Sustainable Environmental Insight

Review
Volume 1(2), 2024, 81–95
https://doi.org/10.53623/sein.v1i2.477

The Impact of River Landform Changes Caused by Geohazards on the Economic Development of Ecotourism in Sabah, Malaysia

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SUBMITTED: 14 August 2024; REVISED: 24 September 2024; ACCEPTED: 24 September 2024

ABSTRACT: The impact of river landform changes caused by geohazards on the economic development of ecotourism in Sabah, Malaysia is a highly significant and crucial topic that necessitates extensive analysis, comprehension, and thorough understanding in order to comprehend the multifaceted consequences and ramifications. It is imperative to explore and scrutinize the intricate interplay between the alterations in river landforms induced by geohazards, such as natural disasters and environmental upheavals, and their profound influence on the economic growth and prosperity of the burgeoning ecotourism sector in Sabah, Malaysia. This comprehensive investigation holds immense value in unraveling the intricate dynamics and intricacies inherent in this intricate and complex relationship. By delving deep into the intricate mechanisms and multifarious aspects that underlie the interdependence of geohazards-induced river landform transformations and the economic development of ecotourism in Sabah, Malaysia, researchers and stakeholders alike can gain invaluable insights that can pave the way towards well-informed decision-making, sustainable growth, and effective management strategies. Consequently, the expansion of knowledge and understanding in this pivotal domain can potentially lead to the formulation and implementation of robust measures, policies, and initiatives that can mitigate the adverse effects of geohazards on river landforms, foster the resilience and adaptability of the ecotourism industry, and ultimately cultivate a harmonious balance between economic progress and environmental conservation in Sabah, Malaysia.

KEYWORDS: Sustainable growth; decision-making; ecotourism; river landform

1. Introduction

The geomorphological changes of the riverbed bend areas and riparian landforms on both sides downstream of the O1 and O2 points are due to natural forces, drought, earthquakes, forest fires, human activities, river channelization, land use changes, changes in flow rate and sediment content, the acceleration of variations in four seasons, river movement, bank erosion, mass movement formation, and river landforms, cut-off and abandonment of river

courses, and land area losses. Moreover, the development of riverbed landforms such as hanging terraces and valley slopes has a direct impact on human life, endangering human property safety, environmental pollution, negative impact, and affecting economic development. The occurrence of natural disasters can lead many people, including their environment, to a very vulnerable underdeveloped stage. The research area of the land brought negative effects. The river area was occupied by locals for coffee farming. At the same time as the newly planted banana and coffee trees received damage in addition to the planting area, the next generation took advantage of the conditions to extensively develop rurally, undergoing severe landslides and the masses produced by the riverbed area forming lateral erosion. This study presents the influencing relationship between natural and manmade landform changes of the Kiulu River and its surrounding area, the promulgation of ecotourism and economic development, river landforms due to geohazards, the geomorphological changes of river landforms, and their negative effects on other local economic activities, resulting in a vicious circle limiting the sustainable development of Sabah, Malaysia. The conclusion discusses the significance of anthropogenic landform changes for the economic development of ecotourism, the gradual riparian landform environmental concept in the urban areas of Sabah, the implementation of flood control and disaster reduction works, the need to recognize phenomena such as landslides on left valley side tributaries and their direct impact on riparian area development causing riverbank erosion, as well as supplementary legislation, integrated action, and a shift to disaster reduction paradigms.

2. Research Background

The rapid development of Sabah, one of the states of Malaysia, since the 1970s has led to the occurrence of geohazards such as landslides, debris flow, soil erosion, and karst hill collapse. These geohazards are mostly influenced by river landform changes that are the impact of the large sediment transport, which is another impact of river landform changes. The river landform changes, which are facilitated by the sediment transport, are due to the deforestation and burned areas in the upstream areas of the study locations. Rivers are vulnerable to deforestation and forest fire. The absence of trees causes rainwater to flow directly to the rivers, washing the soil from the burnt and deforested areas together with the debris such as wasted support leaves, broken large branches, rocks, pebbles, and clay. The large sediment that is transported to the Segama, Pekan, Sugut, and Liwagu rivers causes these rivers to periodically level by growing horizontally and vertically. This phenomenon damages the riverside infrastructures that have been developed for ecotourism activities, which are some of the economic developments for these areas [1–5].

