

INTEGRATING LOCAL KNOWLEDGE IN ADAPTATION TO DIFFERENT TYPES OF DISASTERS: A CASE STUDY OF THE SUNDARBANS

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Abstract: The Sundarbans is a cluster of low-lying islands. It is spread about 10,000 sq km across India and Bangladesh, of which 40% lies in India. Sundarbans name has been taken from the Heritiera tree, the one of the most abundantly growing mangrove trees and are called 'Sundari'. As per 2011 census 4.37 million people living this area. The Sundarbans are direct threat of several environmental problems like: Global Warming, Changing Landscapes, Biodiversity Lost, Wildlife at Risk Rising Sea Level Increased Risk of Drought, Fire and Floods, Stronger Storms and Increased Storm, Damage More Heat-Related Illness and Disease, Economic Losses etc. The study aims to assess the coastal community's resilience comprehensively by adopting a multiple community-based approach in the eco-fragile delta for disaster risk management of Indian Sundarbans. The Local knowledge has different sets of ingredients to foster the development of the relational or holistic approach as it involves, interacts and interconnects humans, non-human (animals and plants) and nature together, setting a perfect balance for sustainable development. The study also makes some recommendations and offers an action plan for fostering disaster resilient communities where conservation and enhancement of ecosystem services remains central.

Key words: Climate change, Adaptation, Community-based approach, Disaster, Disaster risk management.

1.1 Introduction:

The Sundarbans is a cluster of low-lying islands. It is spread about 10,000 sq km across India and Bangladesh, of which 40% lies in India. Indian Sundarbans (IS), situated in the Ganga-Brahmaputra-Meghna delta, is home to numerous rare, endangered, threatened floral, faunal and microbial species. Sundarbans name has been taken from the Heritiera tree, the one of the most abundantly growing mangrove trees and are called 'Sundari'.

As per 2011 census there are approximately 4.5 million people living in and around the Sundarbans delta. In the absence of any industry, the local population in this region dependent on agriculture. Both the people who have land or landless supplement their income by fishing, collecting, farming tiger prawn seeds and exploiting the mangrove forests, which causing to damage to marine biodiversity.

Amphan affected over 60% of the state's population, killed 98 in Sundarbans, collapsed more than 100 km of embankments and 176,000 semi-permanent houses. It cause great damage in 5 block (Sandeshkhali-I, II, Minakhan, Hasnabad and Hingalganj) of N. 24 Parganas. In Canning II (of S. 24 Parganas), almost 25 km of land was affected by saline water due to Amphan (20thmay,2020). Almost 70-80 poultry farms of Sandeshkhali-I, II and Hingalganj was completely devastated. Salt-water inundation of agricultural lands has made farming infeasible for three consequent years. Cyclone occurrence is not an un-common incident in Sundarbans. Moreover, toxic trace metal pollution in mangroves of Sundarbans, sea-level rise is further aggravating the situation. Higher erosion rates than in the past due to combined effects of artificial sediment traps upstream and higher water discharges; increased potency of tidal bores increased population growth from 1951 to 2011.

The Sundarbans are direct threat of several environmental problem like : Global Warming, Changing Landscapes, Biodiversity Lost, Wildlife at Risk Rising Sea Level Increased Risk of Drought, Fire and Floods, Stronger Storms and Increased Storm, Damage More Heat-Related Illness and Disease, Economic Losses etc. Therefore, to combat and reduce climate risks it is necessary to enhance awareness of coastal people about their local climate risks, its probable extent and after effects so that it will be possible to formulate appropriate mitigation measures with the active prior preparation and participation of local peoples.

Aim of the study: The present work aim to provide a new bases for integrating local knowledge in Disaster Risk Reduction (DRR) activities in the Sundarbans. This think about tries to discover out how human reaction and adjustment to common risks. This straightforwardly challenged the standard logical see which had made light of the potential of innate information. The More specifically, it acknowledges that local knowledge and practices should be used to “complement scientific knowledge in disaster risk assessment” and to “develop policies, strategies and plans” for DRR (UNISDR, 2015, p. 15). By doing so, the study consider eventually contributes to making a better environment for both indigenous and for scientific communities. With these points the study focuses on the following question:

1. What are the challenges within the integration of local information with DRR as well as conditions that contribute to such challenges within the Sundarbans?
2. How we can integrate local knowledge with DRR within the Sundarbans be moved forward?

Importance: The Sundarbans is a big area of mangrove forests in Bangladesh and India. It is where three big rivers meet, and it has a lot of different plants and animals. In 1987, the Sundarbans was named a very special place by UNESCO. Then in 1989, the Indian government said it was a protected area for plants and animals. The Sundarbans has a lot of different plants and animals, and some of them are in danger of dying out. This includes the only group of very rare Royal Bengal Tigers that live in a mangrove forest near the coast. Sundarbans has 300 kinds of plants and about 425 kinds of animals, like the Gangetic Dolphin and Irrawady Dolphin. The Sundarbans have 85% of the mangrove habitats in India and 63 out of 69 types of mangrove plants in the country. At least, seven of these types of mangrove trees are in danger and need to be protected

right away. This includes *Aegiceras corniculatum*, *Heritiera fomes*, *Kandelia kandel*, *Nypa fruticans*, *Rhizophora* spp., and *S. Apetala* and *S.* The people who live nearby really need the mangroves because they use them for food, wood for fires, materials for tanning hides, fish to catch, honey and medicine. The Sundarbans helps the environment by providing food for coastal water, creating nutrients through mangrove roots, and adding biomass to the area. Mangroves drop about 6,000 tonnes of dead leaves and other plant materials per hectare every year, adding a lot of nutrients to the environment. These natural processes have turned the brackish waters of the Sundarbans into a special place where lots of important fish and sea animals are born and raised. Also, the mangrove swamps and backwaters act as a barrier to cyclones, tropical storms, and tidal surges. They protect the inhabited areas and the coast, and help keep the shoreline stable.

Definition and character of local knowledge: Many people have tried to define what local and indigenous knowledge means, but there is no exact definition. According to UNESCO's program on Local and Indigenous Knowledge Systems (LINKS), local and indigenous knowledge refers to "understandings, skills and philosophies developed by societies with long histories of interaction with their natural surroundings" (Hiwasaki et al., 2014). The intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) defines indigenous and local knowledge as "the multi-faceted arrays of knowledge, know how, practices and representations that guide societies in their innumerable interactions with their natural surroundings" (MoSTE, 2015). To synthesize definitions found in relevant literature, local and indigenous knowledge can be understood as 'a body of different types of knowledge and practices of societies accumulated through a continuous interaction with their natural surroundings' (Brokensha et al., 1980; Fernando, 2003; and Sillitoe, 2000).

Types of Local knowledge: Categorized local knowledge and practices into five groups based on how they were learned: (a) watching animals; (b) looking at the stars and planets; (c) observing nature; (d) tools and objects; and (e) traditional and religious beliefs and customs.

Hiwasaki et al. (2014) classified local knowledge and practices into five different categories based on acquisition methods: (a) observations of animal behaviour; (b) observations of celestial bodies; (c) observations of the environment; (d) material culture; and (e) traditional and faith-based beliefs and practices.

Value of Local knowledge in Disaster Risk Management

Many indigenous communities in the Sundarbans region have many ways to respond to disasters. In the Amphan disaster in 2020, it was clear that local and indigenous knowledge about disaster risk reduction (DRR) was very important. Different communities and people had their own ways of dealing with the disaster. People and groups with traditional knowledge about tornadoes were able to survive them. For instance, the Mawalli community in the Sundarbans noticed that when animals and nature acted strangely, it meant a cyclone was coming. With their knowledge of the

area, the community was able to get away from the sea and find safe places to stay. On the other hand, many other groups of people, like migrants and tourists, did not see the signs and could not leave the dangerous area. This shows how people in the community can use what they know to react fast and do a good job.

Countless practices adopted in many indigenous communities in the Sundarbans region have demonstrated a deep understanding and ability to respond to disasters. The importance of local and indigenous knowledge about DRR became clear in Amphan in 2020, when it was recognized that many different communities and individuals responded to disasters in different ways together. Communities and individuals who held indigenous knowledge about tornadoes were able to survive them. For example, from traditional folk tales, the Mawalli community in the Sundarbans recognized signs such as unusual behaviour of animals and nature as signs of cyclones. Using this local knowledge, this community escaped from the sea to protected areas. In contrast, many other communities, including migrants and tourists, failed to identify these signs and were unable to evacuate the danger zone. This shows how local actors can use their knowledge to respond quickly and effectively.

