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Disaster-risk, climate change challenges and strategies in small islands in Bird's Head Papua

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Abstract

A Disaster Risk Index analysis has never been conducted on small islands in Indonesia, particularly in the Bird's Head region of Papua, which includes 4,110 small islands that are now vulnerable and have become hotspots for climate change and hydrometeorological disasters. This study explores disaster risk indices, future climate change challenges, and Disaster Risk Reduction plans and policies at the site level on the small island of Bird's Head in Papua. Disaster risk index analysis includes threat, vulnerability, and capacity indexes. Climate change scenarios are derived from CMIP, using scenarios SSP2-4.5 and SSP5-8.5. Strategy and policy are based on the National Disaster Management Agency's seven priorities. Field measurements demonstrate that the Disaster Risk Index ranges from 0.73 to 0.82, including the high index class category, which is also directly related to the Hazard Index and Vulnerability Index and inversely proportional to the Capacity Index. Extreme rainfall estimates in the SSP2-4.5 and SSP5-8.5 scenarios result in a 10% and 20% increase in rainfall in the Papua Birds Head region, respectively. The assessment of the seven priorities for tiny islands ranges from 0.2 to 0.37 in the low category. As a result, it is critical for stakeholders, particularly local communities and traditional and village officials, to actively participate in developing DRR strategies and policy ideas for small islands.

Keywords: Disaster Risk Index; Hazard Index; Vulnerability Index; Capacity Index; Small island; Bird's Head Papua.

1. Introduction

Overall, the concentration of monitoring and evaluation efforts regarding natural and man-made disasters continues to be on densely populated large islands instead of smaller ones. Limited research and measurement have been conducted regarding disaster risk indices about small islands, which are presently focal points of climate change. Similarly, West Papua Province, comprising 4,110 small islands, including Bird's Head Papua (23.47% of the total 17,508 islands in Indonesia), is susceptible to the impacts of climate change [1,2,3]. Due to climate change, most small islands are struck by tropical cyclones originating in the Pacific Ocean. These cyclones manifest as storm waves and heavy rainfall, often accompanied by subsequent catastrophic events, including erosion, landslides, and flash flooding. Over the previous seven decades (1945-2021), the Joint Typhoon Warning Center (JTWC) recorded a total of 2,030 storms, ranging in intensity from tropical storms (deep depression) to supercyclonic storms (low cyclone category 5). The annual average of these storms was 26 (Figure 1). This tropical cyclone in the West Pacific accounts for 31% of typhoons worldwide. Due to typhoon conditions, storm surges and heavy precipitation are intensifying along the Bird's Head Papua coast and a small island (60% of the total 4,110 islands). [4,5,6,7].

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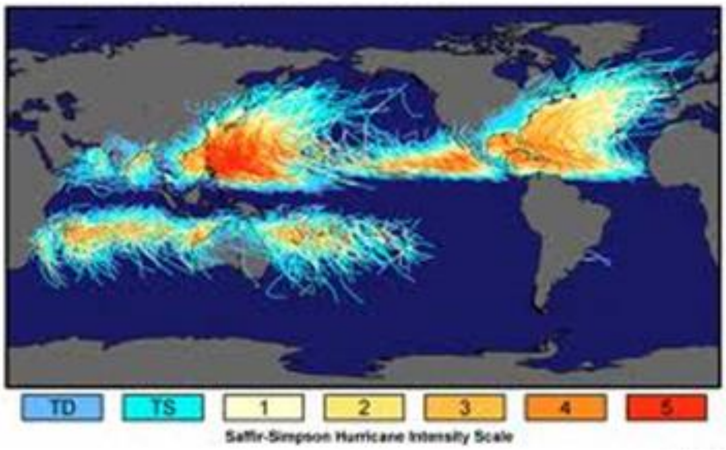
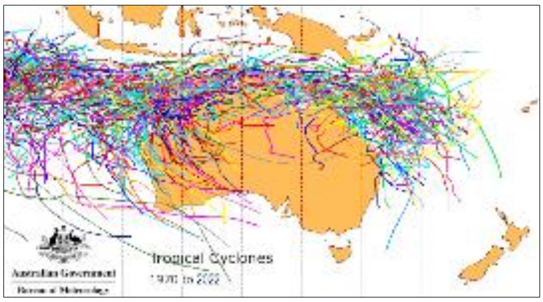
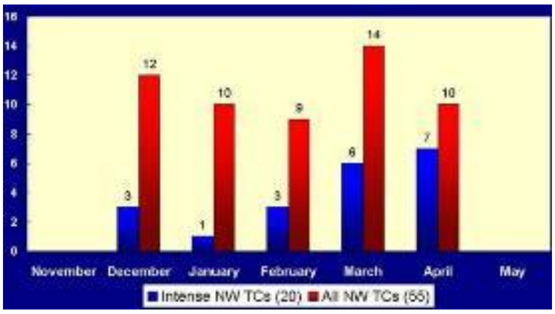


Figure 1 Tracks and intensity of Tropical Cyclone (1945-2021)

In addition to the northern coast, the southern coastal region of Bird's Head is also impacted by the tail effects of Australian-generated tropical cyclones. According to data from 1970 to 2022 (Figure 2a), 545 typhoons of severe classification traversed from the southern coast of Java to Papua. The frequency of tropical cyclone activity in the Southern Hemisphere from December to April averaged sixteen hurricanes per year (Figure 2b) [8]. In addition to significant precipitation and storm surge, the typhoon causes environmental degradation and damage, further compounded by the consequences of aftershocks, including erosion and inundation [9,10].



