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DISASTER MANAGEMENT AND RESILIENCE

Case Study: Earthquake and Flood

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Abstract

In the presence of disasters, it has been a struggle for people to completely avoid both natural or man-made disasters. Natural forces have their way to be uncontrollable and impact the communities through threats like earthquake and flood. Man-made disasters are assumed to be preventable but natural disasters are more unpredictable. Humans cannot know where or when the occurrences of disasters or the severity and the scale of one disaster, but disasters can be recognized from the past experiences which location is most vulnerable or if the location has probability of being impacted by disasters. Earthquakes and floods are the first and the fourth highest number of the annual average number of deaths respectively. In this case, certain locations must have disaster management to prevent, reduce, or respond toward these disasters. For example, a destructive flood happened in the Philippines and an earthquake occurred in Haiti. No one was prepared for the collateral damage these disasters affected. Disaster has localized or large-scale impact, this will immobilize humans to do their activities regularly and cost nearly multiple deaths, casualties, and destruction of infrastructure. Rebuilding the communities and infrastructure is not simple as it might be, thus to minimize the impact of these natural hazards, disaster management is a must to do method for people to mitigate, prepare, respond, and recover from disaster. The disaster management conduct area to be more disaster resilient and respond in case of emergency management. The emergency procedures, due to limited resources and manpower, are the best case to operate during a disaster.

Keywords: Disaster, Disaster Management, Disaster Resiliency, Earthquake, Floods, Emergency

1. Introduction

Disasters, either natural or man-made, are bound to happen at some point. Whether we like it or not, these disasters are inevitable and might strike nations world-wide regardless of the intensity. Different geo-climatic conditions in several parts of the world cause distinctive types of natural disasters like floods, earthquakes, droughts, hurricanes, volcanoes, tsunami, etc. The exact occurrences behind natural disasters are mostly unknown to humans as they occur due to natural forces and phenomena in which humans only have an approach method to predict the range of time. Regardless, humans consider that the challenge to explain about natural disasters is to predict where and when a disaster may strike because there are many variables that can influence the chances and severity of the disaster. According to the data collected by the United Nations Office of Disaster Risk Reduction (UNDRR), the annual average number of deaths from 2001 to 2020 is observed to be 64,363. These fatalities are classified according to the types of natural disaster with the highest number due to earthquakes, followed by storm, extreme temperature, flood, and other severe natural hazards.

The types of man-made disasters are technological disasters and human caused disasters. Technological disaster is an event series of man-made activities, may it be an accident or not, but they are mainly caused by the built environment such as chemical accidents, power outages, and lack of design quality. To give some examples of man-made disasters, Chernobyl and the oil spill were a technological failure. Another type of man-made disasters is caused by human activities like terrorism, wars, and civil unrest for example, the 9/11 buildings attack that happened in 2001. It was a normal day in New York City and no one ever predicted the attack that happened. In recent years, humans also contribute to the scale of various natural disasters to become more catastrophic, shown in the recent trend of increasing frequency and widespread affected area. The severity of human man-made disasters is assumed to be preventable but is upsetting more to the community.

Disasters are not only acute situations but also chronic. They can cause unexpected deaths, casualties, and destruction of infrastructure. Infrastructure devastated might take years to rebuild the community and develop the area. This will impact the economic growth for the scale of regional or nations as the accessibility is hindered, either in or out of the area. The transportation, communication, water resource, gas, and light systems are crashed and human activities are halted. Disasters that happen in the developed infrastructure areas have more damage than in the open, empty field due to the massive infrastructure failure.

However, we could always prepare for these disasters even though they are difficult to predict which results in a lot of fatalities. May it be a natural disaster which tends to be uncontrollable or man-made disasters which actually can be prevented. In this paper, we would like to give more highlights toward natural disasters: earthquakes and floods.

For an instance, earthquakes are unpredictable. The likelihood of an earthquake to happen is by basing it from the history of past earthquakes that happen in a certain location. Scientists can study the seismic activity of the area but cannot really predict the exact moment and the frequency when a major earthquake may happen. Floods are also disasters usually caused by excess surface run-off from rainfall and consequence to existing sewage systems of an area. In this case, disaster resiliency is a mandatory procedure for every country to have an emergency management phase. According to the Federal Emergency Management Agency (FEMA), 4 phases of emergency management are mitigation, preparedness, response, and recovery. Today, the government made a lot of measures and strict laws that will prevent it from

happening again, particularly regarding the infrastructure design. This is how Disaster Management provides critical advantages to us humans and the whole community.

