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GUIDEBOOK ON COMPOUND & CASCADING DISASTER RISK MANAGEMENT

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GUIDEBOOK ON COMPOUND & CASCADING DISASTER RISK MANAGEMENT

Formulation & Publication

Department of Disaster Management, Ministry of Disaster Management and Relief

Government of People's Republic of Bangladesh

Brac University, Bangladesh

Institute for Global Environmental Strategies, IGES

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Introduction

Research on the challenges of compound and cascading risks has increased in recent times. These ideas are gradually becoming more and more mainstreaming regarding the question of resilience. These concepts are essential to adapting to climate change, to protecting critical infrastructure, to building complex social flexibility.

By utilizing these ideas properly, Bangladesh has the opportunity to bring about radical changes in disaster management. This guidebook is designed to provide an overview of compound and cascading disaster risks in Bangladesh to help all those involved in the field of disaster management in the country gain a holistic understanding of the risks these kinds of disasters project and ways to mitigate them. This guidebook attempts to convey the concepts of compound and cascading disaster risks to the people involved in the disaster management of different sectors of the country through refined definitions and easy-to-understand terminologies. In addition, the case studies mentioned in it will help researchers, field workers and practitioners understand the concept of risks associated with specific incidents. These case studies will also help create a coherent basis for implementing preventive measures for such disasters.

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Introduction to Guidebook

Purpose of the Guidebook

- Readers of the guidebook will be able to gain general knowledge about compound and cascading disasters and
- what can be done to deal with them, and
- the book will be helpful in conducting planned, organized and effective training according to the needs of the training participants.

Outlines of the Guidebook

The module discusses two special categories of multi-disasters – cascading and compound disasters. A general discussion of these two disasters followed by descriptions of four different disasters explain cascading and compound disasters and their effects. A strategy for subsequent risk mapping through cascading four different types of disasters and compound disaster risk assessment methods is presented. People in the community themselves can use this risk map to visualize different risk scenarios and learn how to deal with them using their own resources and practice resilience and capacity building.

Chapter 01
General Concepts of Compound and Cascading Disasters

Contents

- Definitions of disaster-related terminology
- General concept regarding compound and cascading disasters
- Why is it significant to gain knowledge about these kind of disasters?
- Steps of assessing any compound and cascading disaster-risk.

Purpose

At the end of this chapter, readers/participants will gain an understanding of basic disaster related terms-Hazard, Exposure, Vulnerability, Risk etc. and also of Compound and Cascading Disaster. They would be able to develop a 'Risk map' assessing hazards and vulnerability and take precaution accordingly in times of a disaster.

Through this, a disaster-stricken community will be able to better deal with potential disasters with their own resources and capabilities.

Introduction

According to the definition of the United Nations, a disaster is defined as a man-made, physical, economic or environmental impact that seriously disrupts the daily activities of a community or society, which cannot be overcome by the people of that community/society on their own. This could occur suddenly or gradually.

A small or large-scale hazardous situation which is created by various interactions among exposure, vulnerability and capacity and severely hinders the activities of a population/society and ultimately causes loss of human lives with material, economic and environmental harm, is called a disaster.

Whenever the effected human settlements and infrastructure cannot withstand the negative impacts cast upon them, that's when a hazard is considered a disaster. As a result, economic losses like human casualties, destruction of buildings etc. are incurred.

For example, if there is heavy rain in the middle of the ocean or any other uninhabited places, there is no calamity/disaster; This is just a general meteorological phenomenon. But if the same heavy rainfall happens near a community and negatively affects people and their property, then that is considered as a disaster.

According to EM-DAT, an event could be acknowledged as a disaster if it meets one of the following criteria:

- If ten or more people lose their lives,
- If there are a hundred or more affected people,
- If a state of emergency is declared, or
- International aid is called for.

The Standing Orders on Disasters-2019, published from the Ministry of Disaster Management and Relief, Government of the People's Republic of Bangladesh, listed some of these disasters under the definition of it:

- Cyclone, Thunderstorms, tornado, tidal surge, lightning, abnormal/high tide, earthquake, tsunami, heavy rain, non-rainfall, flood, river erosion, coastal erosion, drought, excessive salinity, excessive arsenic pollution, building collapse, landslide, hillside landslide, hillside flooding, hailstorm, wildfire , cold flow, chronic waterlogging etc.;

- Explosions, fires, chemical explosions or accidents, disasters/accidents caused by chemical weapons or toxic chemicals, industrial accidents, shipwrecks, major train, road and plane accidents, chemical and nuclear radiation, fuel oil leaks or gas spills or any mass destruction or event;
- Epidemic diseases such as pandemic influenza, bird flu, anthrax, diarrhoea, cholera etc.;
- Infections with harmful micro-organisms, toxic substances and bio-infectious agents including infections of biological origin;
- Failure to provide essential services or damage/failure of disaster prevention infrastructure;
- any unusual event or natural disaster causing extensive loss of life and damage;

Let's illustrate this with the case of the 2020 heavy rainfalls in Kyushu, Japan. During this event, rainfall rates exceeded 100 millimeters (3.9 in) per hour which was absolutely unprecedented in the region. If this record-breaking rainfall had happened in the middle of the Pacific Ocean, there would have been no disaster. However, in the populated areas of Kumamoto and Kagoshima, the rainfall turned into a disaster, devastatingly affecting the lives and assets.

Considering the incident of the flash flood of Sylhet in 2022 in Bangladesh, we can understand it a bit more. According to the Flood Forecasting and Warning Centre, Sylhet's normal rainfall averages around 840mm in June–July, often resulting in short-lived seasonal floods, which residents can adapt to because of their frequent exposure to those.

However, in 2022, heavy rains started in the Indian states of Meghalaya and Assam in March and exceeded the average of 1500 mm long before June. As a result, at the end of April the people of Sylhet and Sunamganj districts were hit by the worst flood occurred in 122 years.

Here, if normal and timely rainfall had took place, the people of Sylhet would not have been affected by calamities; But, floods caused by untimely and excessive rainfall created a massive disaster.

How can a hazard turn into a disaster or be expressed as risk?

Disaster risk can be defined as a function of hazard, exposure, vulnerability and capacity at a given time which causes casualties and destruction of assets in a system, society or community and can be identified with the help of probabilistic formulas. Therefore, a region should be called at being high disaster risk, when there is a possibility of destruction due to existing hazards in that region.

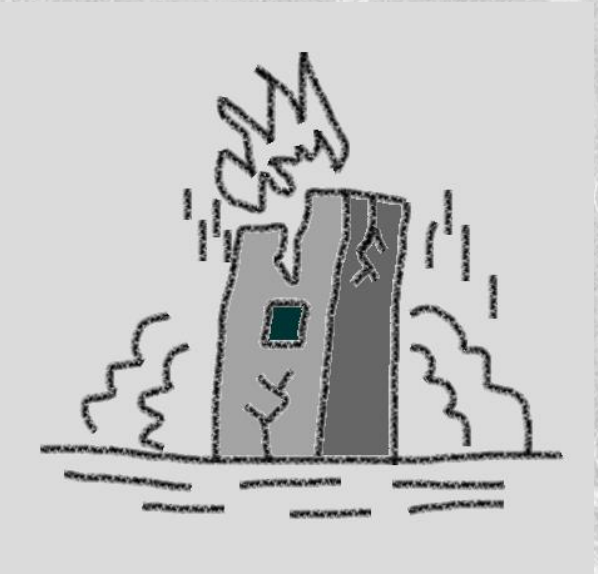
Whether a community is at high disaster risk depends on the following factors:

- The extent to which the community has been exposed to existing hazards
- How endangered is the community by that disaster?
- How well the community is able to prevent disaster?

To understand this better, let's go back to the case of the 2020 Kyushu floods. A total of 68 people lost their lives in this incident, fourteen of which (or 20% of the total) occurred in just one flooded nursing home in Kuma, Kumamoto. People were trapped there as mud and flood water entered the building. Rescue workers were able to save residents on the second floor but unable to reach the rest on the first floor after water entered through the windows.

The residents of the old home were living in areas that could be affected by rain and floods. Their exposure was quite high. Also, they were elderly and many were sick and unable to walk, and there was no mechanism existing for their rapid evacuation. They were highly vulnerable.

If we review the Rana Plaza building collapse that happened in Savar, Bangladesh in 2013; Residents were staying in a building that was likely to fall. The building had construction faults with no proper emergency exits. Users of that building were exposed to this highly imperil situation (hazard) and due to this, they were vulnerable. The collapse of that building later made an unforgettable accident in the history in the world let alone the country.



Analyzing the above cases, it can be seen that the level of risk depends on two variables: exposure and vulnerability.

- Exposure is “the situation/location of people, infrastructure, housing, production capacity and other tangible human resources located in hazard-prone areas”.

- Vulnerability is "a condition determined by physical, social, economic and environmental factors or processes that lacks the ability to reduce the risk of an individual, population or resource or system due to the impact of a disaster".

There are many types of hazards, including both natural and human-induced.

According to a recent study by UNDRR, the hazard classification includes 8 categories:

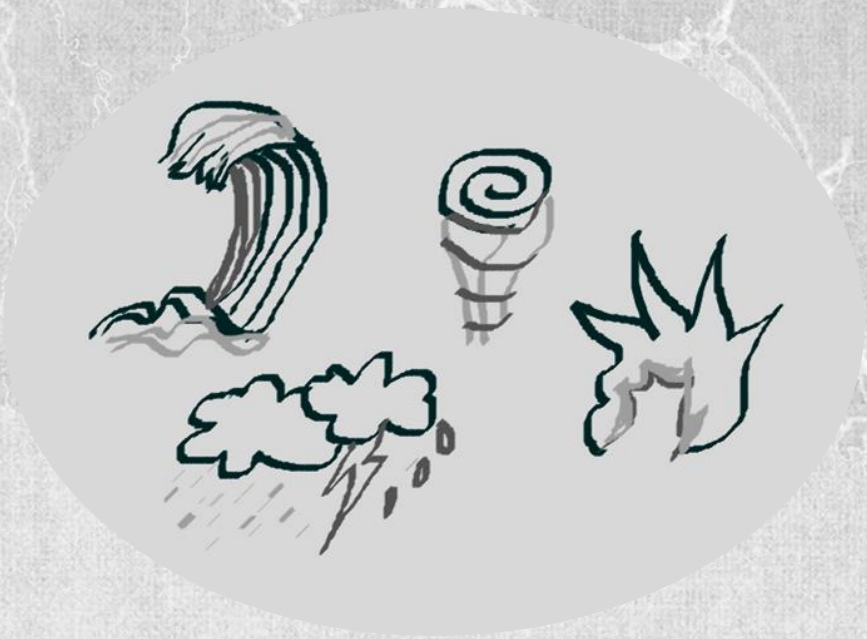
- Hydro-meteorological
- Extra-terrestrial
- Geological
- Environmental
- Chemical
- Biological
- technical, and
- social hazards.

Some examples:

・Tropical cyclones, droughts, river floods, and heat waves are examples of “Hydro-meteorological" hazards.

・Meteorological and Hydro hazards are caused by the interaction of the Earth's atmosphere with its land and oceans, the resulting weather and climate, and the resulting distribution of water.

- Pandemics like COVID-19, insect infestations and animal accidents are all considered “biological hazards” caused by an “exposure” to living organisms and their toxic substances or vector-borne diseases that may be carried. Like venomous wildlife and insects, poisonous plants and mosquitoes carrying disease-causing agents such as parasites, bacteria or viruses like the coronavirus and malaria.
- Technological hazards arise from the possibility of failure of an existing technology as well as from emerging technologies. Chemical spills, collapses, explosions, fires, gas leaks, poisonings, radiation leaks and oil spills are examples of industrial accidents. There are also transport accidents in the air, road, rail, or water. And finally, miscellaneous technological hazards like factory collapse, explosions, and fires.



In 2015, during the Third United Nations World Conference on Disaster Risk Reduction in Japan, several countries came together to find solutions and developed the Sendai Framework for Disaster Risk Reduction 2015-2030. The Sendai Framework sets seven goals to be achieved by 2030, aimed at building new resilience and reducing existing disaster risk.

To achieve this, the Sendai Framework outlines the following four priorities for disaster risk prevention and reduction:

(i) understanding disaster risk;
(ii) strengthening disaster risk governance for disaster risk management;
(iii) investing in disaster reduction to build resilience;
(iv) Enhancing disaster preparedness for effective response and to "build back better" in recovery, rehabilitation and reconstruction.

The community that has been stricken by disasters face tremendous suffering and hardship; Damage to physical and social infrastructure, collapse of social structure, disruption of normal life - etc. need to be tackled with special measures and initiatives. Without external relief and rehabilitation activities it is not quite possible for those affected by disasters to return to normal life easily .

However, in some regions, specific natural disasters occur annually; The people of those areas have developed their own culture of dealing with disasters and overcoming them.

Geographical location, topography, numerous rivers, effects of climate change, population density, unplanned urbanization and industrialization etc. increase the disaster risk of our country. To understand and assess the ever-occurring disasters, knowledge of different terminologies is essential which can then be applied to create various multi-disaster risk maps.

Hazard

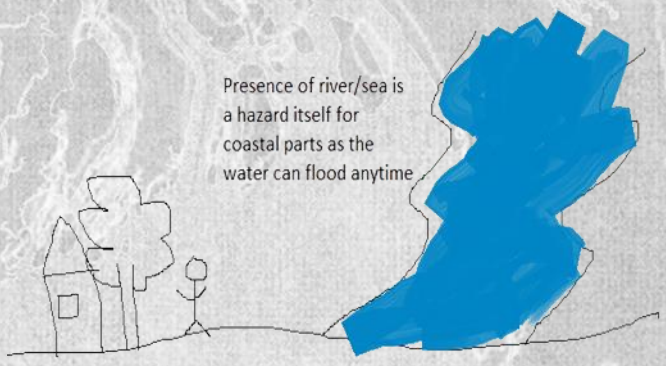
Hazard is a dangerous event, object, man-made activity or condition. It has the potential to cause human death, injury and other negative health effects, physical property damage, loss of livelihood, socio-economic and environmental damages.

A hazard simply refers to a condition or source that threatens to cause harm. This malefic condition affects human life, health, environment, social status etc.

The possibility of inducing a calamity, is called a hazard.

The rock on top of the hill in the above picture has a high probability of falling. If this rock falls, the people, animals, birds, forests, houses at the foot of the mountain will be jeopardized; This stone is therefore a hazard.

Sea/river is a hazard in coastal areas as disasters like flood/cyclone could arise any time.



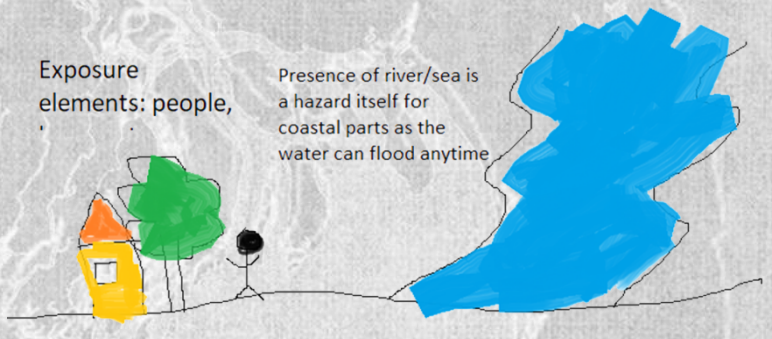
- presence of sharp objects or heavy machinery at any construction site is a hazard; Because there is a possibility of damage through it.
- Similarly, a busy road is a hazard itself because there is a possibility of accidents while crossing it.
- Presence of rivers near community residence in flood prone areas, faulty embankments, etc. are all hazards.
- Rainfall, high temperature, rise in sea water temperature etc. in cyclone prone areas are hazards.
- Low-quality buildings are a hazard in earthquake-prone areas.

