

DEFENDING AGAINST DROUGHT

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ABSTRACT

Tempe lake is located in South Sulawesi – Indonesia at about 210 km north of Makassar, located on a large flood plain of Walanae-Cenranae river, consist of three separate shallow bodies of water Lake , namely :Tempe, Sidenreng and Buaya, that form interconnected system during wet season with maximum inundated area of 35,000 ha. The study area is located on the alluvial flat plain created by the Walanae, Bila, and other small tributary. The altitude in range El. 3.0 to 10 m, climate characterized by two season, 5 months rainy season (March to July) and 7 months dry season from August to February, and annual rainfall varies in widely ranging from 1400 to 4000 mm. In the Tempe Lake and surrounding area 80 % of the population is engaged in agriculture and fishery, about 15,520 farm household and 3,120 fishery household.

The main problem consist of wide-range social problem and decreasing a complex both physical quantity and quality of environment as follows: Decreasing of fishery yield ,sedimentation ,flood inundation on wetland agriculture ,water shortage during drought season, high drawdown water level and Water Quality . The others social problems: conflict of interest between stakeholders, unclearly land right surrounding Tempe Lake , degradation of natural conservation .

During rapid drawdown often occurs on May to August, caused permanently damaged some rooted plant and perhaps seed. When higher water level drawdown, therefore followed with dry season, deficit of dissolved oxygen can be causing the death of plants and fish, those that remain are restricted to a very small area, where they are subject to greater risk of predation than in their normal habitat, may caused fishery yield decreasing by year.

The water shortage during dry season may suffer either farmers or fishermen. In the Year 2001 – 2002 the Indonesian government has conducted study with Public Consultation Meeting (PCM) concluded that a barrage must be constructed at Cenrenae River (outlet of Tempe Lake) to maintain water level at elevation +5.0 m during dry season. The barrage were provided with main gate (4 x 17.5 m), navigation lock and fish ladder. The construction of barrage will be started this year 2010 up to 2012.

Key words : Tempe Lake , drought , water level drawdown , maintained water level
Barrage construction

INTRODUCTION

This study is dealing with water shortage condition at Tempe Lake during dry season , and the method to solve the problem . The existing condition of Tempe Lake;.

A. Location Map

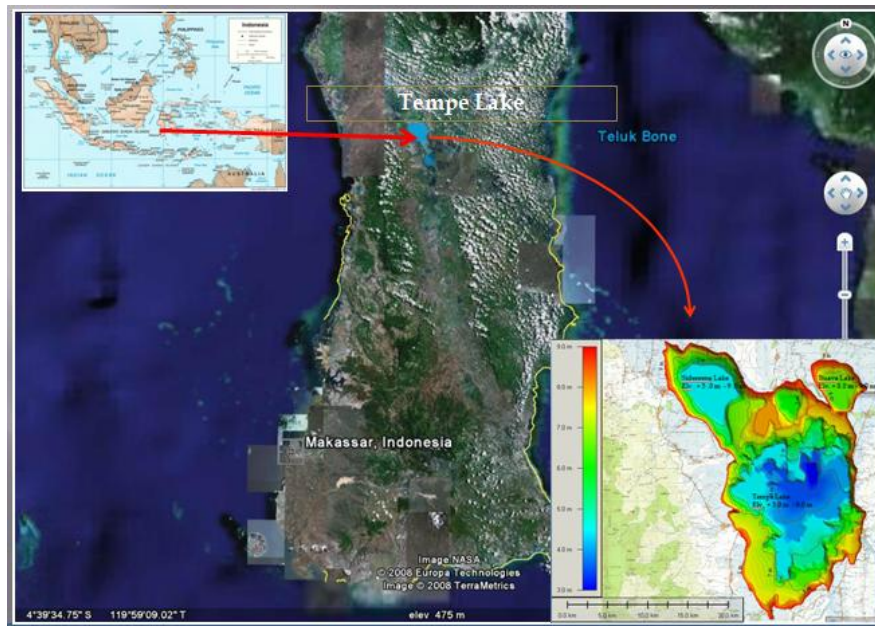


Fig 1. Location Map

Tempe Lake is located in Wajo District -South Sulawesi Province – Indonesia and about 200 km from Makassar. The Tempe Lake also lies within Walanae – Cenrenae River Basin, this is one of the biggest River Basin in South Sulawesi.

