International Journal of Sciences: Basic and Applied Research (IJSBAR)

ISSN 2307-4531

(Print & Online)

http://gssrr.org/index.php?journal=JournalOfBasicAndApplied

Modeling Abundance and Control of Litter on Kuta Beach, Bali, Indonesia

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Abstract

The research aims to simulate the behavior of the abundance of litter on Kuta Beach and the dominant cause factors. Studies using models of dynamic systems with software Powersim Constructor 2.5d. The data that will be simulated is data of litter fluctuations in Kuta Beach for 72 months from May 2007 until April 2013. Modeling results has been declared valid by the AME value of 0.127 or 87.3% confidence level. Modeling Projection conducted for 72 months from May 2013 to April 2019. Be found 2 leverage factors that affect the abundance of litter at Kuta Beach (ALKB) i.e. the percentage of litter that is discharged into the river (F_DLDIR) and the percentage of unmanageable agricultural litter (F_AL). The results of simulation modeling with four conditions are as follows: 1) Simulation modeling are extended (Business As Usual/BAU) will increase ALKB volume on average by 7.16% than base models 2) the pessimistic scenario by changing F_DLDIR doubling would increase the average volume ALKB by 234.70% compared to BAU Model 3). Moderate scenario by changing F_DLDIR to half the initial value will decrease the ALKB volume by 10.79% compared to BAU models. 4) Optimistic scenarios by changing F_DLDIR and F_AL in half will reduce the ALKB volume by 16.13% compared to BAU models.

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Control scenario can be implemented by promoting cooperation with governments in priority watersheds in the Bali Strait to the target work and F_AL F_DLDIR decline.

Keywords: Modeling; system dynamic; abundance of litter beach; control model

1. Introduction

Volume of litter beaches and ocean in Indonesia has been increasing at an interval of 1985 to 1995 in the Thousand Islands, Jakarta [1]. Conditions of litter piled in Coast will have an impact on environmental problems and economics [2]. In general, the environmental problems of marine litter such as: beach cleanliness, aesthetics, environmental health, migration of aquatic animals, movement of undesirable species and disruption of fishing activities [3,4,5,6,7]. While the economic problem of marine litters associated with to declining economic value of the region and costs due to environmental disturbances as a result of litter [8].

One of the beaches are experiencing problems of litter is Kuta Beach, Bali island, Indonesia. The problem of litter on Kuta Beach is the high litter fluctuation along the coast . The difference between the litter at normal conditions with abnormal conditions is very high. In normal conditions the litter at Kuta Beach ranged from 130 - 144 m3/month, whereas the abnormal conditions of up to 630 m3/month [9]. In normal conditions, the litter dominated by Kuta Beach tourist activities and in abnormal conditions, the litter dominated by litter from the sea (marine litter). Marine litter generally occur at a specific time in the rainy season, with the characteristics of high rainfall and the presence of westerly winds. The high volume of litter above normal, impact on the lack of personnel, equipment and costs to handle the litter. Besides, litter fluctuating conditions requires good management mechanism.

The problem of litter beach is a complex issue, because it is the result of the interaction of the three main components of the environment, namely: the natural environment, social environment and artificial environment. Components of the natural environment plays an important role in litter beach problem is landscape (e.g. topography, bathymetry, land use, etc. and supporting components (e.g. wind, currents, precipitation, climate, etc.) [10,11,12] . Social component (culture, customs, habits and institutions) play a role in the dynamics of the production of litter and litter management (e.g. [13,14]). Components of an artificial environment such as a means of supporting hygiene contributed to the large amounts of litter [14]. These components can be used to explain the abundance of litter on Kuta Beach using causal loop diagrams (CLD) in dynamic systems. Dynamic system is a way of thinking about systems and characterized by the dynamics and the relationship between the components of the system from time to time.

The complexity of the problem of litter on Kuta Beach elusive than one point of view. A systems approach combines various disciplines to understand the diversity of components and linkages. This is the importance of the system approach as an alternative to understanding the real world (e.g. [15,16,17]). Literally any dynamic systems characterized by interdependence, mutual interaction, information feedback, and circular causality (e.g. [15,18]). Simulation of dynamic systems is a quantitative procedure that describes the system behavior

and to develop predictive models and apply a series of tests planned in a given time. It is generally used for the simulation of dynamic models that involve multiple time periods (e.g. [19,20]).

This study aims to determine the dynamics of the abundance of litter and alternative policies of handling litter at Kuta Beach using dynamic system modeling. The results of this study can predict the behavior patterns of the abundance of litter at Kuta Beach and mitigation efforts.

2. Methodology

This study uses a dynamic system. Research has been conducted on Kuta Beach, Badung regency, Bali Province, Indonesia. Kuta Beach is geographically located at coordinates latitude $8^0$43'21, 4 " S and longitude $115^0$10'10 " E . Southern limit Kuta Beach is the Patra Jasa Hotel and the northern boundary is Stone hotel with a length of 3.75 Km .

Stages modeling conducted which includes: concept drafting, modeling, simulation, validation of the simulation results and applications or use (e.g [18,20,21]). Details of the stages are as follows:

a. Concept Development Phase

The initial phase of the modeling is done by mapping the influential variables that can explain the behavior of the abundance of litter on Kuta Beach. Selection of alternative concept of cause litter at Kuta Beach is based on facts, ideas and information that are considered valid. Selection is done to determine the concept model abundance of litter behavior that are considered appropriate. All variables that have been mapped relationship, both unidirectional relationship and that forms a feedback loop, it will produce a conceptual model, called a causal loop diagram (CLD). This diagram includes elements (system-process descriptors) and an arrow, which is known as the causal chain, which connects the various elements together. Causal relationship between one element with another element is positive if these changes are the same, meaning that if A increases, causing an increase in B, or vice versa, if there is A decline it will cause a decrease in B anyway. This relationship is called the same direction (s). Conversely, if the causal relationship between one element with another element is negative, then if there is an increase of the A element will cause a decrease in element B. This relationship is also called the opposite direction (o) (e.g. [22]).

b. Modeling stage

At this stage, CLD modified using symbols of Stocks Flows Diagram (SFD) with the help of software Powersim Constructor 2.5d. The main variables in CLD should be found in the SFD, because SFD derived from CLD. Other additional variables that are considered necessary for making explicit models can be added in the SFD.

c. Phase Simulation Model

Furthermore, computer simulations will be used to determine the behavior of all the variables in the system over time by first entering the required data. Simulations are run to simulate the conditions of the dynamics of the abundance of litter at Kuta Beach. Simulation modeling is the process of creating and analyzing a digital prototype of a physical model to predict its performance in the real world.

