“STUDY ON EFFECTS OF NATURAL DISASTERS ON SOCIETY”

SUBMITTED BY

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UNDER GUIDANCE OF

PROF. CMA NIYATI JOSHI

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RAJEEV GANDHI COLLEGE OF MANAGEMENT STUDIES, GHANSOLI

CERTIFICATE

This is to certify that project titled "**STUDY ON EFFECTS OF NATURAL DISASTERS ON SOCIETY**" is successfully completed by **Mr. RAJDEEP CHAKRAVORTY** during the IV Semester in partial fulfillment of the Master's Degree in Management Studies recognized by the University of Mumbai for the academic year **2020-21** through **RAJEEV GANDHI COLLEGE OF MANAGEMENT STUDIES, GHANSOLI**. This project work is original and not submitted earlier for the award of any degree/diploma or associateship of any other University / Institution.

Name: RAJDEEP CHAKRAVORTY

Date: (Signature of the Guide)

DECLARATION

I, **RAJDEEP CHAKRAVORTY** hereby declare that this Project Report titled "**STUDY ON EFFECTS OF NATURAL DISASTERS ON SOCIETY"** submitted by me to **RAJEEV GANDHI COLLEGE OF MANAGEMENT STUDIES, GHANSOLI** is a bonafide work undertaken by me and it is not submitted to any other University or Institution for the award of any degree diploma/certificate or published any time before.

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CHAPTER 1

INTRODUCTION

India's geophysical and climatic conditions make it one of the most disaster-prone countries in the world. Of the different types of natural disaster, hydrological disasters have the largest number of recorded instances and the highest mortality and damage costs. Since the 1990s, floods have accounted for more than half the natural and climate-related disasters in the country, with damage costs running into billions of dollars. The impacts on people of such extreme, large-scale events depends on their vulnerability and exposure. The impacts are further intensified by socioeconomic factors such as population increase, rapid urbanization, infrastructure expansion, and large numbers of people residing in informal settlements in poor and destitute conditions. This underscores the need to characterize the impacts of extreme precipitation on different stakeholders and formulate policies and action plans to mitigate them.

This report uses field-level and secondary data to characterize and analyze the impacts of extreme precipitation events at the micro level on vulnerable households and small and medium-sized enterprises (SMEs) in three locations—Mumbai, Chennai, and Puri district. Chennai and Mumbai are large megacities with millions of people and critical economic activities. Their coastal locations, land reclamation, and rapid infrastructure expansion in low-lying areas make them highly vulnerable to large-scale flood impacts. Puri district, in contrast, is predominantly rural, and the main livelihoods are agriculture, fishing, and tourism. All three locations have faced devastating extreme rainfall events in recent years and offer rich insights into asset exposure and direct and indirect impacts on urban and rural households and SMEs.

The unique mix of hybrid data, field-level and secondary, is analyzed in this study for assessing flood impacts. Studies conducted by the author in Mumbai, studies carried out by researchers in Chennai, and impact assessment done by government agencies in Puri are extensively used in this paper. This offers a multidimensional view of flood impacts with quantitative estimates and qualitative insights into devastation and distress suffered by different stakeholders. Such insights are normally not captured in routine damage assessments, which focus largely on loss estimates that can be easily quantified.

The economic and other impacts of flooding are often not homogenous, and some people and locations tend to be more vulnerable because of socioeconomic and geophysical characteristics. Studies also tend to focus more on household impacts and other vulnerable groups like SMEs remain under investigated. This study specially focuses on understanding how and why different stakeholders, such as households and SMEs, are impacted during extreme precipitation and floods.

EXTREME PRECIPITATION: EXPOSURE, VULNERABILITY, AND IMPACTS

During 1980–2017, more than 5,200 flash flood events were recorded worldwide, with more than 220,000 fatalities and global economic losses of $1,000 billion (Munich Re 2018). Asia accounted for 45% of these events, 74% of total fatalities, and 57% of overall losses. India experienced 278 floods during 1980–2017 that affected more than 750 million people and caused about $58.7 billion in losses (EM-DAT 2018). Precipitation events in India are generally characterized as extreme when rainfall exceeds 150 millimeters (mm) per day and flooding affects a large area (Goswami et al. 2006; Rajeevan, Bhate, and Jaswal 2008). The scale of the impacts of such events on human and ecological systems depends on changes in climate, vulnerability, and exposure (IPCC 2012). Extreme rainfall and resultant floods cause extensive damage to infrastructure and affect millions of people through loss of life, health impacts, damage to property, and socioeconomic disruption. In developing countries such as India, calculations of losses from extreme events are usually lower-bound estimates because impacts, such as the loss of cultural heritage and ecosystem services, are difficult to value and monetize, and impacts on the large informal economy, as well as indirect impacts, are generally hard to estimate (IPCC 2012). Settlement patterns, urbanization, population growth, and changes in socioeconomic conditions also determine exposure and vulnerability to extreme events and the impacts of such events. In future, developing countries such as India, which have large numbers of people living in informal settlements and rising concentrations of people and assets in urban areas, will experience greater direct and indirect losses from extreme precipitation events.

To characterize the impacts of extreme precipitation events, this paper considers three locations: Mumbai in the state of Maharashtra, Chennai in the state of Tamil Nadu, and Puri district in the state of Odisha. Mumbai is the world's fourth-largest megacity with 21.3 million people (United Nations 2016). As India's financial capital and an important sea port, the city is home to large commercial and trading companies, industries, multinational corporations, finance institutions, and defense establishments. Originally a cluster of seven islands, these areas were joined from the 17th century through drainage, reclamation, causeways, and breakwaters to form the present-day landmass (MCGM 2018). The city has a low-lying coastal tract, some of which is barely 1 meter above mean sea level, and its suburbs have four main rivers that drain into the Arabian Sea (MCGM 2018).

Mumbai's average annual rainfall has historically averaged 2,200 mm with significant variations from 1,299 mm in 2002 to 3,274 mm in 2010. The worst extreme precipitation event Mumbai has endured occurred in July 2005, when 944 mm of rain fell on a single day causing loss of life and millions of dollars in damage. Almost every year since 2006 there have been 2 or 3 days when the 24-hour rainfall total exceeded 200 mm and could be termed extremely heavy under the revised classification of 24-hour accumulated rainfall. Thus, Mumbai experiences extreme precipitation events with alarming regularity. Analysis of the probability of such events and their return period based on historical data reveals that in any year, the probability of 24-hour

rainfall exceeding 200 mm is 50% for the western suburbs and 33% for the island city in the Greater Mumbai metropolitan region (MCGM 2006).

Like Mumbai, Chennai is also one of the world's largest megacities. It is ranked 30th and has a population of 10 million (United Nations 2016). The city has been an important trading base since the 17th century and has played the key role as South India's center for art, culture, architecture, and tradition. The city has a diversified economic base of automobile manufacturers, software services, hardware manufacturing, and healthcare and financial services institutions (Government of Tamil Nadu 2018). Its special economic zone caters to apparel and footwear industries and accounts for 50% of India's leather exports. Chennai receives 45% of the country's medical tourism. Prominent international finance institutions have back offices and development centers in the city (Government of Tamil Nadu 2018). Located on a flat coastal plain near the equator, annual average rainfall is about 1,300 mm and is experienced during two seasons—the southwest monsoon (June–September) and the northeast monsoon (October–December). The city is prone to heavy to extreme rainfall during the monsoon seasons and is exposed to cyclones from the Bay of Bengal. It has experienced regular flooding since 1976 and was subject to extreme precipitation in 2015. Heavy rainfall caused major floods in 1976, 1996, and 1998. Between 2005 and 2012, Chennai was also affected by five cyclones that caused heavy losses.

Puri district is named after its main town of Puri, which is an ancient town of great cultural significance, and is famous for the Jagannath Temple that attracts thousands of pilgrims and other national and international visitors each year. Unlike Mumbai and Chennai, most (84%) of Puri's residents live in rural areas. Agriculture is the predominant occupation followed by fishing since the coastal plain also offers rich marine and aquatic resources. During 2009–2018, the government promoted agro-based, textile, chemical, engineering, and rubber-based industries in the district (Government of Odisha 2018). Puri's tropical climate is greatly influenced by proximity to the sea, and has moderate temperatures through the year and annual average rainfall of 1,392 mm with an average of 62 days of rain during July–September. The state of Odisha has experienced floods every year since 1970, with 6.7 million hectares of crops damaged and more than $3.14 billion in losses incurred (UNDRR 2018). Puri district has been one of the areas most affected by recurrent flooding. Since 1990, the district has been affected by floods almost every year. Cyclones in 1999, 2013, and 2014 also brought extreme rainfall and inundation. All villages in the district are vulnerable to the impacts of cyclones, and 760 villages (44% of the total) are flood prone (Government of Odisha 2018). Vulnerability to floods and cyclone

is exacerbated by the large number of small and marginal farmers, landless laborers, and fishing communities in the district.

Children observe destroyed homes in Guatemala, which suffered a massive earthquake in November 2012.

NATURAL DISASTER FACTS AND STATISTICS

- According to a 2014 report by the United Nations, since 1994, 4.4 billion people have been affected by disasters, which claimed 1.3 million lives and cost US$2 trillion in economic losses.
- Low- and lower-middle-income countries are disproportionately affected by natural disasters. In the same 20-year period, 33 percent of countries that experienced disasters were low- to lower-middle income, but 81 percent of people who died in disasters lived in these countries.
- Women and children in developing countries are often the most vulnerable demographic groups after natural disasters.
- 8 out of 10 of the world's cities most at risk to natural disasters are in the Philippines.
- Natural disasters affect the number of people living below the poverty line, increasing their numbers by more than 50 percent in some cases. The problem is getting worse; up to 325 million extremely poor people are expected to live in the 49 most hazard-prone countries by 2030.

Millions of people are affected by natural disasters every year, and their impact can be calamitous. From the destruction of buildings to the spread of disease, natural disasters can devastate entire countries overnight. Tsunamis, earthquakes and typhoons do not just wreak havoc on land; they also disrupt people's lives in both densely populated cities and remote villages.

Typhoon Haiyan devastated this village on the island of Leyte when it struck the Philippines in November 2013.

HAZARD VS. DISASTER

Earthquakes, floods, hurricanes and volcano eruptions are all types of natural hazards, but when do they become natural disasters? The difference is the events' effects on people. When a typhoon strikes a populated island in the Philippines, destroying homes and lives, it becomes a disaster. People living in poverty are even more vulnerable to natural disasters because they have fewer resources or people to turn to when trying to rebuild their homes and livelihoods.

An Increase in Natural Disasters

According to a **November 2015 report from the United Nations**, the rate of weather-related disasters (such as cyclones, typhoons and droughts) is growing. Between 2005 and 2014, the annual average of weather-related disasters was 335, an increase of 14 percent from 1995 to 2004 and almost twice the average recorded from 1985 to 1995.

In the past 20 years, 90 percent of major disasters have been caused by 6,457 recorded floods, storms, heat waves, droughts and other weather events. Indonesia, India and the Philippines are among the five countries hit by the highest number of disasters, besides the United States and China.

Why Are Developing Countries More Vulnerable to Natural Disasters?

Developed countries are better prepared to handle the impact of disasters as well as the aftermath. In developing nations, natural disasters trap people in a cycle of poverty because they do not have the resources

to rebuild their homes and meet other basic needs, making them less able to recover in the long run. Certain factors present in poverty environments will turn a natural hazard into a disaster:

- Poorly constructed buildings
- Poor sanitation
- Rapid population growth/high density population
- Limited resources for disaster response and rebuilding
- Lack of economic safety nets

Small Island Developing States and Vulnerability to Natural Disasters

Many of the countries most vulnerable to natural disasters are small island developing states (SIDS). These countries experience frequent storms and flooding and have very little resources and man-power to cope. Additionally, the size of these islands means that already fragile economies, usually agriculture-based, can be totally devastated by a natural disaster. With sea levels rapidly rising, SIDS are becoming more vulnerable to natural disasters with little hope for the future.

HUMAN FACTORS AND THE SEVERITY OF NATURAL DISASTERS

There are several human factors that influence the severity of a natural disaster. Even within the same region, different people have different levels of vulnerability to natural hazards.