There are "natural hazards" such as earthquakes or heavy rain, and there are also "man-made hazards" such as chemicals or vehicles.

Exposure

In a hazardous environment, those who are likely to be harmed, they are exposed or their exposure is high. Human presence, livelihoods, biodiversity and ecology, environmental services, infrastructure and economic, social and cultural resources – the mentioned areas due to risk situations will be considered as exposure.

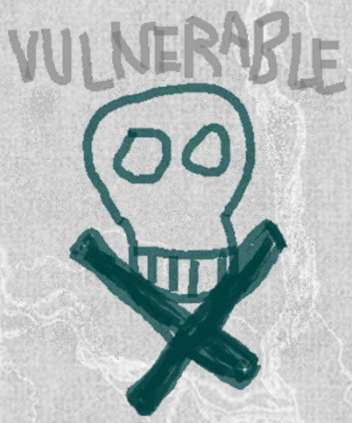
In the picture, people, houses, plants etc. are all at risk in the riparian area due to the upheaval caused by the presence of the river nearby; Therefore, people, houses are exposure factors in this scenario.



In all disasters like floods, cyclones, earthquakes, river bursts, people, infrastructure, human livelihood, livestock, environment etc. are exposure elements.

Vulnerability

Vulnerability is the inability to deal with the harmful effects of a disaster when it strikes. For example, in the earlier image, the riparian zone is endangered i.e. the exposure elements are in danger.



People living in low-lying floodplains are more vulnerable to flooding than people living in higher elevations; People in coastal areas are at risk from cyclones; people living in vulnerable buildings are at risk from earthquakes, etc. and hence they are vulnerable.

Risk

According to the definition of UNDRR, risk refers to the potential death, injury or property damage occurring in a system, society or population at a given time and is a function of hazard, exposure, vulnerability and capacity. The combined effect is specified as risk.

In coastal areas, heavy rains is a hazard; human and households are exposure elements and their vulnerability are lack of resilient infrastructure. The risk here is the combined effect.

Compound & Cascading Disaster

As we have seen in some of the basic concepts of disaster risk management, they refer to a single hazard or a single disaster. But, most of the disaster risk reduction research and strategies deal with a series of disasters or adverse impacts. As the intensity of disasters in today's world is increasing, so is the frequency of occurrence and multiple disasters hitting a population at the same time, which is partly related to climate change. This alarming trend is highlighted in the latest assessment of the IPCC AR6 report as well.

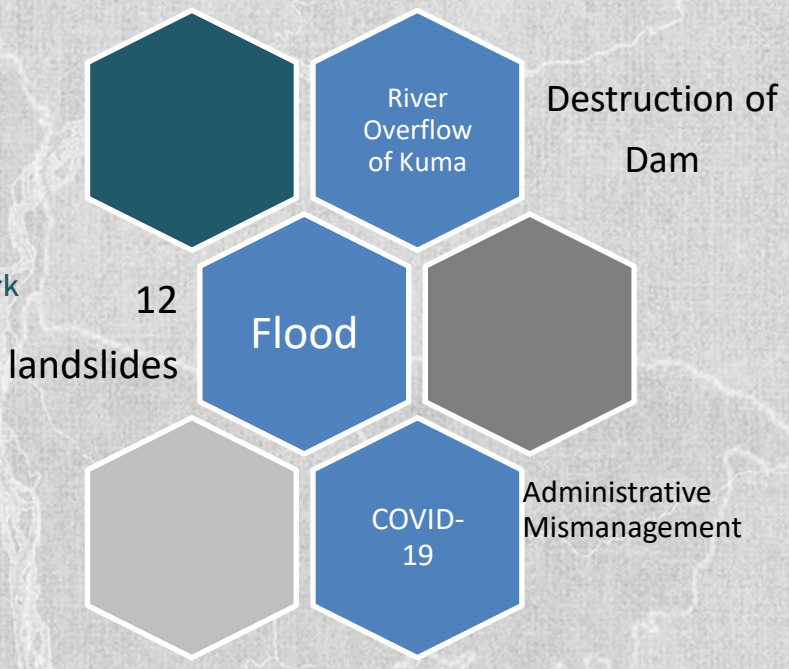
Confronting cascading and compound disasters simultaneously becomes extremely difficult for government officials and others engaged in initial response. In order to react to such disasters, concerned persons and authorities need to have the right knowledge and coping strategies.

A first approach to understanding the risk of compound and cascading disasters is to examine how individual disasters are connected and related to each other both spatially and over time. Here, we will mainly discuss two types of hazards: compound hazards and cascading hazards.

- A **compound** hazard is a situation where multiple disasters occur simultaneously or in sequence.
- In this case, the events do not trigger or cascade each other; They are "compound".
- Which means they reinforce each other, creating a more complex situation that amplifies the impact of individual disasters.

A water-related disaster such as a flood can be compounded with a meteorological disaster (such as a storm). Geological disasters like earthquakes can combine with biological disasters like Covid-19.

In the case of Kyushu in 2020, the Kuma River exceeded its danger mark in eleven places and crossed a dam, causing flooding.



During the same period, 12 landslides occurred. When these disasters occurred, those populations were struggling with the Covid-19 pandemic, a different kind of biological disaster that made the whole response a lot more difficult.

At that time, authorities ordered the evacuation of more than 75,000 residents in the Kumamoto and Kagoshima regions, and 109 shelters were opened in the region. Since volunteers from faraway places were unable to come due to the Covid-19 restrictions, they had to rely on local volunteers.

Refugees and local officials had expressed concern about emergency shelters. Because some refugees arriving at shelters were asked to go elsewhere to maintain social distancing. Some asylum seekers stayed in their cars, while others stayed with friends.

Another situation we may encounter is cascading hazards.

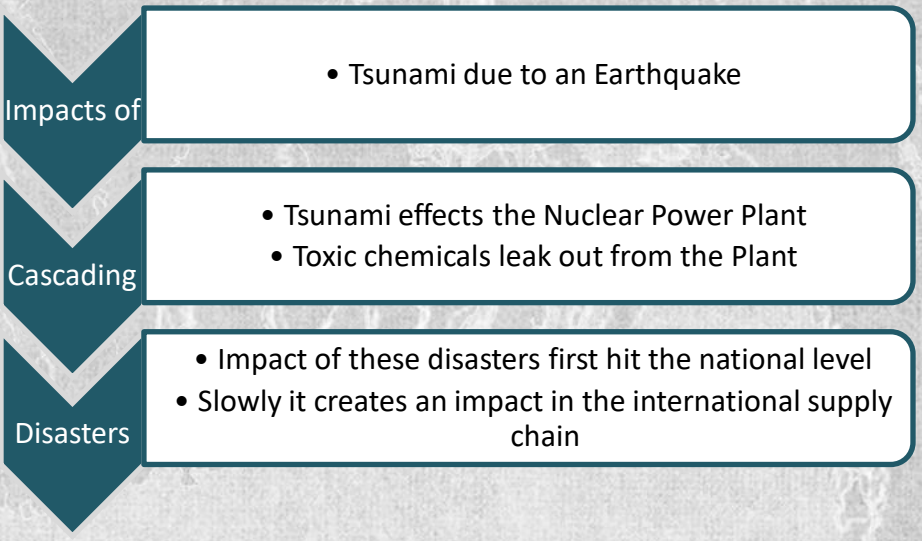
- A **cascading** hazard is a situation where one disaster occurs in succession and one disaster creates (triggers) another disaster.
- Similarly, each cascading hazard can trigger a disaster depending on exposure and vulnerability level.

- Cascading disasters are usually not sequential and the effects of a disaster extend beyond the location of impact and/or over an extended period of time.

For example, suppose a region first experiences an earthquake, which is a geological disaster. This earthquake triggers a tsunami what is known as a water-related disaster. If the tsunami causes a techno-industrial accident by exploding a factory and releasing toxic radioactive chemicals,, it can damage a nuclear power plant in the area if it exists there.

In this event, the communities were first affected by the earthquake. Minutes later, they were hit by a tsunami and then, potentially exposed to toxins from a malfunctioning power plant.

The effects of disasters tend to cascade at the national level and then into the international supply chain of electronics, cars and other exportable goods. In the case of cascading hazards, the interaction between disasters can be unidirectional, such as a domino effect or a contagion effect, but can also be complex interactions, where disasters can feed back on each other.



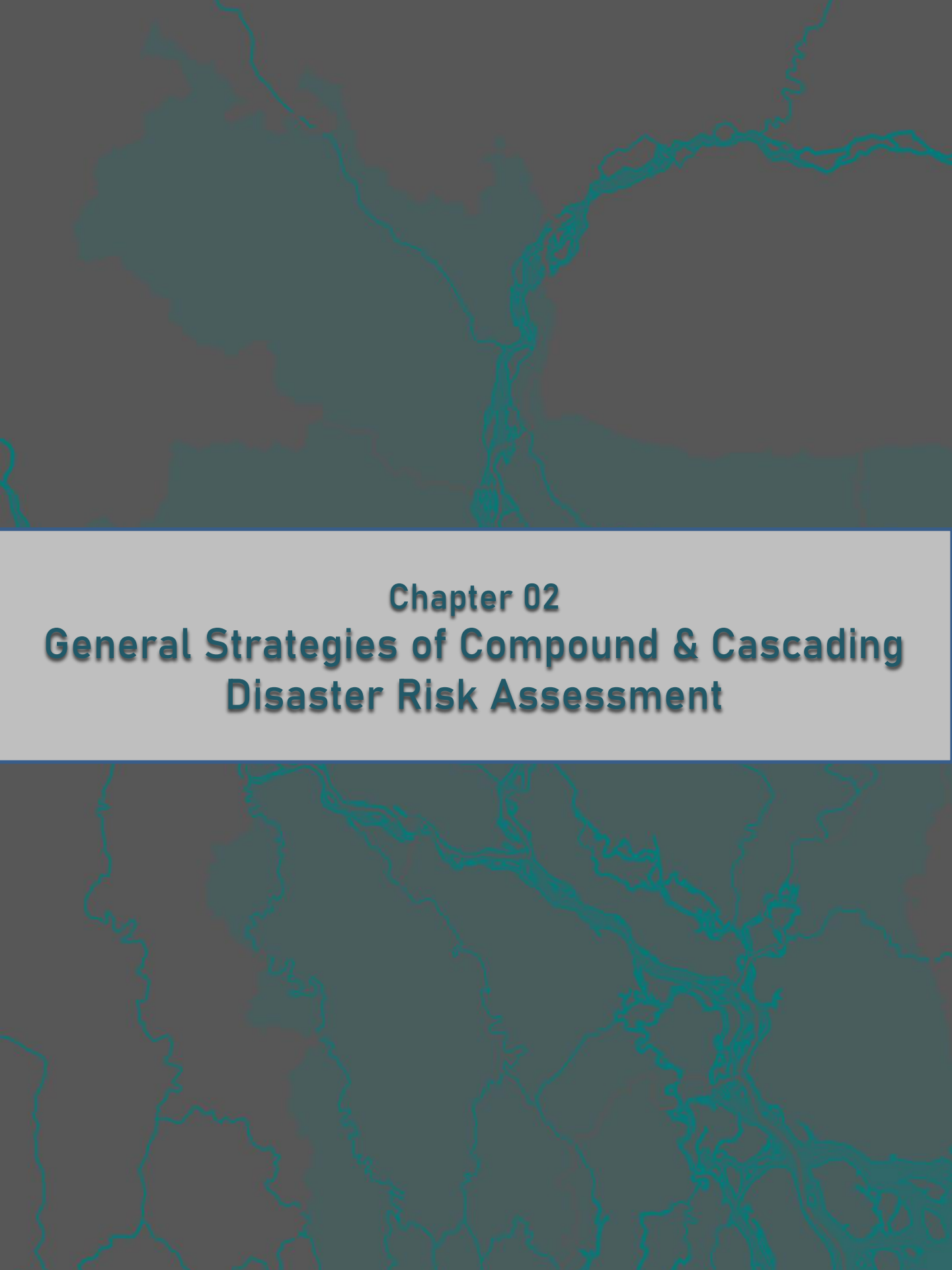
Thus, we can see from these examples, compound and cascading hazards can combine different types of hazards, resulting in numerous combinations of potentially catastrophic situations and system-wide effects.

When considering cascading hazards, one water-related disaster such as a flood can create or cascade another disaster such as a landslide; Waterborne diseases can trigger a biological disaster and eventually, a technological disaster in the form of a factory fire.

To understand the properties of compound and cascading disasters, we need to examine the following various factors:

- Trigger/cause/origin
- Event
- Scale/dimension
- Effects and damage
- Response

These factors shall be discussed in detail in the next chapter.



Chapter 02
General Strategies of Compound & Cascading Disaster Risk Assessment

Trigger

First, a trigger causes the disaster.

This trigger can be a single event or a combination of events.

A disaster can trigger other disasters over time.

And interrelationships among disasters can concoct complexity and create non-linear relationships.

Occurrence

Disasters can occur simultaneously or sequentially, but not all compound disasters occur simultaneously.

For example, if heavy snow falls weeks after an earthquake, it will still affect and complicate the earthquake recovery process.

Disasters can start quickly or slowly. It may start slowly and gradually increase in severity in multiple cases.

Scale

Disaster exposure can reach different scales/magnitudes. They can be small in size, affecting only the local level, but can also have an impact at the national, regional and even global level.

For example, Covid-19 started as a local problem and at that time, people never thought that the virus would spread globally and change people's lives almost forever.

Impact & Damage

Arising directly from the accident, effects may be primary. But there are also secondary and tertiary cascading effects. A chain of consequences can have an out-of-control domino effect that stirs many connected systems.
Furthermore, affecting multiple areas can have system-wide and long-lasting repercussions. There may also be sudden and immediate or knock-on outcomes across multiple sectors.

Response

When there is no adequate understanding of the underlying causes and effects, responses tend to be ad hoc and uncoordinated owing to the fact that information and orders might vary from different government agencies. Lack of information and harmony can be confusing and ultimately result in abortive response and recovery.

Fundamentally, what is needed is a coordinated, systematic response process that helps mitigate all impacts.
In order to be better prepared to deal with compound and cascading disaster risks, there is a distinct method for analyzing these risks – the “Impact Chain“.
It is a chain of reactions caused by one effect that triggers or initiates other effects across different sectors or a series of effects in different sectors resulting in a cumulative effect.

Strategies to Assess the Risk of Compound and Cascading Disaster

First of all, it is important to understand that there is a difference between assessing the risk of a single disaster and that of a compound or cascading disaster. A good first step would be to start with conventional risk assessment methods and then gradually add up more assessment tools to engage in complicated disasters.

Based on the primary steps of disaster risk assessment, we can follow a 6-step process to assess the risks of compound and cascading disasters. The steps are as follows:

1. Hazard analysis
2. Exposure assessment
3. Vulnerability assessment
4. Risk assessment and mapping
5. Risk scenario Development
6. Resource and Capacity Mapping

First step, Hazard analysis.

Cascading and compound hazards follow complex patterns in space and time. Understanding these types is crucial to manage a well-curated response process.

The types of these kinds of hazards are still being researched and difficult to classify. For this, three possible local types as well as temporal dimensions could be discussed that assist compound and cascading hazards to originate and eventually spread.

The first type is local sources. When a single or multiple shocks at the primary impact center occur at the local level, sometimes a cascading shock occurs at the local level as well. Then, there are secondary and tertiary impacts that spill over to regional and national levels. Sometimes, it can spread widely across country borders and even globally.

