

Measuring the Impact of Water-Related Disasters on Poverty and Inequality, and Evaluating Climate Adaptation Policies to Strengthen Societal Resilience

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Introduction

The concept of human security has long been the subject of international attention. The 1994 report of the United Nations Development Programme (UNDP) defined security not merely as a nation's military stability, but as a state where people can enjoy “freedom from fear” and “freedom from want.” Human security thus refers to a state where people can live without their “survival, livelihood, and dignity” being threatened. Among these threats, natural disasters, particularly water-related disasters, pose a severe threat to lives, livelihoods, and economic foundations. Water-related disasters encompass damage caused by floods, droughts, tropical cyclones, and typhoons, directly impacting the lives of hundreds of millions of people annually. Indeed, analysis from the international disaster database EM-DAT¹ indicates that approximately 73.9% of natural disasters between 2001 and 2018 were water-related, including floods, heavy rainfall, and droughts.

¹ The International Disaster Database, which has systematically recorded information on natural and technological disasters since 1900, is operated by the Centre for Research on the Epidemiology of Disasters (CRED) at the Catholic University of Louvain, Belgium. It collects standardized data on the scale of damage from disasters worldwide, including death tolls, numbers of people affected, and economic losses. The database is widely used for research, policy formulation, and risk analysis.

Water-related disasters not only cause loss of life and property but also threaten people's long-term livelihoods by perpetuating poverty, widening disparities, and hindering the accumulation of human capital, such as education and health, in developing countries. The impact is not uniform; the most vulnerable suffer greater damage and recover more slowly. It has been noted that people lacking assets and social capital recover more slowly than wealthier people living in stable circumstances when faced with disasters of the same scale; ultimately, this leads to increased poverty and inequality.

In recent years, the number of water-related disasters globally has increased due to climate change, among other factors, leading to expanding economic losses. Against this backdrop, there is a growing trend toward shifting the focus of assessment away from a traditional emphasis on damage and loss to the restoration of livelihood opportunities and socioeconomic activities. In other words, it is essential to quantify direct damage such as housing damage, asset loss, road inundation, and agricultural damage, *and* to clarify the medium- to long-term socioeconomic spillover effects brought about by water-related disasters, such as widening inequality and the intergenerational entrenchment of poverty. Moreover, this focus calls for the development of pioneering monitoring and evaluation methodologies.

The author's research group has conducted extensive studies in Asia and Africa. These studies are grounded in the

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recognition that “water-related disasters are not merely natural phenomena but factors that exacerbate socioeconomic inequality.” Our hypothesis is that optimal flood protection investment as a climate adaptation measure has the potential to reduce damage and loss, as well as contribute to reducing inequality and strengthening societal resilience. This paper, based on field surveys of flooding in Southeast Asia, presents: 1) empirical analysis of the impact of flooding on poverty and economic inequality; and 2) an evaluation of the long-term socioeconomic spillover effects of climate adaptation measures, particularly flood protection investments, that enhance a society’s resilience.

1. Reproduction of Socioeconomic Inequality through Water-Related Disasters: Field Surveys and Empirical Analysis of Negative Impacts

1.1. Socioeconomic Impacts on People’s Livelihoods in Flood-prone Areas

The World Bank (World Bank 2016; Rentschler et al. 2020) has found that floods are not merely a temporary shock but a factor that delays poverty reduction over the long term. Its estimates of the potential economic damage from flooding in low-income countries indicate that, on average, approximately 26 million people face the risk of falling into extreme poverty annually due to floods and tropical cyclones. In countries prone to frequent flooding, such as Bangladesh, Vietnam, and the Philippines, significant differences in the speed of income recovery after floods were observed, with these differences explained by the presence or absence of government flood protection investments and social protection systems (Hallegatte et al. 2020; World Bank 2022). Furthermore, the UNDP (2014, 2019), drawing on research conducted in South and Southeast Asia, demonstrated that water-related disasters affect the poor primarily through deprivation of livelihood opportunities rather than the loss of assets. Disrupted education and increased malnutrition are linked to the entrenchment of intergenerational disparities,

underscoring the importance of viewing water-related disasters not merely as natural phenomena but as processes that reproduce social inequalities.