- Wealth: People living in poverty cannot afford adequate housing or infrastructure. They are unable to acquire resources needed before and after a disaster strikes.
- Education: Education increases awareness about avoiding or reducing the impact of disasters. A better-educated population will have more professionals trained to prepare for catastrophic natural events.
- Governance: Governments can set policies and establish infrastructure to reduce vulnerability to hazards. Some governments have more resources available to dedicate to disaster risk reduction.
- Technology: Technology allows us to forecast weather, significantly reducing vulnerability.
- Age: Children and the elderly are more vulnerable because they have less physical strength and weaker immune systems. Children and the elderly are more dependent on others for survival but may not have anyone to depend upon after disaster strikes.
- Gender: Women are more likely to be poorer and less educated than men, making them more vulnerable to hazards.

THE HUMAN IMPACT OF NATURAL DISASTERS

Displaced-Populations

One of the most immediate effects of natural disasters is population displacement. When countries are ravaged by earthquakes or other powerful forces of nature, many people have to abandon their homes and seek shelter in other regions. A large influx of refugees can disrupt accessibility of health care and education, as well as food supplies and clean water.

Health-Risks

Aside from the obvious immediate danger that natural disasters present, the secondary effects can be just as damaging. Severe flooding can result in stagnant water that allows breeding of waterborne bacteria and malaria-carrying mosquitos. Without emergency relief from international aid organizations and others, death tolls can rise even after the immediate danger has passed.

Food-Scarcity

After natural disasters, food often becomes scarce. Thousands of people around the world go hungry as a result of destroyed crops and loss of agricultural supplies, whether it happens suddenly in a storm or gradually in a drought. As a result, food prices rise, reducing families' purchasing power and increasing the risk of severe malnutrition or worse. The impacts of hunger following an earthquake, typhoon or hurricane can be tremendous, causing lifelong damage to children's development.

Emotional-Aftershocks

Natural disasters can be particularly traumatic for young children. Confronted with scenes of destruction and the deaths of friends and loved ones, many children develop post-traumatic stress disorder (PTSD), a serious psychological condition resulting from extreme trauma. Left untreated, children suffering from PTSD can be prone to lasting psychological damage and emotional distress.

Child-Centered Spaces, or CCSs, help families cope with their new reality following a disaster; they allow parents to seek water, food and shelter while their children are in a safe place with supervision. Also, children can talk about the traumatic things they saw and experienced during the disaster, allowing them to gradually recover. In the Philippines, Child Fund and our local partner organizations were able to start setting up Child-Centered Spaces only four days after Super Typhoon Haiyan struck in November 2013, affecting nearly 1 million people.

INDIVIDUAL IMPACT

At the individual level, the impact can often be felt physically, mentally and emotionally. Natural disasters cause destruction of property, loss of financial resources, and personal injury or illness. The loss of resources, security and access to shelter can lead to massive population migrations in lesser-developed countries.

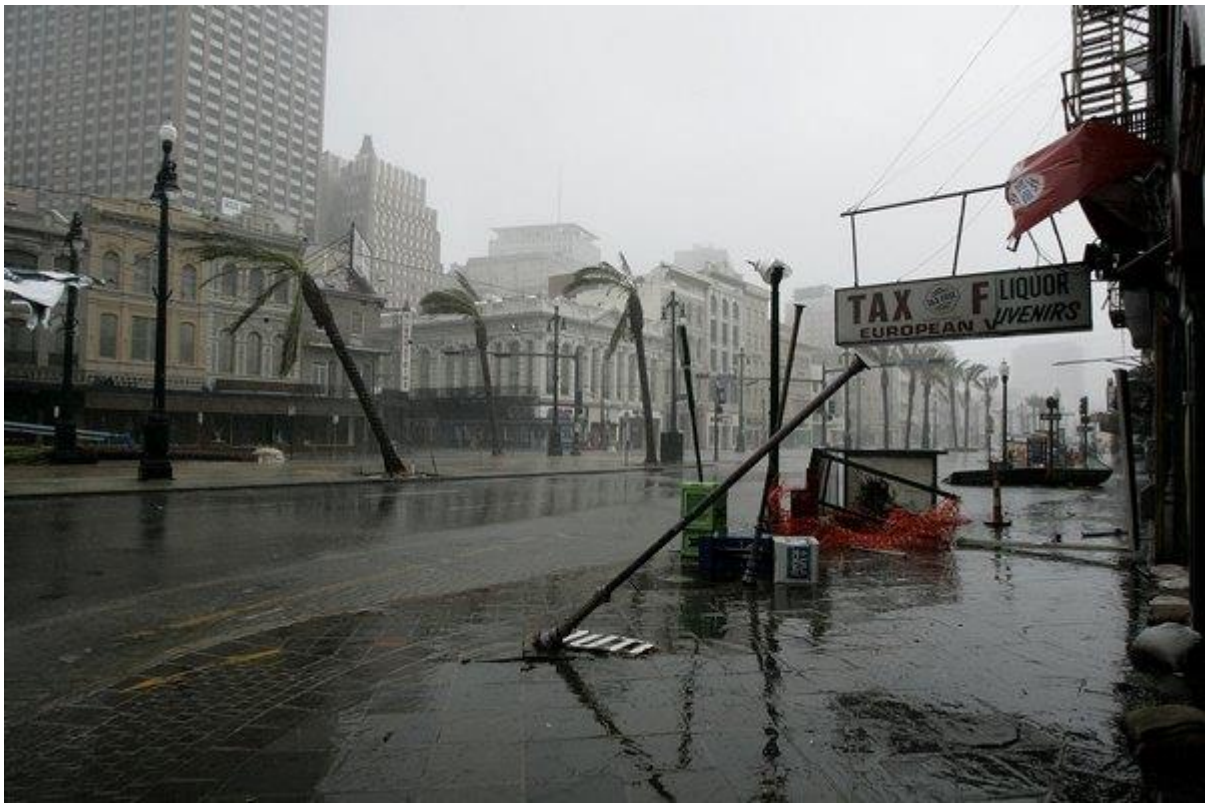
After experiencing a natural disaster, many individuals develop severe post-traumatic stress disorders or withdraw into states of depression. Others develop negative associations with the environment, in more developed nations; this can also lead to significant population migrations.

COMMUNITY IMPACT

Communities that experience a natural disaster must also absorb the impacts of these destructive events. Many local communities lose so much in economic resources that recovery becomes difficult, if not almost impossible. Some communities find opportunity in the aftermath of a disaster to rebuild better and stronger communities than before. Communities must often recognize population, demographic, and cultural shifts as a result of the impact of the natural disaster on their individual citizens.

ECONOMIC IMPACT

In 2005, Hurricane Katrina devastated New Orleans and the Mississippi gulf coast. In New Orleans alone, more than 200,000 homes were destroyed; over 70 percent of the resident population had to be at least temporarily relocated outside of the greater New Orleans area. In addition, huge sums of federal assistance were necessary to help jump start recovery efforts in the city and surrounding region. Estimates of over $105 to $150 billion in reduced tax revenue, loss of infrastructure, expense of reclamation efforts, and loss of normal revenue were lost to the city. Beyond the economic losses to New Orleans, it is estimated that the United States economy suffered a 2 percent loss of overall gross domestic product within one year of the disaster as a direct result of the hurricane and its impact on this important international port city.



ENVIRONMENT

Just as a natural can change the landscape of our personal lives as well as aspects of our community, so too can different types of disasters drastically alter the natural environment. The cyclones that occurred in Myanmar in 2008, or the wildfires that spread throughout California in 2009 are examples of how areas of land that detail whole ecosystems can be dramatically damaged or transformed from a single disaster event. On a larger scale, the debate regarding how to address global climate change and the resulting natural impacts is further punctuated by estimates of sea level increases that will completely swamp some island nations. Furthermore, the rapid desalination of salt water oceans caused by melting glaciers could deprive the world of

30 percent or more of its edible fish supply, and the loss of coral reefs from the same cause would put numerous coastal regions in jeopardy of tidal waves and surges.

EFFECTS OF DISASTERS: RISK AND RESILIENCE FACTORS

Every year, millions of people are affected by both human-caused and natural disasters. Disasters may be explosions, earthquakes, floods, hurricanes, tornados, or fires. In a disaster, you face the danger of death or physical injury. You may also lose your home, possessions, and community. Such stressors place you at risk for emotional and physical health problems.

Stress reactions after a disaster look very much like the common reactions seen after any type of trauma. Disasters can cause a full range of mental and physical reactions. You may also react to problems that occur after the event, as well as to triggers or reminders of the trauma.

Risk Factors

A number of factors make it more likely that someone will have more severe or longer- lasting stress reactions after disasters:

Severity of exposure

The amount of exposure to the disaster is highly related to risk of future mental problems. At highest risk are those that go through the disaster themselves. Next are those in close contact with victims. At lower risk of lasting impact are those who only had indirect exposure, such as news of the severe damage. Injury and life threat are the factors that lead most often to mental health problems. Studies have looked at severe natural disasters, such as the Armenian earthquake, mudslides in Mexico, and Hurricane Andrew in the US. The findings show that at least half of these survivors suffer from distress or mental health problems that need clinical care.

Gender and family

Almost always, women or girls suffer more negative effects than do men or boys. Disaster recovery is more stressful when children are present in the home. Women with spouses also experience more distress during recovery. Having a family member in the home who is extremely distressed is related to more stress for everyone. Marital stress has been found to increase after disasters. Also, conflicts between family members or lack of support in the home make it harder to recover from disasters.

Age

Adults who are in the age range of 40-60 are likely to be more distressed after disasters. The thinking is that if you are in that age range, you have more demands from job and family. Research on how children react to

natural disasters is limited. In general, children show more severe distress after disasters than do adults. Higher stress in the parents is related to worse recovery in children.

Other factors specific to the survivor

Several factors related to a survivor's background and resources are important for recovery from disaster. Recovery is worse if you:

- Were not functioning well before the disaster.
- Have had no experience dealing with disasters.
- Must deal with other stressors after the disaster.
- Have poor self-esteem.
- Think you are uncared for by others.
- Think you have little control over what happens to you.
- Lack the capacity to manage stress.

Other factors have also been found to predict worse outcomes:

- Bereavement (death of someone close)
- Injury to self or another family member
- Life threat
- Panic, horror, or feelings like that during the disaster
- Being separated from family (especially among youth)
- Great loss of property
- Displacement (being forced to leave home)

Developing countries

These risk factors can be made worse if the disaster occurs in a developing country. Disasters in developing countries have more severe mental health impact than do disasters in developed countries. This is true even with less serious disasters. For example, natural disasters are generally thought to be less serious than human-caused. In developing countries, though, natural disasters have more severe effects than do human-caused disasters in developed countries.

Low or negative social support

The support of others can be both a risk and a resilience factor. Social support can weaken after disasters. This may be due to stress and the need for members of the support network to get on with their own lives. Sometimes the responses from others you rely on for support are negative. For example, someone may play down your problems, needs, or pain, or expect you to recover more quickly than is realistic. This is strongly linked to long-term distress in trauma survivors.

After a mass trauma, social conflicts, even those that have been resolved, may again be seen. Racial, religious, ethnic, social, and tribal divisions may recur as people try to gain access to much-needed resources. In families, conflicts may arise if family members went through different things in the disaster. This sets up different courses of recovery that often are not well understood among family members. Family members may also serve as distressing reminders to each other of the disaster.

Keep in mind that while millions of people have been directly affected by disasters, most of them do recover. Human nature is resilient, and most people have the ability to come back from a disaster. Plus, people sometimes report positive changes after disaster. They may re-think what is truly important and come to appreciate what they value most in life.

Resilience Factors

Human resilience dictates that a large number of survivors will naturally recover from disasters over time. They will move on without having severe, long-lasting mental health issues. Certain factors increase resilience after disasters:

Social support

Social support is one of the keys to recovery after any trauma, including disaster. Social support increases well-being and limits distress after mass trauma. Being connected to others makes it easier to obtain knowledge needed for disaster recovery. Through social support, you can also find:

- Practical help solving problems.
- A sense of being understood and accepted.
- Sharing of trauma experiences.
- Some comfort that what you went through and how you responded is not "abnormal."
- Shared tips about coping.

Coping confidence

Over and over, research has found that coping self-efficacy - "believing that you can do it" - is related to better mental health outcomes for disaster survivors. When you think that you can cope no matter what happens to

you, you tend to do better after a disaster. It is not so much feeling like you can handle things in general. Rather, it is believing you can cope with the results of a disaster that has been found to help survivors to recover.

