Dynamic Model of Sustainable Tourism Case Study
Mampie Lampoko Reserve Indonesia

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Abstract. Tourism development model in Polewali Mandar Regency is an interesting model to study to be able to analyze the ability of Mampie Lampoko nature reserve to be developed as one of the national tourism destinations with its distinctive features. The research method used is survey and power simulation dynamic model of ecotourism system in order to be part of the development of local government policies in planning strategy of the nature reserve area. Data were collected using survey and questionnaire methods by taking public perception data. The results showed that the ability of tourist areas to be developed using the concept of ecotourism. The tourism area also produces a minimum impact on pollution and can increase community income and the management of the necessary facilities to minimize the impact that will be fulfilled in the tourism sector.

Keywords: tourism development model, Mampie Lampoko, ecotourism, sustainable

1. Introduction
The development of sustainable tourism, especially in Polewali Mandar Regency is part of the development of regional and national tourism in Indonesia. The basis of the vision and mission of tourism development in Polewali Mandar Regency, is based on the potential diversity of tourism objects and attractions such as; flora and fauna, especially endemic birds such as Ibis Mandar (Rallidae or Aramus platioptron paleale), hornbills, and even Pelecanus conspicillatus birds who fly from Asia to Australia.

The ecosystem contained in the area is patterned into mangrove areas, seagrass beds, and coral reefs; the beauty of coastal landscapes; the uniqueness of coastal cultural values of various traditional relics. Development efforts by Polewali Mandar Regency are carried out by applying the concept of ecotourism where it is expected, the management of the wildlife reserve area of Mampie-Lampoko will prioritize aspects of protection, preservation, utilization, balance, and sustainability. Therefore, can contribute positively not only to increase the country's foreign exchange and regional income, but also to produce added value to the economy of the local community. Also, it is also expected to create a sense of security, able to maintain cultural and environmental sustainability.
Ecotourism is a concept of developing and organizing tourism activities based on environmental utilization for protection and core community active participation with the presentation of products containing education and learning, having a negative impact on the environment, contributing positively towards regional development and applied to protected areas, open areas, built areas and cultural areas [1][2]. So that the ecotourism development model in Polewali Mandar Regency is based on the criteria of the application of the concept of ecotourism in the development of the region, namely: a) protection of the preservation of the environment and local culture; b) provide a minimum negative impact; c) positive contribution to the local economy; d) active community participation; and e) education and learning.

The dynamic model design for ecotourism development can be divided into 4 submodels, namely: a) sub-model of natural resource, b) sub-models of tourists and community income which shows the number of local community revenues and the number of tourists included, c) sub-model of community participation based amount of labor, d) pollution sub-models that show the negative impact of tourism activities [3][4]. Furthermore, one of the critical factors in the development of tourism is the arrangement of local space based on Law Number 5 of 1990 concerning the conservation of living natural resources and ecosystems. Also, the Government Regulation number 68 of 1999 concerning natural reserve areas and nature conservation areas and Government Regulation number 18 in 1994 concerning the exploitation of nature tourism. It was hoped that a pattern of regional spatial arrangement could be produced that was adjusted to the tourism area development policy. It is expected that the strategy and model of tourism development can produce a comprehensive policy for the development of the tourism sector in Polewali Mandar Regency.

2. Research method

This type of research is Research and Development (R&D) modeling. Also, this research is also stated as descriptive research to describe and to analyze various criteria related to ecotourism development. Also, this research method also uses stakeholder needs analysis and system approach in designing ecotourism development. Data retrieval is carried out in several main stages:

a. Secondary data collection carried out at various agencies related to the tourism sector to conducting literature studies by looking at the development and planning of ecotourism in other regions.

b. Field surveys are conducted for primary data by looking at the various current conditions of Mampie-Lampoko wildlife reserve, such as: physical-chemical, biological, socio-cultural, and tourism infrastructure in the form of transportation, accommodation, communication systems, as well as the interaction pattern between Mampie Lampoko SM and regional areas other tours that are in a single tourist destination.

