Solid Waste Management System Model of Village Tourism Area of Nagari Tuo Pariangan, Indonesia

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Abstract. Nagari Tuo Pariangan is one of the three leading tourist attractions in Tanah Datar Regency. The increase of tourists visits Nagari Tuo Pariangan Area has resulted in increased waste generation, improperly managed existing solid waste management endanger the environment, and sustainable development. This study aims to develop a solid waste management system model of Nagari Tuo Pariangan as an effort to preserve the environment and support tourism development. The generation of solid waste of this area was 786,803 kg/day, with the largest were food waste as 35% and plastic waste of 32% of total waste. The solid waste management system model considers three categories of sorting types (compostable, recyclable, and residue), while the storage use of individual type (trash bags and bin) and communal (bin 40 L, 6 m\textsuperscript{3} containers). The collection system uses a 1.5 m\textsuperscript{3} motorized pedicab. The processing method applies composting, enumerating plastic waste, selling paper, and metal waste to the collectors. Moreover, the residue transport using a 6 m\textsuperscript{3} arm roll truck from the recycling center (TPS 3R) to Bukit Sangkiang Landfill. Meanwhile, the non-technical aspects planned for regulation on waste management by Wali Nagari, the formation of Non-Governmental Organizations, adjusting funding according to applicable regulations, and increasing the participation of traders, communities, and visitors.

1. Introduction

Nagari Tuo Pariangan is one of the nagari/villages located on Mount Merapi, Pariangan District, Tanah Datar Regency, which covers 1,792 hectares. It is one of the favorite tourist attractions in Tanah Datar Regency. In 2012, it was chosen as one of the five most beautiful villages in the world because of its natural beauty, according to the United States’ influential tourism media, namely the Travel Budget. The tourism objects in Nagari Tuo Pariangan consist of historical/cultural tourism and nature. It has a strong potential to meet the demand for the tourism market. The number of tourists visits to this tourism area in 2014 was 6,162 visitors and increased in 2016 to 8,915 visitors\textsuperscript{1}. The increasing number of tourists visit has increased tourists' waste. The waste produced from this area comes from the tourist attraction and residential areas.

The Nagari Tuo Pariangan area has not been included in the waste service area of Tanah Datar Regency and does not have a waste management system. The waste generated by the surrounding community and visitors is managed independently by collecting garbage, then throwing the garbage into the river/ditch, and some of the garbage is burned. As a waste producer, the community does not concern with reducing and utilizing waste that can still be used. People tend to use product packaging that cannot be recycled to increase the amount of waste generated, and the community has not carried out waste management activities. This situation has caused pollution in the environment and disturbed the beauty of the tourism region.

This research aims to develop a solid waste management system model in the Nagari Tuo Pariangan area as an effort to preserve the environment and support tourism development.
out sorting the waste produced. If waste cannot be appropriately managed, it will become a burden and cause significant problems. However, if managed properly, it will become an asset and benefit the government and society. The problem of solid waste must be anticipated to prevent the danger of environmental pollution to get worse in the future. It is necessary to develop a waste management system with the 3R (reduce, reuse, and recycle) concept. The improperly managed waste in the tourism area will also affect tourists' attractiveness to NagariTuoPariangan. Therefore, it is necessary to plan a waste management system.

Tanah Datar Government issued a policy that explains the solid waste network system, which consists of increasing the community's participation and the business/private sector to implement a solid waste management system. Solid waste processing carried out with environmentally friendly technology following technical principles, increasing service coverage, and quality of service systems and reducing waste input to the final waste processing site with the 3R (reduce-reuse-recycle) concept around the waste source area. While according to the district/city tourism regional development plan for tourism, it must pay attention to the carrying capacity of the physical, socio-cultural, and economic environment of tourism.

Considering the solid waste management problems, the regulations, and the district/city tourism development plan above, it is necessary to develop a solid waste management system model for the NagariTuoPariangan area to increase tourist attraction and maintain the environmental sustainability. Study on tourism waste has developed since last fifteen years located in the various region around the world, while in Indonesia it is located in Kalimantan, Bali, Java, and Sumatra, especially in West Sumatra. The study reported the quantity of solid waste generation. Some of the studies reported the composition and recycling potential and solid waste management systems.

2. Materials and methods
The research stages include a literature study sourced from textbooks, journals, and previous research on waste management system planning. Furthermore, data collection is carried out in the form of secondary data and primary data. Secondary data is a general description of the location, number of tourist facilities, area, number of visitors, map of tourist areas. Primary data are solid waste generation, composition, and recycling potential, and existing practice of solid waste management. Primary data collected by interviews and field observations. Interviews were conducted at the Tourism Office and the Environmental Affairs Agency of Tanah Datar Regency.