However, much existing research has leaned toward macro-level analysis using national or macro-scale statistical data and satellite imagery (e.g., Hallegatte et al. 2017; Rentschler et al. 2022; Winsemius et al. 2018); such analysis struggles to fully capture the causal processes that link floods and poverty. To achieve greater precision, it is necessary for researchers to conduct detailed household interview surveys targeting villages and small communities. Although there is extensive research on poverty and development in the humanities and social sciences (Chambers 1983; Wisner et al. 2004; Banerjee and Duflo 2011), much of this research remains descriptive or qualitative, with few studies specifically focused on disasters. To formulate and implement effective flood protection measures, such as climate adaptation, it is essential to draw a quantitative link between the natural phenomena of floods and their impact on socioeconomic activities. We must develop a better understanding of how physical flood-hazard parameters, such as inundation depth and duration, shape socioeconomic impacts over time.

To address this challenge, the author and his team collaborated with local university researchers to conduct household interview surveys in flood-prone areas across Thailand, Myanmar, the Philippines, Sri Lanka, and Bangladesh. Approximately 9,000 households were approached as part of our efforts to collect quantitative data. **Figure 1** presents analysis results from the lower Bago River in Myanmar, the lower Chao Phraya River in Thailand, and the lower Pasig-Marikina River in the Philippines. People who live in flood-prone areas and are regularly exposed to deep inundation are more likely to reside in structurally vulnerable houses built of timber, bamboo, and straw (Kawasaki et al.). Through these surveys, we demonstrated that deeper flood inundation tends to correlate with lower annual income per household member.

A similar negative correlation was found between flood depth and educational attainment (Kawamura and Kawasaki 2017). A series of studies in flood-prone areas of Southeast Asia revealed that flooding is the cause of both direct damage and loss, and indirect impacts such as interrupted education,

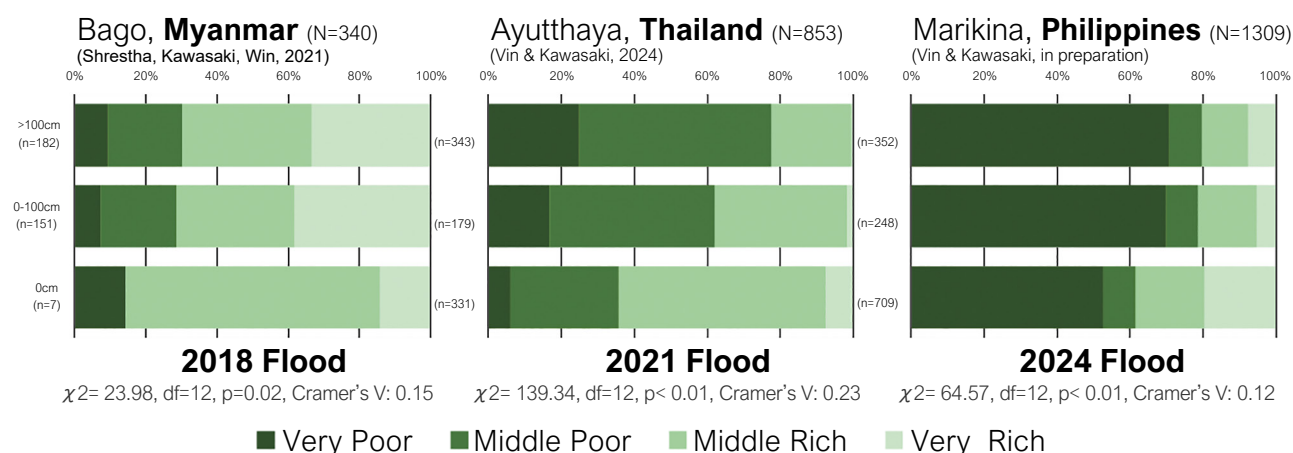


Figure 1 Relationship between flood inundation depth and income level of the residents

Source: Author

health problems, and job losses. These findings suggest that even if flood protection measures cannot eliminate the problems caused by flooding, keeping inundation depths as low as possible can mitigate adverse effects on residents' income and education.

