



Norges miljø- og
biovitenskapelige
universitet

Master's Thesis 2023 30 ECTS

Faculty of Landscape and Society, LANDSAM

Department of International Environment and Development Studies, Noragric

A Study on The Adaptive Capacity of Ecological System and The Sundarbans Community in Response to Climate Change in Bangladesh

Md Mahfuzur Rahman

Global Development Studies

The Department of International Environment and Development Studies, Noragric, is the international gateway for the Norwegian University of Life Sciences (NMBU). Established in 1986, Noragric's contribution to international development lies in the interface between research, education (Bachelor, Master, and PhD programmes) and assignments.

The Noragric Master's thesis are the final theses submitted by students in order to fulfil the requirements under the Noragric Master's programmes 'International Environmental Studies', 'Global Development Studies' and 'International Relations'.

The findings in this thesis do not necessarily reflect the views of Noragric. Extracts from this publication may only be reproduced after prior consultation with the author and on condition that the source is indicated. For rights of reproduction or translation contact Noragric.

© Md Mahfuzur Rahman, May 2023

bdrm99@gmail.com

Department of International Environment and Development Studies, Noragric

Faculty of Landscape and Society, LANDSAM

Norwegian University of Life Sciences, NMBU

P.O. Box 5003

N-1432 Ås

Norway

Tel.: +47 67 23 00 00

Internet: <https://www.nmbu.no/fakultet/landsam/institutt/noragric>

Declaration

I, Md Mahfuzur Rahman, declare that this thesis is a result of my research investigations and findings. Sources of information other than my own have been acknowledged and a reference list has been added. This work has not been previously submitted to any other university for the award of any type of academic degree.

Signature.....

Date.....

Acknowledgement

Whoever supported me in my entire journey.

Gratitude to -

My parents, families, teachers, friends

And also Lars Kåre Grimsby, my supervisor.

Dedicated to –

A better living world for all the species.

Every day the sun is rising,

Starting a new day.

Make sure all of us-

Get the blessings of this ray.

Abstract

This paper delves into the study of the adaptive capacity of the Sarankhola Bazar community residing near the Sundarbans mangrove forest in Bangladesh. The people in this coastal area are intricately connected to the ecological system of the Sundarbans, upon which their livelihoods heavily rely. However, the forest is experiencing ecological imbalances due to the effects of global warming, climate change, and rising sea levels. Furthermore, human exploitation of forest resources has further exacerbated these challenges, posing additional threats to the ecological equilibrium. In response, the government of Bangladesh has implemented strict restrictions on the forest, designating it as a reserve forest and wildlife sanctuary.

The Sundarbans reserve forest is not only a habitat for a diverse array of flora and fauna but is also home to endangered species such as the Royal Bengal Tiger. It encompasses a complex ecological balance between saltwater and freshwater environments. Recognizing the ecological significance and biodiversity of the Sundarbans, UNESCO declared it a Ramsar site and World Heritage Site 1997. While these conservation measures aim to protect the forest, they have resulted in the local community losing access to the forest resources they depend on for their livelihoods. Consequently, the socio-ecological resilience of the Sarankhola Bazar community has been compromised, rendering them vulnerable to socio-economic challenges.

To address the vulnerability of the community, the government has initiated certain measures. However, the effectiveness of these interventions remains a subject of investigation. This paper aims to explore the extent to which the people of Sarankhola Bazar are responding to environmental changes and government interventions. It seeks to analyze the adaptive strategies employed by the community in the face of changing circumstances and shed light on their ability to adapt to the evolving situation. By examining the community's experiences and responses, this research endeavors to contribute to our understanding of the adaptive capacity of vulnerable communities residing in close proximity to ecologically sensitive areas like the Sundarbans.

Table of Contents

Table of Contents	V
Chapter 1: Introduction	1
1.1. Background of The Study	1
1.2. The Sundarbans and local community	4
1.3. Sarankhola: Research Area	5
1.4. Problem statement and research questions	7
Chapter 2: Conceptual Framework	9
2.1. Socio-ecological resilience theory: Resilience, adaptability, transformability	9
2.2. The Adaptive Cycle of Resilience	9
2.3. A case study on The Sundarbans' ecological system and climate change	12
Chapter 3: Methodology	16
3.1 Study Location	16
3.2 Interview Triangulation	17
3.3 Sampling techniques and sample size	19
3.4 Limitations	20
3.5 Interviews	20
3.6 Research Ethics	21
3.7 Data analysis	22
Chapter 4: Analysis	23
4.1. Social-ecological System of Sarankhola	24
4.2. Economic Aspects and Connection with Forrest Conservation	25
4.3. Governance of the Sundarbans	28
4.4. Co Management	28
4.5. Tiger habitation	30
4.6. Potential Employment Alternatives	31
4.6.1. Agriculture: Rice and Vegetables	31
4.6.2. Tourism and Economy	33
4.6.3. Ali Banda Eco Resort	33
4.7. Contribution of Forest pass revenue	34
4.8. Embankment on Balaswar River and Cyclone Shelter: An effort of resilience	35
4.9. The Connection of Vulnerability with The Declaration of Reserve Forest and World Heritage	36
4.10. Vulnerability Assessment	45
Chapter 5: Discussion	47