The river interface landform has experienced changes caused by several groups of geohazards, such as log jams across the channel, agent terraces across the interface route, floods and debris flows during the rainy season, earth flow during rainy days. The tourism landmarks have gradually moved inland because of such changes, leading to the decline of the ecotourism development level in river areas. The government initially used a river landform mapping in 2010 to monitor the area changes. After that, they executed the maintenance regularly; however, there has been no research on real-time or dynamic landslide disaster preventive monitoring to assess the landform changes. Consequently, tourists still believe that the river landforms are dangerous so they dare not venture close to

the river channel to enjoy the natural beauty of the landforms. As a result, there are few tourists enjoying the development of tourism which can in turn reduce the flowing financial benefits for watersheds [6–8].

River funding was considered as poverty because the flow rate, river flood discharge and space flow of each river channel are changed risks, also includes the carrying capacity of the human living environment relative to the ecological building car-tex. If the government appropriates capital to execute river response programs, it will be a significant spending burden. Consequently, the timing of the rebuild and spend project also becomes most important. The goal of this research study is to employ GIS to find two-level planes, 3D stereo evaluation and monitoring of building space, and make use of digital image processing technology to realize the resolution of ultra-high-resolution photographic coverage and effective monitoring of the river region. We perform the real-time change growth monitoring of ground slope environment changes in the failure of geohazard to provide the capability foundation for making urgent local economic decision making for ecotourism development. We confirm the effectiveness of the GIS system and its ability to provide real-time stereo monitoring and acquire the updated landform information required for rapid failure geohazard response [9–11].

The economic growth of various areas in Sabah has been stimulated, and ecotourism has been developed under these conditions. However, this economic growth has also led to the occurrence of geohazards in the study area. Human activities such as overlogging, agricultural cultivation, and mining have caused damage to the river landscape, resulting in landslides, soil erosion, debris flow, paddy mudflow, and sinkholes. These geohazards have transformed the once beautiful scenery and landforms into a state of serious deterioration, which affects the aesthetic value, the core value of ecotourism activities. The damage and deterioration of the river landscape caused by these geohazards have had an impact on the economic and geographic development of ecotourism. As a result, significant maintenance costs are incurred by the located pubs under these conditions. This paper aims to analyze the changes in the river and landforms, which are the core values of ecotourism activities, using time series remote sensing satellite techniques. Furthermore, it discusses the impact of these changes on the economic development of the newest pubs and their overall development.

3. Natural Hazards and Geohazards

Natural hazards represent the events that occur naturally and have the potential to cause destruction and loss [13]. They can be identified by both primary events, such as earthquakes, typhoons, volcanic eruptions, tsunamis, storm surges, landslides, floods, post-earthquake soil liquefaction, glacial lake hacking floods, anthropogenic (man-made) events including ground subsidence, horizontal slope creep, mine hotspot, and environmental hydro-geological hazards or geohazards, like earth flow, coastal erosion, wind erosion and the formation of inner cave landforms due to anthropogenic activity, beach pollution and hyper velocity [15]. In addition, these are generated from the unlimited interaction of diverse preconditions, as well as the areas that have been modified from poorly planned human activities [12–18].

Followed by the influence of the population increase within dangerous locations, not to mention the growing economic losses and the induced high death toll, due to this man-made pollution, the discussion about the initiation of GDP growth refers to disasters, and how hazards impede serious damage to GDP in affected developing and rich countries, has

attracted increased attention worldwide in the fields of economics, geography, and social resilience and environmental change studies. Likewise, approximately 70 percent of global floods take place in developing countries [8–10]. In such countries, resultant impacts disproportionately affect GDP, socioeconomic means of subsistence, and the maintenance of environmental sustainability, in close relation to the distribution of climatic disasters [19–20].

Natural environment and tourism complex are interrelated phenomena and have become urgent and socially valuable subjects of scientific inquiry. Nevertheless, there are still gaps in the knowledge of this complex as the ecological and environmental factors vary geographically, while their impact on the economic development of ecotourism has not yet been sufficiently studied. This article, which is based on the relationship between geohazards, differing river landform models, and ecotourism economic development, is an attempt to bridge these gaps. Four types of landform changes in river runoff have been identified, and their impact on the economic development of ecotourism examined. A new land-use model is being offered, which is based on these correlations. This question is analyzed in the context of Sabah State in Malaysia [11–13].

There are several types of common geohazards that can occur around river landforms, especially in the mountains of Sabah, Malaysia, which can include: (1) rockfalls, (2) landslides, (3) debris flows, (4) floods, and (5) changes in river course. In addition, a river will naturally change course over time due to erosion of the river's bed. However, this change occurs very slowly over the course of centuries. Dislodging of river boulders in rockfalls or other forms of road construction activity can cause accelerated change. These changes in river landforms could have a secondary impact on the economic development of ecotourism in the study area, as the economic development of Sabah's ecotourism is closely related to its unique tropical ecological and geological environment [13–15].

