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Community Based Tourism and Renewable Energy Potential Study of the Sano Nggoang Lake, Flores, Indonesia

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Abstract

Aims: This research employed qualitative methods focused on in-depth research at the Sano Nggoang site. The problem solved by this research is to examine the potential of community-based tourism and renewable energy so that it can bring benefit in economic, social, and environmental benefits for the community.
Methods: The methods employed included observation, interviews, and literature review. The goal was to gather information about the potential for community-based tourism, particularly geo-tourism, and renewable energy. This research can then be used to develop the local economy in Sano Nggoang.
Result: The results of this study revealed the tourism and renewable energy potential in Sano Nggoang. Attractions include birdwatching, horse riding, village tours, and forest tours. Available amenities include hot springs and homestays. Renewable energy potential includes geothermal energy and renewable energy. All of this potential can be developed through community-based tourism, thereby providing economic benefits to the residents of Sano Nggoang.
Conclusion: The conclusion is that there is considerable potential in renewable energy and geotourism. However, it must be developed collaboratively with the community using a community-based tourism concept. This can then be further developed and implemented within the community to provide sustainable benefits.

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1. Introduction

Community-based tourism (CBT) is one of the latest developments in the tourism sector and is currently being widely promoted, particularly in rural areas where sustainable development-based CBT is urgently needed (Arintoko *et al.,* 2020). CBT is important to develop because it emphasizes local-level responsibility and practices in tourism development and management, prioritizing care for both nature and the community so that tourism becomes more environmentally friendly. Regulating the number of tourist visits as well as prioritizing meaningful experiences and social interaction during travel are among the key objectives of CBT (Fafurida *et al.,* 2022). The CBT approach also helps minimize disruptions to local community privacy, biodiversity, congestion, and other negative impacts. Moreover, it reduces economic dependency on tourism by diversifying rural income sources, preserving agricultural traditions, and aligning the tourism economy with the ecosystem's carrying capacity (Rocca & Zielinski, 2022).

Geothermal energy, as a source of electricity, offers significant benefits, including access to affordable modern energy services, a sustainable energy supply, responsible energy consumption, and improved energy security (Cook *et al.,* 2022). This energy source is classified as renewable, although it still faces considerable public controversy. Exploration and development of renewable energy projects are often perceived as environmentally damaging,

which may negatively affect tourism. The concept of "energy tourism" has been introduced as a response to this issue; however, it continues to generate concerns due to its perceived negative impact on landscape aesthetics and wildlife quality (Sæþórsdóttir & Hall, 2019).

Community-based tourism and renewable energy can generate significant economic benefits and foreign exchange for a country (Riojas-Díaz *et al.,* 2022). In Indonesia, the number of visitors to such destinations has been increasing year by year. Although the trend over the past five years has shown fluctuations due to the Covid-19 pandemic, which severely disrupted the tourism sector and reduced visitor numbers, recovery has begun. Starting in 2022, foreign tourist arrivals have started to rise again and are projected to continue showing a positive trend in the coming years (BPS, 2024).

Figure 1. Amount of Foreign Tourist Visit in 5 Year (2019-2023)
Source: Badan Pusat Statistik, 2024

Global tourism trends in sustainable community-based tourism, particularly in geotourism, have been increasing year by year, including in Indonesia. According to BPS data, tourist visits have risen consistently, driven by a growing preference for nature-based and community-oriented travel (Strzelecka *et al.,* 2023). With this increase in visitors, improvements to various tourism destinations are expected to continue, including those in the geotourism subsector. Geotourism is a branch of tourism that focuses on the geological environment. It centers on visits to geo-sites and efforts to conserve biodiversity. This is achieved through activities such as geological feature exploration, geo-trail viewpoints, guided tours, geo-activities, and the establishment of protected visitor centers. Geotourism can attract both independent travelers and group tourists, who may visit natural or urban areas, as long as geological features of interest are present (Xu & Wu, 2022).