1.2. The Medium-to-Long-Term Impact of Recurrent Flooding on Household Economies: A Comparative Analysis Using a Control Group

When floods occur in flood-prone areas, some residents relocate, but many choose not to move despite being aware of the risk. This stems from multiple social factors: dependence on familiar communities, proximity to workplaces and facilities, livestock losses, attachment to ancestral land, and land scarcity or lower land prices elsewhere. It has long been pointed out that disasters disproportionately harm the poor and create a long-term poverty trap through a vicious cycle of declining income and human capital (Rentschler 2013). Because few studies have empirically demonstrated this relationship through field research, the author's team conducted a study in the aforementioned flood-prone areas to clarify the long-term socioeconomic impacts of recurrent flooding (Figure 2). These regions have experienced multiple large-scale floods. Households unaffected by these floods were designated as the control group. Changes in household economies were then analyzed comparatively across low-income and high-income households.

In Myanmar, major floods in 2011 and 2018 have caused long-term deterioration in the economic circumstances of low-income households. Many residents in flood-prone areas rely on daily wage labor for their livelihood; prolonged flooding leads to lost income opportunities. Without savings, they are forced to borrow at high interest rates, plunging them into a vicious cycle of poverty (Kawasaki and Shimomura 2024). Thus, in the aftermath of disasters, low-income households tend to rely heavily on asset sales and borrowing, delaying their recovery, while middle- and higher-income households recover more swiftly by utilizing savings and social networks. Our data from the field suggest this disadvantage accumulates, leading to widening inequality within communities in the years after disasters (Vin and Kawasaki 2024). In Thailand, the economic gap between high-income households in non-flooded areas and low-income households in flooded areas widened 1.8 times in the decade between the 2011 and 2021 floods. Furthermore, within each income group, disparities increased 2.1 times among high-income households and 1.6 times among low-income households. In the Philippines, following floods in 2009, 2020, and 2024, the economic gap between high-income households in non-flooded areas and low-income households in flooded areas widened 1.7 times. Inequality within the same income group also increased for both the high-income and low-income groups, rising 1.1 times among high-income households and 8.2 times among low-income households.

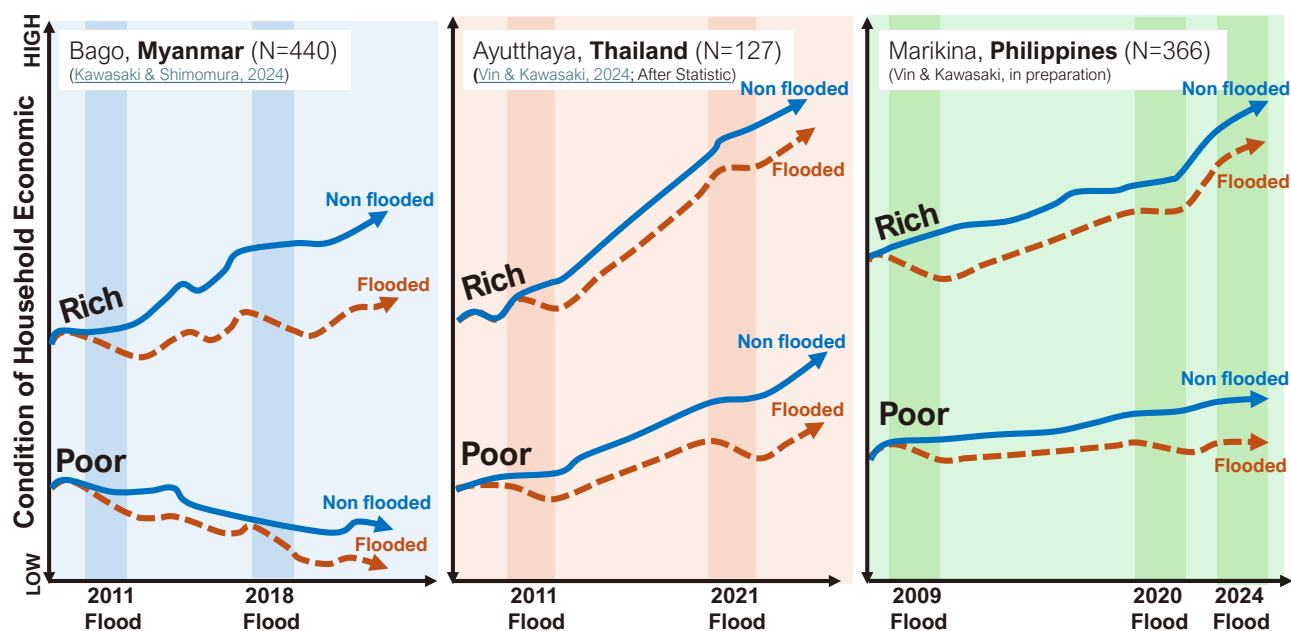


Figure 2 Widening economic disparity between high- and low-income households due to recurrent flooding