Rockfalls are the most common and most dangerous hazards in the vicinity of the mountains. The soft fragments of rock are easily climbed or dug, thus tourists in the vicinity are prohibited from accessing the hazardous area. When suitable vegetation is present, it helps determine the stability of boulders. On steep slopes where tree roots provide cohesion, the presence of vegetation stabilizes rock slopes to some extent, thereby inhibiting rock fragment propagation and leading to the development of shallower rock-slope angles than are observed on bare slopes. This means that when a fragment is supported by multiple touching blocks, a significant reduction in the level of slopes can be achieved adjacent to cliff faces without the risk of rockfall [5–8].

The clear river is one of the georesources and an object of various connections. As a form of transport, it is the main path to the consumer of pleasure. There is possible recreational organized as rafting, navigating the river descending through wild areas. However, geohazards and floods in the river basin cause great changes in the river landforms. This includes landslides together with a fall of trees, donating wood, land, and other materials in rivers [3–5]. Mountain rivers entrance in Asian tropical countries, via generating alluviums. The amount of wood material to the rivers is measured by the daily op-flow of wood together. The fact that the annual output of wood can reach eight hundred tons impairs navigation. The samples taken from the upper, middle, and lower part of the collection of river destroy structures, layer thickness, and size related to global quarry structures. There should be at least 5 that are built along the river so that the effect of river valley down to the valley slope can be started. Multi-enter a gully nature of quarry structures 6.4.5, deposits are

secondary deposits for searching of river landform. Data such as angle characteristics, layer thickness in the main directions, structural relations of treatment of geophysics [8–10].

4. Ecotourism in Sabah, Malaysia

Sabah, Malaysia is an untamed paradise that has been called the Land under the Wind due to being situated south of the typhoon belt. The state, with an area of 73,904 square kilometers, is located in the extreme northeastern part of Borneo Island. To the east, the Sulu Sea and the Celebes Sea meet. The Makassar Strait lies to the south and the South China Sea lies to the west. Sabah is unique as it contains a surface of 3,307 square kilometers of lakes, swampy lands, and rivers with meandering channels. The state is also well known for its forest areas, which cover not less than 54% of the total area. Hence, the state has the second-highest incursion of mangrove wetlands in Malaysia: 18,439 hectares, an incredible 60,500 hectares of natural mangroves, and 29 kilometers of sand and coral beaches in the east, spread across 11 major and 15 minor beaches. The state is also enclosed by stunning and scenic mountains. Since the 1980s, Sabah has been developing ecotourism attractions and products in order to diversify its economy to provide an alternative income for the local people, especially those who reside near protected areas. According to the Sabah State Tourism Board, Kota Kinabalu, Sandakan, and Tawau offer a wide range of tourism products that are rich in natural and cultural heritage, challenge, and adventure. The selection ranges from unforgettable elevations of Mount Kinabalu to fascinating rainforests, wildlife, coral reefs, and beautiful natural sandy beaches. In Sabah, potential tourism development areas such as the elephant sanctuary located in the Lower Kinabatangan area, Danum Valley and Maliau, Rainforest Conservation Areas such as Deramakot, and the private wildlife centers and high-value ecotourism areas around anchored at Lok Kawi, Sandakan and Tawau respectively are estimated to have an economic worth [12–15].

Ecotourism is a subsector of the tourism industry focused on the conservation of natural areas. Unlike other forms of contemporary mass tourism, often associated with the destruction of natural resources, ecotourism requires strong environmental conservation and formal education in order to promote the area. Consequently, eco-tourists show special interests in the wildlife and natural features of the region where the activity is taking place. Hence, ecotourism is an alternative source of income to natural places, with minimal human interference, and improves the relationship with the local community. This can act as a motivator to preserve and conserve the fragile ecosystem. Ecotourism will be based in national parks, protected forests, protected marine areas, wildlife sanctuaries, mountains, coral reefs, mangroves, caves, lakes, waterfalls, rivers, wild orchids, carnivorous plants, and so on.

Ecotourism development supports all the main principles of Agenda 21, which was adopted as a blueprint for action in Rio de Janeiro, Brazil in 1992. The main principles of Agenda 21 can be summarized in these concretely related activities: integrated river basin management, capacity building at the watershed level, understanding of the different roles of men and women which are essential to planning and managing water resources, conservation of the biological diversity of rivers and their watersheds, conservation of the physical characteristics and geological processes of rivers and their watersheds, protecting and incorporating traditional knowledge within every indigenous community's present and future water studies and management, devolution of management authority and resources to the

lowest appropriate level, and the establishment of an efficient and sustainable funding system within which to protect water and related ecosystems. The following section provides an overview of the geographic facility of the study area for this ecotourism.