Indonesia must continue to support geotourism development, and various related policies have emerged. According to the Ministerial Regulation of Tourism and Creative Economy No. 2 of 2020 concerning Technical Guidelines for Geoparks as Tourism Destinations, geoparks are not only intended to promote the conservation of geological, biological, and cultural diversity, but also to stimulate community and regional economic growth through empowerment initiatives. The regulation highlights three key pillars: conservation, education, and sustainable community-based economic development. Additionally, the Minister of Energy and Mineral Resources Regulation No. 1 of 2020 concerning Guidelines for the Designation of Geological Heritage (geo-heritage) aims to preserve the value of geological heritage as a resource for scientific research, earth science education, and geotourism. It can also serve as a foundation for geopark development.

The problems addressed in this research include the underutilization of community-based tourism potential. Although Sano Nggoang has rich natural and cultural tourism resources, local community involvement remains limited and poorly organized. There is also a lack of integration between the tourism and renewable energy sectors. While the area has strong potential for development through clean energy approaches, few studies have explored these two aspects in an integrated manner. Furthermore, there is limited data and research on the renewable energy potential of this volcanic lake region, such as geothermal, solar, or micro-hydro power. Public understanding of the sustainable economic opportunities that could be gained from managing local resources wisely is also still low.

Ancient Lake Sano Nggoang is one of the deepest ancient lakes in Indonesia and is currently recognized as both a geotourism destination and a site designated by the government for geothermal renewable energy development (ESDM, 2017). In terms of geotourism, tourism initiatives in Nunang Village—located on the shores of Sano Nggoang Lake—have included the development of homestays, village tours, birdwatching, forest trekking, hot springs, and traditional caci dance performances. However, these efforts have not yet attracted a significant number of tourists due to their niche or special-interest nature. On the other hand, the geothermal development plan was rejected by the local community in 2022 due to environmental concerns (Widiatmoko *et al.,* 2020). This research is crucial for exploring strategies for sustainable community-based tourism (CBT) while identifying renewable energy potential as part of an environmentally friendly development approach. With the growing demand for clean energy and sustainable tourism, integrating these two sectors could serve as a model for inclusive and ecologically responsible development in remote areas. Previous studies have tended to examine tourism and geothermal energy separately, without exploring their interconnection. This study aims to identify the most suitable CBT model for the Sano Nggoang area, including its alignment with future renewable energy development. The purpose of this paper is to provide a comprehensive overview of tourism, local community dynamics, and renewable energy potential in Sano Nggoang, ultimately presenting an integrated assessment of opportunities for renewable energy-based geotourism. The findings of this study are expected to serve as a reference for stakeholders in developing community-based renewable energy tourism in the Lake Sano Nggoang area, West Manggarai, East Nusa Tenggara.

2. Methods

This research adopts a qualitative design. It outlines the chosen methodology and explains the rationale for using a qualitative approach. The design includes a description of the study sample as well as the procedures for data collection and documentation. Furthermore, it elaborates on the steps of data analysis and the strategies used for presenting, interpreting, and validating the findings, while also indicating the expected outcomes of the study (Creswell *et al.,* 2018). Data collection techniques are the most crucial component of research because the primary objective of any study is to obtain accurate data. Without a proper understanding of data collection methods, researchers will be unable to gather data that meets the required standards (Sugiyono, 2018).

This research was conducted in Nunang Village, part of the Sano Nggoang Tourism Village, using a qualitative approach focused on in-depth on-site observation. The informants included the head of the Tourism Awareness Group (Pokdarwis), the manager of the Sano Nggoang homestay, local community members, and data gathered through direct field observation. Through these informants, the study explored ongoing tourism activities such as attractions, homestay operations, birdwatching, visitor trends, energy-related initiatives, and other relevant qualitative information. In addition, the researchers directly observed real conditions, facts, and challenges encountered in the field.

