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Geotrail development to connect the dots in Muara Caldera Toba, Indonesia

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Abstract. The growth of awareness in sustainable tourism has led to the development of geotourism all around the world, in which geotourism promotes conservation of geoheritage, appreciation of geosites, and interpretation of geoscience. The Toba Caldera in Indonesia is a genuine evidence of geological phenomena, and at present, the remaining geosites in its surrounding are potential as the tourism attraction. Previous works on geotourism have shown several perspectives in geology, however, research for geotourism planning in destinations is limited. Using the principle of tourism attraction, this paper introduces geotrail concept by connecting the values of each geosite in the Toba Caldera, particularly in Muara. Through qualitative approach, the prospect of initiating a geotrail in Muara is explored using panels, viewpoints, timeline, and stops. Collected data from observations and interviews were analysed with triangular method. The result indicates that natural element is dominant, built element can complement the nature, and it is suggested to strengthen cultural and social elements to optimize the geotrail development.

1. Introduction

The primary product of any tourism activities is the experience given by a destination to the visitors [1][2]. As tourism activities bring major contributions in enhancing a country's economy [3][4], escalating human development index [5], and increasing life quality [6][7], it is obvious that tourism is capable of improving the welfare of the people living in the destinations. However, to invite numerous visitors, a destination itself must be prepared in integrating its attractions to be able to compete and survive, because to integrate its resources and competencies and change them into products and services required by the tourists is the priority obligation for a destination [8].

To support tourism sector in Indonesia, a massive infrastructure development initiated by the current government will allow a huge number of tourist to visit the country. Meanwhile, research in geotourism is happening on the global scale [9] and at the same time, in Sumatra, Indonesia, lies the Toba Caldera as the evidence of an epic supervolcano phenomena that erupted 74.000 years ago, with Muara in its southern part [10]. The area is rich in geological values and attributes. Within this context, since geotourism is a beneficial form of tourism [11] and proved to be a strategy to develop a destination [12][13], geotourism suits most to strengthen Muara's tourism potential. Furthermore, in geotourism, one of the ways to explore the destination's features is geotrail [14], which is why, it is important to identify Muara's major attractions and connect them through a geotrail, so that visitors can reach and access geosites without any barriers and the benefits carried by tourism activities will be impactful for the country, the host destination, and the people involved.



2. Geotrail Based on Geotourism Attractions

Geotourism has five principles, namely geologically based, sustainable, educative, locally beneficial, and tourists' satisfactory [15]. Linking these principles to a destination, they will bring advantages for both visitors and residents. Meanwhile, in a tourism destination, the attraction is the key element to invite visitors [16]. Despite of the complexities of tourism attractions, in geotourism, geosites are the main attraction [17]. The existence of geosites is the requirement in a geotourism destination, since they are the primary resource of attraction that engage the principles of geotourism.

According to Middleton et al., attraction is divided into four components, namely natural attraction, cultural attraction, social attraction, and built attraction [2]. On the other hand, to study the intrinsic components of a geosite, there are four values to observe, namely scientific values, aesthetic values, historic values, and economic values [18][19]. Therefore, in determining geotourism attractions, the values of geosites are observed inside the attraction components to obtain certain geotourism potential in each geosite that can be used in the development of a geotourism destination.

A geotrail has been proved for its functionality to intensify geotourism potential [20] also to complement the concept of geotourism [21]. In a geotourism destination, interpretation from the visitors to the geosites is the key factor [12][20]. Therefore, the utilization of a geotrail must be settled with interpretative elements. According to Newsome et al. [22], panels, viewpoints, tours, gardens, visitor centers, and museums can be used for interpretative strategies in a geotourism destination. Moreover, panels, timelines, brochures, academic visits, and downloadable apps are important in interpreting geosites as written by Norrish et al. [20]. However, gardens, visitor centers, museums, and other supporting facilities are special factors that can be used as stops for visitors, meanwhile, brochures, tours, academic visits and apps are additional factors. Therefore, several elements from these interpretative factors namely panels, viewpoints, stops, and timeline are considered necessary to develop a geotrail.

Table 1. Elements used in a geotrail.

