SIMULATION OF SIDEMENTATION PREDICTION DUE TO GROWTH OF WATER BIOMASS ' ECENG GONDOK ' IN LAKE BUYAN BULELENG BALI

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Abstract

Buyan Lake, is one of the caldera lakes originating from an ancient volcanic eruption in Bali. Geographically, Lake Buyan is located in Pancasari Village, Sukasada District, Buleleng Regency. The existence of this lake is very important for the surrounding community. This lake is a source of drinking water, tourism, agriculture for the people in Buleleng Regency. One of the factors that influence the existence of Lake Buyan is the uncontrolled growth of water biomass (Eceng Gondok) is influenced by fishing and agricultural activities that produce nitrite and phosphate. 10 individuals of eceng gondok can grow to 600000 individuals within 8 months. The relationship of the number of cementations (Ton) to the area covered by eceng gondok (Ha) is expressed by the relationship y = 0.25 x -11,525. The sedimentation prediction simulation model is carried out by taking conditions in 2020, in Lake Buyan there are 8 JKA (Floating Cage Net) stations, the value of nitrite and phosphate growth rates for each station, and the growth of fishery activity is 1%. It was found that the sedimentation deposits showed a significant effect which caused the shrinkage of Lake Buyan. Sedimentation in 2020 are still around 0.48 tons, but in 2050 the annual will be 40.34 tons. This causes the shrinkage of Buyan Lake in 2020 which is still 370 Ha, but in 2050 only 31 Ha.

Keywords : Sedimentation, Biomass, Eceng Gondok , Buyan Lake, Simulation

Introduction

The lake is one of the most important environmental aspects, which is a life support for the surrounding community. Bali has 4 large lakes, Lake Batur in Bangli Regency (1607, 5 Ha), Lake Bratan in Tabanan Regency (370 Ha), and Buyan Lake (360 Ha) and Tamblingan (110) in Buleleng Regency (BPS, 2018). The four lakes are called chess danu, which are the source of life for the Balinese people, the four lakes in their main function as producers of clean water sources for the Balinese people.

Balinese people in general, based on culture and regiosity in the Hindu concept, really appreciate the existence of these lakes. In the Hindu concept of knowing the term sad kertih, Sad Kerih comes from the root word sad meaning six and kertih meaning a positive work. It is stated that to maintain a balanced and sustainable life, there are six things that must be done or implemented. The six things are Atma Kertih, Samudra Kertih, Wana Kertih, Danu Kertih, Jagad Kertih, and Jana Kertih. The concept of Sad Kertih is a Hindu teaching as a form of practicing and living the Tri Hita Karana.

Respect for nature gets a very important portion (Lontar Purana Bali).

But on the other hand, human life is increasingly complex, economic interests are the most important thing, uncontrolled population growth, population migration, the entry of other interests such as politics, and others, causes the sustainability of the lakes to be increasingly threatened.

Specifically regarding Buyan Lake, which is in the administrative area of Pancasari Village, Sukasada District, Buleleng Regency. Together with Tamblingan Lake, it is a source of drinking water for Buleleng Regency, and the city of Singaraja in general. Some people say the two lakes are twin lakes. Based on research conducted by the Udayana university team [1], [2] The study showed that there was silting in both lakes. For Lake Buyan in 1999, the area of the lake was about 439 Ha, ten years later it shrank by 5.9%, the area was only 413.15 Ha, then in 2015, only 376.6 Ha. from the period 2009 to 2015, the period of 6 years depreciation was 8.8%.

Based on these data , this condition is very worrying . So far, no significant action has been taken, which is visible to the goverment. Except for economic activities, developing the level of economy, life, exploitation of nature. This is a natural thing, because one of the tasks of the government is the welfare of its citizens. However, the government must not forget to protect its natural resources and the lake's ecosystem. if we use time series forecasting, or with linear regression
 [3] With assuming 8.8% depreciation every 6 years, then approximately 1 century from now Buyan Lake is only about 70 Ha.

This study aims to develop a model to describe the area and volume of Buyan Lake in the next few years. From the simulation model provided, it is hoped that it will provide an overview of what factors influence the damage to Buyan Lake, so that the government is expected to be more responsive in determining strategies, both preventive and curative.

2. Basic Teory

2.1 Balinese Philosophical veiw on the Lake

The lake as one of the important elements of the environment has a very important place. One of the yadnya homage to the lake in Bali is known as danu kertih.

