JOURNAL OF EARTH SCIENCE AND GEOMATICS INDONESIA
Volume 2 (2026), Page 17-34, E-ISSN 3163-9763

Economic Losses from Flood Disasters in Strategic Tourism Areas in West Lombok Regency (A Case Study of the 2021 Floods in Batulayar District)

Vusva Pandini [1], Joko Sujono [2] and Dina Ruslanjari [1]*

1. Departement of Disaster Management, Graduate School, Gadjah Mada University, Central Java, Indonesia
2. Departement of Civil Enginering, Faculty of Engineering, Gadjah Mada University, Central Java, Indonesia

*corresponding author: vusvaindah@gmail.com

Received: April 23, 2026
Revised: July 22, 2026
Accepted: August 20, 2026
Published: November 10, 2026

Citation: Pandini, V. (2026). Economic Losses from Flood Disasters in Strategic Tourism Areas in West Lombok Regency (A Case Study of the 2021 Floods in Batulayar District). Journal of Earth Science and Geomatics Indonesia, 2, 17-34.

Copyright: © 2026 by the authors. Submitted for possible open access publication under the terms and conditions of the Creative Commons Attribution (CC BY) license

Abstract

Batulayar Sudistrict designated as a strategic tourism area in West Lombok Regency has a flood-prone area of 1,366.82 ha and accounts for a dominant 98.83% of total tourist visits at the regency level. This study employs a mixed-methods approach with descriptive analysis, while economic loss estimates were calculated using the ECLAC (Economic Commission for Latin America and the Caribbean) methodology, which systematically distinguishes between direct losses resulting from physical infrastructure damage and indirect losses reflected in the decline of economic activity in the tourism sector. Based on the analysis, the study shows that the December 2021 floods affected all nine villages in Batulayar Subdistrict with the highest impact concentrated in the villages of Batulayar Barat, Meninting, and Sandik, affecting a total of 10,519 people. The total calculated direct economic losses amounted to Rp 3,223,696,500, while indirect economic losses were recorded at Rp 1,368,797,845. Recommended mitigation strategies include structural interventions such as the rehabilitation of drainage systems, bridges, and affected housing, as well as non-structural interventions through the implementation of disaster-risk-based spatial planning, the integration of disaster risk reduction principles into Regional Spatial Planning documents and the Regional Tourism Development Master Plan, reinforced by a participatory approach and integrated cross-sectoral coordination.

Keywords: Flood; Tourism; ECLAC

1. Introduction

Natural disasters are becoming more frequent and intense as the world climate changes. Global climate change has intensified Hydrometeor-

ological disasters such as excessive temperatures, heavy rainfall, and flooding (Salman & Li, 2018). Extrem storm events have significantly increased flood frequency in response to global warming, as evidence by major disasters around the world, including the 2011 Thailand flood, the 2013 Elbe River flood in Germany, the extreme rainfall event in Henan, China, in 2011, and the catastrophic Pakistan flood of 2022 (Wu et al., 2023). These occurrences are supported by severe flood events caused by extreme weather conditions, such as those observed in Central Europe in 2021 and the significant storm that struck Zhengzhou, China on 20 July 2021 (Yu et al., 2022). The 2011 Thailand flood case is a vivid example of the resulting macroeconomic devastation, with economic losses from business disruptions in the industrial and service sectors totaling USD 14.7 billion. The cumulative impact of these indirect losses reduced Thailand GDP by 4.81%, resulting in a massive total loss of USD 55.3 billion (Tanoue et al., 2020). Such phenomena offer significant challenges to the vulnerability of several sectors, including tourism.

Tourism is a sector that capitalizes on the diversity of natural and cultural resources, which are key factors in determining the attractiveness of places. It is one of the fatest-increasing sources of national income and foreign cash and is commonly recognized as one of the main sectors expected to grow in the third millennium, behind telecommunications and transportation (World Travel & Tourism Council, 2019). However, the appeal of tourism destination is not solely determined by its attractiosn, it is equally influenced by natural conditions, including weather patterns and climate change (Berrittella et al., 2004). As a result, the tourism sector is especially susceptible to losses caused by disasters such as flooding, which may result in decreased tourist arrivals, facility damage, and sifts in visitor perception, all of which contribute to decrease in visitation (Rittichainuwat, 2006).

Indonesia, as an archipelagic nation situated at the convergence of three active tectonic plates, faces a compratively elevated risk of natural disasters, including floods (Dematoto Argyo, 2019). This conditions presents a distinctive challenge to the development of the national tourism sector. West Lombok Regency is an internationally recognized tourism destination, strategically positioned between Komodo Island to the east, Bali to the west, and Tana Toraja to the north, a configuration that has led to its designation as the "gloden triangle" a highly advantageous geographical positioning for tourism development (Marchiavelly et al., 2012). Acording to the Disaster Risk Assessment of West Nusa Tenggara Province for 2022-2026, West Lombok Regency exhibits a high flood hazard index, with a total of five recorded flood events in 2021 distributed across nearly all subdistricts within the regency (BNPB, 2025). Figure 1. illustrates the affected areas, which include Batulayar, Sekotong, Gunungsari, Lingsar, Narmada, Kediri, Lembar, and Gerung subdistricts.

The 2021 flood events predominantly affected strategic tourism zones, areas with substantial potential for significant economic and infrastructural impacts. Regonal Regulation of West Lombok Regency Number 6 of 2016 concerning the Regional Tourism Development Master Plan 2016-2025 designates four subdistrict as strategic tourism areas, namely Batulayar, Sekotong, Lingsar, and Narmada. These four zones serve as regional tourism development centers whose primary function is to support the growth of the tourism sector. Among the most severely affected

areas was Batulayar Subdistrict. Batulayar Subdistrict functions as the primary hub of tourism development in West Lombok and demonstrates a high level exposure to flood risk. The tourism sector contribution to West Lombok Regency Gross Regional Domestic Product (GRDP) followed a pattern of pandemic-induced contraction and post-disaster recovery, accounting for 4.65% of total GRDP in 2020, dropping to 4.50% in 2021 as the sector faced concurrent pressures from the COVID-19 pandemic and the December flood event, and rebounding to 5.51% in 2022 (Dinas Pariwisata, 2025). By 2023, the tourism sector reached 17.18% in