d. Validation of Simulation Results

At this stage the validity of the model was tested successively through the validation of the model structure and performance of the model. Validation of the model structure includes the logical consistency of the model structure and the suitability of the model structure with the structure of the real system. Validation of the model structures associated with boundary, variables and assumptions used in the system. Validation is done by comparing the model's performance on field data from the Department of Hygiene and Urban Landscaping (DKP), Badung Regency for 72 months from May 2007 until April 2013 with data from the simulation. The validation process using AME (Absolute Means Error) with the formula:

$$AME = [Si - Ai] / Ai \times 100\% \quad \text{.....(1)}$$

where :

A = actual value

S = the value of simulation

N = the time interval of observation

AME values in this study using a limit value of 30%, this value was considered sufficient because it is associated with a number of variables that cannot be controlled [23]

e. usage Models

Once the model is valid and can explain the condition of the abundance of litter on Kuta Beach then the model can be used. Furthermore, the projection is done by extending the simulation for 72 months from May 2013 until April 2019. Simulation results will describe the behavior of the abundance of litter on Kuta Beach in the future. Intervention on the model made where conditions abundance of litter are not as expected. Interventions performed by considering various policy scenarios. Feasibility of policy alternative based on the most realistic scenarios, and successful in reducing the abundance of litter on Kuta Beach.

3. Results And Discussion

3.1 Abundance of litter in Kuta Beach

Litter in the marine environment derive from two main sources: litter dumped from ships at sea and land-based sources such as runoff from rivers, waste water systems, wind-blown litter and recreational litter left on beaches

[24]. There is a tendency of increase of plastic waste in the marine litter in the world (e.g. [25,12]), similar case also happened at Kuta Beach. Based on the cause, litter on Kuta Beach derived from tourism activities and marine litter. Litter of tourism activities comes from tourist and maintenance work Kuta Beach. Litter volume average tourist is 0.3 liters per visit in the form wrapping food, drinks, newspapers and others. Litter on Kuta Beach from maintenance work in the form of tree trimming. Litter from tourism activities depend on the number of tourist arrivals, more and more tourists visit the greater the litter generated. Intense use of the beach for tourism and religious activities have increased the potential for litter on Kuta Beach. Conditions the abundance of litter caused by tourism and religious activities also occur on the coast of India Mumbai [26]. Litter loads increasing with numbers of visitors to beaches (e.g. [27]).

The amount of litter in the sea correlated with land vegetation, land activities and land use [12]. Research has been done to identify the origin of Kuta Beach litter using particle trajectory models [28]. Shipment of marine litter is litter that comes from several rivers that empty into the waters of the Bali Strait (watershed of Bali Strait). Land activities are influenced by the activity of the population, the higher the number the greater the population of litter generated. In general, according to SNI 19-3964-1995, litter generation in major cities is 2 to 2.5 l/person/day or 0.4 until 0.5 kg/person/ day. Meanwhile, litter generation in medium cities/small cities is 1.5 to 2 l/person/day or 0.3-0.4 kg / person/day. Population growth in the watershed of Bali Strait follow a certain value depends on the district.

Average litter dumped into the river in Indonesia, based on 2008 data was 2.99% of the total production of litter generated [29]. Litter management services in Bali and Nusa Tenggara reached only 47% of the population or 53% of the population unserved in litter management [29,30]. The litter that is not managed properly or accidentally discharged into the river a great opportunity to get to sea [24]. In the dry season, the litter that cannot be managed properly remain on mainland or on the riverbank. While the rainy season, the accumulation of litter in the watershed mainland Bali Strait disbursed by rain water through the river to the Bali Strait, then with the help of the wind and currents, litter stranded to Kuta Beach. This condition is exacerbated by the topography of Kuta beach shaped basin of so litter piling up on the beach.

Various attempts have been made to cope with the abundance of litter, such as routine cleaning and emergency cleaning. Routine cleaning is done every day by the cleaning management team Kuta Beach. At the time of abundant litter and ability cleaning team limited, cleaning litter assisted by teams of emergency cleanup from DKP Badung regency. The greater the volume of litter, the operational costs to litter clean up will also increase. This condition is also weighing on the budgets government, especially Badung regency.

Kuta Beach is tourist icon and one of main destinations of arrival tourist in Bali. Abundance of litter in tourist area is very avoidable because alleged effect on the enthusiasm of tourists visiting. Declining interest in tourists visiting to Kuta Beach affect arrival tourist to other areas in the Bali Island. These conditions affect not only the economic slowdown around Kuta Beach, but also other areas.

Fluctuations in the abundance of litter on Kuta Beach is data of litter dumped into landfill Suwung from May 2007 until April 2013 issued by DKP Badung regency. Fluctuations in the data of litter is a reference pattern as a comparison of the model to be built. Reference pattern of litter abundance in Kuta Beach as in Fig 1.

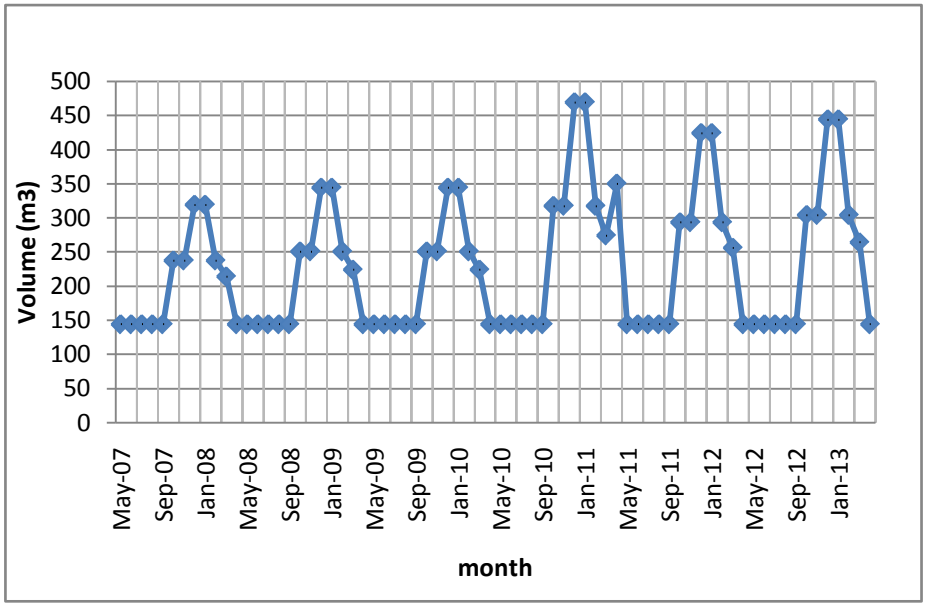

Fig 1. Reference patern of the volume litter abundance in Kuta Beach

3.2. Causal Loop Diagram

Conceptually, the feedback concept is at the heart of the system dynamics approach. Diagrams of loops of information feedback and circular causality are tools for conceptualizing the structure of a complex system and for communicating model-based insights [18]. Feedback loop is positive (reinforcing loop) if the multiplication sign of all elements of circular variables is positive. Feedback loop is negative (balancing loop) if the multiplication sign of all elements of the circular variable is negative. The structure is characterized by a positive feedback reinforcing exponential growth. The structure is characterized by a negative feedback to achieve growth objectives or achieve maximum growth patterns or decrease to near zero. There are five relationship feedback loop that make up the model of the abundance of litter at Kuta Beach i.e.:

a. Balancing Loop 1 (B1)

