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Impacts of Funding Gaps on Disaster Management: A Case Study of Bangladesh

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Abstract:- This study provides a comprehensive analysis of the funding gap in disaster management in Bangladesh from 2000 to June 2024. By examining the relationship between estimated economic damage caused by natural disasters, the corresponding investment in disaster management, and the resulting funding shortfalls, the research underscores the significant challenges faced by Bangladesh in effectively preparing for and responding to such events. The study critically evaluates the trends of funding inadequacies over the years, revealing a persistent gap that has serious implications for disaster preparedness, response, recovery, and mitigation efforts. Additionally, the research explores the socioeconomic impacts of these funding gaps on affected populations, particularly in terms of exacerbating vulnerability, prolonging recovery, and increasing the risk of future disasters. By providing these insights, the study aims to contribute to the ongoing discourse on disaster risk reduction and management, offering recommendations for more effective allocation of resources to enhance resilience in one of the most disaster-prone countries in the world.

Keywords:- *Bangladesh, Disaster, Finance, Risk Reduction, Damage and Loss, Vulnerability.*

I. INTRODUCTION

Bangladesh is one of the most disaster-prone countries in the world, a consequence of its geographical location, low-lying deltaic landscape, and climatic conditions (Islam & Walkerden, 2017). The country frequently experiences natural disasters such as cyclones, floods, storm surges, and severe storms, all of which have devastating impacts on both its population and economy (Haque & Uddin, 2013). Over the past two decades, the frequency and intensity of these events have increased, exacerbating the country's vulnerability to natural hazards (Rahman et al., 2020).

Cyclones are among the most destructive natural disasters in Bangladesh. The coastal regions of the country are particularly susceptible to cyclones, which can lead to loss of life, displacement of communities, and severe economic damage (Paul, 2009). For instance, Cyclone Sidr in 2007 was one of the deadliest cyclones in recent history, causing over 3,000 deaths and displacing millions of people. It resulted in an estimated $2.3 billion in damages (Government of Bangladesh, 2008). Another significant event was Cyclone Aila in 2009, which affected over 3.9 million people, leaving long-term impacts on the livelihoods of coastal communities (UNDP, 2010). More recently, Cyclone Amphan in 2020 caused widespread devastation, affecting millions and resulting in significant economic losses (UNICEF, 2020).

Floods are another major natural hazard in Bangladesh. The country's extensive river systems, including the Ganges, Brahmaputra, and Meghna rivers, make it highly susceptible to flooding, particularly during the monsoon season (Mirza, 2011). The floods of 2004 were particularly severe, inundating nearly half of the country and affecting over 36 million people (Khan & Ali, 2004). Similarly, the 2017 floods were devastating, impacting millions and leading to substantial economic losses (ReliefWeb, 2017). In 2022, floods caused by excessive monsoon rains and river overflow once again ravaged the country, resulting in significant human and economic tolls (Islam & Naser, 2023).

Severe storms and storm surges, often associated with cyclones and floods, also pose significant risks to Bangladesh. These events can cause widespread damage to infrastructure, agriculture, and housing (Paul & Dutt, 2010). For example, the storm surge during Cyclone Mora in 2017 caused extensive damage to homes and infrastructure, further exacerbating the vulnerability of affected communities (IFRC, 2017).

Despite ongoing efforts to enhance disaster preparedness and response, Bangladesh continues to face a significant funding gap in disaster management.The financing gap in disaster management refers to the difference between the financial resources needed for effective disaster response and recovery and the actual funds available. This gap can significantly impact the extent of residual damage, which is the portion of damage and needs that remain unaddressed after a disaster. Indeed, this gap hinders the country's ability to effectively mitigate the impacts of natural disasters and protect vulnerable populations (Ahmed & Rahman, 2020). As climate change continues to increase the frequency and intensity of natural disasters, addressing this funding gap is crucial for building resilience and reducing future risks (Haque et al., 2019).

- *Objective*

The primary objective of this study is to analyse the trends and implications of the funding gap in disaster management in Bangladesh from 2000 to 2024. The study

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also aims to assess the relationship between the funding gap, the extent of damage, and the socio-economic impact on the affected population.

➢ *Research Questions*

Aligned with the research objectives, the three potential research questions:

- What are the trends in the funding gap for disaster management in Bangladesh from 2000 to 2024, and how have these trends evolved over time?
- How does the funding gap in disaster management correlate with the extent of damage caused by natural disasters in Bangladesh during the same period?
- What is the relationship between the funding gap in disaster management and the socio-economic impact on affected populations in Bangladesh?

II. LITERATURE REVIEW

The global discourse on disaster management increasingly emphasizes the critical role of adequate and timely funding in mitigating the adverse effects of natural disasters. As the frequency and intensity of disasters rise due to climate change, the need for robust financial frameworks becomes ever more urgent. The financial resources allocated to disaster preparedness, response, and recovery are pivotal in determining the resilience of communities and the effectiveness of disaster management strategies.

Several scholars have highlighted the persistent funding gaps in disaster management, particularly in developing countries. According to Smith (2018), insufficient funding leads to inadequate preparedness, delayed response, and prolonged recovery, which exacerbate the overall impact on affected populations. The situation is particularly dire in countries like Bangladesh, where frequent natural disasters place immense pressure on already limited resources. Ahmed and Rahman (2020) emphasize that the gap between estimated damage and available funding is a consistent issue, resulting in increased vulnerability and slower recovery in disaster-affected regions.

Haque et al. (2019) further support this view, noting that the financial shortfalls in disaster management often translate into significant socio-economic impacts. The underfunding of critical infrastructure, such as communications, early warning systems, and healthcare facilities, leaves communities exposed to the full brunt of disasters. This underfunding is not only a result of limited domestic resources but also reflects broader issues in the global financial system for disaster management.

The socio-economic consequences of underfunded disaster management are profound and long-lasting. Chowdhury (2021) argues that the lack of adequate financial resources contributes to the persistence of poverty in disaster-prone areas. In regions frequently hit by natural disasters, the affected populations struggle to rebuild their lives with limited support, perpetuating cycles of poverty and vulnerability. This view is supported by Islam and Shamsuddoha (2018), who found that funding gaps in disaster management are closely linked to higher mortality rates and greater displacement during disaster events. These outcomes are particularly evident in Bangladesh, where large segments of the population reside in low-lying coastal areas that are highly susceptible to cyclones and floods.

While international aid and donor funding have played a significant role in addressing some of these gaps, their unpredictability and inconsistency pose substantial challenges for long-term disaster resilience. Rahman et al. (2020) observe that international aid often arrives in the aftermath of disasters, rather than being allocated for pre-disaster preparedness. This reactive approach not only delays response efforts but also fails to build the necessary resilience in vulnerable communities.