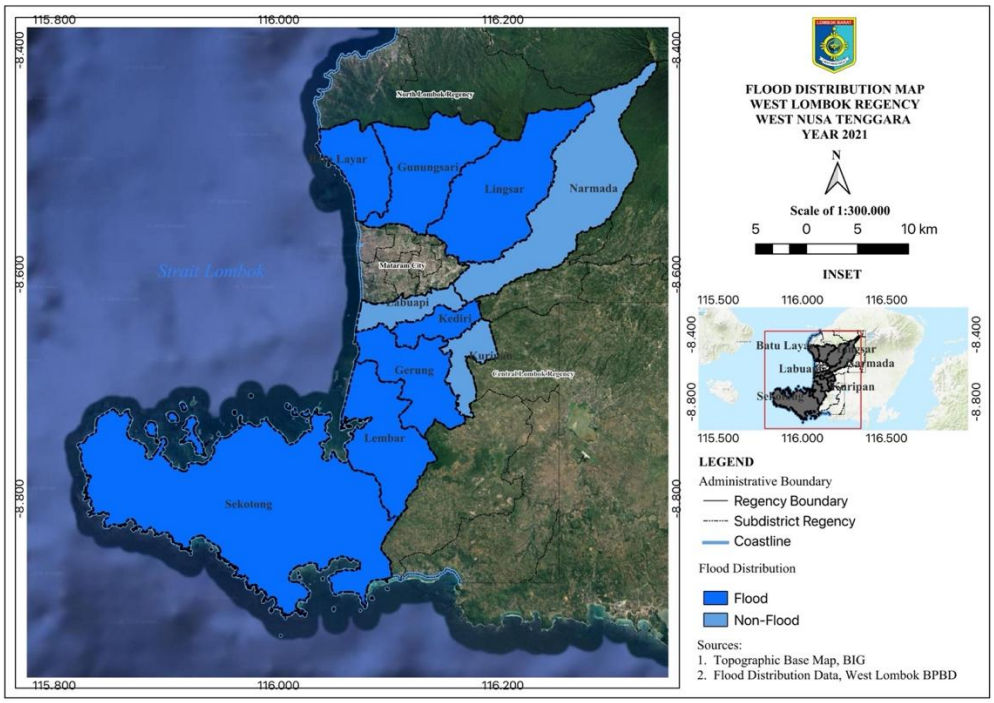

Figure 1. Map of Flood Distribution in West Lombok Regency in 2021

2023 (BPS Lombok Barat, 2024). Batulayar Subdistrict is the key development hub in this steadly increasing tourism economy, and the visitor arrival data shown in Table 1. highlight its dominant role in supporting the regional tourism sector.

Table 1. Tourist Visits to Strategic Tourism Areas in West Lombok Regency

Subdistrict	Number of Tourist Visits					
	2019	**2020**	**2021**	**2022**	**2023**	**2024**
Batulayar	391.412	131.659	165.799	285.127	259.037	432.737
Sekotong	20.161	4.362	1.270	3.882	792	6.401
Lingsar	4.890	1.778	280	156	0	0
Narmada	11.576	3.446	414	46	0	0
Total	**428.039**	**141.245**	**167.763**	**289.211**	**259.829**	**439.138**

Tourist arrival trend in Batulayar Subdistrict from 2019 to 2024 exhibited considerable fluctuation. As shown in Table 1. the number of tourist arrival declined sharply in 2020, reaching its lowest pont at 131.659 visits. Arrivals subsequently recovered in the following years, reaching a peak of 432.737 in 2024. Nevertheless, the threat of flooding remains a serious impediment to sustainable tourism development. According to the West Lombok Disaster Risk Assessment 20203-2028, Batulayar Subdistrict encompasses a flood prone area of 1.366.82 ha, with a population exposure

classified at a high risk level. The disaster potential raises significant concerns regarding the long-term sustainability of the subdistrict as a premier tourism destination. In December 2021, a major flood triggered by the Asoan Monsson struck Batulayar Subdistrict, rendering it the most damaging disaster event in the preceding five years. The flood was preciptated by heavy rainfall reaching 92 mm/day, classified as heacy intensity, which exceeded the capacity of the existing drainage system, resulting in inundation of residential areas and damage to critical infrastructure, including brideges providing access to tourist zones (BMKG, 2021; Wu et al., 2023). In addition, to extreme perciptation, poor environmental management arising form the conversion of agricultural alnd and orchards into residential and villa developments within tourism zones has compounded flood frequency by diminishing soil infliltration capacity and increasing surface runoff (Herman Rakha, 2020).

The impacts of flood disasters extend beyond physical damage to encompass both direct and indirect economic losses. Between 2000 and 2019, floods accounted for 44% of all recorded disaster events globally, causing losses estimated at USD 651 billion (Chen et al., 2022). Direct economic losses occur when assets sustain damage as a consequence of natural disasters, whereas indirect losses encompass disruption to economic activities that emerge as downstream consequences in the post-disaster period (Biardeau & Sahli, 2024). The assessment of flood-induced economic losses mat be conducted by qauntifying the value of damage to buildings, infrastructure, and other assets Bagus Adityawan et al (2024), and by integrating rainfall data, socio-economic conditions, and historical disaster records to identify the most vulnerable areas (Guo et al., 2020). The multifaceted impacts of disasters on the tourism sector also contribute to a reduction in revenue streams for those economically dependent on this sector (ILO, 2020).

To systematically quantify the magnitude of such losses, the ECLAC (Economic Commission for Latin America and the Caribbean) method has been widely recognized as a standarized approach for estimating the economic impacts of disasters. This method offers a structured framework for measuring disaster-induced economic losses, with practical implications for the formulation of risk management planning and strategy implementation across multiple sectors, including tourism (Pirngadi et al., 2024). The assessment of flood related losses in the tourism sector encompasses both direct and indirect dimension, incorporating indicators such as tourist arrivals, accommodation revenue, tourism site income, and average length of stay before and after the disaster event (Biardeau & Sahli, 2024).

A crucial methodological decision within the ECLAC framework is to categorize affected assets and infrastructure into distinct loss categories a procedure known as the clustering approach. This strategy divides damaged items into sectors (such as public infrastructure, the private sector, or the social sector) and damage severity categories (minimal, moderate, or severe). Each cluster is then assigned a unit cost and damage multiplier (Marselina et al., 2022). In practice, this strategy considerably simplifies data collection; assessors do not need to inventory and enumerate each item manually in the field but may instead link rated severity classes with standardized unit costs. However, this strategy has an inherent constraint, namely the assumption that assets within the same damage-severity cluster are sufficiently similar in value and function. While this assumption is reasonable for standardized infrastructure such as highways, bridges, or irrigation channels, it may generate systemic mistakes when applied to extremely diverse tourism assets such as boutique resorts, cultural attractions, or visitor-facing commercial premises. Unit costs for such assets vary significantly depending on their nature and quality (Toubes et al., 2021). The estimates in this study make use of damage severity multipliers from InaSafe (2023) as well as unit costs from the West Lombok Standard Building Cost Schedule. Explicitly noting where this homogeneity assumption

is most shaky, particularly with bridges, which are the primary loss cause, is critical for calibrating the data's uncertainty boundaries. By establishing these precise uncertainty bounds, assessing flood-related damages becomes a key requirement.