(1a)



(1b)

Figure 2 a Track and intensity of Tropical Cyclone in Western Australia; b Monthly frequency of Tropical Cyclone in Western Australia (1988-2004)

The amount of research conducted on small islands in West Papua Province is quite limited, and there is a notable absence of topics on disaster risk analysis and climate change. Several interconnected studies were conducted on small islands located off the coast of Papua, including Fiji, Vanuatu, and Solomon Islands, as well as various islands that are part of SIDS (Small Islands Developing States). The issues discussed relate to the way forward for small island communities to adapt their way of life to a future environment affected by climate change [11,12]; changes in forest and land use [13,14]; causes of changes in future ecosystems, biodiversity, and maximum fishing potential [15,16]; renewable energy [17,18]; sea level rise [19,20]; integrated policy integration for the sustainability of small islands: a landscape scale planning approach[21,22]; small islands that depend on tourism, inclusive growth, and the blue economy [23,24]; local ecological knowledge of indigenous communities regarding climate change adaptation [25,26]; vulnerability of coastal communities' livelihoods [27,28]; downscaling climate models [29,30]; waste management [31,32]; social and cultural [33,34]; climate vulnerability assessment [35,36]; and adaptive capacity [37,38].

The West Papua government has assessed the disaster risk index and disaster management plans in collaboration with the National Disaster Management Agency. This analysis is part of their strategy and policy initiatives to prioritize reducing catastrophe risks on the large island [39,40]. Hence, this study aims to examine disaster risk indices, assess climatic change patterns according to IPCC forecasts, and formulate strategies, policies, and priorities for mitigating catastrophe risks in the small islands of West Papua Province.

2. Material and methods

2.1. Study area

The research was conducted on small islands inhabited by natives in the Bird's Head Papua. To decide the sampling of populated small islands, a purposive sampling method was employed, selecting 30 islands for measuring the Disaster Risk Index (DRI). The small islands mentioned are located in various regions, including Raja Ampat Regency (10 islands: Fani, Igi, Miarin, Reni, Kanobe, Wajag, Gebe, Penem, Mansuar, and Waigeo), Sorong City (3 islands: Doom, Ram, and Tsiof), Sorong Regency (3 islands: Sisi, Yewya, and Makmak), Manokwari (2 islands: Mansinam and Lemon), Wondama Bay (3 islands: Roswar, Roon, and Maransabudi), Bintuni Bay (3 islands: Sabuda, Ogar, and Asap), Fak-Fak (3 islands: Panjang, Semai, and Karas), and Kaimana (3 islands: Namatota, Aiduma, and Dramai) (Figure 3).

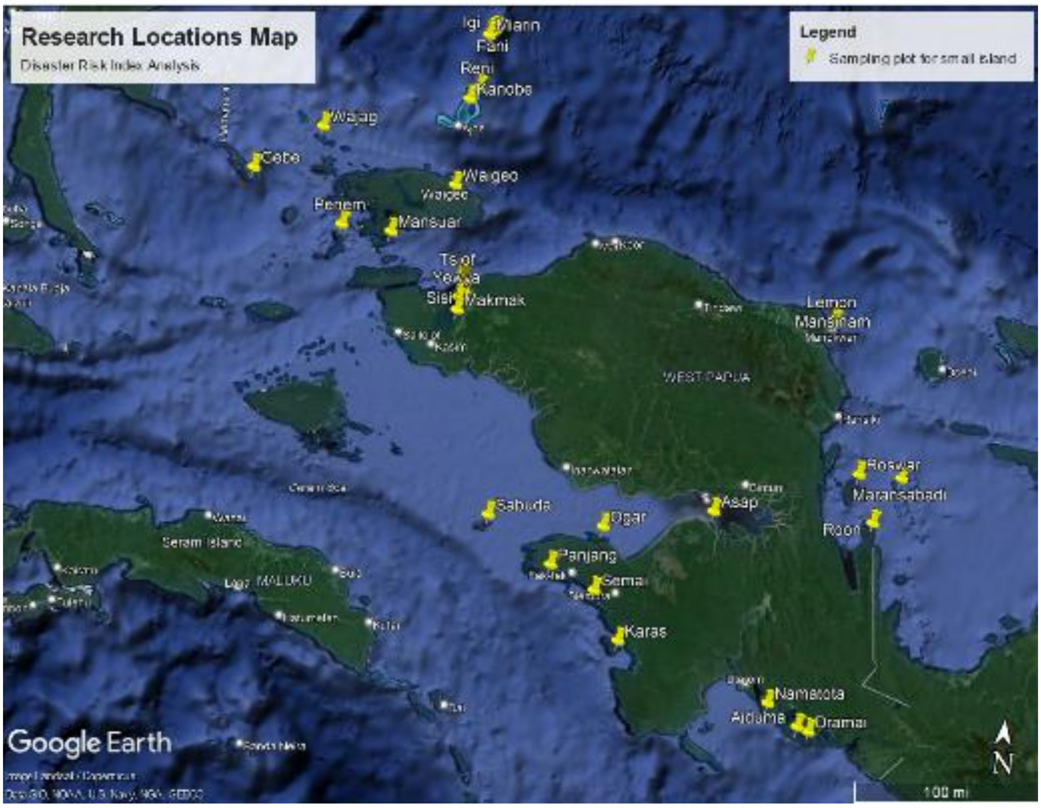


Figure 3 Disaster Risk Index plot for small islands in Bird's Head Papua

2.2. Method of data analysis

The Disaster Risk Index (DRI) is constructed using a predetermined index. The Index comprises the Threat, Exposed Population, Loss, and Capacity Index. The other indices, except the Capacity Index, are highly dependent on the type of disaster threat. The Capacity Index is classified according to the study's administrative area. Because the Capacity Index focuses on government institutions and the readiness of local communities in the study area, this specialization is necessary. A Disaster Risk Study must be prepared for each type of disaster threat present in the study area, particularly on hydrometeorological disasters on small islands [41]. The DRI formula is as follows:

$$R = \sqrt[3]{HxVx(1-C)} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad 1$$

with R = Risk Index, H = Hazard Index, V= Vulnerability Index and C = Capacity Index

The Hazard Index (HI) is constructed using two key components: the likelihood of a threat occurring and the significant impact reported in the disaster that occurred. This index is produced using data and historical records of events in an area. The acquired data was categorized into three hazard classes: low, medium, and high. The elements and criteria used to compute the hydrometeorological disaster HI are presented in Table 1.