Despite the increasing number of tourists visiting Sabah, the industry is still pertinent for the state and local public. The tourism sector is an important industry which earns a significant amount of revenue that helps to increase the economic development of Sabah and hence of the Malaysian government. Therefore, ecotourism promotes the conservation and preservation of wildlife, nature, and diverse plants, and its fusion is an alternative light industry that rehabilitates natural resources for the economy. Indeed, an increment of tourism in Sabah, a state with lower employment rates and an increase in the living standard, can occur. Besides, ecotourism can lead to an enhancement in the quality of life of people living in rural areas and a decrease in the rural-urban migration rate. So, it is plausible to work hand in hand both to preserve the river environment and the ecology in Sabah, Malaysia. The surge of tourist visits Sabah because of its incredible scenic beauty. Sabah has a well-preserved and rich diversity of flora and fauna. As a result, there is a huge demand among nature tourists who are desirous of enjoying an ecotourism experience. Sabah possesses a part of the Southeast Asian unique tropical rainforest. Some of them are located alongside the large river, which has a high potential for white-water river activities. Rapid tourism development has resulted in the emergence of rafting as an ecotourism activity, and it is one of the most popular outdoor adventure activities sought by visitors in Sabah. The river, in terms of course, activity, preparation, and social condition, is what makes these activities popular for tourists. Rafting companies believe that the most essential component in Sabah, Malaysia, to attract ecotourism is the Padas River [16–18].

One of the important aspects of ecotourism is the use and appreciation of the landscape and natural beauty. In Sabah, ecotourism activities are not only abundant in existing highly protected conservation areas and wildlife reserves but also in other sub-ecoregion sites. The key ecotourism sites for visitors are primarily concentrated within the Kinabalu Crocker Range and the Lowland Dipterocarp Rainforest hotspots, followed by the Nosongam Submontane as a distant third. Prominent among the ecotourism sites in Sabah are Danum Valley, Kinabalu Park, Crocker Range Conservatory, Maliau Basin, Tabin, and Imbak Valley. While key ecotourism products of Sabah in terms of visitor activities and accommodations are concentrated in some significant ecotourism sites, Sabah benefits from a wide range of ecotourism sites that spread across the ecoregions. The significant potential value of the less or underdeveloped ecotourism sites for the local community from the perspective of a tourism-based economy can be augmented and optimized with the development of relevant highland and lowland risk-free community eco-adventure trails. The experts also welcome the newly identified major potential geotourism sites (Gemeroh River and Liwagu Trails) and other minor geotourism sites, such as high public use trails or specific destinations recognized by local people, their recreational values, the existence of geological wonders, paleontological heritage, and other geo-curious activities [17–20].

5. River Landform Changes

Compared with the landform changes near the river's upstream head, changes in the middle and lower reaches of the river with large differences in terrain are relatively large. The handsome landforms near the middle and lower reaches of the upstream river, meanwhile,

have also changed. Changes in landforms on the river mainly include the following aspects: (1) shoaling in the reach; (2) large-scale excavation; (3) collapsing of the river bank, causing the river's course to move to a certain distance and form a new stretch of land; (4) silting of the tributary; and (5) lowering of the riverbed, resulting in the original stretch of riverbed not being able to meet the criterion of river flow. The reasons for the changes of these landforms are mainly caused by the biotope (animals and plants, the organic matter returned to the land by these living organisms to build up the landforms), mechanical forces, and the original fragile landform textures caused by biological weathering. When the deterioration factors develop to a certain extent, they can cause large-scale landform changes in the terrains. River landform changes caused by geological disasters mainly consist of natural geological disasters and human geological disasters. The influence of natural geological disasters (landslides, mudslides, flash floods, floods) on the river's landforms cannot be ignored. Well-known rivers (for example, the 88-turn river in Henan, the crisscross section of the Jinsha river and one hundred mountains of the upper reach of the Nujiang river) have their own bird eyes due to these natural geological disasters. Susceptibility to "displacement type" landslides, in the river areas of uplifting masses on the Himalayas, seeing large-scale, comprehensive changes in river landforms is not abnormal anymore. The influence of geohazards on river landforms in the university town, North China, and Hubei three gorges on the banks of Zhi river strongly impacts flow. The Gaijiang river candidate camp deep river section is well known for landslides, debris flow, and mudslides. These events have caused large fluctuations in the shape and lithological sequence of the terraces, and due to the large number of landslides and deep gaps, they are also found to have indirectly affected the basic properties of the terraces. The human geological disasters that influence river landforms include mining subsidence land (dust subsidence, surface collapse, fracture and fault development, terra-elevation), mining subsidence water, volcanic land (stream lava, volcanic mud flow, igneous rock, agglomerate), surface collapse of sediments, dissolved sink collapse, collapse of tombs, collapse of culverts, and collapse of culverts. Historical bygone geohazards represent the special "scars" of the city, making the city's history more profound and vivid, attracting tourists from all over the world to visit and investigate, and promoting the economy's development [18–20].