Source: Author

Thus, while floods cause short- to medium-term income stagnation and economic deterioration in low-income households, in relative terms they comparatively strengthen the economic position of high-income households, widening disparities. This study (Figure 2) presented a framework that drew on field data to quantitatively demonstrate this mechanism.

1.3. Recovery Speed from Flood Damage as a Resilience Indicator

Assessing the socioeconomic impact of disasters requires a comprehensive framework that encompasses not only the economic value of damage but also the loss of livelihood opportunities and the speed of recovery following damage. Figure 3 compares the recovery rates from flood damage between low-income and middle-income households in the flood-prone areas of the lower Pasig-Marikina River basin, Philippines. For households affected by three meters of inundation, 96.5% of the middle-income group and 77.2% of the low-income group recovered within 120 days. When the flood depth reached 6 meters, the 120-day recovery rate was 80.2% for the middle-income group but only 59.8% for the low-income group. This analysis quantitatively

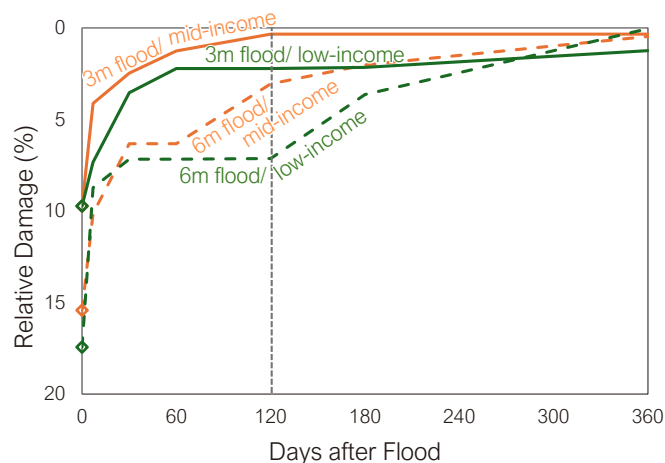


Figure 3 Comparison of recovery speeds from flood damage between low-income and middle-income households (N=351)

Source: Author

demonstrates, for the first time, that significant differences in post-flood recovery speed occur between income groups. This disparity in recovery speed suggests it is a factor contributing to widening inequality (Figure 2).

2. Socioeconomic Benefits of Flood Protection Investment as Climate Adaptation: Evaluating Long-Term and Indirect Positive Effects

2.1. Optimizing Investment in Disaster Risk Reduction by Considering Secondary Benefits: Development of a Livelihood Improvement Model

Decisions on investing in disaster risk reduction are typically made through cost-benefit analysis based on the amount of damage expected to be mitigated through infrastructure development, i.e., the primary benefits. However, in many low- and middle-income countries, flood protection investments are often avoided due to high upfront costs. Consequently, disaster-related budgets tend to focus on post-disaster emergency responses, recovery, and reconstruction rather than on upfront investments such as disaster risk reduction facility development, hazard mapping, and the installation of early warning systems (Takeya 2023). In recent years, scholars have recognized that flood protection

measures enhance residents' safety levels and improve risk awareness, thereby changing attitudes towards safety and promoting positive socioeconomic activities, resulting in the long-term accumulation of assets.

Yamagami and Kawasaki (2024), using an innovative approach, modeled these long-term, indirect benefits (secondary benefits) and attempted to integrate them into flood protection benefit assessments (Figure 4). Their case study, which focused on the lower Bago River, Myanmar, assessed the benefits of flood protection measures across 127 different protective combinations. These included reservoir and embankment construction, river channel widening and dredging, land-use regulations, and the installation of early-warning systems. Figure 5 shows projected accumulated economic benefits from 2040 to 2070 on the vertical axis, and the horizontal axis depicts the ratio of people whose lives would be improved (the responsiveness ratio) through the adoption of flood protection measures. For instance, reducing or eliminating the effects of floods would be expected to allow individuals who previously earned a living as street sellers to open permanent shops in previously inundated areas, or allow day laborers to work in factories without fear of constant absenteeism. Such positive shifts would likely facilitate transitions to higher-income occupations.