Table 1 HI components

No	Disaster	Component	Index Class			Value	Weight	Score	Reference
			Low	Medium	High				
1	Tsunami	Tsunami Inundation Height Estimation/ Tsunami Hazard Map	< 1 m	1 – 3 m	> 3 m	1 2 3	100%	0,33 0,67 1,00	National Geological Agency-Energy & Mineral Resources and Meteorology Climatology and Geophysics Agency (BMKG)
2	Flood	Delimitation of flood-prone zones (verified using event data)	< 1 m	1 – 3 m	> 3 m	1 2 3	100%	0,33 0,67 1,00	Ministry of Public Works, BMKG and Bakosurtanal
3	Landslide	Ground Movement Hazards (verified using event data)	Low-ground movement vulnerability zone	Medium-ground movement vulnerability zone	High-ground movement vulnerability zone	1 2 3	100%	0,33 0,67 1,00	National Geological Agency-Energy & Mineral Resources
4	Drought	Drought danger	Very low-low	Medium	High-very high	1 2 3	100%	0,33 0,67 1,00	BMKG – Ministry of Agriculture
5	Extreme waves and abrasion	Wave height Current Land cover/ coastal vegetation (%) Shape the coastline	< 1 m < 0,2 > 80% Bay	1 – 2,5 m 0,2 – 0,4 40 - 80% Straight-bay	> 2,5 m > 0,4 < 40% Straight	1 2 3	30% 30% 15% 15%	0,33 0,67 1,00	BMKG, Dishidros, Ministry of Environment and Forestry (MoEF), and Bakosurtanal
6	Extreme weather	Open land Slope slope Annual rainfall	< 0,34	0,34 – 0,66	> 0,67	1 2 3	33,3% 33,3% 33,3%	0,33 0,67 1,00	BMKG
7	Forest and land fires	Types of forest and land Climate Soil type	Forest Rain Non-organic/non-peat	Plantation land Rain-drought Semi-organic	Dry grasslands and shrubs, agricultural land Drought Organic/peat	1 2 3	40% 30% 30%	0,33 0,67 1,00	MoEF, BMKG, and the Ministry of Agriculture

Table 2 VI of hydrometeorological disasters

Disaster	Vulnerability
Extreme weather	VI = (0,4 * social vulnerability score) + (0,3 * economic vulnerability score) + (0,3 * physical vulnerability score)
Landslides, Flood, Tsunami, and Extreme waves and abrasion	VI = (0,4 * social vulnerability score) + (0,25 * economic vulnerability score) + (0,25 * physical vulnerability score) + (0,1 * environmental vulnerability score)
Drought	VI = (0,4 * social vulnerability score) + (0,3 * economic vulnerability score) + (0,3 * environmental vulnerability score)
Forest and land fires	VI = (0,3 * social vulnerability score) + (0,2 * economic vulnerability score) + (0,1 * physical vulnerability score) + (0,4 * environmental vulnerability score)

Table 3 CI components

No	Disaster	Component	Index Class			Value	Weight	Score	Stakeholder
			Low	Medium	High				
1	Hydro-meteorological disasters	Disaster Management Rules and Institutions; Early Warning and Disaster Risk Assessment; Disaster Education; Reduction of Basic Risk Factors; Pembangunan Preparedness on all lines	Endurance Levels 1 and 2	Endurance Levels 3	Endurance Levels 4 and 5	1 2 3	60% 40%	0,33 0,67 1,00	FGD of Disaster Management actors (BPBD, Bappeda, Social Service, Health Office, UKM, Business Actors, Universities, NGOs, Community Leaders, and Religious Leaders

The vulnerability index (VI) is calculated by combining the social vulnerability index, economic vulnerability index, physical vulnerability index, and environmental vulnerability index. Each category of hazard is assigned a specific weighting factor. The equation containing the VI conversion parameters for each category of hydrometeorological disaster threat is presented in Table 2.

The Capacity Index (CI) is derived from the level of regional resilience at a specific moment. The capability index is derived through targeted deliberations with multiple stakeholders involved in disaster management within a particular region. The constituent elements of the CI are detailed in Table 3.

The Coupled Model Intercomparison Projects (CMIP) are behind these coordinated efforts. Climate models from CMIP5 were used in the 2013 IPCC Fifth Assessment Report (AR5), and new state-of-the-art CMIP6 models will be used in the upcoming 2021 IPCC Sixth Assessment Report (AR6). A set of scenarios was chosen to provide a range of distinct end-of-century climate change outcomes. The IPCC AR5 included four Representative Concentration Pathways (RCPs) looking at future greenhouse gas emissions scenarios. RCP2.6, RCP4.5, RCP6.0, and RCP8.5 now have new versions in CMIP6. SSP1-2.6, SSP2-4.5, SSP4-6.0, and SSP5-8.5 are the updated scenarios, and they all result in similar 2100 radiative forcing levels as their predecessors in AR5 [42]. The RCP scenarios SSP2-4.5 (intermediate scenario) and SSP5-8.5 (worst-case scenario) are used in this study to predict variable rainfall conditions caused by tropical storms that will increase in intensity and quantity as climate change progresses.