Disaster management is the process of planning, coordinating, and executing the activities and protocols to safeguard the lives of people and protect properties from being devastated. Governments, organizations, and people that manage these are responsible to determine the risks and to develop integrated plans and procedures to minimize the terrible impact of disasters to the people. From the preparation before the disaster, during the disaster, initial response and the long-term recovery, disaster management's main role is to provide safety, assistance, and resources to the community. Since there are many variables to consider, these disaster management procedures should be specific and custom for the area, community, and type of disaster. Disaster management is different from place to place, country to country, nevertheless, the main goal is to keep people alive and have the quality of lives we ought to have.

2. Literature Review

2.1 Defining disasters

Understanding the terminologies: Disaster, crisis, and emergency: Al-Dahash H, Thayaparan M and Kulatunga U.

The terms disaster, crisis, and emergency are highly connected to each another and often exchanged and combined in mainstream literature. This article comprehensively reviews the definitions of these terms individually. To understand these terminologies in detail, the review has been conducted in the relative field systematically. To prove the differences and similarities between disaster, crisis, and emergency, a subjective conceptual content analysis has been carried out. The common features seen in disasters and crises with the help of this analysis are sudden nature and damage caused by them while explaining that emergency is not always sudden in nature. With more research, it has been found that disaster and crisis have many similarities and can be used interchangeably up to a particular point. The term emergency has many dissimilarities with the other two terms and has some contrary features. In the end, the authors conclude that crisis and emergency, both can lead to disaster if not paid attention.

2.2 Disaster risks

Flood risk management through a resilience lens: Karin M. de Bruijn, Bramka A. Jafino, Bruno Merz, Neelke Doorn, Sally J. Priest, Ruben J. Dahm, Chris Zevenbergen, Jeroen C. J. H. Aerts & Tina Comes

The authors promoted that for added recovery capacity, distributional impacts, and impacts beyond design events, the welfare of different social groups should be included. With the help of successful strategies against floods, society is now able to live in river valleys, deltas, and coastal areas. But, the frequency and intensity of floods have increased due to climate change. To reduce flood risks, governments are favoring the strategies which have the highest risk reduction benefits with the lowest cost. The authors think that the high impact of recent rare events in Europe, Asia, and Central America has ringed a bell for the renovation of flood risk management. As the expected damage during rare and extreme events is less, conventional risk analysis is not that important. Where the main focus of risk reduction measures is to minimize direct impacts and reduce total flood risks keeping the cost on the lower side. In contrast, few measures have been put in place to improve the ability to cope with flood hazards, recover rapidly, reduce indirect flood effects, and account for poverty and wealth disparities. This might affect the inequalities and disregard disastrous outliers. Increased flood hazards due to climate change need additional flood risk management investments. According to the authors, a more comprehensive analysis rooted in societal welfare should be used by policymakers when considering resilience.

Earthquake Loss Assessment for Integrated Disaster Risk Management: Omar D. Cardona, Mario G. Ordaz,Luis E. Yamin,Mabel C. Marulanda &Alex H. Barbat

Developing planning options and tools to cope with risk, such as allocating the sustained budgetary resources necessary to reduce potential damage and safeguard development, is a powerful incentive for countries to understand likely earthquake losses and reconstruction costs. Building by building, a specific catastrophic risk model was developed, taking into account the seismic micro zoning of cities to calculate probabilistic losses and pure premiums. In this model from the authors, contingent credits, reserve funds, insurance/reinsurance, and cat bonds are considered to determine the government's fiscal contingency liabilities. In addition, the model provides decision-makers with an innovative and ground-breaking tool to analyze the net benefits of risk mitigation strategies such as earthquake retrofitting and seismic code enforcement, by evaluating the exceedance probability curve of the benefit-cost ratio. A model and the derived tools are presented in this article with regard to loss scenarios and strategies implemented in earthquake-prone urban areas.

2.3 Classification according to intensity

Natural Disasters Intensity Analysis and Classification Based on Multispectral Images Using Multi-Layered Deep Convolutional Neural Network: Muhammad Aamir, Tariq Ali, Muhammad Irfan, Ahmad Shaf, Muhammad Zeeshan Azam, Adam Glowacz, Frantisek Brumercik, Witold Glowacz, Samar Alqhtani and Saifur Rahman.

Besides disrupting the ecological system, natural disasters such as earthquakes, floods, wildfires, and cyclones, destroy human infrastructure, destroy property, and even result in permanent changes to the ecosystem. The complex and imbalanced structures of images continue to pose challenges in detecting natural disasters because of the wide variety of deep learning techniques being applied. To overcome this, authors proposed a neural multilayered network that has two blocks: Block 1 (B-I CNN) convolutional neural networks, to detect disaster occurrence and Block 2 (B-II CNN) convolutional neural network, to divide natural disasters according to their intensity. The test was conducted on above 4000+ images to calculate the statistical values: accuracy rate 99.92%, sensitivity 97.54%, precision 97.79%, specificity 98.22%, and f1 score 97.97%. The overall accuracy of this model was found to be 99.92%.

