Dynamic model of ecotourism management in Mount Rinjani National Park

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Abstract. Mount Rinjani National Park (MNRP) in Indonesia which is popular as one of ecotourism destination has facing problems including forest destruction which then becomes critical degraded lands, watersheds damaged, decreased river water, garbage due to lack of awareness. This study aimed to analyze the dynamic model to simplify and simulate the behavior of the ecotourism management system. The method used was powersim dynamic system software based on the scenarios compiling from controlled inputs: (1) the number of tourists, (2) the ticket price, (3) carrying capacity. The simulation of the first scenario for year 2015 to 2030 shows the total tourists in 2015 exceed the carrying capacity of 42,525 people per year. On the first-stage ticket of IDR 384,000, the number of tourists increased in 2018, reached 52,268 people and in 2030 reached 57,268 people. The second scenario applied a higher ticket price policy based on Willingness to Pay (WTP). The increasing ticket prices in stages up to IDR 650,000 for international tourists and IDR 45,000 for domestic tourists, and in 2030 the number of tourists will decline around 15,013 people. 

Keywords: carrying capacity, ecotourism, modeling, willingness to pay,

1. Introduction 

The Mount Rinjani has an unique landscape and great attraction for ecotourism as a form of national park utilization. Based on the regulation of the Minister of Forestry Number 448/Menhut-VI/90 the status of the function of Mount Rinjani is shifting from a wildlife reserve to a national park (NP) \cite{1}. This regulation is to create better Mount Rinjani National Park (MRNP) management. Therefore the objective of MRNP as a conservation area as well as for education, research and tourism is achieved. The purpose of national parks is to protect nationally and internationally a variety of natural and cultural resources, as well as unique landscapes while providing opportunities for science research, recreation or tourism, community development, etc \cite{2}. National parks can improve the protection of natural resources and the environment by adjusting the balance between protection and use \cite{3}. 

The previous studies revealed that the number of tourists coming to MRNP had exceeded the carrying capacity \cite{4}. In this case, various approaches generally only see this issue partially, making it difficult to manage tourism or ecotourism activities that lead to sustainable tourism \cite{5}. Ecotourism needs to be considered as a system because many components interact with each other and involve various stakeholders \cite{5}. Nature tourism and ecotourism are not only defined as an industry but also as a system that has a structure and environment \cite{6}. The tourist destination area is a complex dynamic system of

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economic, social and environmental components that are interconnected with each other and offer opportunities for tourists to gain satisfaction from the attractiveness and services [7]. High interactions in the ecotourism area need to be identified and elaborated into ecotourism factors, then it should be optimized based on scientific principles, making it possible to make changes and improvements approaching sustainability [8]. Ecotourism utilizes the existence of natural resources and the environment which is a system framework with elements that contain complexity, uncertainty, change, and conflict. As a management concept, ecotourism is difficult to separate the tourist destination from the influence of the surrounding area. Ecotourism contains interactions and linkages between economic, social and environmental elements that can receive flows of energy, material, and information from the surrounding area and needs to be scientifically structured to produce improvements that organize human behavior [8].

At this stage, the research aims to analyze the dynamic system and develop an ecotourism management model. This model will help to simplify, explain and integrate various issues related to ecotourism that provide appropriate learning and decision making mechanisms to achieve desired goals. Dynamic system analysis is to simulate the behavior of the system, namely the management of ecotourism in MRNP.

2. Methods

2.1. Place and Time
The study was conducted in the MRNP, at two management resorts, namely 1) Senaru in Senaru Village, North Lombok Regency and 2) Sembalun in Sembalun Lawang Village, East Lombok Regency. The area which became the object of the research is 41,330 ha. The study was conducted in September 2014- July 2016 including the writing of the report.

Figure 1. Map of Mount Rinjani National Park
2.2. Dynamic Systems Analysis Method

The data and information to build a dynamic model of ecotourism is collecting through interviews, Focus Group Discussions and literature studies.

Dynamic system analysis is to simulate the behavior of the system of MRNP ecotourism management, which is prepared based on the scenario to apply. The process to develop a dynamic model of ecotourism used the software Powersim for academic version, through the following stages:

1) Requirement Analysis
   At this stage stakeholder identification is carried out in the system and their respective needs are related to the performance and achievement of system goals.

2) Problem Formulation
   This stage analyzes the synergistic and contradictory needs among the actors and opposes them, and identifies their solutions based on factors and scenarios in the model.