3. Results and discussion

3.1. Developed modeling

The existence of the development process of the tourism sector will have an impact on the environment, while in the concept of ecotourism is attempted to minimize the environmental impact of the utilization of the area as effectively as possible. So that the focus in this model includes the pollution component as one of the components that support the model. Moreover, in the development of the model, several environmental variables were identified which would have an impact on humans and damage to natural resources. The measurement of the impact used the index which is potential pollution that might occur. Air pollution will be represented by vehicle emissions, solid waste obtained from waste by calculating the rate of population growth and commercial waste by calculating the number of solid waste discharges carried out from tourism and tourism support. Wastewater is a waste of the total population that exists by taking into account the total water needs used by the population. To be able to see the conceptual pollution, it can be seen in the diagram below (Fig.1).
Figure 1. Ecotourism model

Notation;

- **IPOL** = pollution index
- **IPW** = pollution index from wastewater
- **IPV** = pollution index from the air
- **IPS** = pollution index from garbage
- **VUW** = $IVUW + WW$ = volume of wastewater
- **IVUW** = initial wastewater volume (m$^3$/year)
- **WW** = additional volume of wastewater (m$^3$/year)
- \( \frac{d}{dt}APV \) = \( \frac{d}{dt}IAPV + PV \)
  - **IAPV** air pollution volume
  - = volume of initial air pollution (mm air) PV
  - = additional air pollution (mm. air)
\[ \frac{d}{dt} \text{SWG} = \frac{d}{dt} \text{ISWG} + \text{WG} \]
\[ = \text{ISWG amount of solid waste (m}^3/\text{year)} \]
\[ = \text{initial amount of solid waste (m}^3/\text{year)} \]
\[ \text{WG} = \text{additional amount of solid waste (m}^3/\text{year)} \]

3.1.1 Water pollution
Disposal of wastewater can be calculated from the volume of untreated water. The volume of wastewater is calculated based on the proportion of water demand from each tourism activity, in addition to the main needs of the population [5]. The formulation of the pollution index from wastewater is calculated based on the amount of untreated wastewater, minus the amount of treated wastewater can be seen in the formula below:

\[ \frac{d}{dt} \text{UWW} = \frac{d}{dt}(\text{WW} - \text{TWW}) \]
\[ \text{WW} = \text{S WW reg} \]
\[ \text{TWW} = \text{S TWW reg} \]
\[ \text{TWW} = \text{FWWT reg x WW reg} \]
\[ \text{Wwreg} = 0.9*\text{WDDreg+0.85*(WFHreg-WFRreg)+0.9*(WDFPreg)} \]

Notation;
\[ \text{UWW} = \text{total untreated wastewater (m}^3/\text{year)} \]
\[ \text{WW} = \text{total wastewater (m}^3/\text{year)} \]
\[ \text{TWW} = \text{total wastewater treated (m}^3/\text{year)} \]
\[ \text{FWWT} = \text{fraction of treated wastewater (m}^3/\text{year)} \]
\[ \text{FWWreg} = \text{total wastewater in one unit area (m}^3/\text{year)} \]
\[ \text{TWWreg} = \text{total wastewater treated in one unit area (m}^3/\text{year)} \]
\[ \text{WDD reg} = \text{domestic wastewater in one unit area (m}^3/\text{year)} \]
\[ \text{WFH reg} = \text{lodging wastewater in one area unit (m}^3/\text{year)} \]
\[ \text{WFR reg} = \text{restaurant wastewater in one unit area (m}^3/\text{year)} \]
\[ \text{WDFPreg} = \text{wastewater from aquaculture in one unit area (m}^3/\text{year)} \]

3.1.2 Air pollution
The air pollution index is obtained from motor vehicle emissions which are calculated based on the number of population and the type of motorized vehicle that serves tourists in the region [6]. This is also based on the emission factors of each vehicle where in this model it is assumed that the emission fraction of each vehicle type is based on fuel requirements per kilometer (Table 1).

| Vehicle type       | Consumption vehicles (1 liter) |
|--------------------|-------------------------------|
| Trucks             | 4 – 5 km                      |
| Bus                | 5 – 6 km                      |
| Light vehicles     | 8 – 12 km                     |
| Motor              | 30 – 50 km                    |

Source: Field processed data, 1997

The mathematical formulation of air pollution is:
\[ \frac{d}{dt} \text{PV} = \frac{d}{dt} (0.4* \text{truk} + 0.35* \text{bus} + 0.2* \text{crin} + 0.05* \text{motor}) \]
\[ \text{APV} = \text{IAPV} + \text{PV} \]
3.1.3 Waste
To be able to calculate waste, the same method is used by using liquid waste model monitoring system where the volume of waste is calculated based on the amount of waste produced by households, commercial facilities, industry, and non-commercial activities [7]. Only in this model will only take into account household and commercial waste generated based on data previously collected.

**Table 2. Type of household and amount of waste**

| Type of household       | The average amount of waste       |
|-------------------------|----------------------------------|
| Low-income level        | 150 kg/person/year               |
| Middle income level     | 250 kg/person/year               |
| High income level       | 900 kg/person/year               |

For commercial areas based on data collected in 1997-1998 in RIPP South Sulawesi, it is known that the assumption of the amount of waste per room can be seen in Table 3.