Danu kertih, is one part of Sad Kertih, the basis of this teaching is taken from the Balinese lontar Purana, which teaches 6 noble things that humans must do to maintain the harmony of life, Atma, Samudra, Wana, Danu, Jagat and Jana Kerti. Kertih itself means doing something right [4]. Lebih lanjut dalam [4] , Furthermore, in[4] , related to danu kertih it is stated as an effort to maintain, maintain existing water sources, in this case especially lakes (as well as all other land springs). Performed with a melasti ceremony, pekelem, symbolic to maintain the sustainability of the lake ecosystem. At each headwaters of the lake, there is always a temple of a holy place, as a worship of the goddess Danu as a powerful form of the god Vishnu. So psychologically the Balinese Hindus really respect the existence of the lake, they don't think of the lake as just a big puddle of water, but there is a religious spirit in it.

In the article presented by [5] , mentions that there is a very sacred place, with the term tri danu (three lakes). This area is declared as Utamaning Angga, which is the upper reaches of the island of Bali. This area is a source of life, a source of water for both community drinking and agriculture. The royal government at that time, to preserve the lake, stated that it was not allowed to take wood from the forest around the three lakes, known as forbidden wood. The three lakes in question are Lake Bratan, Lake Buyan, and Lake Tamblingan.

2.2 Buyan Lake Environmental Conditions

Lake Buyan is a confined basin or caldera, which occurred as a result of a volcanic eruption thousands of years ago. Geographically, Buyan Lake is located in the Panca Sari Village, Sukasada District, Buleleng Regency. This lake is a source of drinking water and agriculture for the people of Central Bali, especially Buleleng Regency. Besides being a source of drinking water, Buyan Lake also provides benefits for fertile agricultural land (in the lakeside area), an extraordinary tourist charm. Realizing this, the

Buleleng district government has actually made efforts to protect it, such as government regulation No. 36 of 2005, which regulates environmental and building layouts around Buyan Lake. Figure 1 shows the geographic location of Buyan Lake [6].
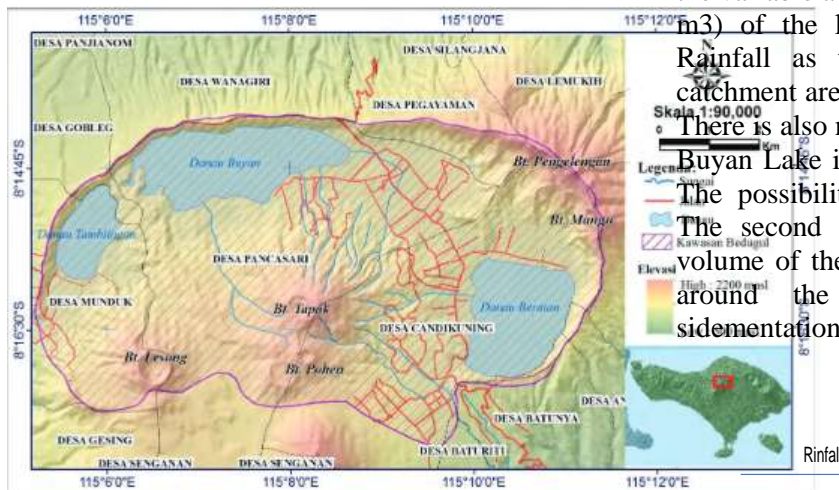

Figure 1 Location of Buyan Lake and Other Lake In Bedugul Bali [6]

2.3 Dynamik Modeling

One of the existing simulation model methods is the dynamic simulation model, which is a simulation model that involves time as an influential factor. In dynamic modeling, the goal is to describe quantitative changes in one or more certain variables. To be able to do this, the details of the system must be determined, the characteristics, the phenomena that occur in it, the elements that make up the system, the relationships and interrelationships between the constituent elements (system structure). All of them refer to the field of science related to the discussion of systems. For lake systems, there will be a lot of involvement in civil engineering, especially soil science for landslide analysis, biological or environmental sciences for discussing lake biomass, chemistry for analysis of lake inorganic organic matter content, fisheries science for lake fisheries activities.

From the analysis of various disciplines, the structure of the system is finally obtained, which is then used as the basis for determining the causal model / structural model and finally used as a behavior model (final simulation model).