Hope

Better outcomes after disasters or mass trauma are likely if you have one or more of the following:

- Optimism (because you can hope for the future)
- Expecting the positive
- Confidence that you can predict your life and yourself
- Belief that it is very likely that things will work out as well as can reasonably be expected
- Belief that outside sources, such as the government, are acting on your behalf with your welfare at heart
- Belief in God
- Positive superstitious belief, such as "I'm always lucky."
- Practical resources, including housing, job, money.

TYPES OF DISASTERS

Disasters can be mainly categorised as – natural and man-made. Mother Nature has always been at the giving end. However, she can be equally devastating, highly destructive, and unforgiving at the same time. This catastrophic manifestation of Nature in the form of floods, hurricanes, earthquakes, volcanic eruptions, landslides, forest fires, and tsunamis is referred to as a natural disaster.

On the other hand, a man-made disaster is the one that involves an element of human intent, error, negligence, mishandling of dangerous equipment. For instance, train accidents, aeroplane crashes, or a building or flyover collapsing due to faulty engineering are man-made disasters.

Different types of disasters are classified in terms of their nature and extent of impacts. Let categorically understand various forms of disasters. Generally, According to Disaster Management in India (Ministry of Home Affairs – Government of India), Disaster can be categorised as,

TYPES OF NATURAL DISASTERS

- Flood
- Hurricanes
- Earthquake
- Volcanic Eruption
- Landslide
- Tsunami
- Drought
- Avalanches

FLOODS

A flood is a situation that typically occurs in the monsoon season. Flooding is a temporary overflow of water on to the land, that is normally dry from water bodies such as rivers, lakes or ocean where the waters flow over top embankment, floods occur during heavy rain or when snow melt for fast or where a dam breaks, when the water moves beyond its normal boundaries. Flash of floods are the most dangerous sometimes due to heavy rain, the city's drain fails to discharge storm water and it floods the city's routes and even houses.

Due to the rise of sea tides into rivers and lakes the rainwater overflows on the land, submerging it completely. The concentration of rain increases on the ground due to the problem of sediment deposition, drainage congestion, and synchronization of rivers.Floods can also be caused due to other natural disasters like thunderstorms, hurricanes, and tsunamis. Since floods cause massive damage to lives and the economic wellbeing of an area, it takes a lot of time for people to live a normal life again.

Usually, the weather department of a particular country is able to predict the occurrence of a flood. Though people are alerted ahead of time they face tough times during floods. This is because most people do not know what's to be done when hit by this natural calamity. The below-mentioned tips will help you stay safe in case a flood is predicted.

What to do Before the Flood?

Following precautions should be taken before the flood can occur:

- Know about your local relief centers and evacuation routes which are arranged by the government.
- Follow the weather forecasting instruction which is telecast on television, radio, etc.
- Make sure everything that is important like jewellery, documents, pets, and other valuables is secured.
- Keep emergency numbers and important information handy, as well as emergency supplies kits, first aid items.

What to do During the Flood?

If a flood is likely in our area, following precautions should be taken during the flood:

- Turn off all electrical appliance, gas and other appliances.
- Keep your emergency kit close at hand, in a portable container such as a bag or suitcase with wheels.
- Do not walk, swim, or drive through flood waters. Just six inches of moving water can knock you down, and one foot of moving water may sweep your vehicle away.
- Do not try to drive over a flooded road. If your car stops, leave it immediately and try to find alternate route.
- If you feel threatened with water rising level, leave your home or move to upper floors.
- Stay away from drowned power lines or broken power transmission cables.
- Try to keep away from flood water as it may contain chemicals or other hazardous materials.

What to do After Flood?

Following precautions should be taken after flood:

- Make sure you have permission from emergency officers to get back inside your house. If the main power switch was not turned off before the flooding, do not enter your home until the expert electrician has determined it is safe to do so.
- Appliances that may have been flooded cause a risk of shock or fire when turned on. Do not use any appliances or sewage system until electrical components have been thoroughly cleaned, dried, and inspected by a skilled electrician.
- Clean the entire home, together with all the objects in it very well before you use them again. They may be contaminated.
- Wear suitable mask or gloves before cleaning begins.

HURRICANES / CYCLONES

Hurricane is a high-intensity cyclone with a violent wind, occurring over the ocean and traveling towards the land. A cyclone is usually named depending upon the location of its occurrence. For example,

- In the Atlantic Ocean and Northeast Pacific, it’s referred to as the Hurricane.
- In the Northwest Pacific, it’s known as the Typhoon.
- In the South Pacific and the Indian Ocean, it’s called the Tropical Cyclone.

According to National Oceanic and Atmospheric Administration – USA, the hurricane in the Atlantic Ocean may strike between June 1 to November 30, and in the Pacific Ocean, it may strike between May 15 to November 30. All cyclones cause heavy loss of life and damage to the properties. Hence, it is better to be prepared in case of an impending cyclone. These are the Dos & Don'ts when a cyclone strikes.

Do's

1 If your house is around a low-lying beach area, it may get swept due to high tides or storm waves. Make sure you vacate the area before your way to a high ground gets flooded.
2 Check the surroundings of the house. Remove dead or dying trees. Anchor or get rid of objects like loose bricks, garbage cans, sign-boards, or loose zinc sheets.
3 Keep some wooden boards or asbestos/cement sheet ready so that glass windows can be boarded. If you do not have wooden boards or asbestos/cement sheets, paste paper strips on glasses to prevent splinters from flying into the house.
4 Keep a hurricane lantern handy and make sure it's filled with fuel (kerosene). Also, keep a flashlight loaded with dry cells handy.
5 Prepare and store an emergency kit in a safe place. The kit should contain –

   a) A portable radio (battery operated), torch and spare batteries (i.e. AA or AAA as per requirements)
   b) A first aid kit and manual, masking tape for windows, and waterproof bags.
   c) Matchboxes, fuel lamp, portable stove, cooking gear, and eating utensils
   d) Make provisions for children and adults requiring special diets.
   e) Get extra food, especially dried or canned food and a can opener; also, make provision for items which can be eaten without cooking or need very little preparation. Store drinking water in a suitably-covered vessel.

Don'ts

1 Avoid being misled by rumours. Spread only official announcements from the Weather Bureau.
2 Don't leave shelters until informed by the rescue personnel.
3 Don't leave a safer place during a lull. Minor repairs can be carried out.
4 Don't touch any loose and hanging wires from a lamp post. They may be live and result in an electric shock.
5 Don't stand below a tree.
6 Don't park your car/scooter below trees. Also, see that your vehicles are not parked in the basement or in low lying area.

EARTHQUAKE:

The earth's crust is made up of uneven layers of soil or rocks which consist of faults at many places. These geological faults appear as planar fractures or cracks on the earth's crust. The geological faults form a tectonic plate which moves over time. At times, these moving plates release higher energy in the form of the wave, causing the earth to shake. Simply put, this shaking of earth is known as an Earthquake.

The Richter scale is used to measure the magnitude of the earthquake. The severity of shaking at a particular location is said to be worst based upon the intensity of the earthquake.

When an Earthquake Strikes,

01. Drop

- DROP down to floor.

02. Cover

- Take Cover under a sturdy piece of furniture.
- If that is not possible, Cover against an interior wall and protect your head and neck with your arms.
- Do not stand near windows, hanging objects, mirrors, or tall furniture.

03. Hold

- If you take cover under a sturdy piece of furniture, Hold it and be prepared to move with the piece of furniture.
- Hold the position until the ground stops shaking and it is safe to move.

Following are the 8 tips to protect yourself during an earthquake.

- If you are in a HIGH-RISE BUILDING, and you are not near a desk or table, go against an interior wall and protect your head with your arms.
- If you are standing OUTDOORS, go to a clear area, away from trees, buildings, signs, downed electrical wires and poles.
- If you are on a SIDEWALK NEAR BUILDINGS, move into a doorway to protect yourself from falling glass, brick, plaster, and other debris.
- If you are DRIVING, go to the side of the road and stop. Avoid overpasses, and other hazards. Stay inside the vehicle until the shaking is over.
- If you are in a CROWDED STORE, do not rush for exit. Stay away from display shelves containing objects that could fall.
- If you are in a WHEELCHAIR, stay in a wheelchair. if possible move to cover, lock your wheels, and protect your head with your arms.
- If you are in the KITCHEN, stay away from the refrigerator, stove, and overhead cupboards.
- If you are in a STADIUM or THEATER, stay in your seat and protect your head with your arms. Do not try to leave until the shaking is over.

VOLCANIC ERUPTION:

A volcano is the most explosive vent in the earth's crust from which the molten rock in the form of lava, a cloud of ash, and gases are released into the atmosphere. When the tectonic plates move, the magma (a molten and semi-molten rock mixture) present under the earth's crust applies pressure at a particular location, causing the volcano to erupt. The vent continuously discharges hot lava which floats out on the ground.

LANDSLIDE:

Landslides are defined as a downward movement of a solid mass like soil or rock under the effect of gravity. The melting snow, heavy rainfall, stream erosion, earthquakes, volcanic activity, human-made disturbances, or a combination of these can cause an earthy solid mass to become unstable and slide down under the influence of gravity. Landslides cause massive damage to property, injuries, and even death. It also destroys the water supply system and the sewer disposal system, and other utilities like power, gas etc. thereby disrupting normal life.

TSUNAMI:

A tsunami is a series of large tidal waves often caused by an earthquake or undersea volcanic eruption. The huge tidal waves are the outcome of the displacement of a large volume of water in the ocean. As they travel towards the coastal areas, the waves build up to dramatically-great heights, destroy everything that comes in its way. The height of the tidal wave increases continuously as it travels to the shore due to the decreases in the depth of the ocean.

DROUGHT:

- According to 'Catherine Soanes, Sara Hawker & Julia Elliot' (Author of Pocket Oxford English Dictionary), Drought is a deficiency in rainfall over a long period – a season, a year or several years. As a result, shortage in water causing adverse impacts on vegetation, animals and people.
- It is a standard, recurrent feature of climate that occurs in virtually all climate zones from very wet to very dry.
- Drought is a temporary aberration from normal climatic conditions; thus, it can vary significantly from one region to another.
- Drought is different than aridity, which is a permanent feature of the climate in regions where low precipitation is the norm as in the desert.

AVALANCHES:

- The avalanche is a mass of snow under motion, sliding and rushing down a steep mountain slope.
- Under natural conditions, they arise due to disruption of the snow stability on a slope which has been affected by meteorological phenomena.

INDIA AND NATURAL DISASTERS

As per the report of a high-powered committee on disaster management published by National Centre for Disaster Management (India), floods, high winds, and earthquakes dominate (98%) the reported injuries, with ever-increasing numbers over the past ten years.

India is one of the most disaster-prone countries in the world

Prone to **Earthquake** – Over 65% of land area

Prone to **Drought** – 70% of the land under cultivation

Prone to **Floods** – 5% of the land (40 million hectares)

Prone to **Cyclones** – 8% of the land (8,000 km Coastline)

A major disaster occurs every 2-3 years, affecting nearly 50 million peoples annually. 1 million houses were damaged annually along with human, social, and other losses. From 1985 to 2003, the annual average damage due to natural disasters has been estimated to be 70 million USD.

CONSEQUENCES OF NATURAL DISASTERS

Listed below are the adverse effects caused by natural disasters:

- Loss of life.
- Injury to human beings.
- Damage and destruction of property.
- Damage and destruction of production.
- Disruption of lifestyle.
- Loss of livelihood.
- Disruption of essential services.
- Damage to the national infrastructure like the roads, railways, bridges, and ports.
- Disruption of government systems.
- National economic loss.
- Sociological and psychological after effect.

HOW CAN WE MEASURE THE IMPACT OF NATURAL DISASTERS?

According to 'Patrick Mahar' (Author of Disasters and their Effects on the Population: Key Concept), The factors taken into consideration while measuring the impact of any natural disaster are as follows:

- Intensity of hazard
- Duration
- Spatial extent
- The density of population and assets
- Time and frequency of occurrence
- Hazard + Vulnerability = Disaster

Disaster can interrupt the essential services, namely electricity, water, healthcare, sewage/ garbage removal, transportation, and communications. The interruption can affect the social, health, and economic networks of local communities and countries. The various kinds of natural disasters have a major and long-lasting impact on humans, long after the immediate effects have been mitigated. Poorly-planned relief activities can have a specific and significant negative impact on the disaster victims, donors, and relief agencies.

Disaster Management – Prevention and Preparedness

All local, regional, national, and international organisations are involved in mounting a humanitarian response to disasters. Each of them has a prepared disaster management plan. These plans cover prevention, preparedness, relief and recovery. Therefore, it's best that everyone joins an established disaster management program rather than attempting individual efforts.