1.2 Study Area:

Sundarbans is the biggest delta in the world, made by the Ganges-Brahmaputra River system. The Indian Sundarbans is located on the northeast coast of India and covers an area of 9630 square kilometers. It is surrounded by the Raimangal river to the East, the Hooghly River to the West, the Dampier Hodges line to the North, and the Bay of Bengal to the South. The creeks in Sundarbans have 56 islands of different sizes. Some of these islands let freshwater from the high land flow through them.

Sundarbans is the largest delta in the world formed at the formed at the Ganges-Brahmaputra River system. The Indian Sundarbans is situated in between latitude 21°32'-22°40'N and longitude 88°22'-89°0'E in the north east coast of India occupy 9630 square kilometre and surrounded by Raimangal river in the East, Hooghly River in the West, Dampier Hodges line in the North and Bay of Bengal in the South. There are 56 islands of various sizes in Sundarbans creeks, some of which act as pathways for freshwater discharge from upland. The world's

In 1997, the Sundarbans was given a big award by UNESCO for being the biggest Heritage Site. It's a group of many islands that cover 9630sq km in India and 16370sq km in Bangladesh. In India, it covers two areas: 13 parts in South 24 Parganas and six in North 24 Parganas. It has 19 administrative sections. According to a 2011 survey by the Indian government, about 4.5 million people live in and around the Sundarbans delta. The Sundarbans delta has formed over the last 300 years. The islands are flat, wet, and are still being made. They are divided by a system of tidal rivers.

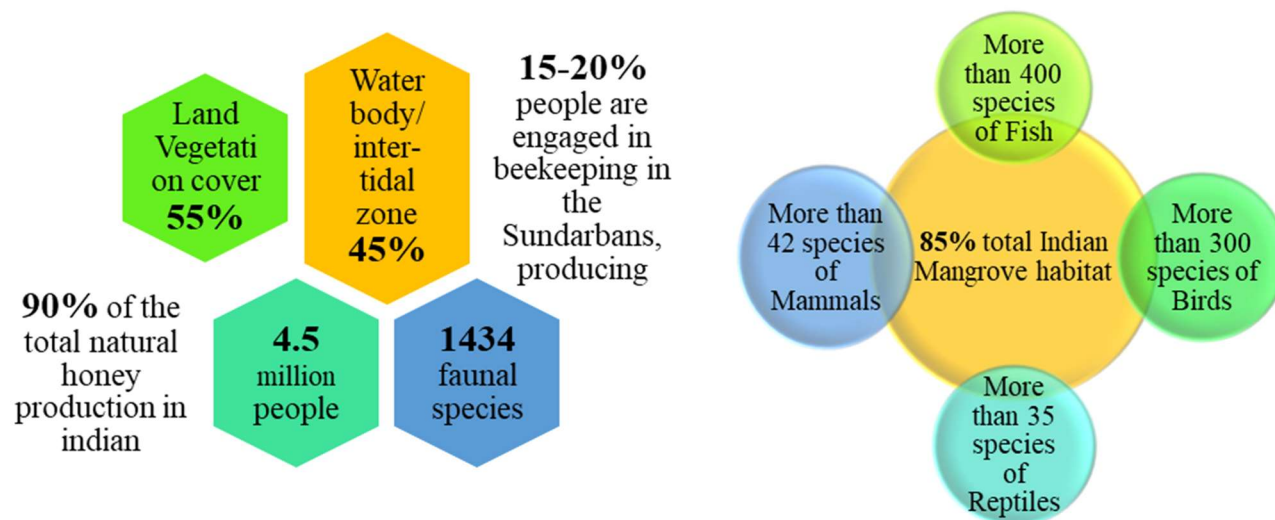
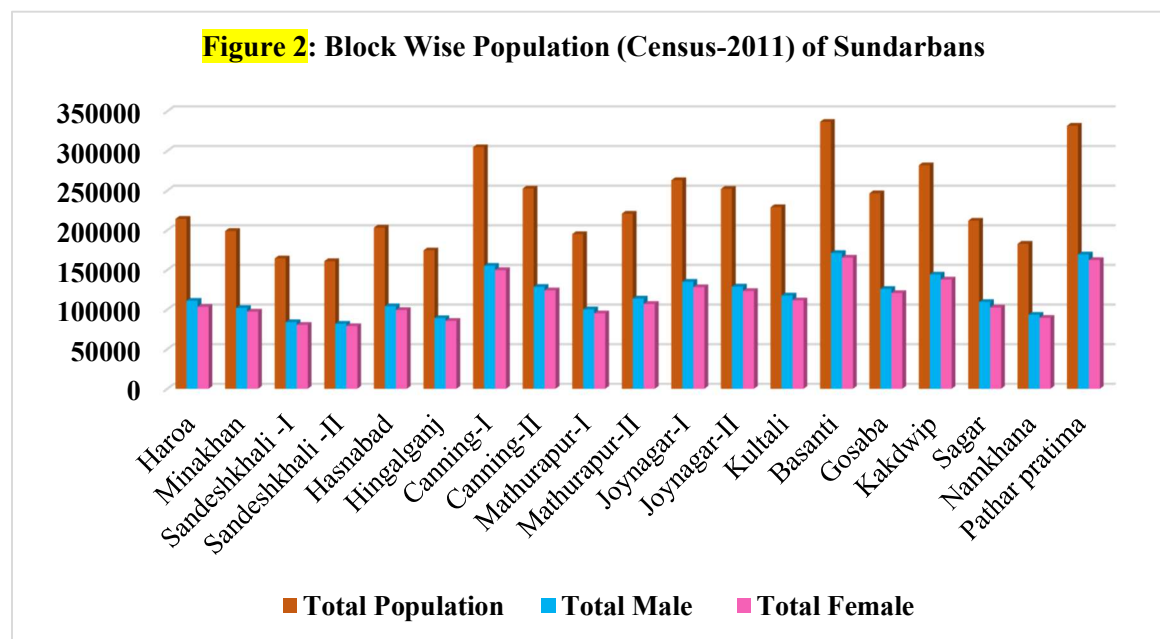


Figure 1: Sundarbans and biodiversity statistics

largest Heritage Site awarded by UNESCO in 1997, the Sundarbans is an archipelago of several hundred islands, spread across 9630sq km in India and 16370sq km in Bangladesh. On the Indian side, it extends over two districts: 13 blocks in South 24 Parganas and six in North 24 Parganas. It comprises 19 administrative blocks. As per 2011 census conducted by the



The Indian government says there are about 4.5 million people living in and near the Sundarbans delta. The shape of the Sundarbans Delta has formed over the last 300 years. The islands are flat, wet areas of land that are still being formed. They are separated from each other by tidal channels and strong tidal currents. Erosion and sediment build-up are always happening. New land is constantly being added, but at the same time, some parts are wearing away in a natural process.

The Sundarbans delta has a lot of tidal waterways, mudflats, and small islands with mangrove forests that can survive in salty water. It's a good example of how nature keeps changing and growing. The Sundarbans is really important for people and many make a living from it. Some of the things people do are farming, fishing, cutting wood, and collecting honey. The Sundarbans, including its plants, animals, and the people who rely on it, have been around for a long time. Many plants and animals are in danger of disappearing. Many books, songs, and movies in Bengali and Indian English have **praised** the Sundarbans. Sundarbans is in West **Bengal** and the people there follow Bengali **culture**. **It's all forest, so the lifestyle** is tribal.

Government of India, there are approximately 4.5 million (Fig: 1 & 2) people living in and around the Sundarbans delta. The Sundarbans Delta has taken its current shape over the past 300 years. The islands are low, marshy, alluvial plains that are still in the process of being formed through and these are separated from each other by a network of tidal channels and siltation and powerful tidal currents, a continuous process of erosion and accretion. As new land is added to the existing mass, some parts are eroded away as part of a natural cycle.

The Sundarbans delta is intersected by a complex network of tidal waterways, mudflats and small islands of salt-tolerant mangrove forests, and presents an example of ongoing ecological processes. Not only is the Sundarbans ecosystem of enormous value to mankind, millions of people are generating their livelihood from the resources of the region. Some of the activities include agriculture, fishing, woodcutting, honey collection etc. However, the Sundarbans, its flora, fauna and the people who depend upon it, are in danger. Many of the species of flora and fauna are endangered. The Sundarbans has been celebrated in numerous Bengali language and Indian English novels, songs and film. Sundarbans being a part of West Bengal, the people follow Bengali culture; since it is total forest area tribal life style is followed.

The average maximum and minimum temperature are 34°C and 20°C respectively. Rainfall is heavy with humidity as high as 80% as it is close to the Bay of Bengal. The monsoon lasts from mid-June to mid-September. Prevailing wind is from the north and north-east from October to mid-March and south-west westerlies prevail from mid-March to September. Storms which sometimes develop into cyclones are common during the months of May and October. Sundarbans where a highly vulnerable system would be a system that is very sensitive to modest changes in climate,

where the sensitivity includes the potential for substantial harmful effects, and for which the ability to adapt is severely constrained.