2.4 Factors causing the disaster

Floods and Climate Change: Interactions and Impacts: Axel Bronstert

Many debates are being conducted about whether the floods in Germany are caused by human activities. Intensified land use and forestry are possible anthropogenic contributors to increased flood risk, as well as global warming caused by greenhouse gases. By reviewing the available resources, this article discusses the latter part. Initially, under the possibilities of anthropogenic climate change, the capabilities and relevance of this model have been analyzed for flood risk. The hydrological flood models and typical spatial scale of climate models are given special attention. Then, the climate variables related to river flooding issues are observed. And lastly, the summarization of the cascade of flood risk is done by modeling different parts with the help of features like meteorological, hydrological, and river hydraulic models. With the help of spot images and detailed field investigations, over 10,000 landslides were mapped. The classification based on type, size, ground motion, slope angle, bedrock geology, and distance from the earthquake source was carried out with the help of Geographic Information Systems (GIS). The landslides which are well known for their susceptibility in many parts of the world were primarily seen in Tertiary Sedimentary rocks. There is a steep decline in landslide concentration values beyond distances of 40 and 70 km from the epicenter and surface projection of the fault plane, respectively, located at 40 and 70 km from the epicenter.

The region where 74% of all slope failures occurred had horizontal accelerations greater than 0.15g and 74% had vertical accelerations greater than 0.2g. These factors were considered to differentiate between the Chi-Chi earthquake and landslides due to the 1989 Loma Prieta earthquake and the 1994 Northridge earthquake. The major difference in these cases was the slope angle distribution. In the Chi-Chi earthquake, the majority of failures occurred on slopes steeper than 45°, whereas in California, more than 80% of failures occurred on slopes steeper than 50°. This may be a result of Taiwan's steeper and more active geologic setting.

2.5 Disaster recovery planning

Local responses to disaster: Raven Marie Cretney (RMIT University, Melbourne, Victoria, Australia)

As evidence of the role of grassroots organizations in shaping a community-defined concept of resilience through self-organized disaster response action, this paper provides case study evidence of the earthquake in New Zealand on 22nd February 2011 with a magnitude of 6.3. The study states that citizen participation after the disaster was on the higher side due to the project Lyttleton. Also, some findings said that social support and social learning conducted before disaster occurrence was important. Case study evidence for the value of community-led and defined resilience frameworks is provided in this research. This study supports the importance of integrating and supporting local community preparedness and response initiatives, and it demonstrates the value of taking pre-disaster measures. Therefore, this work is relevant to academics interested in community response to disasters, as well as emergency management practitioners interested in ways to promote and encourage locally-centered disaster preparedness efforts.

2.6 Government recovery planning

Role of government in flood disaster recovery for SMEs in Pathumthani province, Thailand: S. Pathak & M. M. Ahmad

The major stakeholder in the recovery process post-disaster is government. Policies of the government affect the economy from all angles, whether it is from a financial, social, or managerial standpoint. To cope faster with disasters, flood preparedness strategies and recovery mechanisms could minimize the vulnerabilities from natural hazards such as floods. The responsibilities, strategies, and roles of the government during the Thailand floods in 2011 were studied. For the study area, the recovery mechanism and loss from floods are evaluated critically. The data was collected with the help of surveys, interviews, and group discussions. This data revealed the mismanagement and miscommunication, and lack of transparency between government officials and their action plans in the flood-affected area. This study also suggests plans to enhance sustainability in the area.

Community Recovery and its Sustainability: Lessons from Gujarat Earthquake of India: Rajib Shaw; Manu Gupta; Anshu Sarma

In the aftermath of the 2001 Gujrat Earthquake in India, communities needed to be involved, leading and taking ownership of the recovery process. In Patanka, one of the Gujrat’s hardest-hit villages, a multi-stakeholder, and multi-organizational rehabilitation program was implemented. This paper informs about the learnings during this disaster. The first step was to interact with the community and build trust, follow proper planning processes, and be flexible with budgets. Furthermore, with the help of society, capacity-building and confidence-building processes were undertaken. As part of the development initiative, the reestablishment project became part of a sustainability focus. In the end, the most important aspect was the exit policy of the project team, leaving the community with an institutional framework to serve its own needs.