The Buyan lake model is based on the timjaun on soil science and the occurrence of sedimentation, we state in this study as follows:

2.3. 1. Lake Existence

The existence of a lake which is expressed by the variable area (Ha) / volume of water (million m3) of the lake, is influenced by 3 factors. Rainfall as the main water source for the catchment area (catchment area) of Lake Buyan. There is also no river flowing from Buyan Lake, Buyan Lake is truly a perfectly confined basin. The possibility of seepage from rocks exists. The second factor that affects the area and volume of the lake is the landslide/soil erosion around the lake. The third factor is sidementation due to biomass decomposition.
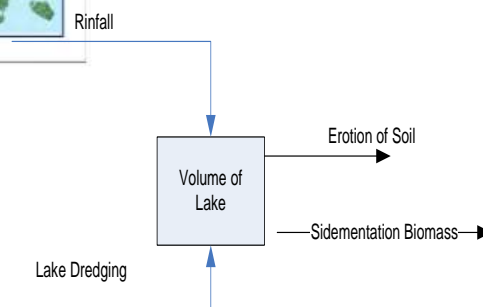

 Figure 2. Causal Diagram of Lake Existence

2.3.2. Sedimentation of Biomass,

Sedimentation due to biomass (water hyacinth) in the model stated that water hyacinth occurs due to the activity of JKA (Floating Cage Net), which produces nitrite and phosphate. the more JKA stations, the more nitrite and phosphate, and will produce water hyacinth in the estimated unit kilogram. To determine the number of water hyacinth individuals, data from the Udayana University assessment were used, the estimated density of water hyacinth was 180 individuals / m2. With these data, it can be calculated that each JKA station at the beginning can produce 12 water hyacinth individuals. Based on water hyacinth life cycle data, within 8 months 10 individuals can become 60000 individuals. With this calculation, within a year the growth of water hyacinth at each JKA station is approximately 720000 individuals (equivalent to the area covered by water hyacinth 6 Ha). The correlation/regression equation between the area

covered with a lot of sediment, then the number of lake sediment deposits can be determined
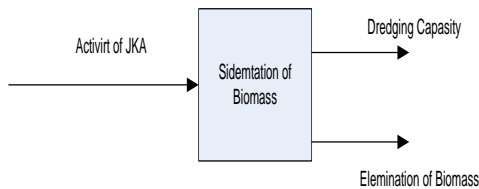
Figure 4. Causal Diagram of Biomass Sidementation

3. Research Methods
3.1 Data Acquisition
The data used are data issued by the official agency of the Public Works Agency (PU) of the province of Bali, Meteorological Agency data, as well as data from previous research results. The following is the data obtained related to the condition of Lake Buyan.

a. Rainfall data.
Rainfall data for the last 10 years in the area around Pos Lake, Pancasari Village, Baturiti, Wanagiri , Buleleng Bali.

Tabel 1. Data of Rainfall in Baturiti/ Wanagiri

Tahun	Januari	Februari	Maret	April	Mei	Juni	Juli	Agustus
2010	645.4	458.4	373.9	701.4	302	119.5	108.4	130.7
2011	558.2	405.7	165.5	445.7	285.1	13	22.9	6.2
2012	565.3	332.7	444.1	362.9	156.3	17.3	90.6	10.9
2013	294.5	550	333.7	328	220.8	207.8	141	20
2014	388	134	94	198	60	4	141	22
2015	326	233	534	298	89	20	5	14
2016	315	640	312	260	410	130	284	153
2017	513	396	402	305	147	106	106	51
2018	644.9	616.1	446.6	163.6	43.7	104.9	93.4	177.8
2019	563.7	261	469.9	446	70.1	128.2	11.9	8.4

b. USLE Data of Buyan Lake
Universal Soil Loss Equation (USLE) data, in addition to rainfall used in this study are:

Tabel 2. USLE Data of Buyan Lake

No	Variabel	Value	Description
1	Erobilitas of Soil (K)	0.21	Soil Condition meditern
2	Land Slope (Ls)	3.1	Condition of soil Slope 15-20%
3	*Cultivation of Land* (C)	0.4	Treatment soil with activity algiculture vegetables
4	Conservation of Land (P)	0.5	conservation of Land follow land countur
5	Unit of *JKA (Floating Cage Net)station*	8	Unit Floating Cage Net

c. Assumption
1. The growth of water hyacinth at each JKA station is approximately 720000 individuals (equivalent to the area covered by water hyacinth 6 Ha).
The number of sidementations per Ha, the area covered with water hyacinth is expressed by the equation.