The allocation of funds also presents a significant challenge. UNDP (2019) reports that the distribution of international aid often fails to match the scale of damage, leading to substantial shortfalls that hinder effective disaster management. In many cases, donor priorities do not align with the actual needs on the ground, resulting in the misallocation of resources. For example, funds may be earmarked for high-profile projects while neglecting critical but less visible areas such as mental health support and long-term livelihood restoration.

Despite the consensus on the importance of adequate disaster financing, there are contrasting views on the most effective approaches to funding allocation and management. Some scholars advocate for a more centralized approach, where national governments take the lead in coordinating disaster finance, arguing that this would ensure a more equitable and needs-based distribution of resources (Khan & Hossain, 2021). Others, however, contend that decentralized, community-based approaches are more effective in addressing local needs and fostering community resilience (Barua & Alam, 2022).

Another emerging perspective is the role of innovative financial instruments in disaster management. Catastrophe bonds, insurance schemes, and risk pooling mechanisms are increasingly being explored as ways to address the funding gaps. For instance, the World Bank (2020) has promoted the use of catastrophe bonds in Bangladesh, which allow the country to quickly access funds in the aftermath of a disaster. However, the effectiveness of these instruments in the long-term remains a subject of debate, with concerns about their accessibility to the most vulnerable populations and their ability to provide sufficient coverage for large-scale disasters (Oxfam, 2021).

➢ *Research Gaps*

Despite the extensive literature on disaster management, there is a paucity of research specifically focusing on the funding gap in Bangladesh over an extended period. Most studies have either concentrated on single events or short-term impacts, leaving a gap in understanding the long-term trends and implications of underfunding in disaster management. This study aims to fill this gap by providing a

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comprehensive analysis of the funding gap in Bangladesh from the year 2000 to 2024, exploring its implications for disaster preparedness, response, and recovery.

➢ *Rationale of the Study*

Bangladesh's vulnerability to natural disasters is well-documented, with climate change expected to exacerbate the frequency and severity of these events (IPCC, 2022). However, the persistent funding gap in disaster management remains a critical barrier to effective disaster response and resilience building. This study is essential as it provides a longitudinal analysis of the funding gap in disaster management, offering insights into how this gap has evolved over the years and its socio-economic implications.

By understanding the trends and underlying causes of the funding gap, policymakers, donors, and stakeholders can develop more effective strategies to address the challenges in disaster management. Moreover, this study contributes to the broader discourse on disaster risk reduction (DRR) by highlighting the importance of adequate and timely funding in reducing the vulnerability of disaster-prone communities.

➢ *Problem Statement*

Despite significant efforts to enhance disaster management in Bangladesh, a persistent funding gap has hindered the effectiveness of these initiatives. This gap not only undermines disaster preparedness and response but also exacerbates the socio-economic impact on affected populations. The problem is further compounded by the inconsistent allocation of funds and the challenges in accessing international aid. This study seeks to explore the extent and implications of the funding gap in disaster management in Bangladesh from 2000 to 2024, providing a comprehensive analysis of the trends, challenges, and opportunities for addressing this critical issue.

➢ *Theoretical Framework*

This study is anchored in multiple theoretical frameworks that collectively provide a comprehensive lens for understanding the funding gap in disaster management and its broader implications in Bangladesh.

- **Vulnerability and Capacity Framework (VCA):** The study primarily draws upon the Vulnerability and Capacity Framework (VCA) developed by Cannon et al. (2003). According to the VCA framework, the impact of disasters is a function of the vulnerabilities and capacities of affected communities. Vulnerability is shaped by socio-economic factors such as poverty, education, and access to resources, while capacity refers to the resources, strategies, and systems available to individuals and communities to cope with disasters. In the context of Bangladesh, the persistent funding gap in disaster management exacerbates vulnerabilities by limiting the resources available for preparedness, response, and recovery. Conversely, adequate funding can enhance capacity, thereby reducing vulnerability and enabling more effective disaster mitigation and resilience.
- **Sen's Capability Approach:** Amartya Sen’s Capability Approach (Sen, 1999) offers an additional dimension to understanding vulnerability in disaster-prone areas. According to this approach, development should be assessed in terms of individuals' capabilities – their ability to achieve the kind of lives they have reason to value. In disaster management, the funding gap limits the capabilities of affected populations by constraining access to essential services and opportunities for recovery. Insufficient financial resources impede the ability to rebuild livelihoods, secure adequate shelter, and maintain health, thus preventing affected populations from achieving a standard of living they have reason to value. Incorporating Sen’s Capability Approach into the VCA framework underscores the importance of adequate funding not just for immediate disaster response, but for the longer-term enhancement of human capabilities and resilience in disaster-prone regions.
- **Pressure and Release (PAR) Model:** The Pressure and Release (PAR) model, developed by Blaikie et al. (1994), further enriches this study by framing disasters as the intersection of socio-economic pressures and the release of these pressures through disaster events. According to the PAR model, vulnerabilities are created by a "progression of vulnerability," where root causes (e.g., economic, social, and political factors) create dynamic pressures (e.g., lack of investment in disaster management) that lead to unsafe conditions. The funding gap in disaster management can be seen as a dynamic pressure that exacerbates unsafe conditions in disaster-prone regions of Bangladesh.

The PAR model suggests that to effectively manage disasters, it is important to tackle the fundamental issues that make people vulnerable in the first place. These root causes include socio-economic inequalities, such as poverty, lack of education, and poor governance. These inequalities often lead to insufficient funding for disaster management systems, which in turn makes it harder to prepare for, respond to, and recover from disasters. Essentially, the PAR model is saying that by addressing these deep-rooted socio-economic problems, we can create a more robust disaster management system that is better equipped to handle future disasters.

- **Resource Dependency Theory (RDT):** The study also incorporates Resource Dependency Theory (RDT), as articulated by Pfeffer and Salancik (1978). RDT suggests that organizations, including government agencies and non-governmental organizations (NGOs) involved in disaster management, are dependent on external resources to achieve their goals. The theory posits that organizations may take strategic actions to secure and manage critical resources; however, the unpredictability and inconsistency of funding, particularly from international donors, pose challenges for sustainable disaster resilience.The availability of financial resources from external donors and development partners is crucial for effective disaster response and recovery. As studies show that there is a clear gap between the economic loss caused by disasters and the fund available to recovery and rehabilitations, this funding gap creates a critical resource dependency that influences the effectiveness of disaster management efforts in Bangladesh.

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By integrating these theoretical frameworks, this study provides a comprehensive understanding of the funding gap in disaster management in Bangladesh. The VCA and PAR models highlight how socio-economic factors and structural vulnerabilities are exacerbated by underfunded disaster management, while Sen's Capability Approach underscores the broader human impacts of these funding shortfalls. RDT offers insights into the organizational challenges and dependencies that arise from limited financial resources. Together, these perspectives suggest that addressing the funding gap is not only about increasing financial resources but also about enhancing the capabilities of affected populations and addressing the root causes of vulnerability.