This feedback loop linking between the abundance of litter on Kuta Beach (ALKB) and litter from tourist visits (LTV). Tourist visit (TV) to Kuta Beach will provide increasing impacts on the beach litter from tourist visit (LTV). The higher the number of BTV will provide increasing abundance of Litter Kuta Beach (ALKB). ALKB the higher will result in decreasing the number of TV. Feedback structure is a negative feedback (B1= balancing loop 1 in the feedback loop). This feedback structure leads to a balance of the existing system so that the abundance of Litter on Kuta Beach (ALKB) initially grows exponentially restrained by reduced tourist visits (TV).

b. Balancing feedback loop 2 (B2)

This feedback loop linking between abundance of Litter on Kuta Beach (ALKB) and emergency cleanup (EC). Abundance of Litter on Kuta Beach (ALKB) will improve emergency cleanup (EC). Feedback structure is the structure that forms a negative feedback (B2=balancing loop in the feedback loop 2). This feedback structure leads to balance the system. Abundance of litter on Kuta Beach (ALKB) initially grows exponentially restrained by the emergency cleanup (EC) .

c. Reinforce feedback loop 3 (R3)

This feedback loop linking between abundance of Litter on Kuta Beach (ALKB) and the Emergency cleanup Preparedness (ECP). Litter management investment (LMI) conducted by the local government for cleanup preparedness program (CPP) in the form of equipment financing and reserves Cleanup. Readiness Cleanup (RC) serves to anticipate the marine litter to Kuta Beach with emergency cleanup (EC) program. The greater concern for emergency cleanup (EC) will have an impact on the abundance of Litter on Kuta Beach (ALKB) can be handled. Clean Kuta Beach will increase of tourist arrivals (TA). The increase in tourist arrivals (TA) will boost the regional economy (RE), and will further increase local government revenues (LGR) . LGR will also increase investment in the Litter management area (LMI). Feedback structure is positive feedback (R3 = Reinforce feedback loop 3). This feedback structure leads to a mutually reinforcing growth primarily on improving litter from tourists.

d. Balancing feedback loop 4 (B4)

This feedback loop linking between emergency cleanup (EC) and local government revenue (LGR). Emergency Cleanup (EC) is implemented by local governments will have an impact on the rising costs of litter management (CPM) which is charged to the local governments Revenue (LGR). LGR reduction will impact on the reduction of litter management Investment (LMI), subsequently will reduce readiness cleanup (RC) and emergency cleanup (EC) will decrease. Feedback structure forms a negative feedback (B4 = Balancing feedback loop to loop 4).

e. Reinforce feedback loop 5 (R5)

This feedback loop linking between abundance of litter on Kuta Beach (ALKB) and integrated litter management program (ILMP). Abundance of litter on Kuta Beach (ALKB) impact on tourist arrivals in Kuta Beach, the higher ALKB resulted in the decline in tourist arrivals (TA). The increase in TA will boost the regional economy (RE) and vice versa, a decrease in TA impact on the decrease RE. Increased RE impact on improving local government revenue (LGR). LGR will be reinvested in the form of litter management investments (LMI), the higher LGR, the greater the investment made. Integrated Litter management program (ILMP) is an alternative financing from LMI. ILMP aims to reduce the litter that goes into the water with the involvement of local governments in the Bali Strait watershed. ILMP is expected to have an impact on the reduction of Abundance of litter Bali Strait (ALBS). Reduction of ALBS have an impact on the reduction of

ALKB. Feedback structure forms the structure positive feedback (R5=Reinforce feedback loop 5). This feedback structure leads to a mutually reinforcing growth primarily on improving litter from Bali Strait.

Based on the description of the problem, then made a causal loop diagram (CLD) model of the abundance of litter on Kuta Beach as in Fig 2.