Here are a few key things to bear in mind when you face a natural disaster.

- Stay informed about the different types of emergencies that could occur and their appropriate responses.
- Make a family emergency plan.
- Build an emergency supply kit.
- Get involved in your community by taking action to prepare for emergencies.

CHAPTER 2

LITERATURE REVIEW

In a review of research on disasters as experienced by people in poverty, Fothergill and Peek (2004) report mixed findings related to perception of disaster risk. They cite some studies (Flynn, Slovic, & Mertz, 1994; Pilisuk, Parks, & Hawkes, 1987; Palm & Carroll, 1998) that found that people who were poorer and with lower incomes perceived more risk and felt more concern regarding both natural and technological disasters. However, they note, other research (Vaughan, 1995; Greene, Perry, & Lindell, 1981) has found people of lower SES and working class people whose jobs involve exposure to risk— those with fewer resources, presumably, than those of higher SES and people of middle or other classes with greater access to resources—to be less cognizant of the risks associated with their work. Still other research they mention found no effect of education or income on risk perception (White, 1974). Given the range of findings in this area, Fothergill and Peek conclude that "a characteristic such as socioeconomic status should be considered as a possible contributor to, and predictor of, how risks are perceived and interpreted (Vaughan, 1995)"—but Fothergill and Peek do not predict what the relationship of SES to risk perception will be in most situations (Fothergill & Peek, 2004).

The National Center for Disaster Preparedness at Columbia University conducted a national survey in which nearly two-thirds of respondent households (65 percent) reported having no disaster plans or having plans that are not adequate (Sury et al., 2016). And according to national survey data from the Federal Emergency Management Agency (FEMA), less than half of Americans are familiar with local hazards, fewer than 40 percent have created a household emergency plan and discussed it with household members, and only about half (52 percent) reported having disaster supplies at home (FEMA, 2014).

Fothergill and Peek report on research that has found people in poverty, with low incomes, and with less education to be less prepared for disasters (Turner, Nigg, & Paz, 1986; Vaughan, 1995; as cited in Fothergill and Peek, 2004). They point out that this finding may relate to the fact that some preparedness actions are costly, and possibly too costly for people in poverty to afford (for example, purchasing earthquake or flood insurance or strengthening a home for greater earthquake resilience) (Palm & Carroll, 1998; Fothergill, 2004; as cited in Fothergill and Peek, 2004). In a paper about the effects of Hurricane Katrina on New Orleans, Louisiana residents Masozera, Bailey, and Kerchner (2007) report that districts of the city with high percentages of people in poverty also had low percentages of people with flood insurance.

On the other hand, Fothergill and Peek also relate that researchers investigating preparedness behavior prior to Hurricane Andrew (which took place in August 1992) found no association between income levels and timing of preparedness activities, such as having non-electric sources of lighting on hand (for example, candles, a flashlight, a gas-powered lantern), buying or preparing water reserves, buying canned or nonperishable food, and bringing loose objects indoors. The time between beginning preparation and the onset

of the hurricane did not vary significantly by income (Gladwin & Peacock, 1997, as cited in Fothergill & Peek, 2004).

In line with the idea that preparedness may be too costly for people of low SES, a report from the World Bank and the Global Facility for Disaster Reduction and Recovery (GFDRR) on the impacts of natural disasters around the world notes that "poor people, with fewer resources, tend to invest less in preventing and mitigating the adverse effects of natural hazards and environmental changes" (Hallegatte, VogtSchilb, Bangalore, & Rozenberg, 2017).

One team of researchers looked specifically at preparedness in 1,304 adults ages 50 and older. They found that those in their sample with lower levels of income were significantly less prepared for natural disasters (Al-rousan, Rubenstein, & Wallace, 2014). This suggests that, as noted in the introduction to this Bulletin, more than one type of vulnerability—in this case, older age and lower income—may interact to shape how people prepare for, and perhaps eventually experience, disasters.

In a paper about race and SES and their association with evacuation behavior related to Hurricane Katrina (which took place in August 2005), Thiede and Brown (2013) review research that suggests that SES and race matter, but that location and other variables matter as well. Race and SES are not deterministic alone regarding whether people follow evacuation orders. They mention one study of Florida residents and their evacuation behavior in the 2004 hurricane season that found that race and income did not predict evacuation to a statistically significant extent—but when the researchers zeroed in on regions of the state, race and income *did* predict evacuation behavior in some areas (Smith & McCarty, 2009, as cited in Thiede & Brown, 2013). Thiede and Brown cite additional research on the evacuation behavior of people in areas affected by Hurricane Katrina based on race. Again, findings suggest that context matters: in New Orleans, low-income people were most likely to have evacuated during or after the hurricane or not at all, but income did not affect evacuation timing and behavior in Katrina-affected areas outside of New Orleans (Elliott & Pais, 2006, as cited in Thiede & Brown, 2013). In another study using some of the same data as Elliott and Pais, Haney, Elliot, and Fussell analyzed data from both New Orleans and surrounding areas and found that "poor householders were more likely to have stayed up to or through the storm, or to have left at least one family member behind" (Haney, Elliott, & Fussell, 2007, as cited in Thiede & Brown, 2013). Evacuation behavior was strongly affected by location: New Orleans households were more than four times less likely than households in other affected areas to have stayed together at home than to have evacuated together (Haney, Elliott, & Fussell, 2007, as cited in Thiede & Brown, 2013).

Thiede and Brown also present the findings of their own review of baseline year data from the Harvard Medical School's longitudinal study conducted with the Hurricane Katrina Community Advisory Group, a sample of people affected by the hurricane.

Research findings reflect a world in which people of low Social status are more vulnerable in the face of disasters and are more likely to suffer more serious consequences during impact, from property damage to homelessness to physical and financial impacts. Disasters can contribute to more adversity for people of low

SES than for others who are not low Social status—and, as the World Bank and GFDRR report observes, in part due to their financial effects, natural disasters make it more likely that people in poverty will remain in poverty (Hallegatte et al., 2017).

Disasters in some cases have been more likely to make low-income people homeless. They cite research on the effects of the Loma Prieta earthquake (which occurred in October 1989) in California, which was more likely to cause homelessness for groups including lowincome Latinos, and Hurricane Hugo (which took place in September 1989), which affected North Carolina, South Carolina, Florida, Georgia, and several mid-Atlantic and northeastern states in the United States and led to homelessness for an estimated 60,000 people, including many people with low incomes (Phillips, 1998; FEMA, 1990).

In the World Bank and GFDRR report, authors observe a worldwide trend, among people at all levels of wealth and poverty, toward living in high risk of disaster locations: "From 1970 to 2010 the world population grew by 87 percent, while the population in flood plains increased by 114 percent and in cyclone-prone coastlines by 192 percent" (Hallegatte et al., 2017). The authors go on to cite an assessment of damages from natural disasters around the world, which showed that costs of damages from natural disasters have risen correspondingly over a similar period. The assessment examined average annual damages over two 10-year periods—from 1976 to 1985 and from 2005 to 2014—and found that the averages increased more than tenfold from the earlier to the later period, from $14 billion to over $140 billion (GFDRR, 2016, as cited in Hallegatte et al., 2017).

Fothergill and Peek cite extensive evidence of barriers faced by people with lower incomes and in poverty in interacting with bureaucratic systems to receive housing and other types of aid. Research has highlighted barriers including lack of knowledge of the systems through which disaster survivors receive aid; discomfort with these systems; and issues in getting to and from disaster assistance centers, such as transportation, child care, and work schedules (Rovai, 1994; Fothergill, 2004; Dash, Peacock, & Morrow, 1997 ; as cited in Fothergill & Peek, 2004).

This suggests that non-disaster aid programs are not sufficient to offset at least some types of disaster-related financial losses, even in wealthier countries like the United States.

In an article describing findings of a rapid needs assessment conducted in the Rockaway Peninsula, part of New York City, 3 weeks after Superstorm Sandy, authors report that lower income households were significantly more likely to express worry about food than higher income households (Subaiya, Moussavi, Velasquez, & Stillman, 2014). Additionally, higher SES households were 4.5 times more likely to leave the Rockaways to get food. Given that the storm and its aftermath severely affected public transportation for the Rockaways and also damaged and destroyed many cars, it is probable that lower income households worried more about food because of the difficulty of getting to a grocery store (Marritz, 2012, as cited in Subaiya et al., 2014). Subaiya et al. (2014) also found a trend toward psychological disturbance among low SES households in their rapid needs assessment, but the trend was not statistically significant.

In another study drawing on baseline survey data from the Hurricane Katrina Community Advisory Group, researchers examined posttraumatic stress and posttraumatic growth, or positive changes in personal, spiritual, and social dimensions of life after trauma, in relation to race; other demographics, including poverty and educational attainment; and additional, experiential variables among survivors of Hurricane Katrina (Rhodes & Tran, 2012). The researchers looked only at data from people who identified themselves as black or African American or as white. In the introduction to their paper, they describe problems with the emergency response to Hurricane Katrina, and they relate that "although all racial groups were impacted by the disaster and problems with the emergency response, it is notable that low-income African Americans were disproportionately affected, and more likely to view the problems in the governmental response to be discriminatory" (Adams, O'Brien, & Nelson, 2006; Shapiro & Sherman, 2005; Pew Research Center, 2005; Sanders, 2005; as cited in Rhodes & Tran, 2012). Because they were interested in understanding more about the emergency response and how African American Katrina survivors conceived of it, and the implications for their well-being, the researchers looked specifically at African American and white survivors.

In the study using data from the GSPS of people affected by the Deepwater Horizon oil spill, researchers found that being unemployed and earning less than $25,000 in annual household income were associated not only with frequent mental distress and depression, but also with frequent physical distress. As with mental distress, physical distress was considered frequent if GSPS respondents said that their health had not been good for 14 or more of the past 30 days (Fan et al., 2015).

Disasters differentially affect people in poverty around the world, according to the World Bank and GFDRR report, and health is a key area in which they do so. "Disasters force poor households to make choices that have detrimental long-term effects, such as withdrawing a child from school or cutting health care expenses," the authors write (Hallegatte et al., 2017).

CHAPTER 3

RESEARCH METHODOLOGY

STATEMENT OF THE PROBLEM

The focus of this report is on characterizing impacts of natural disasters such as extreme precipitation events and floods on households and businesses in the selected locations. To understand flood impacts, it is necessary to understand the nature of the hazard—in this case extreme rainfall—and assess factors that expose people and assets to floods and contribute to their vulnerability. After evaluating the nature of the flood risk in the three locations, this report focuses on the impacts on households, retail businesses, and SMEs using field-level and secondary data.

OBJECTIVE OF THE STUDY

Following are the objectives of the study:

- To study the different types of Natural disasters.
- To understand the nature of the disasters and its effects on society
- To improve the understanding of disaster risk, hazards and vulnerabilities.
- To enhance disaster preparedness for effective response, and form mitigation strategies.

SCOPE OF THE STUDY

To evaluate the impacts of extreme precipitation on exposed and vulnerable groups, some of the most extreme events in recent history in terms of intensity and magnitude were selected in each location. The impacts of floods on people and assets in these areas were identified, quantified where feasible, and compared using primary and secondary data.

SIGNIFICANCE OF THE STUDY

Even before the industrialization of the modern world, natural disasters have been a fact of life. There are records of the migratory travels of Native Americans away from coastal Florida specifically to avoid seasonal hurricanes. However, with the modernization of many societies worldwide and the changes our industrial activities have brought to the environment, many weather related natural disasters have gained in both frequency and intensity. This translates to in increased global impact of natural disasters at all levels.

RESEARCH METHODOLOGY

Type of Research Design : Descriptive Research

I have used *Descriptive research* as my research design for this particular project. Descriptive research is defined as a research method that describes the characteristics of the population or phenomenon that is being studied. This methodology focuses more on the "what" of the research subject rather than the "why" of the research subject.

Data collection method : Secondary data

For the purpose of my project *Secondary data* is used. It consists of information that already exists somewhere and has been collected for some specific purpose in the study.

Secondary Data used for my project were as follows :

- Business Magazines
- Research papers
- Articles
- Internet Sources

LIMITATIONS TO THE STUDY:

In the course of the study, some challenges were encountered that limited the research in one way or another and some of them are as follows so that the findings of the study are understood in proper perspective.

The limitations to the study are as follows:

- The first and foremost important limitation was time constraint.
- The subject of this project is quite vast and deep so it is very difficult to cover every aspect of the topic.
- The study was region specific.