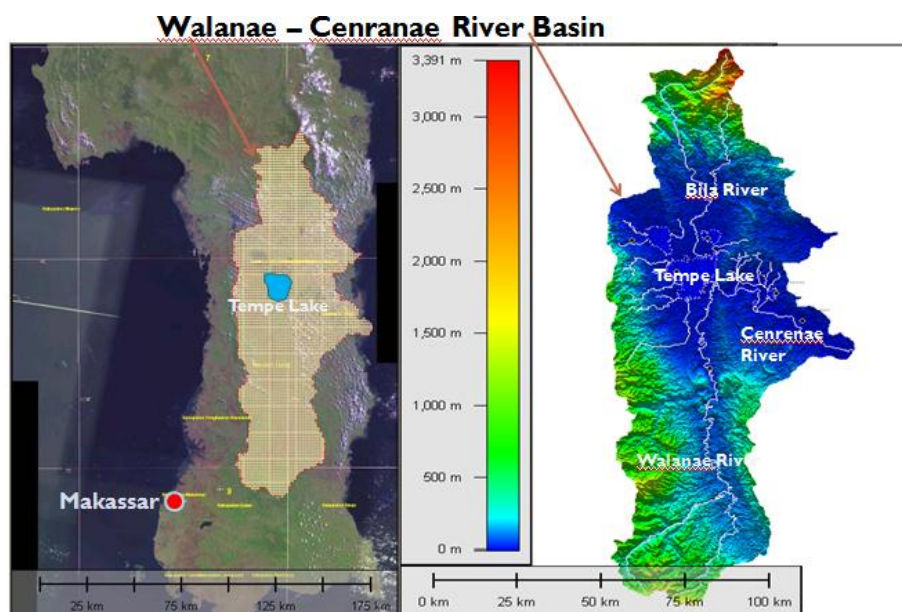


Fig 2. Walanae – Cenrenae River Basin

B . Bathymetry

Based on the latest survey measurement data then the bathymetry of Tempe Lake can be built into DEM (Digital Elevation Model) format. Tempe Lake System is comprising of Temple Lake, Sidenreng and Buaya Lake, elevation range from + 3.0 m to 9.0 m . This map using projection UTM, zone 50 (southern hemisphere), datum WGS 84 .