3) System Identification
   At the system identification stage, the relationship between needs and problems is arranged, through the best solution to meet the needs of the actors and achieve the system objectives in the form of Input-Output diagrams (black box diagrams). Then a causal loop diagram is drawn up which illustrates the relationship between dynamic elements or variables. This diagram illustrates the dynamic system as a whole, provides the basis for forming equations in the interrelationships of the elements in the model, as well as finding important elements for achieving the goals of the model and causal loop diagrams.

4) System Modelling
   Modelling is the formulation of a problem in a mathematical form, which is a simplification of real system conditions. The model formulation shows the important elements that have been identified previously and their interrelationships in symbolic language using powersim software.

5) Validation
   Model validation is to see whether the model output resulting from the simulation process is approaching empirical data or actual data, using a statistical approach. Validation of this model is done by comparing the magnitude and nature of the error [9] with AME (Absolute Mean Error), ie the difference or deviation between the mean value (mean) of the simulation results with the actual value. The acceptable deviation limit is <10 %.
   
   $$\text{AME} = \left[ \frac{\sum_{i=1}^{N} (S_i - A_i)}{A_i} \right]$$

   Where:
   - $S_i = S_i N$, where $S =$ simulation value
   - $A_i = A_i N$, where $A =$ actual value
   - $N =$ Interval of observation time

6) Implementation
   Implementation of the model is ready to run after going through the validation stage and can be run in accordance with the desired scenario to see how the model provides conclusions.

3. Result and Discussion

3.1. Needs Assessment
   At this stage, the actors are government, community, private sectors (travel agent/trekking organizer), and tourist /eco-tourist (table 1).
Table 1. Need assessment

| Actors          | Needs                                                                 |
|-----------------|----------------------------------------------------------------------|
| Government      | Fund for conservation<br>Preservation of Environment / low damage of environment<br>Garbage is managed<br>Income from ecotourism for community |
| Community       | Income from ecotourism for community<br>Preservation of Environment / low damage of environment<br>Garbage is managed |
| Private sector  | Income from ecotourism for community<br>Preservation of Environment / low damage of environment<br>Garbage is managed |
| Tourist / Eco-tourist | Preservation of Environment / low damage of environment<br>Garbage is managed |

Source: interview and FGD

3.2. Problem formulation

At this stage, synergistic and contradictory needs are analyzed, and conflict is a problem. Then based on factors and scenarios in the model, solutions are sought to solve the problem at table 2.

Table 2. Problem formulation

| Need synergy | Opponent need / problems | Solution |
|--------------|--------------------------|----------|
| Preservation of Environment / low damage of environment<br>Garbage is managed | Tourist visits and ecotourism revenues increase but cause environmental and waste problems without management. | Analysis of carrying capacity and its application |
| Income from ecotourism for community | Ecotourism is a limited tourism activity. | Analysis of carrying capacity and its application<br>The WTP analysis forms the basis for the price of admission and a budget for conservation and management as a policy |

Source: interview and FGD

3.3. System identification

At the system identification stage, the relationship between needs and problems is arranged, and the solution is to achieve the desired goals, by identifying uncontrolled and controlled inputs, desired and undesirable outputs which is in the form of input-output diagrams (black box diagram) at figure 2.

The causal loop diagram begins with the number of visitors who open up employment opportunities and increase income and can improve welfare. However, the number of visitors increases the amount of rubbish, increasing the demand for land for tourist areas. These conditions can increase or decrease the value of WTP. Carrying capacity will limit the addition of excessive numbers of tourists there by reducing environmental damage so that the value of Willingness-to-Pay (WTP) can increase and can be a basis for admission and contribute to income and conservation.
3.4. Implementation or Modelling

The ecotourism management model is simulated from controlled inputs which are the main variables in supporting ecotourism and most influential on the behavior of the model which is also the needs of the stakeholders in the ecotourism management system, including (1) the number of tourists, (2) the ticket price, (3) carrying capacity which in details consist of the number of tourists, the amount of income, the amount of waste, the WTP value of international and domestic tourists. Implementation of the model is ready to run after going through the validation stage and can be run in accordance with the desired scenario to see how the model provides conclusions. The relationship between variables in the model is illustrated in the stock-flow diagram at figure 3.