As for data collection and analysis techniques using several qualitative techniques below, such as:

- Observations were carried out in Nunang Village, located within Wae Sano Village, which is administratively part of the Sano Nggoang Sub-district. Additional observations were conducted at several nearby tourist attractions within the Sano Nggoang area. The observation process involved direct field visits as well as photo and video documentation focusing on tourism potential and renewable energy opportunities.
- Interviews were conducted through direct, in-depth discussions with key informants involved in geotourism and renewable energy. In the context of geotourism and ecotourism, several relevant stakeholders were interviewed to obtain accurate and reliable data.
- Document study was conducted by reviewing various literature sources related to tourism potential and renewable energy in the area. The materials used included government reports, private sector publications, mass media articles, and documents from non-profit organizations involved in regional development. Tourism-related data was primarily obtained through direct observation and interviews, while renewable energy information—particularly regarding geothermal exploration in the Sano Nggoang area—was sourced from third-party studies and research reports.

The criteria for selecting informants were as follows: (1) individuals recognized as community leaders with decision-making influence in the village; (2) those who actively participate in local community activities; (3) individuals involved in community-based tourism initiatives; and (4) those who have direct engagement with external stakeholders such as NGOs, government agencies, or private sector actors.

Data analysis was conducted through a process of data reduction, organizing information on tourism potential and geothermal resources into visual formats such as images and diagrams to clearly illustrate existing issues. Finally, conclusions were drawn to assess the potential of community-based tourism and renewable energy development in the Sano Nggoang Lake area.