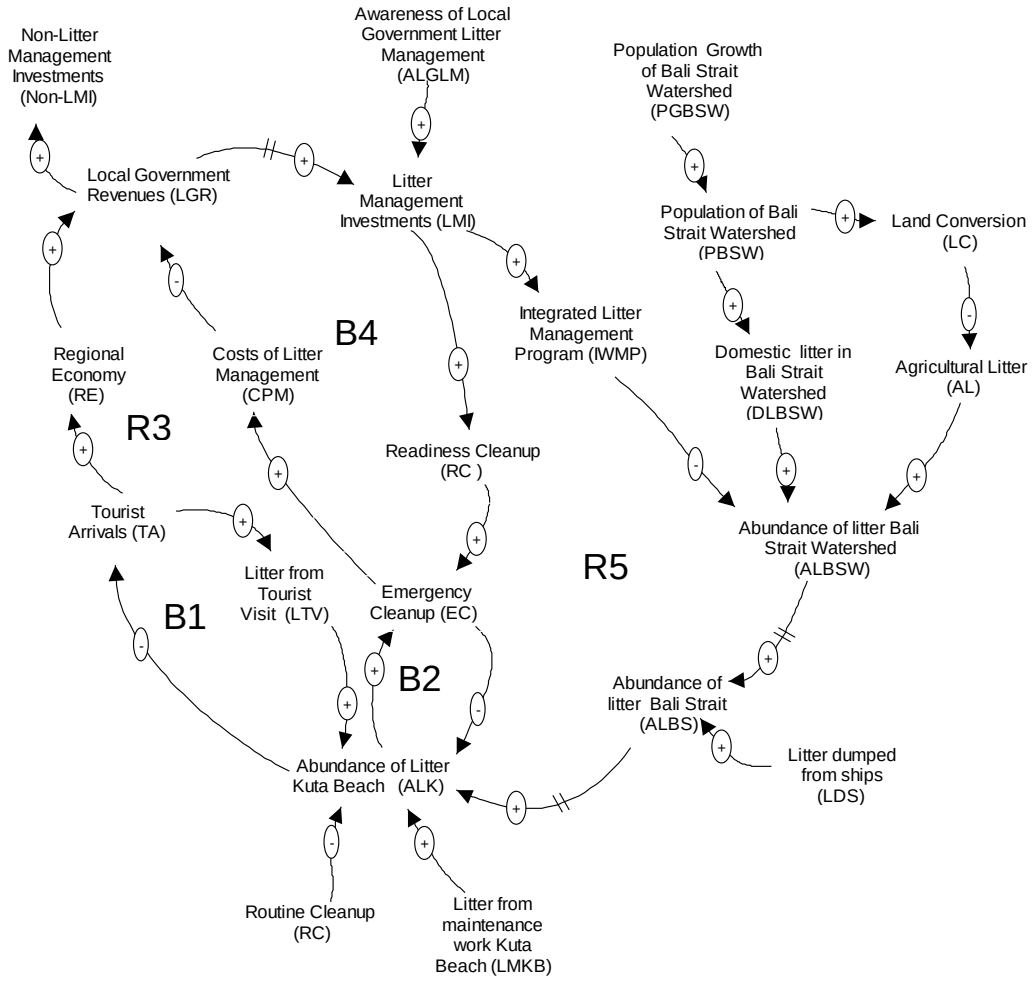

Fig 2. Causal Loop Diagram (CLD) modeling of the abundance of litter Kuta Beach

3.3. Stocks Flows Diagrams

Stocks flows diagram (SFD) is a product of the second step in the modeling work cycle commonly called modeling. Stocks flows diagram is a translation of causal loop diagram (CLD) using symbols software selected. Because derived from CLD, the main variables in CLD should be found in the SFD. In SFD allowed to add any additional variables that are considered necessary for making explicit models. An example is ability

routine cleanup (RC) Kuta Beach is very dependent on the number of tools (N_tools) and the ability of the tool (A_tools). The number and capabilities of tools not found in CLD but for the model can operational, the existence of such variables is important.

Based on the causal diagram in Fig 2., will be created a quantitative model SFD abundance of Litter at Kuta Beach with the help of Software Powersim Constructor 2.5 D. The models SFD are as in Fig 3.

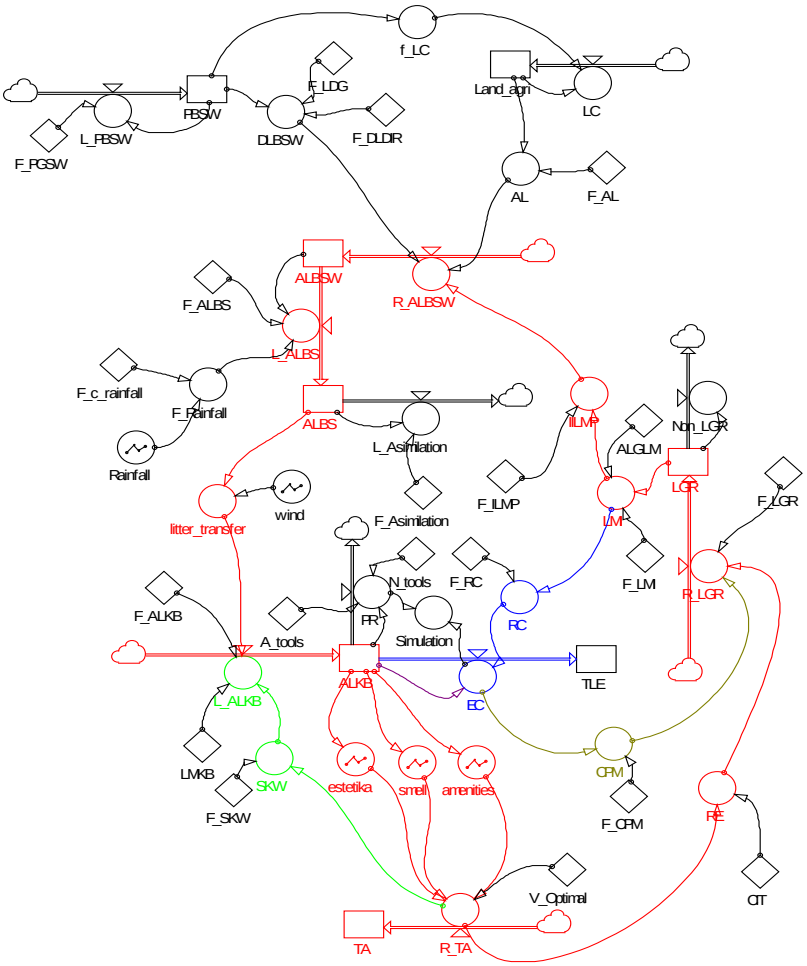

Fig 3. Stocks Flows Diagram (SFD) modeling of the abundance of litter Kuta Beach

3.4. Process of Simulation

The model is an abstraction or simplification of the real world, so that the model has certain limitations. Assumption was built to bridge the limitations of the model to be built. Modeling the abundance of litter on Kuta Beach is built based on the following assumptions:

a. Abundance of litter on Kuta Beach is the total volume of litter on Kuta Beach disposed to Suwung landfill from data recording by the Department of Hygiene and urban landscaping (DKP), Badung Regency. Opportunities litter from outside Suwung landfill ignored.

b. Type of litter dominant in Kuta Beach from tourism activities and marine litter from land- based sources such as domestik litter (DLBSW) and agricultural litter (gardens, fields and forests), while other types of litter that are not overly dominant ignored or considered represented in existing activities.

c. Marine litter from land-based sources only derived from litter dumped from ships (LDS) at Bali Strait and land-based sources from Bali Strait watershed, while other source ignored.

d. Production of domestic litter for each person is the same regardless of age, gender, ethnicity and religion but still distinguished by the origin of modern or traditional area by population in the district unit.

e. Agricultural litter that comes from existing agricultural activities (gardens, fields and forests) regardless of plant density, plant species, management model, etc. However, is determined by the area

f. Contributions Kuta Beach on regional economic (RE) improvement is based on the costs incurred by travelers (CIT) per day not distinguish between foreign tourists and local tourists. That amount includes the cost of transportation, food and accommodation during a visit to Kuta Beach.

g. There are allocation local government revenue used for investment of litter management by the same proportion.

h. Integrated litter management program (ILMP) is an investment made to lessen the litter into the sea from the Bali Strait Watershed (Abundance of litter Bali Strait Watershed /ALBSW).

Initial value of simulation and estimation methods are shown in Table 1.