5.1. Impacts Of Declaration of Heritage Site and Administrative Intervention of Government on The Livelihood and Socio-Ecological Resilience-----	47
5.2. Changes of Ecological Balance for Tourism and Ali-Banda Eco Park -----	48
5.3. Impacts of Shadow Governance: Mahajans -----	49
5.4. Salinity Influence -----	50
Chapter 6: Conclusion -----	51
REFERENCES -----	53
APPENDIX 1 -----	56
APPENDIX 2 -----	57
Qualitative Research: Interview Guide-----	57
APPENDIX 3 -----	59
Assent Form-----	59

Figure 1: Southern Coast/ The Sundarbans: Bangladesh -----	2
Figure 2: Sarankhola sub-district -----	6
Figure 3: Bogi Canal -----	7
Figure 4: Adaptive Cycle of Resilience -----	10
Figure 5: Sarankhola Bazar -----	24
Figure 6: Golpata trees -----	25
Figure 7: Riverbank erosion (Bogi Canal) -----	41
Figure 8: A diagram showing the connections of the variables of socio ecological system -----	46

Chapter 1: Introduction

1.1. Background of The Study

Climate change has significant impact and challenges on human beings, especially those who are directly dependent on the natural environment. This dependence is linked to various factors such as economic activities like agriculture and fishing, socio-economic structure, food security, habitation, migration, and climate adaptation. Climate change is a regular phenomenon, but the term 'climate change' specifically refers to a permanent change in temperature and weather patterns. The traditional agricultural system is heavily reliant on the natural environment, including planting, sowing, and irrigation. However, even with the advancement of modern technology, some places still follow traditional ways.

There is intricate relationship among the environment, society, and the management practice of human. Forests, as a part of environment, are not only vital ecosystems but also serve as a source of livelihood and resources for local communities. However, the delicate balance between human needs and ecological preservation poses significant challenges. Climate change and natural calamities, such as cyclones, disrupt the equilibrium of ecosystems, impacting both the environment and the people dependent on them.

The effects of climate change and natural disasters have deep consequences. For instance, the once-thriving forest and its biodiversity suffer, leading to the loss of crucial species and the distortion of the aquatic system. The local communities, heavily reliant on the forest for their livelihoods, experience the devastating consequences, including the loss of their life, assets. Additionally, the relationship between society and environment extends beyond ecological considerations. Governance, management for conserving the environment can have impact on people's way of living. The involvement of parallel shadow authority, informal moneylenders, highlight the complex social and economic dynamics at play.

The Sundarbans is one such place, heavily dependent on its unique geographical location. This river delta receives significant sediment each year from flash floods and water flows from the Himalayas. At the same time, the saline water connects it to the forest area, creating a unique ecosystem that facilitates flora and fauna of both fresh and saline water (Salam et al., 2000). The habitation, cultivation, and livelihood of people adjust with both characteristics. People

cultivate during the monsoon when fresh water comes and engage in fish farming in saline water during the dry season. Unfortunately, climate extremes are causing loss of food security, biodiversity, species, ecological balance, increased calamity, rising ocean, health risk, poverty, and displacement (United Nations n.d.). This has pushed people beyond climate adaptability, resulting in significant challenges for the region.

Migration is happening as a strategy of climate adaptation in response to the adverse effects of climate change, natural disasters, and other environmental factors in Bangladesh. The increasing global temperature due to climate change is affecting the weather patterns, and this has resulted in extreme weather events such as rising sea levels, floods, droughts, cyclones, and storms. These events have a significant impact on the environment and human settlements, especially in low-lying areas such as Bangladesh.

Bangladesh, a densely populated country in South Asia, is home to the largest inter-tidal delta in the world also known as ‘Ganges River Delta’ (Bangladesh - the World Factbook, n.d.). It has a long coastline along the southern part of the country, which is fed by major rivers originating from the Himalayas and ending up in the Bay of Bengal.