<i>Elements</i>	<i>Description</i>
Panels	Panels are physical boards consist of written information or illustration about certain sites, they can be placed along the sites to point on rocks, stones, roads, flora fauna, views, etc. Panels must be easy to be seen and read for visitor's interpretation also integrated to the real physical environment.
Viewpoints	Viewpoints are certain positions for visitors to stand and enjoy the sceneries. They can be placed in peaks, valleys, shores, nodes, etc., where visitors are able to see the panoramas and appreciate the landscapes. Photo area and sitting area can be added to make viewpoints more attractive.
Stops	Stops are supporting facilities that can enhance the potential of natural sites. The forms are diverse, such as museums, visitor centers, shops, thematic areas, etc. To have the visitors comfortable during the trip and to accommodate them in gaining understanding towards geosites is the purpose of making stops in the trail, as the element can be built around or close to the important sites.
Timeline	Timeline is the chronological order of the geological features in a trail. They mainly follow the rule of time, so that in certain situations, the trail can be connected through the chronology of each geosite to build interpretative stories for visitors and ease them in gaining knowledge about the visited spots accordingly.

Based on the explained literature, it can be seen that the principles of geotourism must be adhered in developing a geotourism destination. The strategy of the development is obtained from the priority attraction, which is geosite. The development strategy itself implicates to the requirement for a geotourism destination, which is having geological features as the primary attraction. In addition to the attraction, the tourism program must bring benefits for the environment, the locals, and the tourists.

Prior to the development of the geotrail, the values of each geosite covered in attraction elements must be observed first to recognize the attraction potential. Once the potential are determined, they are distributed through panels, viewpoints, stops, and timeline since they are efficient in delivering the concept of geotourism in a natural setting. Moreover, these elements also work as interpretative tools for visitors in achieving the geotourism experience they look for in the destination.

3. Methodology

3.1. Method

The research is conducted to find the geotrail concept. It should be based on the current observation and the perception from the stakeholders to get the correct result, which is why, descriptive qualitative method is used. Qualitative method is appropriate in providing broad knowledge from many perspectives regarding to the wide phenomena in the field of tourism [23]. This method was also adapted in designing similar researches focused on geotourism development in Indonesia [21][24].

In order to recognize the attraction potential, observation was conducted in the study site. Meanwhile, to gain better understanding on the attraction, depth interviews with associated stakeholders were held. The data collected from field observation and depth interviews were brought as the basis in distributing the interpretative tools in the geotrail, be it panel, viewpoint, stop, or timeline. Both observation and interviews took place in the study site engaging 4 stakeholders, namely geologist, accommodation provider, community leader, and government officer. The key informants were chosen based on their knowledge and experience in accordance with geotourism in the study site, each of them represents certain position of those involved in geotourism activities. By using this method, factual elements of geotourism attraction will be described and further linked with the elements of geotrail development to obtain a precise geotrail concept that meets all the considerations.

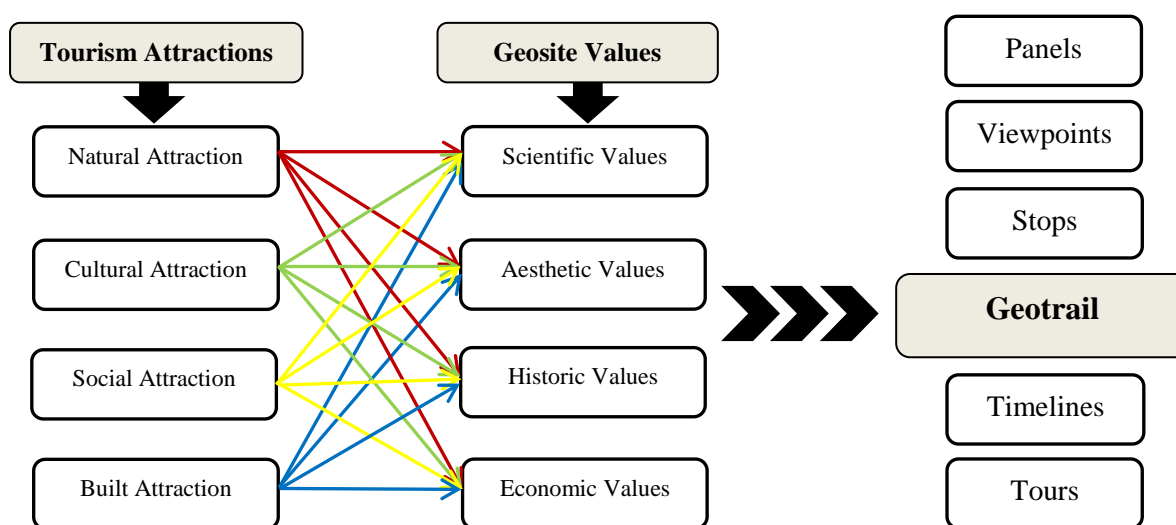


Figure 1. Chart analysis to develop geotrail based on geotourism attraction.