When the “responsiveness ratio” is 0% (i.e., no

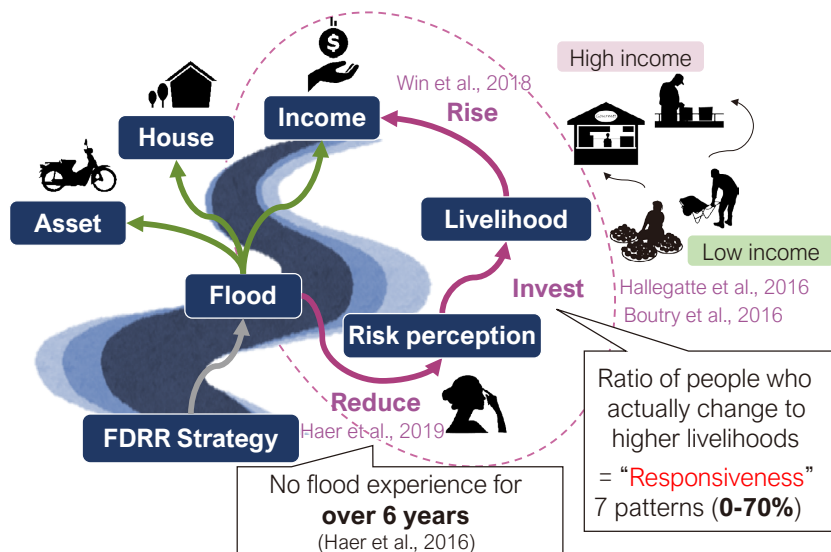


Figure 4 Livelihood advancement model for the poor representing the long-term effects of flood protection investments

Source: Author

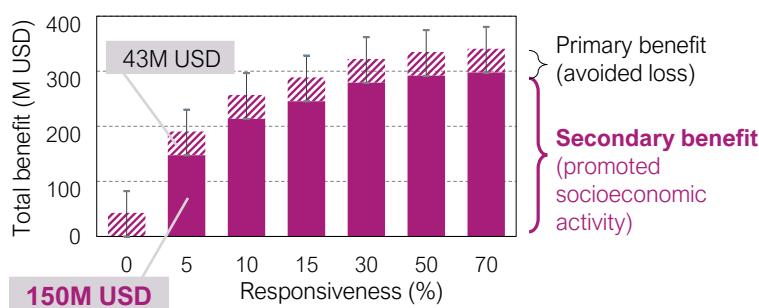


Figure 5 Average benefit of 127 flood protection investment strategies (2040–70) under a scenario of very high greenhouse gas emissions (SSP5-8.5)

Source: Author

occupational change is anticipated), the total economic benefit for 2040–2070 remains at \$43 million (primary benefit only, **Figure 5**). However, if flood protection measures result in residents changing their occupation (even if only 5% do so), the secondary benefit could reach \$150 million over 30 years. This demonstrates that the long-term accumulation of secondary benefits has the potential to significantly exceed direct benefits. This stems from the fact that benefits from damage mitigation only manifest during flood events, whereas income increases from changing occupation and other accumulated benefits progress continuously, irrespective of whether flooding occurs. As illustrated in **Figure 2**, while flooding traps low-income groups in a vicious cycle of poverty, flood-protection investment in flood-prone areas can help break this cycle. Consequently, investment in flood protection measures can serve as a powerful tool to reduce the vulnerability of the poor and to reduce economic disparities.

This methodology suggests that conventional cost-benefit analysis may have underestimated the socioeconomic benefits of flood-protection measures by ignoring the indirect effects of such measures on improving residents' livelihoods. Specifically, when secondary benefits are taken into account, we may reach different conclusions about the most cost-effective flood protection measures than when we consider only primary benefits through conventional cost-benefit analysis. Integrating secondary benefits into the benefit assessment enables measures to become cost-efficient, even with small initial investments.