Figure 2. Interview and Observation in Sano Nggoang
Source: Private Source, 2018

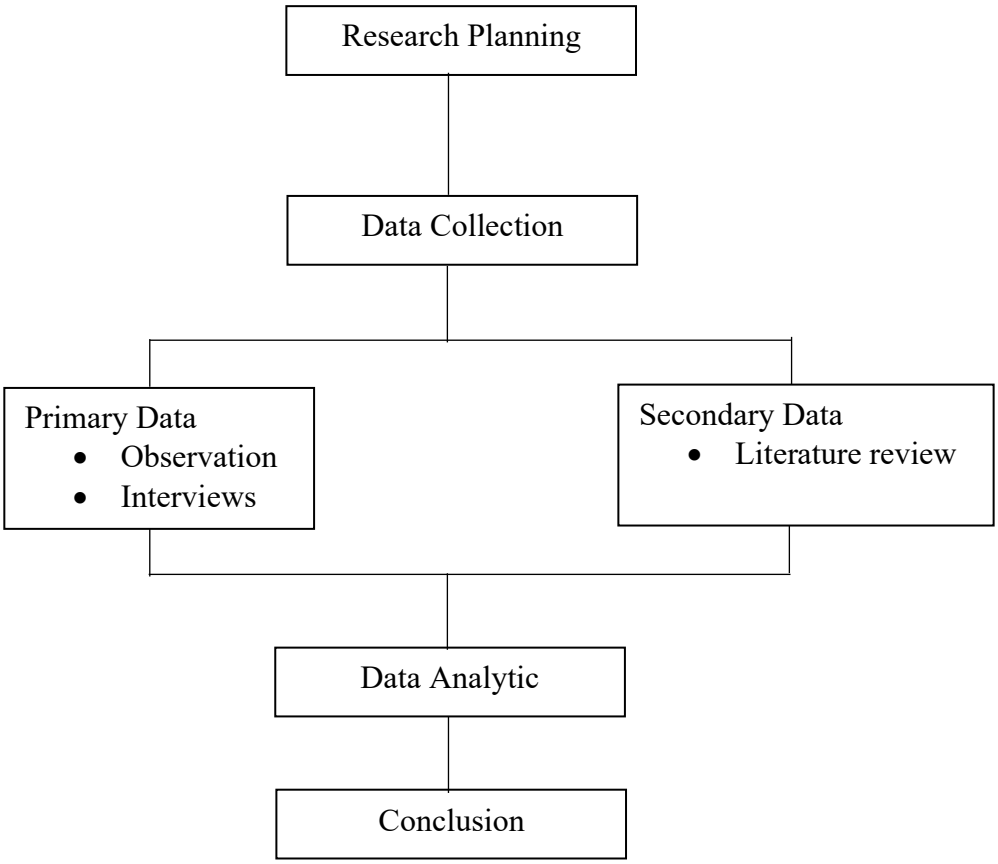

Figure 3. Research Diagram
Source: Private Source, 2025

3. Results

3.1 Location, Accessibility, and Landscape

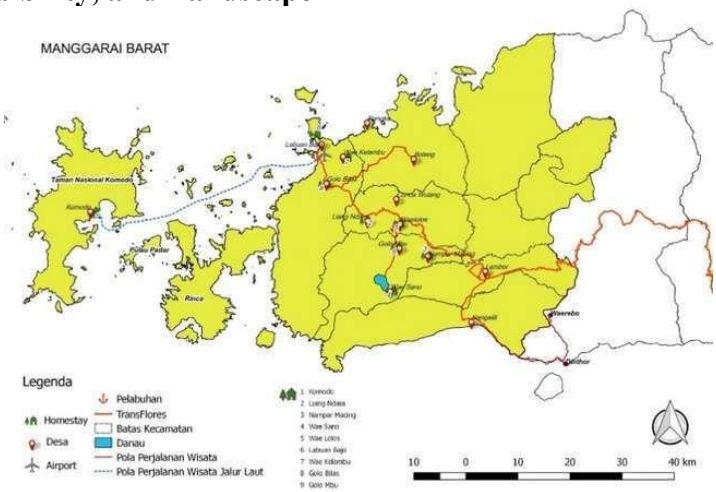

Figure 4. Accessibility Map to Sano Nggoang Lake
Source: Indecon, 2018

Sano Nggoang Lake is located in Sano Nggoang District, West Manggarai Regency, East Nusa Tenggara Province (Figure 4). Administratively, the lake area falls within Wae Sano Village, Sano Nggoang, and Nuncung Island. The site can be accessed from Labuan Bajo, the capital of West Manggarai Regency, which is also widely known as the gateway to Komodo Island, a popular international tourism destination. The journey from Labuan Bajo to Wae Sano

Village takes approximately 3–4 hours by car. The route follows the winding Trans-Flores road, which is generally in good condition, although road conditions deteriorate upon entering the village area.

The average air temperature in the West Manggarai region, including Sano Nggoang, is around 27.7 °C with an annual humidity of approximately 78%. Rainfall and sunshine are present throughout the year due to the area's tropical climate (BPS, 2023). The Wae Sano forest and mountainous landscape is adjacent to the Mbeliling forest and mountain range in West Manggarai and is home to diverse flora, fauna, and rich biodiversity.

The Wai Sano volcano features an elliptical caldera measuring approximately 2.5 × 3.5 km, which now forms Lake Sano Nggoang, known for its high solfatara (sulfur) content. The peaks of Poco Sesok and Poco Dedeng are located near the center of the eroded volcanic structure. The area has been the focus of geothermal exploration, with two solfataras identified along the southeastern shore of the lake. Although no eruptions have been recorded or dated historically, the site has been mapped as Holocene in age (Smithsonian Institution, 2024).

3.2 Attraction

Sano Nggoang has strong potential as a key tourist attraction, primarily due to its volcanic lake rich in sulfur content. In addition, the area offers significant tourism opportunities, particularly among foreign visitors. Since it falls under special interest tourism, its target audience is more segmented, which naturally affects the number of visitors. Some of the main tourism attractions at Lake Sano Nggoang include the following:

3.2.1 Horse riding around the lake

Lake Sano Nggoang covers an area of approximately 512 hectares and can be explored by riding along a trail that circles the lakeside forest (Figure 5). Visitors do not need to walk, as horses are provided by the local tour operator, who also runs the only roadside stall at the entrance to Nunang Village. Along the journey, travelers can enjoy scenic views of the lakeshore as well as observe daily activities of the local community. The trip around the lake takes approximately 3–4 hours at a normal pace, covering a distance of about 14 km.