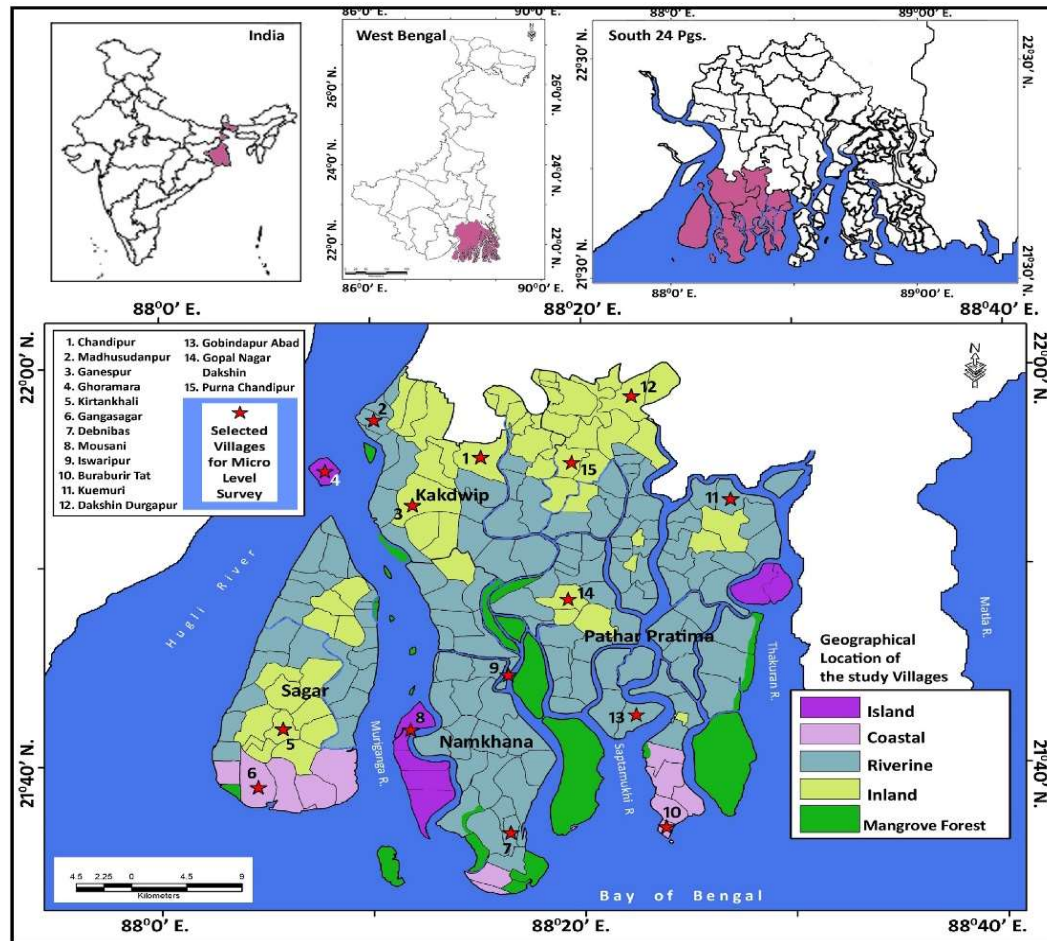


Fig: 3 Location Map of Sundarbans

1.3 Methodology:

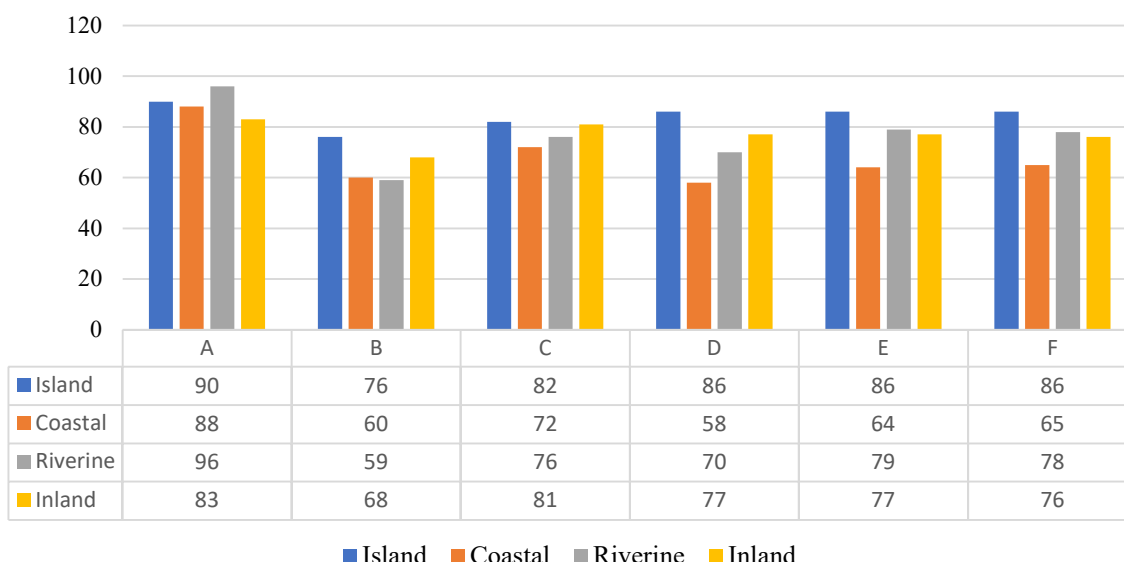
The following section presents and elaborates on the methods of data collection and analysis employed in this study. While investigating the research question, the author adopted a qualitative research approach, because it does not study a fixed and uniform reality, but rather many forms of reality constructed through meanings, experiences and social actions of people (Creswell, 2003). These are important features to this study because the integration of local knowledge with Disaster risk management might be understood differently in various contexts.

1.5 Results and Discussion:

1.5.1. Climate changing hazards:

Many people in Sundarbans have experienced cyclones, floods, salty water, lack of rain, and rivers getting smaller. A study showed that many people experienced cyclones, high tides, and floods. 91.67% of people experienced cyclones, 66.67% experienced high tides, and 50% experienced floods. The people had to deal with river erosion, tsunami, and heavy rain causing flooding. The people who live by the coast always experienced natural disasters. They experience multiple disasters every year. The disaster really made it hard for Sundarbans to develop in a sustainable way. Cyclones, big waves, flooding, and river erosion were some of the worst disasters that hurt the lives of our people, especially in the coastal area. Living near the coast is dangerous because the people who live there are at risk of many natural disasters like cyclones, floods, and erosion.

Fig:4 Distribution of hazards in Sundarbans during the past 20 years



Note:

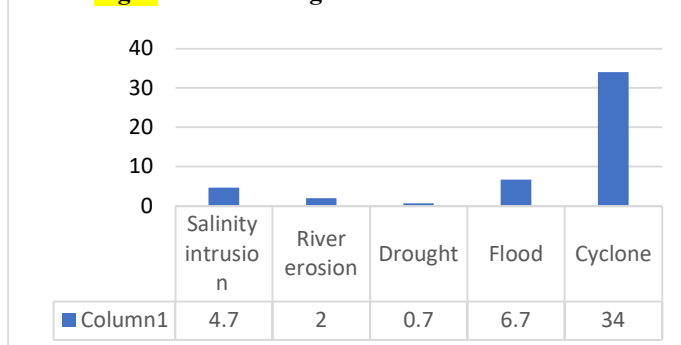
(A) Shows Frequencies of severe Cyclones has increase in number and its intensity. (B) Shows Ground water salinisation has increase due to sea level rise and embankment breaching. (C) Shows Earthen embankment severely damaged due to Cyclones tidal surge. (D) Shows Height of Tidal surge and Cyclonic Surge has increased. (E) Shows Coastal erosion is increasing and (F) shows water logging and constantly evident after cyclones and in Monsoon.

The dangers of hurricanes, high waves, and floods are focused in certain areas of the Sundarbans.

1.5.2. Devastating natural disasters:

The fishers are more at risk because extreme events like cyclones, strong winds, and big waves happen often. In the past, there were many bad weather events in the region, like floods, cyclones, and tidal surges. These caused a lot of damage to people's homes and fishing equipment. Some people even started fishing illegally to make up for their losses. Most of the disasters were shown in the chart in figure 5. Many people said that the 2020 storm Amphan was more dangerous than the 2019 storms Bulbul and Fani, as well as the storms Komen in 2015 and Aila in 2009. People said that cyclone Amphan was going to hit in the evening. Many people knew about the disaster, but it caused more damage than expected. Many people, animals, and birds were hurt. About 72 people died, and many more lost their homes. Between 2010 and 2021, 93 big disasters happened in Sundarbans. Climate change caused a lot of problems for the people living in the coastal areas. The Sundarbans, a coastal area, was hit by two very strong cyclones in 1970 and 1991. These cyclones caused the deaths of about 500,000 and 138,000 people in the area.