2.7 Government policies for emergency management

Evaluating Local Government Emergency Management Programs: What Framework Should Public Managers Adopt: Daniel Henstra

For a productive response to community emergencies post-disaster, it is important for local authorities to develop the required procedures and policies. In most jurisdictions, emergency measures are rarely activated, so public managers are unable to evaluate and assess the effectiveness of existing emergency management programs. This expert literature review identifies 30 elements of a high-quality emergency management program, which are refined and synthesized into a single framework that provides clear-cut best practices for evaluating and evaluating emergency programs.

3. Methodology

This study deemed it appropriate to utilize the descriptive research since it seeks to determine the correlation between disaster, disaster recovery planning and how policies affect the objective of disaster management.

The required data that we gathered with the use of journals and secondary-data research. The data materials we have combined are dealt with civilian response toward disaster and the satisfaction rate of Government action to handle, mitigate, and prevent the disasters. The data shows the cause, fatalities, effect on infrastructure, disaster management, and response for earthquakes and floods disasters.

This study focused on the impact of disaster and the level of implementation regarding the disaster management. As earthquake and flood are a recurring event series, disaster management are anchored to the emergency management. The method used for the disaster management are according to the Federal Emergency Management Agency (FEMA) in which 4 phases of emergency management are mitigation, preparedness, response, and recovery.

A. Mitigation

First steps of emergency management in which includes operation to prevent, reduce, and alleviate the impact, cause, and consequences of disasters. This phase draws the action from the design of the area, development infrastructure, emergency facilities, and temporary shelter. Example of mitigation activities are:

1. Sewage and water channels systems to reduce excess surface run off
2. Using specific materials for buildings and infrastructures depends on the probability of disaster
3. Construct the fire management system in the buildings and communities
4. Buying insurance policies

B. Preparedness

Second steps of emergency management are designed to plan, train, give motivational encouragement, and educational activities for circumstances that cannot be mitigated in the first phase. Example of preparedness activities are:

1. Prepare plans for the scheme of disaster preparedness action (what to do, where to go, who to call for help in disaster)
2. Conduct simulation of emergency alert through exercises, emergency alert model
3. Give training to people what is needed in a disaster and how to supply the list of items

C. Response

Third steps of emergency management are response towards real-time disaster. This phase occurs during and in aftermath of a disaster. During the disaster, all of operations do not function normally and emergency alert is activated. The response phase duration and operation depend on the preparedness phase, intensity, and frequency of the disaster. Example of response activities are:

1. Operate the disaster response plans
2. Conduct search and rescue missions
3. Follow the news or responsible officer in the field
4. Build temporary shelter

D. Recovery

Last steps of emergency management are recovery period. This phase occurs after the government declare that the area is not in an emergency alert. During the recovery period, all of operations are concurrently functioned regularly. The duration of recovery phase depends on the impact and the scale of the disaster. Example of recovery activities are:

1. Rebuild the damaged infrastructures
2. Evaluate the response of disaster
3. Design and plan the financial advice for communities

This emergency management's method is integrated in cycle which all community in the disaster range area is at least in the position of one phase. This is to ensure that the community and affected area are disaster resilient and can adapt or survive the unpredicted disaster in the future.

To draw recommendations for earthquakes and floods disaster, it is to be concluded from the civilian response and evaluation of government policies to expose ideas, awareness, and coordination needed or upgraded.

4. Disaster Case Studies

4.1. Flood

September 27, 2009, a date that most Filipinos will never forget. Almost a month's worth of rain fell in just six hours over Metro Manila that brought the worst floods in the area causing people to be stranded on rooftops, black-outs and killing hundreds of people. The capital and 25 provinces were declared in a state of calamity as massive flooding paralyzed the entire area.

More than a decade has passed since the tropical storm Ondoy has hit the entire areas of the Philippines and since then, rainfall memories are still lingering in the minds of common people especially the victims. Even though the country was no stranger to floods, the trauma that Ondoy brought by Ondoy was incomparable. Up to this day, every time that there is heavy rainfall, the pain of Ondoy's catastrophe and the fear of irreparable losses of lives and properties resurfaces.

Figure 1 Floods Cause by Tropical Storm Ondoy in Philippines

4.1.1. Effects and Damages

The tremendous amount of rainfall and floods caused damage to 185,004 houses with 4.9M people affected, 70,124 people to be evacuated, 529 people to be injured and worst, deaths counting to 464 people. The typhoon caused an estimated loss of 11B pesos both in infrastructure and agriculture.

4.1.2. Disaster Effects on Infrastructure

Most damages of this disaster point out to the deficiencies of the government's preparedness, disaster management and failings in the physical planning and design which is within the horizon of engineering, architecture, urban design, and industrial professionals. It is necessary to generate new inventions and design proposals for the built environment to be more resilient to hazards.

The cause of disaster can be partly because of uncontrolled urbanization, settlements are spread to areas that are not meant for intensive developments. Areas like riverbanks, steep mountainsides or flood plains that are always in conflict with natural disasters are continuously being used as settlements.