Figure 5. Accessibility Map to Sano Nggoang Lake
Source: https://sanonggoanglabuanbajo.blogspot.com/, 2024

3.2.2 *Birdwatching*

Sano Nggoang is also one of the best birdwatching locations in West Manggarai (Figure 6). Several endemic species of Flores birds inhabit this area, including the Flores Hawk-Eagle, Wallace's Scops-Owl, Russet-capped Tesia, and Brown-capped Fantail. Birdwatching activities are typically conducted around the villages of Nunang, Lempe, Ta'al, and Golo Lampang. These areas are surrounded by forested landscapes with clear streams and natural springs, providing ideal habitats and food sources for various carnivorous bird species (Burung Indonesia, 2017).

Figure 6. Birdwatching Activity
Source: https://www.jagarimba.id/5-lokasi-birding-paling-direkomendasikan-di-flores-barat/, 2021

3.2.3 Village and Forest Tour

In addition to birdwatching and horse riding, visitors to Sano Nggoang can enjoy forest and village exploration (Figure 7). For jungle treks, tourists can climb Waisano Mountain (903 m) and experience Flores' endemic biodiversity. The trek passes several peaks, including Poco Dedeng, and goes through Sesok Forest, a key source of regional biodiversity. From the Golo Dewa savanna peak, visitors are rewarded with a panoramic view of Sano Nggoang Lake. Another attraction is a village tour, where visitors can observe various local plantation commodities such as candlenuts, coffee, cloves, avocados, and more. This village experience can be packaged as part of a tour, offering an alternative tourist activity in the Sano Nggoang area.

Figure 7. Sano Nggoang View from Village (left) and Sano Nggoang Forest (right)
Source:field survey, 2018

3.3 Tourist Amenities

3.3.1 *Hotsprings*

The bathhouse is situated on the edge of the lake, which has a high sulfur content (Figure 8). Several hot springs in the area have temperatures high enough for visitors to boil food such as eggs, sweet potatoes, and cassava. With proper packaging and adequate supporting infrastructure, this activity has the potential to become a unique and attractive tourist experience.

Figure 8. Hotsprings Pool in Sano Nggoang *(Source: field survey, 2018)*.

3.3.2 Homestay

Homestay opportunities already exist in the area, as some residents have begun renting out rooms to visiting tourists (Figure 9). The homestay concept emphasizes living alongside the local community, experiencing their way of life, and engaging closely with residents. This creates an atmosphere of intimacy and facilitates the exchange of experiences between tourists and villagers. Currently, about 10 households are committed and ready to operate as homestays, supporting the development of community-based tourism. These accommodations complement the geotourism potential of the Sano Nggoang area, which includes volcanic rocks, sulfur-rich lakes, biodiversity, birdwatching, and other interesting geo-sites.

Figure 9. Homestay in Sano Nggoang *(Source: field survey, 2018)*

Based on the previous explanation, the tourism potential in Sano Nggoang is summarized as in the image below (Figure 10).

Figure 10. Potential Tourism Attraction List
Source: Waesano ESIA, 2019

3.4 Renewable Energy

In terms of renewable energy, Sano Nggoang has significant potential, particularly for geothermal energy, although its development remains a point of contention among the government, developers, and local communities. Additionally, the area has solar energy potential, which is currently utilized at the household level to power a few lamps at night.

3.4.1 Geothermal

Geothermal energy is an alternative energy source often classified as renewable (Figure 11). Renewable energy is generally more environmentally friendly, producing relatively fewer greenhouse gas emissions compared to fossil fuels. For this reason, renewable energy, including geothermal, has been increasingly developed by many countries worldwide. Geothermal energy is also highly stable compared to other renewable sources such as hydropower, solar, or tidal energy, which experience peak production at specific times. This stability allows geothermal energy to provide a reliable and consistent electricity supply.

The feasibility study for this project has been ongoing since 2016, conducted by PT SMI as part of the Environmental Impact Assessment (EIA) process. The plan involves drilling four well pads, each executed in two stages, to generate a total of 45 MW of electricity. The stages include exploration and exploitation. During the exploration stage, studies and various tests are conducted to assess the feasibility of the geothermal resource. The exploitation stage encompasses construction, operation, and maintenance activities.