3.2. Study site

A geotourism destination must have form, process, and tourism with geological phenomena as the platform [15]. As a destination, The Toba Caldera shows its significance in all geotourism aspects, since it has geological heritage [10] also diversities in geology, biology, and culture [21]. Following the tourism lifecycle of the Toba Caldera, Muara in North Tapanuli Regency is now ready on the development stage [25].

For the study site itself, the recorded data on geosites around the Toba Caldera provides five major geosites around the area, known as Huta Ginjang, Tapan Nauli, Dolok Martumbur, Muara, and Sibandang.

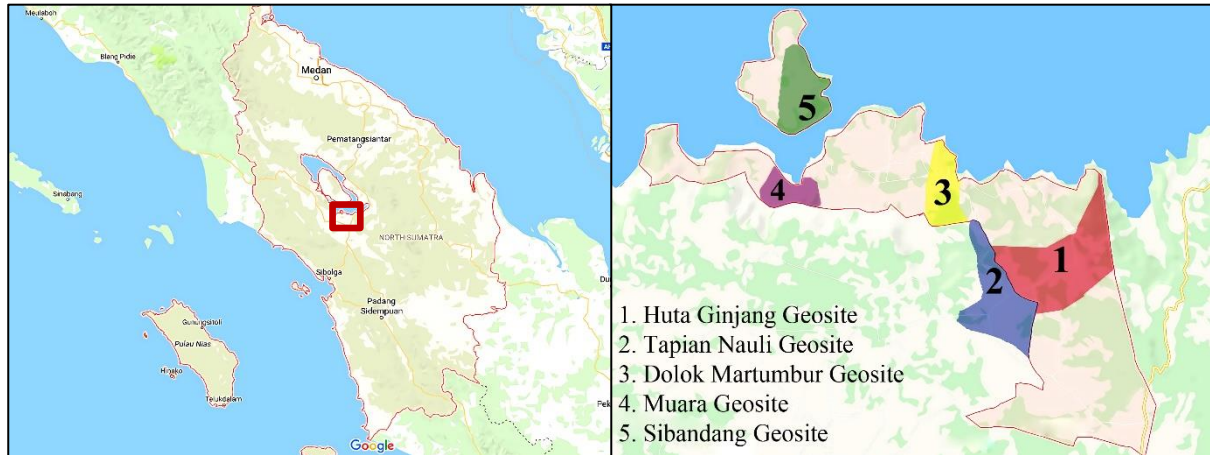


Figure 2. Study site in Muara, North Tapanuli of the Toba Caldera, Indonesia.

4. Results and Discussions

4.1. Panels for Geotrail in Muara

Panels are the primary feature in a geotrail to provide information for the visitors about the geological heritage. They can be situated in certain objects, such as stones, roads, paths, and other significant sites [22]. Mostly, the scientific values in natural attraction are utilized to map the panels, because the purpose of panels' interpretation is visitors' understanding on geosites through sharing information and appreciation of science. The values of certain sites in Muara can be delivered in written information or illustrations framed on the panels that pointed the natural sites.

“This geoarea is the center of the supervolcano eruption around 74.000 years ago. After the massive eruption, the current Toba landscape was formed up until now ... Each geosite has specific physical and chemical nature.” (Key informant: geologist)

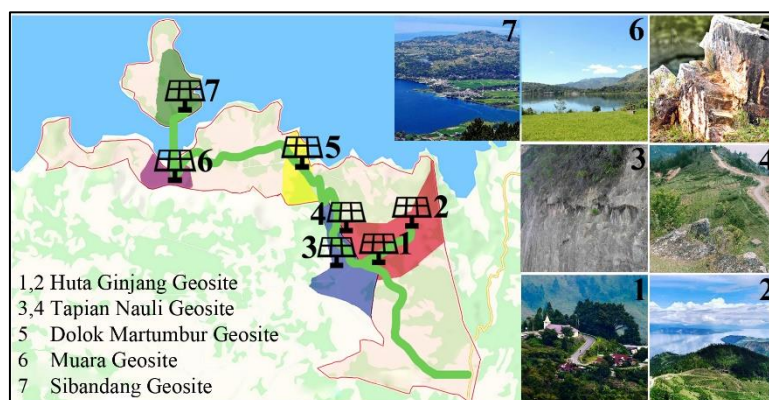


Figure 3. Panels placement for geotrail in Muara, North Tapanuli, Indonesia

In this geotrail, the first panel can be placed in the node before Huta Ginjang, containing information about the geological attributes of Huta Ginjang *plateau*, continued by the second panel in the top of Huta Ginjang, informing the visitors about the classification of *geoareas* for the wide visualization from this peak. The third and fourth panels is in Tapan Nauli, pointing the significant geological evidence of the Toba eruption as proven in the *colored nonwelded stones* and *volcanic breccia rocks*. The fifth panel can be put in Dolok Martumbur *metasediment*, and the sixth is in Muara shore carrying