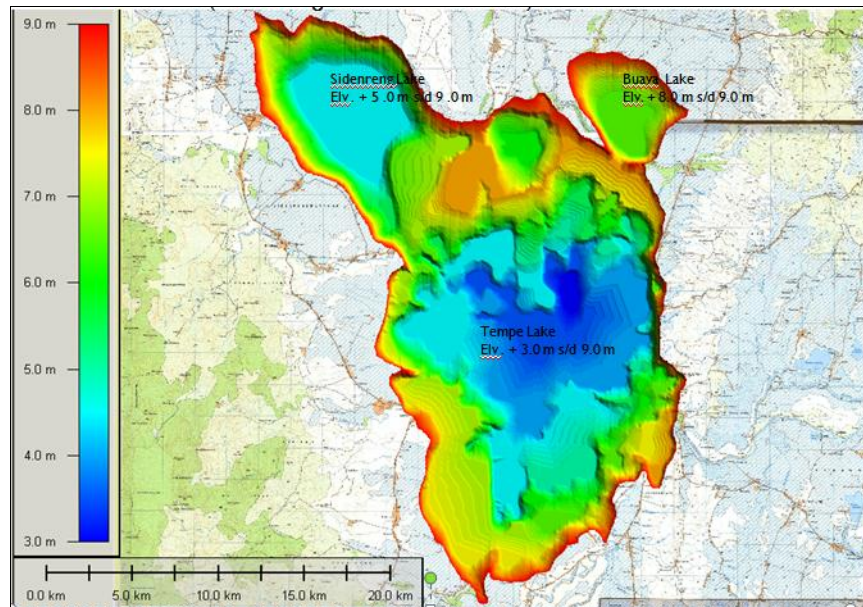


Fig 3. Bathymetry of Tempe Lake

C . River System

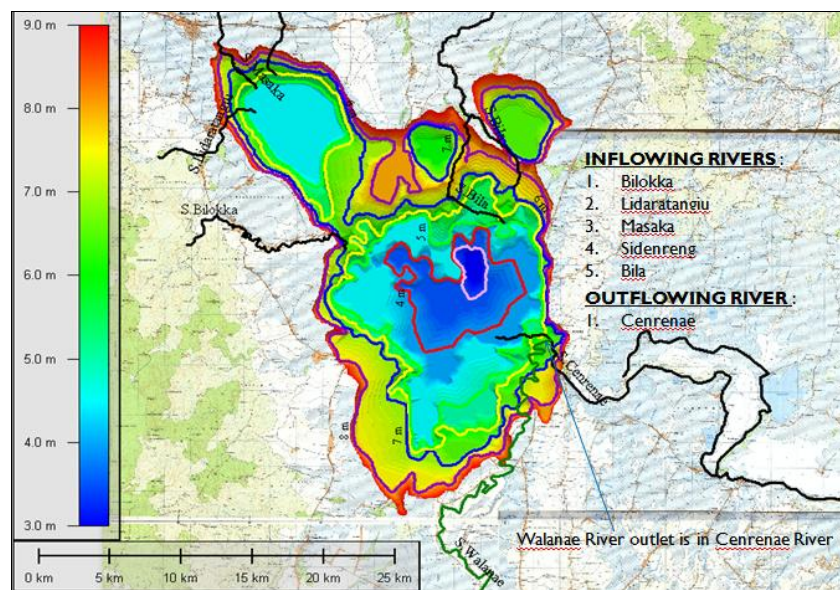


Fig 4. River System of Tempe Lake

Tempe Lake River system consist of in-flowing rivers and out-flowing river as follows:

In-flowing Rivers : Bilokka ,Lidaratangui , Masaka ,Sidenreng ,Bila

Out-flowing River: Cenrenae

The Walanae River is very long river flowing from the Southern part of Walanae – Cenrenae River Basin and has the outlet at Cenrenae River about 600 m from Tempe Lake outlet .

D . Hydrology Station

Hydrology station in Tempe Lake system is comprising two AWLR (Automatic Water Level Recording) located one inside Tempe Lake and one in Tampangeng (Cenrenae River) . This station has recorded data more than 20 years.

Table 1. Monthly Water Level at AWLR Tempe Lake

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
Mean	5.490	5.713	5.729	5.835	6.171	6.721	6.603	5.954	5.037	4.594	4.432	4.891	5.597
Max.	8.035	7.985	7.226	6.795	8.435	8.675	7.951	8.193	7.006	6.725	6.365	6.355	8.675
Min.	3.628	4.056	4.435	4.862	4.285	4.541	4.355	3.975	3.514	3.300	3.256	3.300	3.256

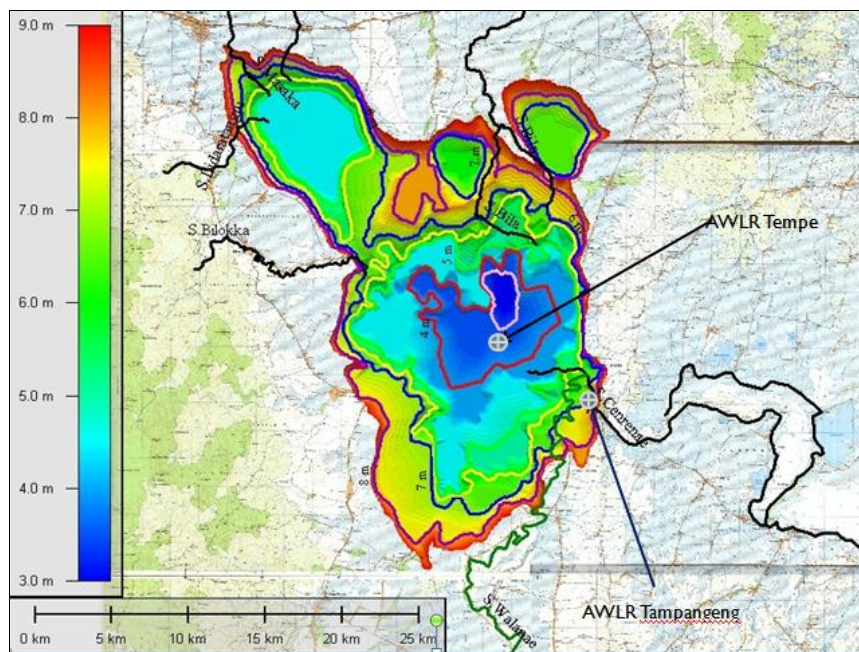


Fig 5. Location of Hydrology Station

E . Storage Capacity of the lake

Table 2. Storage Capacity of the lake

<u>Elevation</u>	<u>Area (km2)</u>	<u>Volume (MCM)</u>
3	0.25	0.1
3.5	22.54	5.76
4	62.13	26.89
4.5	97.13	66.71
5	132.90	124.2
5.5	151.00	195.1
6	160.00	245
6.5	166.30	274.5