The Government's Urban Planning Department should set boundaries for which areas are allowed to be developed. Also, the cities' drainage strategies should also be assessed. A lot of subdivisions and public roads in Metro Manila have ill-designed drainage systems that are vulnerable to floods. In fact, the process of obtaining permits for these drainage systems is done before actual detailed planning has started. There is an extreme lack of any real urban design and landscape architectural input into how the cities are planned and that is evident in the lack of well-designed parks, open spaces, and streetscape. These projects could have helped in mitigating the effects of stormwater, pollution, and solution to the increasing density of population in the cities and suburbs. Commercial and residential developments are supported intensively instead of providing areas for open green spaces.

In the aftermath of the disasters, there were many suggestions that the country needs a new type of house. Elevated structures which mimicked traditional nipa huts of the country have been a practical alternative. Structures that are more prone to high flood levels are suggested to have more than four levels. Government centers should be able to store lifeboats and have a helipad for rescue operations. There is also a call to ban basements altogether and emergency provisions were to be permanently stored in upper levels.

Designs can save lives. Engineers, architects, and allied professionals can apply their creative skills and talents to provide solutions for people and communities to prevent harm to them. Sustainable designs should be applied before disaster's ways and prevent them from affecting lives. Cities and settlements should be designed with nature and not against it. Forests, parks, and open spaces should be restored and most importantly, building and infrastructure design should be sensitive to the fragility of the environment. Awareness of the effects of everything we do to our surroundings has effects that can last for centuries and improvements on the ways things are done are important to mitigate these types of disasters from taking our precious properties, communities, and lives.

4.1.3. Disaster Management and Response

During the typhoon, no one was prepared for the destructive floods as it happened fast. Normally the first responders were the local people and volunteers who start their relief and rescue work with the help of Local Government and other organizations, then second responders like Non-governmental Organizations will come after the incident has passed. This happened when the typhoon hit but the response was not very efficient because responders also became victims of the typhoon, so they prioritized the safety of their families before reporting to their assignments.

The final report of the National Disaster Coordinating Council regarding the humanitarian assistance in response to typhoon Ondoy for food, non-food items, early recovery and shelter amounted to 371M pesos. This was very little as compared to the required amount identified for recovery and reconstruction as per the assessment report from Post-Disaster Needs Assessment. However, this assessment lacked information and details as to where specifically these funds will be spent and as effect, did not so much attract donors and funding agencies.

Since the typhoon Ondoy, the Philippine government and local government units have been developing and improving the country's disaster risk-reduction and management plans. It has been evident with the recent floods where there were minimal casualties and the evacuation of affected communities was more rapid and responsive after declaring a probable hazard. Local government units have adopted different climate change mitigation and adaptation plans since then which is also evident in the enhanced awareness of the public about the hazards due to the impacts of climate change.

There were also several laws passed that recognize that climate change is taking its course. One is the Republic Act 10121 or the Philippine Disaster Risk Reduction and Management Act of 2010. Subsequently, it has been the country's council that focuses on mitigating the risks and hazards brought about by calamities. Another law was an upgrade to the existing law named Upper Marikina Basin Protected Landscape which mainly aims to protect the landscape and watershed of the city. Third law was the Republic Act 10174 named People's Survival Fund that provides long-term financing projects dedicated to climate-change mitigation and making calamity-prone communities more resilient to disasters.

As for the government's long-term plan, the city's water concessionaires, Maynilad, Manila Water and Bulacan Bulk Water, adopted a better management, protection, and restoration of critical watersheds to maintain beneficial environmental conditions and provide sufficient potable water supply to the constituents.

Most recent project the Philippines launched is the "Ayoko ng Plastik" (I do not like plastic) that campaigns the awareness of the negative effects of single-use plastics and promotes producers to use better alternatives to these plastics.

4.1.4. Role of Media

This event showed the role and importance of media both in updating the public about incidents and hazards attached to natural catastrophes and events for future preparations. All forms of media are helpful in issuing warnings to the public to protect them from future hazards. Government and non-government agencies in the Philippines have developed pages in Facebook and websites which they regularly update by posting weather updates and reports regarding preparedness. Additionally, they also attract volunteers through online training. Even though online platforms become irrelevant for victims to gather information once gadgets and equipment get destroyed too, they are relevant to attract funds, finding missing people and for many other ways.