information about *pardepur dacitic dome*, followed by the seventh panel in Sibandang, telling the visitors about the land formation after the supervolcano erupted. All these panels are integrated into the natural environment of each geosite to simplify the visitors' interpretation processes also to balance the nature of the sites.

4.2. Viewpoints for geotrail in Muara

Viewpoints are the feature in a geotrail that can make geosites more attractive because of natural sceneries. The epic scenes are transferred through beautiful panoramas in the sites that can increase the potential of the site. In addition, the purpose of viewpoints is to catch visitors' attention so that they can experience the geosites through the beauty of the landscapes.

"People often visit this place to see the panorama, either domestic or international tourists, they wish to look around Toba, sometimes they use our boats ... What makes this place special is the open nature and everything looks very close." (Key informant: accommodation provider)

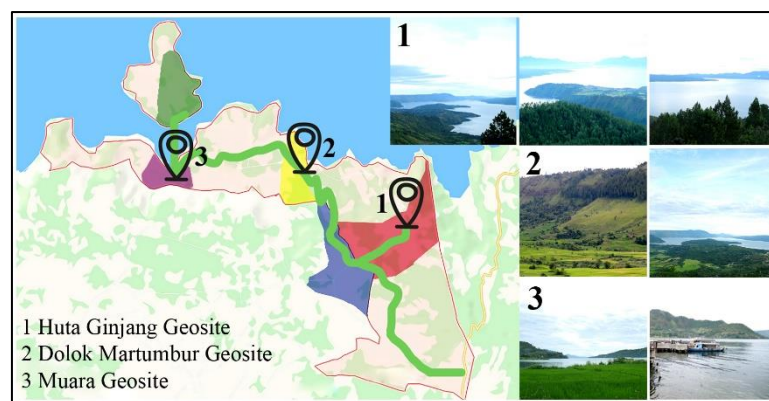


Figure 4. Viewpoints placement for geotrail in Muara, North Tapanuli, Indonesia.

In this geotrail, there are several viewpoints potentials, considering the aesthetic values of natural attraction. The first viewpoint is in Huta Ginjang. Since its position is in the highest peak, it naturally brings different panorama visualization with quite a few interesting perspectives, such as views to Sibandang, Samosir, and Tarabunga around the Toba Caldera complex. Moreover, hilly sides, pine forests, and water in the bottom are interesting features to be seen. The second viewpoint is Dolok Martumbur, considering its position that makes the water looks nearer and the caldera's walls that can be seen from this point. The third one is in Muara port, as it is the closest point to the water and surrounded with villages and rice fields. All the viewpoints have special identities that are needed in geotourism [15], as they strengthen the geographical character of the destination [26].

4.3. Stops for geotrail in Muara

Stops are utilized to strengthen the character of geosites in the trail, which means natural sites can be supported with other complementing facilities, such as museums, visitor centers, thematic areas, etc. [20]. These facilities can help visitors' interpretation regarding to the geological features. However, for the geotrail in this study site, natural attractions followed by supporting landscapes are dominant. Therefore, the stops can be translated into several activities for visitors with certain interests, because activities provided within a trail can enhance the potential in a geotourism destination [27]. Apparently, by considering the natural attractions, stops can get along with viewpoints. However, viewpoints with limited space are not adequate to be stops. In this geotrail, stops are placed in a few big points only and are made from built attraction with both aesthetic and economic values. Furthermore, the benefits given from stops in beautiful sites can improve the economy of the people.