III. METHODOLOGY

The data for this study are sourced from the EM-DAT[2] database, focusing on disaster events[3] in Bangladesh from 2000 to 2024. The analysis also incorporated data from the publication of ADB titled "Disaster Risk Financing in Bangladesh" (Ozaki, 2016, page 23). Data of annual budget allocation for the Ministry of Disaster Management and Relief (www.modmr.gov.bd), Planning Commission of Bangladesh (www.plancomm.gov.bd),andMinistry of Finance, Bangladesh (www.mof.gov.bd)are also considered for the analysis. The part of the allocation of the budget for the MoDMR dedicated only for disaster management and activities related to DRR, Early Warning System and disaster resilience are considered in this analysis (MoF, 2023, page 121-122). All these data sources aresecondary and quantitative.

Since the data used in this research is quantitative, descriptive statistics are employed to analyse the data, and visualizations such as graphsare used to present the findings. Inferential statistics correlation analysis is conducted to assess the relationship between estimated damage, and other indicators including funding gaps as shown in Table 1.

➢ *Data Overview*

In the dataset five specific indicators are considered: (a) Estimated Damage (non-life), (b) Investment/Funding, (c) Funding Gap (which is the difference between 'a' and 'b'), (d) Human Death Toll, and (e) Number of affected populations by the disaster events from 2000 to June 2024 (Table 1). Various analyses are conducted on these indicators.

Table 1 Disaster Events, Damage, Investment, Death, Affected People, and Funding Gap Data of Bangladesh from 2000 to 2024

Year	Event	Estimated Damage in Million USD	Investment/Funding in Million USD	Funding Gap in Million USD	Death Toll	No of Affected Population
2000	Flood, Cyclone, Severe Storm	581	66	515	374	3416475
2001	Flood, Severe Storm	85	69	16	257	729250
2002	Flood, Cyclone, Severe Storm	1073	135	938	281	7725737
2003	Flood, Cyclone, Earthquake, Severe Storm	1042	11	1031	178	8200202
2004	Flood, , Cyclone, Severe Storm	2335	378	1957	1095	41089844
2005	Flood, Severe Storm	139	101	38	221	1253606
2006	Flood, Severe Storm	27	71	-44	144	221289
2007	Flood, Cyclone Sidr,	2744	1018	1726	5004	19659073
2008	Flood, Cyclone, Earthquake	145	339	-194	53	1298135
2009	Cyclone Aila, Flood	1206	128	1078	211	5419188
2010	Flood, Severe Storm	254	84	170	145	1497660
2011	Flood	186	131	55	66	1853371
2012	Flood, Cyclone, Severe Storm	627	79	548	272	5587284
2013	Cyclone Mahasen, Flood, Severe Storm	351	60	291	50	1777050
2014	Flood, Storm	206	300	-94	79	3205709
2015	Cyclone Komen, Lightning,	108	315	-207	159	4073354

[2] The Emergency Events Database (EM-DAT) is a comprehensive global database that tracks and records significant natural and technological disasters. It was established in 1988 by the Centre for Research on the Epidemiology of Disasters (CRED) with the primary goal of improving preparedness and decision-making in disaster management. EM-DAT provides detailed information on various disaster events, including earthquakes, floods, storms, droughts, and technological incidents, such as industrial accidents and transport incidents.

[3]Web address https://doc.emdat.be/docs/data-structure-and-content/emdat-public-table/ accessed on 20 July 2024

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Year	Event	Estimated Damage in Million USD	Investment/Funding in Million USD	Funding Gap in Million USD	Death Toll	No of Affected Population
	Earthquake, Flood, Landslide					
2016	Cyclone, Lightning, Earthquake, Flood	952	350	602	198	3103625
2017	Cyclone Mora, Lightning, Flood, Mudslide	780	340	440	338	11467013
2018	Cold wave, Lightning, Flood	50	362	-312	102	14000
2019	Cyclone Bulbul, Lightning, Flood, Landslide, Cold Wave	96	370	-274	260	7884062
2020	Cyclone Amphan, Flood	2354	365	1989	283	7884067
2021	Cyclone Yaas, Flood	40	360	-320	24	8048271
2022	Flood, Cyclone	481	325	156	176	1568744
2023	Storm, Cyclone Mocha, Flood	251	322	-71	147	8200000
2024	Heat Wave, Cyclone Remal, Flood	500	355	145	16	3250018
	Total	16613	6434	10179	10133	158427027

IV. DATA ANALYSIS AND RESULTS

A. *Descriptive Analysis*

Using MS Excel and Python, we conducted Descriptive Analyse on the dataset as shown in Table1 and found the following output:

Table 2 Output of Descriptive Data Analysis

Metric/ Statistic	Estimated Damage in Million USD	Investment/Funding in Million USD	Funding Gap in Million USD	Death Toll	No of Affected Population in Thousand
Mean	664.52	257.36	407.16	405.32	6337.04
Standard Deviation	771.98	206.64	688.65	980.30	8465.89
Minimum	27	11	-320	16	14
Median (50th Percentile)	351	315	156	178	3416
Maximum	2744	1018	1989	5004	41090

➢ *Major Observations:*

- **Estimated Damage**: During the period 2000 to 2024, Bangladesh experienced multiple disaster events, including cyclones, floods, and severe storms. The average estimated damage over the years is approximately USD 664.52 million, with the highest damage recorded in 2007 at USD 2744 million (Cyclone Sidr).This suggests that disasters generally cause significant economic disruption, requiring considerable financial resources for recovery and reconstruction. The wide range of estimated damages indicates that the financial impact of disasters can vary widely. While some disasters have a relatively moderate economic effect, others can be extremely costly.
- **Investment/Funding**: On average, the investment or funding provided is USD 257.36million. The maximum funding was USD 1018 million in 2007 for Cyclone Sidr.This indicates a consistent financial resource allocated for disaster response and recovery relative to the estimated needs.
- **Funding Gap**: The funding gap shows significant variation, with an average of USD 407.16million. The most considerable funding gap occurred in 2020 (Cyclone Amphan), where the gap was USD 1989 million. Some events have negative funding gaps, suggesting instances where not only was the funding insufficient, but it was also over-allocated or inadequately planned, leading to deficits or unmet needs.
- **Death Toll**: The average death toll is 405, with the highest being 5004 during Cyclone Sidr in 2007.The wide range in death tolls, from 16 to 5,004, highlights that while some disasters result in relatively few fatalities, others can be catastrophic in terms of human lives lost.