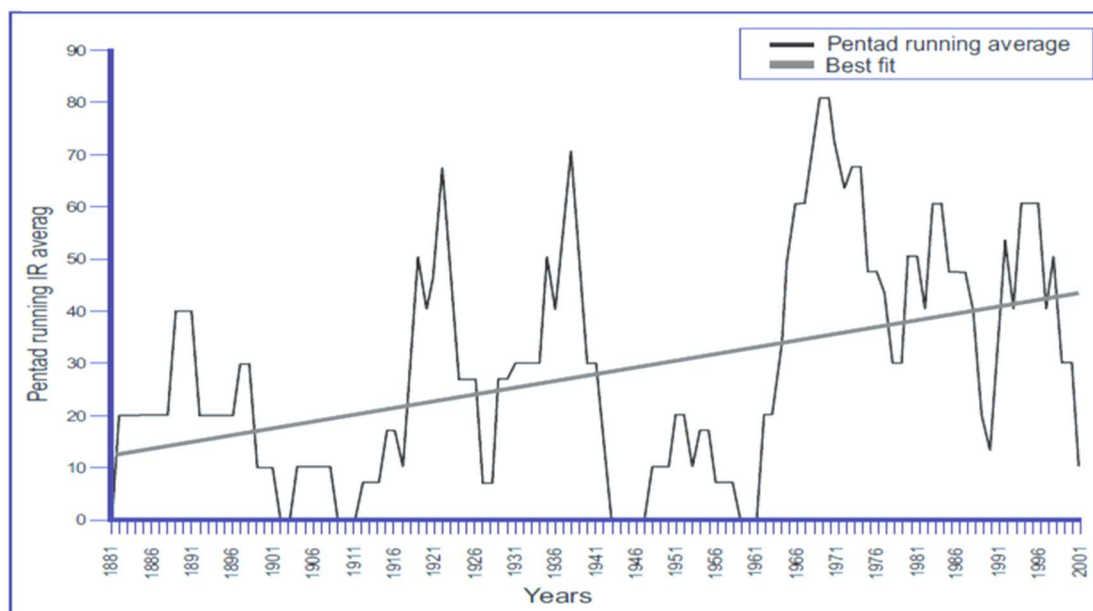
Fig.5 Climate change hazards of Sundarban.



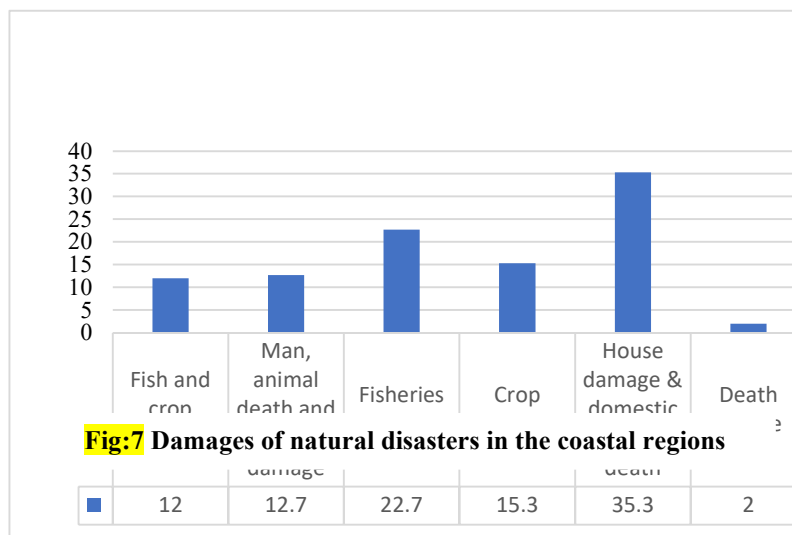
1.5.3. Damages of natural disasters:

This study discovered that some people experienced death, damage to their homes and their animals, and damage to their crops and fisheries. The study also found that some people experienced a combination of these problems. Natural disasters caused a lot of damage by destroying homes, trees, roads, and dams. They also caused the deaths of people, animals, and birds. Additionally, they damaged fish farms and croplands. Sagar, Namkhana and Pathar Pratima in

Fig:6 Rise of frequency of severe cyclonic storm over Bay of Bengal during the past 120 years



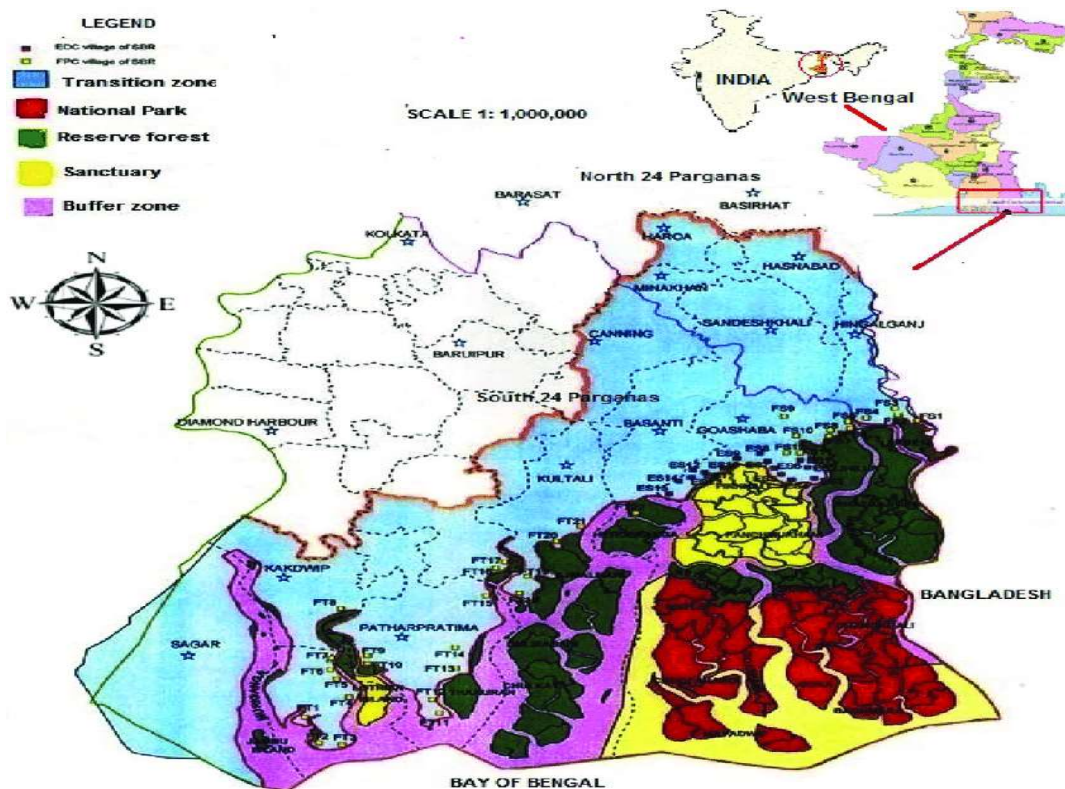
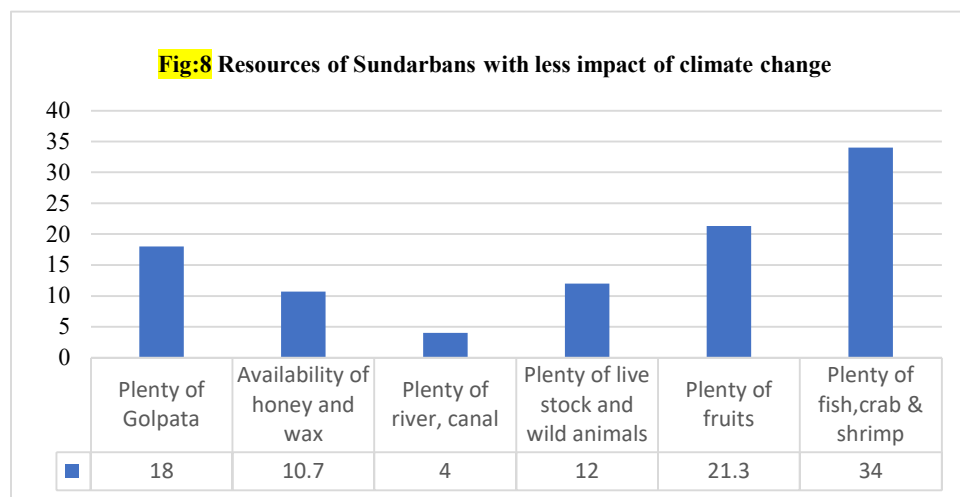
the south-west part of the Sundarbans were very badly affected by cyclones Aila and Amphan. The big wave from the storm destroyed all the houses, farms, gardens, and animals in the area, causing a lot of damage to people's lives and how they make money. Aila and Amphan caused a lot of problems in those areas and made things very chaotic. The cyclone Amphan damaged 25% of the Sundarbans Forest. About 8-10% of the forest is completely damaged and 15% is partly damaged.