Small island strategies and policies refer to National Disaster Management Agency guidelines with the following emphasis:

Priority 1: Strengthening Policies and Institutions
Priority 2: Risk Assessment and Integrated Planning
Priority 3: Development of Information Systems, Training and Logistics
Priority 4: Thematic Handling of Disaster Prone Areas
Priority 5: Improving the Effectiveness of Disaster Prevention and Mitigation
Priority 6: Strengthening Disaster Preparedness and Emergency Management
Priority 7: Development of a Disaster Recovery System

3. Results and discussion

3.1. Hazard Index

The Hazard Index (HI) calculations for 30 small island samples in Bird's Head Papua are displayed in Table 4. The obtained values fall within the range of 0.70 - 0.71, which is classified as the high index category. Consequently, the presence of hydrometeorological disaster indicators in Bird's Head Papua's small islands has been demonstrated to be substantial and has consequences for the local inhabitants and the surrounding ecosystem.

Table 4 HI of small islands in Bird's Head Papua

No	Regency	Small Island	Hazard Index							
			Tsunami	Flood	Landslide	Drought	Extreme waves and abrasion	Extreme weather	Forest and land fires	Hydro-meteorological disaster
1	Raja Ampat	Fani	1.00	0.70	0.70	0.40	0.67	1.00	0.40	0.70
2		Igi	1.00	0.70	0.70	0.40	0.67	1.00	0.40	0.70
3		Miarin	1.00	0.70	0.70	0.40	0.67	1.00	0.40	0.70
4		Reni	1.00	0.70	0.70	0.40	0.67	1.00	0.40	0.70
5		Kanobe	1.00	0.70	0.70	0.40	0.67	1.00	0.40	0.70
6		Wajag	1.00	0.67	0.70	0.50	0.67	1.00	0.40	0.71
7		Gebe	1.00	0.67	0.70	0.50	0.67	1.00	0.40	0.71

No	Regency	Small Island	Hazard Index							
			Tsunami	Flood	Landslide	Drought	Extreme waves and abrasion	Extreme weather	Forest and land fires	Hydro-meteorological disaster
8		Penem	1.00	0.67	0.70	0.50	0.67	1.00	0.40	0.71
9		Mansuar	1.00	0.67	0.70	0.50	0.67	1.00	0.40	0.71
10		Waigeo	1.00	0.67	0.70	0.50	0.67	1.00	0.40	0.71
11	Sorong City	Doom	1.00	0.67	0.70	0.50	0.67	1.00	0.40	0.71
12		Ram	1.00	0.67	0.70	0.50	0.67	1.00	0.40	0.71
13		Tsiof	1.00	0.67	0.70	0.50	0.67	1.00	0.40	0.71
14	Sorong Regency	Sisi	1.00	0.67	0.70	0.50	0.67	1.00	0.40	0.71
15		Yewya	1.00	0.67	0.70	0.50	0.67	1.00	0.40	0.71
16		Makmak	1.00	0.67	0.70	0.50	0.67	1.00	0.40	0.71
17	Manokwari	Mansinam	1.00	0.70	0.70	0.40	0.67	1.00	0.40	0.70
18		Lemon	1.00	0.70	0.70	0.40	0.67	1.00	0.40	0.70
19	Wondama Bay	Roswar	1.00	0.67	0.70	0.50	0.67	1.00	0.40	0.71
20		Roon	1.00	0.67	0.70	0.50	0.67	1.00	0.40	0.71
21		Maransabudi	1.00	0.67	0.70	0.50	0.67	1.00	0.40	0.71
22	Bintuni Bay	Sabuda	1.00	0.70	0.70	0.50	0.67	1.00	0.40	0.71
23		Ogar	1.00	0.70	0.70	0.50	0.67	1.00	0.40	0.71
24		Asap	1.00	0.80	0.70	0.30	0.67	1.00	0.40	0.70
25	Fak-Fak	Panjang	1.00	0.70	0.70	0.40	0.67	1.00	0.40	0.70
26		Semai	1.00	0.70	0.70	0.40	0.67	1.00	0.40	0.70
27		Karas	1.00	0.70	0.70	0.40	0.67	1.00	0.40	0.70
28	Kaimana	Namatota	1.00	0.70	0.70	0.40	0.67	1.00	0.40	0.70
29		Aiduma	1.00	0.70	0.70	0.40	0.67	1.00	0.40	0.70
30		Dramai	1.00	0.70	0.70	0.40	0.67	1.00	0.40	0.70

The elevated HI observed on small islands due to hydrometeorological disasters can be attributed to the location of tropical cyclones that originate in the Pacific Ocean along the north coast of Papua and storms that travel through the Banda Sea from Australia along the south coast. Due to their location in the deep sea and their status as seismic ring routes, these deep ocean positions have significant tsunami potential in an area with a documented history of tsunamis [43, 44,45]. Small islands in SIDs, most of which are situated north of Papua Island, including Fiji, Vanuatu, Salomon, Guam, and Guyana, are also impacted by this severe threat. As climate change contributes to the escalation of tropical cyclones in intensity and quantity, the threat level is rising concurrently [46,47].

3.2. Vulnerability Index

The monitoring and evaluating of the vulnerability index (VI) for the impact of hydrometeorological catastrophes on the small island of Bird's Head, Papua, revealed a value ranging from 0.79 to 0.85, which falls within the high category, as shown in Table 5.