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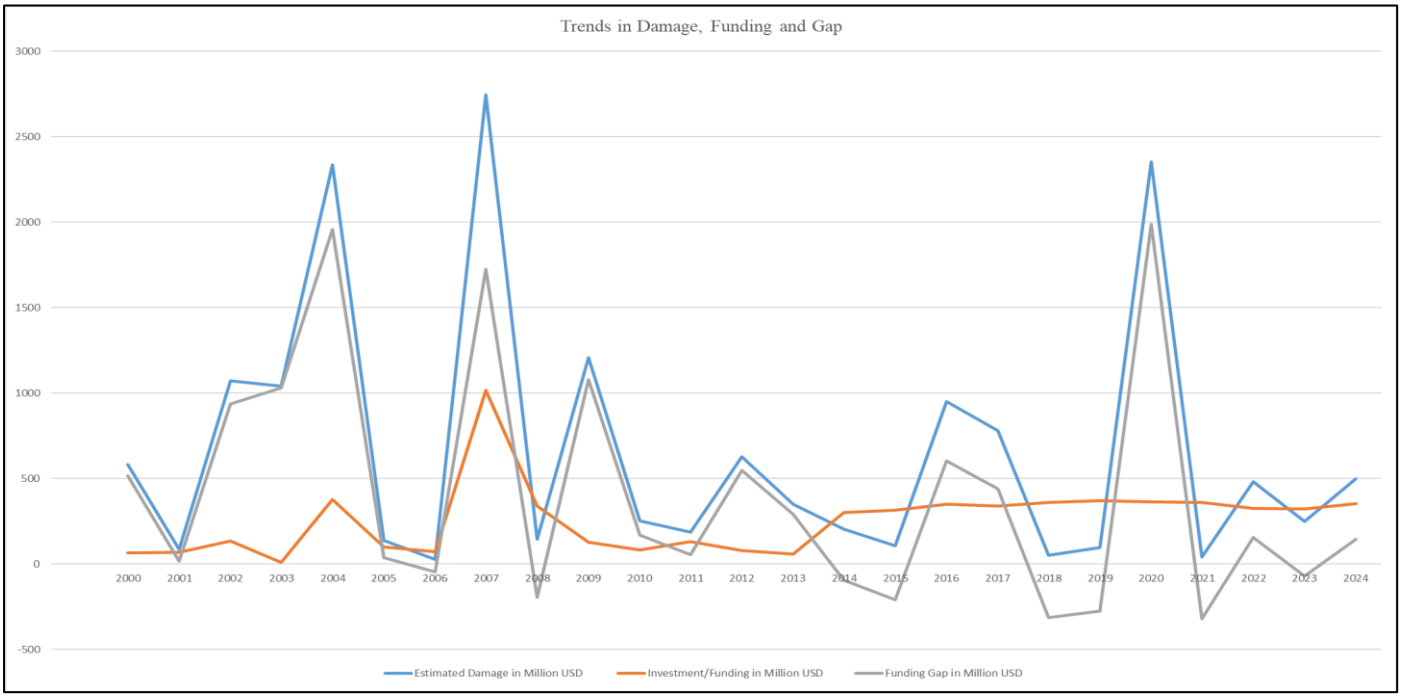
- **Affected Population**: On average, approximately 6.34 million people were affected by these disasters, with the most extensive impact in 2004, where over 41 million people were affected. It indicates that these events disrupt the lives of large segments of the population, leading to displacement, loss of livelihoods, and other social and economic hardships.
- **Implications for Disaster Management and Policy:** The persistent funding gaps and variability in investment highlight the need for better financial planning and allocation strategies to ensure adequate resources are available for disaster preparedness, response, and recovery. Given the skewed nature of the data, with some disasters causing disproportionately high damage and loss of life, there may be a need to focus on building resilience and preparedness for extreme events, even if they occur less frequently. The significant variability in impact suggests that some areas or events may be less prepared or have different levels of vulnerability. Strengthening disaster risk reduction strategies, early warning systems, and community resilience could help mitigate these impacts.

This analysis provides a comprehensive overview of the economic, social, and human impacts of disasters. The data underscores the importance of enhancing disaster preparedness and response capabilities and the need for strategic investments in risk reduction to minimize the adverse effects of future disasters. Policymakers and stakeholders should consider these findings when planning for disaster risk reduction, ensuring adequate funding, and improving resilience against the varied and often severe impacts of natural disasters.

B. Trends in Estimated Damage, Funding, and Funding Gap



Graph 1 Trends in Estimated Damage, Investment/Funding, and Funding Gap

The above visualization represents the trends in Estimated Damage, Investment/Funding, and Funding Gap for disaster management from 2000 to 2024.

➢ *Key Observations:*

- **Peaks in Estimated Damage**: Significant peaks are visible in the years 2004, 2007, and 2020. These correspond to major disasters, such as Cyclone Sidr (2007) and Cyclone Amphan (2020).The total estimated damage across the years fluctuated significantly, with major peaks observed in 2007 (2744 million USD), 2020 (2354 million USD), and 2004 (2335 million USD).
- **Investment/Funding:** The investment or funding trend shows relatively smaller fluctuations compared to estimated damage, indicating a lack of proportional increase in funding with rising disaster costs. Investment in disaster management remained inconsistent, with significant underfunding in several years, particularly in 2003, 2006, and 2013.
- **Funding Gap:** The funding gap shows significant positive peaks in the years where estimated damage was high, indicating underfunding in disaster response. The funding gap varied considerably, with the most significant shortfalls recorded in 2007 (1726 million USD) and 2004 (1957 million USD). Conversely, years such as 2014, 2015, and 2018, 2019 and 2021 experienced negative gaps, indicating overfunding or underestimations of damage. A consistent underfunding trend was observed, particularly in years with high estimated damages, suggesting a reactive rather than proactive approach to disaster financing.