For example, in 2011, Thailand experienced the worst floods in its history and it caused shortages of critical components for Thailand's electronics industry, which in turn disrupted computer hardware production and its supply chain around the globe. A second type of multi-hazard is when they have an external source. When compound or cascading disasters occur at a remote location, the primary, secondary or tertiary effects cascade or spread simultaneously at the local level.

A third pattern is when multiple-incidents arise simultaneously in complex ways. When multiple or consecutive different disasters occur simultaneously in multiple locations, the effects influence each other in convoluted ways. In this type, local level has different reactions in different places.

In order to better apprehend the local patterns of poly-hazards, it is necessary to create a hazard map. Here, stakeholders can map potential hazards in different regions and the locations where they might occur. We have to remember that only natural hazards are considered in this multi-layered hazard map. Others, such as technological or biological disasters, as well as compound and cascading effects may not be adequately included. Compound and cascading hazards need to be checked over time, season and even year as well.

Different types of climate related disasters can occur in different seasons. For example, in any seasonal calendar, torrential rains and floods occur during the rainy season, while heat waves, droughts, and wildfires occur during the dry season.

Some disasters may arise or persist throughout the year, for example, infectious diseases. Thus, getting an idea of local impacts on a seasonal calendar or timeline helps to identify and properly understand potential cascading and compound impacts on population.

Another significant point to consider is the impact of climate change on disaster assessment. Due to the effects of climate change, communities cannot simply rely on historical data anymore. The use of climate impact assessment or decision-making tools, such as Impact Viewer and Climo-Cast, which are freely available on the AP-PLAT website, can help in this regard.

Step two, exposure assessment.

Exposure is the presence of people, infrastructure or other resources in a place that could be affected by disaster. In other words, they are 'elements at risk'.

When dealing with compounds and cascading hazards, the most important aspect to consider is the scope of the exposure assessment, where the number of components at risk can increase substantially.

For example, let's assume an existing hazard map of a hypothetical city that may only include common exposure elements such as buildings, bridges, farmlands, and people located near a specific hazard impact area such as flood plains or coastal areas.

However, under compound or cascading hazard conditions, components that were considered safe (e.g. critical infrastructure such as hospitals, schools, major highways, airports or industrial establishments such as chemical plants) or located outside the main hazardous area (food supply chain, export products) may now fall within the scope of exposure assessment.

Third step, vulnerability assessment.

Vulnerability is the tendency of a population, system, or resource to fail to mitigate the adverse effects of a particular hazard on its victims. Generally the lower the ability to respond and recover, the greater the vulnerability. Therefore, vulnerability assessment means estimating losses as well as determining the ability to ameliorate such losses.

There are two types of damage – tangible and intangible. Quantifiable damages can be directly measured, such as the number of deaths, destroyed infrastructure or the number of houses. Meanwhile, intangible losses are critical to measure, such as economic losses due to business closures, psychological effects and psychosis.

Capacity assessment involves identifying the physical, social and economic systems available to counter hazardous impacts.

Assessing cascading and compound hazard losses is quite complex. Damage information is usually unknown, especially when it is difficult to estimate the type of disaster that hasn't yet been there. Damage and capacity assessment, therefore, is based on identified exposure factors as well as damage data from the past disasters.

Since exposure and vulnerability are closely related, let us try to understand exposure and vulnerability assessment in a more concrete way by referring to two recent examples involving compound and cascading disasters in Japan and Myanmar.

The first event took place in Okayama, Japan; Heavy rains, floods, landslides and factory explosions occurred in July 2018. Heavy rains caused widespread and simultaneous river flooding, inundation and mudslides, resulting in 224 deaths, eight missing persons and extensive damage, including destruction of houses.
An aluminum furnace at the city's plant in the Okayama region exploded on July 6. Several residents were injured and three buildings were burned. With roofs and windows of several houses were also damaged. City officials say heavy rains flooded the plant before the explosion, prompting its workers to suspend reactor operations and evacuate.

In this case, it is important to identify the exposure elements and hazards that might have contributed to the factory explosion. The exposure was the factory's location near a river; a location that could be in the risk of flooding if the river overflowed its banks. In this case, the hazard assessment might consider loss of life, injury to people, damage to homes, loss of aluminum in factories, indirect economic impact on disrupted services or loss to consumers of aluminum factories.

Let's review our second example from Myanmar. Between April and October 2015, heavy rains caused floods and landslides in central and western Myanmar, killing more than 200 people, displacing more than 1,200 people and affecting more than 1.6 million people. The floods had long-term health effects as well. 285 health facilities were harmed which after a while failed to serve people suffering from water borne diseases from contaminated water or vector borne diseases such as dengue fever and malaria. Mosquitoes and snake-borne malaria spread among people who lost their homes and were forced to live in makeshift huts. These endemics were responsible for high mortality rates in Myanmar, particularly among children in rural areas. Thus, while more and more people were contracting water- and vector-borne diseases, health facilities were at its worst, making it challenging or somewhat impossible to provide medical care.

In this case, what were the exposure elements and hazards?
The exposure was: Hospitals with limited infrastructure and facilities and weak houses, vulnerable to floods / limited infrastructure for shelters.
Vulnerabilities were: Hospital patients especially children and elderly people who tend to get sick easily.

Now, let's move on to **step number four**, which is **risk assessment and mapping**.

After determining potential hazards, exposure elements, and resulting vulnerability, we now can conduct risk assessments and generate maps. When we are assessing risk, it is very important to categorize the level of that. A risk map is an extension of a hazard map that includes exposure factors and hazard levels.
For example, in this risk map, you will be able to identify which components are at high risk, which are at medium risk, and which are at low risk based on the assessment regulated so far. Seasonal risk maps could also be designed.

In **step five**, the community will develop **risk scenarios** based on the identified risk levels.

A "scenario" is a description of an event that may occur in the future, leading to a specific outcome. Based on assumptions about the root causes of the situation and their causal relationships. There are different types of methods for creating risk scenarios for different levels of stakeholders.
Here, we show the example of a risk scenario development in Koriyama City, Fukushima Prefecture, Japan attended by a wide range of sections from the Koriyama city office with the support from the regional environmental research institutes.
Experts attending the workshop developed risk scenarios using the “Impact Chain methodology”, a tool to visualize the chain of impacts of climate change that was developed by the GIZ from Germany. Together, they developed risk scenarios for complex chain of disasters such as how heavy rain caused landslides and subsequent chain of impacts to vulnerable and exposed areas such as roads, farmlands, and residential areas near the mountain slopes.

After the workshop, this impact chain risk scenario was included in Koriyama City's Climate Change Adaptation Strategy. Similarly, communities can develop one or more scenarios for future planning and actions through interaction and participation of key stakeholders, most importantly, the vulnerable groups or sectors.

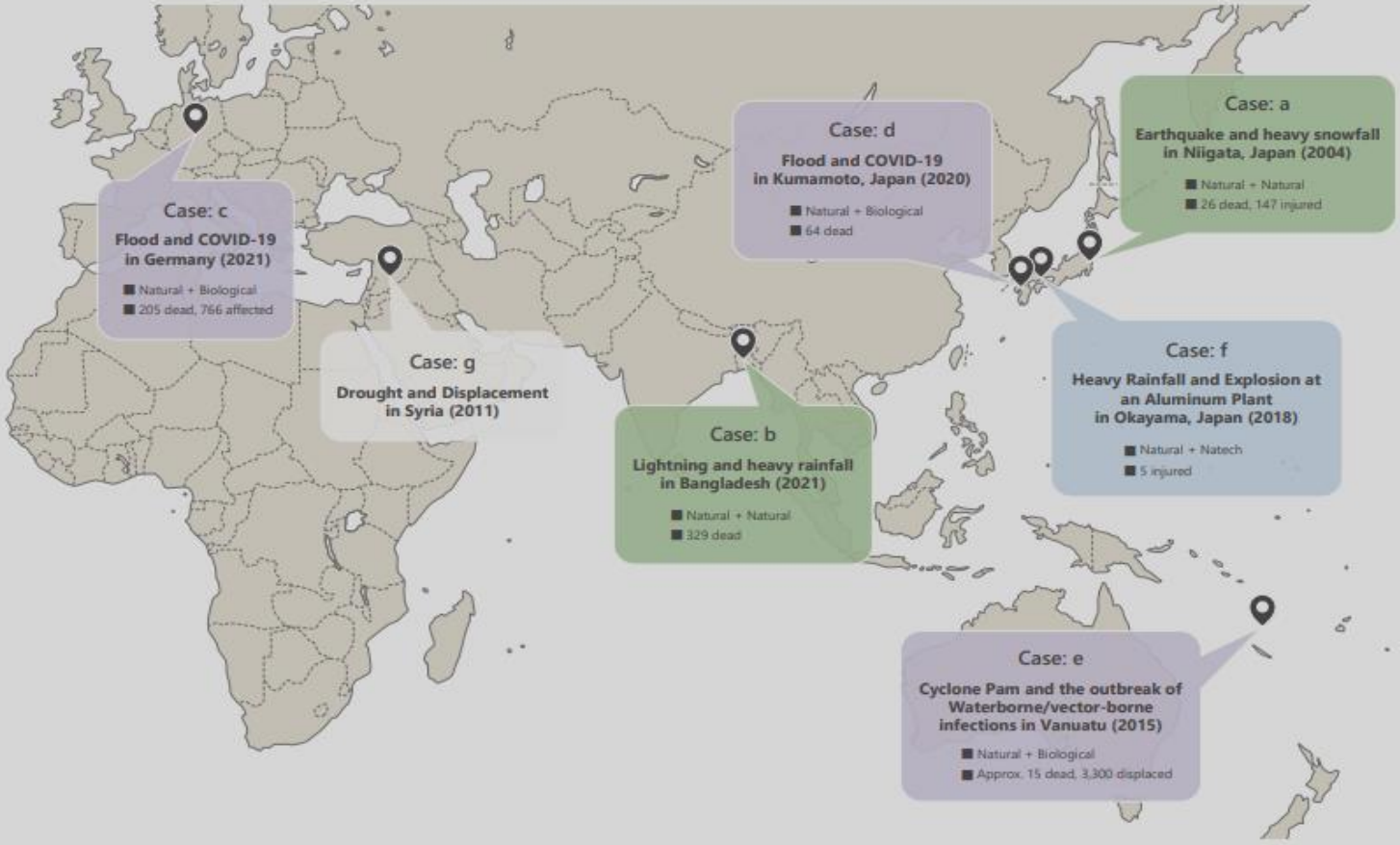
.

And finally, **step six** is **resource and capacity mapping**.

After risk assessment and mapping as well as visualizing risk scenarios, communities can develop their own resource inventory and capacity building that could be used to prepare for any future disaster. Assets and capabilities should be assessed to ensure that they can be serviceable during a disaster. This process helps communities identify resource and capacity gaps.

Compound & Cascading Disasters around the World

List of Cases Studies



	Europe	Japan	Developing countries of Asia
Category 1 (Natural+ Natural)		Earthquake+ Heavy Snowfall (2004)	Lightening+ Heavy Rainfall (Bangladesh)
Category 2 (Natural+ Biological)	Flood + COVID-19 (Germany)	Flood + COVID-19 (2020)	Cyclone Pam and Water-borne diseases (Vanuatu-2015)
Category 3 (Natural+ Technological/ Industrial)		Flood+ Industrial Disaster (2018)	
Others			
Drought+ Displacement (Syria-2011)			

	Bangladesh
Category 1 (Natural+ Natural)	Erratic Heavy Rain+ Flash Flood (Sylhet, 2022)
Category 2 (Natural+ Biological)	Flood+ COVID-19 (Rangpur, 2020) Cyclone Amphan+ Waterlogging+ Salinity Intrusion (Coastal areas-2020) Flood+ Dengue Epidemic (Dhaka 2021)
Category 3 (Industrial+ Technological/ Industrial)	Fire+ Chemical Explosion (Sitakunda, 2022)

Chapter 3
Cyclone Amphan & its Impacts

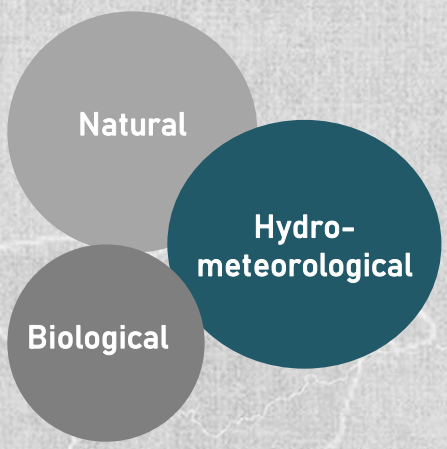
Cyclone Amphan- At a Glance

Duration: May, 2020

Killed: 28 people

Affected area: 45 districts

Total damage: 297 million US dollars



Contents

Amidst the Covid-19 pandemic, Super Cyclone Amphan and its associated ramifications have affected different regions of the country in divergent ways. Understanding the full impact of such multi-disaster situations through risk analysis and detailed discussion on disaster response, recovery and rehabilitation processes is the subject of this chapter.

Purpose of this Chapter

Through this session, readers/participants will learn about the cascading effects of Cyclone Amphan on coastal areas and its overall response mechanisms. They will also gain insights on how to increase the resilience of affected communities by analyzing the risk of such multi-disasters or compound and cascading disaster scenarios.

Introduction

Halfway through to 2020 and and the world is in the turmoil of Covid-19. Just then, in May 2020, Bangladesh was hit by Cyclone Amphan, the most powerful cyclone ever created in the Ganges estuary. It holds the record for the highest damage ever done by a cyclone in the North Indian Ocean – about US$297 million.

Image: Cyclone Amphan hits Bangladesh in 2020 (Image credit: Save the Children)

Around 45 districts of Bangladesh including Satkhira, Khulna, Patuakhali, Barguna, Bagerhat, Jhalkathi, Pirojpur, Bhola, Barisal, Lakshipur, Chandpur and other islands and grasslands were directly affected by this cyclone. Amphan killed 28 people and caused extensive damage to agricultural production and fisheries; The people of coastal areas have not yet overcome the impact of this super cyclone.

Compound disasters during cyclones

Cyclone Amphan + COVID-19 + Heavy Rain

Cascading disasters during cyclones

Cyclone Amphan → Waterlogging → Salinity Intrusion → Water-borne Diseases

Cyclone Amphan → Storm Surge → River Erosion

Case Study: Cyclone Amphan

Image: Damage of brick road due to Amphan in Koira Upazila, Khulna; Next to the dam given by local residents (2022)

Image: Destroyed trees in Amphan in Koira Upazila of Khulna (2022)

For the sake of detailed analysis, 2 upazilas (sub-district) of Khulna district and 1 upazila of Satkhira district of Bangladesh were chosen to practically witness the harms that Amphan had done. A major objective of the study is to find out what the response situation was like during such a severe cyclone that happened during the Covid-19 pandemic.

The two villages that have been considered in the two upazilas of Khulna district are Katmar-char village of Uttar Bedkashi union of Koira upazila and Malopara village of Raduli union of Paikgacha upazila. Shyamnagar, Munshiganj and Gabura unions of Shyamnagar upazila of Satkhira district were also visited for the sake of testimony.