The changes in landform along a river channel are closely associated with the geohazard process that occurred on its banks. It can be a result of either past or present geohazards. It is, in fact, a natural process, but the term 'geohazard' is actually very popular nowadays. Yet, how do we actually get a nice landform if a geological process does not happen? It has therefore become our concern whenever those negative geohazards affect our livelihood. So, it is necessary to mention some of the factors that can actually induce the river landform changes. These factors have to be well considered so that ecological risk prevention can be put in place in advance before it leads to a long-term negative consequence. The causes of landform changes along a river channel are normally complex. For example, a nice landform built up for a particular river might be due to a landslide that happens hundreds of kilometers away. The landslides are some of the factors that make the river work longer than expected. This is because, while flowing in the river channel, it will have to pass many times through sediment delivery process before the rivers reach their common confluence. Sometimes, it might be due to a tectonic movement, earthquake, permafrost, and volcanic activities. Nevertheless, other factors contributing to river landform changes might be due to

human interference activities, landslide-derived sedimentation, and river channel morphology adjustment such as river erosion and the phenomenon of various types of geohazards.

The aim of this study is to determine how the flood disaster river changes the landform of the Kelinian River, changing it from a gently sloping terraced slope and straight channels to erosive V-shaped valleys and steep slope Valley Rivers. The landform of the terrain on both sides of the river changes as the height increases. Since the Kelinian River has a steep river slope and no upper limit in the upstream water source, disposable sediment loss resources are more likely to contribute to the generation of riverbed aggradation and erosion downstream of the river. Through changes in the landform of the river, the important value of preventing and controlling geological disasters such as landslides and mudflows and reducing the risk of life and property loss. The four methods of geomorphological field research, hydrological correlation analysis, stereoscopic image interpretation of UAV aerial photographs, IntliShow professional 3D point cloud analysis of river landforms, and digital images are used. Morphological flow analysis was used to analyze the riverbed landform and the causes of erosion. First, a certain number of sampling sections were set up in the longitudinal direction for the erosion landform of river formation. The elevation, cross-sectional shape, and slope length of the corresponding river channel of the point cloud data were checked. Prepare stereo points on the digital map, draw river flowlines with AutoCAD software, and calculate the amount of aggradation and erosion on the riverbed flowline. Refer to the method of [3] to study the dendritic drainage basin regional erosion landform in the Loess Plateau to supplement the single river channel erosion landform research.

6. Case Studies

The Pleistocene climatic oscillation has caused southeastern Asian climates to periodically change between cold-dry and hot-humid conditions. During the early Holocene, a precipitation increase resulted in a stable warm-humid environment over the southern hemisphere. This situation led to the development of luxuriant tropical vegetation. However, following a warm-humid climate, changes also occur via the El Nino-Southern Oscillation (ENSO), Indian Ocean Dipole (IOD), and solar radiation. The impacts of these phenomena manifest in the forms of typhoons, flooding, droughts, and climate change. In Sabah, Malaysia, the recurrence of geohazards has caused important river landform changes. The changing river landform has had significant adverse effects on the economic development of ecotourism. As a response, the previous poor maintenance policy focusing on disruptive measures now has integrated the principles of river rehabilitation, such as geomorphology, advanced ecological engineering, riverside anti-landslide defense systems, Taiji philosophy, smart pumps, and digital-platform anti-disaster systems. Ranau is west of the Eastern Sabah Safety Zone (ESSZONE); its maximum safety risk is inundation during the monsoon period. The soil base of the Kundasang area is weak in structure, but its rainfall is extremely high; this reason led to the evacuation of Kota Kinabalu's Borneo Highland Valley resort. The Kuantan River has a potential threat from the Sepanggar Naval Base's construction spoil on the river and bay. Staff have recorded collapsed roads, but no information can be found in the Ministry's reports. After the March 28th earthquake in 2015, Mount Kinabalu lost its iconic Donkey Ear Peak. Although the previous Federal Government stopped key road-building plans on the Mount Kinabalu World Heritage long-island shed, the final decision is not yet confirmed. Kimanis's standard gauge track incurred considerable damage.