The evaluation of flood-induced losses constitutes a critical step in disaster prevention and control, risk minimization, and sustainable tourism development planning. Research on such losses plays an essentia role in risk management and serves as a scientific foundation for mitigation policy formulation and public awareness enhancement (Toubes et al., 2021). However, the Regional Tourism Development Master Plan 2016-2025 of West Lombok Regency does not articulate any mitigation policy framework to address future disaster threats. This policy gap may negatively affect the sustainability of tourism destination development, given that recurring flood events inflict significant losses on infrastructure, public facilities, and a broad range of social activities (Jayantara, 2020). Disaster resilient tourism planning not only strenghtens destination resilience but also fosters investor and tourist confidence in the long-term sustainability of strategic tourism areas (Becken & Hughey, 2013).

Drawing upon the preceding discussion, a significant gap exists between the eleveted flood risk confronting Batulayar Subdistrict as a strategic tourism area and the absence of a comprehensive analysis of economic losses and integrated mitigation stategies. Beyond providing an empirical estimate of flood-induced economic losses, this study improves conceptual understanding of disster impacts in strategic tourism areas by demonstrating that flood losses should not be interpreted solely as infrastructure damage but as a multidimensional process influencing destination redilience via both direct and indirect pathways. The findings show that direct losses to vital infrastructure, particularly bridges and public facilities, have a cascading indirect influence on tourist performance, resulting in fewer visitor arrivals, shorter stays, and lower tourism revenue. The interaction of physical infrastructure fragility and tourism-system vulnerability shapes tourism resilience, lending credence to this association. This study expands the aplication of the ECLAC paradigm by integrating disaster loss assessment into tourism planning and destination governance. While past research has examined economic losses across sectors, this study views critical tourism locations as socioeconomic systems in which catastrophe consequences spread beyond physical assets to tourism market performance and institutional readiness. This perspective adds to the disaster management and tourist resilience literature by offering a sector-specific loss-resilience paradigm that connects disaster impacts, economic losses, and mitigation-oriented tourism strategy. As a result, the study makes a theoretical contribution by presenting economic loss assessment as an analytical tool for understanding and increasing destination resilience in disaster-prone tourism locations, rather than only a post-disaster accounting tool. Accoodingly, this study aims to (1) identify the spatial distribution of flood affected areas within the strategic tourism zone of Batulayar Subdistrict, (2) quantify both direct and indirect economic losses using the ECLAC method, and (3) formulate flood disaster mitigation strategies for the strategic tourism area.

To fulfill the research objectives, the following portions of this study are organized in logical sequence. Section 2 describes the methodology design, which combines geographical analysis with the ECLAC economic valuation approach. Section 3 describes the empirical results, which include spatial flood hazard mapping, multi-tiered loss quantification, and strategic catastrophe mitigation frameworks. Section 3 and 4 combine these findings to address structural policy gaps and destination resilience. Sections 5 of the paper summarizes the theoritical contributions and actual policy consequences.

2. Materials and Methods

This study employs a mixed-methods approach by combining quantitative and qualitative methods. The aim is to provide a more comprehensive understanding of a phenomenon based on both methods, which are then analyzed descriptively. Descriptive analysis was used to provide a detailed account of the actual conditions on the ground. The quantitative research design involved collecting data from various relevant sources to assess the economic losses caused by flooding in strategic tourism areas, both directly and indirectly, followed by qualitative analysis to explore the impact of flooding on the operations and revenue of tourism businesses, using triangulation of sources. The variables used in this study are presented in the table 2.

Table 2. Research Variables

No	Objective	Variable
1.	Identification of flood distribution in strategic tourism areas in Batulayar Subdistrict	Flood distribution map
2.	Calculating the economic losses in the strategic tourism area due to flooding in Batulayar Subdistrict	Direct Economic Losses: 1. Damage to house 2. Damage to educational facilities 3. Damage to places of worship 4. Damage to bridges 5. Damage to retaining walls Indirect Economic Losses: 1. Tourist visits 2. Accomodation revenue 3. Tourist attraction revenue 4. Length of stay
3.	Developing a flood mitigation strategy for the strategic tourism area in Batulayar Subdistrict	1. Flood distribution map 2. Direct economic losses 3. Indirect economic losses

This study uses primary and secondary data collected from various technical agencies and tourism businesses to analyze the impact of the damage in Batulayar Subdistrict. The information used includes the extent of the flooding, economic losses, and other relevant supporting data. Details of the data requirements, along with their sources and the years they were obtained, are presented in Table 3.

Table 3. Data Requirements

No	Data Requirements	Data Source	Years
2021 Flood Distribution			
1.	2021 flood data	BPBD	2022
2.	Flood vulnerability	KRB West Lombok	2024
Direct Economic Losses			
3.	Damage to house	Disperkim	2022
4.	Damage to educational facilities	DPUTR	2025
5.	Damage to places of worship		
6.	Damages to bridges		
7.	Damage to retaining walls		
Indirect Economic Losses			
8.	Number of tourists	Dispar	2025
9.	Lenght of stay		
10.	Tourism revenue	BAPENDA	2025
11.	Impact before and after the flood	Tourism business operatos	2025
Supporting Data			

12.	Contribution of tourism to GRDP	BPS	2023
13.	Rainfall	BMKG	2025

Data processing was conducted to identify the categories of damage caused by the flood, which were then analyzed using the ECLAC method with descriptive analysis to determine the amount of direct losses resulting from the flood disaster. Data on indirect economic losses were also obtained from the relevant authorities, supplemented by data from affected tourism businesses. Quantitative data were analyzed by examining the number of tourist visits, tourism revenue before and after the flood, and the length of stay of tourists, and were then processed using the ECLAC method. This method provides a structured approach to measuring the economic impact of disasters, which has practical implications for the development and implementation of risk management strategies across various sectors, including the tourism sector (Pirngadi, Rahmawaty, Ayu, & Rauf, 2024).