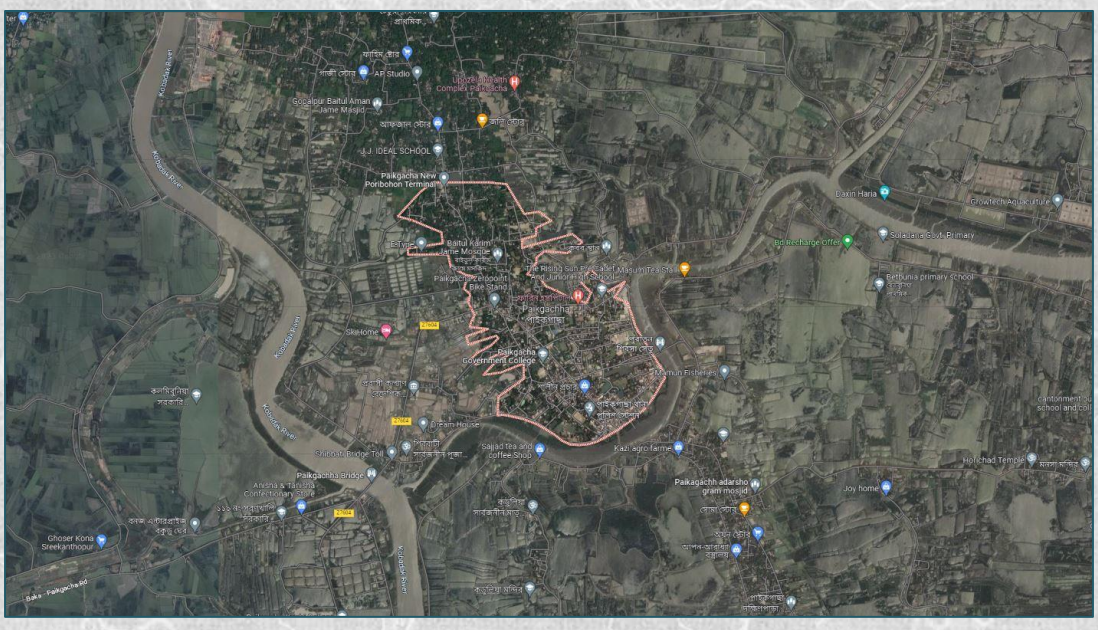


Image: Map of Paikgacha Upazila of Khulna District (Google Earth Image)

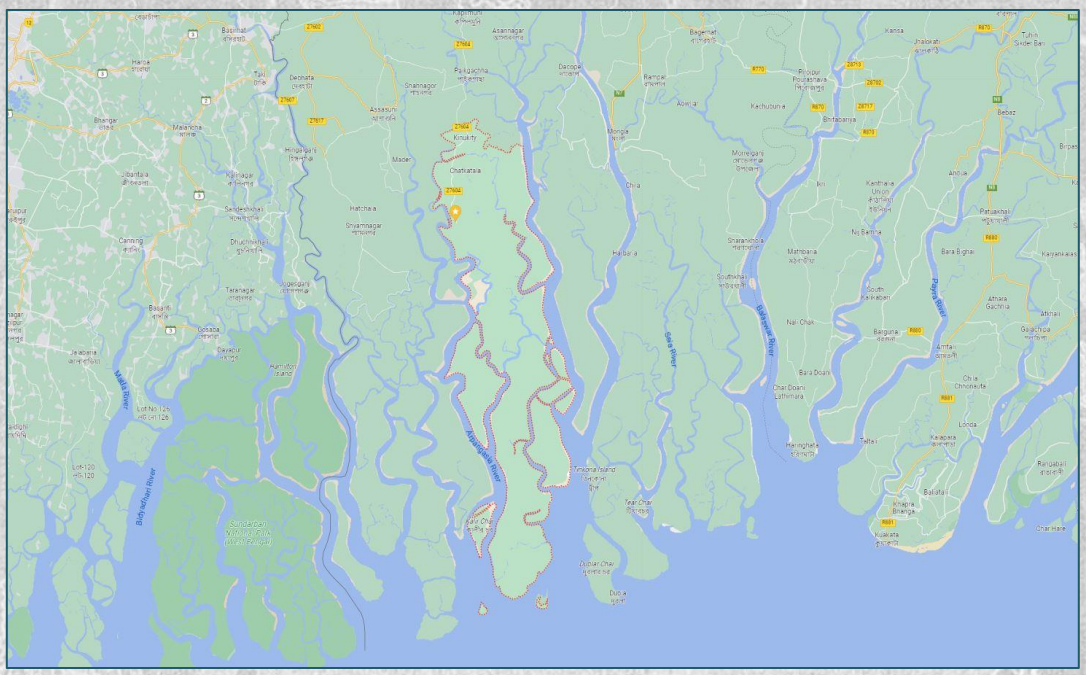


Image: Map of Koira Upazila (Google Earth Image)

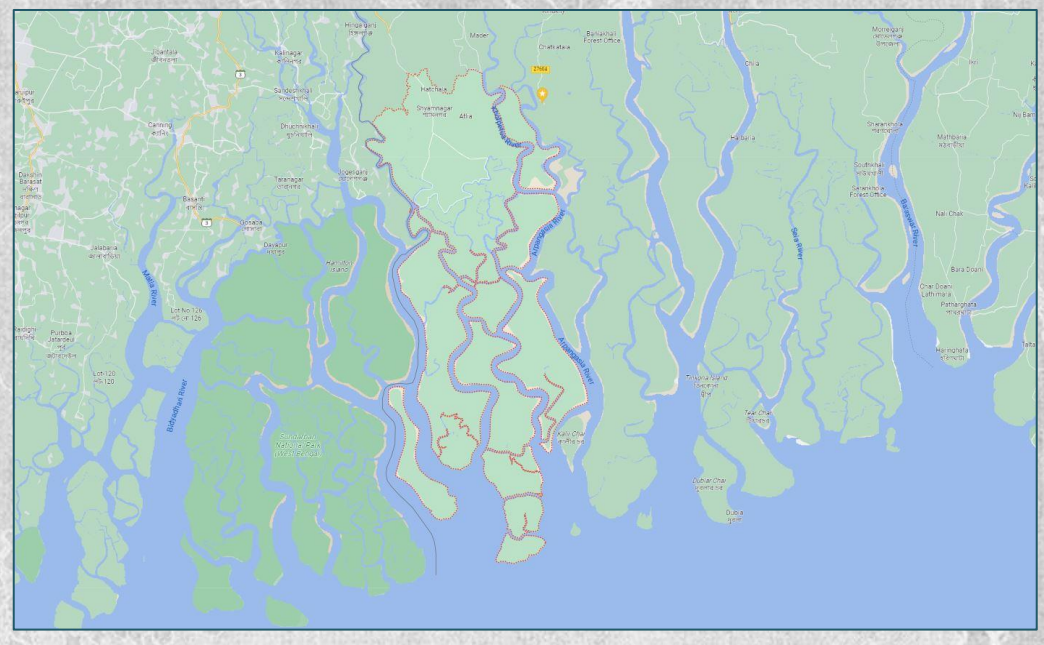


Image: Map of Shyamnagar Upazila of Satkhira District (Google Earth Image)

In the figure above, village scenes from Koira are shown; The only culvert in the village was destroyed due to Amphan. As a result, there is widespread disruption of communication right now. (Left) In the adjacent image, a dam built by local residents is shown which ultimately couldn't hold the tidal surge during the cyclone. (right)

The community was undefeated by Covid-19 and as being naturally resilient to cyclones, they fought back to Amphan with whatever they had. But, repeated vagaries of nature didn't give them enough options or chances to prepare. The people of Katmar-char region were water-logged for about 9 months; there were houses under about 3 feet of water; Only the tops of the coconut trees could be seen. Due to the insufficient number of shelters, it wasn't possible to reside everyone there. There was no gender-segregated accommodation, no adequate maternity or disabled facilities, no adequate supply of food and water. As per government directives, they all had to wear masks but there was absolutely no opportunity to maintain the required social distance.

Compound Disasters during Cyclone Amphan

COVID-19 and Cyclone Amphan

People of Koira and Paikgacha weren't really scared of or not sufficiently aware about COVID-19. Those who have to rely regularly on nature's whims are naturally predestinarian. Although they follow the government regulations imposed on Covid-19 to some extent, due to economic reasons, this marginalized population has to break the guidelines and go to respective works.

Cyclone Amphan and Heavy Rain

A part of the Kapotaksha river flows by the side of Malopara village, Radulli Union of Paikgacha Upazila; The river usually rises 10 feet in normal tides, during Amphan the water rose about 4-5 feet more and s subsequently submerged most of the village lands. The entire village was under water for about 15-20 days. Just before the water receded, there was heavy rain in the area for about 1 week which further pushed the limits of sufferings of the people; There was no end to the misery of the villagers due to the compound effects of the waterlogging and consequent heavy rains.

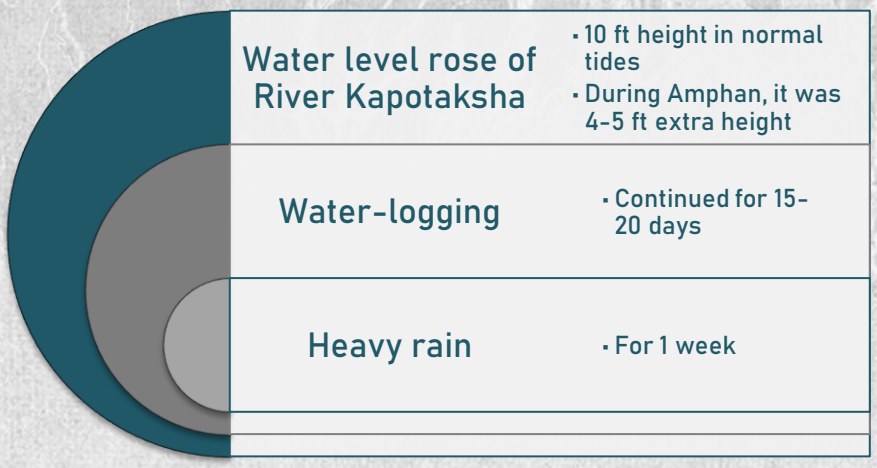


Figure: Compound effects of Cyclone Amphan in Paikgacha region

Cascading Disasters during Cyclone Amphan

Cyclone Amphan, Waterlogging, Salinity and Water borne diseases

The inundation caused by saltwater overflowing the dam during Cyclone Amphan varied among coastal villages, but in no case was it less than at least 15 days. This brackish water also resulted in salinization of freshwater sources, including agricultural lands and livestock pastures, with harmful effects that persist to this very day.

Due to the lack of safe water during and after the cyclone, residents were forced to drink brackish water or untreated water. As a result, various water-borne diseases as well as skin diseases became more prevalent.

Cyclone Amphan, Storm Surge and River Erosion

Malopara of Paikgacha upazila of Khulna district and several other villages were flooded due to flash floods during Amphan alongside river erosion. Every month the river is consuming a little bit of the cultivable and residential lands.

Chairman of the village Abul Kalam Azad said, from the time of Aila to Amphan, about 20 bighas of land had disappeared under the river.

Compound and Cascading Effects of Cyclone Amphan

Effects of Salinity Intrusion

According to a research report of Bangladesh Soil Resources Development Institute, about 53 percent of the country's coastal areas are directly affected by salinity. (Source: CPP Guidelines)

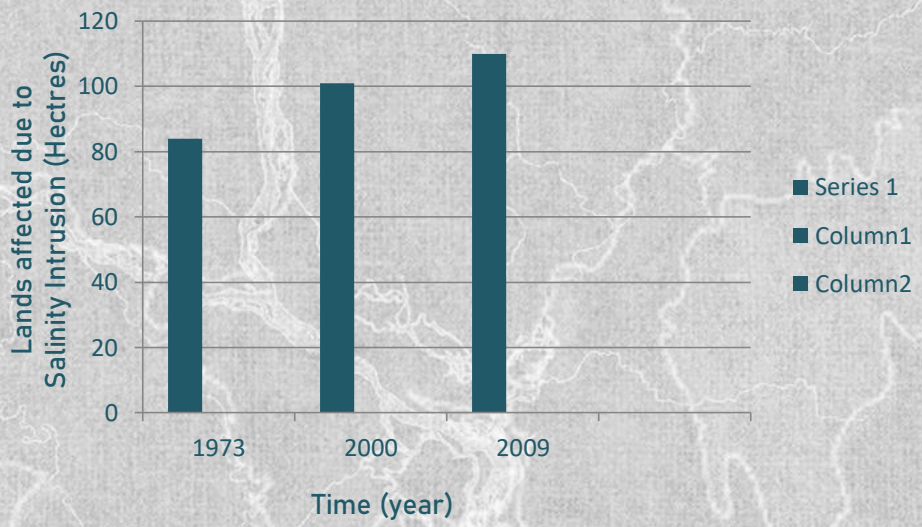


Figure: Amount of land lost to salinity intrusion

Loss of Agricultural Lands

Agricultural production has the most devastating effect due to salinity intrusion. Moreover, there is an acute shortage of drinking water, on top of that, water-borne diseases and environmental disasters are on the rise. Out of about 28.6 lakh hectares of coastal area in southern and southwestern parts of Bangladesh, 10.56 lakh hectares are affected by salinity to varying degrees.

North Bedkashi Union of Koira Upazila was the worst affected by Amphan; Also various villages of Koira namely Maharajpur UP, Dakshin Bedkashi etc. unions have suffered in numerous ways.

After Amphan, Mathkhali village of Maharajpur union was waterlogged for 2 months, Koira village of No. 2 of Koira union was under water for 2 months, most of the villages of South Bedkashi union for 1 month and Katmar Char village of North Bedkashi was waterlogged for about 9 months and it was saline water to the core.

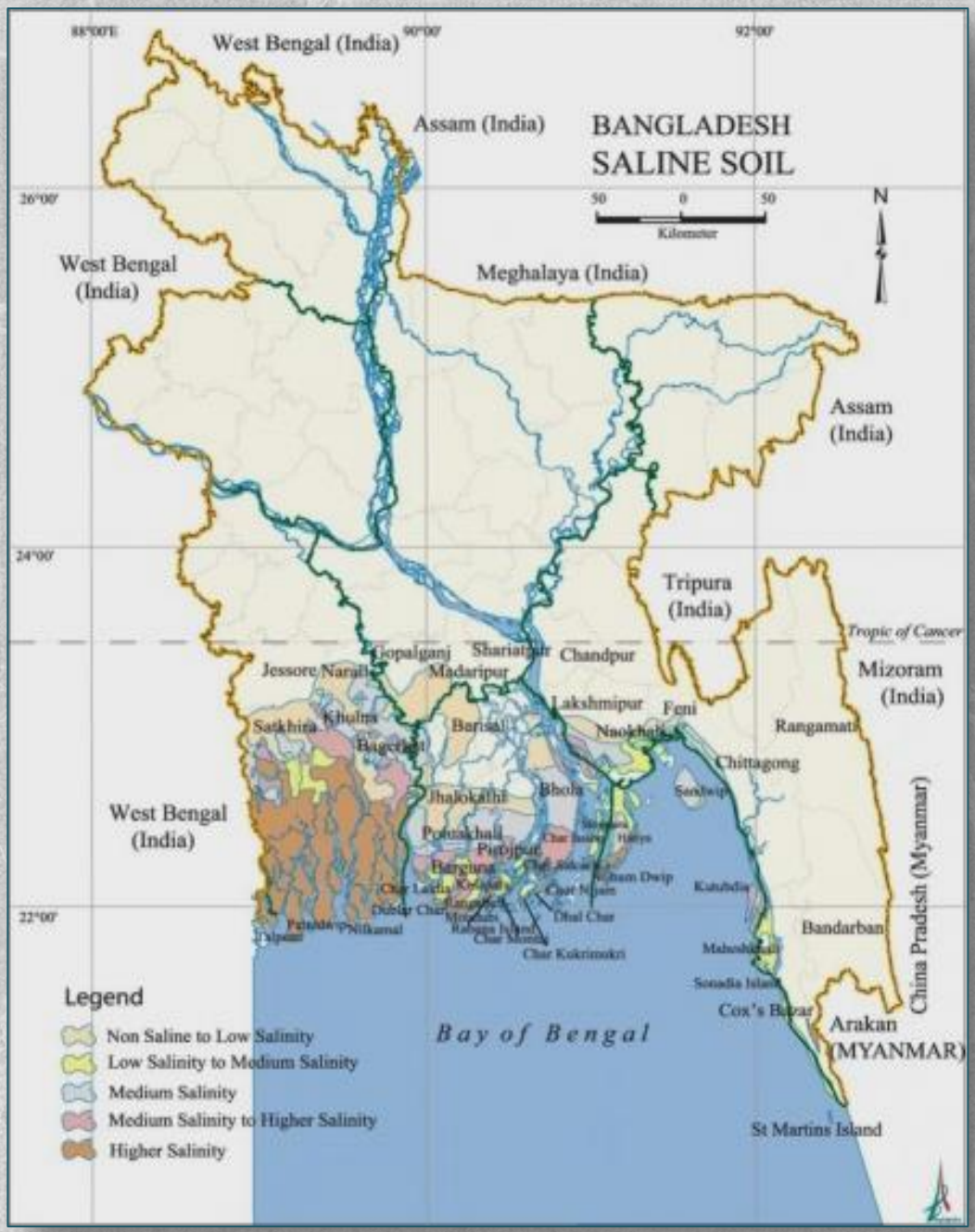


Figure: Map of saline soils, Bangladesh

This saline water penetrates deep into the soil of agricultural fields and increases the salinity of the soil thus destroys the balance of the nutrients which results in poor production or no production even; The land hasn't gained its fertility yet since the post-Amphan period. Due to this, crop cultivation has become unfeasible in the dry season. especially in Rabi and Khalif-1 seasons.