"The beautiful view is what makes people visit this place, however, tourism is still not our income priority ... But I think geotourism fits best for us, since we have our natural attraction as the resource." (Key informant: community leader)

"All we have here is knowledge about earth science, as it is also marked in the history. This kind of education is what we need to sell to the world." (Key informant: government officer)

The first stop within this trail is Huta Gintang, as the land is suitable for picnic and the wind around are good for paragliding activity. The second stop is Muara, as the port is good for resting and the nature surrounded by water is good for kayaking or canoeing activity. After visitors reach Sibandang that is separated by water, the third stop can be placed there as it is appropriate for swimming and mango-picking activity. In these stops, people can provide several services to develop their economy, such as selling foods, renting activities' equipment, offering plantation products, etc. Through the utilization of stops in the geotrail, it can be assured that visitors spend more time to interact with the geosites. As a result, visitors will be able to achieve the highest interpretations from a geosite, for the main objective of geotourism is appreciation and interpretation of earth-heritage [28].

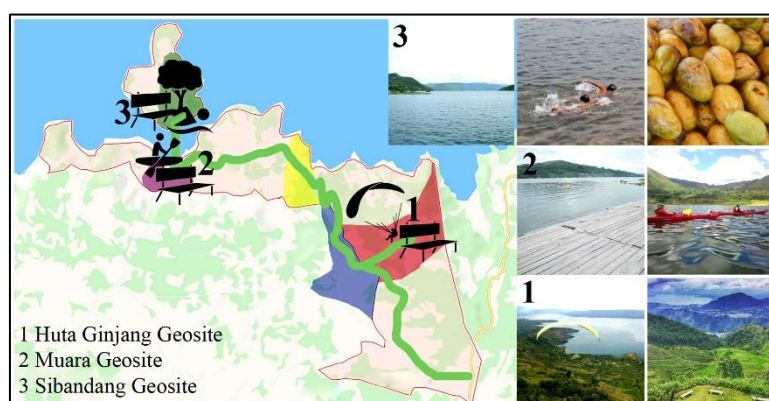


Figure 5. Stops placement for geotrail in Muara, North Tapanuli, Indonesia.

4.4. Timeline for geotrail in Muara

One of the strategies to link and interpret geosites is by following their chronological orders. However, the accessibility component such as main roads is also important. In this geotrail, there is only one road that connects the geosites. On the other hand, if the entire periodical rules of each geosite were followed, the efficiency of the trip for the visitors is lessened since they need to move back and forth, since the geosites' positions are not linier.

The first geosite *plateau* in Huta Gintang and the second *colored nonwelded rocks* in Tapian Nauli were formed 74.000 years ago, while the third *volcanic breccia* in Tapian Nauli is approximately 250.000 years by age. The oldest is the fourth geosite, which is the 2,5 million year-old ancient *metasediment* Dolok Martumbur. The walk downwards are the youngest geosites of Muara and Sibandang which were formed 35.000 years ago, apparently after the supervolcano eruption finished, proving that the geological activities were continued producing evidences. During the way, the disordered positions of the geosites make it hard to follow the time rules.

Since the main road does not connect every position of the geosite accordingly, the trail cannot be built upon the age of each geosites. Nevertheless, it is still possible to build the linkage based on the existing road, since the geosites themselves have certain histories to be interpreted and the visitors can understand the stories from each geosite through the support from panels as one of the geotrail elements as well.

"This geoarea has several types ... volcanic ashes stones, produced by the eruption 74.000 years ago, there is also 250.000 years basic ancient rocks ... on our way downwards, we will see the oldest rocks

in Dolok Martumbur, covered by volcanic materials ... the last and the youngest is Sibandang, which was formed after the eruption around 35.000 years ago.” (Key informant: geologist)

“The geosites starts from Silangit, we continue downwards, then we will step into Huta Ginjang, followed by Tapian Nauli, Dolok Martumbur, and finally we will arrive in Muara. If we sail across the water, we will reach Sibandang. That’s the track.” (Key informant: geologist)

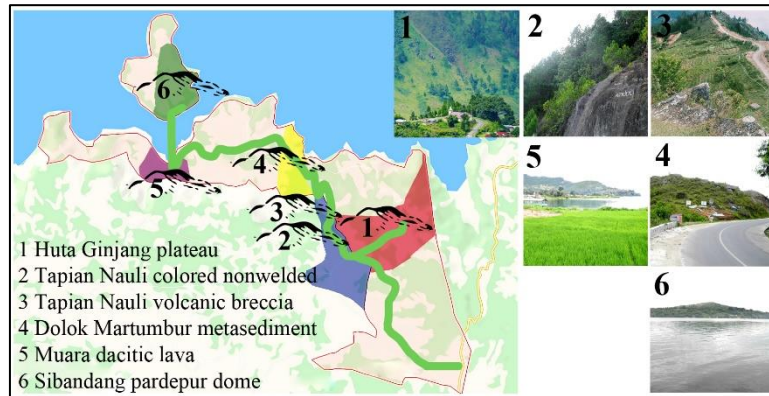


Figure 6. Timeline for geotrail in Muara, North Tapanuli, Indonesia.