4.2. Earthquake

4.2.1 Introduction

Haiti is a seismically active country of Caribbean. On 12th January 2010 at 21:53 UTC (Coordinated Universal Time) the earthquake of magnitude of 7.0 Mw hit Haiti which generated an approximate death toll raging between 160,000 to 230,000, affecting more than 300,000 people in the country. Around 250,000 residential and 30,000 commercial buildings were disintegrated resulting the cause of huge amount of human, property, and economic loss. The earthquake occurred at 25 km west from the capital city, Port-au-Prince, with its focus being just 13 km below the surface. Until 24th of January, 52 aftershocks were recorded measuring magnitude of 4.5Mw and greater. 32 Aftershocks were already recorded in first 9 hours of the incident varying magnitude from 4.2Mw. Strongest aftershock was hit on 20th January with an intensity of 5.9Mw.

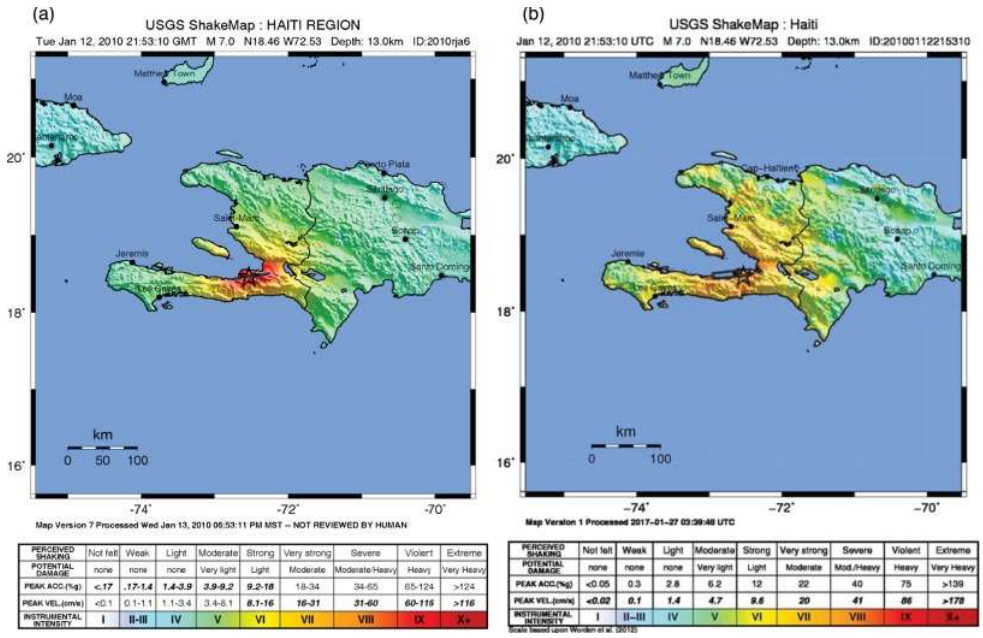

Figure 2 USGS estimated Shake Maps (a) recorded on 13th January. (b) recorded on 27th January

The fault of the earthquake observed was a conservative plate margin, which had huge tension force built up for many years resulting in rough frictional slide between 2 lateral plates. However, based upon seismological, geological, and ground deformations, there is no evidence of surface cracking recorded due to the reason that the earthquake did not result significant lateral slip on the main Enriquillo fault. These

high magnitude plate slides cased underwater landslide in Caribbean Sea near a small town named Petit Paradis causing Tsunami shortly after the earthquake. Due to these unpredicted ques of disasters, the country was not capable to recover from the damages until several years.

4.2.2 Infrastructural behavior after earthquake:

Reconnaissance was performed on commercial, institutional, and industrial buildings about 3 months post event to gather reports and check the stability with a perspective to identify the flaws in the structure for future stability and safety. Moreover, these buildings were built by domestic as well as international technology.

The report is classified by various buildings listed below:

5.2.2.1 Digicel Tower

The Digicel Tower was a 12-story frame wall building which was the tallest building in Port-au-Prince, provided telecommunication facilities mainly phone communications. The damage intensity was severe for this structure especially in the data tower and parking lot. The concrete quality was a significant reason for the destruction of the columns throughout the building. Moreover, segregation of concrete was observed visually at the time of inspection. However, structural team inspected the columns by scrabbing 1 inch deep into the column's core behind the reinforcement and observed – the only damaged part is the cover concrete, while the column was still intact and dense from its core. There was a very severe rotational force exerted from walls which caused crucial damage to the beams connected to it.

Figure 3 Shear failure of columns at parking garage

4.2.2.2 Turgeau Hospital

Turgeau was a private hospital constructed in 2008. Apparently, this structure was built without the consideration of seismic loads which resulted in complete collapse. The structure was constructed typically by erecting columns, placing beams and flat slabs which are insufficient to carry seismic load. The walls infilled were completely crushed and beam-column connections were destructed.