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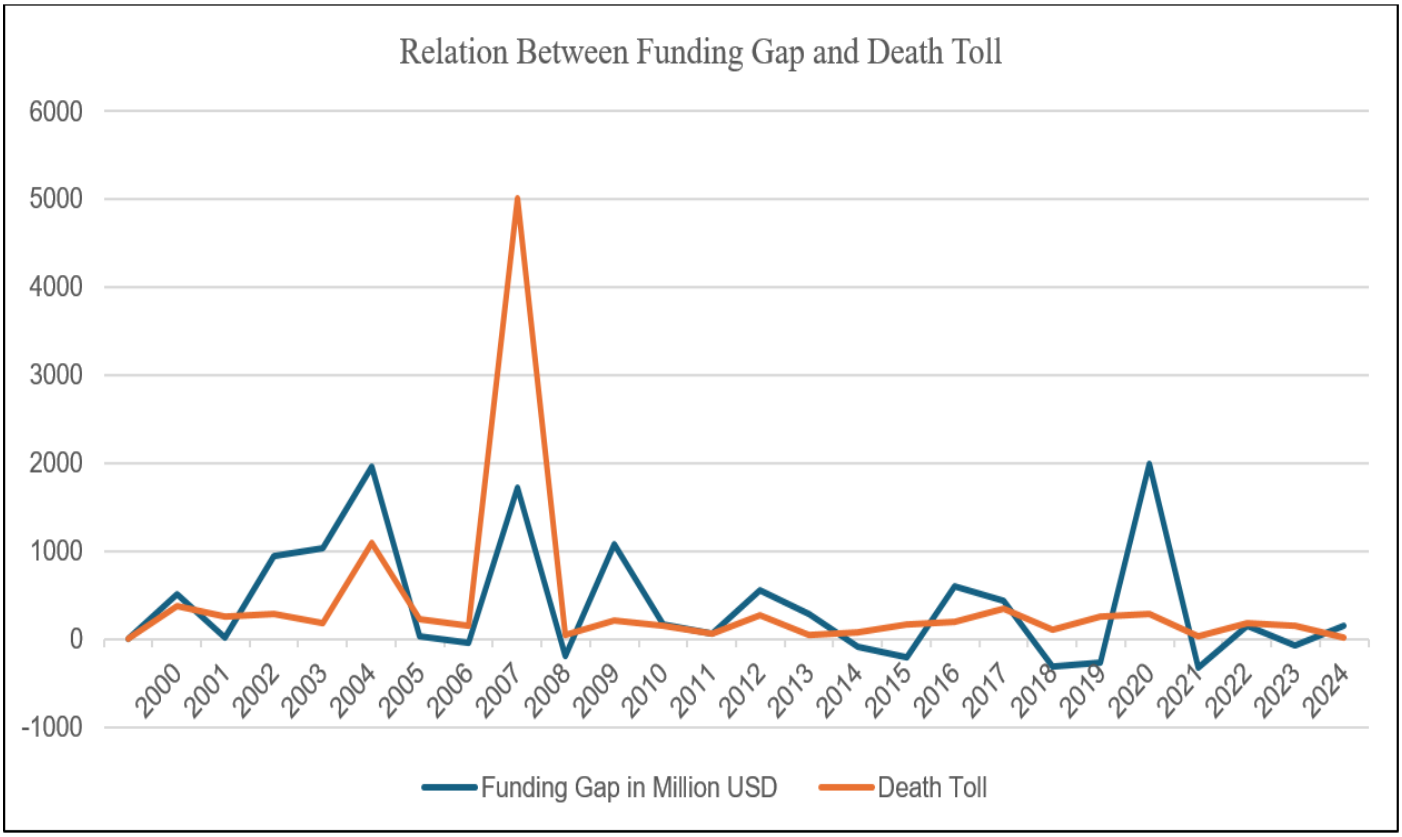
Overall, there is a consistent pattern of underfunding relative to the estimated damages over the years, as shown by the frequent occurrence of positive funding gaps. This pattern highlights the challenge in mobilizing adequate financial resources for disaster management and underscores the need for better financial planning and risk reduction strategies. In the later years, closer to 2025 and onwards, there seems to be a trend of slightly increasing investment levels, but these are still not sufficient to close the funding gaps significantly, particularly when estimated damages are high.

C. Socio-Economic Impact

➢ *Funding Gap and Death Toll:*

High funding gaps were generally associated with higher death tolls and larger affected populations. For instance, in 2007, the funding gap was 1726 million USD, with a death toll of 5004 and an affected population of nearly 20 million. The inability to bridge the funding gap has often resulted in prolonged recovery periods and exacerbated poverty levels in affected regions. Let us visualize the relationships between the Funding Gap and the Death Toll.



Graph 2 Funding gaps and death toll from 2000-2024 (June)

➢ *Key Observations:*

- **Inverse Correlation:** There seems to be a general inverse correlation between the Funding Gap (in million USD) and Death Toll. This suggests that when the funding gap increases, the death toll tends to decrease. However, this relationship is not always consistent and there are exceptions.
- **Fluctuations:** Both the Funding Gap and Death Toll exhibit significant fluctuations over the years. This indicates that factors other than the funding gap likely influence the death toll. There are a few years with extreme outliers, particularly in 2007 for the Funding Gap and potentially in 2009 for the Death Toll. These outliers can significantly impact the overall correlation analysis.
- **No Clear Causation:** While the graph suggests a correlation, it does not definitively prove causation. Other factors, such as the type of disaster, response efforts, and regional variations, may also play a significant role in determining the death toll.

➢ *Estimated Damage and the Number of Affected People:*

The graph shows the relationship between the estimated damage (in million USD) and the number of affected people (in thousands) from the year 2000 to June 2024.

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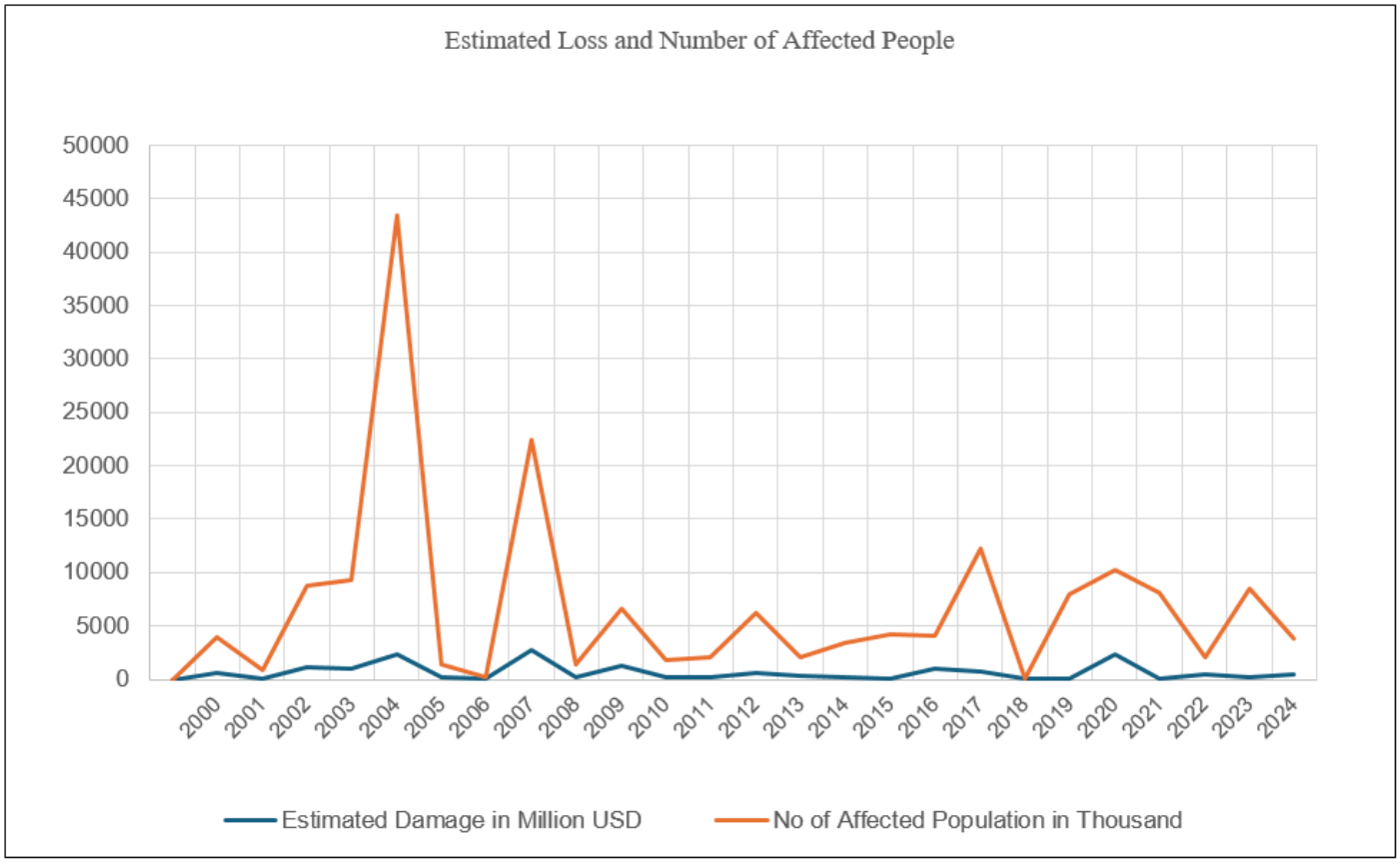