The storage capacity is calculated using the latest topography survey , the volume at elevation + 6.0 m is 245,000,000 m³ .

F . Photograph documentation during dry season



Fig 6. Tempe Lake during dry season

This condition : many fish were death , river transportation are difficult , low water quality and irrigation is impossible .

G . Outlet River Capacity

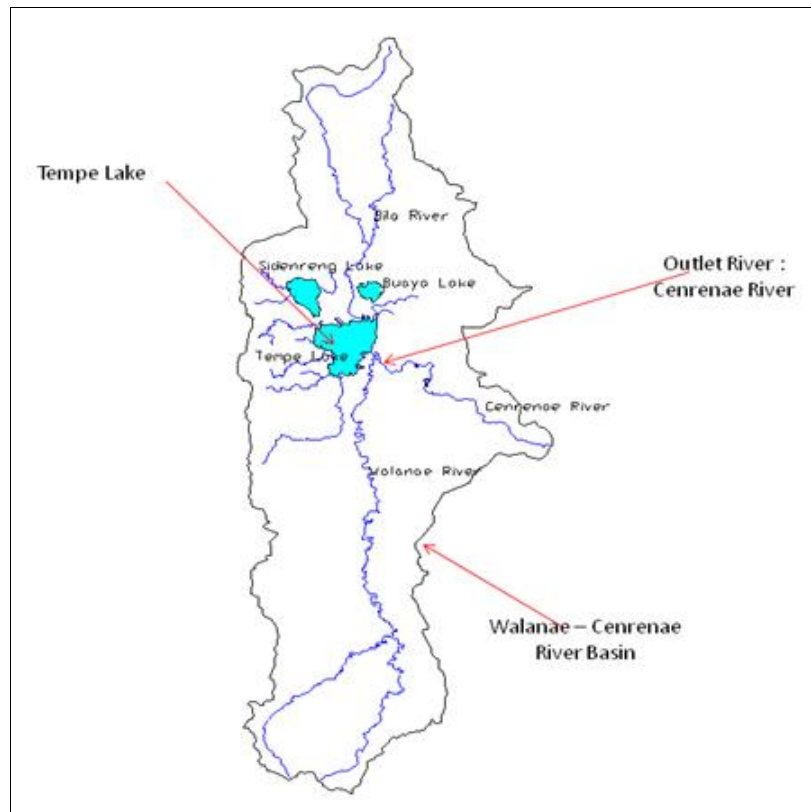


Fig 7. Outlet River

During dry season, outflowing River capacity is too big, water flow from Tempe Lake will be very fast, Lake storage decrease and water level get lower accordingly to become dry.

H . Hydraulic Resident Time (HRT)

Hydraulics residence time is the average time required *to completely renew lake water volume, or equal to lake volume / flow rate.*

Improving lake water quality will face a lag period between the time that incoming water quality gets better and the time that change becomes evident in the lake. Longer lag time the incoming water stay in the lake also make greater opportunity of dissolved solids to clogging (due to the natural coagulant) and sink through water static water column.

Average HRT of Tempe Lake computed from average flow rate entering the lake during dry, and wet season compared with lake volume.

Average Lake Volume (at El. 6.00: 245,000,000 m³

Average Inflow /outflow rate: 42.76 cms

Average Hydraulics Residence Time: 63.0 days

Tempe Lake with hydraulics residence time > 60 days is classified in to long HRT provide plenty of time for algae biomass to accumulate (if there are sufficient nutrients and enough sunlight present) and natural coagulation of dissolved particles and organic matter.