Table 1. Initial value of simulation and estimation methods

No.	Variable name	Value & Parameter	Unit	Metode Estimasi
1.	Initial value of total population in Strait Bali Watershed *(PBSSW)*	645,498	person	S,C
2.	Initial value of abundance of litter on Kuta Beach (ALKB)	144	m^3	S
3.	Initial value of abundance of litter Bali Strait (ALBS)	200	m^3	C
4.	Initial value of abundance of litter Bali Strait Watershed (ALBSW)	5000	m^3	C
5.	Initial local government revenue (LGR)			

6.	Litter from maintenance work Kuta Beach (LMKB)	59	m^3/month	P,S,C
7.	Litter from tourist visits (LTV)	0.3	l/person/visit	P,S
8.	Costs of litter management (CPM)	386,012	Rupiah/m^3	P,S,C
9.	The ability of the tool (A_tools)	72	m^3/month	P,S,C
10.	The number of tools (N_tools)	2	Set	P
11.	Costs incurred by travelers (CIT)	500,000	Rupiah/person/day	P,S,C
12.	Rainfall	Graph monthly Data	mm/month	S
13	Fraction agricultural litter	0.055	m^3/ha	S,C
14.	Fraction local government revenue (F-LGR)	0.02		S,C
15.	Fraction of litter management Investment (LMI)	0.01		S,C
16.	Fraction population growth in Strait Bali Watershed (F-PGSW)	0.00175	1/month	S,C
17.	Average litter domestic generation in Bali Strait Watershed *(*LDG)	0.063	m^3/person/month	S,C
18.	Fraction of domestic litter manageable (F - DLM) in Bali Strait Watershed	0.47		S,C
19.	Fraction of domestic litter dumped into the river (F- DLDIR)	0.0299		S
20.	Initial time simulation	May 2007	month	Scenario
21.	Initial time simulation	April 2018	month	Scenario

where:

P: estimated from primary data

S: estimated from secondary data (BPS Data, Data relevant agencies and literature)

Q: What is expected of qualitative information

C: calculated from the model of the other parameters

The model in Fig 3. executed by first inserting the relationship between variables and the values of the modeling variable. Simulation is done to simulate data the abundance of litter on Kuta Beach of the Month May 2007 until March 2013. Results of simulation is presented in Fig 4.

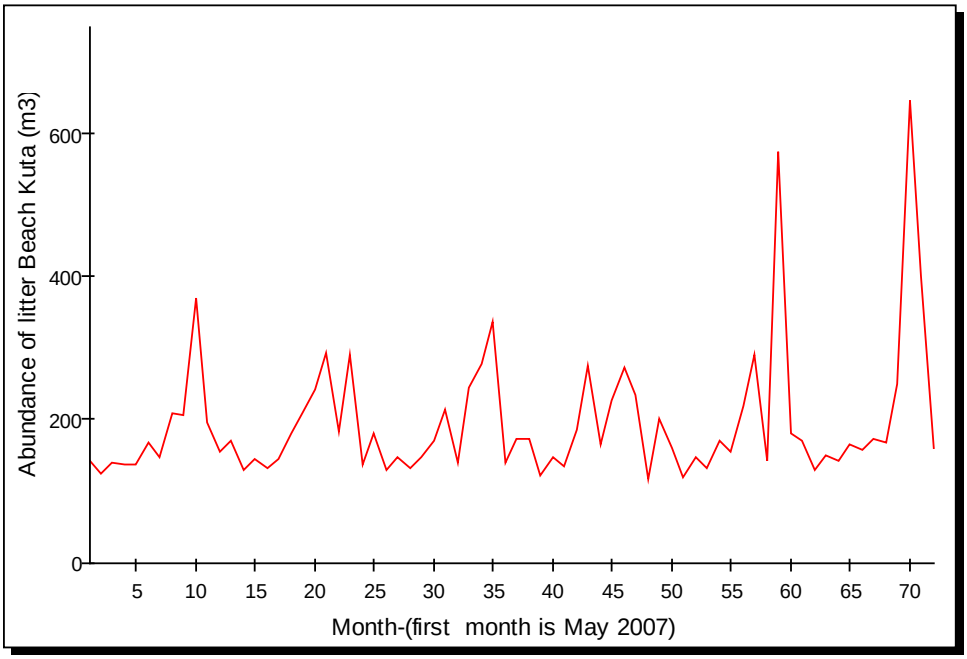

Fig 4. Simulation of basic models abundance of litter on Kuta Beach

3.5. Validation Model

Comparison between simulation data from base model and field data as in Fig 5.

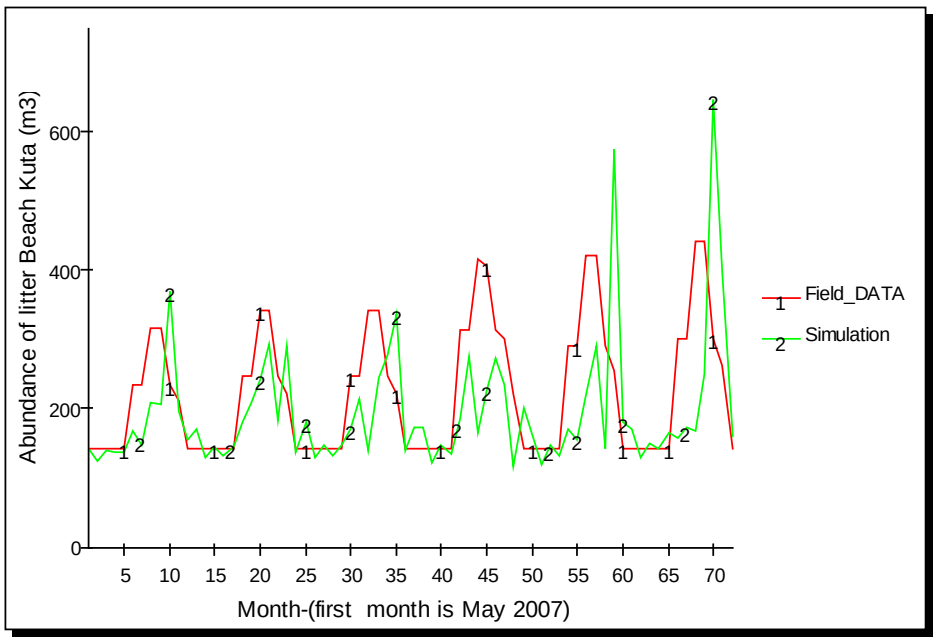

Fig 5. Comparison between simulation data from base model (green) and field data (red)

AME value of the model validation obtained is equal to 0.127. Based on AME value, can be seen average deviation of 12.7%, or in other words, the model can explain the truth with confidence interval of 87.3%. Based on these values, the model is valid and can be used to predict the abundance of litter on Kuta Beach.