The assessment of losses in this study focuses on the economic sector, specifically the tourism sector. The steps for developing technical guidelines to estimate damage and direct economic losses involve classifying the types of affected assets and infrastructure, as well as determining the value of economic losses based on the severity of damage, namely severe damage, moderate damage, and minor damage (InaSafe, 2023). The direct loss estimating technique is carried out in a sequence of systematic, replicable steps. The first stage is flood distribution mapping, which involves delineating the breadth and level of the inundation using a GIS-based overlay analysis of BPBD field reports and hydrological data from the closest rainfall station. The second stage is asset inventory and damage classification, which records the precise asset types, their pre-disaster physical conditions, and their post-flood situations. Each asset is then assigned a damage severity class (minor, moderate, or severe) using the InaSafe (2023) classification standards, which define severity based on the proportion of structural integrity lost. The third stage is the direct loss calculation. For each damage severity class, the unit replacement cost is derived from two primary references: the West Lombok Standard Building Unit Cost Schedule 2021 for structural and residential assets and the InaSafe (2023) multiplier tables for infrastructure. Based on Table 4, the steps for calculating loss estimates involve determining the affected area, the value per unit of loss, and the damage factor (Marselina et al., 2022). The equation is as follows.

Table 4. Guidelines for Assessing Building Damage

No	Indicator	**Unit Price (Rp)	Multiplies (%)		
			Low	Moderate	Heavy
1.	Public Buildings		10	50	100
	• Educational facilities	4.530.000			
	• Places of worship • Retaining walls	4.530.000			
		170.000.000/package			
2.	Bridges	**3.000.000.000	10	50	100
3.	Permanen house	3.265.000/m²	10	40	70

Source: *InaSafe and **SHST West Lombok

Based on the ECLAC method, the assessment of indirect economic losses in strategic tourism areas is conducted by comparing economic loss indicators—such as tourist visits, lodging revenue, and revenue from tourist attractions—before and after a disaster, as well as the length of stay of tourists, with the aim of carrying out better rehabilitation and reconstruction efforts to mitigate the losses caused by the disaster. Indirect losses are evaluated by comparing important tourism

performance indicators across two time periods: the pre-disaster baseline (October-November 2021) and the post-disaster phase (December 2021-January 2022). For each indication, the calculation is as follows: Indirect loss equals (pre-disaster value - post-disaster value). The assessment of indirect economic losses in strategic tourism areas is outlined in Table 5.

Table 5. Assessment of Indirect Economic Losses

Indicator	Before of The Flood (a)	After of The Flood (b)	Loss (c = a - b)
Tourists Visits			
Number of tourist visits (people)			
Length of stay (night)			
Revenue			
Accomodation revenue (IDR)			
Tourist attraction revenue (IDR)			

Source: Biardeau dan Sahli, 2024

Loss = Value Before the Flood - Value After the Flood ..... (1)

The equations used in the ECLAC Method are as follows.
Total Losses = (Direct Impact + Indirect Impact) .....(2)

To address the uncertainty inherent in ECLAC-based calculations, a three-scenario sensitivity analysis was built into the analytical framework. The provided numbers are robust due to two key uncertainty factors. In eastern Indonesia, regional construction cost premiums frequently differ by ±20% from standard price lists, resulting in roughly 93% of total direct losses for bridge reconstruction (Guo et al., 2020). Second, the duration and depth of post-flood tourist demand suppression are fundamentally unknown, with one end limited by rapid coastal recovery trajectories and the other by long-term destination-image degradation (Biardeau & Sahli, 2024; Rittichainuwat, 2006). The full scenario parameterization and findings are shown in Table 8. of the findings section.

Furthermore, the data were obtained from interviews identified and conducted using triangulation of sources to validate the data on indirect economic losses resulting from the flood disaster in Batulayar Subdistrict, which were collected from affected tourism business operators, as detailed in Table 6.

Table 6. Operational Definitions of Indirect Economic Variables

Research Aspects	Indicator	Explanation	Question
Indirect Economic Losses	Number of Tourists	What was the number of tourists like before and after the 2021 flood ?	1. How did tourists visitation patterns change from before to after the flood ? 2. What was the most significant factor influencing tha change ?
	Length of Stay	Have there been any changes in the length of stay for tourists before and after the flood ?	1. Have post-flood facilities/infrastructure affected tourist comfort ? 2. What operational challenges did you face during and after the flood ? Did they affect room occupancy rates ?
	Accomodation Revenue	How did the accomodation business's revenue	1. What was the average occupancy rate (percentage of available rooms) before and after the flood ?

Research Aspects	Indicator	Explanation	Question
		change before and after the flood ?	2. Was there change in revenue during the flood period compared to normal periods ?
	Revenue Tourist Attraction	How has revenue from admission tickets changed since the flood ?	1. Have any tourist sites been closed ? 2. What is the estimated monthly revenue (admission tickets, food, and other attractions) ?

Based on the results of the analysis identifying flood distribution and the economic losses caused by flooding, a flood mitigation strategy was formulated for strategic tourism areas in Batulayar Subistrict. This analysis process draws on the findings from the first and second objectives. Subsequently, areas with the highest levels of impact—both in terms of damage and economic losses—are identified and analyzed in depth. The findings from this analysis serve as the basis for developing mitigation strategies grounded in the ECLAC Method, with the aim of anticipating future disasters and reducing the potential for damage and losses that may occur.

3. Results

3.1 Identification of Flood Distribution in Strategic Tourism Areas in Batulayar Subdistrict

According to data from the West Lombok Regional Disaster Management Agency, the flood event occured on 5 December 2021 and persisted until 7 December 2021. Intense rainfall triggered river overflow and inundation reaching depths of 1.5 to 2 meters across several subdistricts. As documented in West Lombok BPBD, inadequate drainage capacity, combined with ongoing landuse changes was the primary cause of flooding in tourist areas and residential neighborhoods. Figure 2. shows the nine villages affected by the flooding ini Batulayar Subdistrict.

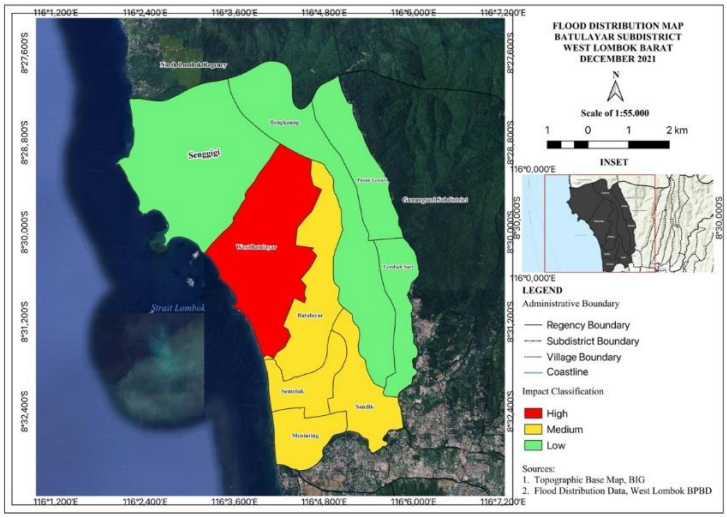

Figure 2. Flood Distribution Map of Batulayar Subdistrict

The flood affected nine urban villages, with a total 3.333 household units and 10.519 individuals recorded as impacted. A total of 1.082 people were evacuated to safer locations, among whom 5 fatalities and 8 injuries were reported. Three vilages sustained the most severe impacts, West Batulayar with 573 affected residents, 388 evacuess, and Sandik with 3.534 affected residents and 345 evacuees.