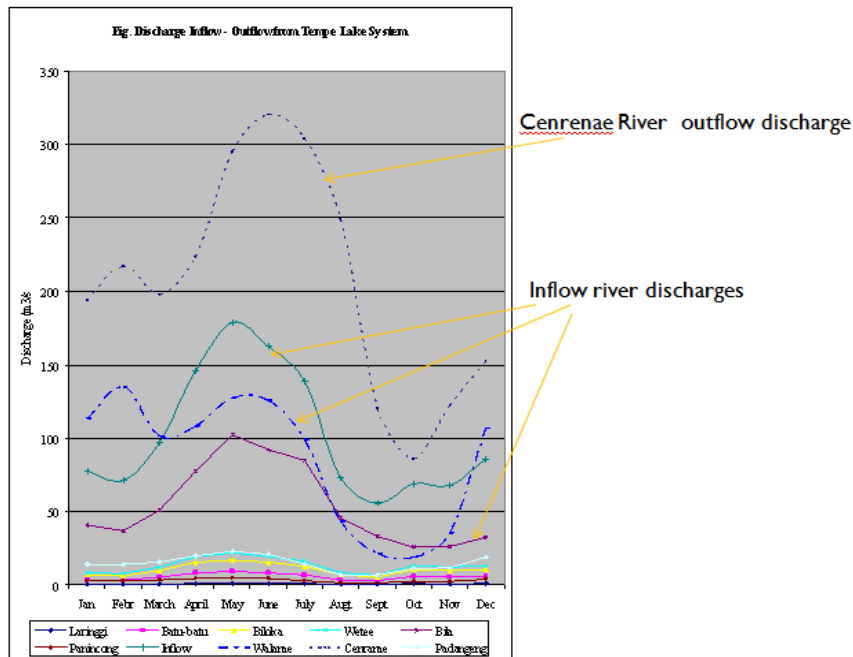


Fig 8. Discharge Inflow – Outflow of Tempe Lake System

METHODOLOGY

The main problem of Tempe Lake during dry season and their solution used by the project. The several considerations were taken into account as the method to find the best solution.

A . Problem Statement

In dry season, water depth in worst condition is about 0.50 m, it is impossible for either fishery and agricultural activities done by the people. The public river transportation were not continued and many fish were died. According previous studies showed that water flow from Tempe Lake to outlet Cenrenae River were too fast as Cenrenae River Capacity is too big at this dry season. This drought condition will be solved through both engineering studies and public consultation meeting. The conclusion of the solution is to maintain water level during dry season at certain level. The previous study recommended that during dry season the water level must be maintained at + 5.0 m with below mentioned consideratio.

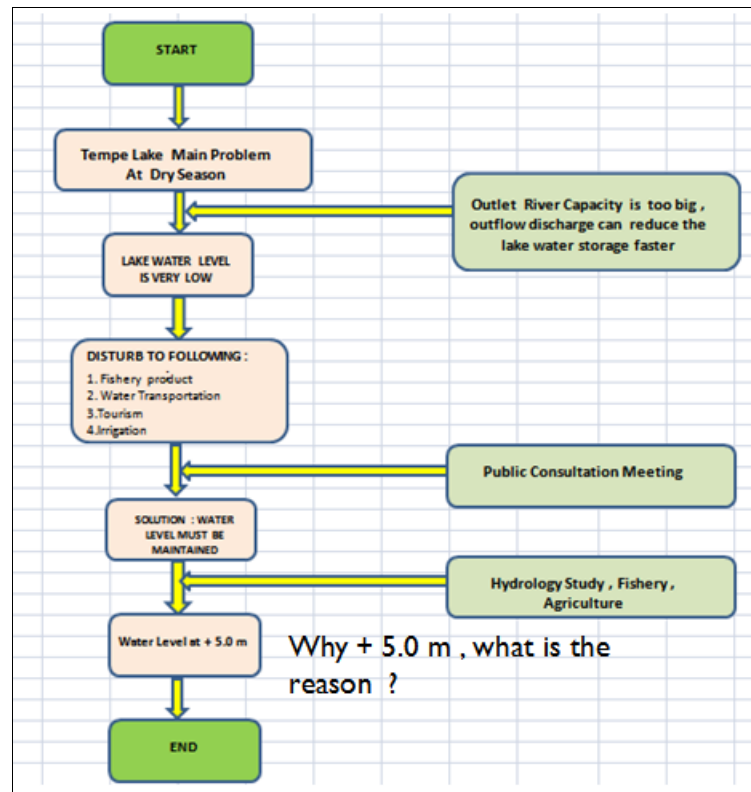


Fig 9 . Problem chart of Tempe Lake during dry season

B . Hydrology consideration

Table 3. Monthly Water Level of Tempe AWLR

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
Mean	5.490	5.713	5.729	5.835	6.171	6.721	6.603	5.954	5.037	4.594	4.432	4.891	5.597
Max.	8.035	7.985	7.226	6.795	8.435	8.675	7.951	8.193	7.006	6.725	6.365	6.355	8.675
Min.	3.628	4.056	4.435	4.862	4.285	4.541	4.355	3.975	3.514	3.300	3.256	3.300	3.256