CHAPTER 4

DATA ANALYSIS AND INTERPRETATION

To evaluate the impacts of extreme precipitation on exposed and vulnerable groups, some of the most extreme events in recent history in terms of intensity and magnitude were selected in each location. The impacts of floods on people and assets in these areas were identified, quantified where feasible, and compared using primary and secondary data.

Mumbai experienced the most extreme precipitation in its history on 26 July 2005 when a cloudburst resulted in record rainfall of 944 mm over the city's suburbs. The city recorded 43% of its annual average rainfall amount in a single day. The rainfall intensity was 5 times greater than that the old storm water drainage system was designed to accommodate and 2.5 times more than the current system is designed to cope with (MCGM 2006). The city administration had no experience of dealing with an event of this magnitude. Combined with a high tide, the unprecedented rainfall brought Mumbai to a standstill, stranding 2 million people on the roads and 2.5 million in partly or fully submerged houses (MCGM 2006). Basic services, such as electricity, water supply, transport, and communication, were shut down, and it took 1–4 weeks for them to start functioning smoothly again.

Estimated losses ranged from $1.1 billion to $5 billion depending on the evaluation methodology used. However, these damage assessment exercises did not reflect the extent of vulnerability and impacts on households, particularly the poor residing in informal settlements, and on the small retail businesses in the informal sector (Patankar and Patwardhan 2015). To focus on these vulnerable segments, primary surveys were carried out among affected households and retail businesses (Patankar et al. 2012, Patankar 2015). Estimates of losses were also obtained from SMEs as part of another study (Schaer and Patankar 2018). This paper uses some of these studies' findings to characterize the impacts of the flood on vulnerable segments of the population.

A similar precipitation event occurred in Chennai during the northeast monsoon from November to December 2015 when extremely heavy rains fell over the city due to the formation of a depression over the Bay of Bengal and a strong El Niño event (ISRO 2015). A period of heavy, incessant rainfall began when 167 mm fell on 9 November 2015. On 1 December, the city recorded 290 mm of rainfall, and the next day Chennai experienced 320 mm—the highest rainfall in a single day (GCC 2017). This deluge came after 1,200 mm of rainfall in November—300% more than the usual average for the month (ISRO 2015). The ensuing flooding brought Chennai to a standstill for many days. Residential areas along water bodies (the Cooum and Adyar rivers and micro drainage canals) and those encroaching over them remained submerged for more than 10 days. The

international airport was inundated and had to be shut down for a week. Industries and the commercial sector reported heavy losses due to direct damages and closure for several days. To assess the extent of vulnerability and impacts on households, a primary survey was carried out in some of the most affected areas around Chennai (CAG 2016). A similar survey was carried out among SMEs, which form an important part of the local and state economy (Mercy Corps and Okapi 2016). This paper uses findings from both studies to understand flood impacts on households and SMEs.

For Puri district, the report considers the extreme rainfall caused by Cyclone Phailin. On 12 October 2013, Cyclone Phailin, a very severe cyclonic storm, passed over the state of Odisha and the northern coast of the state of Andhra Pradesh. It made landfall in Ganjam District, Odisha, bringing sustained maximum wind speeds of 200–220 kilometers per hour (NIDM 2014). The cyclone brought very heavy to extremely heavy rainfall to Odisha and storm surges of 3.5 meters, inundating extensive low-lying areas in the districts of Puri, Ganjam, and Khordha, and Chilika Lake (NIDM 2014). Although the mass evacuation executed during the cyclone is considered a success story of disaster management for limiting loss of life and the extent of damage compared with the super storm of 1999 (Government of Odisha, ADB, and World Bank 2013), people suffered significant impacts during the cyclone. This paper uses the damage assessment report (Government of Odisha, ADB, and World Bank 2013) and damage estimates for Puri district (Government of Odisha 2018) to analyze the flood's impacts on households and small businesses.

A. Household Impacts

Extreme precipitation events lead to losses that are a combination of (i) physical, financial, and human capital damage costs; and (ii) reductions in the economic activities of consumption, production, investment, and employment (World Bank 2004). Most of the literature on natural hazards and their impact focuses on the first types of losses, where short-term and immediate damages to property and physical assets can be estimated using insurance values. When insurance penetration is very high, as in the case of developed countries, damage is assessed using insured exposure analysis (Hallegatte et al. 2011). However, in developing countries such as India, nonlife (general) insurance penetration is quite low at 0.93% and insurance density is $13.2 (compared with a global average of $285.3) (Government of India 2018). Using insurance estimates to quantify the impacts of extreme events may therefore not reflect the true losses.

Empirical studies assessing flood-related damages focus mostly on capturing losses at the macro or meso levels where affected assets are aggregated across the affected area using land use and hazard -exposure maps and census data (Merz et al. 2010). These studies consider only direct and tangible damages because indirect damages, such as the effect on the provision of goods and services, water supply, electricity, and transport, are difficult to estimate because of a lack of data and measurable variables (World Bank 2004). However, a few studies have tried to assess flood impacts at the micro level using household or community surveys. They include a study in Limpopo Province, South Africa, using structured household interviews (Khandlhela and

May 2006); a primary survey of affected floodplain residents in Bangladesh (Brouwer et al. 2007); a multi-country study to assess climate change impacts on households (Warner and van der Geest 2013); and a study in Nepal that constructed a household vulnerability index using primary data (Piya, Maharjan, and Joshi 2012).

This section focuses on micro-level analysis of the impacts of extreme precipitation and resultant floods across the three locations as assessed and characterized in different studies using primary surveys and secondary data from field reports of government and research organizations. Single households or businesses are the units of analysis, and the focus is on estimating direct and tangible losses. The losses are disaggregated into monetary damage to property, physical assets, appliances, equipment, and products, as well as loss of income, investment, and other impacts. Indirect impacts, such as disruption of basic services, are difficult to measure, but their overall effect on households and businesses has been captured qualitatively through the surveys.

1. Mumbai

To estimate the impacts of extreme precipitation in July 2005 on households in Mumbai, the author carried out a detailed survey in the worst affected wards: F North, F South, K East, H East, L Ward, and P North (Patankar et al. 2012). This study uses the primary database from this survey to estimate and characterize the flood's impacts. The selected wards are acutely vulnerable to flooding because of their location in reclaimed areas, low-lying areas, or on the river flood plain. The wards contain key infrastructure, such as the international airport, highways, interconnecting subways, and suburban railway stations, and a large percentage of their residents live in informal settlements (Table 2).

Table 2: Profile of Surveyed Wards in Mumbai

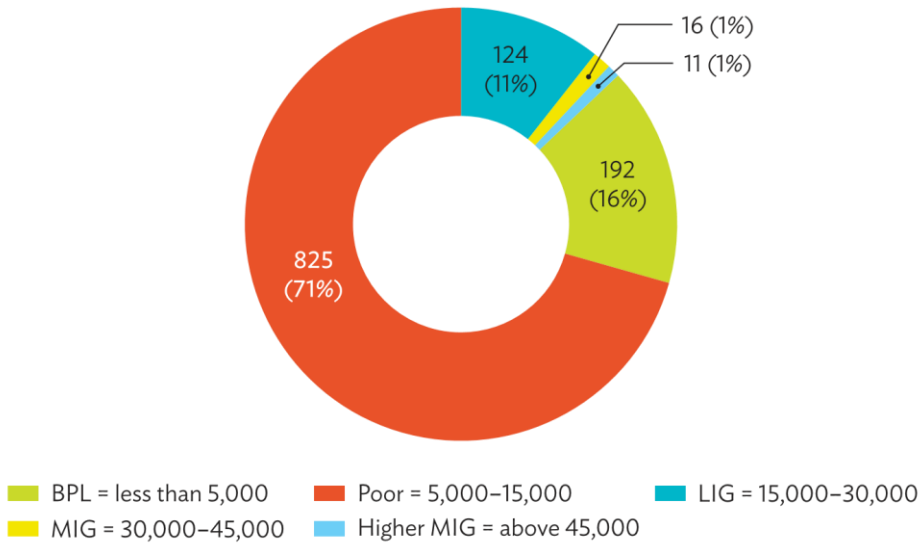
Ward	Area (km^2)	Residential Area (km^2)	Residential Density	Total HHs	Slum HHs	% of Slum HHs	Number of HHs Surveyed
F North	12.01	4.03	131,411	132,259	61,680	46.6	177
F South	9.65	2.34	154,380	90,243	19,040	21.1	103
H East	12.89	2.83	199,280	140,861	48,201	34.2	176
K East	24.00	6.85	120,200	205,971	80,760	39.2	241
L Ward	15.56	5.45	165,573	225,556	98,080	43.5	231
P North	46.72	10.27	91,645	235,342	100,900	42.9	240

GIS = Geographic Information System, HH = household, km^2 = square kilometer, MCGM = Municipal Corporation of Greater Mumbai. Households surveyed as part of the study presented in Patankar et al. 2012.

Source: Calculations based on GIS-based exposure maps developed by author for affected wards using existing land use maps of the MCGM and superimposing flood maps of the Disaster Management Unit of MCGM.

To understand the nature and magnitude of the impacts of extreme precipitation in July 2005, the study randomly selected 1,168 families from the chosen wards to administer primary surveys. These households were classified into socioeconomic categories to contextualize the total damage they reported (Figure 1). According to the urban poverty line estimated using the Tendulkar method, the approximate per capita income of the urban poor in Maharashtra is 1,000 Indian rupees () (Government of India 2013). The 2011 census estimated that families in slum settlements have five members, so families with a monthly income of less than 5,000 are classified here as below poverty line (BPL) households. Similarly, based on the income distribution analyzed by Annez et al. (2010), other families are classified as poor or belonging to lower-income, medium-income, or highermedium-income groups. This classification of surveyed households is used throughout the flood impact analysis presented here.

Figure 1: Socioeconomic Categories of Surveyed Families
(₹'000)



BPL = below poverty line, LIG = low-income group, MIG = medium-income group.
Source: Author's calculation based on primary data.

A family's house is usually its most important asset and investment. Its location, type of construction, material used for construction, other amenities, and general surroundings determine the family's vulnerability to natural hazards such as flooding. Most surveyed households were poor and lived in poorly constructed, dilapidated houses in poorer neighborhoods. The surveyed households were classified into the standard dwelling types,

kutcha, semi-*pucca*, and *pucca* houses, that are mainly found in slums and are single- and multistory building types found in apartment blocks. More than 90% of the surveyed families lived on the ground floor and suffered direct impacts when their houses were flooded with rainwater, sewage, and garbage.

Most (87%) of these households owned the houses they lived in and had invested their earnings and life savings to build their asset base. During the extreme floods of 2005, the average flood depth was 5 feet, and in some areas, it reached a depth of 8 feet. Houses remained flooded for an average of 3 days and in some cases, up to a week. These families suffered heavy damage to the structure of their houses and their assets, but only 6.8% reported having any form of insurance cover (life, medical, or general) and only 3.6% raised claims for insurance to cover their losses. Thus, almost all surveyed families used their own funds to cover their losses.

Households across all socioeconomic categories reported extensive damage on account of extreme rainfall on 26 July 2005 and the unprecedented flooding. Table 3 lists the average estimated repair or replacement cost of damage to different assets and equipment. Affected households reported the following categories of damage: house structure (floor, walls, roof); household appliances (television set, refrigerator, washing machine, stove, computers); household assets (furniture, utensils); and vehicles (bicycles, motorbikes, three wheelers, cars).

Table 3: Estimated Repair or Replacement Cost of Damage

Socioeconomic Category	House Repair	HH Appliances	HH Assets	Vehicles	Total Damage Cost	Share of Average Monthly Income (%)
Below poverty line	15,000	11,000	6,700	6,500	37,000	1,480
Poor	22,000	13,000	7,000	9,000	48,000	480
Low-income group	30,000	14,000	10,000	10,000	57,000	253
Medium-income group	45,000	17,000	13,000	2,500	69,000	184
Higher-medium income group	40,000	19,000	8,500	5,000	69,000	115

HH = household.