3.2 Results of the Economic Loss Calculation in the Strategic Tourism Area of Batulayar Subdistrict

Economic losses in Batulayar Subdistricts were substantial, particularly with respect to damage sustained by educational facilities and residential infrastructure. Based on data from West Lombok Regency Regional Disaster Management Agency, a total of 149 residential units were recorded as damaged as a result of the disaster. However, following field verification conducted by the Housing and Settlement Area Office, it was established that of total, 15 units sustained severe damage, 4 units sustained moderate damage, and 6 units sustained minor damage . Meanwhile, data from the Public Works and Spatial Planning recorded damage to public facilities, comprising 26 educational facility units with minor damage, 1 place of worship with minor damage, 1 retaining wall with severe damage, and 3 bridge units with severe damage. The economic losses attributable to infrastructure damage were calculated based on several indicators, as presented in Table 7.

Table 7. Damage and Direct Economic Losses

No	Indicator	Damage (Quantity)			Unit Price (IDR)	Multiplier (%)			Loss (IDR)		
		HD	MD	LD		HD	MD	LD	HD	MD	LD
1.	Permanen House	15	4	6	3.265.000/m^2	70	40	10	34.282.500	5.224.0000	1.959.000
2.	Educational Facilities	-	-	26	4.530.000	100	50	10	-	-	11.778.000
3.	Place of Worship	-	-	1	4.530.000	100	50	10	-	-	453.000
4.	Retaining Walls	1	-	-	170.000.000	100	50	10	170.000.000	-	-
5.	Bridges	3	-	-	1.000.000.000	100	50	10	3.000.000.000	-	-

Notes:

HD : Heavy Damage
MD : Moderate Damage
LD : Low Damage

The flood event also produced indirect impact on the tourism sector, although its influence on tourist arrival volumes within the area was not statistically significant. In the post-flood period, tourist arrivals in January 2022 declined to 19.218, compared to 29.728 recorded under normal conditions in November 2021, representing a reduction of 10.510 visitors. Figure 3 presents tourist arrival and revenue data for the period from October 2021 to January 2022, reflecting the declining trend attributable to the flood impact in Batulayar Subdistrict.

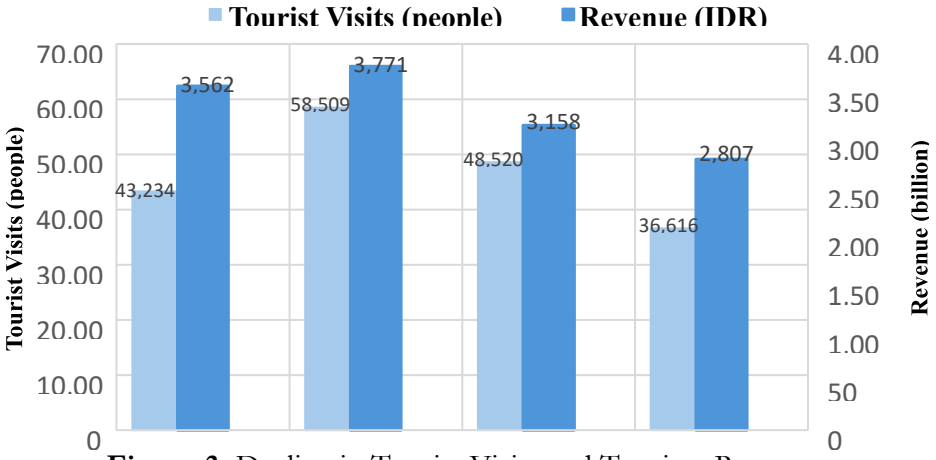

Figure 3. Decline in Tourist Visits and Tourism Revenue

Based on data obtained from the West Lombok Tourism Office and the Regional Revenue Agency, Figure 3. illustrates the decline in tourist arrivals and its consequential impact on tourism revenue. Priorr to the flood event, tourist arrival demonstrated an upward trend from October (43.2234 visits) through November (58.509 visits), before declining during the disaster period in December 2021 (48.520 visits). The adverse effects became more pronounced in January 2022, when tourist arrivals registred a significant decline to 36.616 visitors, representing a total reduction of 14.255 tourists compared to the pre-disaster peak.

Impact economic losses in the post-disaster period are not confined solely to declines in tourism revenue and visitor arrivals, but also extend to disruptions in the stability of tourist length of stay, a metric previously recorded as consistent, which may undergo significant alteration following a disaster event at a tourism destination. The stability of tourist length of stay in Batulayar Subdistrict is further elaborated based on Figure 4.

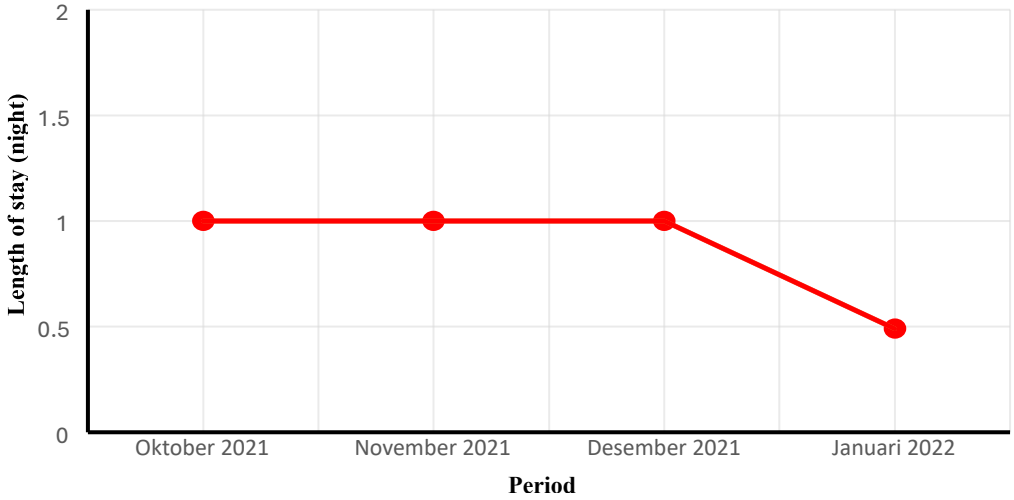

Figure 4. Decline in the Length of Stay of Tourists
Source: West Lombok Tourism Office

Figure 4. illustrates a decline in the average length of stay to 0.49 nights in January 2022, representing a decrease of 0.51 nights compared to the pre-flood period. This trend reflects a diminished interest or comfor among tourists to remain for extend durations, effectivelym the average visitors stayed for less than half a night, or merely a few hours. Such a downturn

underscores the vulnerability of the tourism sector to external disruptions, paricularly natural disasters. Table 8. presents the data concerning indirect economic losses resulting from the flood within the strategic tourism area of Batulayar Subdistrict as follows.