Ecotourism is strongly influenced by tourist management and the number of tourists on the area for tourist attractions and activities. The increasing number of visitors accompanied by environmental damage will reduce the appeal of ecotourism. The decreased attractiveness of ecotourism will reduce the preference of tourists to visit the ecotourism destination which is expressed by the WTP value. This will certainly also affect the income of local people from ecotourism. When income from ecotourism decreases then the income from other fields increases which can also arise encroachment activities that damage the environment. There should be restrictions on visitors who will increase the added value of ecotourism. Creativity and optimization of ecotourism services can be an opportunity to improve the welfare of local communities. A systems approach to the management of tourist destinations in the form of protected areas allows understanding of tourism and biodiversity conservation as a system consisting of interrelated and interactive components.
3.5. Tourist Management

The number of tourists will continue to increase along with the increasingly popular Mount Rinjani as an ecotourism destination. Various national, provincial and district level policies support tourism. Support in the form of promotions and the mushrooming of travel agents or trekking organizers will increase the number of tourists. The simulation results show the number of tourists increased until 2015 exceeding the carrying capacity. Therefore there was an excess of tourists until the simulation in the years after 2015 to 2030 at figure 4.

Based on the latest data, namely in 2014, with the price of TNGR entrance tickets of IDR 150,000/day for foreign tourists and IDR 5,000/day for domestic tourists, the total number of tourists has reached 44,713 people. While the carrying capacity of the analysis results is 42,525 people per year. In 2014 the number of tourists has exceeded the carrying capacity. Simulation results show that in this condition, the number of tourists in 2030 will reach 58,442 people.

Most travel agents or trekking organizers tend to focus only on aspects of marketing and promotion. These tourism actors have an interest in increasing profits from the implementation of ecotourism packages. Generally, these private institutions are not directly involved with efforts to conserve natural resources, waste management and planning for sustainable use. They assume there are administrative and organizational functions that are responsible for managing protected areas. Then the problem arises between the marketing and planning or implementation of ecotourism that affects the sustainability of the tourist destination. In protected areas, the challenge is the issue between management for use, namely
for visits and shelter or camping, and conservation for biodiversity and culture. There also appears to be a gap between the need for utilization and the need for conservation.

![Figure 4. Simulation of the number of tourists and carrying capacity between 2010-2030](image)

The management of tourists can be done by implementing a carrying capacity policy. Besides that, there needs to be an effort to avoid the accumulation of tourists at certain times, for example on holidays. The management of tourists can also be done by avoiding congestion in certain areas. You can also add ecotourism attractions, create circulation and distribution of tourists based on group size and available space. The management of visitors is a very important and critical part because open nature tourism is the management of visitors [10].

![Figure 5. Simulation graph of ticket price increase scenarios based on government regulations and average WTP value to the number of tourists between 2010-2030](image)

To link the scenarios arranged into the model, an interpretation of factor conditions is carried out into the model variables. In this case, some changes were made to the variables based on government policy regarding the price of admission and the results of the analysis of the WTP value. Based on the Regulation of the Ministry of Forestry of the Republic of Indonesia No.37 year 2014 concerning...
procedures for establishing division or rayon in National Parks, Forest Parks, Nature Tourism Parks and Hunting Parks in the Field of natural tourism, the application of the first scenario to limit the number of tourists is based on the application of a ticket price increase policy for TNGR located in rayon III increased to rayon I, which is IDR 250,000 for foreign tourists and IDR 15,000 for domestic tourists [11]. Simulation results show that increasing ticket prices only slightly reduce the number of tourists (figure 4). The simulation results show that in the period until 2030 the number of visitors will reach around IDR 57,268 people per year (figure 5).

3.6. Model Scenario
The model scenario is simulated from a controlled variable input model, namely (1) the number of tourists, (2) ticket price and (3) carrying capacity.

The application of the second scenario to limit the number of tourists is by applying a policy of increasing ticket prices based on the WTP value given by tourists in stages. Assumptions for the increase in ticket prices based on the WTP value beginning in 2018. Based on the simulation results of the first stage ticket increase up to IDR 384,000, the number of tourists would still increase in 2018 around 52,268 people and in 2030 it will reach 57,268 people at figure 5. Tourists are still interested to come, even though ticket prices are raised, especially foreign tourists. Increased ticket prices can be done in stages up to IDR 650,000 for foreign tourists and IDR 45,000 for domestic tourists. The simulation results show that the increase in ticket prices can put a halt to the increasing number of tourists. The simulation results show that in the period until 2030 the number of visitors will decrease by around 15,013 people and the number will be 42,255 people at figure 4. This policy of limiting the number of tourists needs to be implemented to maintain the conservation area as well as to control it. Another policy that can be applied is a reservation system for camping activities, in every camping area. This policy requires the readiness of the administrative system and field staff.