Table 4. Probability analysis of Tempe Lake Water Level

Probability Analysis of Tempe Lake Water Level		
Return Period (Years)	Low Water Level (m)	
	Current	Design
10	3.5	5
5	3.6	5
2	4	5

From the Monthly Water Level of Tempe AWLR showed (Table 3) that average mean of water level is 5.597 m (or more less + 5.0 m) . The probability analysis for several return period 10 years, 5 years and 2 years found the current water level 3.5 m, 3.6 m and 4 m . Based on other consideration so the water level of + 5.0 m were used for design to maintaining water level during dry season.

C . Fishery and Agriculture consideration

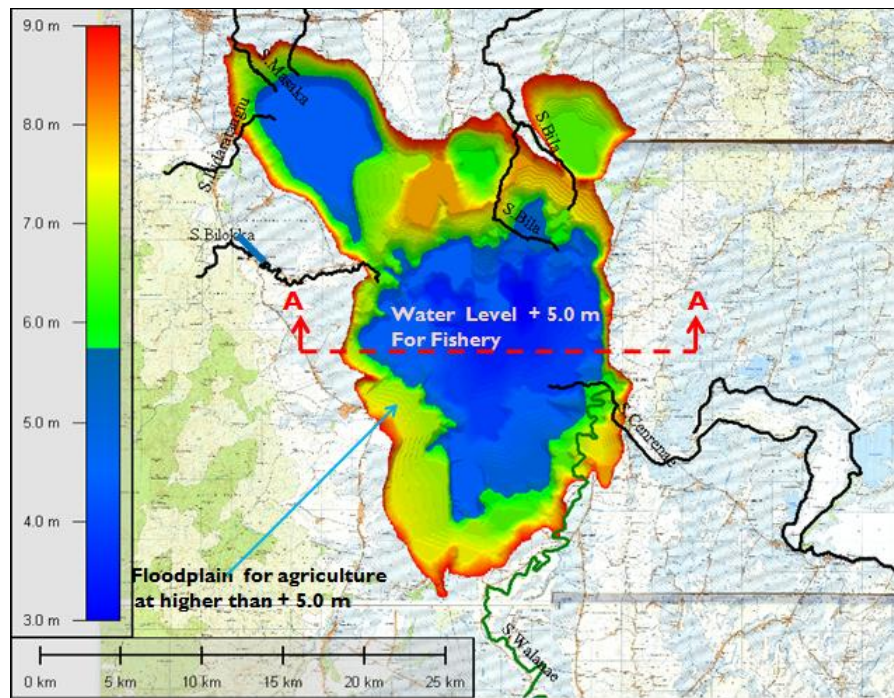


Fig 10. Tempe Lake Territory division into water body and floodplain

The Lake territory must be divided wisely for both farmers and fishermen to avoid any internal conflict. There are about 15,520 farm household and 3,120 fishery household. With maintaining water level into + 5.0 m, therefore the water body can be used for fishery and area higher than + 5.0 m for agriculture. This maintaining water level, the water depth of lake is about 2 m, it is enough depth and sunshine, it's good for fish production.