Table 8. Indirect Economic Losses

Indicator	Before The Flood		During a Flood		After The Flood	
	October 2021	November 2021	December 2021	Loss	January 2022	Loss
Tourist Visits						
Number of Tourists (people)	43.234	58.509	48.520	2.351	36.616	14.255
Length of Stay (night)	1	1	1	No decrease	0.49	0.51
Revenue						
Revenue Pariwisata (IDR)	3.562.404.302	3.771.098.771	3.157.882.135	508.869.402	2.806.823.094	859.928 .443

The total indirect economic losses resulting form the flood amounted to IDR 1.368.797.845. Based on the analysis in Table. 8, the values of indirect economic losses is relatively smaller than that of direct economic losses. However, given that direct loss estimates for public tourism infrastructure are particularly subject to on-site asset value variations, a thorough assessment of these uncertainty limitations is critical. Table 8 shows the findings of the sensitivity analysis for three different scenarios. Bridge reconstruction expenses are the primary driver of direct losses: three bridge units categorized as severely damaged and subject to a 100% damage multiplier account for almost 93% of total direct losses (InaSafe, 2023).

Table 8. Sensitivity Analysis of Total Economic Loss Estimates

Scenario	Bridge Unit Cost (IDR)	Direct Loss (IDR)	Indirect Loss (IDR)	Total Loss (IDR)
Pessimistic (+20% cost; 30% decline, 3 months)	1.200.000.000	3.823.696.500	2.524.422.255	6.348.118.755
Base Case (SHST; 24.4% decline, 2 months)	1.000.000.000	3.223.696.500	1.368.797.845	4.592.494.345
Optimistic (-20% cost; 15% decline, 1 month)	800.000.000	2.623.696.500	420.737.043	3.044.433.543

Note: Direct loss = (3 units x bridge unit cost x 100% damage multiplier) + IDR 223.696.500 (fixed non-bridge component).
Indirect loss scaled from base case (IDR 1.368.797.845) by ratio of (duration in months x %visitor decline) relative to base case (2 months x 24.4%).
Scenario asumption: (i) ±20% bridge unit cost per documented construction cost premium in eastern Indonesia infrastructure (Ghozali, 2011). (ii) demand recovery duration per Riitichainuwat (2006) for rapid coastal recovery and Biardeau & Sahli (2024) for prolonged destination-image suppression.

3.3 Flood Mitigation Strategies in Strategic Tourism Areas in Batulayar Subdistrict

The flood event in December 2021 resulted in substaintial losses, encompassing both physical damage to infrastructure and a decline in business revenue due to diminished tourist arrivals. Based on the research objectives an the integration of the primary and secondary findings, flood mitigation sttategies for the strategic tourism areas of Batulayar Subdistrict have been formulated. These strategies consder both structural and non-structural mitigation measures, as reflected in the ECLAC Method, and are detailed in Table 9.

Table 9. Flood Mitigation Strategies in Batulayar Subdistrict

No	Probelm Description	Economic Impact	Implications	Recommendations	Types of Strategies
1.	Damage to drainage systems and flood control structures (retaining walls).	Direct	Flooding in tourist areas, resulting in disrupted mobility.	Improvements to flood control infrasturcture, such as increased drainage capacity and the construction of retaining walls.	Structural
2.	Damage to access to tourist areas.	Direct	Decreased visitor comfort and satisfaction.	Road and bridge rehabilitation and maintenance	Structural
3.	Damage to house and public facilities.	Direct	Disruption education, and loss of housing.	Accelerated rehabilitation based on the Build Back Better (BBB) principle.	Structural
4	Land conversion for housing and villas in tourist areas.	Indirect	Increase flood vulnerability.	Risk-based spatial planning enforcement, evaluation of building permits, and public outreach.	Non-Structural
5.	Decline in the number of tourists following the flood.	Indirect	Decline in revenue for tourism businessess.	Promotion of tourism recovery and business incentives.	Non-Structural
6.	RIPPARIDA has not yet incorporated risk mitigation.	Indirect	Weak institutional preparedness	Integration of mitigation into planning documents.	Non-Structural

4. Conclusions

4.1 Identification of Flood Distribution in Strategic Tourism Areas in Batulayar Subdistrict

The concentration of flooding in Batulayar tourist settlements is consistent with Yu et al. (2022) findings, which identified high-intensity and protracted rainfall as the key causes of significant flood. This assumption is supported by the findings of Wu et al. (2023), who found that heavy rainfall frequently surpasses the capacity of inadequate drainage systems—exactly the mechanism identified by BPBD as the direct cause in this case. When considered together, these studies indicate that flood exposure in Batulayar is not a random occurrence but rather structural in nature: the drainage infrastructure was designed for rainfall patterns that no longer apply under current climate variability, implying that the risk of recurring floods must be treated as a design parameter rather than a one-time event. The disproportionate impact on West Batulayar and Sandik further demonstrates that flood exposure in these subdistricts is exacerbated by land-use changes driven by tourism—the progressive conversion of natural water absorption areas into built tourism infrastructure has worsened surface runoff, consistent with broader observations by Yu et al. (2022) that such exposure exacerbates the severity of consequences (including fatalities and injuries) in areas with concentrated development. This modifies the context for anayzing flood distrubtuin patters, which are influenced ain part by the tourism sector growth trajectory.