The application of carrying capacity can limit the number of tourists who enter to enjoy ecotourism. But there are still opportunities for the development of ecotourism products in the form of special interest or recreational nature from the potential and attractions available in the area around TNGR, for example in the villages supporting the TNGR region. The development of ecotourism and nature tourism products can support the adoption of a carrying capacity policy. Diversification of income can be obtained from various opportunities that arise due to the development of ecotourism activities of special interest and recreational nature tourism. For example, as a tour package provider, food ingredients provider, food stall and restaurant provider, guide and porter service provider, transportation service provider, community-based lodging provider, local specialty souvenir maker, shop selling souvenirs, organizing traditional ceremonies, making local special food and others -other.

Based on the results of the analysis of the structure of the program, one of the obstacles in managing ecotourism is the low participation of the community in management, which leads to the low welfare of the local community. The community considers the existence of the ecotourism area has no significant effect on the financial income of the local community. There are still activities of tour guides and actors who only aim to pursue personal gain. Even the tariff war between them often results. Community indifference to the management of ecotourism raises complaints from tourists and there are reports from tourists about safety along the hiking trail such as robbery of tourists, even accidents during climbing. The collaborative approach will increase community participation, solutions will be found or formed awig-awig for ecotourism activities. Community involvement in the management of tourist areas needs to be supported by improving the quality of human resources in community empowerment activities. For example by counselling and training, coaching and mentoring and others.

3.7. Development of Ecotourism Products / Services to Improve WTP
WTP value is the value that tourists want to pay or want to pay, both foreign and domestic tourists for the costs of managing and maintaining ecotourism and conservation. This WTP value is obtained after tourists feel the experience of doing ecotourism activities. This assessment is given by tourists based on tourist preferences towards ecotourism. Therefore the magnitude of the WTP value also reveals whether
the community understands and is aware of the importance of managing and maintaining ecotourism, as well as conservation. When the number of tourists increases, the amount of garbage will also increase. When the amount of unmanaged waste continues to increase and cause environmental conditions in the ecotourism area to be uncomfortable it will affect the WTP value of tourists, which will decrease further because their preferences also decrease. Likewise, if waste is managed well, the condition of the ecotourism area will be more comfortable, maintained and protected, then the WTP value will be higher. Improving the quality of ecotourism and its services will increase the value of ecotourism benefits.

Product development and ecotourism quality consisting of ecotourism attractions (attractions), tourist support facilities (amenities), and accessibility [12] can also be a factor in providing WTP value. The attraction of ecotourism which is TNGR's ecotourism superior product is the beauty and challenges of the landscape for trekking and camping activities. Based on the characteristics of the TNGR environmental conditions and the results of land suitability analysis, there are still many potential ecotourism attractions that can be developed especially for special interest activities. Bird watching, orchid, and endemic vegetation observation and photography can be developed with suitable ecotourism packages. In addition, the development of various environmentally-friendly facilities for developing ecotourism packages needs to be improved or added to. For example, tower or observation shelters, as well as integrated and environmentally friendly campsite facilities.

Other policies are by developing ecotourism sites, tourist management, ecotourism channel management including visiting day arrangements, ecotourism package management, development of an integrated education center and arboretum center in the Torean lane, ecotourism development in the entrance gate village or in other buffer zones. On the Torean track, education and arboretum centers can be developed to distribute tourists, optimize the potential of ecotourism, manage tourists and their activities. This policy requires the readiness of the administrative system and field staff. In addition, the ecotourism service officers also need to improve their knowledge, attitudes, and skills to carry out ecotourism in accordance with its principles.

In terms of ecotourism services, the development of a travel agent or trekking organizer business continues to increase due to demand and an increase in the number of tourists to the island of Lombok. To control the number of tourists and types of tourist activities, it is necessary to have the participation of these business actors. Starting from fulfilling agency requirements, tidying up the administrative aspects of business actors, raising agency standards, for example, it needs a number of trainings on ecotourism and the environment for agents who are interested in organizing ecotourism packages. In addition, the number of existing forums to establish communication should be developed so that ecotourism managers and tourism businesses can collaborate and work together. Socialization, training, outreach and communication programs need to be conducted for ecotourism entrepreneurs in order to be able to organize ecotourism packages in accordance with the principles of ecotourism and sustainable tourism.