The Amount of Garden Cultivation has Decreased

Many homemakers cultivated their backyard gardens that gave them an opportunity to earn a small income and provide an additional source of food. But due to the salinity intrusion of this long period of 9 months that hope has also become slender. Due to brackish water, the cultivation of agricultural products in these coastal areas has reduced to a larger extent, which has even affected the country's GDP. Especially, the scarcity of agricultural produce is a matter of great concern in this post-COVID global economic recession.

Damages to Fisheries

The fisheries sector suffered huge losses; In these parts of the country, shrimps are cultivated by trapping brackish water in the land. This malpractice and the accompanying increase in salinity due to the effects of natural cyclones are increasing the overall salinity of the groundwater which is adversely affecting the biodiversity and balance of the region.

The only community clinic in Katmar-char village was affected by Amphan and is currently closed. (2022)

Community latrines damaged by brackish water; Bricks have fallen, sewage system is completely destroyed. (2022)

Damage to Buildings and Roads

Salt water has caused extensive devastations to houses, roads, bridges and culverts etc.; A community clinic, community toilets, culvert and the only paved road connecting the village were destroyed in Katmar-char village. The houses that were not completely destroyed in the cyclone, the salt water did the rest; Tins rusted due to corrosion, furniture rotted in salt water, wooden doors crumbled.

Image: Damage to houses in salt water in Amphan's aftermath (2022)

Image: Damage to houses in salt water in Amphan's aftermath (2022)

Lack of Safe Water and Diseases Caused by It

Long-term salt-water inundation had caused contamination of brackish water with regions' source of drinking water. The freshwater tube-wells were all submerged in saline water. Coastal women always have to walk at least 4-5 km to fetch drinking water, but getting drinking water during Amphan was a rare thing.

Most of the people of the Koira region lived and are still living during and in the post-Amphan period without access to safe drinking water, consuming this brackish water, resulting in waterborne diseases - which later became regional epidemics. Diarrhea, dysentery etc. were common during this period of water retention and even later as well. Even pregnant women were sometimes forced to drink this saline water which increased their health risks severely.

Image: Saline soil in Shyamnagar Union (2023)

Also, due to prolonged exposure to salt water and bathing with this water, many people have developed various skin diseases.

Economic Instability and Growth of Floating Population

1, 2 or 9 months of inundation, loss of agricultural land, death of cattle and other animals and destruction of houses - all these are really doomsday for the poor people living in that region. 40 percent people of Katmar-char village have left the village in search of a new livelihood. Many people have left their homes in a single cloth; families have become completely destitute as the sole bread earner in many families had become disabled.

Image: People of Malopara village in Paikgacha region have been suffering damage due to river erosion since Cyclone Aila which has been exacerbated by Cyclone Bulbul and Amphan. (2022)

Image: Effects of salinity in coastal areas, areas where houses are exposed to salt water and wind, where salt accumulates and initiates building decay (2023)

Figure: Damage to wall-coating of mud houses due to salinity in coastal areas (2022)

In the words of a resident of Koira region,
“Works we never have done earlier, have to do it now".

“Our main concern during Amphan is to save lives; Then there is the problem of livelihood, since one cannot go out, survival becomes questionable. How long will aid from NGOs come? Everyone has limited resources.”
-Md. Hazrat Ali, a resident of Katmar-char village

The people of Paikgacha Upazila have brought various changes in their professions in order to earn bread. Residents of Malopara village are the worst victims of river erosion since Amphan; As a result, they have to rely only on luck to adapt to the harsh nature. The land is constantly being submerged in the river and along with it the arable land and their abode. Since Cyclone Sidr till 2022, about 300 bighas of land of this village had disappeared under the river.

Image: Livelihood of fishermen in Malopara village becoming increasingly difficult (2022)

This scarcity of agricultural land necessitated a shift in the occupation of their ancestors; Fishermen who used to catch fish in the river had to move to deeper water. Many don't have that ability or enough capital, so maybe some have chosen to be a rider of a cycle-rickshaw as a profession, some have gone to the bigger cities to look for work. But in most cases this change of profession did not bring anything good in their life and sometimes degrading quality of living standards all together.

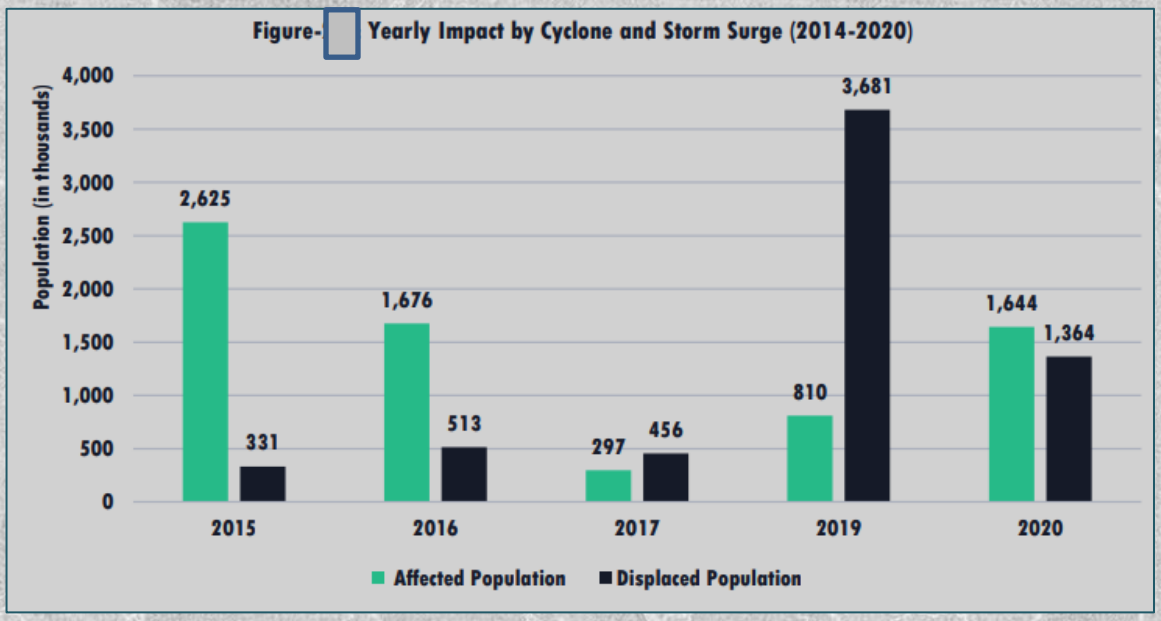
“I have to go fishing, pick up big iron chains, I'm old now and can't do it like I did before“

-A crying fisherman, Malopara village, Paikgacha upazila

Image: A woman describing the damage to her house in Amphan, Paikgacha, Khulna (2022)

Image: A woman converted agricultural land to shrimp farming due to salt water intrusion in Amphan, Shyamnagar, Satkhira (2023).

Beyond the regional poverty, people are becoming economically marginalized due to the impact of Amphan, which is contributing to the existing list of floating and ultra-poor people in the country. Because of this,, we are gradually moving away from the sustainable development goals.



In the above chart, a survey based on Jamalpur region of Bangladesh shows that the number of internally displaced people has increased due to cyclones and wildfires in the 6 years 2014-2020, which is extremely high in 2019. These people most commonly known as climate migrants, live an extremely below standard life.

Disaster Risk Assessment

Based on the normal disaster risk assessment steps, cascading and compound disaster risk assessment can be done through 6 steps:

Hazard Analysis

Drawing a hazard map of a cascading or compound disaster or a hazard map of the cascading or compound effects of a particular disaster could be quite tricky. If the disaster is like Super Cyclone Amphan, its secondary and tertiary effects will last for a long time which could both be in time and space dimensions.

Abnormal rise in temperature and changes in rainfall patterns are serious outcomes of climate change which eventually results in an increase in cyclones/tornadoes in the tropics. Several cyclones have formed in the Indian Ocean and Bay of Bengal over the past few years, with rising intensity and frequency one of which is cyclone Amphan.

.

Amphan hit during the Covid-19 pandemic and brought saline water, catastrophic devastation and unheard cries of millions of people. In Koira only, 126 sq km of land was affected due to salinity intrusion and summing up all the coastal areas,the damage would be immeasurable.

Due to the intrusion of saline water into all these cultivated lands, the yield is disrupted on a larger scale. The amount of grazing land for livestock decreases which results in sufferings of livestock from malnutrition. This begets economic decline; the amount of milk, meat, etc. obtained from cattle decreases which directly affects the health of children in the region.

Loss of agricultural produce, loss of arable land, decline in livestock production—all of these factors push a family into undeniable poverty. Incomes fall – economic marginalization develops, impacting GDP and Bangladesh is falling behind to achieve the Sustainable Development Goals. This is only one cyclone's impact; imagine all of those that occurred during the last 10 years.

Environmental characteristics of coastal areas, low-lying locations, lack of resources and capacity etc. can be considered as cyclone related hazards in those areas.
If we want to analyze the compound or cascading hazards of cyclones in coastal areas then the above issues must be considered.

Exposure Assessment

In any single disaster, exposure is mainly limited to people, agricultural land, livestock, houses, roads, culverts-bridges etc. which are at risk. But in cascading and compound disasters the elements of exposure can be more extensive.

A person whose livelihood is greatly altered by the effects of this cyclone will be considered an exposure element. As salinity level of land and water increases due to cyclones, the amount of grazing land for livestock and the nutritional quality of forage derived from it decreases, which ultimately has a negative impact on child nutrition; So here, livestock, pasture, baby food etc. are exposure elements. Storm-damaged vegetation and the natural environment are also exposure factors.

Vulnerability Assessment

Vulnerability and exposure are inextricably linked. Vulnerability assessment requires knowledge of hazard assessment and resilience of affected populations

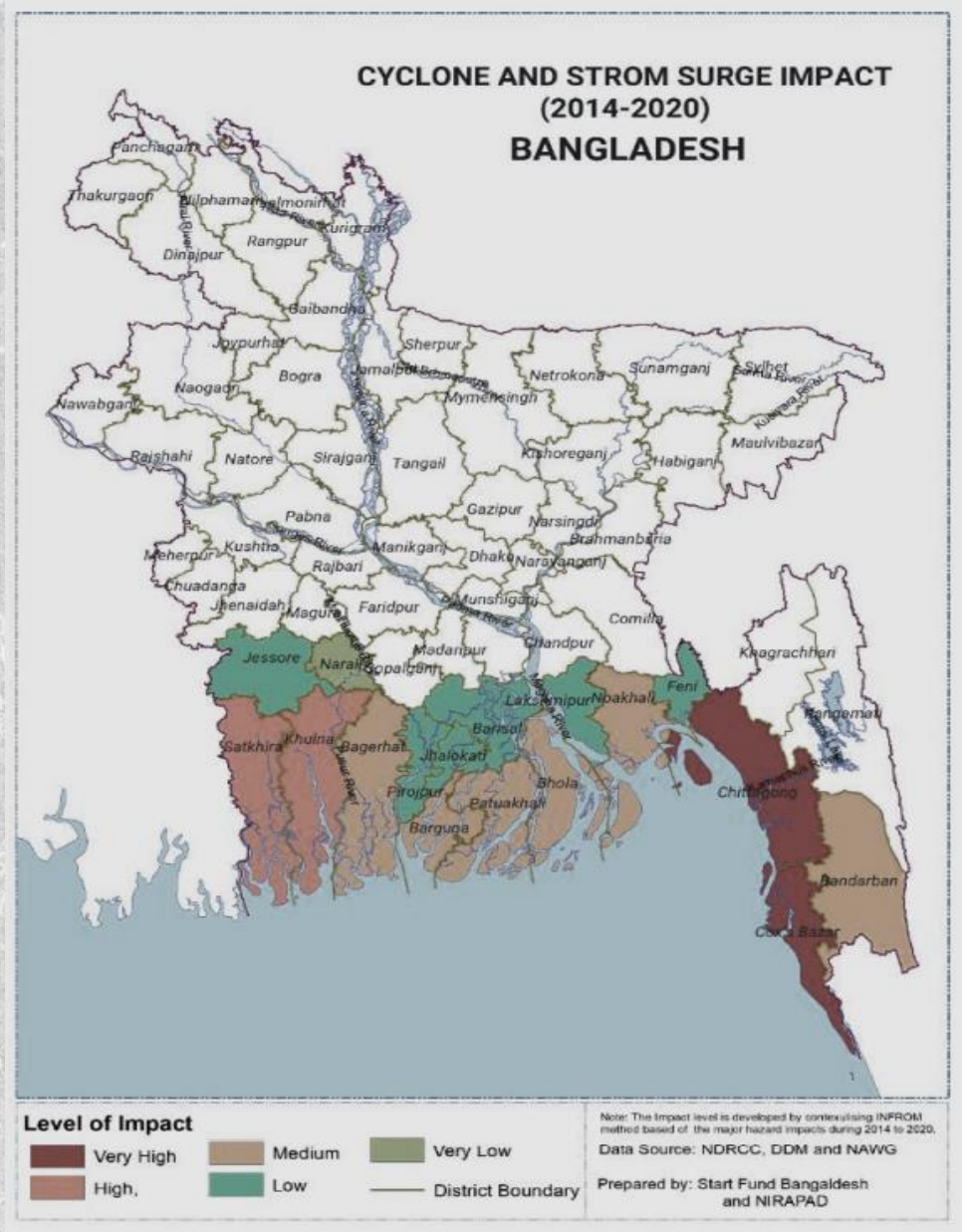
.

Losses can generally be of two types – quantifiable losses such as death or injury to people, loss of houses, loss of agricultural land etc.; And immeasurable damage that is not directly related to economic loss but has a far-reaching impact on an affected person and the environment. For example: psychological stress of losing everything, psychological trauma, increase in criminal tendency, increase of child marriage, drug use, environmental damage etc.

The potential for physical and mental harm to humans as an exposure component shall be considered a vulnerability. Inability to overcome the loss due to economic instability, i.e. a person whose livelihood is drastically altered by the impact of the cyclone, will be considered as an element of vulnerability.