4.2 Result of the Economic Loss Calculation in the Strategic Tourism Area of Batulayar Subdistrict

The fact that birdge damage accounted for 93% of direct losses suggests that public infrastructure face the biggest financial burden as a result of flooding. Consistent with the findings of Marselina et al. (2022) on the need for categorizing damaged by severity for accurate loss assessments. These findings are supported by Jayantara (2020) study on the disproportionate vulnerability of transportation assets to recurrent flooding, as well as Suryani & Sekarjati (2023) study on the detailed identification of direct damage as a prequisite for recovery planning in this case, with a focus on bridge reconstruction. These estimates are relatively resistant to uncertainties in the input data. According to Guo et al. (2020), who noted that the unit cost of bridges in eastern Indonesia

can vary by approximately ±20% depending on location and procurement conditions, direct losses are estimated to range from IDR 2.623.696.500 (optimistic scenario) to IDR 3.823.696.500 (pessimistic scenario). Indirect losses are also affected by the duration of the decline in tourist visits: the baseline scenario reflects a 24.4% decline over two months (December 2021–January 2022). A delay recovery would correspond to a 30% decline over three months and indirect losses of IDR 2.524.422.255, for example if negative perceptions of the destination persist among tourists (Biardeau & Sahli, 2024). onversely, a faster recovery would correspond to a 15% decline over one month and indirect losses of only IDR 420.737.043, consistent with the receding of floodwaters within one to two days and the absence of permanent site closures (Rittichainuwat, 2006). Taking both sources of uncertainty into account.

4.3 Flood Mitigation for Strategic Tourism in Batulayar Subdistrict

The flood-related losses are classified into six mitigation priorities, which comprise both structural and nonstructural interventions. Flood-related infrastructure damage must be repaired in order to reinforce flood control infrastructure, particularly drainage systems and water retention structures like retaining walls. The damage has caused floods in tourist regions due to insufficient drainage system capacity. Consider climate change estimates and extreme events like La Niña when designing flood control infrastructure. These situations highlight the relevance of infrastructure in a community's socioeconomic resilience. In practice, infrastructure recovery strategies require inter-agency coordination, including PUPR and BPBD, in responding to post-disaster rehabilitation. Closely connected is the damage caused by road access to tourist regions, which immediately reduced tourist comfort and contentment while weakening the appeal of tourist locations. As stated in Law No. 10 of 2009 on Tourism, strategies for road and bridge rehabilitation must be designed with the principles of sustainability and improved accessibility in mind, with success dependent on collaboration among agencies such as PUPR and BPBD to ensure that rehabilitation proceeds quickly, is targeted effectively, and does not disrupt economic activities in the tourist area. Flood damage to residential areas, educational facilities, and places of worship has also hampered the community's social, religious, and spiritual activities. Infrastructure rehabilitation guided by the Build Back Better (BBB) principle is expected to result in resilient structures that are adaptable to disaster risks, in accordance with the Sendai Framework for Disaster Risk Reduction 2015-2030, which emphasizes the importance of post-disaster infrastructure recovery to higher standards to reduce the risk of recurrence. This rehabilitation process requires collaboration between BPBD and Disperkim, as well as cooperation with the central government, to guarantee that the recovery process is inclusive and sustainable.

Disaster-risk-based spatial planning and public awareness campaigns are critical elements in risk reduction efforts, particularly in tourism areas experiencing massive land-use change, and align with the findings of Herman Rakha (2020), who supports the urgency of reforming permit management as an integral part of disaster risk reduction strategies in tourism areas. Implementation of these policies involves the Environmental Agency, PUPR, and BAPPEDA, who play an active role. At the same time, the decline in a destination's appeal due to flooding has a direct impact on the decrease in tourist visits and business revenue, so the recovery of the tourism sector requires promotional strategies and economic stimulus measures to restore tourist confidence and accelerate economic recovery. The resilience of the sector is largely determined by the speed of response and post-disaster recovery, which requires effective cross-sectoral coordination. Finally, at the institutional level, tourism sector planning needs to be strengthened by integrating mitigation policies into planning documents such as the Regional Tourism Development Master Plan (RIPPARDA), which in West Lombok Regency's current form has not

yet explicitly incorporated adaptation strategies to address the risks posed by hydrometeorological hazards—despite the Ministry of Tourism and Creative Economy Regulation No. 9 of 2021 mandating it. By incorporating mitigation elements into planning documents, local governments can ensure that tourism development is not only focused on economic growth but also on sustainability and disaster resilience. Within this regulatory framework, strengthening the economic resilience of communities also plays a crucial role in adapting to disaster risk, including through retraining of the tourism workforce to expand business capacity and resilience in facing post-disaster conditions. Implementation of these mitigation measures necessitates cross-sector collaboration between the Tourism Office and BAPPEDA, as governed by Ministry of Tourism and Creative Economy Regulation No. 9 of 2021 and Presidential Regulation No. 87 of 2020.

5. Conclusions

Based on the findings and analysis, this study indicates that the flooding event in Batulayar Subdistrict was caused by high exposure to hydrometeorological risks. The villages of Batulayar Barat, Meninting, and Sandik were recorded as the most affected areas due to flood distribution patterns and high daily rainfall reaching 92 mm, which falls into the heavy category. The findings indicate that the economic impact is not limited to infrastructure damage amounting to IDR 3,223,696,500, but also extends to a decline in the productivity of the service sector, with losses totaling IDR 1,368,797,845 due to a decrease in tourist visits and the length of stay. These findings make a significant contribution to the disaster management literature by demonstrating the effectiveness of the ECLAC method in analyzing specific sectoral impacts within the tourism industry—an area that has been under-researched in Indonesia. The study's results argue that the economic sustainability of tourist destinations heavily depends on integrating risk mitigation into planning documents such as the RIPPARIDA, which currently does not explicitly account for disaster risks.

In practical terms, this study underscores the need for policies that prioritize preventive mitigation—both structural and non-structural. This approach aligns with the "Build Back Better" theory in post-disaster management, which emphasizes cross-sectoral integration and community engagement during the disaster response phase. Mitigation strategies must be implemented through cross-sectoral collaboration, such as between the Public Works and Spatial Planning Agency (DPUTR), the Tourism Office, and social sector agencies, to strengthen the role of the community and tourism business operators in local disaster management forums. Additionally, this research opens opportunities for future studies to conduct in-depth exploration of these aspects.

6. Limitations

This study has several limitations. First, the ECLAC method used here estimates indirect losses primarily through changes in the number of visits and revenue, and does not account for broader impacts on supply chains or employment in the informal sector, which may be quite significant given the tourism economy's reliance on small and microenterprises. Second, the sensitivity ranges applied to unit costs and recovery durations represent illustrative boundary scenarios, not those empirically derived from specific data. Fourth, this analysis is limited to a single flood event in a single subdistrict, thereby limiting generalizability to the three other designated strategic tourism areas, which have different exposure profiles and infrastructure. Finally, while qualitative testimonies from tourism stakeholders are valuable for contextualizing quantitative trends, they

were obtained from a small number of informants and may not represent the full range of impacts across all tourism businesses in Batulayar Subdistrict.