3.8. Validation of the Ecotourism Model

The model validity test is done by comparing the model output with simulation empirical data, using statistical techniques. The goal is to see the percentage difference between the two types of data. The validity test consists of validating the number of tourists and validating income.

The validity test of the number of tourists is carried out on the component of the number of tourists based on tourist visit data for 5 years from 2010 to 2014 sourced from the 2015 MRNP Office [13]. The results of the validation test show that the AME value is 0.26 at table 3. The number is still within the deviation limit, which is less than 10 percent. This shows that this model is able to simulate changes that actually occur in the field. Thus, the model is ready to be implemented.
### Table 3. Validation of total tourist

| Year | Real  | Simulation | Percentage |
|------|-------|------------|------------|
| 2010 | 13,956| 13,956     | 0.00       |
| 2011 | 15,030| 15,606     | 3.83       |
| 2012 | 14,524| 14,123     | 2.76       |
| 2013 | 22,943| 22,452     | 2.14       |
| 2014 | 44,112| 44,713     | 1.36       |
| Rataan| 22,113| 22,170     | 2.02       |

**AME** 0.25776692

Source: data processing 2016

### Table 4. Validation of income

| Year | Real  | Simulation | Percentage |
|------|-------|------------|------------|
| 2009 | 8,618,000|           |            |
| 2010 | 10,216,141| 10,216,141| 0.00       |
| 2011 | 11,814,282| 11,314,179| 4.23       |
| 2012 | 13,412,423| 12,909,164| 3.75       |
| 2013 | 15,010,564| 14,371,632| 4.26       |
| 2014 | 16,608,705| 15,715,881| 5.38       |
| 2015 | 18,206,844| 17,121,813| 5.96       |
|      | 14,211,493| 13,608,135| 3.93       |

**AME** 4.24556491

Source: data processing 2016

The validity test of community income was carried out on the components of community income for 5 years from 2010 to 2015, which were sourced from NTB data in 2015 [14]. The results of the validation test showed that the AME value was 4.25 at table 4. The number is still within the deviation limit, which is less than 10 percent. This shows that this model is able to simulate changes that actually occur in the field. Thus, the model is ready to be implemented.

The tourism or ecotourism system is a collection of systems where the focus of sustainability can be revealed in a complex adaptive system with consideration of space and time factors, as well as the dynamics of decision making [15]. Interaction of the system with other fields also increases the scale and scope of impact, which complicates complexity. Therefore, it is recommended to use a collaborative approach, integrated planning, and models as an interactive system. Based on the dynamic system simulation results, the variable number of tourists, WTP, and carrying capacity are variables that can be managed so that ecotourism can run well. This ecotourism management model was developed based on TIES’ ecotourism definition and principles (2015) with scenarios based on the value of WTP and carrying capacity control, which is intended to minimize impacts on the physical, social, behavioral and psychological environment, and then provide direct economic benefits for conservation, society and industry, and design, build and operate low-impact facilities [16].

### 4. Conclusions

Simulation results show that the number of tourists coming has exceeded the carrying capacity and will continue to increase. It is necessary to have a special policy in implementing carrying capacity so as not to cause environmental damage and also an inconvenience for tourists. Due to environmental damage and tourist inconvenience, tourist preferences for ecotourism will continue to decline. Therefore, it is necessary to apply a policy to limit the number of tourists as well as law enforcement for monitoring and control. Increasing the price of admission gradually needs to be done as a way of limiting the number of tourists who come. The ecotourism management model was developed based on the TIES ecotourism definition and principle (2015) with scenarios based on the value of WTP and carrying capacity control.
Other policies are by managing tourists by developing ecotourism sites, managing ecotourism flows including arranging visiting days, managing ecotourism packages, developing special interest ecotourism activities, developing education and arboretum centers, and developing ecotourism in the village of the entrance gate or in the buffer zone.

The increase in community income from ecotourism is expected to minimize conflicts resulting from encroachment or destruction of protected forest areas. Education, counselling, outreach and environmental communication are expected to improve the learning process, understanding and increasing awareness of the community and tourists towards the environment in the ecotourism area.

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