Identification of problems and development needs is carried out by comparing the existing conditions of waste management in the TuoParianganNagari Area with the criteria for Indonesia's existing waste management system. The criteria for the waste management system refer National Standard of Indonesia, National Constitution, and Ministry Regulation.

The model of the waste management system for NagariTuoPariangan area is developed for seven years of the design period, namely 2020-2026. The solid waste management system model includes technical aspects and non-technical aspects. Technical aspects include sorting and packaging, collection, transportation, and processing. Simultaneously, Non-technical aspects include regulatory aspects, institutional aspects, financing aspects, and community participation aspects.

3. Results and discussion
3.1. The existing practice of solid waste management
The waste management system of NagariTuoPariangan is carried out independently by the community by collecting garbage in an open area. The garbage is burned, and some of it is dumped into a ditch/river. The source of waste varied from tourist objects, tourist visitors, and residential waste. The waste produced is in food scraps, beverage bottles, plastic, and food wrapping paper. The existing condition of waste in the NagariTuoPariangan area can be seen in Figure 1.
3.2. Solid waste generation, composition, and recycling potential

The waste source can be grouped into residential areas and tourist areas. The average waste generation for the residential area is 0.928 Liter/cap. /day. The tourism area is 0.697 Liter/m²/day or 2.611 Liter/cap./day. Waste generation in NagariTuoPariangan area can be seen in table 1.

| Sources          | Unit Generation | Unit Generation rate | Unit          |
|------------------|-----------------|----------------------|---------------|
| Settlement       | 0.928           | L/cap./d             | 5,428.743 Lit./day |
|                  | 0.105           | kg/cap./day          | 615.051 Kg/day  |
| Tourism Area     | 2.611           | L/cap./d             | 386.395 Lit./day |
|                  | 1.160           | kg/cap./day          | 171.752 Kg/day  |

Waste generated from the NagariTuoPariangan area has a different composition. The separation of waste according to the type of waste consists of food waste, yard waste, plastic, hazardous waste, and other waste. The highest average waste composition is food waste, with 35% and plastic waste at 32%. Meanwhile, for recycling potential for each waste type, yard waste, tin can, and paper & waste can fully be recycled, while food waste has recycling potential as 88.59% while plastic only 32.23%.

3.3. Problem Identification

The following is an explanation of the identification of waste management problems in the Tuo Pariangan Nagari Area:

1. A high percentage of plastic waste is generated in the Nagari Tuo Pariangan area.
2. No community concern as a waste producer to reduce and utilize waste that can still be used.
3. People tend to use product packaging that cannot be recycled, thereby increasing the amount of waste generated.
4. Some waste generated is burned, and some of it is thrown into the river.
5. Nagari Tuo Pariangan area is not included in the service area of Tanah Datar Regency.
6. Waste has not been separated. The waste is still mixed.
7. There are no waste containers provided in the Tuo Pariangan area.
8. Absence of a collection system and no means of collecting garbage.
9. There is no vehicle for transporting waste from the Nagari Tuo Pariangan area to the final waste processing site.
10. There is no regulation on area scale waste management.
11. There is no financial budget for regional waste management.
12. No organization manages regional level waste.

3.4. Waste Management Development Needs
The development needs include technical aspects and non-technical aspects. The development of waste management in the Nagari Tuo Pariangan area needs to create a waste management system, which applies for a regional scale. The waste management system consists of sorting and storage, collection, processing, transfer, and transportation systems. Meanwhile, for non-technical aspects, making rules regarding waste management in the Tuo Pariangan Area, forming a waste management organization, making a budget for regional waste management, and increasing community participation in waste management.

3.5. Solid waste management system model
This system model aims to reduce waste from the source and increase community participation in 3R-based waste management. The waste management system model considers the Spatial Planning and Territory of Tanah Datar Regency for 2011 to 2031. The solid waste management system model for the Nagari Tuo Pariangan area can be seen in table 2.