**Table 3. Type of lodging and amount of waste**

| Lodging and restaurant category | Amount of waste         |
|---------------------------------|-------------------------|
| Non Star: Melati I dan Melati II| 1.5 kg/room/day         |
| Restaurant                      | 1 kg/chair/day          |

For other commercial types such as markets, shops depend on the size of the population and tourists visiting, so the most likely assumption is 15% of the total household solid waste. Other assumptions for non-commercial types such as; Educational facilities, health facilities, and offices are assumed to be 5% of household solid waste. The assumption assumptions above are expected to have a minimal impact on the environment and the overall system model. The mathematical formulation is as follows:

\[
\frac{d}{d\tau} \text{SWG} = \frac{d}{d\tau} \text{DSW} + \text{CSW} + \text{NCSW} + \text{INSW}
\]

\[
\frac{d}{d\tau} \text{DSW} = \text{SPop} \times \text{SWGP}
\]

\[
\text{CSW} = \text{SWGH} + \text{SWGR} + \text{SWGO}
\]

\[
\text{SWGH} = \text{SROOM} \times \text{SWGR}
\]

\[
\text{SWGR} = \text{TKURSI} \times \text{SWGR}
\]

\[
\text{SWGO} = 0.15 \times \text{DSW}
\]

\[
\text{NCSW} = 0.05 \times \text{DSW}
\]

**Notation;**

- **SWG** = additional amount of solid waste every year (m³/year)
- **DSW** = domestic solid waste (m³/year)
- **CSW** = commercial solid waste (m³/year)
- **NCSW** = non-commercial solid waste (m³/year)
- **INSW** = the amount of solid waste that already exists (m³/year)
SWGP = additional amount of solid waste from each household (m³/year)
SWGH = additional amount of solid waste from each lodging (m³/year)
SWGR = additional amount of solid waste from each restaurant (m³/year)
SWGO = additional amount of solid waste from each other commercial (m³/year)
SWGRH = solid waste from each type of lodging (m³/year)
Room = occupancy rate of accommodation per room
Chair = level of seat needs per restaurant
Pt = population (people)

3.2. Model verification
Model verification will be carried out in 2 stages, namely by performing a test verification structure and model behavior. The structure of the model validity is the most crucial factor in the dynamic system model because in each step the model must know how the structure of the model is formed. So that obtained model behavior that is similar to the existing reality. This can be achieved if the model has its supporting structure and components by the actual conditions.

The mathematical model is revisited to see the actual relation, whether the component components in the model have been clearly described in actual conditions so that the model can indeed be used and facilitated by decision makers. For this reason, verification of the structure of the Ecotourism Development Model is based on the logic of information that each increase in the number of tourists will increase income, in addition to increasing labor requirements. These relations can be seen in Figure 2 and Figure 3.

![Model Simulation](image)

**Figure 2.** The relationship between the number of foreign tourists and income

Based on the graph above shows the compatibility between the increase in the number of tourists with an increase in income factors and the use of labor, therefore, it can be said that the model represents the mechanism of system work.
The concept of developing/managing tourist areas in the Mampie Lampoko area is based on natural principles that support efforts to preserve the environment (natural and cultural) and improve the welfare of the surrounding community. The aspects of management are based on the unity of vision from its stakeholders. The strategies needed to develop ecotourism should fulfill the basic principles:

1. Ecotourism does not cause degradation of natural resources and development is always based on environmentally friendly principles.
2. Ecotourism should support participation and new experiences for tourists.
3. Ecotourism should include knowledge of local communities, government, non-governmental organizations, industry, and tourists before and after traveling.
4. Ecotourism should find all intrinsic value of resources [8].
5. Ecotourism includes resource carrying capacity [9].
6. Ecotourism promotes mutual understanding and bridges relationships between related parties. All related parties should promote responsibility for moral and ethical behavior related to nature and culture.
7. Ecotourism should provide long-term benefits for resources, local communities, and industries where these benefits can be in the form of conservation, science and culture or economics [10].
8. Ecotourism is oriented towards environmental-oriented development goals while continuing to heed the sustainability of natural resources and the environment.
9. Ecotourism activities should ensure that the basic ethics of environmental practices that are responsible are applied not only as external resources that become permanent tourism attractions as well as internal operational factors.