Graph 3 Estimated damage in million USD and number of affected population.

Graph 3 shows the relationship between the estimated damage (in million USD) and the number of affected people (in thousands) due to various disasters in Bangladesh from 2000 to 2024.

- **Affected Population:** In 2004, there is a significant spike in the number of affected people, reaching nearly 41 million. This coincides with a severe event in 2004 (Flood, Cyclone, Severe Storm), indicating a high-impact disaster. Again in 2007, there is another sharp increase is observed, with over 19 million people affected. This year corresponds to Cyclone Sidr, one of the deadliest cyclones in recent history. In 2017, a notable rise in the affected population is seen again, with approximately 11.4 million people impacted, corresponding to multiple events including Cyclone Mora. Also in 2020, another peak occurs, with nearly 7.9 million people affected, correlating with the impact of Cyclone Amphan and floods.
- **Estimated Damage:** The estimated damage shows several significant spikes. In 2004, the estimated damage peaks at approximately 2.3 billion USD, aligning with the spike in the affected population. In 2007, the damage reaches around 2.7 billion USD during Cyclone Sidr. Another peak in damage occurs in 2020 which is at approximately 2.3 billion USD, which aligns with Cyclone Amphan.
- **Recent Trends:** From 2020 onwards, both the estimated damage and the number of affected people show moderate values compared to the peak years. For instance, 2020 has an estimated damage of around 96 million USD and an affected population of about 7,884 thousand, which is lower than the peaks but still significant. The most recent data point in 2024 shows an estimated damage of 350 million USD and an affected population of 3,250 thousand (or approximately 3.25 million), indicating a moderate level of impact.
- **General Trends:** The number of affected people fluctuates significantly over the years, with notable spikes in specific years (2004, 2007, 2017), suggesting the occurrence of significant disasters during these years. The estimated damage generally follows a similar pattern to the affected population but does not always correlate directly. For example, in 2004 and 2007, both metrics peak, indicating major disasters with widespread impact. However, there are years like 2013 and 2019 where damage is minimal, but the number of affected people is still relatively high, which might indicate less severe but widespread impact events.
- **Other Observations:** The chart suggests that the impact of disasters varies significantly from year to year, with some years experiencing extreme events that affect millions of people and cause substantial economic damage. The highest impacts in terms of both economic loss and affected population occurred in 2004 and 2007, likely due to major natural disasters such as cyclones, floods, or earthquakes. In the years following 2017, while there are fluctuations, the overall trend seems to suggest a reduction in both damage and affected populations, which could indicate improvements in disaster preparedness, mitigation, or a period of fewer extreme events.

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However, the number of affected people does not always align proportionally with the estimated damage, reflecting possible differences in the nature and severity of the disasters. The data suggests a continued vulnerability to severe weather events in Bangladesh, with recurring peaks in both the number of affected people and financial losses over the years. This analysis highlights the critical need for effective disaster preparedness and response strategies to mitigate both human and economic losses in the future.

D. Correlation Analysis:

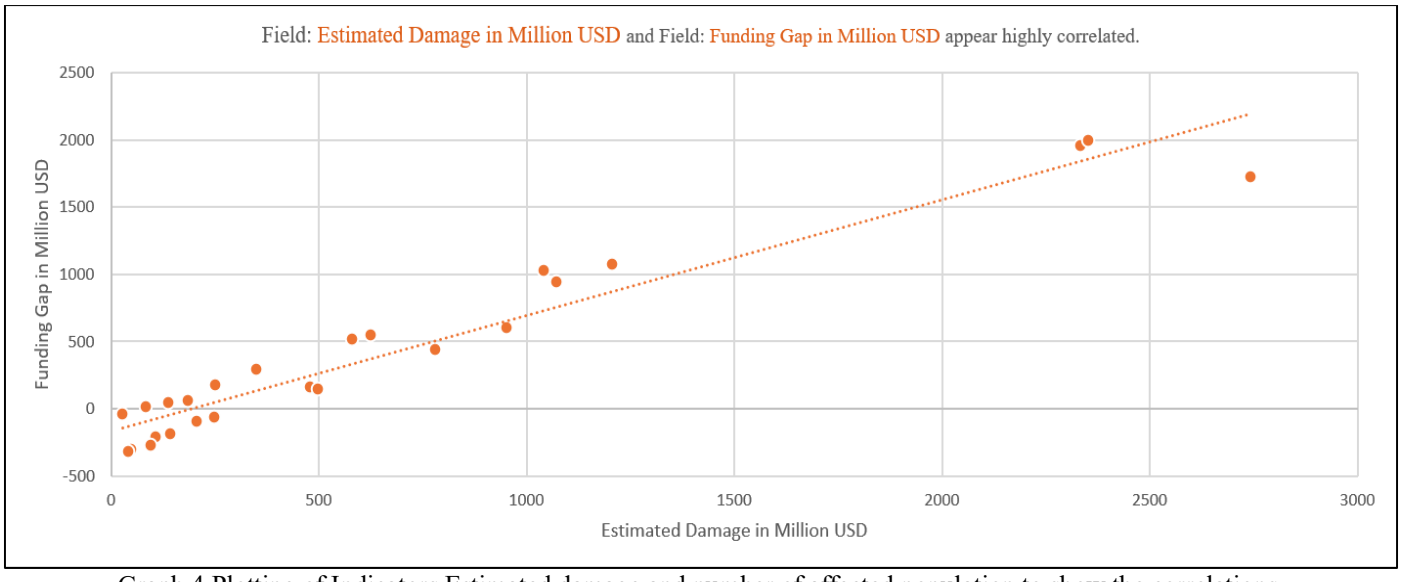
This table summarizes the correlation coefficients between the different pairs of variables, highlighting the strength and direction of their relationships.