Table 2. The solid waste management system model of Nagari Tuo Pariangan Area.

| Solid wastes management system                  | Model                                                                                                                                 |
|------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------|
| Segregation and Storage                        | It is separated into compostable waste, recyclable waste, and residue. Communal storage uses plastic bins 40 Lit capacity at the tourism spot. Indirect individual pole. Collection vehicle motorized cart with a partition on the box capacity 1.5 m$^3$. Service areas: settlement, shops. Collection frequency: daily for all waste types. |
| Collection                                     | Indirect communal pole. Collection vehicle motorized cart with a partition on the box capacity 1.5 m$^3$. Service areas: settlement, tourism spots. Collection frequency: daily for all waste types. The treatment takes place in the Recycling Center (TPS 3R). |
| Treatment and Processing                       | Type of treatment: composting, chopping, processing of recyclable waste, and trading.                                                                                                       |
| Transfer and Transport                         | Transport uses 6 m$^3$ containers at TPS 3R.                                                                                                                                             |
| Landfilling                                    | Located in TPA Bukik Sangkiang                                                                                                                                                    |
| Regulation                                     | Provide regulation and sanction for solid waste management system offenders                                                                                                           |
| Financial                                      | Sources could be from Corporate Social Responsibility, traders’ retribution, the community served, visitors, and waste processing product sales.                                             |
| Institution                                    | Develop community groups to manage the recycling center (TPS 3R)                                                                                                                        |
| Community participation                        | Provide training and education to elevated community awareness on solid waste management                                                                                                  |
3.6. **Infrastructures and Facility Needs**

The planned storage of waste is an area scale by applying individual and communal container patterns. Containerization is carried out in a segregated manner in order to facilitate the further processing of waste. The number of containers is adjusted to the type of waste that is sorted. The number of communal storage located on the tourism area fade of fiberglass bin with 40 L volume is 41. This storage has three types of purposes, green-colored containers for compostable waste, yellow for recyclable waste, and gray for other waste. While for settlement, it needs only one 6 m³ container.

The waste collection system uses indirect communal and individual indirect collection patterns. The indirect communal collection pattern is the collection of waste from communal containers to 3R TPS. The number of means of collecting is one motorized pedicab with a capacity of 1.5 m³ with four times a day rite, and the age of using a motorized pedicab is 5-8 years.

Waste processing activities at TPS 3R include composting, plastic waste for sale, other recyclable material, and other waste. Composted waste is food waste, yard waste. The processing of biodegradable waste is carried out using the Takakura composting method. The Takakura composting method at TPS 3R uses a basket of 14 units with a composting time of 14 days. Plastic waste for sale is the plastic waste that will be sold in the form of used plastic drink bottles. Plastic waste will be cleaned, chopped, and packaged for third parties (dealers).

Other recyclable material consists of paper, metal, and aluminum cans, which can be recycled will be cleaned and packed to be sold to third parties (dealers). In contrast, other waste will be combined with residual waste and disposed of in a 6 m³ container located in the TPS 3R area.

The TPS 3R to be built is in the Nagari Tuo Pariangan area. TPS 3R has 200 m², including the parking area and the road inside TPS 3R. The supporting facilities available at TPS 3R are chopping machine, manual sieving, shovel, broomstick, water hose, scales, and cart. The number of requirements for waste processing facilities at TPS 3R can be seen in table 3.

| No  | Items                                | Number | Unit |
|-----|--------------------------------------|--------|------|
| 1.  | Total area                           | 200    | m²   |
| 2.  | Takakura basket                      | 17     | unit |
| 3.  | Chopping machine for compost material| 1      | unit |
| 4.  | Chopping machine for plastic         | 1      | unit |
| 6.  | Manual siever                        | 1      | unit |
| 7.  | Cart                                 | 3      | unit |
| 8.  | Shovel                               | 2      | unit |
| 9.  | *Thermometer*                        | 2      | unit |
| 10. | Scale                                | 2      | unit |
| 11. | Sewing machine                       | 1      | unit |
| 12. | Sack                                 | 10     | unit |

The transportation of residual waste and other waste from TPS 3R uses the Hauled Container System (HCS) transportation pattern to the TPA to Bukik Sangkiang with an arm roll truck with a capacity of 6 m³.

4. **Conclusion**

Based on the waste management planning for Nagari Tuo Pariangan Area that has been carried out, it can be concluded that the container pattern used is a communal container with three types of waste. Waste collection is carried out every day uses an indirect communal pattern and an indirect individual using a motorized pedicab with a capacity of 1.5 m³. The transportation system uses an arm roll truck.
with a capacity of 6 m³ to TPA Bukik Sangkiang. A recycling center building (TPS 3R) can be in Jorong Guguak and apply composting using the stacking takakura method. Meanwhile, non-technical aspects consist of developing the institutional structure at TPS 3R, the financial source planning, and the participation of visitors in the waste management system.

It will be interesting to assess the solid waste management system correlation with the environmental impact that contributed to the study further. It will help find the sustainable system one, as the requirement stated in the national law of solid waste management, one of the methods that can be applied is Life Cycle Assessment.

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