4.2.2.3 Union School and other structures

Many more structures were destructed including Union School which was a 3-story frame built from reinforced concrete and the structural elements were designed according to ACI 318-99 which is a standard code used for public safety buildings. It was an erect but damaged structure where the failure of short columns was very severe and the walls failed due to diagonal shear tension.

Other structures like University Adventiste, CDTi Hospital, etc., faced similar damages as that of Union School.

4.2.3 Post earthquake recovery approach for Haiti:

The unseen and unpredicted damage of Haiti weakened the government's potential to come back from the loss. Haiti faced collapse of its important administrative buildings like: the National Penitentiary, the Parliament, The National Palace, and ministries.

The approach to stabilize the country again started with IIERP (Infrastructure and Institutions Emergency Recovery Project) supporting the government by re-constructing the buildings and the infrastructure.

The IDA (International Development Association) funded the urgent recovery actions like providing support to people and keep government vital functions functioning and recovering. Moreover, institutional strengthening was carried out by training, capacity building and urban planning restructuring. This was a very important step in improving the situations for a long-term planning.

The staff of IMF (International Monetary Fund) supported Haiti by donating $138,499. Also, the relief funds were immediately approved by IMF making a total relief effort of $276,998.

The reconstruction and development of Haiti was greatly supported by USAID (U.S. Agency for International Development) which disbursed $2.3 billion to support the growth of infrastructure. Furthermore, $798 million was distributed among health and disabilities department, and $557 million was allocated to economic and food security development.

5. Discussion

5.1. Recommendation for Flood

The Philippines is always vulnerable to natural hazards especially typhoons because of the geographic location but few changes have been made in terms of improvements to make cities and areas more resilient from natural hazards. Here are some of recommendations for better disaster resiliency:

A. Improved forecasting system by installing more radars and developed rainfall measurement systems. More technologically improvements for better forecasting and better advance advisories.
B. Making advisory systems more understandable to the public. Innovative warning systems should be introduced to the public like alarms, color alerts, flag raising, etc.
C. DRRM offices should have training and drills which are important to prepare for alertness and offices should be equipped with modern equipment and technology to be used in times of calamities.
D. Building better evacuation centers aside from using school, gyms, sports complexes, and municipal halls as they are too damaged during disasters.

E. Making ordinances and acts that enforces safe construction of houses. Local government units should advise and guide people to make their houses more resilient to hazards by introducing construction systems that may protect them from future natural disasters.
F. Informal settlers should be provided with more permanent and safe houses as they usually live by riverbanks. This causes waterways to be blocked and at the same time they are usually the first ones to be affected by floods.
G. Flood control measures should be improved and implemented. Since there are more buildings being erected each year, it should be mandatory to get approval for their sanitation and drainage systems before actual construction.
H. Staff and officers should be well-compensated for the hard and risky work they will be doing. Salary should be competitive to retain experienced and qualified staff and to attract more skilled workers.
I. DRRM offices should be permanent, well-furnished, and well-equipped to ensure 24/7 duty.
J. Advanced back-up systems for electricity and communications should be installed in case of emergencies.
K. Coordination of all stakeholders at all levels is necessary for better planning, implementation, and mitigation by making plans more community-based.
L. Deforestation, pollution, inefficient mining, etc. should be controlled and regulated.
M. Green buildings, green technologies and environment-friendly approaches to construction should also be part of the government's preparedness.

5.2. Recommendation for Earthquake

5.2.1. Response during Earthquake

1. Drop down to the baby walk stance as it helps in better stability during earthquake.
2. Do not use elevators and if trapped, stay calm and try to get attention of someone.
3. Sit down under a table or equivalent furniture and cover your head with hands to avoid any head injuries.
4. Hold on to any shelter until the earthquake passes

5.2.2. Response after Earthquake

1. Check for injuries of yourself and others around you. Call 911.
2. Check for any leakage of gas, water, or electric lines.
3. Vacant the structure immediately
4. Wear closed toe shoes to avoid any further injuries.
5. Check for any damages in the structure and stay away from the destructed structural elements.

Table 1 Emergency Management for Floods and Earthquakes Disaster

No	Emergency Management	Floods	Earthquakes
1	Mitigation	1. Green buildings, green technologies and environment-friendly approaches to construction 2. Coordination of all stakeholders 3. Improved forecasting system	1. Seismic design building and infrastructures 2. Coordination of all stakeholders 3. Making ordinances and acts that enforces safe construction of houses
2	Preparedness	1. Making advisory systems more understandable to the public	1. Simulation and training for earthquake alert

