Models of Warmed Sedimentation Method Based on Community Bali Island

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Smart Village Sustainable Development (1)

Abstract

Community-based sedimentation prevention is aimed at maintaining the balance of Lake Batur, Beratan Lake, Lake Buyan and Lake Tamblingan. Sedimentation triggered by the pattern of management of agricultural lands less attention to aspects of soil and water conservation. The purpose of this research is; (1) to obtain a community-based sedimentation prevention model, (2) Mapping Land management on the edge of the lake, (3) erosion control strategy at the edge of the lake. This research was field experiment and surpei, sampling was done by purposive sampling at Batur Lake 20 samples, Beratan Lake 16 samples, Lake Buyan 16 samples and Danau Tamblingan 12 Sampel. The socio-economic support data of the community was determined by 180 respondents in cluster sampling. Interviews and questionnaires are closed questions on a conventional scale. The characteristics of the lake were analyzed descriptive statistics using the SPSS tool. Land mapping is done by GPS method with GIS device. Predict erosion using the Universal Soil Loss Equation (USLE) Model, for sedimentation using the Stanford Sediment model. The analysis of the rate due to erosion, done by non linear regression analysis. The analysis shows that the settlement has an average of 115,85%, plantation 245,50% and sedimentation level 1,017,93 m3 / year. Sedimentation was tested on both sides with a 95% confidence level on the modeled sediment data. The conclusions and outcomes of this study are community-based models that collaborate with elephant grass and vetiveria.
Keywords : Lake, Erosion, Sedimentation, Plants, Models

1. Introduction

The existing lake on the island of Bali water surface conditions continue to decline. Sedimentation process and silting of the lake is triggered by the pattern of management of agricultural land on the edge of the lake is less attention to aspects of soil and water conservation. Land damage occurs mostly on dry land, especially on land planted with food crops and smallholder plantations. The damage occurs, among others, because the dry land is open by soil processing, burning, weeding and grazing so that the soil is easily eroded and landslide. Erosion and flooding can degrade the quality and quantity of natural resources and water so that the productivity of the resource becomes decreased. The purpose of this research is; (1) to obtain a form of community-based sedimentation prevention model, (2) Mapping Management of agricultural lands and tourism activities on the edge of the lake, (3) erosion control strategy at the edge of the lake. Targets to be achieved in the form of model of

Lake sedimentation model and shape of erotic prediction mapping model in each lake area. The research was conducted in four lakes: Batur Lake in Bangli Regency, Beratan Lake in Tabanan Regency, Lake Buyan in Buleleng Regency and Lake Tamblingan in Buleleng Regency.

2. literature Review

2.1 *Sedimentation*

Sedimentation is the process of precipitation of erosion, while sediment is the result of erosion process, either surface erosion, trench erosion, or other soil erosion types. Sediments generally settle at the bottom of the foothills, in areas of flooded puddles, in waterways, rivers and lakes. Sediment yield is the amount of sediment derived from erosion occurring in the catchment area measured over a period of time and place. Sediment yield is usually obtained from measurements of soluble sediments in the lake or direct measurements in the lake (Asdak, 1995). The sediment type and particle size are presented in Table 1

Table 1. Type of sedimentation and particle size

Num	Type of sedimentation	Particle size (mm)
1	Clay	< 0.0039
2	Dust	0.0039 – 0.0625
3	Sand	0.0625 – 2.0
4	Silt	2.0 – 64.0

Source: Asdak (1995).

2.2 *Sedimentation Movement*

Generally there are three types of movements of sedimentation, namely transport base (bedload), transport suspension (suspended load), and transport drain (washload). Ilyas (2002) suggests that bedloads are particles that are transported by shifting, rolling or jumping around, and always near or nearly settling on the river bed. Bed load consists of coarse particles, such as gravel or sand that move regularly or randomly and always reach the bed of the lake. Suspended load moving float without touching the bed of the lake, or at least it has a long trajectory before it touches the bed of the lake. According to M.A. Ilyas (2002)the charge of material of either bedload or suspended load is determined by the condition of the base flow movement.