3.6. Simulation Analysis and Optimization Results

3.6.1 Simulations were extended

Based on the modeling that has been declared valid, then the extension of time modeling done without changing the value variable or constant of an existing. Values such as rainfall, wind, and season follow field data 6 years back, while the other variables and constants follow a predetermined value. Simulation modeling results by extending the modeling for 6 years (72 months) is as apparent in Fig 6.

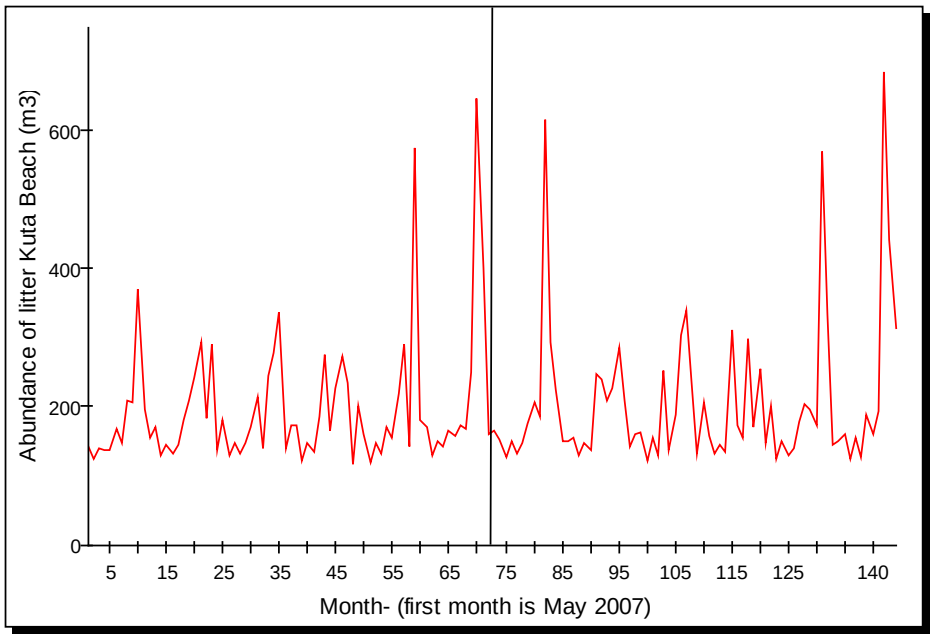

Fig 6 . Simulation models are extended (business as usual)

Based on the simulation results in Fig 6, by comparing the simulation results the first month until the 72nd month (the period of the base model) and the 72nd month until 144th month (simulation period extended), occur an increase in the volume of abundance of litter beach in simulation period extended compared to the base model. Simulation modeling are extended (business as usual) indicated an average increase of litter by 7.16% compared to the data of 72 months earlier (base models). This condition will likely increase over time.

Delay in anticipation of the abundance of litter will have an impact on the environment such as the onset of loss of disease vectors, the transfer of alien species, the decline in tourist perceptions and the decline of tourists visiting Kuta Beach. One effort to reduce the negative impacts of abundance of litter is the emergency cleaning with deploy a rapid reaction unit and equipment cleanup. Emergency cleanup is done when the amount of litter

cannot be dealt with regular cleaning team. Emergency cleanup team working in accordance with the needs of the field. Litter management strategy is reactionary not lead to treatment in an effort to reduce litter at the source.

3.6.2 Simulation model of litter abundance Kuta Beach with a variety of scenarios

Simulation model of the abundance of litter on Kuta Beach performed with functional intervention. Functional interventions carried out on the model by changing the value of a constant or variable without changing the structure of the model. Control the abundance of litter on Kuta Beach using pessimistic scenario, moderate scenario and optimistic scenarios. Scenario is done by changing the leverage of factors that affect the model. The use of leverage factor aims to find the most effective policy with the lowest possible effort and the most optimal results. Based on test results, obtained on leverage factor is the fraction of domestic litter dumped into the river (F-DLDIR) by the Bali Strait Watershed residents and the fraction of Agricultural Litter (F-AL). F-DLDIR is the percentage of litter generated by communities in the Bali Strait Watershed that discharge directly into the river, while F-AL is a non-domestic litter from agricultural litter either from agricultural activities namely: plantation and forestry hat are not managed properly.

Based on the existing leverage factors developed three (3) modeling scenarios are pessimistic scenario, moderate and optimistic, the change in the value of the parameter is as Table 2.

Table 2. Scenario of reduction in abundance of litter on kuta beach

No	Scenario	The change in the value of parameter	The Initial Value	The Scenario Value
1.	Pessimistic	1.Fraction of domestic litter dumped into the river (F-DLDIR)	0.0299	0.0598
2.	Moderate	1.Fraction of domestic litter dumped into the river (F- DLDIR)	0.0299	0.0149
3.	Optimistic	1.Fraction of domestic litter dumped into the river (F- DLDIR)	0.0299	0.0149
		2.Fractions of Agricultural Litter (F-AL)	0.055	0.023

A. Pessimistic scenario

Based on a pessimistic scenario, the percentage of litter dumped into the river rose 2 (two) times the original state. This situation is assumed that the range of litter management services by the relevant management unit can not compensate for the growing amount of litter generated so that the people are not manage their litter by properly so that the litter into the river. Based on the changes in the parameter values in Table 2 do simulation modeling pessimistic as Fig 7.