Table 3 Output of Correlation Analysis.

Variables	**Estimated Damage** (Million USD)	**Investment/Funding** (Million USD)	**Funding Gap** (Million USD)	**Death Toll**	**No of Affected Population (Thousand)**
Estimated Damage (Million USD)	1.000	0.494[4] (p-value[5] 0.011)	0.966 (p-value 0.000)	0.668 (p-value 0.000)	0.716 (p-value 0.000)
Investment/Funding (Million USD)	0.494	1.000	0.278	0.765 (p-value 0.000)	0.443 (p-value 0.023)
Funding Gap (Million USD)	0.966	0.278 (p-value 0.173)	1.000	0.569 (p-value 0.003)	0.671 (p-value 0.000)
Death Toll	0.668	0.765	0.569	1.000	0.498 (p-value 0.010)
No of Affected Population (Thousand)	0.716	0.443	0.671	0.498 (p-value 0.010)	1.000

➢ *Key Observations:*

- **Estimated Damage (Million USD) & Investment/Funding (Million USD):** There is a moderate positive correlation (0.494) between estimated damage and investment/ funding, which is statistically significant. This suggests that as the estimated damage increases, the amount of funding or investment also tends to increase, but the relationship is not very strong. This could indicate that while funding generally rises with increased damage, other factors may influence investment decisions.
- **Estimated Damage & Funding Gap:** There is a very strong positive correlation (0.966) between the Estimated Damage and the Funding Gap, which is statistically significant. This suggests that as the estimated damage from disasters increases, the funding gap (difference between required and available funding) also tends to increase. This may indicate that higher damages often lead to greater financial shortfalls.



Graph 4 Plotting of Indicators Estimated damage and number of affected population to show the correlations.

[4] The correlation coefficient (r) measures the strength and direction of the linear relationship between two variables. The value of r ranges from -1 to 1. r=1: Perfect positive correlation. As one variable increases, the other variable increases proportionally. r=-1: Perfect negative correlation. As one variable increases, the other variable decreases proportionally. r=0: No correlation. There is no linear relationship between the two variables.

[5] A p-value less than 0.05 generally indicates that the correlation is statistically significant, suggesting that the observed relationship is unlikely due to random chance.

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For this particular pair of indicators, we attempted to understand their correlation using a scatter plot. The plot (Graph 4) depicts the relationship between **Estimated Damage** and **Funding Gap**. Each orange dot represents a data point, indicating the values for estimated damage and corresponding funding gap. The data points are closely clustered around a line with a positive slope, indicating a strong linear relationship between the two variables. This aligns with the interpretation from the correlation coefficient, which suggests a very strong correlation. The dotted trend line illustrates the overall linear trend in the data, reinforcing the positive correlation between estimated damage and funding gap.

- **Estimated Damage (Million USD) & Death Toll:** There is a strong positive correlation (0.668) between Estimated Damage and Death Toll, indicating that higher estimated damages are associated with a higher death toll. This relationship is statistically significant, suggesting that more severe disasters (in terms of economic impact) are likely to result in a higher number of fatalities.
- **Estimated Damage & No. of Affected Population:** There is a strong positive correlation (0.716) between Estimated Damage and the Number of Affected Population, which is statistically significant. This indicates that higher estimated damages tend to be associated with a larger affected population, reflecting the broader social impact of disasters.
- **No. of Affected Population & Funding Gap:** There is a moderate positive correlation (0.671) between the Funding Gap and the Number of Affected Population, which is statistically significant. This indicates that larger funding gaps are associated with a higher number of affected people, suggesting that funding shortages may lead to a broader impact on the population.
- **Death Toll and Number of Affected Population**: There is a weak positive correlation (0.498) between Death Toll and the Number of Affected Population, which is statistically significant. This indicates that as the number of affected individual increases, there is a slight increase in the death toll. This relationship is weaker compared to other correlations, suggesting that other factors may more strongly influence the death toll.

The correlation analysis reveals significant relationships between various disaster-related variables. Most notably, estimated damage is strongly correlated with funding gaps, death tolls, and affected populations, indicating that more severe disasters have broader and deeper impacts. The very strong correlation between estimated damage and the funding gap suggests a systemic issue where the funding response is not keeping pace with the scale of disasters, highlighting the need for better-preparedness and response strategies. Furthermore, the funding gap correlates with both the death toll and the number of affected people, underscoring the critical importance of adequate funding in disaster response and recovery.

V. DISCUSSION

➢ *Implications of the Funding Gap:*

The persistent funding gap in disaster management has significant implications for a country's ability to respond to and recover from natural disasters. This study's analysis indicates that years with substantial funding gaps correlate with higher death tolls and more extensive socio-economic impacts. For instance, the data shows that in years with significant funding deficits, such as 2004 and 2010, there was a corresponding spike in both the number of fatalities and the scale of economic damage. This relationship suggests that inadequate funding directly impacts the efficiency and effectiveness of disaster response efforts, as well as the speed and quality of recovery initiatives (Fakhruddin et al., 2021).

Moreover, the funding gap exacerbates vulnerabilities in already at-risk populations. When resources are insufficient, communities are less likely to receive timely assistance, such as emergency relief, medical care, and shelter. This delay not only heightens immediate suffering but also prolongs the recovery process, increasing the long-term socio-economic costs of disasters. A study by UNDRR (2019) highlighted that regions with less financial capacity to respond to disasters experience a slower recovery, resulting in a prolonged period of economic stagnation and increased poverty levels.

➢ *Challenges and Opportunities:*

The challenges in closing the funding gap are manifold. Limited financial resources are a primary concern, particularly for developing countries that often face competing priorities for government spending. Inadequate disaster preparedness further compounds this issue, as many countries lack the necessary infrastructure and systems to manage disasters effectively (Coppola, 2020). For example, a lack of resilient infrastructure and insufficient stockpiles of emergency supplies can delay response efforts and increase the overall impact of a disaster (Aitsi-Selmi et al., 2016).

Additionally, the absence of robust early warning systems in many disaster-prone areas limits the ability to mitigate the effects of natural disasters. Early warning systems are crucial for enabling timely evacuations and minimizing loss of life. However, in many low-income countries, these systems are either non-existent or underdeveloped due to financial and technological constraints (Basher, 2006).