Damage and imbalance of the existing natural environment; Damage to livestock etc. are all vulnerability - which are vulnerable because of cyclones.

Now, due to post-cyclone inundation and increased salinity, the exposed elements will suffer again; Eventually the intensity of the same harm done will increase or multiple damage will be in the scenario. People who are physically and economically affected by the cyclone will suffer more extensive damages due to flooding. Homes partially destroyed by cyclones may be completely destroyed by salt water inundation; Survivors of Amphan may later suffer from various diseases due to flooding or health risks may arise for drinking brackish water. So, the vulnerability of exposure components is multiplied in cascading and compound disasters.



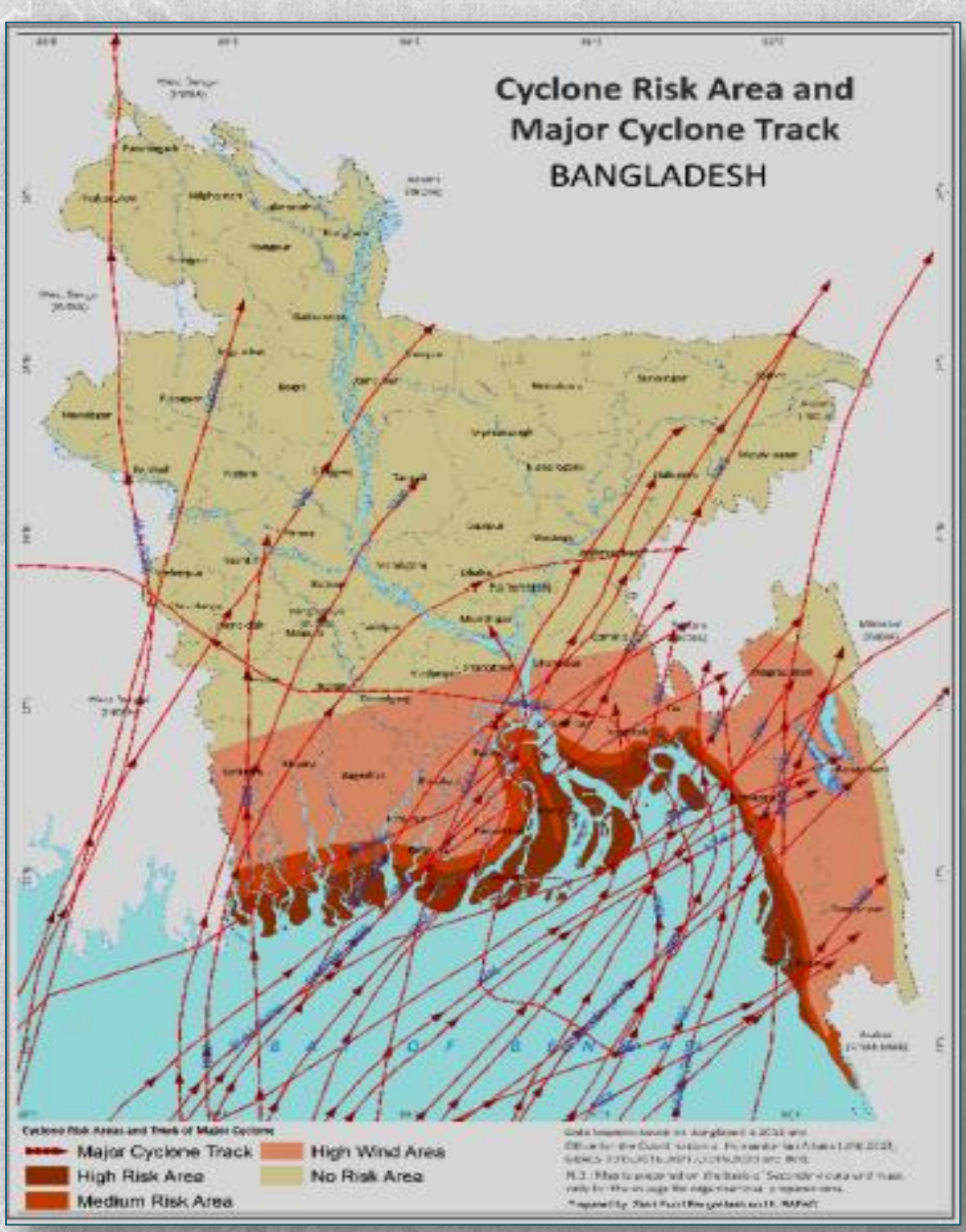
In the above map, the areas most affected by cyclones and wildfires of Bangladesh are shown. With the help of this map, it could be understood which areas are at risk due to cyclones and at what level. (2023)

As salinity increases due to cyclones resulting in reduction of grazing land for livestock and loss of nutritional quality of forage derived from it, which ultimately has a negative impact on child nutrition; So here, the tendency to increase salinity in the pastures, the overall nutritional status of the people in the area, the food quality of the livestock etc. are all elements of danger.

Risk Assessment and Mapping

Once hazards, exposures and vulnerability elements are identified, risk assessment and mapping becomes much easier. A risk map is an intricate version of a hazard map. However, in risk maps, it is useful to specify how much of a component is at risk; That is, it is smoother to specify the value of risk in this case.

It is useful to separate the seasonal risk components in addition to the risk quality in the map. Coastal areas are at high risk of cyclones during the monsoon season. When high tide/ tidal surge comes from any cyclone, the water crosses the dam and enters the lowlands, but in many cases, when the water level decreases, this salt water cannot come out, resulting in waterlogging, which increases the salinity of the agricultural land. After the monsoon, the yield is disrupted due to salinity in the winter season.



The map shows an average of the tracks of major cyclones in Bangladesh. Also, areas which are likely to be affected by strong winds during cyclones and flash floods are also shown. Coastal areas are also shown as high risk, medium and low risk. ()

In the case of Cyclone Amphan, the villages closest to the coast were at high-risk, so the cyclone shelters located in these villages needed to be more careful of that. Since the source of drinking water in that area is a high-risk exposure element, alternative measures should have been put in place to ensure the community's access to safe drinking water. In this way, potential risk maps could be curated considering exposures and hazards.

Table 2: District wise annual projected households in need by cyclone and storm surge

S. N.	District Name	Major Primary Disaster Type	Major Secondary Disaster Type	Multi-Hazard Risk Index	Multi-Hazard Risk level	Rank Multi-Hazard Risk	Rank For Cyclone	Rank for Landslide	1-Minimal %	2-Stress %	3- Severe %	4-Extreme %	1-Minimal #	2-Stress #	3- Severe #	4-Extreme #	Total Potential Impact HH
1.	Khulna	Cyclone		5.7	High	9	1		20	30	30	20	11,153	16,729	16,729	11,153	55,765
2.	Cox's Bazar	Cyclone	Landslide	5.6	High	10	2	1	20	25	25	30	8,383	10,479	10,479	12,575	41,916
3.	Chattogram	Cyclone	Landslide	5.5	High	12	4	2	25	30	30	15	8,628	10,354	10,354	5,177	34,513
4.	Barguna	Cyclone		5.5	High	12	3		10	25	40	25	2,349	5,873	9,396	5,873	23,491
5.	Noakhali	Cyclone		5.4	High	14	5		20	25	25	30	2,358	2,948	2,948	3,537	11,792
6.	Satkhira	Cyclone		5.4	High	14	6		15	30	25	30	10,969	21,938	18,282	21,938	73,128
7.	Patuakhali	Cyclone		5.1	High	22	7		10	25	40	25	2,641	6,601	10,562	6,601	26,405
8.	Bandarban	Cyclone	Landslide	5.0	High	24	10	3	10	15	40	35	1,084	1,626	4,337	3,795	10,843
9.	Barishal	Cyclone		5.0	High	24	8		20	20	30	30	19,993	19,993	29,989	29,989	99,965
10.	Bhola	Cyclone		5.0	High	24	9		20	20	35	25	7,821	7,821	13,687	9,776	39,105
11.	Bagerhat	Cyclone		5.0	High	24	11		15	20	35	30	6,048	8,064	14,111	12,095	40,318
12.	Pirojpur	Cyclone		4.7	Medium	36	12		20	25	35	20	5,222	6,528	9,139	5,222	26,111
13.	Lakshmipur	Cyclone		4.7	Medium	36	13		10	20	40	30	2,504	5,007	10,014	7,511	25,036
14.	Feni	Cyclone		4.3	Medium	42	14		20	30	20	30	4,567	4,567	3,806	2,283	15,222
15.	Jhalokati	Cyclone		4.1	Medium	48	15		15	25	35	25	2,056	3,426	4,796	3,426	13,704
16.	Jashore	Cyclone		4.1	Medium	48	16		20	30	25	25	8,826	13,238	11,032	11,032	44,128
17.	Narail	Cyclone		3.2	Low	54	17		15	35	30	20	318	742	636	424	2,120
												Total	104,919	145,935	180,299	152,409	583,562

In the said table an attempt has been made to specify cyclones as major disasters in 17 of the coastal districts and other devastations caused by it. A risk index is specified in each district to calculate the probability of occurrence of more than one disaster (compound or cascading). Further, they are divided according to the severity of the risk and from that an amount of total potential loss is calculated.

LIKELIHOOD						
	HIGH	>89 km/h maximum sustained wind speed (Signal 8,9,10) >3 m surge height				
	MEDIUM	62-88 km/h maximum sustained wind speed (Signal 5,6,7) 2-3 m surge height				
	LOW	51-61 km/h maximum sustained wind speed (Signal 4) 1-2 m surge height			X	
	VERY LOW	<50 km/h maximum sustained wind speed (Signal 1, 2, 3) up to 1 m surge height				
Risk Seriousness			500,000 Pop	1,000,000 Pop	1,500,000 Pop	2,000,000 Pop
			VERY LOW (MINIMAL)	LOW (MINOR)	MEDIUM (SIGNIFICANT)	HIGH (SEVERE)
			IMPACT (The cyclone landfall district plus other two adjacent districts)			

Table 3: Risk matrix for cyclone and storm surge

Seasonal fluctuations can also be shown here. Generally, the incidence of cyclones is high in the months of September-November. And during the dry season, crop production is disrupted due to salinity intrusion. Two different risks dominate in two seasons.

Risk Scenario Development

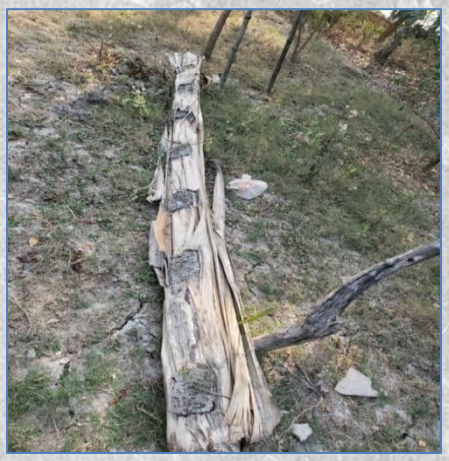
With the help of existing hazard, exposure, vulnerability and risk maps, the community will carry out some local/ regional risk scenarios based on their own knowledge and understanding. It is a good practice to make the community aware of potential disasters in coming future.

This practice is still not prevalent in our country. However, an example can be illustrated - if a family knows that they live in coastal area, and at a certain time of the year they have a high risk of experiencing a cyclone, then they will be able to consider all possible losses. Thinking about how much water can enter the house, how much damage can cause to agriculture, what will happen to the food of cows and goats, how much damage could occur to their living space - etc. are the incarnation of risk visualization.

Resources and Capacity Mapping

Once the potential risk scenarios are mapped out, the community itself could be able to identify what needs to be done to recover from those risks by inventorying their existing resources.

For example, to recover from Cyclone Amphan and its impacts– in case of agricultural produce, sowing of saline resistant crops; cultivation of salt water tolerant fish; taking the help of farming methods like “vertical farming”, “tower farming” etc. in the garden, carrying out various awareness activities including everyone in the community etc.



The aforementioned pictures are pictures of one of the most affected areas of Bangladesh - Shyamnagar Upazila of Satkhira district - affected by cyclone, waterlogging and salinity intrusion. By visiting couple of unions, one can see patterns of utilization and implementation of the community's own capabilities and resources which are in many cases excellently effective because indigenous knowledge is highly potent.

The first picture is of banana tree saplings, which are used during floods and chronic waterlogging and a fine example of floating agriculture. The next image is an example of “vertical farming”. The image on the lower left is the picture of the PSF (Pond sand filter) which is managed by the community itself. The photo below on the right side is a photo during a focal group discussion (FGD) with a youth organization of Banbibipara Union of Shyamnagar - they do volunteer work in their upazila development works and disaster risk reductions with their own and local funding.

Response, Rehabilitation, Recovery

In Super Cyclone Amphan, Bangladesh government and various non-governmental and international humanitarian organizations were very active due to which the death toll was not too high even in the face of Covid-19. But reaching people in remote areas is also a major barrier, for which the marginalized populations suffer greatly.

In both Koira and Paikgacha regions, the tendency of people to go to shelters has increased many times than before. Women are especially more aware of this.

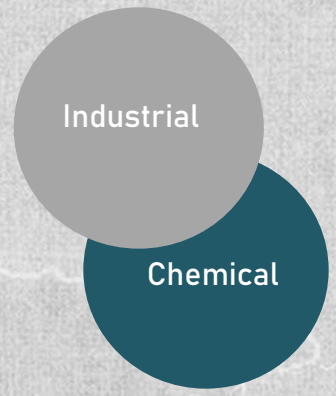
As the dam in Katmar Char village of Koira collapsed and the engineering department of the local government failed to fix it before the cyclone, the locals built the dam themselves in a show of solidarity. It can be understood by looking at the people of these remote areas that severe disasters unite people. Repeated calamities every year have made them resilient by nature.

During and after the disaster, the Government of Bangladesh and various NGOs and international organizations carried out various developmental activities for the people of the region. With funding from the Government, UNDP and Global Climate Action, CNRS has implemented household-based rainwater harvesting in the region to meet drinking water shortages. JICA has facilitated various roads, community sewerage systems. Bangladesh Army constructed several important roads that connect villages to important places.

If it is possible to analyze the risk of these recurrent cyclones through the above mentioned 6 steps, then we can be aware of its compound and cascading effects in advance and be able to increase capacity and resilience of the community accordingly.

Chapter 4
Fire Incident at Sitakunda BM Container Depot

Fire Incident at Sitakunda BM Container- At a Glance



Time of Occurrance: June, 2022

Killed: 52 people

Casualties: 300+

Compensation: Around 40 Crore BDT

Contents

This lesson will review chemical and fire accident controls, hazards, exposure elements and their vulnerabilities and related risks, taking the Sitakunda BM Container fire incident and chemical explosion as an example. Also, the things shall be discussed are:

- Bangladesh's position to deal with fire and chemical disaster management;
- Related regulations and its proper implementation and necessary adjustments;
- Potential risk scenarios;
- Risk mapping due to accidents;
- Strategies to address these risks through existing assets and
- Resources and building resilience etc.

Purpose of this Chapter

At the end of this session, participants/readers will know about the cascading and compound effects of fire and chemical explosions at the regional and national levels and how they should be responded to. They will also gain an understanding of how to increase the resilience of affected populations by analyzing the risks of such larger disaster or compound and cascading disaster scenarios.

Introduction

Due to the rapid progress of industrialization over the last decade, the number of disasters related to fire and chemicals in industrial plants has been on the rise in the country. The 2010 Nimtoli fire accident in Old Dhaka and the 2012 Tazreen Garment Factory fire in Dhaka, along with the largest chemical explosion in Sitakunda in 2022, are some among many examples.