The study also addresses potential impacts on biodiversity, particularly forests and endemic species such as local Flores birds. It further considers the environmental and human health effects of exploration and exploitation, including small earthquakes, noise, dust, residual materials, pollution, and groundwater depletion. These impacts are projected to have minimal effect on the broader ecosystem and community life. Additionally, the well pad drilling sites are located near residential areas, plantations, and community farms, avoiding protected forests and habitats of endemic species.

The study found that the majority of residents (89%) support the geothermal project, citing benefits such as improved community welfare, strengthened local economy, enhanced household well-being, and access to environmentally friendly electricity (Waesano ESIA, 2019).

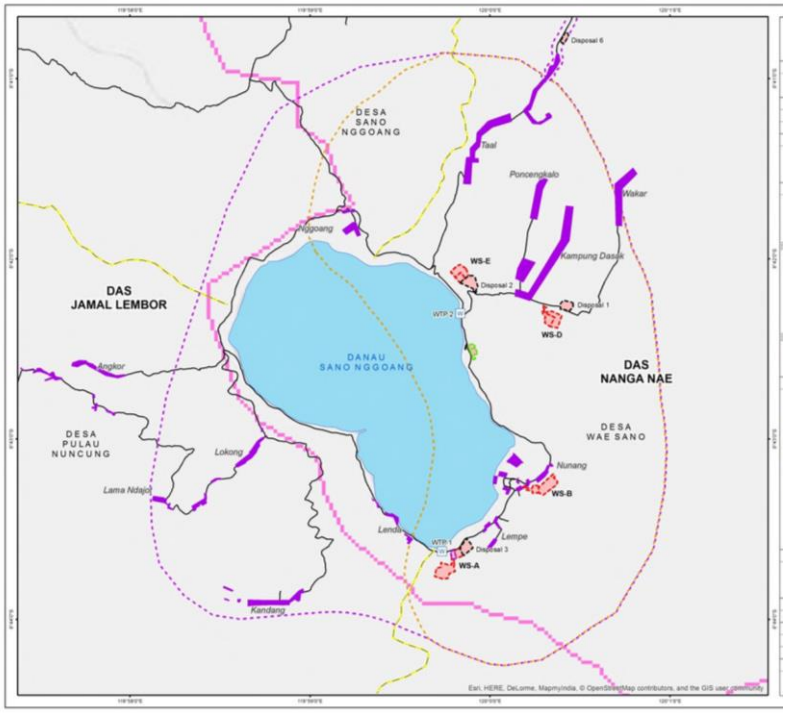

Figure 11. Potential Geothermal Wellpad
Source: Waesano ESIA, 2019

However, despite all previous environmental impact assessment studies, in 2022 the World Bank, the largest funder of the Sano Nggoang geothermal project, visited the site but was rejected by the local community. The villagers strongly opposed the project, and the World Bank did not proceed due to a lack of negotiation and consensus regarding the project implementation

plan. The community's main concern was that geothermal development would damage their sources of livelihood, potentially reducing or destroying crops such as candlenuts, cassava, sweet potatoes, bananas, and others (Jempau, 2022).

In 2023, the government planned to resume the geothermal project, as it is part of the nationally strategic Geothermal Energy Upstream Development Project (GEUDP). The government, through the Ministry of Energy and Mineral Resources, also issued Ministerial Decree No. 2268 K/30/MEM/2017, designating Flores Island as a geothermal island. The project funding will be provided by the government, with PT Geo Dipa Energi appointed as the developer (Floresa Team, 2023).

3.4.2 Solar *Energy*

The renewable energy potential in the Sano Nggoang area is not limited to geothermal energy; solar energy is also significant. Until 2018, Nunang Village and its surrounding areas were not connected to the National Electric Company (PLN) grid. The plan is for geothermal energy to become a primary electricity source for local residents. In the meantime, the community has access to solar-powered lighting systems initiated by the government and several non-governmental organizations. These systems include rooftop solar panels and solar battery-powered flashlights, primarily used at night.

The solar energy potential in this village is considerable, as the area receives abundant sunlight throughout the year, with peak solar intensity lasting about four hours per day—enough to power one to three lamps at night. For cooking, most households rely on firewood, while a few families occasionally use kerosene. The widespread use of firewood is facilitated by the village's rural location, surrounded by forests, where residents often collect dry wood for daily cooking needs.