1.5.4. Resources of Sundarbans before frequent occurrence of natural calamities:

It was found that 34% of people said there were lots of fish, crab, and shrimp. 21% said there were lots of fruits. 12% said there were lots of livestock and wild animals. 4% said there were lots of river and canal. 11% said there was honey and wax available. 18% said there were lots of golpata. The Sundarbans is a big mangrove forest with a lot of natural things. It's a home for many different animals like fish, birds, reptiles, and others. There were a lot of Sundari trees (*Heritiera fomes*). The local people gathered golpata leaves to use for making roofs. Mangroves were a great place to get wood for building houses and making things like firewood and fishing poles. Mangrove trees were used to make honey and wax, which were really valuable and could be sold for a lot of money. The forests and marshes of the Sundarbans are important homes for wildlife and also help clean the water and add nutrients to the environment. The forest helps to keep nutrients and dirt in place, protects against storms, keeps the shore from eroding, and stores energy. The Sundarbans had a lot of different types of fish. This place helped 27 groups of families and 53 kinds of fish that live in the open sea, 49 groups of families and 124 types of fish that live near the ocean floor, 5 groups of families and 24 kinds of shrimps, 3 groups of families and 7 kinds of crabs, and 8 kinds of lobsters. We found 334 different plants in the Sundarbans and nearby area. These included 165 types of algae, 13 special orchids, 17 types of ferns, 87 types of monocotyledons, and 230 types of dicotyledons. They belonged to 245 different genera and 75 different families. The main type of tree was Sundry, covering 73% of the land, and the second type was Gewa, covering 16% of the forest. The plant collection had 35 legumes, 29 types of grass, 19 sedges, and 18 euphorbias. Out of 50 different types of mangrove

plants found worldwide, the Sundarbans have 35 of them. The impressive animals on land were the Royal Bengal Tiger, spotted deer, barking deer, and wild boars were abundant. Other than the jungle cats, there were also fishing cats, civet cats, monkeys, Bengal foxes, jackals, water monitors, and snakes. These were important animals in that area. Furthermore, in the Sundarbans, there are many different kinds of birds like herons, egrets, storks, kites, doves, parakeets, pheasants, woodpeckers, and more. Some animals like wild buffalo, deer, and rhinoceros are extinct, and others like amphibians, reptiles, birds, and mammals are in danger of becoming extinct. This paper was written to create a new understanding of the environment in the Sundarbans mangrove.



1.5.5. Resources of Sundarbans after frequent occurrence of natural calamities:

People who use natural resources said that there is not enough fish, crab, and shrimp (29%), there are not enough trees (23%), there are not enough animals (13%), there is less honey and wax (9%), and 26% said there is not enough golpata (Figure 11). Climate change made less resources available. Saltwater increased as the sea level rose, and because of this, freshwater fish lost their homes. One study found that if the sea level rises by 25 cm, 40% of the mangroves would be lost. The people in the area noticed that the really hot weather made the land not able to hold as much water, so the trees didn't get enough water and died. The rain didn't come on time, so animals and fish couldn't have babies. As a result, the number of fish went down every day. The tree died because there was not enough rain, there was too much salt in the soil, and it was too hot. This caused there to be less honey each day. The river and canals were filling up with mud, so it was harder for plants and animals to live there. More people in these areas might be poor because they have difficulty making a living and face tough environmental conditions. People in these areas mostly relied on the things around them like the forest for their jobs, such as farming and fishing.

Figure 10: Monthly frequency of cyclone

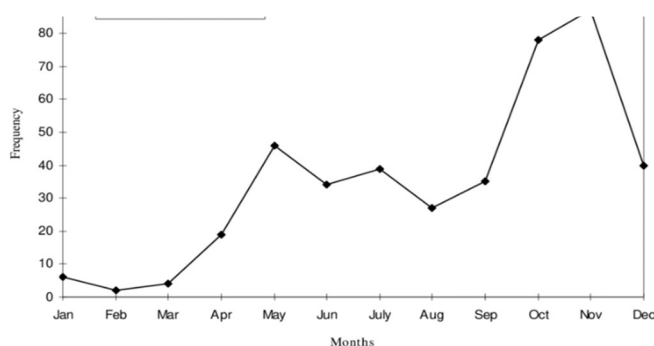
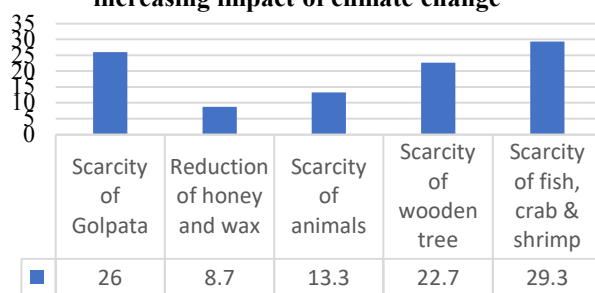


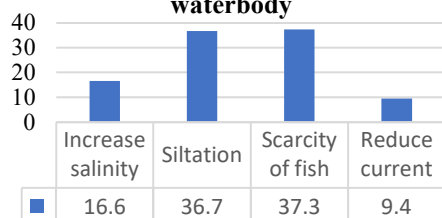
Fig:11 Resources of Sundarbans with the increasing impact of climate change

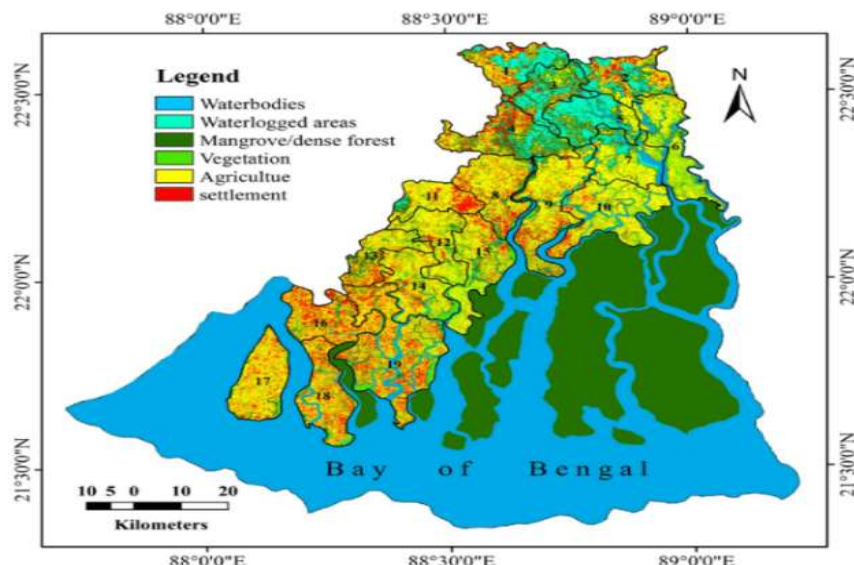


1.5.6. Impact of climate change on water body:

Rivers, canals, and swamps stopped flowing, and the number of fish and other water animals decreased a lot every day. Salty water went into the canals with fresh water. Silt buildup in rivers, canals, and swamps caused flooding when it rained. Water moving in rivers and canals. The Sundarbans helped to push away salty water from the sea. The Sundari trees are in danger because the salt in the water is increasing, and it could get worse if the sea levels rise.

Fig:12 Impact of climate on the waterbody





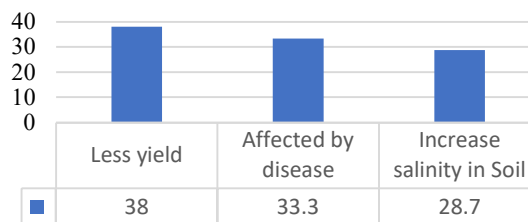
1.5.7. Climate change impact in Agriculture:

Fig:13 Distribution of area

Research has proven that because of climate change, crops are not growing as well as they used to. This is causing them to be more easily affected by disease and the soil is becoming saltier. Currently, the saltiness in river water has made the flooding problems from Cyclone Amphan worse. The big waves during the storm went over the rivers' edges and flooded the farmland with salty water.