7. Declaration of Interest

The authors declare that I have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

8. Acknowledgement

The author would like to express gratitude to the West Lombok Regency Government, particularly the Batulayar Subdistrict administration and relevant agencies in West Lombok Regency, for their cooperation and for providing the necessary data. Thanks are also extended to the tourism business operators in Batulayar Subdistrict who agreed to serve as informants during the collection of primary data for this study.

References

Becken, S., & Hughey, K. F. D. (2013). Linking tourism into emergency management structures to enhance disaster risk reduction. Tourism Management, 36, 77–85. https://doi.org/10.1016/j.tourman.2012.11.006

Berrittella, M., Bigano, A., Roson, R., & Tol, R. S. J. (2004). A general equilibrium analysis of climate change impacts on tourism. Tourism Management, 27(5), 913–924. https://doi.org/10.1016/j.tourman.2005.05.002

Biardeau, L. T., & Sahli, M. (2024). Investigating the non-linear impacts of seven types of natural disasters on inbound tourism: Insights from the EM-DAT database. Tourism Economics, 30(4), 900–923. https://doi.org/10.1177/13548166241229319

BMKG. (2021). Laporan Analisis Klimatologis Hujan Ekstrem di Wilayah Nusa Tenggara Barat Minggu, 5 Desember 2021.

BNPB. (2025). Geoportal Data Bencana Indonesia. https://gis.bnpb.go.id/

BPS Lombok Barat. (2024). PDRB Pariwisata Tahun 2023.

Chen, H., Xu, Z., Liu, Y., Huang, Y., & Yang, F. (2022). Urban Flood Risk Assessment Based on Dynamic Population Distribution and Fuzzy Comprehensive Evaluation. International Journal of Environmental Research and Public Health, 19(24). https://doi.org/10.3390/ijerph192416406

Dematoto Argyo. (2019). Kajian Refleksivitas Masyarakat Risiko dalam Pengembangan Pariwisata Siaga Bencana Berbasis Collaborative Governance. Talenta Conference Series: Local Wisdom, Social, and Arts (LWSA), 2(1), 1–7. https://doi.org/10.32734/lwsa.v2i1.586

Dinas Pariwisata. (2025). Kontribusi Sektor Pariwisata terhadap PDRB. 1.

Ghozali, I. (2011). Aplikasi Analisis Multivariate dengan Program IBM SPSS 19 (5th ed.). Badan Penerbitan Universitas Diponegoro.

Guo, J., Wu, X., & Wei, G. (2020). A new economic loss assessment system for urban severe rainfall and flooding disasters based on big data fusion. Environmental Research, 188. https://doi.org/10.1016/j.envres.2020.109822

Herman Rakha. (2020, November 17). Kurang Nalar Memahami Hujan Sebagai Penyebab Utama Banjir di Lombok Barat. Lombok Research Center. https://www.lrcfoundation.com/kurang-nalar-memahami-hujan-sebagai-penyebab-utama-banjir-di-lombok-barat/

ILO. (2020). ILO Sectoral Brief: The Impact of COVID-19 on the tourism sector. International Labour Organization, 2–9.

InaSafe. (2023, December 16). Module 5: Calculating Damages and Losses. https://manual.inasafe.org/training/old-training/intermediate/qgis-inasafe/405-calculating-damages-and-losses.html

Jayantara, I. G. N. Y. (2020). IMPLEMENTASI QGIS UNTUK MENGESTIMASI KERUGIAN EKONOMI AKIBAT BANJIR DI KABUPATEN BANDUNG. Jurnal Pendidikan Teknologi Dan Kejuruan, 18(2).

Marchiavelly, M. I. C., Narieswari, L., Munajati, S. L., Sumaryono, Santoso, W. E., & Martha, S. (2012). PEMETAAN RISIKO BENCANA PADA DAERAH PARIWISATA KABUPATEN LOMBOK BARAT, NUSA TENGGARA BARAT (Hazard Risk Mapping on Tourism Region of West Lombok Regency, West Nusa Tenggara).

Marselina, M., Nurhayati, S. A., & Pandia, S. L. (2022). Flood Analysis and Estimating Economic Losses in an Affected Area (Case Study: Cikapundung Watershed). Air, Soil and Water Research, 15. https://doi.org/10.1177/11786221221131277

Pirngadi, R. S., Rahmawaty, Ayu, S. F., & Rauf, A. (2024). Estimation of loss of rice farmers due to flood at Krueng Kluet Watershed (with the eclac method approach). IOP Conference Series: Earth and Environmental Science, 1302(1). https://doi.org/10.1088/1755-1315/1302/1/012125

Rittichainuwat, B. N. (2006). Tsunami recovery: A case study of Thailand's tourism. Cornell Hotel and Restaurant Administration Quarterly, 47(4), 390–404. https://doi.org/10.1177/0010880406289994

Salman, A. M., & Li, Y. (2018). Flood Risk Assessment, Future Trend Modeling, and Risk Communication: A Review of Ongoing Research. Natural Hazards Review, 19(3). https://doi.org/10.1061/(asce)nh.1527-6996.0000294

Tanoue, M., Taguchi, R., Nakata, S., Watanabe, S., Fujimori, S., & Hirabayashi, Y. (2020). Estimation of Direct and Indirect Economic Losses Caused by a Flood With Long-Lasting Inundation: Application to the 2011 Thailand Flood. Water Resources Research, 56(5). https://doi.org/10.1029/2019WR026092

Toubes, D. R., Araújo-Vila, N., & Fraiz-Brea, J. A. (2021). Factors influencing the assessment of tourism damage caused by river floods. Journal of Tourism and Development, 2021(36), 51–61. https://doi.org/10.34624/rtd.v1i36.8917

UNDRR. (2015). Global Assessment Report on Disaster Risk Reduction 2015: Making Development Sustainable: The Future of Disaster Risk Management. UN, ISDR.

World Travel & Tourism Council. (2019). Economic Impact Research. https://wttc.org/research/economic-impact

Wu, Z., Zheng, X., Chen, Y., Huang, S., Hu, W., & Duan, C. (2023). Urban Flood Loss Assessment and Index Insurance Compensation Estimation by Integrating Remote Sensing and Rainfall Multi-Source Data: A Case Study of the 2021 Henan Rainstorm. Sustainability (Switzerland), 15(15). https://doi.org/10.3390/su151511639

Yu, Q., Wang, Y., & Li, N. (2022). Extreme Flood Disasters: Comprehensive Impact and Assessment. Water (Switzerland), 14(8). https://doi.org/10.3390/w14081211