5. Discussion

As a success story in Mozambique, community-based tourism operators in the Ponta do Ouro Partial Marine Reserve (PPMR), particularly tour guides, have been shown to influence tourists' attitudes and behaviors toward the environment, effectively turning consumers into environmental stewards (Rocha et al., 2022). Geo-tourism and renewable energy should be integrated into a comprehensive concept, and community-based management provides an effective approach to develop both sectors simultaneously.

To date, Sano Nggoang geotourism has implemented community-based tourism managed by local residents, encompassing tour guides, operators, homestays, food and beverage services, and other tourism-related activities. Nunang Village has established a tourism management group aimed at leveraging the geo-tourism potential of the Sano Nggoang area to improve the local economy while maintaining environmental sustainability. Additionally, the formation of social capital through the Tourism Awareness Group (Pokdarwis) of Wae Lolos Tourism Village has positively influenced the community in Nunang Village and surrounding areas near Sano Nggoang Lake. Several tourism managers have received training in areas such as tour operations, marketing, English language skills, homestay management, and various aspects of sustainable tourism management.

Community-based tourism management in Sano Nggoang is relatively straightforward, partly because the number of tourist visits to the area is still minimal. Visitor management, homestay operations, and tourist attractions have not yet been fully developed. The community currently receives guests directly through bookings or travel agents. Within various tour groups and homestays, tasks are organized and divided among community members to serve visitors. The willingness of residents to convert their homes into homestays serves as the initial foundation for community-based tourism. The presence of mining employees who stay overnight demonstrates that the community can manage home accommodations for tourists.

In addition to homestays, micro-based tourism businesses (small and medium enterprises) provide alternative income opportunities (Junaid, 2021). All these activities are managed by the local community, contributing to economic growth in the Sano Nggoang area. Nevertheless, the primary occupation of the community remains agriculture, with tourism serving as a supplementary source of income.

Regarding renewable energy, community management remains very limited. While some households use solar panels, their use has not been fully optimized. This is due to difficulties in accessing or acquiring the technology, as well as the relatively high cost of installation, leaving many households still reliant on traditional lamps. Geothermal energy also presents an alternative for the community, offering more feasible energy access and low carbon emissions, particularly CO_2. However, concerns remain that geothermal development could harm the surrounding environment, including forests, water resources, and biodiversity in Sano Nggoang.

By comparison, Ijen Geopark in Banyuwangi, Indonesia, has successfully developed geotourism alongside geothermal energy. Its three pillars and four aspects of geopark development are implemented in an integrated manner through the involvement of the Triple Helix Village, the construction of infrastructure networks, drafting necessary regulations, and strengthening community commitment and trust. This integrated management approach leverages local areas and potentials through geotourism, fostering community participation in Ijen Geopark activities (Mastika *et al.,* 2023).

In Sano Nggoang, there is also concern that external labor might dominate geothermal projects, preventing local residents from benefiting economically. This has led to skepticism among the community about whether geothermal renewable energy development will positively impact them. Unlike industrial-scale geothermal development, solar photovoltaic systems can be implemented on a smaller scale and managed by the community. Therefore, a community-based management system is essential to ensure positive outcomes, including community acceptance and access to affordable energy.

6. Conclusion

The potential for geotourism and renewable energy in Sano Nggoang is expected to enhance the village's development and increase the economic value for the local community, although much work remains to be done. Tourism attractions such as birdwatching, forest and village exploration, and homestays need further development. Similarly, the area's renewable energy potential, including geothermal and solar energy, is significant and requires proper management to avoid negative impacts on the community and the surrounding environment. A community-based approach is essential, as these lands and resources belong to the local population. Ensuring community involvement helps maximize benefits while minimizing potential adverse effects.

The recommendations from this research can be applied to the development of tourism in Sano Nggoang based on community-based tourism (CBT). Additionally, they can serve as a foundation for future studies, including environmental impact assessments, community vulnerability analyses, and other research aimed at evaluating the effects of changes implemented in the area.

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