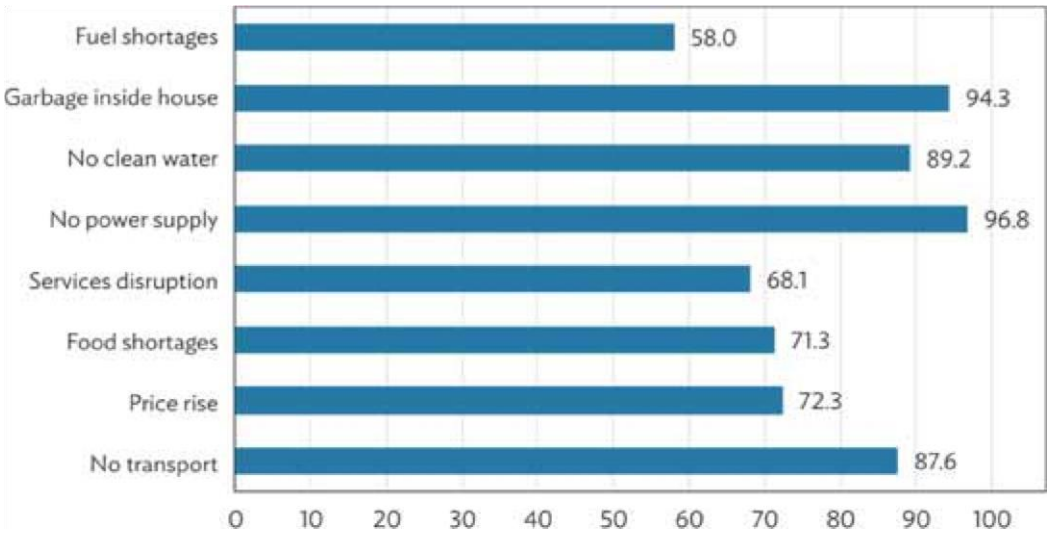
The largest amount was spent on house repairs, followed by repairs or replacements of household appliances. Families that could afford to own more household appliances and assets, such as families categorized in the low-income, medium-income, or higher-medium-income groups, reported higher associated damage costs. They experienced extensive damage to television sets, refrigerators, washing machines,

furniture items, and motorbikes, which are expensive to repair or replace. The overall damage costs increased in ascending order of income category in the survey. However, the scale of the damage costs does not paint the true picture of hardships suffered by poorer families. Considering the mid value of each income category, the damage cost of the extreme precipitation of 2005 amounted to 1,480% of the average monthly income of BPL families and 480% of the monthly income of poor families. In absolute terms, this means BPL families lost the equivalent of more than 12 months' income due to damage to their meager assets. This compares with 5 months' income for poor households and 1–2 months' income for other groups.

This important finding highlights the extent to which the asset base of the poorest families is threatened by an extreme event. Assets in which families invest their lifetime earnings and savings, such as their house, appliances, and furniture, are affected the most by floods. Lacking adequate compensation, social protection, or insurance coverage, these families must bear the costs themselves using savings or by borrowing. Thus, extreme precipitation events have the potential to push poor families into a debt trap and even below the poverty line if there is no support mechanism to help them overcome their losses.

Besides the direct impacts on their assets, families reported several indirect impacts (Figure 2). Almost all families experienced power supply disruption. Most also had to cope with garbage left behind by the receding floodwater; fuel, food, and drinking water shortages; and transport disruption. People had to pay higher prices for essential items. Although the monetary cost of these indirect impacts cannot easily be measured in the absence of reliable data and measurable variables, it is clear that there would have been serious disruption of economic activity and substantial economic losses for households and businesses.

Figure 2: Indirect Impacts of Mumbai Flood
(% of households affected)



One of the most critical impacts of floods is the incidence of vector-borne and waterborne diseases and respiratory ailments. Table 4 shows the health impact in the immediate aftermath of extreme floods as reported

by government hospitals. The impact would be considerably higher if admissions to private hospitals were included.

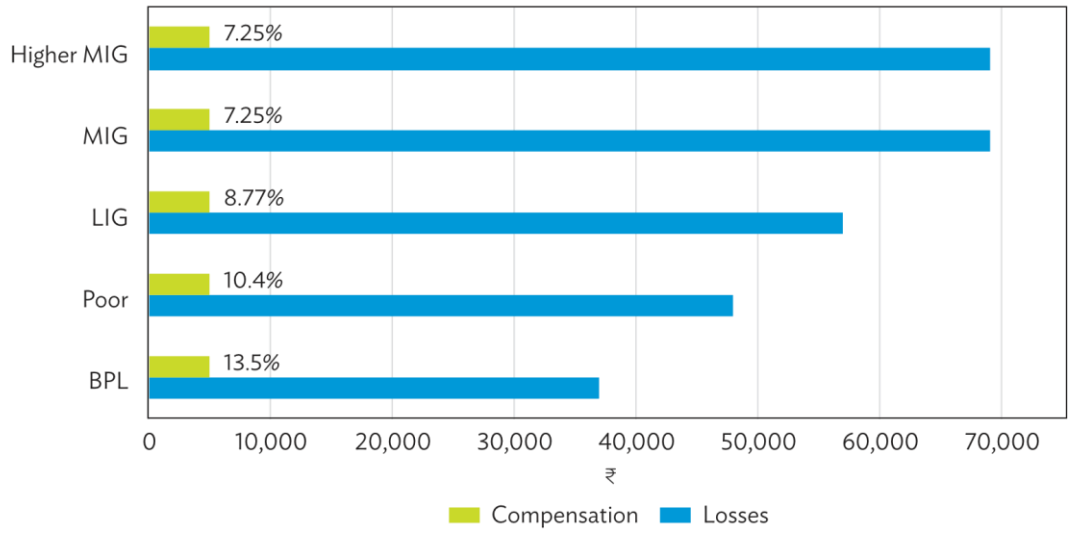
Table 4: Number of Admissions at Government Hospitals

Disease	Admissions in Last 24 Hours	Total Admissions Since 29 July 2005	Deaths
Gastroenteritis	154	1,318	1
Hepatitis	27	194	0
Typhoid	5	53	0
Malaria	62	406	2
Dengue	5	49	0
Leptospirosis	56	197	10
Fever (unknown cause)	597	1,044	45
Total	906	3,261	58

Note: Data are as of 12 August 2005. Source: Patankar et al. (2012).

As households across the affected parts of Mumbai suffered substantial losses during unprecedented floods, the state government offered monetary compensation—known as gratuitous relief assistance—as predetermined by the Government of Maharashtra's standing orders of 1983. Affected families were offered 5,000 to assist with their immediate requirements such as food and clothing. However, the amount of relief given was unrelated to the actual losses reported by the families because the government did not carry out a postdisaster assessment to capture losses suffered by families who had no social protection or insurance coverage to shield them. Government compensation only covered 13.5% losses of BPL families and 10.4% of those suffered by poor households (Figure 3). And while the absolute amount of compensation might appear to be slightly pro poor as it offers more for the losses of poor households than better-off households, on a per capita basis, the compensation for a BPL family was only 1,000 (assuming an average of five members per family) compared with 1,250 for others (with four members per family) (Patankar 2015). Thus, even this meager compensation favored better-off households rather than their poorer counterparts (Patankar 2015).

Figure 3: Compensation as a Percentage of Total Damage Cost



BPL = below poverty line, LIG = low-income group, MIG = medium-income group.
Source: Author's calculation based on primary data.

2. Chennai

Chennai suffered from incessant rainfall during November 2015 and extreme single-day precipitation on 2 December 2015, which led to large-scale inundation across the city. Community-based organizations and concerned citizens involved in relief work carried out a damage assessment of households in some of the city's worst affected areas (CAG 2016). This section uses the findings of the sample survey conducted during that assessment exercise to understand the extent of losses suffered by affected families, the loss of jobs or workdays, and the families' experiences during relief operations after the floods had ravaged their homes and possessions.

Some of the worst affected areas were Mudichur, West Tambaram, Manapakkam, Saidapet, Kotturpuram, and Zafferkhanpet (GCC 2017) As the water-holding tanks on the outskirts of Chennai district overflowed after excessive rainfall, flooding occurred in areas near the main Adyar and Cooum rivers. The carrying capacity of Cooum and Buckingham canals exceeded their design capacity. These major canals and 31 minor ones overflowed and inundated nearby areas. The Greater Chennai Corporation recorded flooding in 859 locations across the city (GCC 2017).

The damage assessment study included a sample survey of 610 households in some of these worst affected areas. The location characteristics of these areas are very important because they play a critical role in vulnerability to floods. Table 5 provides details of the surveyed areas and their household profiles.

Table 5: Profile of Household in Surveyed Areas of Chennai

Survey Area	Number of Households	Location Characteristics	Household Profile	House Type
Saidapet	200	Adyar River floodplain	Low-income families	Constructed single-story houses
Ponneri	77	Fringe area on Chennai outskirts	Working class and lower-middle class	Constructed single-story houses
Perumbakkam	52	Resettled communities	Very poor and lowincome families	*Kutcha* houses in informal settlements, constructed multistory tenements of housing board
Mudichur, Tambaram	42	New residential areas	Middle class	Constructed single- or multistory houses
Semmencheri	50	Resettled communities	Low-income families	Constructed single-story houses
Kotturpuram, Raja Annamalaipuram	54	Adyar River floodplain	Low-income families	Constructed single- or multistory houses
Ekkatuthangal	11	Adyar River floodplain	Low-income families	Constructed single- or multistory houses
Puttamma Nagar, OMR Taluk	46	Interstate migrant population	Low-income families	*Pucca* houses in informal settlements
Semencherry Thoppu, OMR	10	Interstate migrant population	Very poor families	*Kutcha* houses in informal settlements
Jaffarkhanpet	20	Adyar River floodplain	Low-income families	Constructed single- or multistory houses
Kodungaiyur, MGR Nagar	48	North Chennai neighborhood	Low-income families	Constructed houses

OMR = Old Mahabalipuram Road.

The damage assessment survey captured the types of damage suffered by flood-affected households, although monetary estimates for individual damage categories are not available. Because the survey was carried out by volunteers participating in the postdisaster relief work, the interviewers were able to see how houses had been damaged and how the families had suffered as a result of the floods. Based on the reported losses, the volunteers recorded five types of damage: (i) house structure (damage to floor, roof, walls, and access roads); (ii) household assets (provisions, furniture, clothes, books, and important documents); (iii) appliances (refrigerator, washing machine, fans, and lights); (iv) vehicles (bicycles and motorbikes); and (v) work tools (sewing machines, carpentry tools, equipment, and inventory).

The interviewers gained important insights into flood-related damage. Average total losses reported by surveyed families ranged from 7,500 to 125,000. No breakdown of the damage costs is available. Poor migrant families in the Old Mahabalipuram Road settlement near Semmencheri reported the lowest average losses because the rains in November had prevented the migrant workers from finding gainful work and therefore they had no possessions to lose in the December floods. Their *kutcha* houses were, however, destroyed by waterlogging. Families who lost occupational tools in addition to their household assets reported higher average losses of 100,000–125,000.

Almost all families in the selected areas reported significant damage to the structure of their homes. In Ponneri, Old Mahabalipuram Road settlement near Semmencheri, and Zaffarkhanpet, houses were washed away or partly destroyed and people had to move to shelters. Houses in Kotturpuram, Ekkatuthangal, and Kodungaiyur suffered extensive structural damage. Families in Semmencheri also reported robberies as houses that had filled with water and garbage had to be abandoned.

Many families lost important identification, bank, or insurance documents and certificates along with other household assets such as clothes, provisions, and furniture. This was a significant loss with serious short- to medium-term implications for affected families. Identification documents were required to claim relief for damage or establish ownership of houses and other assets. It would also have been difficult to restore bank and insurance documents or education certificates.

Many households lost work tools, such as sewing machines, carpentry tools, and printing machines, and small shops lost inventory. The consequent short-term loss of livelihood until the tools could be repaired or replaced put an additional financial burden on low-income households with limited means and no social or insurance protection to cover such losses.

Most families reported loss of 15–45 workdays with an average loss of wages of 250–500 per day. In addition, some people lost their job because they could not report to work for more than 2 weeks. This includes families working as domestic helpers in wealthier households in the city. Many people also had to relocate, either to relatives' houses or to their native town or village, and hence, lost workdays or jobs.

Overall, flood-affected households experienced damage to assets in which their life savings were invested (houses) or on which their livelihood depended (work tools). This underlines how extreme events threaten the

critical asset base of poor families. The lack of a protective net offered by social security or insurance to help poor families rebuild their lives pushes them into a debt trap and makes them poorer.

Besides the direct impacts in terms of damage to household assets and work tools, households described several indirect impacts to the interviewers. People suffered from power cuts, food and water shortages, higher prices, and lack of transport. Many neighborhoods remained inundated for 2–3 weeks, hampering families' efforts to recover from losses and rebuild their lives. People had to leave houses filled with water and garbage and move to shelters run by the government or private groups or to friends' or relatives' houses.