Table 5 VI of small islands in Bird's Head Papua

No	Regency	Small Island	Vulnerability Index				
			Social Vulnerability Score	Economic Vulnerability Score	Physical Vulnerability Score	Environmental Vulnerability Score	Total
1	Raja Ampat	Fani	1.00	0.80	0.80	0.50	0.85
2		Igi	1.00	0.80	0.80	0.50	0.85
3		Miarin	1.00	0.80	0.80	0.50	0.85
4		Reni	1.00	0.80	0.80	0.50	0.85
5		Kanobe	1.00	0.80	0.80	0.50	0.85
6		Wajag	1.00	0.70	0.70	0.40	0.79
7		Gebe	1.00	0.70	0.70	0.40	0.79
8		Penem	1.00	0.70	0.70	0.40	0.79
9		Mansuar	1.00	0.70	0.70	0.40	0.79
10		Waigeo	1.00	0.70	0.70	0.40	0.79
11	Sorong City	Doom	1.00	0.67	0.67	0.70	0.81
12		Ram	1.00	0.67	0.67	0.70	0.81
13		Tsiof	1.00	0.67	0.67	0.70	0.81
14	Sorong Regency	Sisi	1.00	0.75	0.75	0.70	0.85
15		Yewya	1.00	0.75	0.75	0.70	0.85
16		Makmak	1.00	0.75	0.75	0.70	0.85
17	Manokwari	Mansinam	1.00	0.75	0.75	0.70	0.85
18		Lemon	1.00	0.75	0.75	0.70	0.85
19	Wondama Bay	Roswar	1.00	0.70	0.70	0.40	0.79
20		Roon	1.00	0.70	0.70	0.40	0.79
21		Maransabudi	1.00	0.70	0.70	0.40	0.79
22	Bintuni Bay	Sabuda	1.00	0.80	0.80	0.50	0.85
23		Ogar	1.00	0.80	0.80	0.50	0.85
24		Asap	1.00	0.80	0.80	0.50	0.85
25	Fak-Fak	Panjang	1.00	0.80	0.80	0.50	0.85
26		Semai	1.00	0.80	0.80	0.50	0.85
27		Karas	1.00	0.80	0.80	0.50	0.85
28	Kaimana	Namatota	1.00	0.80	0.80	0.50	0.85
29		Aiduma	1.00	0.80	0.80	0.50	0.85
30		Dramai	1.00	0.80	0.80	0.50	0.85

A high social vulnerability score influences the high VI value because vulnerable groups such as the elderly, pregnant women, children, and people with disabilities are found on small islands. Then comes a high economic vulnerability score, which is influenced by the area of productive land and the GRDP affected by hydrometeorological disasters. A high physical vulnerability score also influenced this due to damage to several residential, public, and critical facilities. Finally, the environmental vulnerability score impacts several natural forests and mangroves on small islands in Papua's Bird's Head region [48].

The lesson learned from Small Island Developing States (SIDS) is that they are susceptible to catastrophes and experience an average annual loss of 2.1% of their Gross Domestic Product (GDP) due to these events [49]. The predictability and occurrence rate of catastrophes give rise to distinctive difficulties intensified due to their characteristics: SIDS are typically characterized by their small size, restricted availability of resources, and lack of economic variety. These locations are frequently distant and secluded, which poses challenges in accessing necessary resources and results in elevated expenses for transportation and communication. Due to their isolation, these areas frequently possess distinctive biodiversity and ecosystems in the sea and on land. Small Island Developing States (SIDS) safeguard a vast maritime ecosystem that presents coastal tourism, fisheries, and trade prospects. However, this also renders them extremely vulnerable to rising sea levels, storm surges, weather-related dangers, and coastal deterioration [50].

3.3. Capacity Index

The current measurement of the Capacity Index (CI) in mitigating catastrophe risk, particularly among local communities, is suboptimal, with values falling within the low category ranging from 0.1 to 0.3, as seen in Table 6. Several CI indicators are unavailable on this small island due to the Regional Government's infrequent attention to facilitating information dissemination and simulation exercises to enhance community readiness for disaster management. Aside from that, there are no regulations or institutional tools at the village level for disaster coordination, early warning, risk assessment, preparation of fundamental necessities, and site-level disaster management [51,52].

Small islands in SIDs also face the same issue, explicitly dealing with significant difficulties in creating and maintaining capacity. The primary obstacle is the scarcity of human resources, characterized by a restricted number of job openings, challenges in retaining highly talented personnel due to emigration (often referred to as "brain drain"), a small population from which to recruit expertise, and consequently, a limited pool of qualified workers occupying crucial positions. In numerous countries, a scarcity of personnel leads individuals to undertake multiple responsibilities. This staff shortage has negative consequences, such as missing out on opportunities to secure concessional financing, oversee projects, develop initiatives, engage with stakeholders, and face difficulties in managing and coordinating international aid and post-disaster endeavors. The dependence on consultants and volunteers might result in frequent staff turnover, continuous expenses for training, and a lack of stability. In addition, obtaining funding for mitigating risks, such as planning for recovery based on risk assessment, necessitates using data, modelling, long-term planning, and cost analysis. These tasks can be challenging with a small workforce, particularly when faced with the urgent demands of response and recovery operations. DRR necessitates diverse analytical skills that may provide challenges in attracting and retaining talent [53,54].