This means that even after the water goes down and the land dries up, the salt in the soil will still make it hard to grow crops, feed animals and grow trees. For a long time. Diseases, pesticides, and insecticides harmed farm crops. The chemicals used to protect the crops mixed with water and made the water dirty.

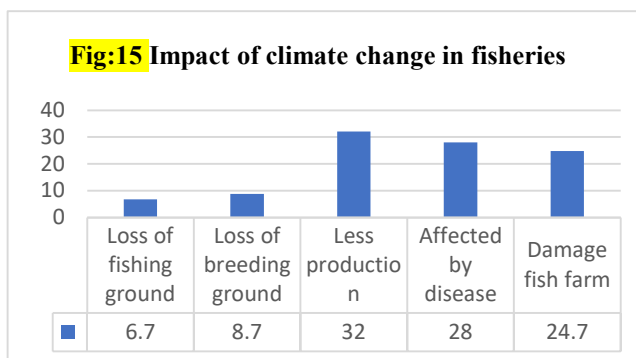
Fig:14 Impact of climate change in agriculture



1.5.8. Climate change impact in fisheries:

Climate change changed how many fish there are in the ocean and where they are found. Shifts in water temperature and rainfall impact how ocean currents move, the flow of rivers, and the size of wetlands. This would change how ecosystems work and how many fish there are in different places. More floods, droughts, and storms can make fishing harder and could harm homes and buildings near the water. Services and things like roads and bridges could also be damaged. Warmer water could make adult Hilsha fish mature and spawn earlier. This could change the time they usually migrate to freshwater rivers and estuaries to spawn.

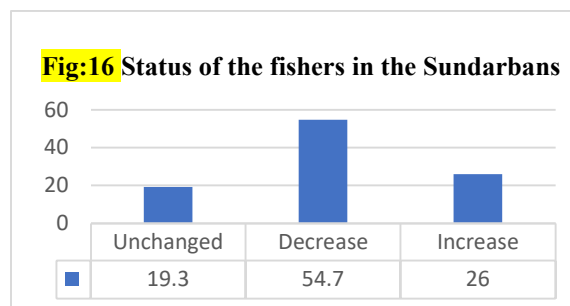
Fig:15 Impact of climate change in fisheries



1.5.9. Status of fisherman of Sundarbans:

Less fish is available because the climate is changing, so there are fewer fishers every day. Climate change made some communities more likely to be affected, depending on their status and where they are located. During a big storm called Aila, a fisherman said in a newspaper interview, "The water came suddenly and took away my children and my house. " Fishermen also said that they are more at risk during natural disasters because they are out fishing, and their families suffer the most because they live in coastal areas. However, there were some fishermen who fished because they didn't have any other job options. Research shows that 85% of the women living near the coast were working in shrimp farming. Most of the women were busy collecting baby shrimp from rivers and marshes near the coast. The saltiness of the river water was getting higher and it was making it hard for people in those communities to live the way they always have.

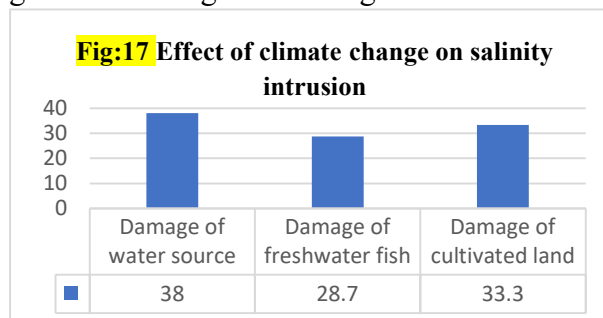
Fig:16 Status of the fishers in the Sundarbans



1.5.10. Effect of climate change on salinity intrusion:

Rising sea levels would harm the forest by causing more flooding and making rivers saltier. Less water coming in from rivers, and higher sea levels would make the dry season in the Sundarbans even saltier. Climate change will have a big impact on the Sundarbans during the dry season from November to April.

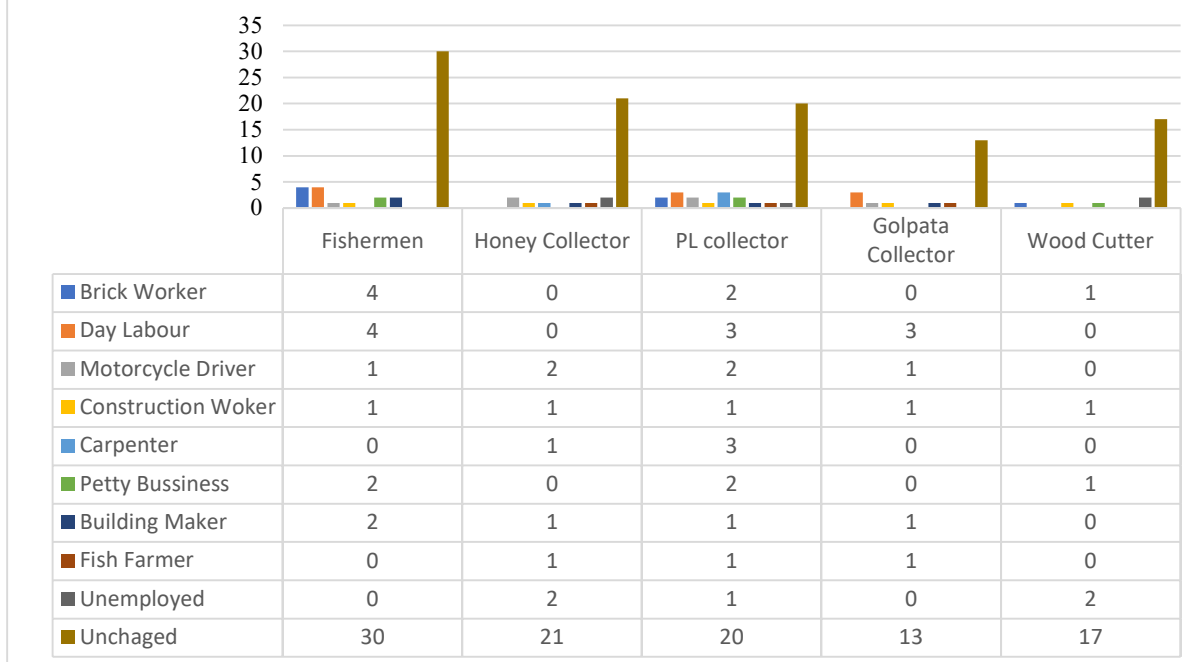
Fig:17 Effect of climate change on salinity intrusion



1.5.11. Occupational changes of resource users:

It was found that 14 out of every 100 fishermen got new jobs, while 30 out of 100 kept their fishing jobs. As for honey collectors, 6 out of 100 changed jobs and 21 out of 100 stayed the same. For

Fig:18 Occupational changes of resource users



post-larvae collectors, 15 out of 100 changed jobs and 20 out of 100 stayed the same. 6 out of 100 golpata collectors changed jobs and 13 out of 100 stayed the same. Finally, 3 out of 100 woodcutters changed jobs and 17 out of 100 stayed the same. 7 out of 100 people became brick workers, 10 out of 100 became day laborers, 6 out of 100 became motorcycle drivers, 4 out of 100 became construction workers, 4 out of 100 became carpenters, 5 out of 100 became patty businessmen, 5 out of 100 became building makers, 3 out of 100 became fish farmers, 5 out of 100 became unemployed, and 101 out of 100 stayed the same. People who use mangrove resources changed their jobs on a big scale. Some stayed the same. In addition, some new things were also included. The mangrove forests support more than 70 different activities that people do, like collecting wood for fuel and fishing.