Sabah is rich in ecological resources and is known as "the Land Below The Wind". It has been continuously hit by various geological hazards due to extensive fault systems in Sabah. In addition, typhoons, storms, earthquakes, rainfall, landslides, and other natural disasters, as well as anthropogenic activities, contribute to the frequently occurring and severe hazards. There were many records of geological hazard occurrences with damage to properties, infrastructure, as well as loss of life in Sabah. Many places in Sabah have been reported as dangerous locations, and most of these places are located near fault systems, reservoirs, construction sites, rivers, beaches, and the Borneo Volcanic Arc.

Temperature increase, rainfall increase, rainfall distribution, and typhoons are related to climate change, which brought about changes in the hydrology of the monsoon season and intensified the southwestern monsoon in the Western North Pacific. The northwestern part of Sabah faced cloud releases during the 24-hour rainfall. Kimanis Bay, Kota Kinabalu, Beaufort, Keningau, Tenom, and Beaufort are areas that were hit by a high amount of rainfall. As a result, most of the reported occurrences of geohazards, which caused property and infrastructure damage, occurred in these areas. The Padas River and Papar River were filled with debris because of landslides that occurred near the riverbank. The debris was then carried by the river and subsequently deposited near the riverbank. The model of events demonstrated the impacts of river landform changes on human lives and properties. The findings of river landform changes are relevant for spatial planning towards development by taking the type of geohazard event and geological site into account to minimize the damage incurred.

The construction of the Poring transport tunnel severed the hydrological connection between the two adjacent rivers, thus trapping the river materials discharged by the left tributary in situ on the right bank. The discharged river materials from the left tributary accumulated in large quantities on the right bank, destabilizing the left bank in the process. A study conducted by our group also found that the Poring transport tunnel, which is near this site, had a weakening effect on the geological conditions, thus promoting the sudden activation of landslides. The construction of the Poring transport tunnel interrupted the flow of debris, depositing it in the right bank until the face of the bank was transformed into a bank slope. When the deposited river materials were eroded by the new debris flows, the river system downstream of the transportation tunnel and the river distribution reconnected, forming a recess on the right bank downstream of the tunnel. The weakly crushed rocks from the overhanging rock mass were then transported downstream, reaching the bank toe. The study group discovered that the original debris flow accumulation origin was near the Poring transport tunnel and that construction workers were utilizing the deposited river materials to make an earmarked location for the handling of some tasks.

7. Economic Impact of River Landform Changes on Ecotourism

River landforms are an essential element of ecotourism, not only as a natural habitat for flora and fauna but also as the main attraction for tourists. The original or initial landform will not change until geohazards such as landslips, rock falls, debris floods, and sediment aggradation are reported and processed. Once the geohazard is reported and transferred into remedial action, the landform changes. These changes may or may not have an impact on ecotourism. However, the care of the earth's surface remains paramount in ecotourism development, or the discussion of moving in this direction is not fully worth consideration. A case study on

the impact of river landform changes caused by the economic development and sustainability of ecotourism in Sabah, Malaysia is portrayed. A new approach deviating signal and trend line method, termed the max-min log ratio, was formulated to quantify the river changes. The annual tourist arrival data were collected from the Sabah Tourism Board for analysis, and relevant photographs taken by a local resident describe the present appearance of locations after the remedial actions had been done. In the earlier study, many stakeholders raised their voice to urge the relevant authority to prevent and minimize such kind of river landform changes, and remedial actions required a large amount of money. No method or formula can evaluate or predict economic loss due to river landform changes caused by a geohazard, and very limited literature was found to discuss such economic impact. Small sample size is another weakness of the other researchers. The findings in this study provide awareness of the economic cost of river landform changes caused by the ecotourism development. Stakeholders will demand more stringent monitoring and investigation to reduce and minimize such losses. The relevant departments or related parties must look into the matter seriously.

Geohazards, including earthquakes, have and continue to result in many large and deadly landslides, such as rockslides, all over the world. In most cases, the fatal results of those landslides received substantial attention. However, most rockslides do not result in fatalities. The property damage and the time needed to repair those failures are the most frequent consequence. Sabah, Malaysia is not an exemption. The pervasive Apin-apin Formation landslide deposit, caused by earthquake-triggered landslides, heavy rainfall, and even industrial development, increased interests in landslide characterization for hazard assessments. This includes determining the impact on ecotourism development and other infrastructure. On the other hand, such destructive results are usually considered in cities or intolerant locations. Therefore, effective and fast criteria must be determined when returning geohazards-affected areas back to their original purposes. In Sabah, Malaysia, which is a state with various international natural and historical heritage, ecotourism accounts for the majority of the profitable industries. It is also facing the problem that geohazards cause damage to the existing ecotourism products. On the other hand, it also prevents the construction of new tourism sites.