Table 6 CI of small islands in Bird's Head Papua

No	Regency	Small Island	CI
1	Raja Ampat	Fani	0.10
2		Igi	0.10
3		Miarin	0.10
4		Reni	0.10
5		Kanobe	0.10
6		Wajag	0.10
7		Gebe	0.10
8		Penem	0.10
9		Mansuar	0.10
10		Waigeo	0.30
11	Sorong City	Doom	0.30

No	Regency	Small Island	CI
12		Ram	0.30
13		Tsiof	0.30
14	Sorong Regency	Sisi	0.20
15		Yewya	0.20
16		Makmak	0.20
17	Manokwari	Mansinam	0.30
18		Lemon	0.30
19	Wondama Bay	Roswar	0.20
20		Roon	0.20
21		Maransabudi	0.20
22	Bintuni Bay	Sabuda	0.10
23		Ogar	0.10
24		Asap	0.20
25	Fak-Fak	Panjang	0.20
26		Semai	0.10
27		Karas	0.10
28	Kaimana	Namatota	0.30
29		Aiduma	0.10
30		Dramai	0.10

3.4. Disaster Risk Index

According to calculations using formula 1, the Disaster Risk Index (DRI) value for the small island in Bird's Head Papua falls between 0.73 and 0.82. This places it in the high-index class category, as shown in Table 7. This index demonstrates a strong positive association between HI and VI values on small islands in the research area, which is inversely related to low CI values. According to DRI's estimations, the small island in Papua's Bird's Head region is highly susceptible to hydrometeorological disasters. These disasters have had a significant upward trend in the past decade, both at the local level and over the entire nation, with a rate of 99% [55].

The Global Platform (GP) for Disaster Risk Reduction 2022 aims to assess the progress made in the seven years since the implementation of the Sendai Framework and the impact of the COVID-19 pandemic, which began just over two years ago. The current worldwide crisis has shown the severe repercussions that result from underlying vulnerabilities and inequalities, particularly affecting the most vulnerable populations globally. To attain a sustainable future for everyone, it is crucial to prioritize prevention and the agenda of reducing risks. The 2022 Global Platform will offer a distinct and essential occasion to demonstrate the significance of international solidarity and cooperation and to deliberate on strategies for addressing fundamental risk factors, particularly those affecting small islands, at both local and global levels. Furthermore, it will investigate methods to enhance disaster risk governance and establish more robust frameworks for managing various hazards. The GP 2022 initiative is an opportunity for governments, the UN system, and other stakeholders to reaffirm their commitment, with a sense of urgency, to expedite advancements in disaster risk reduction to attain sustainable development goals [56,57].

Table 7 DRI of small islands in Bird's Head Papua

No	Regency	Small Island	DRI
1	Raja Ampat	Fani	0.81
2		Igi	0.81
3		Miarin	0.81
4		Reni	0.81
5		Kanobe	0.81
6		Wajag	0.79
7		Gebe	0.79
8		Penem	0.79
9		Mansuar	0.79
10		Waigeo	0.73
11	Sorong City	Doom	0.74
12		Ram	0.74
13		Tsiof	0.74
14	Sorong Regency	Sisi	0.78
15		Yewya	0.78
16		Makmak	0.78
17	Manokwari	Mansinam	0.74
18		Lemon	0.74
19	Wondama Bay	Roswar	0.76
20		Roon	0.76
21		Maransabudi	0.76
22	Bintuni Bay	Sabuda	0.82
23		Ogar	0.82
24		Asap	0.78
25	Fak-Fak	Panjang	0.78
26		Semai	0.81
27		Karas	0.81
28	Kaimana	Namatota	0.75
29		Aiduma	0.81
30		Dramai	0.81

3.5. Extreme Rainfall Prediction

According to the AR6 Working Group I Document, the SSP2-4.5 and SSP5-8.5 scenarios are associated with a 10% and 20% increase in rainfall in the Papua Bird's Head region, respectively, as depicted in Figure 5 [58]. This phenomenon also affects the small islands dispersed throughout Papua's Bird's Head; therefore, in the context of the Sendai Framework's objective of disaster risk reduction, the threat, vulnerability, and capacity level must be considered significantly. Hence, it is imperative that the involved parties, with international and United Nations support, work together to strengthen the resilience of small island communities that are exceptionally susceptible to hydrometeorological disasters, extreme weather, and climate change [59,60].

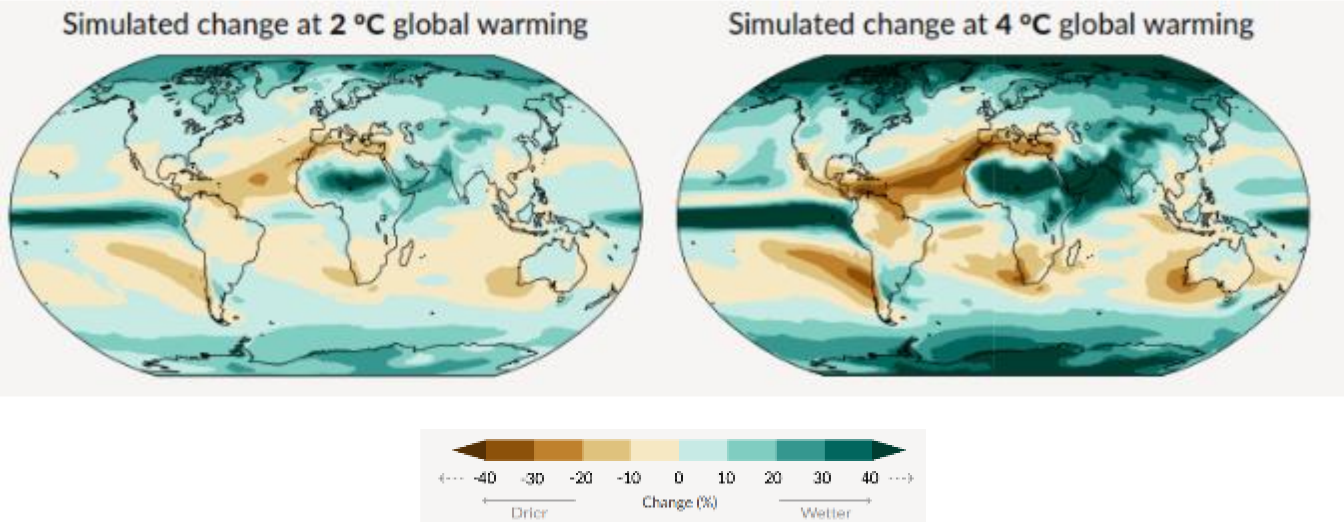


Figure 4 Rainfall pattern of SSP2-4.5 and SSP5-8.5

3.6. Disaster Management Strategy and Policy

The National Disaster Management Agency has established seven critical targets for developing disaster management plans and policies at both regional and site levels. The planning process involved several stakeholders, such as village officials on small islands, who gathered inspiration and assessed the needs at the site level [61]. The evaluation of the seven priorities, as shown in Figure 5, falls into the low category. The formulation of policies and strategies to enhance adaptation and mitigation for Disaster Risk Reduction (DRR) aligned with the Provincial Disaster Management Plan [62,63] is detailed in Table 8.