2.3 *Lake Sedimentation Calculations*

The suspension sediment load can be calculated by measuring the flow velocity U (z) and the sediment concentration C (z), and is the integration equation:

$$Q_{si} = Q_i \ C_i \ \ k$$

Where Qsi = sediment discharge (ton / day), Qi = water discharge (m3 / sec), Ci = concentration (mg / l), k = unit dimension conversion 0.0864
By the power regression equation, we can find the equation of the curvature flow curve combined with the daily discharge data to determine the average annual sediment.

2.4 *Sediment Transport*

Sediment transport is defined as a sedimentary net transfer through a cross-section over a period of time. The amount of sediment transport is expressed in weight, mass, volume per unit time (N / s, kg / s, m3 / s). The initial basic sediment grain motion is the beginning of the occurrence of sediment transport in an open channel. The sediment transport process can be described as including the following three processes (Prasetyo *et al.*, 2017) The method for calculating sediment transport is the method of Bagnold (1996) which develops the function and formula of sediment transport based on the concept of power. He considers the relationship between the average available in the system of flow and average work that has worked together on one such system during the sediment transport process. The relationship is formulated in the following equation (Pangestu and Haki, 2013):

$$q_t = \frac{\gamma}{\gamma_s - \gamma}\ \tau *$$

$$V\ \left[\frac{e_b}{\tan\alpha}\ 0.01\ \frac{V}{\omega}\right]$$

2.5 *Erosion*

Erosion produces sediment, a pollutant that can degrade the quality and quantity of water, especially it affects physical, biological and chemical characteristics on waters (Asdak, 1995). In general, the occurrence of erosion is determined by climatic factors (especially rain intensity), topography, soil characteristics, vegetation, and land use. To find out the magnitude of erosion caused by land conversion, it is used the erosion prediction. The prediction of erosion from a plot of land is a method to estimate the rate of erosion that will occur from certain land use and management (Arsyad, 1989). If the rate of erosion that is to occur has been predicted and the rate of erosion that can still be tolerated can be determined, it can be determined the policy of land use so that no soil damage and it can be used productively and sustainably. The designated land uses are those that can suppress the rate of erosion to be equal to or less than the tolerable rate of erosion. According to (Adnyana, 2001), the longer and steeper the slopes, the greater the causal factor of erosion. The core method will provide smaller erosion value compared to compaction and smoothing methods (Mandagi and Manoppo, 2009)

2.6 *Rainfall*

Rainfall is a climatic factor that affects erosion. The amount of rainfall, intensity, and distribution of rain determines the strength of rain dispersion to the soil, the amount and speed of surface flow and erosion damage. Maximum rainfall in an area according to Central Meteorology and Geophysics Center (BMG) of 531 mm per month that occurred in March. In this process the leveling of the rain using the average method of algebra from the daily rainfall data of rainfall recording results from the area of each post station of rain recorder.

$$R = \frac{1}{N}(R_1 + R_2 + \cdots + R_n)$$

Explanation :

R = Regional Rainfall

$R_1 + R_2 + \ldots\ldots\ldots + R_n$ = Rainfall at each Observation Point

N = Number of Observation Points

2.7 *Erosion Prediction According to Universal Soil Loss Equation (USLE)*

Predicting erosion is essential to evaluate whether potential erosion and actual erosion will damage the land, and this data can be used as a plan and prioritized management of the land. Besides it can also be used to evaluate the results that have been applied whether it is in accordance with the soil conditions. The Universal Soil Loss Equation (USLE) model is a further empirical model for calculating surface erosion and gully. Murtiono (2008) states that based on research results, the USLE model can be applied in the tropics, and USLE estimates can be used to take practical action to control erosion. If the estimation results are greater than that allowed then it is necessary to take the action of plant management and soil conservation.