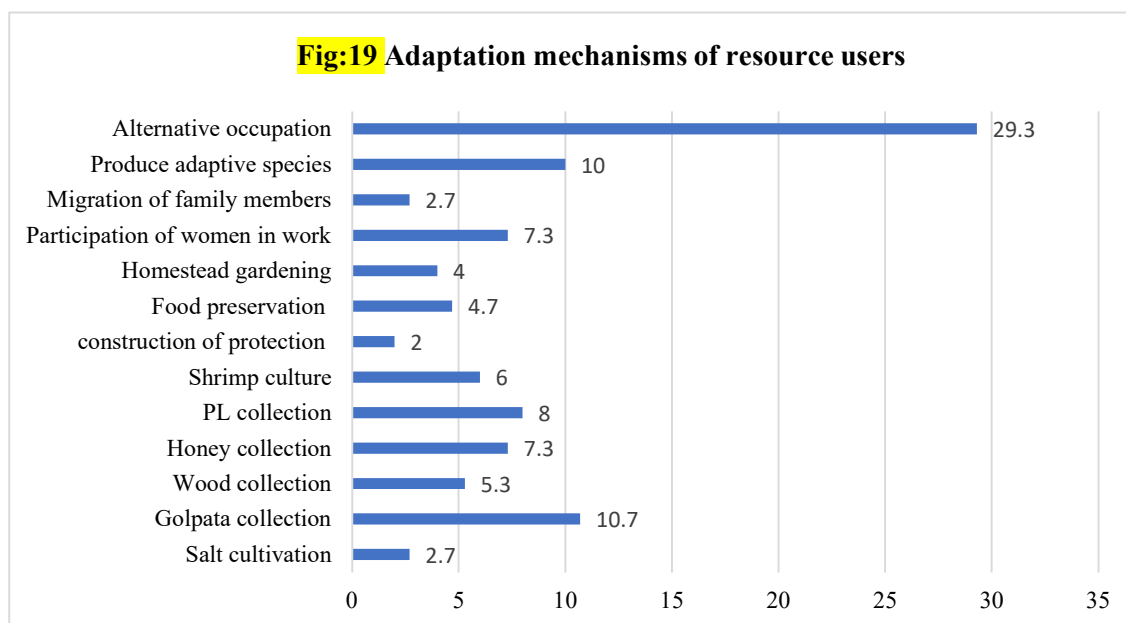
1.5.12. Adaptation of Sundarbans resource users:

The research discovered that 29% of people switch jobs because of the negative effects of climate change on their profession (Figure 19). About 3 out of every 100 people said their family moves to the city, while 10 out of every 100 people are learning new ways to farm rice, fish, and crops that can withstand extreme weather. 7 out of 100 women do work, 4 out of 100 do gardening at home, and 3 out of 100 do salt cultivation. People who lived in the Sundarbans had lifestyles that worked well with the environment there. People built their houses on raised platforms and grew rice that could tolerate floods and salt in the wet season. They protected their land with temporary

walls to keep the salt levels low when there wasn't as much fresh water. The walls were taken down after the crops were collected, allowing the water to move onto the land. During the dry season, people mainly made a living by fishing for types of fish that can survive in salty water. The levels were very high. People were also growing betel leaf as a crop to make money, and it was a good way to earn a profit. But the betel vines were easily damaged by floods and storms. Because of the changing climate, betel leaves got sick and were attacked by pests. Farmers face danger and suffer losses. Women knew that a particular plant grows well in salty water. They planted palm trees, betel nut trees, and sofada trees. A small tree that didn't bring in much money for the family. Women also made things by hand, using their own talents and abilities.

1.6 Findings:

When we look at how the knowledge and traditions of local people can help them adjust to their surroundings, we need to think about how this study can help the Sundarbans improve their ability to handle the challenges of climate change. Experts say that the Sundarbans are at high risk from many things, so it's important to use resources wisely to make them stronger and better able to adapt. West Bengal has started programs like the Sundarbans Adaptation Programme of Action (SAPA) and Local Adaptation Plans of Action (LAPAs) to deal with its weaknesses. The government is making plans to be prepared for the future and to build knowledge about climate change. They want to include ways to deal with climate change in their development plans and policies to make sure they can handle it well. The SAPA was made to help Sundarbans deal with climate change. They are also doing projects to better adjust to climate change. Also, different groups like government agencies, non-profit organizations, international organizations, and



community groups are studying how susceptible people are to disasters and carrying out various plans and activities to help them adjust, lessen the impact, and reduce the risk of disasters. These activities have found important information about the weaknesses, effects, and ways to adjust in different areas of the Sundarbans, but this is not yet included in the main policy process. Projects

and programs in Sundarbans dealing with climate change need to include the knowledge and practices of the local people. It's really important to help local communities, especially women, right away, with the right help, to make them less affected by climate change. We can use the knowledge and abilities of indigenous people, along with their ways of doing things and their technology, to make better plans for dealing with challenges and including everyone. Local communities are not using their traditional knowledge together with modern technologies. Instead, they are getting rid of their old ways of doing things. We might not be able to copy traditional technologies in our plans to deal with climate change, but the knowledge and systems in place might help us deal with the specific challenges we face. (Table 1) shows how the things people do in this study can help with both preparing for climate change and reducing the risk of disasters in the study areas.

Table: 1 *Scientific explanations of selected local and indigenous knowledge documented in Sundarbans.*

Local and indigenous knowledge	Description	Scientific explanation
Observation of the sky and the environment to predict cyclone	Observation of dark towering clouds at the horizon and their movement from winds, in combination with position of beehive in a tree, clam sea-weather during transition period and rancid smell from sea	The cloud formation and movement is Cumulus nimbus cloud type. This cloud is also part of indication of cyclone effects generated around the Indian ocean and the sea-surface. This is also an indication of massive clouds formation process that can accumulate large water volume that can later produce high rainfall.
Observation of the environment to predict flood	When sacred trees (such Sundri, Garan, Geowa) are cut or destroyed the mangrove vegetation, caused the landslide.	When forests are destroyed its loosen or fragile the soil and breaks the natural barrier which prevent flood.
Observation of the animal behaviour	Anecdotal evidence abounds of animals, fish, birds, reptiles and insects exhibiting strange behaviour anywhere from weeks to seconds before the natural calamities. Dog may also sense the change in barometric pressure that comes with storms, causing	This could be due to their keen sense of smell and hearing, along with sensitive instincts. They found out different reactions of various animals for natural disaster like infrasonic vibrations emitted by natural disaster are extremely low-pitched vibrations and animals like cows, elephants, birds can hear low level and interpret vibrations as sign of danger and run for safety.

	them bark, cuddle or hide in an attempt to seek shelter.	
Planting of coastal forest to prevent and mitigate impacts from high waves and strong winds and coastal erosion.	Coastal mangrove forest around the shore where several rows of different species of trees and smaller vegetation grow, which is also considered as a largest mangrove forest of the World.	The forest can effectively reduce the wind velocity blown from the coastal area.
Observing red sky or cloud in north-east (Ishan kon) direction at sun rise.	Local farmers knows that when sky becomes red in north east in the morning that's the sign of heavy rain fall or Cyclonic storm later that day.	A red sunrise can mean that a high-pressure system has already passed, thus indicating that a storm system (low pressure) may be moving from the north-east. A morning sky that is a deep, fiery red can indicate that there is high water content in the atmosphere. So, rain could be on its way
The regional folk tales regarding Bonbibi is an intrinsic adaptive capacity of the local people, in the form of their traditional ecological knowledge and their adaptability to the inhospitable forest.	Bawalis, are the local people who are adept at the process of demonstration, guiding forest workers, especially honey collectors, inside the forest. They are also believed to control storms or prevent ailments, along with power to drive away tigers and evil spirits inside the forest.	At the core of such a placed- based religious framing is a unique perspective highlighting sustainable practices and ecological resilience. The norms for forest workers do not catch fish during certain breeding season and do not extract honey or wood from small flowering trees protect the nature which can also prevent the disaster.

Local communities are engaged in actions to build resilience and adaptive capacity by applying indigenous and local knowledge (Table 2).

Table: 2 Contribution of indigenous and local knowledge and practices to adaptation and resilience building in Sundarbans.

Working strategy applied by indigenous	Adaptation Action
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and local communities	
Integration of modern and traditional technology	1. Building concrete foundations to replace traditional trash dams to divert river water and attempt other innovations. 2. Lining of canals to minimize loss and making cemented weirs to divide water into lower-order canals with equity as a guiding principle. 3. Replacing wooden funnels with metal ones and using plastic pipes in place of open channels to improve flow in water canals. 4. Planting local species (Goran, Sundri, Geowa, Keya) of medicinal plants, grasses and fast-growing trees to increase income and benefits from forests. 5. Using metal wires in place of chains to construct traditional suspension bridges. 6. Using engineering alignment and construction techniques to rehabilitate trails and treks. 7. Combining micro-credit support with local people to form Women's co-operatives.
Synergy	1. Motivation and awareness to resource collector because some times its trigger hazards 2. Surplus labour from agriculture livelihood depends on forest resources extraction 3. Replacing ruins and chain and wooden bridges with modern suspension bridges. 4. Establishing improved water mills and machine-run mills side-by-side with traditional water mills 5. Ban on navigation route for sea-going vessel and cargoes inside the Sundarbans other than the Passur river for control pollution. 6. Strict implementation of Wildlife Act because the Decoits in the Sundarbans often kill the deer, tiger and many other wild-life for meat and skin.
Adapting or Retrofitting	1. Using brick, cement, timber and tins, as well as other construction technologies, to reconstruct ground floors of traditional mud and tile houses to make flood-adaptive shelters. 2. Wooden and chain bridges strengthened with modern suspension-bridge technologies. 3. Regular monitoring of growth and yield, development of MIS and improving harvesting techniques. 4. Restriction on pole cutting and implement the regulation mechanism by the Forest Department.