4.5. Geotrail concept in Muara, North Tapanuli

Following the previous discussions on geotrail development based on geotourism attractions through panels, viewpoints, stops, and timeline as the interpretative tools, the geotrail concept is concluded to unify those elements mentioned. After all, within a geotrail, panels, viewpoints, stops, and timeline are utilized in forming a certain tour. The tour routes in this geotrail depends on these following (1) geosites’ presence, (2) basic infrastructures such as airport, harbor, and trans-road, and (3) duration of each route that connects the geosites.

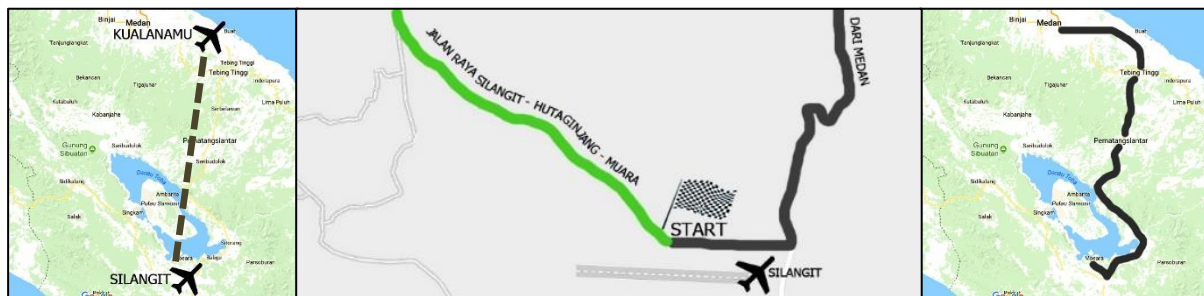


Figure 7. Access to Muara, North Tapanuli, Indonesia.

To begin the tour, Muara in North Tapanuli can be reached by two alternatives, be it (1) 45-minutes flight from Kualanamu Airport in Medan to Silangit Airport in Siborong-borong, or (2) 7-hour drive through the route Medan – Tebing Tinggi – Pematang Siantar – Parapat – Balige – Muara. Meanwhile, the only entrance for the geotrail is Silangit – Muara main road and it approximately takes 5,5 hours to complete the trail, from the starting point in Silangit – Huta Ginjang and continue upwards until the endpoint in Muara – Sibandang.

In addition to the tour, setting up panels and establishing viewpoints by obeying the placement rule for each element are essential to develop the geotrail. Furthermore, making built elements arranged with supporting activities in stops that facilitate visitors with certain interests on earth-based tourism such as paragliding, kayaking, and swimming will complement the dominant nature of Muara for a compact geotourism destination.

Table 2. Tours within the Geotrail in Muara, North Tapanuli.

<i>Route</i>	<i>Transport</i>	<i>Duration</i>	<i>Total</i>
Silangit – Huta Ginjang Geotrail elements to explore: panels, viewpoints, stops	Driving	15 minutes driving 90 minutes sightseeing or paragliding	105 minutes
Huta Ginjang – Tapian Nauli Geotrail elements to explore: Panels	Driving	10 minutes driving 20 minutes appreciating geosites	30 minutes
Tapian Nauli – Dolok Martumbur Geotrail elements to explore: panels, viewpoints	Driving	15 minutes driving 30 minutes sightseeing	45 minutes
Dolok Martumbur – Muara Geotrail elements to explore: panels, viewpoints, stops	Driving	10 minutes driving 60 minutes sightseeing, resting, or kayaking	70 minutes
Muara – Sibandang Geotrail elements to explore: panels, stops	Sailing	15 minutes sailing 60 minutes sightseeing, swimming, or mango picking	75 minutes

Below is the finding of the geotrail concept in Muara, North Tapanuli, by considering the values of its primary geosites covered in tourism attraction components. Generally, the trail encompasses all five geological sites in Muara. However, not every site indicates significance in all geosite values. From this work, it is obvious that geotrail in Muara is dominant in natural attraction. Therefore, the major connecting components for the trail is its nature, such as geosites, waterfronts, and landscapes.