Despite these challenges, there are several opportunities to improve disaster management financing and preparedness. International aid remains a critical component of disaster response, providing immediate relief and funding for reconstruction efforts (Kellett & Caravani, 2013). Moreover, public-private partnerships offer a way to leverage private sector expertise and resources to enhance disaster preparedness and response capabilities. For example, initiatives such as the Global Facility for Disaster Reduction and Recovery (GFDRR) bring together governments, private companies, and international organizations to develop innovative solutions for disaster risk management (GFDRR, 2015).

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Innovative financing mechanisms, such as catastrophe bonds and insurance, also present significant opportunities to mitigate the financial impact of disasters. Catastrophe bonds, for example, provide a way for governments to transfer the financial risk of natural disasters to investors, who receive a return on their investment if no disaster occurs but lose their capital if a pre-defined disaster does occur (Cummins & Mahul, 2009). This type of financial instrument has been successfully used by several countries, including Mexico and the Philippines, to provide a rapid financial response in the aftermath of major disasters (World Bank, 2017).

➢ *Limitations of the Research:*

While this study provides valuable insights into the funding gap in disaster management in Bangladesh, several limitations must be acknowledged. First, the reliance on secondary data sources, such as the EM-DAT database, ADB publications, and national government reports, may introduce inconsistencies due to variations in data collection methods and reporting standards over the years. Additionally, these data sources may not fully capture all aspects of disaster impact, such as indirect socio-economic losses and long-term recovery costs, potentially leading to an underestimation of the true extent of the damage (Guha-Sapir et al., 2015). The study primarily focuses on quantitative data, which, while useful for statistical analysis, may overlook qualitative factors that influence disaster vulnerability and resilience, such as community preparedness, local governance, and social capital (Yin, 2018). Furthermore, the analysis does not account for the effects of inflation and changes in currency value over the 24-year period, which could affect the comparability of financial figures (Ozaki, 2016). Lastly, correlation analysis, while useful for identifying relationships between variables, does not imply causation, and further research would be needed to establish causal links between funding gaps and disaster outcomes (Field, 2018).

➢ *Areas for Future Research:*

To build upon the findings of this study, future research should explore several areas that could provide a more comprehensive understanding of the funding gaps in disaster management. Firstly, integrating qualitative research methods, such as case studies and interviews with local communities, policymakers, and disaster management practitioners, could provide deeper insights into the socio-cultural factors influencing disaster vulnerability and resilience. This approach would help to capture the nuances of community preparedness, local governance, and social capital, which are often overlooked in quantitative analyses. Additionally, expanding the scope to include a longitudinal analysis of indirect socio-economic losses and long-term recovery costs would offer a more accurate assessment of disaster impacts and funding needs. Finally, employing more sophisticated statistical techniques, such as structural equation modelling or path analysis, could help identify potential causal relationships between funding allocations, management practices, and disaster outcomes, thereby offering more actionable insights for policymakers.

VI. POLICY RECOMMENDATIONS

➢ *Given the Challenges and Opportunities, there are Several Recommendations for Improving Disaster Financing in Bangladesh:*

- **Strengthening Domestic Financial Systems:** Building robust domestic financial systems that can allocate resources efficiently and transparently is essential. This includes enhancing the capacity of local governments to manage and distribute funds effectively, as well as developing national disaster funds that can be quickly mobilized in the event of a disaster.
- Allocating a dedicated disaster management fund is essential for ensuring prompt and adequate responses to natural disasters. Such a fund should be adequately capitalized and replenished regularly to meet the anticipated costs of both response and recovery. It should also be flexible enough to allow for rapid disbursement of funds in emergencies (Benson & Clay, 2004). For example, the Caribbean Catastrophe Risk Insurance Facility (CCRIF) allows Caribbean governments to access immediate liquidity after a natural disaster, demonstrating the value of pre-arranged financing in reducing disaster impacts (CCRIF, 2021).
- **Promoting Predictable and Sustainable Funding Mechanisms:** International donors and financial institutions should focus on creating predictable and sustainable funding mechanisms that prioritize pre-disaster preparedness and resilience-building. This could involve multi-year funding commitments and the establishment of contingency funds that can be rapidly deployed when disasters strike.
- **Integrating Innovative Financial Instruments:** The integration of innovative financial instruments, such as catastrophe bonds and insurance schemes, into national disaster management strategies could provide additional financial resources and help close the funding gap. However, these instruments should be designed to ensure accessibility for the most vulnerable populations and to provide sufficient coverage for all disaster scenarios.
- **Fostering Community-Based Approaches:** Empowering communities to manage their own disaster funds and resources can lead to more effective and targeted disaster management. Community-based approaches should be supported by national policies that provide the necessary legal and financial frameworks for local action.
- **Enhancing Early Warning Systems:** Investment in technology and infrastructure is vital to improve early warning systems and reduce the impacts of disasters. Advanced technologies, such as satellite-based monitoring and mobile phone alert systems, have proven effective in enhancing early warning capabilities and facilitating timely evacuations (Glantz, 2009). For instance, the use of mobile technology in Bangladesh has significantly improved the dissemination of early warnings for cyclones, contributing to a reduction in casualties in recent years (Paul, 2009).

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- **Promoting International Cooperation:** Encouraging international aid and collaboration is critical to bridging the funding gap, particularly in years with severe disasters. International cooperation can take many forms, from direct financial aid to technical assistance and knowledge sharing. The Sendai Framework for Disaster Risk Reduction emphasizes the importance of international partnerships in building resilience and reducing disaster risk (UNISDR, 2015). By fostering stronger international cooperation, countries can enhance their disaster response capabilities and better manage the risks associated with natural disasters.

VII. CONCLUSION

Addressing funding gaps in disaster management is crucial for building resilient communities and mitigating the devastating impacts of natural disasters in Bangladesh. This study has underscored the significant disparities between estimated damages and the funding allocated for disaster management over the past two decades, highlighting a critical need for improved financial planning and resource allocation. By systematically analysing the trends in funding gaps and their correlation with disaster outcomes, this research contributes valuable insights to the field of disaster management, offering a clearer understanding of the financial challenges faced by vulnerable regions.

To enhance disaster preparedness and response, it is imperative that policymakers and stakeholders prioritize closing these funding gaps. Specific policy changes, such as establishing dedicated disaster relief funds, implementing transparent and accountable funding mechanisms, and enhancing international collaboration for disaster risk reduction, are essential steps toward more effective disaster management. Furthermore, integrating both quantitative and qualitative data in future research could provide a more holistic view of the socio-economic impacts of disasters and inform more targeted interventions.

As climate change continues to exacerbate the frequency and intensity of natural disasters, the urgency of addressing these financial shortcomings becomes even more pronounced. It is not just about reacting to disasters but proactively preparing for them through sustained investment in infrastructure, community resilience, and adaptive strategies. This study serves as a call to action for governments, international agencies, and local communities to work together in closing the funding gaps, thereby reducing the vulnerability of populations and enhancing their capacity to withstand future disasters.

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