Most families received no flood warning. In some cases, by the time warning was issued, floodwaters had already risen and people could not move to higher ground in time and protect important assets and documents. Those who could not move to a safer place waited on top floors or roofs for rescue and relief material. Airdropped relief packages often became scattered and people could not access and use them. In some areas, relief material and rescue boats reached houses located along the roads, but those living in the interior parts of affected neighborhoods remained without assistance.

Migrant families were denied shelter and relief by government officials because they did not have voter or ration cards with which to establish their identity. These poor families had to look for alternative short-term rental accommodation. They were also denied government compensation of 5,000. Women who lost their jobs and did not have male family members to support them also suffered from the fear of being pushed into a long-term debt trap. Families that had been resettled from previously vulnerable areas once again suffered from floods, raising serious questions about the quality of resettlement and rehabilitation.

Insights from the damage assessment survey of affected households thus raised important questions regarding (i) the long-term economic impacts of extreme events on poor families, (ii) the need for a protective social safety net to prevent their downward spiral into a debt trap and poverty, (iii) the missing human angle during the rescue and relief operations under disaster management and while providing relief and compensation to the affected people.

3. Puri District

Cyclone Phailin made landfall at Ganjam in the state of Odisha on 12 October 2013, where it caused extremely heavy rainfall and large-scale inundation. In response to a request from the Government of India's Department of Home Affairs, the Government of Odisha, the Asian Development Bank, and the World Bank jointly prepared a rapid damage and needs assessment report of this event (Government of Odisha, ADB, and World Bank 2013). The team visited the worst affected districts of Ganjam, Khordha, and Puri and assessed the damage to households and rural and urban infrastructure, and the cyclone's impacts on agriculture, fisheries, and handicrafts. Sector teams used customized templates to collect and aggregate data. This section analyzes the aggregated database generated by this damage assessment exercise. It also includes information on compensation for different types of damage sourced from the district disaster management plan documents to estimate the monetary burden on households (Government of Odisha 2018). No primary surveys were carried

out after Cyclone Phailin to record damage suffered by individual households. Hence, there are no databases to evaluate how people dependent on agriculture and other rural occupations were affected.

The cyclone and floods affected 1.75 million people (350,000 households) in Puri, but the death toll of Cyclone Phailin was far lower than that of the 1999 super cyclone (Table 6). The Government of Odisha and the coastal communities responded to the cyclone warning in an effective and coordinated manner a day before it was expected to make landfall. More than 1.3 million people evacuated from coastal areas and moved to shelters. The armed forces, central and state government disaster management authorities, the local administration, political and social organizations, and residents worked together in the rescue operation (NIDM 2014). The effective early warning and dissemination of the warning, prompt disaster planning, and preparedness of the administration helped ensure minimum fatalities during one of the most severe storms and what is now considered a success story of disaster management and adaptation (NIDM 2014, Walch 2018).

Table 6: Households Affected by Cyclone Phailin

	Total	Puri District
Deaths	44	4
Impacted population (million)	13.0	1.75
Impacted households	2,600,000	350,000
Rural[a]	2,158,000	297,500
Urban	442,000	52,500
Fisher households	44,806	58,268
Artisan households	1,564	722

[a] Rural households are assumed to make up 83% of households in Odisha state and 85% of households in Puri, as stated in the 2011 census.

Source: Compiled from Government of Odisha, ADB, and World Bank. 2013.

However, rural households suffered severe damage. Many houses in Puri district were partly or completely damaged. The cost of reconstruction was estimated at 1,471.18 million ($21 million), including land acquisition for relocation, repair of damaged houses, and the provision of basic services such as electricity and water supply.[3] Partly damaged *kutcha* houses were offered 3,200 and *pucca* houses 5,200 as compensation under the State Disaster Response Fund and the National Disaster Response Fund (Government of Odisha 2018). Based on these figures, the total compensation is estimated at 228.04 million ($3.26 million), or 15.5% of total reconstruction costs. Households bore the remaining costs of reconstructing their damaged or destroyed houses—an amount equivalent to 1,965% of their monthly income.

Odisha is a predominantly rural state where most families depend on agriculture and allied activities for their livelihood. Table 7 estimates the impact of the cyclone and flooding on agriculture. The estimated cost of all agricultural land affected and rainfed, irrigated, or perennial farmlands with 50% or more crop losses is 2,345 million for Puri district. The potential compensation for crop losses of more than 50% is 12,200 per hectare (Government of Odisha 2018). Thus, families that lost more than half of their crops would receive compensation from disaster response funds amounting to 34.31% of losses incurred and would have to bear the remaining costs from their own resources. Similar estimates are developed for households engaged in horticulture and livestock rearing. Overall, losses borne by households dependent on agriculture and allied activities are estimated at 1,654.73 million ($23.64 million), or 111.78% of households' monthly income.

Table 7: Impact of Cyclone Phailin on Agriculture

Item	Total	Puri District
Agriculture		
Agricultural land affected (hectares)	1,292,967	141,271
Estimated loss to crop (million)	17,785.53	2,345.06
Potential compensation to farmers (million)	6,686.73	804.55
Compensation as a percentage of total loss (%)	37.60	34.31
Horticulture		
Estimated loss of horticulture (million)	1,553.30	136
Potential compensation as input subsidy (million)		30.89
Compensation as a percentage of total loss (%)		22.72
Livestock		
Estimated loss of livestock (million)	274.19	16.24
Potential compensation for dead livestock (million)	39.20	7.12
Compensation as a percentage of total loss (%)	14.30	43.84
Total		
Total loss of rural households (million)	19,613.02	2,497.30
Total potential compensation[a] (million)	5,883.91	842.57
Compensation as a percentage of total loss (%)	30.00	33.74
Loss to be borne by households (million)	13,729.11	1,654.73

Loss per household (million)	6,361.96	5,562.13
Loss as a percentage of monthly income (%)	127.85	111.78

[a] It is assumed that the government will offer an average of 30% of total loss as compensation.

For families dependent on fishing, the potential compensation offered for losses incurred was a meager 2.4% of the total loss (Table 8).

Table 8: Impact Cyclone Phailin on Fisheries

Item	Total	Puri District
Fishermen affected (number)	44,806	17,336
Total losses (million)	6,047.00	2,139.00
Potential compensation for boats (million)	38.83	27.35
Potential compensation for nets (million)	59.93	24.67
Total compensation (million)	98.76	52.02
Loss to be borne by fishing households (million)	5,948.24	2,086.98
Compensation as percentage of total loss (%)	1.63	2.43

Source: Author's calculations based on data in Government of Odisha, ADB, and World Bank (2013) and Government of Odisha (2018).

Based on reports and estimates of losses and costs of reconstruction, Table 9 compiles the total estimated reconstruction cost for Odisha state and Puri district. The cost includes reconstruction of damaged houses; loss of agriculture and fishing households; and damage to nonresidential buildings such as schools and health facilities, roads, water supply, and urban infrastructure. Given the norms for compensation, 56% of reconstruction costs would be borne by households across the affected areas in the state. For Puri district, compensation would cover 33% of the damage, with the remaining 67% to be borne by households using their own resources. Given the annual per capita income of $881 in the district, households would have to spend more than 2 months' income to compensate for the losses from torrential rains and flooding.

Table 9: Estimated Reconstruction Cost for Damage Caused by Cyclone Phailin

Reconstruction Cost	Total	Government	Households	Puri District	Government	Households
Housing, basic services, and land acquisition (million)	29,601.19	4,375.26	25,225.93	1,471.18	228.04	1,243.14
Rural roads (million)	7,007.87	7,007.87		475.00	475.00	
Urban infrastructure (million)	1,504.20	1,504.20		306.87	306.87	
Rural water supply and irrigation (million)	9,590.52	9,590.52		401.66	401.66	
Agriculture (million)	19,613.02	5,883.91	13,729.11	2,497.30	842.57	1,654.73
Fishing (million)	6,047.00	98.76	5,948.24	2,139.00	52.02	2,086.98
Total (million)	79,807.95	34,904.67	44,903.28	7,495.34	2,510.49	4,984.85
Total ($ million)	1,140.11	498.64 (44%)	641.48 (56%)	107.08	35.86 (33%)	71.21 (67%)

Source: Author's calculations based on data in Government of Odisha, ADB, and World Bank (2013) and Government of Odisha (2018).

B. Impacts on Businesses

Besides households, extreme precipitation events affect businesses through damage to building structures, machinery, equipment, and inventory and disruptions to normal business activities. This section focuses on a primary survey of retail businesses carried out by the author in Mumbai (Patankar et al. 2012), a study conducted among SMEs in Chennai (Mercy Corps and Okapi 2016), and estimated losses suffered by artisans and SMEs after Cyclone Phailin in Puri district (Government of Odisha, ADB, and World Bank 2013).

1. Mumbai

To estimate the direct impacts of extreme rainfall on businesses after the extreme floods in July 2005, a primary survey was carried out among 627 randomly selected retail outlets operating from six floodprone wards. The impacts on retail businesses were estimated as damage costs for different categories, as used in Messner et al. (2007) and Kreibich et al. (2010): premises (physical structures), equipment (appliances and equipment), and material (products and raw materials). Table 10 presents the average damage cost (cost of repair or replacement of premises, equipment, and material) for each ward and for the entire dataset.

Most retail businesses operate from the ground floor of buildings or in single-story roadside structures. Hence, much of the damage cost involved repairing grounds and fencing, foundations, walls, windows, and doors. Businesses also reported damage to machines and tools, refrigerators, escalators, electrical switches, and wiring. Raw materials, inventory, and finished products also sustained extensive damage. Since retail businesses are unwilling to report annual turnover, and business size varies substantially across different types of retail businesses and outlets, it was not possible to estimate damage costs as a percentage of their revenues. However, most businesses (93%) did not have flood insurance cover. Hence, they would have had to use their own resources to cover repairs and replacements.

Table 10: Damage Costs Faced by Typical Retail Businesses in Mumbai

Item F North	F South	H East	K East	L Ward	P North	Total Average
Premises						
Grounds and fences 14,500	35,000	67,000	16,000	95,000	28,700	48,000
Foundations 10,000		22,000	11,300		60,000	15,500
Flooring		13,500	10,500			11,500
Walls 8,400	4,000	8,000	13,700	3,500	12,500	10,200

Windows 7,000	3,000		6,000	13,800	5,000		8,300
Doors 7,500	39,000		8,000	7,000	7,000	7,900	10,000
Appliances and Equipment							
Communication systems	15,000		10,000		1,800		7,000
Escalators	8,000		8,500	15,000	17,500		10,900
Heating equipment				2,700	3,000		2,800
Air conditioning equipment				11,000	1,700		8,675
Refrigerators	14,000	18,000	15,000	7,800	6,500	17,500	10,600
Electrical equipment	10,500	8,800	16,000	7,000	15,000	5,500	10,500
Machines and tools	11,500	24,000	19,000	14,000	22,000	14,400	17,000
Products							
Finished products	15,800	25,000	22,600	24,500	37,000	19,400	23,000
Raw material	12,000	180,000	24,000	17,000	24,000		40,000
Partly assembled products	13,000	6,000	13,700	12,000	6,000		11,600
Inventory	28,000	9,000	21,800	6,000	11,000	10,000	19,300

Source: Author's calculations based on primary data used in Patankar et al. 2012.

Besides repairing and replacing premises, equipment, and products, businesses incurred immediate expenses to cope with floodwaters entering their premises (Table 11). The recovery time for businesses in each ward was 1–16 days, with an average of 3–4 days.

Table 11: Immediate Expenditure after Floods

Item	F North	F South	H East	K East	L Ward	P North	Total Average
Disinfecting premises	10,000	18,000	25,000	14,800	80,000	23,000	34,000
Flood rescue operations	5,000	8,000	7,800	2,500	26,500	5,500	8,600
Removing debris	4,600	6,000	7,800	5,500	16,000	26,400	12,700
Alternative operative costs	6,000	6,700	10,000	4,000	11,000	12,500	9,000
Emergency expenditure	11,500	10,600	24,000	31,000	140,000	70,000	69,000
Revenue loss	100,000	15,500	20,600	42,000	84,500	39,000	60,000
Recovery time	1–12 days	1–15 days	1–15 days	1–14 days	1–16 days	1–10 days	1–10 days

Source: Author's calculations based on primary data used in Patankar et al. 2012.