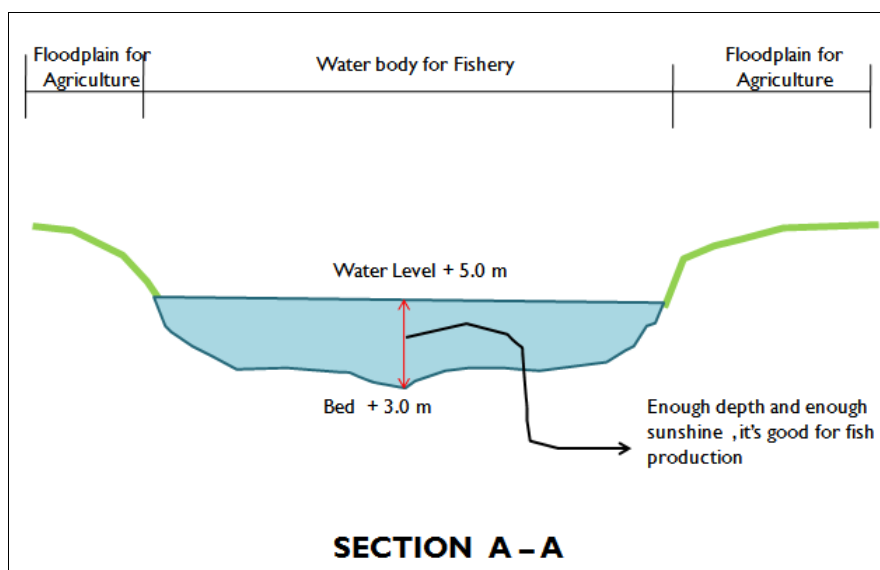


Fig 11. Cross Section of Tempe Lake with maintained water level

RESULT AND DISCUSSION

The selection for a kind of structure to be used to control water level of the lake at elevation + 5.0 m. The structure must consider about either fish movement access from Tempe Lake to Gulf of Bone and vice versa or continuation of traditional both transportation.

Structural intervention required to satisfy the community, judged feasible on engineering point of view is *a construction of a Barrage* on the outlet of Tempe lake to maintain water level at Tempe Lake during dry season. Furthermore the barrage at Tempe Lake outlet will be named as “**Tempe Barrage**“

Tempe Barrage is a kind of hydraulic structure blocking the Cenrenae river flow during the dry season to maintain water level in the lake at certain elevation, in this case + 5.0 m. The area inside elev + 5.0 m of the Lake may be used for fishery, then area outside elev + 5.0 m may be used for agricultural sector. The construction of Tempe Barrage is requested by majority of surrounding people through previous Public Consultation Meeting in 2002.

The crest elev + 5.0 m were based, decided and considered carefully by hydrological studies as follows:

Based on the hydrology data record (water level data of Tempe Lake) the minimum monthly water level is + 3.256 m and maximum is +8.675 m so the average monthly water level is + 5.597 m , therefore this water level around + 5.597 m must be maintained in the Lake during dry season with construction of barrage with crest +5.0 m . The Barrage will be located at Cenrenae River about 600 m upstream of Tampangeng Bridge or about 2 km downstream of the Tempe lake outlet.

The Barrage was provided with 4 pieces of sluice gate with crest + 5.0 m and 17.5 m each in length. The water level at Tempe Lake will be controlled with these gates during dry season. During rainy season the gates will be fully opened.

The Tempe Barrage was also provided with navigation lock in the left side and fish ladder in the right side.

Navigation Lock is a facility for the traditional boats to move from downstream to upstream (or vice versa) of barrage due to difference of water level. The navigation lock will be operated during dry season whenever the main gates were closed. During rainy season the boats could pass through barrage under gates opening. The Navigation Lock is located at the left side of the barrage.

The Fish Ladder is located at right side of the barrage, this is a facility for a fish species (*Anguilla Marmorata*, local name: masapi) that always move from Tempe Lake to Gulf of Bone (river mouth of Cenrenae River). Fish Ladder is stepped structure for which water could always flow during dry season at minimum discharge 25 m³/s.