The prediction of the magnitude of erosion uses the Universal Soil Loss Equation (USLE) that is mathematically formulated as follows:

A = R K LS C P

Where:

A = the amount of soil erosion or the amount of soil loss (ton / ha / yr)
R = rainfall erosivity factor index
K = soil erodibility factor index
LS = index of length and slope factor
C = index of plant management factors
P = index of soil conservation techniques

3. Research Methods

3.1. *Research Design*

The research that will be conducted is field experiment, field survey about land condition from lake area, research on biophysical conditions of the research location i.e. type, structure and texture of soil; morphology or topography of the length of the slope; geological / geophysical properties of the land; vegetation; climates, i.e. rainfall and rain intensity; vegetation and non-vegetation land mapping; and eroded land mapping and this is done with GPS (Geographic Positioning System) with GIS (Geographic Information System) device; and surveys on community participation in the erosion control.

3.2. *Research Sites and Data Sources*

The research was conducted in four lakes: Batur Lake in Bangli Regency, Beratan Lake in Tabanan Regency, Lake Buyan in Buleleng Regency and Lake Tamblingan in Buleleng Regency. This research is field experiment and surei research, pengembilan sample is done by purposive sampling at Batur Lake 20 samples, Beratan Lake 16 samples, Lake Buyan 16 samples and Danau Tamblingan 12 Sampel. The socio-economic support data of the community was determined by 180 respondents in cluster sampling in four lakes in Bali. Interviews and questionnaires are closed questions on a conventional scale (1 to 10).

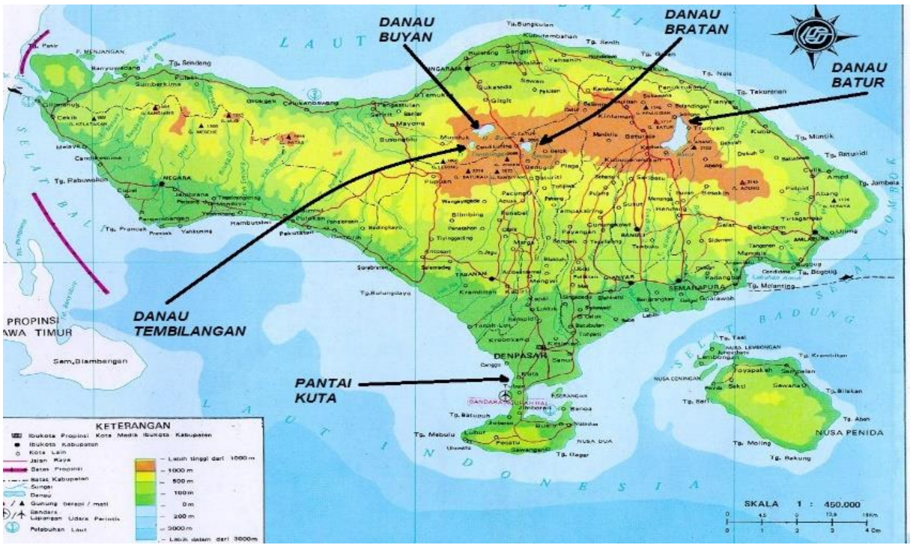

Figure 1. Map of Lake Location on the Island of Bali (source: www.google.com)

A. *Primary Data*

The data collected consists of: a) Soil physical properties consisting of the weight of soil volume, texture, organic matter content, structure and permeability of soil (to determine the value of soil erodibility) .The weight of soil volume, texture and soil organic matter content was done by analysis in soil laboratory at the Faculty of Agriculture of Udayana University, for measurement of soil properties, soil texture is analyzed by pipette, Bulk density by sample ring, permeability is measured by permeameter, organic material by walkley and black, b) Soil sampling is conducted by field surveys in four lakes, both on the banks and in the lake. The depth of the soil is measured by using a soil drill, a soil conservation effort that is applied either technically or vegetatively to the purpose of reducing soil erosion, to determine the value of soil conservation factor (P).

B. Secondary Data

Secondary data are data obtained from related land use information including: a) Rainfall data to calculate rainfall erosion value. This data includes the average rainfall, the average number of rainy days of rainfall of max 24 hours, b) administrative map, topographic map, soil type map, land use map and vegetation covering map.