$$y = 0.25\,x - 11.525 \quad\text{...............(3)}$$

y = sidementation (Ton)
x = Area of Biomass

2 . Determination of Lake Volume Area
The capacity of the lake is expressed by looking at the amount of soil sediment either due to erosion/slides or due to biomass deposits (water hyacinth). By using the physical formula, about the density of soil

$$\rho = \frac{m}{v} \qquad , \qquad \rho \, Soil = 0.15 \, Ton/m3$$

.... (4)

we get a reduction for each tonne of sediment equivalent to

$$Vreduktion \ (m^3) = \frac{mass \ of \ Sidementation \ (Ton)}{0.15}$$

....(5)

3.2 Simulation Model

The simulation model developed is expressed as a behavior model, including a model for the process of erosion avalanches. The second model is a model of formation of sedimentation, and the third is a model of the existence of a lake. The volume of the lake every year will be reduced by the occurrence of sediment either due to landslides or biomass sidemntasi. Figure 5 shows a model of the existence of the lake as a whole
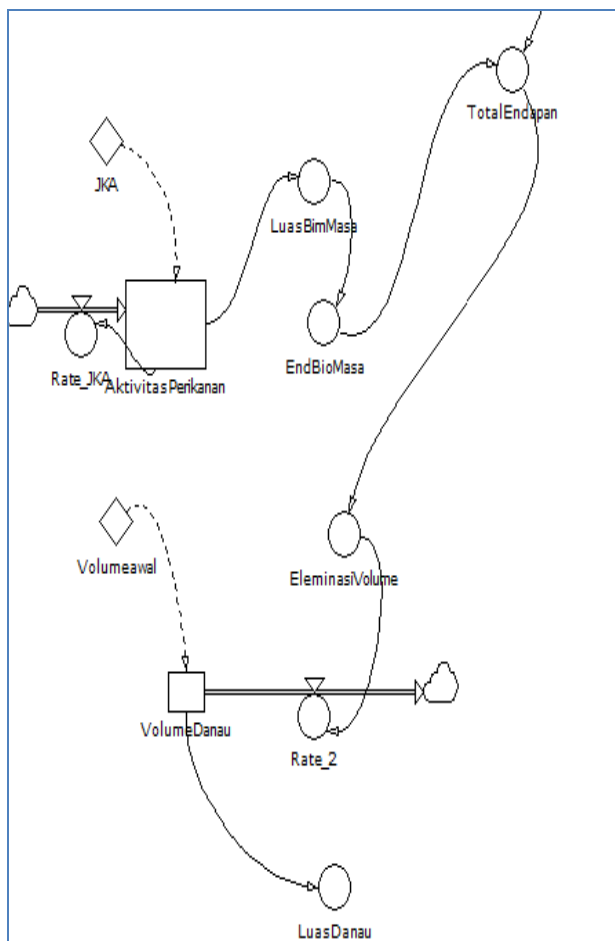

Figure 5 . Simulation Model Existence Buyan Lake

4. Result and Discussion
4.1 Result of Simulation

The simulation results are shown as a prediction of the state of the lake from 2020 -2050, stated as follows:

A. Sedimentation of Biomass
Tabel 4. Sedimentation of Biomass 2020-2050

| year	AktivitasPerikanan	LuasBimMasa	EndBioMasa	TotalEndapan
2,020	8.00	48.00	0.48	116.97
2,021	8.40	50.40	1.08	74.14
2,022	8.82	52.92	1.71	77.95
2,023	9.26	55.57	2.37	85.54
2,024	9.72	58.34	3.06	69.66
2,025	10.21	61.26	3.79	69.93
2,026	10.72	64.32	4.56	129.06
2,027	11.26	67.54	5.36	108.33
2,028	11.82	70.92	6.20	105.72
2,029	12.41	74.46	7.09	93.01
2,030	13.03	78.19	8.02	82.25
2,031	13.68	82.10	9.00	73.18
2,032	14.37	86.20	10.03	65.57
2,033	15.09	90.51	11.10	59.23
2,034	15.84	95.04	12.23	53.99
2,035	16.63	99.79	13.42	49.71
2,036	17.46	104.78	14.67	46.26
2,037	18.34	110.02	15.98	43.54
2,038	19.25	115.52	17.35	41.47
2,039	20.22	121.29	18.80	39.95
2,040	21.23	127.36	20.31	38.93
2,041	22.29	133.73	21.91	38.36
2,042	23.40	140.41	23.58	38.18
2,043	24.57	147.43	25.33	38.36
2,044	25.80	154.80	27.18	38.85
2,045	27.09	162.55	29.11	39.65
2,046	28.45	170.67	31.14	40.71
2,047	29.87	179.21	33.28	42.03
2,048	31.36	188.17	35.52	43.58
2,049	32.93	197.57	37.87	45.36
2,050	34.58	207.45	40.34	47.35

B. Condition of Existence Buyan Lake
The existence of Buyan Lake, in the variables of area and lake volume is presented in Table 5.