2.2. The Importance of Education for Flood Protection Investment and Poverty Reduction

Following floods, the poor face job instability, increased debt, and constrained educational opportunities, increasing the likelihood that they will become trapped in a cycle of poverty. While impoverished people living in flood-prone areas struggle to maintain hope for the future, those residing in low-flood-risk areas tend to have better prospects and greater opportunities to increase their savings. This allows their children to pursue higher education, through which they further improve their chances of escaping poverty (Vin and Kawasaki 2024). Improving educational attainment not only increases employment opportunities and income but also enhances people's understanding of and capacity to respond to disasters, thereby reducing disaster-related losses (De Silva and Kawasaki 2022). Nakamura and Kawasaki (2022) developed a novel methodology to quantitatively link flood protection measures with flood damage, savings, and education, enabling comparative analysis of policy effects at the household level. Their findings suggest that implementing educational support, particularly when budgets are constrained, offers higher cost-effectiveness than the adoption of flood protection measures. Educational support reduces vulnerability among the poor and, as depicted in changes in the Gini coefficient, is effective in reducing income inequality.

2.3. Future Research Directions

Previous research findings indicate that flood protection investment should not be confined to infrastructure development

and flood protection measures alone. Positioning such investment as socioeconomic policy and allowing for its integration with education and social security represents a crucial pathway toward strengthening social resilience and reducing poverty. However, numerous challenges must be overcome in terms of policy formulation and implementation in practice. Key issues are:

—Continuous Collection of Field Data

Long-term monitoring through detailed household interview surveys is essential to elucidate the mechanisms underlying poverty cycles and widening disparities in flood-prone areas. Extended panel surveys, particularly in the field of disaster scholarship, remain scarce. There is a clear need for research that tracks how physical variables such as flood depth and duration influence the formation and expansion of disparities via household economics and individual decisions. This research would need to span a decade or more.

—Analysis Based on the Attributes of Socially Vulnerable Groups

It is necessary to understand the complex impacts of flood damage on poverty and inequality, taking into account socioeconomic factors such as income, occupation, age, gender, and education. International organizations, governments, and the academic community should increase their focus on particularly vulnerable groups—the poor, women, children, persons with disabilities, migrants, and the elderly—and promote inclusive approaches from data collection through to analysis.

—Standardization of Indicators and Data Integration

As water-related disasters and poverty are shaped by natural, cultural, and social environments at the local level, standardized indicators are essential for interregional comparisons. Ideally, poverty thresholds should be defined holistically, incorporating the measurement target (income, consumption, assets), price adjustments (CPI or PPP), and household size adjustments (equivalence). However, obtaining the necessary information is often difficult. Consequently, in practice, approximate measures such as monthly or annual income, savings, and total assets (including household goods

and livestock) are used as indicators of household economic status. Challenges remain regarding sample size variability, differences in aggregation methods, and inconsistencies in indicator definitions.

—Investing in Disaster Risk Reduction and Evaluating the Effects on Resilience

Case studies are needed to demonstrate the long-term effects of past flood protection investments. These evaluations should consider economic efficiency and reassess factors such as the effects on reducing inequality from the perspective of maximizing socioeconomic growth.

3. Conclusion

In Asian and African nations undergoing rapid urbanization and rural development, climate change compounds water-related disaster risks for the poor, threatening human security. Climate adaptation measures, including flood protection investments, have the potential to mitigate damage and loss, and to strengthen resilience and reduce inequality. Positioning these measures as part of socioeconomic policy represents a crucial pathway toward poverty reduction and enhanced societal resilience.

Recent years have seen rapid advances in poverty research, with satellite observations and global datasets finding increased application. Causal inference methods, such as difference-in-differences and propensity score matching, have also been developed. However, field surveys that capture local contexts and people's lived realities, alongside human-centered research frameworks that integrate interdisciplinary perspectives, remain uncommon and underdeveloped (Blumenstock 2020). The author's research group aims to overcome these limitations by utilizing geospatial data, such as satellite imagery and global datasets, as well as deep learning and causal inference methodologies, while prioritizing the incorporation of residents' voices.

It is necessary to develop long-term, multi-faceted survey and measurement frameworks to quantify the socioeconomic spillover effects of water-related disasters and their impacts on human cognition and behavior, thereby supporting policy

formulation that contributes to reducing disparities. From a human security perspective, there is a need to construct new indicators measuring how quickly freedom can be restored after a disaster. This, in turn, will help promote international cooperation and policy formation.

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