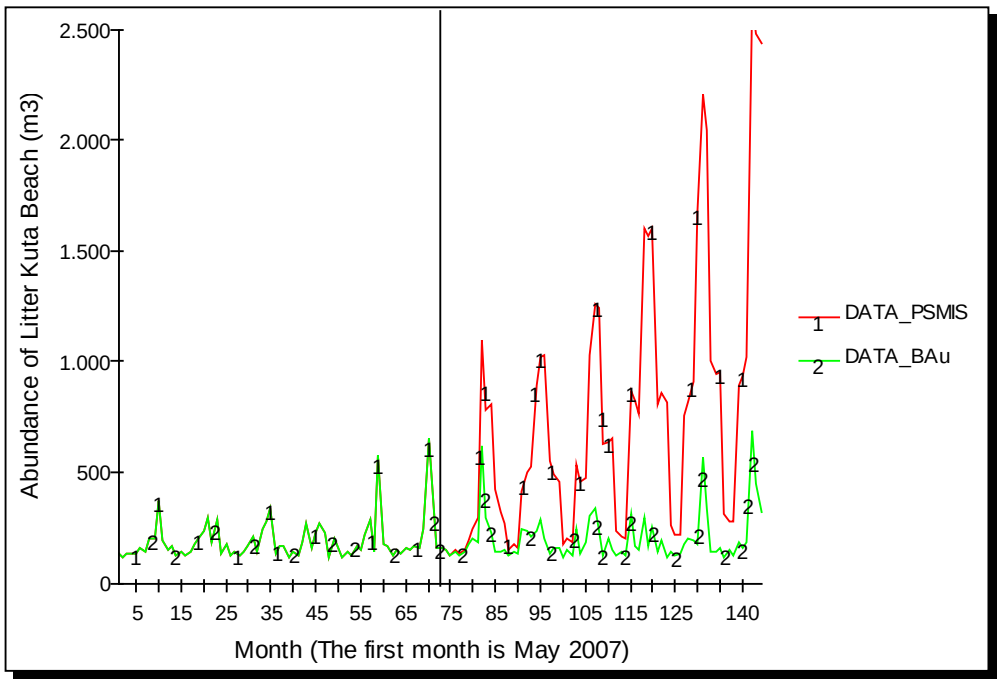

Fig 7. Model Simulation of abundance of Litter Kuta Beach with Pessimistic Scenario.

Based on the simulation results with the pessimistic scenario shows that the litter landed at Kuta Beach increased exponentially (DATA_PSMIS/red) when compared with no change scenario (DATA_Bau/green). Simulation modeling with pessimistic scenario assuming that the percentage of domestic litter discharged into the river from the Bali Strait watershed (DLDIR) doubled have increased the abundance of litter on Kuta Beach on average by 234.70%, up by 2.34 fold. This condition will likely increase over time. This condition will affect the environmental loss of Kuta Beach and others.

B. Moderate Scenario

Moderate scenario is based on the percentage of litter that is discharged into the river reduced by 2 (two) times the original state. This situation is assumed that the range of litter management services by the relevant management unit has been able to expand the new service areas so that the total percentage of litter dumped into

the river population is reduced to 2 (two) times. Based on changes in the value of the parameters in Table 2. Conducted simulation modeling moderate as Fig 8.

Based on the simulation results with moderate scenario, it appears that litter landed on Kuta Beach is reduced (DATA_Moderat/red) when compared with no change scenario (DATA_BAU). Simulation modeling with moderate scenario done with the assumption that the percentage of litter discharged into the river from the Bali Strait watershed (F_DLDIR) can be controlled by half can reduce the abundance of litter on Kuta Beach on average by of 10.79%. These conditions will affect the reduction of environmental damages due to abundance of litter on Kuta Beach.

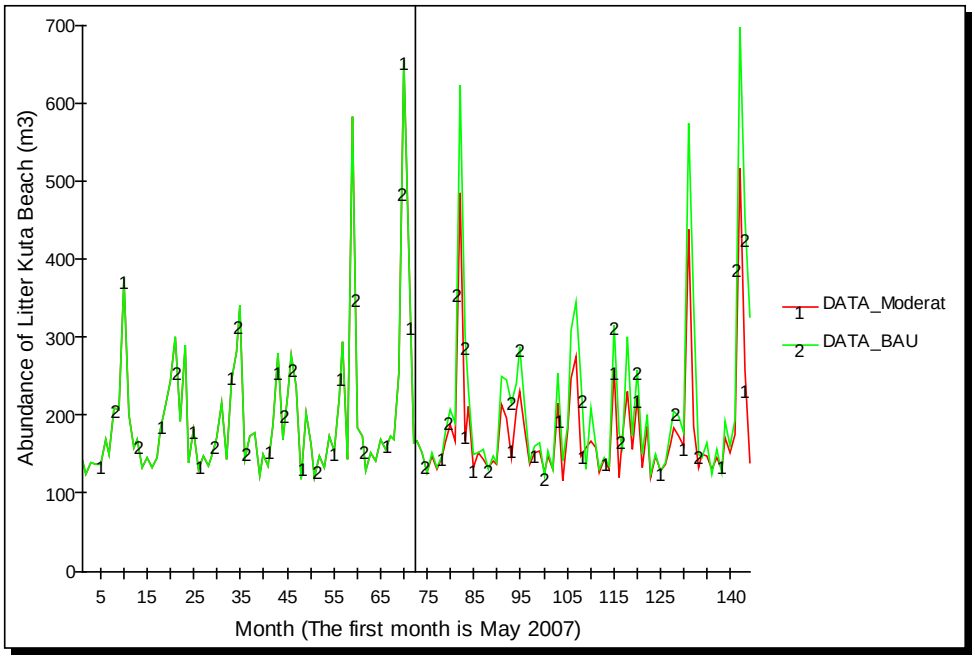

Fig 8. Model simulation of Abundance of litter on Kuta Beach with moderate scenario.

C. Optimistic scenario

Optimistic scenario is based on the change of two (2) leverage factor is the percentage of litter that is discharged into the river (F_DLDIR) and the amount of agricultural litter in the Bali Strait (F_AL). Percentage of litter dumped into the river is reduced 2 (two) times the original state while agricultural litter are reduced by 2 (two) times. This situation is assumed that the range of litter management services by the relevant management unit has been able to expand the new service areas so that the percentage amount of litter dumped into the river population is reduced to 2 (two) times. Agricultural litter (AL) is reduced as much as two (2) times with assumption that reducing deforestation and litter management in agricultural areas.