Others	1. Knowledge exchange and partnerships, facilitating national and regional networks of indigenous knowledge practitioners. 2. Improve natural habitats retention of more mother trees, action research on Phenology and natural regeneration. 3. Eco- friendly land use planning with crop rotation. 4. Determine carrying capacity and, regulate number of tourist and boats. 5. Increase up-stream fresh water inject, increase of Gorai River off-take. 6. River re-excavation of Gorai and Kapataksha rivers.
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A vital include of their procedure is that they address both climatic and non-climatic stresses. Utilizing as a premise a few hones watched within the course of this consider, lessons have been drawn that are valuable for mainstreaming innate and neighborhood information into on-going endeavors to construct strength and versatile capacity. The innate adjustment hones examined over give a number of messages that reflect Sundarbans climate-change arrangement. The SAPA recognizes the significance of inborn information and calls for execution of adjustment measures based on nearby information, abilities and advances. In arrange to assist improve the esteem of neighbourhood information, an effort should be made to gather, synthesize, spread and utilize conventional information, aptitudes, hones and innovations related to climate adjustment and climate affect. This will clear the way for moving forward conventional advances and broadening their utilize in adjustment. To date, inborn and neighborhood information has not been viably synthesized with present day information and the usage of inborn and neighbourhood hones has been incapable. This hole highlights a need of viable approaches and forms for the integration of innate and logical information. At show, the two frameworks are advancing in parallel. The crevice between them ought to be bridged so that inborn information can be mainstreamed into on-going adjustment programs. Concerned organizations can utilize the discoveries of this inquire about to create common approaches, forms and instruments for advancing the trade of information and shared learning between the inborn and logical communities. Approaches and rules should be created for specialists and analysts looking for to gather, spread and utilize innate information related to climate alter adjustment. There's as of now a arrangement provision for considering and moving forward conventional information, but it has not been enough actualized. Moreover, there's deficiently action to empower the co-production of commonsense knowledge-based apparatuses to meet the differing needs of Sundarbans adjustment programs. This will be accomplished through ceaseless discourse between holders of inborn information and common and social researchers, to co-produce a synthesized information framework custom fitted to the nearby setting. This exchange will got to be reflexive and cultivate the inventive cycle required to rise above disciplinary and ideological boundaries.

1.7 Policy constraints, challenges and limitations:

When utilizing inborn and neighbourhood information and hones to arrange and actualize neighbourhood adjustment programs, the taking after imperatives got to be tended to –

- Recognition: Inborn information and hones still need formal legitimate acknowledgment, indeed in spite of the fact that Sundarbans climate-change approach has recognized them and proposed arrangement measures for their more extensive application. The suggested arrangement arrangements have not been well actualized since there's no direction giving a order to either government or non-government organizations to ponder and archive innate information and make utilize of it in their exercises.
- Levelling the playing field: Indigenous-knowledge frameworks need the budgetary and organization back that present day information frameworks get. There has been small investigate into how they can be corrected for utilize in adjustment and resilience-building endeavors.
- Winning trust and confidence: Inborn communities have distinctive world sees and societies from those of logical and advancement communities. On the off chance that the two are to work together viably, they ought to construct shared believe and certainty. In cases where mental property rights are included, the holders of inborn information may be hesitant to share it.
- Integration and synergy: Innate communities got to gotten to be more open to learning from, coordination into and creating synergies with modern knowledge partners. In arrange to do this, they have to be be made mindful of approaches to, and instruments and gatherings for, locks in in exchange. More critically, both inborn and logical communities have to be gotten to be propelled to work together.
- Capacity-building and networking: Innate communities are unconscious of neighbourhood, national and worldwide climate-change issues and future patterns. They need the capacity to create their versatile hones more versatile and avoid their improper utilize. They have to be expand their systems of clients and increment their support in capacity-building exercises conducted by improvement organizations. Submersion courses, educational module modification and capacity-building modules got to reflect the wants, needs and experiential forms of inborn communities.

1.8 Limitations of indigenous practices:

There are a few impediments to the application of innate and neighbourhood information and hones. Since most of these hones advance in a constrained geological locale and inside the limits of a specific culture, community or society, they are appropriate to that region as it were, and may not work in others. As climate alter may be a generally later marvel it has not however been completely absorbed into innate information and hones. Most neighbourhood communities as it were started encountering the impacts of climate alter around 20 a long time prior and government organization as it were started evaluating these impacts 5 to 10 a long time back. As a result, inborn communities have small encounter in joining inborn information into present day climate-change adjustment forms and government organizations, worldwide and residential non-governmental

organizations and community-based organizations have no strong base from which to assess their viability. For this reason, organizations and governments are hesitant to recognize that innate information and hones can be a key calculate in adjusting to climate alter. For their portion, inborn communities lean toward to put their believe in knowledge procured through hones that have been refined over eras instead of what they see as mechanical experimentation. In spite of the fact that the case considers outline a number of versatile and strong innate hones, these practices are as it were pertinent to current climate inconstancy and may not be viable in tending to long run impacts of climate alter, especially the likely increment in extraordinary occasions. Inborn information cannot unravel all of the problems and challenges that climate alter makes. It reflects the social values and specialized information of the nearby individuals in a particular geological region, so it is site-specific, which suggests that no specific hone can effortlessly be scaled up and reproduced without being tested in and custom fitted to diverse areas. Inborn information and hones are moreover more viable as preventive measures, instead of as apparatuses to repair extraordinary harm. That said, inborn information and hones may well be utilized as a beginning point for adaptation-related decision-making.

1.9 Policy prescriptions:

1. Utilizing Socio-Economic and Caste Census 2011 information (or the most recent accessible), recognize the populace most at-risk to storm harm and storm surge harm.
2. Give help to recognized family units to get to PMAY-G benefits.
3. Give salt-tolerant paddy seeds and cultivating information to rural families from among the recognized family units.
4. Recognize at-risk family units with transitory pros and donate them with income-generating openings, advanced get to to open social organizations, and accounts at their ranges.
5. Recognize urban/peri-/semi-urban regions and contribute in their capacity to oblige transients, as well as address social, social, mental, and financial needs of both the transients and the have populaces.
6. Recognize urban/peri-/semi-urban regions and contribute in their capacity to oblige transients, as well as address social, social, mental, and financial needs of both the transients and the have populaces.
7. Order withdraw enactment that avoids the deal, exchange, recreation and handing down of existing properties in at-risk areas.
8. Offer buy-back of properties in at-risk areas when show proprietors are expired or properties are devastated by a storm occasion.
9. Repurpose emptied arrive for mangrove recovery with the plausibility of inferring private benefits in the event that buy-back choice is unexercised.
10. Advance investigate to get it the obstructions to withdraw approach that coordinating long-term improvement objectives.

1.10 Conclusions:

This chapter checked on and examined the climate-change issues, challenges and adjustment needs from the point of view of innate, destitute and marginalized bunches. It inspected the sources, sorts and nature of climatic and non-climatic powerlessness confronted by neighborhood communities. The discernments of nearby communities almost climate alter were compared with inductions drawn from watched changes in climate. Both nearby recognition and logical investigation of authentic patterns show that normal temperatures in Sundarbans are rising and precipitation is getting to be more whimsical. The hones created and embraced by nearby communities are competent of reacting to stresses in a multi-sectoral setting. A multi-dimensional approach would be more viable in managing with defenselessness than an approach that centers as it were on a single issue since helplessness is by its exceptionally nature multi-dimensional. Neighborhood communities and their educate ought to be arranged to effectively bargain with climate-change vulnerabilities. This implies building their capacity to upgrade (or create) innate and nearby information and hones so that they are prepared to deal with the challenges of building versatility. Inborn information isn't well recognized – in a formal sense – as a source of information for planning and arranging nearby adjustment measures. This will be seen as both a impediment and an opportunity. The Government of West Bengal climate-change approach stipulates that 80% of the budget for climate-change adjustment ought to be distributed to local-level exercises. Mainstreaming innate and nearby information would make roads to meet this target, so long as the government recognizes and advances it. In some cases, government offices and the logical community may see neighbourhood information as lacking to bargain with the complex challenges confronted by Sundarbans neighbourhood individuals. In addition, the reality that innate and nearby information is site-specific implies that whereas it would be most valuable in neighbourhood adjustment, there may be impediments to the more extensive application of particular perspectives of it. Inborn and neighbourhood information and hones ought to be recognized as a premise for executing or changing SAPAs. The application of this information to climate alter adjustment is moderately unused; subsequently, its advancement and utilization ought to start with the expulsion of approach obstructions and the arrangement of monetary bolster for building the capacities of conventional social teach. Both the government and improvement organizations ought to bolster innate and neighbourhood information and hones so that they can be more successfully coordinates with logical information.

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