		2. DRRM offices should have training and drills 3. Flood control measures should be improved and implemented	2. Using specific materials for buildings and infrastructures depends on the probability of disaster 3. Construct the fire management system in the buildings and communities
3	Response	1. Operate the disaster response plans 2. Conduct search and rescue missions 3. Cut down the electricity and lights 4. Build temporary shelter	1. Operate the disaster response plans 2. Conduct search and rescue missions 3. Follow the emergency protocols 4. Build temporary shelter
4	Recovery	1. Rebuild the infrastructure facilities	1. Rebuild the infrastructure facilities

6. Conclusion

Disasters are a recurring event series in which the location, range of time, frequency, and the scale are unpredictable. Specific areas in part of the worlds are vulnerable towards some disasters. Disasters are impacting lives and livelihood of people and communities. Social disruption, environmental damage, economic crisis, infrastructure damages and loss of lives are the prime concerns for government and communities to avoid for occurrences. This will result the importance of disaster management come into view. The disaster management is mandatory for government to make protocols, procedures, and give facilities for training, simulation regarding the disasters alert. Technology plays a crucial role in not only foreseeing but also contribute to minimize the losses.

The disaster occurred caused massive destruction to the impacted area. Inefficient warnings and poor forecasting resulted in damage and death, many people stayed on the roof for hours, volunteers and government officers also became victims of the disasters. Better planning, efficient and coherent Disaster Risk Reduction and Management Systems should be implemented. This should not only focus on rescue operations and responses but also include how people can make their houses more resilient to hazards than continuing traditional ways of construction. There should be emergency centers with all the necessary facilities per each municipality and area. Moreover, there should be a nationwide awareness for nature-friendly plans, climate change response, less pollution, more plantations, etc. to prevent a country from future destructive hazards.

References

Cisterna et al. 2022. Government performance, geophysical-related disasters, and institutional trust: A comparison of Chilean and Haitian responses after an earthquake. Earth and Planetary Science Letters, *75*. https://doi.org/10.1016/j.ijdrr.2022.102950

Federal Emergency Management Agency (FEMA). (n.d.). Emergency Management in the United States. https://training.fema.gov/emiweb/downloads/is111_unit%204.pdf

Gould et al. 2011. Behavior of Engineer Constructed Facilities in the Haitian Earthquake of January 12, 2010. Procedia Engineering, *14*, 23-31. https://doi.org/10.1016/j.proeng.2011.07.003

Japan Meteorological Agency. 2009. Annual Report on the Activities of the RSMC Tokyo - Typhoon Center 2009. Tokyo, Japan.

Kadmiel et al. 2021. The 2010 Haiti earthquake revisited: An acoustic intensity map from remote atmospheric infrasound observations. Earth and Planetary Science Letters, *560*, 1-6. https://doi.org/10.1016/j.epsl.2021.116795

Love Joseph, Iverson. 2022. The effect of natural disaster on economic growth: Evidence from a major earthquake in Haiti. World Development, *159*. https://doi.org/10.1016/j.worlddev.2022.106053

National Disaster Coordinating Council (NDCC). 2009. Final Report on Tropical Storm "Ondoy" {Ketsana} and Typhoon "Pepeng" {Parma}. Quezon City, Philippines: National Disaster Coordinating Council (NDCC).

Paultre et al. 2013. Damage to engineered structures during the 12 January 2010, Haiti (Léogâne) earthquake. Canadian Journal of Civil Engineering, *40* (8). https://doi.org/10.1139/cjce-2012-0247

Post-Disaster Needs Assessment (PDNA). 2009. Philippines, Typhoons Ondoy and Pepeng:Post-Disaster Needs Assessment (PDNA). Post-Disaster Needs Assessment (PDNA).

The Big Picture. 2009. Typhoon Ketsana (Ondoy). http://archive.boston.com/bigpicture/2009/09/typhoon_ketsana_ondoy.html

The World Bank. 2019. Rebuilding Haitian Infrastructure and Institutions. https://www.worldbank.org/en/results/2019/05/03/rebuilding-haitian-infrastructure-and-institutions

U.S. Government Accountability Office. 2021. Haiti: USAID Funding for Reconstruction and Development Activities since the 2010 Earthquake. https://www.gao.gov/products/gao-21-263

United Nations office for Disaster Risk Reduction (UNISDR). (n.d.). What is Disaster Risk Reduction? Retrieved Jan 21, 2014, from United Nations office for Disaster Risk Reduction (UNISDR): http://www.unisdr.org/who-we-are/what-is-drr

Wikipedia. 2010 Haiti earthquake. https://en.wikipedia.org/wiki/2010_Haiti_earthquake

Zhao et al. 2021. Evaluation of factors controlling the spatial and size distributions of landslides, 2021 Nippes earthquake, Haiti. Earth and Planetary Science Letters, *415*. https://doi.org/10.1016/j.geomorph.2022.108419