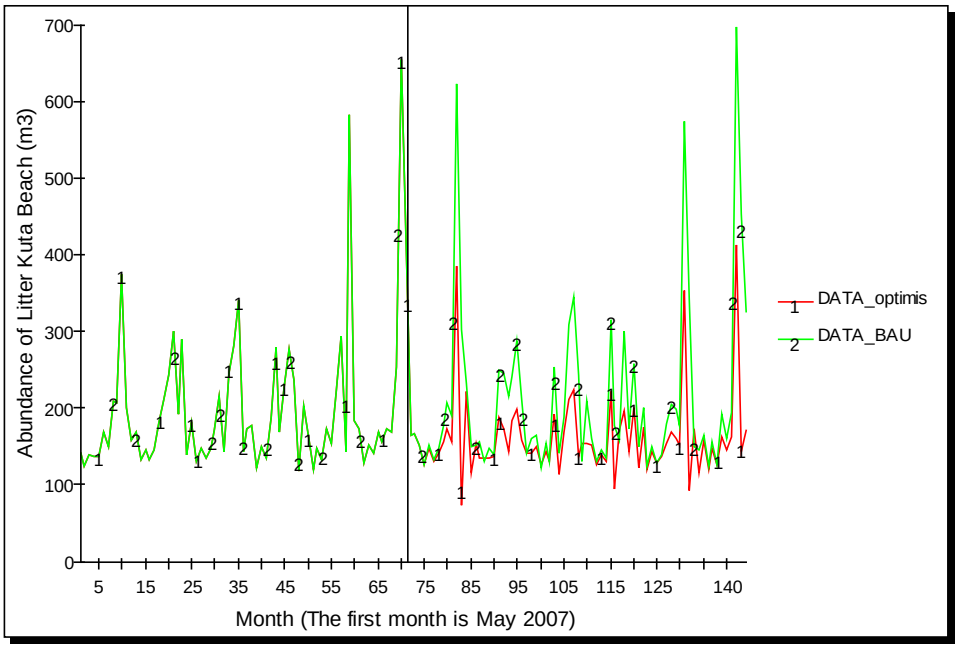

Fig 9. Model simulation of Kuta Beach with an abundance of litter on Kuta Beach with optimistic scenario.

Based on the simulation results with an optimistic scenario (Fig 9.), shows that the abundance of beach litter Kuta much reduced (DATA_optimis/red) when compared with no change scenario (DATA_BAU/green). Simulation modeling with the optimistic scenario is done with the assumption that the percentage of litter discharged into the river from the watershed Bali Strait (F_DLDIR) and the percentage of untreated agricultural litter (F_AL) can be controlled by half can reduce the abundance of litter on Kuta Beach on average by of 16.13%. There is a trend of increasing gap of results between BAU models and optimistic models with time.

These conditions will have an impact on the environment due to reduced losses litter on Kuta Beach. This scenario is the best scenario, but it requires a fairly good cooperation between local governments in the watershed Bali Strait in reducing the chances of litter that goes into the Bali Strait. The whole scenario is carried out through the mechanism of an integrated litter management program (ILMP), so support the implementation of this program would be optimal if the funding also comes from Badung regency as beneficiaries of the tourist area of Kuta Beach. Integrated litter management program between districts caused a feedback loop R5 (reinforcing loop), so the reduction in the existing one variable will affect the overall models .

3.6.3 Policies that can be applied to the existing scenario.

Increased litter on Kuta Beach has the highest loss value, because in terms of utilization of Kuta beach has a higher economic value compared to other beaches in the Bali Strait. Value losses of litter is very dependent on the time and location of areas affected by pollutant. In general, intervention in the control of litter can be performed based on the stages of the process of emergence of litter.

Condition Kuta beach polluted by litter can be prevented by such efforts is to reduce the runoff fraction of litter that goes into water bodies. Reduction of litter runoff fraction into water bodies can be done by: additional litter management service, improved litter management, increasing tools cleanliness and human resources, creation of dam filter litter so that the litter that goes into water bodies will be smaller. Besides, it is also necessary to the public awareness in order to manage the litter that is produced and stop litter discharged into the river that can reduce litter in the Bali Strait as the largest contributor to litter in the Kuta Beach.

Integrated litter management program (ILMP) by involving the district or city government in the Bali Strait Watershed. This intervention is intended to reduce the amount of litter in the ocean waters of the Bali Strait, one of the mechanisms of cooperation is conducted in funding. Funding subsidy payments made by the regency who benefit (Badung Regency) to other regency in the Bali Strait watershed that has been trying to keep the environment by reducing litter into the sea. This mechanism is commonly known as payments for environmental Services (e.g. [31,32]). Integrated litter management program (ILMP) is one of the programs that require funding from the investments made by local governments. The program aims to reduce litter in the Bali strait, administration involving cross-border and cross-sectoral. It is expected that with the increase of the integrated litter management program will have an impact on the reduction of abundance of litter Bali Strait (ALBS). Because one of the sources of abundance of litter on Kuta Beach (ALKB) is litter comes from the Bali Strait, reduction of abundance litter in Bali Strait will have an impact on the reduction of Abundance of litter on Kuta Beach.

Filtering litter in the river is one of the policy alternatives can be implemented in an effort to reduce litter. Filtering litter is not only performed in the province of Bali, but also rivers in Java. This is because of the results of the modeling and analysis of existing litter, litter landed on Kuta Beach and the surrounding areas are also likely to come from areas in Java, although indirectly .

Coordination between regions can be used as a starting point for litter management Kuta Beach. This coordination is a form of perception that the litter problem is not only the problem of Kuta Beach, Badung Regency alone, but also needs support, especially some of the districts directly bordering the Strait of Bali. Handling the Bali Strait together to provide opportunities for the management of litter sources and also for the potential outcomes for the management of the Bali Strait. This step also needs further calculation in its application and the need for an institution with which to calculate the component costs of each region for to be agreed together.

4. Conclusions

1. During normal conditions, the abundance of litter on Kuta Beach dominated by tourism activity, whereas in the rainy season and the west wind is dominated by marine litter from shipment Bali Strait.

2. Modeling of dynamic systems has been carried out to simulate the abundance of data litter on Kuta Beach. Modeling results has been declared valid by the AME value of 0.127 or 87.3% confidence level.

3. Simulation modeling are extended (business as usual) indicated an average increase of litter by 7.16% compared to the data of 72 months earlier.

4. Simulation modeling with pessimistic scenario assuming that the percentage of domestic litter discharged into the river from the Bali Strait watershed (DLDIR) doubled have increased the abundance of litter on Kuta Beach on average by 234.70%, up by 2.34 fold.

5. Simulation modeling with moderate scenario done with the assumption that the percentage of litter discharged into the river from the Bali Strait watershed (DLDIR) can be controlled by half can reduce the abundance of litter on Kuta Beach on average by of 10.79%.

6. Simulation modeling with the optimistic scenario is done with the assumption that the percentage of litter discharged into the river from the watershed Bali Strait (DLDIR) and the percentage of untreated agricultural litter (AL) can be controlled by half can reduce the abundance of litter on Kuta Beach on average by of 16.13% .

7. Control on reducing the percentage of litter discharged into rivers (DLDIR) and decreasing agricultural litter (AL) in the watershed Bali Strait is the best scenario for controlling litter on Kuta Beach.

5. suggestions

1. Scenario control can be implemented by promoting cooperation with local governments in the watershed, especially the Strait of Bali Tabanan and Jembrana in the minimization of litter that chance discharged into coastal waters.

2. Should be carried out studies related to the effectiveness of the preferred scenario costs.

Acknowledgements

The paper is supported by powersim constructor 2.5d (No. C-02519-524)

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