter building (trashrack in road of sun set road) and building at estuary of Mati river
  - c. Central government is responsible for managing all river wall buildings along the Mati river line to the Patas Sri area.

2. The Concept of Mati river Management should be integrated by involving all agencies supported by the surrounding community so that. All made a real contribution to the improvement and maintenance of the river. In more detail the concept of rivers handling as follows:

Short term concept (0-5 years)

This short-term concept is closely related to the Mati river flood handling which can rapidly lower the flood waters.

Widening of several bridges in the middle and downstream of the river. From the research result of stage 1, it can be concluded that several bridges in the middle of the river need to be widened, more bridges need to be widened, namely: Resimuka bridge , Bauana Raya Bridge, Teuku Umar Barat Bridge, Umadwi Dam, Nakula bridge and Lavender Bridge. Besides, a very important thing to do regularly is the dredging of sedimentation on the Umadwi weir to the Lavender bridge.

Medium-term handling (5-10 Years)

In this medium term handling there are several things that need to be done both in construction and non construction. More things to do are as follows;

- a. Enforcement of rules which will serve as a guideline for areas that may be built and areas that should not be built. During this time often violations of some areas should not be awakened utilized for other purposes
- b. Cultivation of bamboo vegetation along the river bank in the Upper (around Sempidi and surrounding areas). The existence of bamboo trees can withstand the landslide of the cliff and maintain the safety of the river slopes from the Gatot Subroto to the upstream to *sempidi*.
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Long Term Handling (above 15 thun)

In the long-term handling of this need to be done several things to keep the condition of Mati river remain ideal can accommodate the flow of water is as follows:

- a. Enforcement of regulation governing river border.  
On several occasions many Mati river have no borders. The absence of river borders causes excess water during the rainy season to easily enter the surrounding settlements.
- b. Inspection road construction along the river  
Inspection road construction along the river is necessary for the operation and maintenance of the river. Especially when it will bring the material for the improvement of the river. In the absence of this inspection road, the value of the river improvement project will increase due to difficulties in working methods.
- c. Settlement o along the river  
Settlements along the river is necessary to make the river as a water rod that provides aesthetics for the environment around it. There are still many houses built back to the river. This condition makes the river become less clear and dirty because not a few of these settlements throw garbage into the river. This condition causes the environmental condition of the river is not good and potentially reduce the capacity of the river.
- d. Making a temporary flood reservoir (retarding basin)  
Making basin retarding is an innovation step that can be done to reduce the amount of flood peak discharge that occurred in the area of Dewi Sri road up to downstream. Hydrolic and hydrological analysis indicates that the presence of retarding basin will be able to reduce the peak discharge of the Mati river flood to 20%. This will certainly be very profitable seen from the desire to free the area of Kuta and surrounding areas free from flooding. From the results of field visits and observations in several locations, places that allow utuk development of retarding basin is the area that lies to the west

of Dadas dam. Current land condition is paddy field with area reach 15 Ha. If simulated area of 15 Ha with a depth of 4 m then the retarding basin is able to accommodate water as much as 600 m<sup>3</sup>.

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