3.3 *Data Source*

Sources of data in this study include: a) Data from the Bali Provincial Forestry Service on administrative map of the study area, b) the District Planning Office, c) Precipitation Stations, d) Central River Region in Bali - Nusa Penida.

4. Results and Discussion

4.1 *Survey of Distribution in Lake Batur Region of Bangli Regency*

The survey results that have been done show that the population growth and rapidly increasing tourism activities in the area around Lake Batur often pose complex problems that require intensive management.

Table 2. Existing Condition of Lake Batur

Num.	Description	Notes
1	Location	Kintamani Sub-District, Bangli Regency
2	Geographical location	115º22'42" – 115º25'33 East Longitude 8º17'14" - 8º13'19 South Latitude
3	Annual Rainfall	1.809 mm
4	Lake Water Front Evaluation	1.032 m asl
5	Lake Type	Caldera Lake
6	Water Type	Natural lake
7	Depth (max.)	80 m
8	Surface Area of Lake	16.213 Km^2
9	Volume of the Lake	773,33 m^3
10	Inlet (inflow)	Only from DTA
11	Outlet (outflow)	not available

Source: Central River Region Bali - Penida

Table 3. Land Use in Lake Area

Num.	Description	1999 (Ha)	2009 (Ha)	2015 (Ha)
1	Field	1634,07	536,67	636,67
2	High density natural forests	608,65	228,56	228,56
3	Natural forest with medium density	260,85	533,32	433,32
4	Settlement	1435,20	2217,00	2342,00
5	Plantation	144,89	529,22	529,22
6	Shrubs	312,34	383,23	258,23
7	Geopark	1066,00	1034,00	1034,00

Source: Central River Region Bali – Penida

Table 4. Sedimentation of Lake Batur

Num	Lake Morphometry	in 2013	in 2015
1	width of the waters (km^2)	14,71	16,55
2	Size of the waters (ha)	1471	1655
3	Water Volume (million m^3)	820,54	773,33
4	Maximum water depth (m)	88	80
5	Sedimentation (m^3)		5.980,47
6	Period (year)		3
7	Sedimentation rate (m^3/year)		1.993,49

Source: Central River Region Bali – Penida

Table 5. Measurement Results of Lake Area

Num.	Description	Sizes (Ha)		
		1999	2009	2015
1	Lake Batur	1661	1630,4	1621,3
2	Lake Beratan	394,41	386	376,4
3	Lake Buyan	439	413,15	476,6
4	Lake Tamblingan	146,6	143,50	146,1

Source: Central River Region Bali – Penida

4,2 *Survey of Distribution in Lake Beratan Tabanan*

Beratan Lake is a lake located in the area Bedugul, Candikuning Village, District Baturiti, Tabanan regency, Bali.

Table 6. Existing Condition of Lake Beratan

Num.	Description	Notes
1	Location	Tabanan
2	Geographical location	115º 9' 53" - 115º 11' 09" BT 8º 15' 44" - 8º 17' 01" LS
3	Annual Rainfall	2.439,54 mm
4	Lake Water Front Evaluation	1.230 m dpl
5	Lake Type	Lake Sesar-Circumference Caldera
6	Water Type	Natural lake
7	Depth (max.)	20 m
8	Surface Area of Lake	3,764 km2
9	Volume of the Lake	29,74 juta m3
10	Inlet (inflow)	Only from DTA
11	Outlet (outflow)	Building spillway

Table 7. Sedimentation of Lake Batur

Num	Lake Morphometry	in 2013	in 2015
1	width of the waters (km^2)	4,29	3,89
2	Size of the waters (ha)	429,14	389,08
3	Water Volume (million m^3)	63,3	29,74
4	Maximum water depth (m)	23	20
5	Sedimentation (m^3)		2.443,32
6	Period (year)		3
7	Sedimentation rate (m^3/year)		814,44