On June 4, 2022, a terrible fire and explosion took place at the BM Container Depot in Sitakunda, Chittagong, resulting in 52 casualties (Source: local Upazila administration) and more than 300 injured. Seemingly caused by simple fire or vandalism, this accident later turned into a huge disaster through series of chemical explosion and caused extensive damages to people, goods and environment all together. It is one of the country's worst ever chemical disasters that started from a simple fire turning into a series of severe chemical explosions; Hence it could be called a cascading disaster.

Image: BM Container Depot, Sitakunda, 2022

According to recent data, around 4.22 million people are employed in the garment industry alone and this is a great example of how Bangladesh is fast moving towards an economy that is industry-based. And as we all know, Industrial plants depend heavily on the use of chemicals.

The Nimtali tragedy in 2010 and the Tazreen Garments fire accident in 2012 followed by the chemical explosion in the Sitakunda BM container in 2022 show that there is considerable indifference in following fire regulations and guidelines for use of chemicals properly.

To collect information about this fire incident and chemical explosion at Sitakunda and to observe the current condition of the BM container depot, the office and shed areas of Sitakunda BM container were visited. Field-level data showed that norms were violated at some places and reluctance to properly collate information even after fire incidents.

After talking to the manager of BM Container, we get a scenario of the event on mind. it is said that the incident of fire was immediately reported to the nearest Kumira Fire Service; They also called 999 and gave information to the control room. The container authorities claimed they had reported the presence of hydrogen peroxide along with garment products in the depot. Even at this stage the fire was at a normal level.

Coming from Kumira fire station to put out the fire, realizing that the situation was not under control, the firefighting team first sought help from Sitakunda and later from Agrabad and Bayezid fire stations. At this point, efforts were being made to extinguish the fire with water from all the fire stations. Speaking to the fire service, Sitakunda unit, it came into light that they did not know about presence of any chemicals there; if they knew, they would cloth their workers in special uniforms. 12 firefighters were killed in the subsequent explosion due to the manipulation of information.

The depot authorities claimed that there was no deficiency in their fire safety measures. They are associated with a Dutch company and the depot is a joint venture with both domestic and foreign financial support; There is no room for them to disobey the rules from that position.
The fire service was called soon after the fire broke but it took them half an hour to reach the spot as the nearest fire brigade office was also quite far away. On arrival, they started extinguishing the fire with water fountains. As they lacked information and there were shortages of necessary materials, especially the protective clothing to be worn in case of fire due to chemical substances, the workers were injured while fighting the fire. Two well-equipped fire brigade vehicles were completely gutted in the blast.

Initially, the fire was small, and neither the staff nor the fire brigade had any idea what kind of chemicals were stored there. Although some people talk about the possibility of a fire due to the stored hydrogen peroxide, the depot authorities, local public administration and fire service offices agree that hydrogen peroxide is not flammable or could have been the cause of the huge explosion that happened.

From the initial fire followed by a series of explosions, people in the depot were killed, maimed, and lost their livelihoods. Nearby houses suffered extensive damage. Remains of the depot were also found about 2 km away. The tremors of the explosion were felt even at a distance of 4-5 km.
The depot company has so far paid about BDT 40 crore as compensation to the killed and injured workers, their beneficiaries and the local fire service.

Let's assess this disaster risk situation through 6 steps.

Hazard Analysis

Many of the truck drivers who used to bring and take goods to BM Container Depot were addicted to smoking. Due to lack of full implementation of customary laws, this habit of smoking has not been stopped.

Apart from this, due to the presence of open spaces and forests nearby, the infestation of insects and mosquitoes is high in that area. So the officers and employees who were on duty at the depot at night, kept the coils lit to protect against mosquitoes - which could easily cause a fire due to carelessness.

The entire depot area was covered with electric cables which are very dangerous and several cables were also faulty. According to the Bangladesh Fire Service and Civil Defense, 80% of fire-related disasters are caused by electrical connections being failed or malfunctioned.

The volume and capacity of their own water tank was insufficient compared to the requirement. This hampered firefighting activities during post-disaster response.

The exact cause of the fire has not yet been ascertained. According to the company's own investigation and reports from some quarters of the government, it is believed that the fire could have been started externally. All the security cameras in the depot were destroyed in the blast. If this information could be collected on the Internet (Cloud Upload), then it would be convenient to take the right action later by knowing the exact reason.

Exposure Assessment

Exposure to a disaster-prone area is, therefore, considered as being exposed to any loss of life or property due to the said hazards; For example, the employees who worked at the depot, the people living in the nearby houses, the drivers who brought the goods, etc.

As there is forest nearby where animals and plants live and have also suffered damage, they were exposed as well. Surrounding houses and livestock also fall into this.

Vulnerability Assessment

Dangerous situation with people/goods exposed to the possibility and hazards. Human exposure to the elements, and potential fire damage from mosquito coils are dangerous situations. The possibility of a fire starting from where the smoke is burning and causing harm to the surrounding people is a vulnerable situation.

Likewise, the possibility of short-circuits from faulty electrical connections, the possibility of more declining situations in a possible disaster due to not having enough water, etc. all indicate danger.
Marginalized people who survived by doing small businesses in the area, their livelihoods are also in jeopardy and hence they are vulnerable.

Risk Assessment and Mapping

The exact cause of the fire at the container depot at Sitakunda is not known, but various elements of the hazards were present there. That is why people and goods were in risk and when the hazard finally turned into a disaster, huge losses were incurred.

When hazards, exposures and vulnerability are all identified, risk mapping becomes easier as said before. With a map of the entire depot, it is possible to easily create a risk map by identifying all the hazards there.

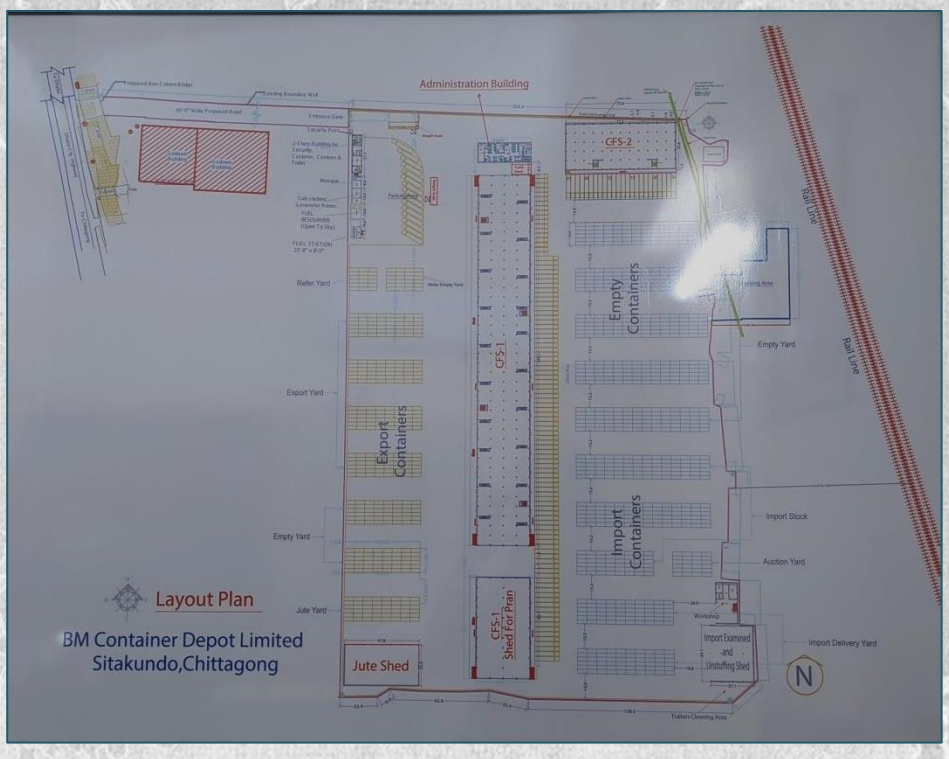


Image: Modernized Map of the Depot (2022)

With the help of this map, it is possible to identify various accidents with the participation of the depot officials and employees. If the location of the hazards is indicated on the map, it will be an effective hazard map and later it is possible to specify which exposure material is at risk due to these hazards. In this way, a successful risk map will be created, which will be quite useful in responding to any future disaster and it eliminates the possibility of any future accident.

With the help of this risk map, it is possible to create a route, known as an “evacuation route”, that is, how to move the exposure components to a safe place in a possible occurring disaster. Since there is a high probability of disasters like fire, chemical explosion and building collapse in industrial factories, making a risk map of these possible disasters will play an effective role in preventing future disasters.

Risk Scenario Development

After creating the potential risk map, various risk scenarios can be practiced with container workers and residents living nearby.

If all the risks specified in the risk map actually occur, how the population is at risk and if any damage is likely to take place, through this exercise, it is also possible to specify.

Resource and Capacity Mapping

The final step in risk assessment is the preparation of a list of each exposed component's own capacity and potential disaster response using risk maps and risk scenarios, the practice of which has long-term implications for any disaster preparedness.

After effects of fire and chemical explosion

Talking to the three type of stakeholders namely Depot Authority, Local Public Administration and Fire Service, certain issues have been identified due to which the potential hazards of industrial accidents still exist in Sitakunda city of Chittagong. According to the partners, Sitakunda is the lifeblood of the Chittagong district industrial zone and proper hazard mapping will help the busy industrial city to deal with various disasters.

The depot authorities have taken the following measures after their disaster:

- Specifying indifference in implementing existing policies
- Improvements in existing depot design and modernization of fire protection system
- Taking measures to assess the permanent disability and economic loss of the concerned employees
- Development and implementation of existing fire safety related building codes

Figure: Use of thermal insulation materials on factory walls and roofs (left); Strengthening of Security at Entry to Depot (Right) (2022)

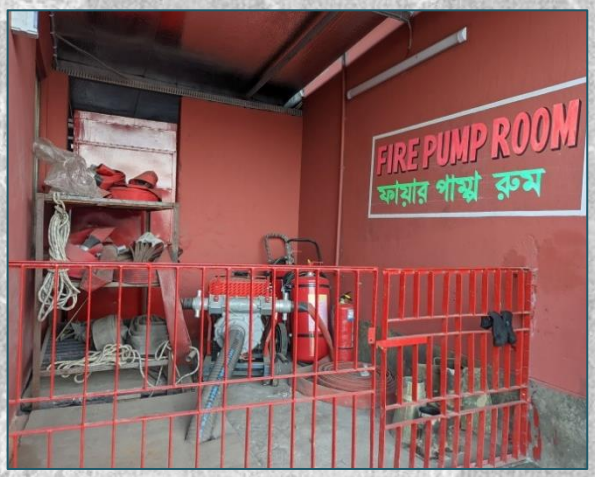
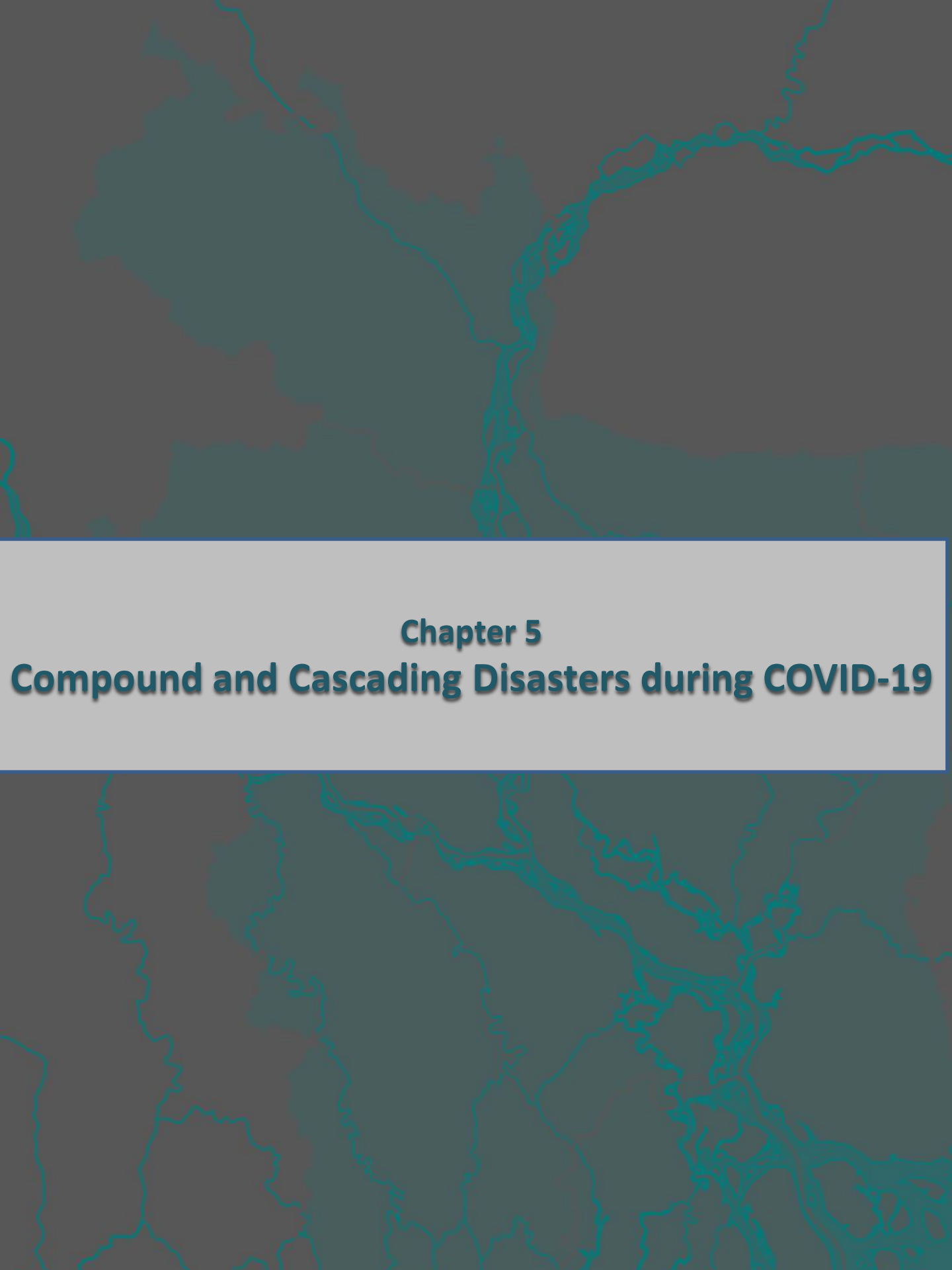


Figure: Development of Fire Fighting System at Depot (2022)



Chapter 5
Compound and Cascading Disasters during COVID-19

Contents

By the end of this chapter readers/participants will know about the Covid-19 pandemic and its associated compound and cascading disasters. They can be aware of the subsequent compound and cascading effects of Covid-19 and understand how it plays a role at individual, local and national levels.

Purpose of the Chapter

Through the topics discussed in this chapter, an attempt has been made to understand how the biological disaster called Covid-19 has generated multifaceted effects on human lives, and to determine the mitigation methods accordingly. Also, how a global disaster is combined with other local/national disasters, endanger the population and how to analyze its risk – that is also discussed in this chapter.

Introduction

Covid-19 is a biological disaster that spread worldwide in 2020 and changed the day-to-day life of people forever and brought about new normal. After the first detection of the virus in Bangladesh on March 8, officially first lockdown instructions came at the end of March, which later continued in several phases. People's lives and livelihoods were greatly disrupted.

Bangladesh as well as people around the world started to face a new type of disaster about which they had no information, experience or knowledge. Lockdown, Social Distance, Quarantine etc. these unfamiliar words became daily companions; Masked faces seemed to be the new normal.

A disaster that people had no idea about, there was no opportunity to prepare for that disaster. However, when compared globally, it is clear that the people of Bangladesh are much more resilient in times of disaster and transition from it than many other countries. People have adapted to the new daily life and have largely succeeded, but the secondary and tertiary effects of other disasters and epidemics have hampered this effort to a larger extent.