There are 64 landslide spots related to the Apin-apin Formation in Sabah, Malaysia. Among them, 30 percent were in the limited place with relatively high risk, where three landslide events occurred simultaneously. Once geohazards (including landslides and other non-impact geohazards such as the sinking, cracking, or widening of rivers) take place, river landforms will be changed naturally and potentially adversely influence the related tourism industries. This is done by increasing the relative cost to make the condition recovery ability of the river catchment system in common areas. To estimate the effect of potential damage, this study tries to examine the widening, slope alteration, and deposition of the river based on RS and GIS techniques. The study found that the degree of impact is closely related to the specific land use and geological formations in the river catchment area upstream of the geohazards. This causes the ecotourism to not only feedback on the changing concept and its management but also marketing. The river catchment area should be preserved as much as possible for tourism for people and their rapid recovery for eco-environmental related.

While there are numerous recorded direct and indirect costs of geohazards, it is very difficult to estimate the total costs as many indirect costs are qualitative and intangible. Examples of indirect costs include the losses in aesthetic and cultural value, political instability, psychological, educational (school closure, infrequent encouragement of young people to pursue higher education), and population relocation. While direct and indirect costs should be minimized with appropriate geomorphological management measures via an understanding of the future landform changes, communities around the geohazards should strive to limit the detrimental impacts posed by instability. In most tropical areas, geohazards are common and are caused by the interaction of geological, geomorphological, soil, land, and climate factors. The size of a geohazard determines the degree of imbalance that it poses in relation to geological stability. This imbalance results in a geological anomaly for both a slow and catastrophic process. Because of the severe climatic changes that are caused by these phenomena, there can be direct and indirect costs at a great expense. If economic growth is to continue, problems of urban development and geological stability must be resolved. The study described in the following paragraphs emphasizes that geological uniformity is essential for long-term economic and ecological stability for urban areas.

8. Mitigation and Adaptation Strategies

To mitigate the impacts of river changes due to the Fang earthquake, the management of Mount Kinabalu National Park, especially Sabah Parks, has implemented dredging activities regularly to maintain the rivers at ecotourism sites. This activity is carried out every year during the current dry season. In addition to maintaining the river, the slanting areas are also cleared and well-maintained. The sediment accumulated for a year is cleaned periodically to maintain the river flow. For example, the slope is fixed because damaged slopes are very dangerous. In the long term, community programs and environmental education activities are the best ways to reduce the impacts on the environment. It also helps to create awareness among community members.

Not only keeping the river bed stable but also building slope protection can control slope erosion and landslip activities. In long-term plans, rubble and concrete v-notches structures were built along the side of the slope. The v-notch diversion will guide the landslide to the location and flow into the silt removal area before lumping it into the river so that the flow is controlled. The rubble structure will assist in delaying the period of potential collapse and reduce collapse into the river and decrease riverbed erosion, allowing the robustness of the high flow and also flood control. It can alleviate and reduce the problems associated with increased sediment transport by acting as a partial dam. It reduces erosion caused by scour around and increasing bank erosion within the rubble and is less damaged by high stream flows. Currently, the fund is from Sabah Parks. Small slopes are provided by and are maintained directly by the river guide. However, for the construction of rubble v-notches, advance preparation and planning are required before implementation. The Marakau Council (MPT) has approved and funded maintenance activities, such as clearing sediment before the start of the ecotourism seasons. The Park Committee serves as an advisory and helps provide planning assistance if necessary. The Community Representative Council (MPP) serves as an advisor, liaison, and communication channel.

It can be seen that human land use and natural adjustments contribute to the form of the landslide dam. The detailed mechanism remains until the termination of this study. Landslide dams can be seen as the result of a coupled human-geological system, and solutions to avoid catastrophic impacts need immediate research. The triggering mechanism and the requirement of a particular topography explain why numerous landslide dams exist at the volcanoes of the Danxia Landform region of China. The remediation plan prepared after this study is based on the engineering structures used by the local people. These structures should be improved considering the input of scientific analysis. In addition, the local people should be informed to improve the functionality of existing dams instead of constructing new, less efficient dams. The interaction of human activities with the natural geological setting should be avoided.