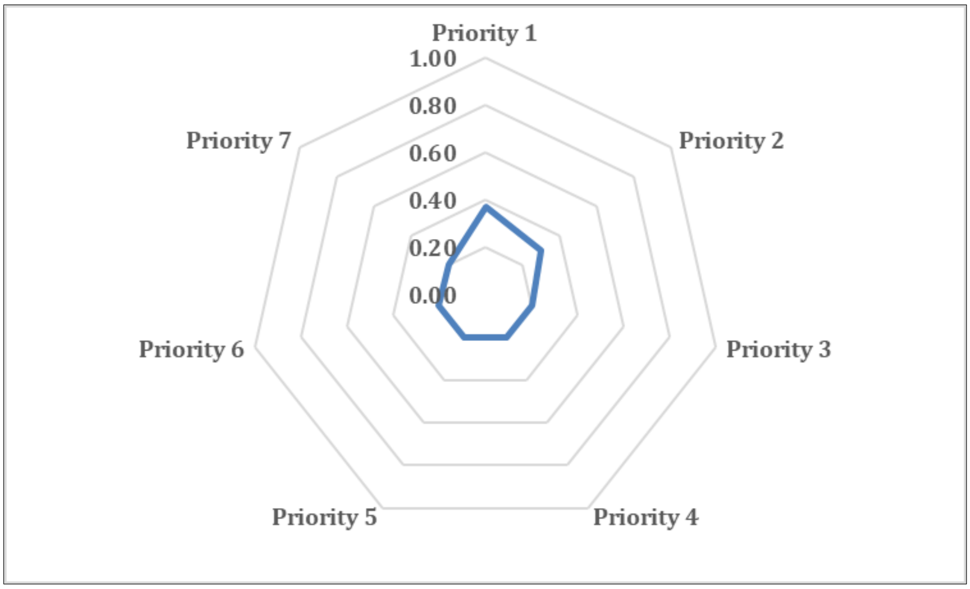


Figure 5 Initial priority data on the small island of the Bird's Head Papua

Table 8 Strategy and Policy DRR in small islands

Priority 1: Strengthening Policies and Institutions	**Priority 2: Risk Assessment and Integrated Planning**	**Priority 3: Development of Information Systems, Training and Logistics**	**Priority 4: Thematic Handling of Disaster Prone Areas**	**Priority 5: Improving the Effectiveness of Disaster Prevention and Mitigation**	**Priority 6: Strengthening Disaster Preparedness and Emergency Management**	**Priority 7: Development of a Disaster Recovery System**
Enhancing small island regulations of the implementation of disaster management	Producing the Small Island Hazard Maps and Updates by regulations	Strengthening Small Island Disaster Information Structures and Mechanisms	Implementation of Small Island Regulations on Regional Spatial Planning for DRR	Reducing the Frequency and Impact of Flood Disasters through the Implementation of Infiltration Wells and Biopores in Small Island	Reducing the Frequency and Impact of Landslides through watershed vegetative conservation in small island	Post-Disaster Planning for the Recovery of Basic Government Services in Small Island
Strengthening Small Island Regulations for the Formation of Small Island Disaster Management Agencies	Providing the Small Island Vulnerability Maps and Updates by regulations	Building Site-Level Information Independence for Disaster Prevention and Preparedness for the Small Island Community	Enhancing the Structure and Information Mechanism for Small Island Spatial Planning	Decreasing the Frequency and Impact of Flood Disasters through Protecting Water Catchment Areas in Small Island	Strengthening the Small Island Preparedness for Tsunami Disasters through Contingency Planning	Post-Disaster Critical Infrastructure Recovery Planning in Small Island
Optimizing the Implementation of the Small Island DRR Forum Rules and Mechanisms	Preparing the Small Island Capacity Maps and Updates by regulations	Enhancing cross-institutional disaster communication policies and mechanisms in small island	Increasing the Basic Capacity of Disaster-Safe Schools on Small Island	Minimizing the Frequency and Impact of Flood Disasters through River Restoration in Small Island	Strengthening the Small Island Tsunami Disaster Early Warning System	Post-Disaster Home Repair Planning in Small Island
Strengthening Rules and Mechanisms for Disseminating Hydrometeorologica l Disaster Information	Introducing the Small Island Disaster Management Plan Documents	Amplifying the Small Island Disaster Management (DM) Center for DDR	Upgrading the Basic Capacity of Disaster Safe Hospitals and Community Health Centers in Small Island	Shortening the Frequency and Impact of Landslides through Slope Strengthening in Small Island	Increasing the Small Island Community Evacuation Capacity and Infrastructure for Tsunami Disasters	Strengthening Policies and Mechanisms for Restoring Community Livelihoods after Disasters in Small Island