Source: Central River Region Bali – Penida

4.3 *Survey of Distribution in Lake Buyan Buleleng*

Table 9. Sedimentation of Lake Buyan

Num	Lake Morphometry	in 2013	in 2015

Source: Central River Region Bali - Penida

Table 8. Land Use in Lake Area

Num.	Description	1999 (Ha)	2011 (Ha)	2015 (Ha)
1	Field	114,46	117,83	270,64
2	High density natural forests	931,56	808,68	1387,51
3	Natural forest with medium density	372,23	217,95	229,04
4	Settlement	424,79	565,89	598,73
5	Plantation	533,66	713,23	112,76
6	Shrubs	8,24	4,37	3,26

Source: Central River Region Bali – Penida

Table 8. Existing Condition of Lake Buyan

Num.	Description	Notes
1	Location	Buleleng
2	Geographical location	115º 5' 28" - 115o 6' 10" BT 8º 14' 55" - 8o 15' 52" LS
3	Annual Rainfall	2.294 mm
4	Lake Water Front Evaluation	1.275 m dpl
5	Lake Type	
6	Water Type	Natural lake
7	Depth (max.)	31,7 m
8	Surface Area of Lake	4,81 km
9	Volume of the Lake	116,25 juta m3
10	Inlet (inflow)	Only from DTA
11	Outlet (outflow)	not available

Source: Central River Region Bali – Penida

1	width of the waters (km²)	4,8	4,6
2	Size of the waters (ha)	480	460
3	Water Volume (million m³)	116,25	49,6
4	Maximum water depth (m)	80	60
5	Sedimentation (m³)	2216.799	
6	Period (year)	3	
7	Sedimentation rate (m³/year)	738,933	

Source: Central River Region Bali – Penida

Table 10. Land Use in Lake Area

Num.	Description	1999 (Ha)	2011 (Ha)	2015 (Ha)
1	Field	736,51	547,81	600,97
2	High density natural forests	744,57	632,27	286,67
3	Natural forest with medium density	323,43	687,79	593,59
4	Settlement	141,05	407,16	485,23
5	Plantation	75,47	87,53	62,17
6	Shrubs	16,03	11,94	8,37

Source: Central River Region Bali – Penida

4.4 *Survey of Distribution in Lake Tamblingan Buleleng*

Table 11. Existing Condition of Lake Tamblingan

Num.	Description	Notes
1	Location	Buleleng
2	Geographical location	115° 5' 28" - 115° 6' 10"BT 8° 14' 55" - 8° 15' 52" LS
3	Annual Rainfall	2.467,05 mm
4	Lake Water Front Evaluation	1.216 m dpl
5	Lake Type	Caldera Lake
6	Water Type	Natural lake
7	Depth (max.)	37 m
8	Surface Area of Lake	1,461km2
9	Volume of the Lake	19,8 juta m3
10	Inlet (inflow)	
11	Outlet (outflow)	

Source: Central River Region Bali – Penida

Table 12. Sedimentation of Lake Tamblingan

Num	Lake Morphometry	in 2013	in 2015
1	width of the waters (km²)	1,57	1,37
2	Size of the waters (ha)	1570	1370
3	Water Volume (million m³)	30,4	19,8
4	Maximum water depth (m)	40	37
5	Sedimentation (m³)		1.574,63
6	Period (year)		3
7	Sedimentation rate (m³/year)		524,87

Source: Central River Region Bali – Penida

Table 10. Land Use in Lake Area

Num.	Description	1999 (Ha)	2011 (Ha)	2015 (Ha)
1	Field	160,06	176,93	151,68
2	High density natural forests	406,00	442,59	465,76
3	Natural forest with medium density	265,00	189,68	119,19
4	Settlement	18,92	38,05	40,73
5	Plantation	24,84	87,53	80,92
6	Shrubs	6,78	11,94	7,388

Source: Central River Region Bali – Penida

5. Conclusion

Four lakes on the island of Bali all lakeside is used for agricultural land and the waters are used for recreation and fish farming. During the rainy season all the waters of the lake to rise that inundated the agricultural land so that fertilizer fertilizer is expected to be brought to the lake, so the lake becomes polluted and sedimentation continues to increase per year. To reduce sedimentation on land-based lakeside management is a community-based land management model that collaborates with elephant grass and vetiveria

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