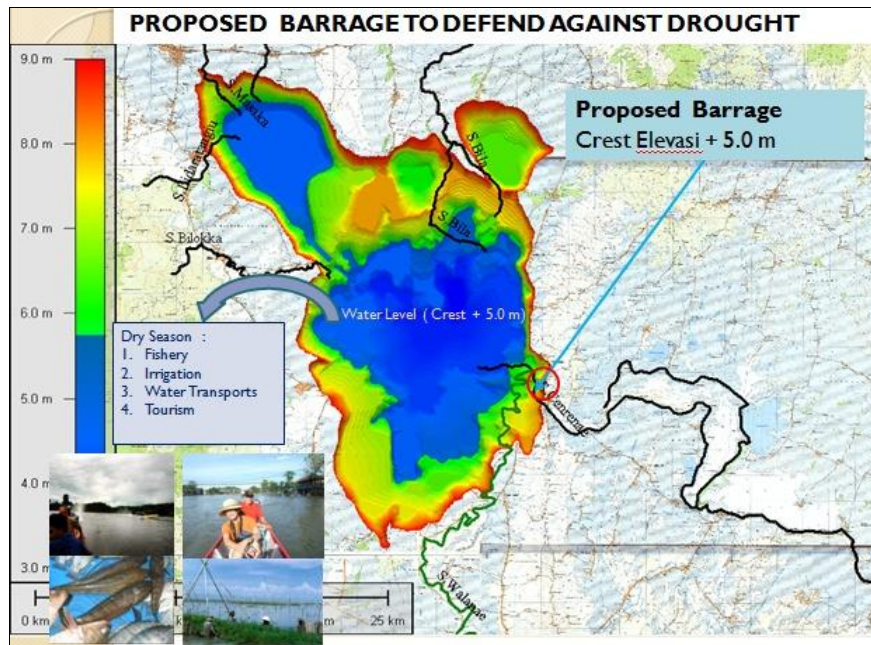


Fig. 12. Proposed Barrage to maintain water level at + 5.0 m

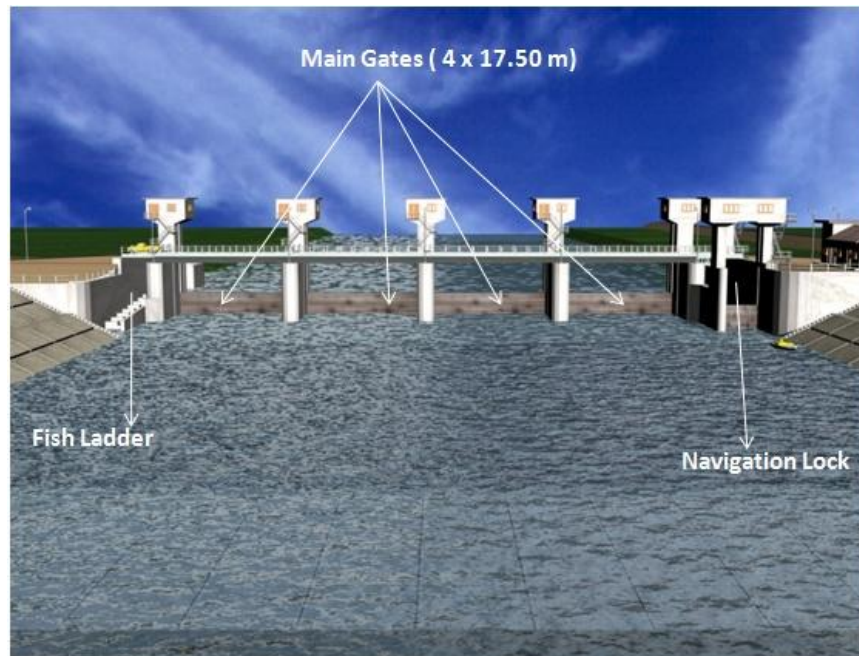


Fig. 13. 3D Drawing of Barrage

SUMMARY AND CONCLUSIONS

1. During dry season water level of Tempe Lake were very low (about 40 cm in depth) as lake's water storage decrease very quickly due to bigger capacity of outlet in this case ;Cenrenae River.
2. Engineering Studies has been conducted with Public consultation meeting (PCM) and concluded that during dry season, water level must be maintained in such away so that fishery and agriculture activities can be still conducted by local community . There are about 15,520 farm household and 3,120 fishery household. The selected water level is at + 5.0 m
3. The most suitable structure to control water level at + 5.0 m will be a barrage , further more will be called as “ **Tempe Barrage** “. Tempe Barrage is a kind of hydraulic structure blocking the Cenrenae river flow during the dry season to maintain water level in the lake at certain elevation, in this case + 5.0 m. The area inside elev + 5.0 m of the Lake may be used for fishery, then area outside elev + 5.0 m may be used for agricultural sector. The Tempe Barrage were also provided with navigation lock in the left side and fish ladder in the right side.
4. Finally with the operation of the main gates of the barrage then water level at Tempe Lake could be maintained at elevation + 5.0, therefore the activities of fisheries, agricultures may continue. The such barrage can *defend against drought* at Tempe Lake during dry season.

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