Tabel 5. Simulation for Area and Volume Buyan Lake 2020-2050

year	VolumeDanau	LuasDanau
2,020	133.00	570.00
2,021	125.20	536.58
2,022	120.26	515.40
2,023	115.06	493.12
2,024	109.36	468.68
2,025	104.72	448.78
2,026	100.05	428.80
2,027	91.45	391.93
2,028	84.23	360.97
2,029	77.18	330.77
2,030	70.98	304.19
2,031	65.49	280.69
2,032	60.62	259.78
2,033	56.24	241.05
2,034	52.30	224.13
2,035	48.70	208.70
2,036	45.38	194.50
2,037	42.30	181.28
2,038	39.40	168.84
2,039	36.63	156.99
2,040	33.97	145.58
2,041	31.37	134.45
2,042	28.81	123.49
2,043	26.27	112.58
2,044	23.71	101.63
2,045	21.12	90.52
2,046	18.48	79.20
2,047	15.77	67.56
2,048	12.96	55.56
2,049	10.06	43.11
2,050	7.03	30.15

Result of simulation showed in Fig 6
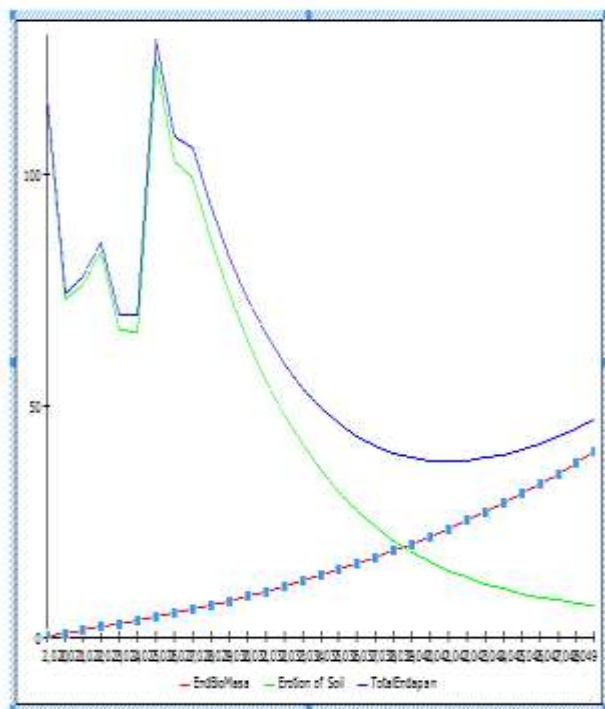
Gambar 6. Lake Deterioration Simulation 2020 - 2050

4.2 Discussion

The simulation results are obtained with several assumptions taken, which can be a concern as a limitation in the analysis of the results shown above.

(a) Sediment growth pattern, referring to water hyacinth growth. This is based on the theory that water hyacinth is the main source of sedimentary biomass. The growth of water hyacinth is very fast, and this is triggered by fishing activities, the existence of a floating cage net station (JKA). In this study the growth rate of fishery activity is used the assumption, the growth is 5%. However, this will certainly depend on future government policies.

(b) Dominant factors, to fight lake siltation, such as lake dredging, or water hyacinth cleaning are already there, but only occasionally, and tend to be ceremonial activities (not routine and periodic). So that in this simulation the influence of this variable is considered not to exist. In this simulation, it is as if there is no lake rescue effort.

(c) From the simulation results show something very scary, to the existence of the lake. In the next 30 years, it will be as if the Buyan Lake, which is now large, has only become a small pool of water with an area of approximately 31 Ha

5. Conclusion

Some conclusions that can be drawn from this research are:
1. Based on the simulation model made, it can be shown that the existence or sustainability of Buyan Lake is strongly influenced by the rainfall that occurs. Buyan lake is a caldera lake, whose water source is obtained from rain, and there are no other water sources.

2. The government should pay special attention to the growth of biomass, especially water hyacinth, naturally the growth is very massive, within 8 months 10 water hyacinth individuals can grow to 600,000 individuals. In the simulation model developed here, it is clear that biomass sedimentation is the source of the death of Buyan Lake.
3. Buyan Lake without adequate rescue activities, based on this simulation model in 2050 it is estimated that the area is only 31 Ha. No longer a lake, but just a pond. You can imagine how dry some areas in Buleleng have

been where the water source has come from Lake Buyan.

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