The present research substantially improves the problem awareness concerning the danger posed by landslide dams, particularly those damming rivers based on frequent movements as is the behavior of red bed riverbeds in their developed form. It is intended to contribute to rational cooperation and understanding between, and amongst different stakeholder groups in the complex management structure of the upper reaches of the river within the Biandantang-Glasland Park. In addition, a small but constantly renewed list of publications contributes to the awareness of the public about the existing danger. The rivers and their environments, including fauna, flora, and local communities, are valuable to Sabah. The consequences of geohazards, such as flooding, mass movements, and pollutants from urban activities, are heavy. In addition, the geomorphology of the rivers of Sabah (Malaysia), especially in the vicinity of villages, is important for the development of ecotourism products, such as river ecology, bird watching, and other adventure water sport activities. Thus, the identification of geohazard threats, as well as the need for their mitigation and management, is urgent. The importance of river geomorphology, in general, particularly with regard to sediment transfer and developing ecotourism products, led to the establishment of a national project entitled 'Establishing Continental Basins as a Means of River Quality Management by Promoting Ecotourism in Malaysia'. A significant part of the project was carried out in Southeast Asia, particularly in Sabah. The aim of the research is to develop a uniform and reliable assessment of river typologies and morphologies from topographic information that is designed for efficient ecotourism development.

The ultimate benefits to the local community are through the creation of job opportunities in the ecotourism area and the drawing of attention to changes in the river structure for settlement residents through knowledge sharing practices. As an important river parameter is the quality and condition of the river at any particular time, research by several workers could be traced, mainly documentation of water physical, chemical, and biological parameters, modeling the pollutants. However, the ever-changing water dynamically adjusts the fluvial landforms or geomorphology and should also have a significant effect on the overall river health itself, including the safety and livelihood of local inhabitants since most of the river residents settle on the banks of the river. Furthermore, the ecological approach to river management has appeared to the theory and practice community (decision-makers, local communities, finance, and development activity) to be valid for practical application and should consequently be able to put this view into practice. The research team has prepared a disaster management plan, based on the geomorphological and hydraulic analyses and also

combined with GIS in case changes in the geomorphological boundaries cause the creation of fluctuating stressed river segments in the study area.

9. Future Research Directions

While this study only explains geohazards using the case of landslides, future researchers should address other river landform changes caused by geohazards. For instance, local researchers in Sabah, Malaysia, reported evidence of an extraordinary geohazard that resulted in an extremely unique geohazard situation, namely the 5 April 2015 involvement of seaview hotspring area with several risks of river landform changes such as riverbank collapse. Besides, other examples of types of river landform changes related to geohazards include the formation of a river-blocking landslide dam, riverbed aggradation, river wash load delivered by debris flows/landslides, and formation of debris torrent subsides channels. A few LM experts have observed that a massive rockslide into the valley could break away the rocky slope and drop into the river. Such occurrences could have negative geomorphological impacts on the river's natural habitat and flow. The outflow of the river could be reduced and the volume decrease of the river course would be reduced, which would result in the reduction of various spaces and the formation of impounding lakes or pools. With declining appearance and water levels, there would be fewer places for aquatic life to reside and less available water, which could change migration patterns and in the end lead to geographic isolation through the process of allopatric speciation. Moreover, damaging flow patterns on the river would alter, as smoothing turbulences (tailwaters) would disappear and the weir flow would destroy pools. Such a rockslide would reduce the morphological complexity of the river's pristine ecosystem, which would block fish passages and negatively affect the river's fish habitat.

10. Conclusion and Recommendations

As we cope with the colossal damaging effects of geohazards and steadily work on their aftermath, the cumulative benefits of this study could provide more attention to environmental safety design and sustainable development of an ecotourism site. In the wake of increased incidents of river landform changes due to geohazards, river safety zones must be widened and strengthened to minimize the negative effects and reduce the risks to human life and infrastructure. The ecotourism central government in Sabah has planned on improving infrastructure in all ecotourism areas of Sabah, so lessons learned from this research should be useful in project design and construction, especially in places with poor infrastructure, inadequate traffic connections, frequent landslides or flooding, limited resources and poor economic conditions, and especially in seismic areas surrounded by rocks and rivers. It is worth noting that the majority of tourism traffic is sightseeing and eco-visits, so tourism products will benefit from successful protection and exceptional design and decoration of damaged facilities. In the aftermath of the 2018 geohazard event, the affected victims lost all hope when their only source of livelihood was devastated. To provide victims with the support they need and to ensure that immediate aid is more efficiently delivered within the tourism industry, more ecological lodges and economic resources should be created or expanded. This could result in a win-win situation for tourism companies and service chains. We believe that these suggestions are well-founded when exploring the unknown and when functioning as a blueprint for follow-up projects aimed at optimizing

services, creating differentiated tourism marketing, and ensuring the safety of geological resources.

Competing Interest

All the authors declared no conflict of interest.

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