The choice of ecotourism as the concept of regional development especially in Polewali Mandar Regency is based on several main elements, namely: First, dependence on the quality of natural resources, historical and cultural heritage. Second, involve the community. Third, increase awareness and appreciation of nature, historical and cultural heritage values. Fourth, the growth of ecotourism markets at international and national levels. Fifth, as a means to realize a sustainable economy [2]. In other words, ecotourism offers the concept of low-high-value investment for resources and the environment while making it a powerful tool for community participation, because all production assets use and belong to local communities.
Inskeep (1991) [11] describes the process of developing tourism areas from time to time, where their development cannot be separated from the support of the local community. In the early stages of tourism development, the response to the potential of ODTW will encourage the growth of accessibility to the region; this is indicated by the growth of transportation systems that connect the nodal of tourist areas and nodal tourism suppliers. At the same time the growth in numbers. Tourists continue to increase along with the development of tourism infrastructure in the region. Stakeholders who influence the exploration stage are tourism businesses and tourists who are continually trying to find new tourist destinations.

In the next stage, with the growth of tourist visitation in the new area, the role of the community as the recipient of tourists also began to be included in the development of the area. At this stage, the community will play a more active role in providing facilities such as accommodation, restaurants, souvenirs and other facilities so that the economic potential of the community will develop. This will undoubtedly lead to increased work needs and attract migration from other areas around it.

The role of the government then began to form after the development process in the region began to be promoted, the formation of tourism institutions became an inevitable part to maintain the continuity of the use of tourism areas. To be able to see a complete picture of the development of a tourist area can be seen in Figure 4.

![Figure 4. Hypothetical diagram (tourism area life cycle - TALC) [12]](image-url)

To be able to see the impact of ecotourism development, it is necessary to first pay attention to the things that have been identified from the ecotourism development planner because this will involve the continuation of the growth of the tourist area and of course it will involve the continuity of tourism actors in the area, including:

1. Volume or number of tourists.
2. Characteristics of tourists with their needs.
3. The type of tourism activity that can be offered in a tourist area along with the possible variations of tourism.
4. Community structure in the tourist area.
5. Environmental carrying capacity.
6. The ability of the community to adapt to the development of tourism.
7. Policies that support development.
8. Integrated area management.

**4. Conclusion**

The model used is valid and has a high enough reality. Waste produced by tourists and management in jungle blocks, core blocks, and limited landscaping is collected in intensive use/landscape areas. The
operator will be brought by the manager himself in a particular place with a particular recycle bin to be recycled according to the waste class. Handling of non-recyclable waste is destroyed by burning while other parts which contain poison and cannot be destroyed are taken out of the area to be destroyed elsewhere.

References

[1] M. Honey, *Ecotourism and sustainable development: Who owns paradise?* Island Press, 2008.

[2] S. Ross and G. Wall, “Evaluating ecotourism: the case of North Sulawesi, Indonesia,” *Tour. Manag.*, vol. 20, no. 6, pp. 673–682, 1999.

[3] B. Garrod, “Local participation in the planning and management of ecotourism: A revised model approach,” *J. Ecotourism*, vol. 2, no. 1, pp. 33–53, 2003.

[4] S. Wunder, “Ecotourism and economic incentives—an empirical approach,” *Ecol. Econ.*, vol. 32, no. 3, pp. 465–479, 2000.

[5] T. Mihalič, “Environmental management of a tourist destination: A factor of tourism competitiveness,” *Tour. Manag.*, vol. 21, no. 1, pp. 65–78, 2000.

[6] A. Faiz, C. S. Weaver, and M. P. Walsh, *Air pollution from motor vehicles: standards and technologies for controlling emissions*. The World Bank, 1996.

[7] N. Pertiwi, G. D. Dirawan, and W. Karmila, “The local government policy strategy in managing waste at the coastal region of central Maluku district,” *Int. J. Environ. Policy Decis. Mak.*, vol. 1, no. 4, pp. 311–319, 2015.

[8] M. F. Kinnaird and T. G. O’Brien, “Ecotourism in the Tangkoko DuaSudara Nature Reserve: opening Pandora’s box?,” *Oryx*, vol. 30, no. 1, pp. 65–73, 1996.

[9] R. Buckley, “A framework for ecotourism,” *Ann. Tour. Res.*, vol. 21, no. 3, pp. 661–665, 1994.

[10] G. D. Dirawan and M. W. Caronge, “The Diversity of Epiphytic Wild Orchids in Mallawa Resort Area of Bantimurung Bulusaraung National Park, South Sulawesi, Indonesia,” *J. Trop. Crop Sci.*, vol. 2, no. 2, 2015.

[11] E. Inskeep, *Tourism planning: an integrated and sustainable development approach*. Van Nostrand Reinhold, 1991.

[12] C. A. Gunn, *Tourism planning*. Crane Russak., 1980.