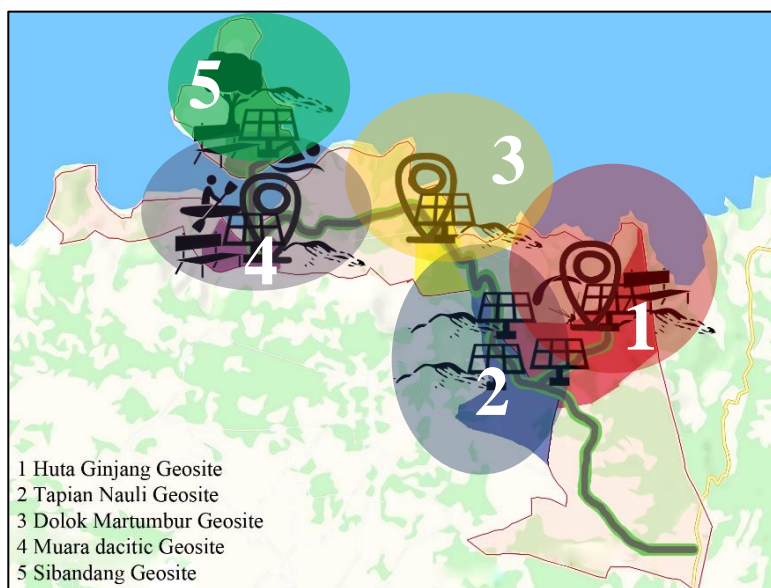


Figure 8. Geotrail concept in Muara, North Tapanuli, Indonesia.

Raising a geotrail concept that considers heritage from both earth and people by linking geosites in lands and waters will promote geotourism development and sustainable tourism in particular [29]. It is reflected in the concept for Muara’s geotrail, since the natural form of the area consists of land and water, the geotrail development has considered the convenient elements, so that the concept is born.

5. Conclusions

Geotrail in Muara is diverse in geological features, no wonder that the primary resource of Muara is the geosites within. These features are now known as geotourism potential that were figured out by observing the values of each geosite under the tourism attraction components. For geotourism development in Muara, nature is the most promising aspect, as it is also complemented with scenic

landscapes. Admittedly, scientific and aesthetic values are the most influential components within the natural attraction, implicating the utilization of panels, viewpoints, stops, and timeline as the geotrail elements that mostly accommodate those two values as measurements. Considering the discussion on each elements, coherently, the geotrail elements namely panels, viewpoints, stops, and timeline are adequate to propose the geotrail concept through the route of Silangit – Huta Ginjang – Tapian Nauli – Dolok Martumbur – Muara – Sibandang in a round trip with natural setting. However, to put more strength in Muara's geotourism potential, it is suggested to enhance cultural and social elements in the community, so that visitors can enjoy both the nature and the people. Moreover, continuation research on geotrail design for certain elements such as viewpoints and stops are needed to comply this work. Another sides of the Toba Caldera are also recommended to be explored further to find their hidden potential for geotourism development in the entire impacted areas of the Toba supervolcano phenomena.

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References

- [1] Crouch, G I 2007 *Modelling Destination Competitiveness: A Survey and Analysis of the Impact of Competitiveness Attributes* (Australia: CRC for Sustainable Tourism Pty Ltd)
- [2] Middleton, V T C, Fyall, A, Morgan, M, Ranchhold A 2009 *Marketing in Travel and Tourism* (Slovenia: Butterworth-Heinemann)
- [3] Zaei, M E and Zaei, M E 2013 The impacts of tourism industry on host community *European Journal of Tourism Hospitality and Research* **1** (2) 12 – 21
- [4] Ginting, N, Nasution, A D, Rahman, N V 2017a More attractive more identified: distinctiveness in embedding place identity *Procedia Environmental Sciences* **37** pp 408–19
- [5] Biagi, B, Ladu, M G, Royuela, V 2015 Human development and tourism specialization. Evidence from a panel of developed and developing countries *Research Institute of Applied Economics, Universitat de Barcelona*
- [6] Enea, C and Tănăsouli, G 2009 The impacts of tourism in enhancing the quality of life *Review of International Comparative Management* **10** (2) 347–51
- [7] Ginting, N, Rahman, N V, Nasution, A D 2017c Increasing tourism in Karo District, Indonesia based on place identity *Environment-Behavior Proceedings Journal* **2** (5) pp 177–84
- [8] Rodríguez-Díaz, M and Espino- Rodríguez, T F 2008 A model of strategic evaluation of tourism destination based on internal and relational capabilities *Journal of Travel Research* **46** 368–80
- [9] Ruban, D A 2015 Geotourism – a geographical review of the literature *Tourism Management Perspectives* **15** 1–15
- [10] Chesner, C A 2012 The Toba Caldera Complex *Quaternary International* **258** pp 5–18
- [11] Pralong, J P 2005 A method for assessing tourist potential and use of geomorphological sites. *Géomorphologie: relief, processus, environnement* **11** (3) pp 189–96
- [12] Ren, F, Simonson, L, Pan, Z 2013 Interpretation of geoheritage for geotourism – a comparison of Chinese geoparks and national parks in the United States *Czech Journal of Tourism* **006** 105–25
- [13] Wójtowicz, B and Wójtowicz, P 2016 The prospects of the development of geotourism in the area of Wadi Rum Desert *Journal of Tourism and Hospitality Management* **4** (1) 1–14
- [14] Newsome, D, Dowling, R K 2010 Setting an agenda for geotourism. In: Newsome, D and Dowling, R K ed *Geotourism: The Tourism of Geology and Landscape* (Goodfellow Publishers, Oxford, UK) pp 1– 12
- [15] Dowling, R K 2013 Global geotourism – an emerging form of sustainable tourism *Czech Journal of Tourism* **2** (2) pp 59–79