Priority 1: Strengthening Policies and Institutions	**Priority 2: Risk Assessment and Integrated Planning**	**Priority 3: Development of Information Systems, Training and Logistics**	**Priority 4: Thematic Handling of Disaster Prone Areas**	**Priority 5: Improving the Effectiveness of Disaster Prevention and Mitigation**	**Priority 6: Strengthening Disaster Preparedness and Emergency Management**	**Priority 7: Development of a Disaster Recovery System**
Strengthening Small Island Regulations on Disaster Management Plans		Strengthening the Small Island Disaster Data Collection System	Development of Disaster Resilient Villages in Small Island	Strengthening Small Island Regulations on Surface Water Utilization and Management for Drought Disaster Risk Reduction	Enhancing the small island preparedness for flood disasters through contingency planning	
Strengthening Small Island Regulations on Regional Spatial Planning Based on Disaster Risk Assessment for DRR		Certification of Disaster Management Personnel for the Use of DM Equipment in Small Island		Increasing Small Island Regulations regarding the Development of Management and Monitoring Systems for Upstream Watershed Areas for the Detection and Prevention of Flash Flood Disasters	Amplifying the Small Island Flood Disaster Early Warning System	
Enhancing Small Island Disaster Management Agencies		Implementation of Small Island Preparedness Training in Phased, Level, and Continuous ways		Application of Earthquake Resistant Buildings in granting Building Construction Permits in small island	Intensifying the small island preparedness for landslides through contingency planning	
Strengthening the Small Island DRR Forum		Preparation of Small Island Disaster Equipment and Logistics Needs Studies		Construction of tsunami wave dampening zones in risk areas on small island	Upgrading the Small Island Landslide Disaster Early Warning System	
Legislative and Executive Comparative Study for Disaster Risk		Procurement of Small Island Disaster Equipment and Logistics		Construction/Revitalization of dams, reservoirs, reservoirs and city parks in areas at risk of	Elevating the small island preparedness for forest and land fire disasters	

Priority 1: Strengthening Policies and Institutions	Priority 2: Risk Assessment and Integrated Planning	Priority 3: Development of Information Systems, Training and Logistics	Priority 4: Thematic Handling of Disaster Prone Areas	Priority 5: Improving the Effectiveness of Disaster Prevention and Mitigation	Priority 6: Strengthening Disaster Preparedness and Emergency Management	Priority 7: Development of a Disaster Recovery System
Reduction Activities in the Small Islands				flooding in small island	through contingency planning	
		Provision of Small Island Disaster Logistics Warehouse		Reducing the Frequency and Impact of Landslides through watershed vegetative conservation in small island	Building the Early Warning System for Small Island Forest and Land Fire Disasters	
		Improving Equipment Maintenance Governance and Logistics Supply/Distribution Network in Small Island			Strengthening small island preparedness for drought disasters through contingency planning	
		Preparation of Strategy and Mechanism for Providing Electricity Reserves for Handling Emergency Disasters in small island			Enhancing the Small Island Drought Disaster Early Warning System	
		Strengthening Small Island Food Fulfillment Strategies for			Increasing small island preparedness for flash flood disasters through	

Priority 1: Strengthening Policies and Institutions	**Priority 2: Risk Assessment and Integrated Planning**	**Priority 3: Development of Information Systems, Training and Logistics**	**Priority 4: Thematic Handling of Disaster Prone Areas**	**Priority 5: Improving the Effectiveness of Disaster Prevention and Mitigation**	**Priority 6: Strengthening Disaster Preparedness and Emergency Management**	**Priority 7: Development of a Disaster Recovery System**
		Disaster Emergency Conditions			contingency planning	
					Raising the Small Island Flash Flood Disaster Early Warning System	
					Boosting the Mechanism for Determining Disaster Emergency Status in Small Island	
					Amplifying the Disaster Emergency Response Command System Mechanism in Small Island	
					Intensifying the Capacity and Operation Mechanism of the Rapid Response Team for Rapid Disaster Assessment in Small Island	
					Strengthening the Capacity and Operational Mechanisms of the Victim Rescue and	

Priority 1: Strengthening Policies and Institutions	Priority 2: Risk Assessment and Integrated Planning	Priority 3: Development of Information Systems, Training and Logistics	Priority 4: Thematic Handling of Disaster Prone Areas	Priority 5: Improving the Effectiveness of Disaster Prevention and Mitigation	Priority 6: Strengthening Disaster Preparedness and Emergency Management	Priority 7: Development of a Disaster Recovery System
					Assistance Team in Small Island	
					Strengthening Disaster Emergency Repair Policies and Mechanisms in Small Island	
					Increasing Policies and Mechanisms for Deploying Humanitarian Assistance to Disaster Affected Communities in Small Island	
					Enhancing the Mechanism for Terminating Disaster Emergency Status in Small Island	

4. Conclusion

The hydrometeorological Disaster Risk Index measurement on the small island of Bird's Head, Papua, varies between 0.73 and 0.82, placing it in the high index class. A high Hazard Index and Vulnerability Index positively correlate with this value, while a low Capacity Index is inversely related.

The DRI is further compounded by forthcoming forecasts derived from the Coupled Model Intercomparison Project (CMIP), wherein the Papua Bird's Head region experiences a 10% and 20% increase in precipitation, respectively, under the SSP2-4.5 and SSP5-8.5 scenarios. Thus, the small island in Papua's Head Nurung has become a climate change hotspot and a vulnerable area, particularly regarding hydrometeorological disasters, which have increased by up to 99 percent at national and site levels over the past decade.

The National Disaster Management Agency's strategies and policies for the seven assessment priorities determined under baseline conditions are categorized as low. Hence, it is crucial to collaborate with various stakeholders, including local and traditional groups and village officials, to formulate precise plans and regulations tailored to the specific location while also aligning with the Provincial Response Plan.

Compliance with ethical standards

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Disclosure of Conflict of Interest

There is no conflict of interest.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

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