COVID-19 Pandemic and Different Compound and Cascading Disasters

- COVID-19 and Flood (Compound) / Flood and River Erosion (Cascading)
- COVID-19, Heavy Rain and Lightening (Compound)
- COVID-19 and Cyclones (Compound) / Cyclones, Waterlogging, Salinity Intrusion and Water borne Diseases (Cascading)
- COVID-19 and Dengue Epidemic(Compound)

Covid-19 and Floods (Compound) / Floods and River Eruptions (Cascading) / Floods and Flooding and Waterborne Diseases (Cascading)

In 2020, the Covid-19 pandemic saw seasonal flooding at the end of June, which preceded the normal flood period, and this year's floods had some notable features. This was the second-highest since 1989 and the second-longest after 1998. Never before has a “triple peak” flood been seen.

In the adjacent figure, a table of disasters that hit Bangladesh in July 2020 is given.

Seasonal rainfall and runoff from the hilly areas upstream inundated the northern and eastern districts of Bangladesh, causing extensive damage. Thousands of people in 7 districts of the country were inundated or displaced and their houses were submerged. In these floods, 5.5 million people were affected, and 1 million houses were destroyed. About 1.1 million people were displaced and about 100,000 had to be evacuated to about 1,500 shelters. About 1 million tube-wells and over 100,000 latrines were damaged, 83,000 hectares of paddy fields were damaged and 257 people lost their lives.

In July 2020, a total of 91,164 people were infected with Covid-19 across the country, of which 1,264 died and 76,554 recovered. According to the NDRCC report for July, 43 people died out of the affected population in 33 districts across the country due to monsoon floods.
Floods and heavy rains lead to increased river erosion, chronic waterlogging and the introduction of various water-borne diseases.

Here, Covid-19 is a biological disaster, combined with a hydrological disaster, flood, to create a compound disaster. Geological disasters like flooding to river erosion are therefore form a cascading disaster. Again, disasters such as flood and water-borne diseases are created from floods; This is also a cascading disaster.

Covid-19 and Heavy Rain and Lightning (Compound)

During the Covid-19 pandemic, excessive rainfall occurs during monsoon floods. During this time, lightning incidents happened in different parts of the country. 19 incidents of lightning occurred in 12 districts including Rangpur, Lalmonirhat, Nilphamari, Dinajpur, Tangail, Moulvibazar, Gaibandha, Kurigram, Feni, Thakurgaon, Chuadanga and Panchagarh. 24 people were killed and six were injured.
A biological and meteorological disaster combined together, created a compound disaster.

Covid-19 and Cyclone (Compound) / Cyclone, Flooding, Salinity and Waterborne Diseases (Cascading)

Note to Chapter-3 of this book

COVID-19 and Dengue Epidemic (Compound)

As Bangladesh grappled with the coronavirus threat, an alarming outbreak of seasonal dengue presented officials with a new challenge. In 2021, when most health agencies and human resources, laboratories, hospitals and epidemiological surveillance were devoted to Covid-19, there was considerable irony in the diagnosis and treatment of other illnesses such as dengue fever.

The outbreak of another epidemic within a global pandemic puts enormous pressure on health systems and responses. As a result, the number of infected and dead from dengue fever was more than usual. Up to 15,000 cases and at least 57 deaths had been reported in dengue alone till January 2021.

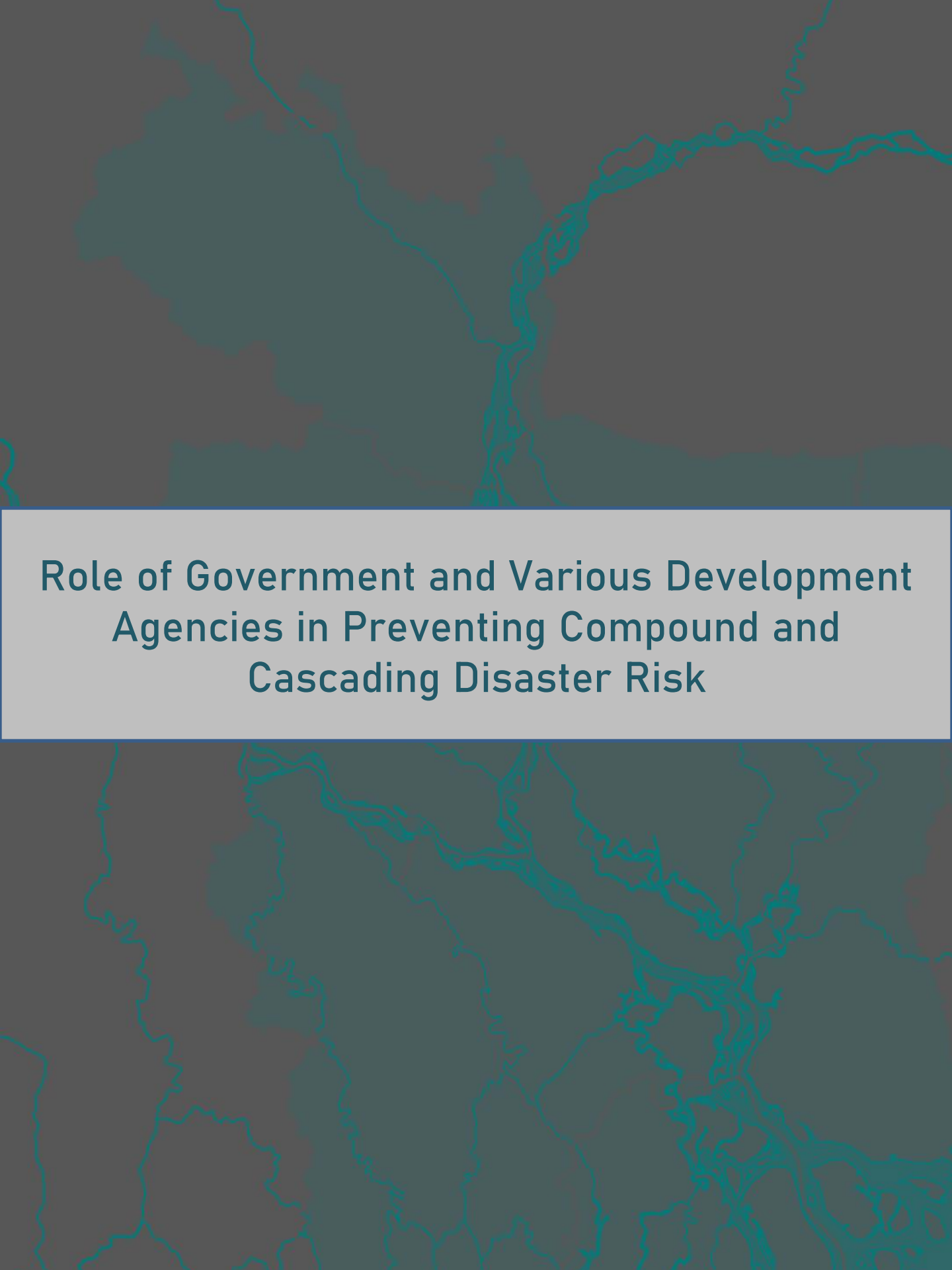
Here both biological disasters combined to create a compound disaster.

Risk analysis of compound/cascading disasters

It is possible to analyze the risk of the above various disasters through the 6 steps mentioned in the previous chapter. Though, there will be some exception in the case of COVID-19. This was a new disaster and there was no opportunity at all to prepare and it took us by shock. However, building capacity to ensure better health care delivery, building one's own immunity, etc., can help prepare and respond to any disaster.

Adhering to all health regulations during the response, Cyclone Preparedness Program (CPP) and Bangladesh Red Crescent Society volunteer activities was quite challenging. Many volunteers also got infected with COVID-19 but none stopped their work. The Red Crescent made several changes in their operations; keeping the pandemic in mind -stopping of cash payments, home visit assistance, ban on congregating in one place etc. directives made the cyclone/flood response much complex but those were necessary.

Bangladesh is known as a role-model in the world in dealing with water-related and meteorological disasters such as cyclones and floods. By assessing the risk of each individual disaster, in the case of compound and cascading disasters, it is possible to find the relationship between the disasters and then calculate the average risk and take preparedness accordingly.



Role of Government and Various Development Agencies in Preventing Compound and Cascading Disaster Risk

Role of government and various development agencies in preventing compound and cascading disaster risk

- Dissemination of pre-disaster warnings including the compound and cascading effects of any specific disaster. For example, during the warning of cyclones, awareness should also be given about subsequent surges and salinity intrusion and properly advice them to prepare accordingly.
- Implementation of various policies related to climate change in the country and proper preservation of the environment as compound and cascading disasters are directly related to climate change.
- Risk reduction in any compound or cascading disaster can be achieved through: adequate knowledge of the disaster, identification of risks associated with the disaster, risk assessment, prioritization of risks and action accordingly.
- Assessment of non-economic losses-In assessing compound and cascading disaster risk, apart from economic loss, there are other losses and damages that need to be properly assessed. Development agencies can play a role in devising effective methods and tools for assessing such damages.
- Provision of shock proof social protection-Livelihood experts working in development and non-governmental organizations can provide a variety of training to vulnerable populations to make it easier for them to cope with any post-disaster situation.
- Location of care services-While preparing any disaster map and risk map, the existing health complexes, voluntary organizations and youth organizations should also be identified in the map.
- Promotion of accurate and timely knowledge and educating bout disasters is a significant and necessary step in mitigation and as we know Adaptation and mitigation are crucial to combating climate change. In that respect, this guidebook can play a massive and required role.

Helpful guidelines for training

Training methods

The course will be conducted by applying some effective participatory methods considering the duration of the training, the type of participants and the possible training location.

Measures of Training

- Question answer
- Expression of ideas
- Speech-discussion
- Display
- Discuss in small groups
- Exchange of experiences
- Analysis of events
- Role playing
- Open discussion

Instructions for helpers

- Prepare well before starting the session and take help of this guidebook to conduct discussion activities.
- Read and understand each chapter of the book thoroughly before undertaking the training program. If you are having trouble understanding anything, seek the advice of an expert.
- Information, procedures and materials required for conducting each session are mentioned.
- Conduct sessions with session aids and other materials provided; Make changes and modifications as needed.
- Prepare all the materials before the beginning of the session, so that there is no need to waste time.
- Ask questions and follow the teaching process according to the sequence of topics mentioned in the session.
- Encourage the participants to elect its own leader during discussions whose responsibility is to ensure that discussions are conducted properly; Help them if needed.
- Encourage everyone to actively participate during group discussions.
- Make every effort to ensure active participation by all during open discussions.
- Validate session learning by asking questions at the end of each session.
- Above all, emphasis should be placed on making the session as lively as possible.

Training Aid Rules

Participants to do	Participants not to do
▪ Attending the training room on time; ▪ keeping mobile phones silent; ▪ talking to each other unnecessarily; ▪ Refrain from mocking others; ▪ Ask questions if you don't understand; ▪ giving importance to the opinions of others; ▪ Be friendly with everyone; ▪ being active in discussions;	▪ Inattentiveness in discussion; ▪ talking unnecessarily; ▪ talking on mobile phones; ▪ going out without saying; ▪ mocking others; ▪ Be full of yourself;

Pre-training activities

- Begin the proceedings of the session by greeting and congratulating everyone.
- Inform the participants about the content and objectives/purpose of the session through PowerPoint/ written poster as per the supporting information.
- Make every effort to make the introduction phase and de-cluttering phase as lively as possible.
- Ask the participants to share a funny story from their life; Or ask everyone to draw something with paper and a sign pen to explain it; Or you can ask them to dance, sing, recite poetry, act, etc. in combination with the first letter of their name.
- Put two large poster papers titled “Participant Dos” and “Participant Don’ts” on either side of the trainer training room. Ask participants to each write one sentence on any poster and be careful not to write two on the same topic. Finally ask everyone to follow these rules.
- Distribute the question papers to everyone for pre-training retention check and explain the questions well to everyone. Set a deadline for completing the questionnaire.
- Once the questionnaires are completed, collect them and announce the end of the session through open discussion.

Pre-Training Concept Check Questionnaire

1) What do you mean by multi-disaster?
2) Give few examples of how one disaster leads to another disaster.
3) What disasters can be caused by floods?
4) What disasters can be caused by cyclones?
5) What might be the difficulties in responding to floods in case of covid-19?
6) What are the difficulties in responding to cyclones in case of Covid-19?
7) How rescue operations should be conducted in case of fire after a building collapse?
8) To what extent is Bangladesh capable of dealing with multiple disasters and what role can be played in developing its response?
9) How can the local population be made aware?
10) What can be done from public, private and private places to deal with multiple disasters (compound and cascading)?

Post-Training Concept Check Questionnaire

The instructors themselves will prepare discussion papers with contemporary examples.

Post training activities

- Start the proceedings of the session by greeting everyone and stating the purpose of the session;
- Divide the participants into two groups and ask each group to discuss among themselves and prepare 10 questions from the training material to ask the other group and keep an extra 5 questions in reserve;
- At the end of the group discussion, ask the members of the two groups to sit facing each other or face to face. Ask members of both groups sitting face to face or face to face to ask each other questions;
- Give 5 marks to the group giving the correct answer. In case of failure to answer, request both members of the same group to answer. If any team member fails to answer, refrain from giving any marks to that team. In this case request the questioning party to give the correct answer. Deduct 5 marks from the questioning team members if they answer incorrectly;
- Conduct the question-answer session in the above process and record the marks obtained by the two teams on the board or poster paper. Make sure that each member of both groups gets a chance to ask and answer questions. At the end of the game, declare the team with the highest number of points as the winner;
- Distribute questionnaires to participants
- for post-training concept checking and set deadlines for completing questionnaires;
- After the post-training concept check, distribute the course evaluation form to the participants for the purpose of training course evaluation and explain how to fill the evaluation form and set the deadline for completing the questionnaire;
- Ask 2/1 of the participants to provide feedback on the training course;
- Invite the guests for certificate distribution and request the guests to make closing remarks after the certificate distribution;
- At the end of the guests' speeches, thank everyone and announce the end of the training course.

Chapter wise guidelines

General discussion of compound and cascading disasters

- Ensure that all participants have a clear understanding of disaster terminologies.
- After explaining the terms, they can be asked to specify hazards, exposures and hazards in different disaster scenarios.
- It can be seen whether they are able to identify hazards, exposures, hazards and risks in any disaster they face in their own lives.
- What they mean by the words cascading and compounding should be clear.
- Their concept of multi-disaster needs to be verified.
- One can be asked to explain the cascading and compound effects of some event in one's life.

Cyclone Amphan and its Impacts

- Make sure to have a thorough understanding of Cyclone Amphan.
- In coastal areas affected by Amphan, any resident present can be asked to share his or her experience if she/he resides in that zone.
- Whether the residents of the capital Dhaka are affected in any way by Cyclone Amphan or how the cascading effects of Amphan contribute to the national economy can be determined through the discussion of the participants.
- There should be a clear understanding of how a disaster risk map will be prepared.
- They can be trained to simulate any cyclone risk scenario in their life.
- Later on, one has to map resources according to one's own capacity to deal with those risk scenarios and inform about strategies to increase one's resilience.

Fire at Sitakunda BM Container Depot

- Participants should have a general understanding of building codes related to fire safety (BNBC Codes).
- Participants should have a general understanding of the principles of safe storage of chemicals.
- Landing possible risk scenarios can be learned according to the modern map of BM Container Depot provided in the session support information.
- A comparative discussion of modern/present and earlier depot designs can be made.
- Custom capability maps can be created.

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