2. Chennai

Incessant rains in November 2015 and extreme single-day rainfall on 2 December 2015 severely affected SMEs in Chennai. SMEs form an integral part of overall industrial growth in the state of Tamil Nadu. They span industries such as automobile components, electronics, textiles, leather, chemicals, and plastics for the domestic and international markets (Mercy Corps and Okapi 2016). The SME sector grew by 50% during 2007–2014 in Chennai and nearby districts (Mercy Corps and Okapi 2016). However, these enterprises are acutely vulnerable because of their location in flood-prone areas.

In a survey after the December 2015 floods of businesses predominantly operating from industrial estates, Nurture Trust, in collaboration with Feedback Consulting and SRM University (Mercy Corps and Okapi 2016), calculated an average direct loss of 1.8 million ($20,000) per business. Medium-scale businesses (those with an annual turnover of less than 100 million) were the worst affected. Most losses were caused by damage to fixed assets such as physical infrastructure. Manufacturing industries with large quantities of these assets and heavy machinery suffered the most. Only 37% of businesses had insurance against natural calamities and only 50% of the insurance claimed for the reported damages was received.

To augment the findings of this study and understand the intangible damage such as loss of customer confidence and disruption of supply chains, semi-structured interviews of 35 business units were carried out in different flood-affected areas (Mercy Corps and Okapi 2016). The survey covered SMEs operating both within and outside industrial estates. Some of the key findings are highlighted in the following paragraphs.

Most surveyed firms suffered damage to buildings, equipment, and inventory. For two-thirds of those interviewed, damage to equipment was far greater than damage to buildings and inventory. Most of the building damage was from water seepage affecting floors or ceilings. Many firms also lost important work-related documents and even soft copies of documents were lost when electronic equipment, such as computers, were washed away. The cost of recovery of damaged equipment ranged from 25,000 to 25 million. Lacking funds to repair equipment, many **businesses started staggered** operations after 1–2 weeks.

Impacts of Natural Disasters on Households and Small Businesses in India

Businesses' locational choices were driven by advantages such as business potential, continuity, proximity to clients, accessibility of workers, presence of specific large industries, and ease of logistics. Exposure to natural hazards, such as floods, was not considered an important factor in the choice of location. Some businesses were aware of this risk but considered it easy to mitigate. The more cash-rich enterprises had invested in raising the floor level of their entire premises by a few feet to mitigate the flood risk.

Some business owners stated that they would not consider relocating from their present plant in the industrial estate even if a similar event were to happen again. They would rather invest in protecting their assets from floodwaters. However, a few firms stated that if they were to start a business after the extreme event, they would not choose the present location but would instead consider other options near Chennai.

Most businesses remained without electricity for an average of 13 days and without water supply for 12 days. For most businesses, solid waste and sewage issues were not resolved for more than 15 days. For some, it took a month or more. It took an average of 9 days to recover from waterlogging inside premises. Businesses on industrial estates had two coping mechanisms that those outside such estates lacked: reliable power supply and the ability to run their business in shifts. Hence, SMEs operating elsewhere stated that they would move to these estates, despite their flood-prone locations, if the opportunity arose.

Increased road heights were another major reason business premises flooded despite their raised floor levels. Many other locational factors that were beyond businesses' control, such as the state of the drainage network, encroachments, and improper desilting, contributed to flooding and impacted the businesses.

Limited or no access to financial capital amplified the impacts of the floods. Some SMEs had to sell their assets, close their business, and find wage employment elsewhere because of the lack of financial support after the December 2015 floods. Most smaller entities had invested their own money or borrowed from private sources to set up their business. They also typically had slim margins and limited supplier credit. These businesses' post flood losses were amplified by a lack of access to emergency funds and additional finance.

With the shutdown of production, lack of inputs, and loss of clients, many firms reported significant financial distress and an inability to repay existing business loans. The extreme floods also exposed a very high reliance on informal financing channels, such as friends and moneylenders. Insurance payouts for those covered were very low and cases were left pending for months.

Post flood losses were higher for businesses that maintain a large inventory of raw materials (often for just-in-time services) and finished products. For those involved in global supply chains, shutting down production risked the loss of international clients. Most businesses that supplied local clients did not lose customers, although some that had to run production with partly repaired machinery lost clients because of the poor quality of the finished goods.

3. Puri District

Compared with Mumbai and Chennai, Puri district is largely rural, and besides agriculture, its only businesses are in the handloom and handicrafts sector and a few SMEs. The cyclone and floods affected artisan and weaver households by damaging their work shades, looms, and materials (Table 12). Average losses were estimated at 6,925 per artisan household and 5,000 per weaver household.

Table 12: Damage Costs to Handloom and Handicrafts Businesses

Handloom and Handicrafts	Total	Puri
Artisans affected (number)	1,564	722
Work shades damaged (number)	736	4
Handicrafts losses (million)	42.00	5.00
Loss per household ()	26,854.22	6,925.21
Weavers affected (number)	501	12
Work shades damaged (number)	385	10
Raw and finished product damaged (number)	706	9
Handloom losses (million)	5.00	0.06
Loss per household ()	9,980.04	5,000.00

Source: Compiled from Government of Odisha, ADB, and World Bank. 2013.

SMEs losses included damage to buildings, plant and machinery, raw materials, and finished products (Table 13). Losses suffered by SMEs from Cyclone Phailin and floods in Puri district totaled 14.8 million, and the average loss per SME was 126,495.

Table 13: Damages Suffered by Small and Medium-Sized Enterprises

Small and Medium-Sized Enterprises	Total	Puri
Units affected (number)	1,039	117
Buildings damaged (million)	41.97	7.20
Plant and machines damaged (million)	28.76	1.60
Raw material damaged (million)	43.58	6.00
Finished products damaged (million)	20.75	0.00
Total loss (million)	135.06	14.80
Per unit loss ()	129,990.38	126,495.73

Source: Compiled from Government of Odisha, ADB, and World Bank. 2013.

CHAPTER 5

FINDINGS AND RECOMMENDATIONS

FINDINGS

- A natural disaster is a **major adverse event resulting from natural processes of the Earth**; types include floods, hurricanes, tornadoes, volcanic eruptions, earthquakes, tsunamis, storms, and other geologic processes.

- A natural disaster can cause loss of life or damage property, and typically leaves some economic damage in its wake, the severity of which depends on the affected population's resilience and on the infrastructure available.

- **Earthquakes, cyclones, volcanic eruptions and floods** are some of the hazards we live with. But we can lessen the impacts of these hazards on our lives and livelihoods by following Disaster Risk Reduction (DRR) strategies. These strategies help societies prepare and respond to hazards, and therefore reduce the associated risks to vulnerabilities.

- The disaster preparedness is the main weapon against the disaster may it be before, during and after a disaster and this can be enhanced by forming effective mitigation strategies.

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RECOMMENDATIONS

- Disaster management organizations should take advantage of opportunities for adoption of existing technology or adjustment of policies and procedures that would allow significant short-term enhancement of disaster management.
- The federal government should do more to prepare for the projected frequency of severe disasters, such as improving interagency coordination and providing more realistic budgeting for disasters.
- We should plan how our household would stay in contact with each other if separated by a disaster. Identify two meeting places. One should be near your home in case of a emergency, and the other should be away from home -at a neighbor or family member, in case you cannot return home.
- More awareness should be spread out in both the rural and urban areas. The people should be imparted the knowledge of the dos and don’ts, the precautionary measures and the mitigation strategies.

CHAPTER 6

CONCLUSION

Floods account for more than half of climate-related disasters in India and cause damages of $54.63 billion during 1990–2017. Global warming and climate change are expected to increase the frequency and intensity of these disasters. Mean annual rainfall and extreme single-day rainfall events are also projected to increase in frequency and intensity. The scale of the impacts of these extreme events on people and ecological systems depends on vulnerability and exposure. Calculations of losses are usually lower-bound estimates because of the presence of a large informal economy and the difficulty of monetizing indirect impacts. Impacts are further intensified by socioeconomic factors such as increasing population, rapid urbanization, infrastructure expansion in high-risk zones, and the large number of people living in informal settlements in poor and destitute conditions. These factors underscore the need to characterize and analyze the impacts of extreme precipitation events on different actors in the economy and society and to formulate policies and plans to mitigate them.

The types of impacts can typically be classified as damage to housing structures (floor, roof, walls); households assets (provisions, furniture, documents); appliances (lights, fans, refrigerator, washing machine); vehicles (bicycles, motorbikes); and work tools (carpentry tools, sewing machines). Although poor households face lower damage costs in absolute terms because they own so little, in relation to their earnings their damage costs are higher than those of better-off families. Overall, flood-affected households experienced damage to assets in which their life savings are invested (houses) or on which their livelihood depends (work tools, livestock). Extreme events therefore threaten the critical asset base of poor families. Households also had to cope with indirect impacts of floods, such as shortages of food, water, and fuel, and disruption of services. Workdays and even jobs were lost after the floods. Therefore, people faced loss of assets, livelihood, and access to basic services with obvious financial implications over the short to medium term to rebuild their lives and restore their assets to preflood levels. Compensation and social protection are partial. In Mumbai and Chennai, the government offered some households a fixed amount as compensation to assist with immediate needs such as food and clothing. However, this amounted to less than 10% of total losses suffered by households across different socioeconomic strata. Many households, such as migrant workers in Chennai or families who had lost their documents and could not prove their identity or place of residence, were excluded as this made them ineligible for compensation. In Puri district, if compensation had been offered under the new notification of central and State Disaster Response Funds, it would have been inadequate to rebuild lives. Families that have limited resources and lack access to compensation mechanisms or government social protection had to use their savings or borrow from informal sources to rebuild their lives. This pushed them into indebtedness and poverty, negating the gains made by poverty reduction programs. Insurance coverage is

low. Penetration levels of general insurance are dismally low in India. More than 90% of the affected families had no insurance of any kind, let alone property or flood insurance. Even when families opted for insurance, claim settlements were lengthy, time consuming, and generally did not cover the full extent of the losses. Impacts on small businesses. Impacts for retail businesses and SMEs can be classified as damage to premises (physical structure, flooring, roof, doors, and windows), equipment (air conditioning, heating, electrical and communication systems), and material (finished products, raw material, inventory). Most of the damage cost related to physical structure. Losses of finished products, inventory, and raw materials were also extensive. Besides the cost of damage, businesses also had to cover the immediate expenses of cleaning their premises, restarting operations, or temporarily moving production elsewhere. Overall, small businesses were more vulnerable to flood impacts than their larger counterparts because of their more limited technical and financial capacity and the absence of effective business continuity plans. They took longer to recover and lost customer confidence as a result. Businesses had to use their funds or borrow to build back to preflood levels. Compensation and insurance. None of the businesses in the three locations studied reported receiving government compensation for their losses. As profit-making ventures, they may have been left to fend for themselves using their own resources. A few SMEs that had opted for flood insurance received less than the claimed amount after months of delay. Thus, compensation and insurance did not help businesses cope with flood impacts and rebuild. Business continuity. After the Mumbai floods, business recovery time averaged 3–4 days, with some taking 1–2 weeks. In Chennai, where waterlogging affected many areas for a long time, businesses began staggered operations after 1–2 weeks. SMEs were without power, water, and other basic services for 10–15 days, impacting business continuity. As the losses from floods were unexpected, businesses took a long time to recover. Many could not repay loans taken from financial institutions. Loss of credit and clients increased their distress, and some businesses sold their assets and closed operations. Besides the assessment of direct and indirect impacts, households shared experiences about rescue and relief operations in the aftermath of floods. These experiences demonstrate why well intentioned efforts may not reach the beneficiaries. In Chennai, for example, rescue operations and relief material only reached houses located along the roadside. Those who lived in interior parts of affected areas received nothing. When food packets and other material were airdropped, they were scattered and people could not reach or use them. In Chennai and Mumbai, people did not receive any flood warning, and by the time they realized the intensity of rainfall, the floodwaters had already entered their homes or flooded access roads. Even when compensation was offered, government officials declared many affected households ineligible because of their migrant status or other reasons. In some areas, people who had been relocated from other hazard-prone areas in the past were affected once again in the supposedly safer areas. Experiences like this raise many questions about the quality of rescue, relief, resettlement, and rehabilitation processes. To conclude, insights offered by the assessment and characterization of flood impacts on households and businesses help us understand and appreciate how extreme events affect people and the assets they have built as financial protection or to improve their lives.

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