- [16] Vengesayi, S., Mavondo, F.T., Reisinger, Y. (2009). Tourism destination attractiveness: attractions, facilities, and people as predictors. *Tourism Analysis*, 14, pp. 621 – 636.
- [17] Rodrigues, M.L., Machado, C.R. & Freire, E. (2011). Geotourism routes in urban areas: a preliminary approach to the Lisbon geoheritage survey. *GeoJournal of Tourism and Geosites* 2(8). 281 – 294.
- [18] Pereira, P. & Pereira, D. (2010). Methodological guidelines for geomorphosites assessment. *Géomorphologie: relief, processus, environnement*, 1(2), pp. 215 – 222.
- [19] Kubalíková, L. (2013). Geomorphosites assessment for geotourism purposes. *Czech Journal of Tourism*, 2(2), pp. 80 – 104.
- [20] Norrish, L., Sanders, D., Dowling, R. (2014). Geotourism product development and stakeholder perceptions: A case study of a proposed geotrail in Perth, Western Australia. *Journal of Ecotourism*, 13(1), pp. 52 – 63.
- [21] Ginting, N., Rahman, N.V., Sembiring, G. (2017). Tourism development based on geopark in Bakkara Caldera Toba, Indonesia. *IOP Conference Series: Materials Science and Engineering* **180** 012086.
- [22] Newsome, D., Dowling, R., Leung, Y. (2012). The nature and management of geotourism: A case study of two established iconic geotourism destinations. *Tourism Management Perspectives*, 2(3), pp. 19 – 27.
- [23] Jennings, G.R. (2012). Qualitative Research Method. In: Dwyer, L., Gill, A., Seetaram, N. (ed.), *Handbook of Research Methods in Tourism*. Edward Elgar Publishing Ltd., Chentelham, UK: pp. 309 – 323.
- [24] Yuliawati, A.K., Hadian, M.S.D., Rahayu, A., Hurriyati, R. (2016). Developing geotourism as part of sustainable development at Ciletuh Sukabumi, West Java, Indonesia. *Journal of Environmental Management and Tourism*, 1(13), pp. 57 – 62.
- [25] Lumbanraja, V. (2012). Tourism area life cycle in Lake Toba. *Indonesian Journal of Geography*, 44(2), pp. 150 – 160.
- [26] Ollier, C. (2012). Problems of geotourism and geodiversity. *Quaestiones Geographicae*, 31(3). 57 – 61.
- [27] Burlando, M., *et al.* (2011). From geoheritage to sustainable development: Strategies and perspectives in the Beigua Geopark (Italy). *Geoheritage*, 3, pp. 63 – 72.
- [28] Allan, M. (2015). Geotourism: an opportunity to enhance geoethics and boost geoheritage appreciation. In: Peppoloni, S. & Di Capua, G. (eds.), *Geoethics: The Role and Responsibility of Geoscientists*. Geological Society, London: 25 – 29.
- [29] Errami, E., Ennih, N., Choukri, A., Enniouar, A., Lagnaoui, A. (2013). The first geotrail in the Doukkala-Abda aspiring geopark (Morocco): a tool for local sustainable socio-economic development. *12th European Geoparks Conference Proceedings*. 51 – 54.