Figure 1: **Southern Coast/ The Sundarbans: Bangladesh**
Source: [Bangladesh - The World Factbook \(cia.gov\)](#)

The mangrove forest, known as the Sundarbans, runs along the coastline of the southern coastline of the country, is a vital source of livelihood and forest resources for a significant portion of the population. The Sundarbans is also known as a natural barrier that protects the coastline from natural disasters like cyclones, floods, and tidal surges.

However, global warming and the resultant sea level rise pose a significant threat to Bangladesh's coastal regions. According to Chen and Muller (2018), almost 40% of productive land in Bangladesh is at risk of being lost due to sea-level rise. If this were to happen, it would displace approximately 35 million people (Ahsan et al., 2014).

Moreover, the United Nations Environment Programme (UNEP) reports that even a one-meter rise in sea level would affect 15 million people, which is 11% of the total population (Ahsan et al., 2014). In addition, 60% of the population would be impacted by river overflows because Bangladesh is a riverine country. Such a rise in sea level would also affect 13% of cultivated land and two major cities.

Floods, on the other hand, cause temporary displacement of habitats during the monsoon season. However, farmers usually return to their homes and continue their cultivation activities once the water recedes. It is worth noting that many local crop cultivators have adapted new strategies to cope with the flood frequency (Chen & Muller, 2018).

Riverbank erosion is a significant impact of climate change in Bangladesh. The erosion of riverbanks causes displacement, destroys farmland and houses, leading to the loss of livelihoods. According to a study by Martin et al (2013), the average displacement due to riverbank erosion is between 50,000 to 200,000 people per year, and the majority of them cannot return to their old place due to the loss of farmland. In addition to riverbank erosion, people also move from cyclone-prone areas due to the lack of job opportunities. Cyclones can cause significant damage to infrastructure, housing, and crops, leading to a shortage of jobs and work opportunities. When the climate becomes too vulnerable for adaptation in agriculture-based economies, people tend to move towards the cities that offer more industrial work opportunities.

Addressing the impacts of climate change on communities like those residing in the Sundarbans requires a holistic approach that considers the complex interactions between the environment,

society, and governance. In this paper, the influence of those factors, including the factors of society has been outlined of the Sarankhola community of The Sundarbans. With the thematic framework, it seeks how the community people develop effective policies and strategies to address these challenges and support climate resilient.

1.2. The Sundarbans and local community

The Sundarbans is located in the southwest part of Bangladesh, in the coastline of the Bay of Bengal. It has two parts, one is in Bangladesh and the smaller one is in the west Bengal province of India (Rahman, 2020). This is the world's largest contiguous mangrove forest and also the largest tide dominated delta in the world (Bangladesh - the World Factbook, n.d.). The forest is so famous for its biodiversity, contributing enormous importance in the local economy and natural ecosystem. For its global importance, it was declared as the Worlds Heritage Site in 1997 by UNESCO (Rahman, 2020). The water outflow through this river delta to the Bay of Bengal is the third largest in the world (Rahman, 2020). It is home of a diversified number of species, such as-fishes, reptiles, birds, mammals, both in the water and the forest including lots of endangered species. This rich presence of fauna and flora made this reserve forest a huge source of livelihood to the local people by resourcing fish, crops, honey, timber, wood, crabs, shrimps etc. (Kibria et Al, 2018). The villagers mainly, along with merchants, pirates have access to this forest resource and forest department (FD), police, and the coast guard are involved in controlling and maintaining forest resources. The FD has the authority that sells the right to enter and collect resources from the forest (Kibria et Al, 2018).

Having a strong relation with the marine ecosystem, the Sundarbans Forest system is facing huge impact from climate aggravations, such as- sea level rising, frequent cyclones, increment of water salinity and the change of seasonal pattern. This is causing a change in the natural balance of the forest, and the density of water has also been affected. As a result, the breathing or prop roots of trees are dying, which is a major concern. These roots have the unique ability to take carbon dioxide from the air, and they are important for the overall health of the ecosystem. The locals heavily dependent on seasonal pattern for crop harvesting, watering the crops, shrimps' cultivation, and other economic activities, which is now impacted due to seasonal change. Frequent cyclones cause tidal surge, loss of physical assets and water salinity. Water salinity pushes to a changing of economic activities and local livelihood gradually to

cultivation of saline water fishes, shrimps, crabs etc. Destruction from sea level rise is far beyond than all the others. People are forced to leave their habitat, temporarily and extreme case, forever. These all together have an empirical effect on the resilience capability of the local ecosystem. IPCC has showed in their report 2014, how climate change is a growing threat to the resilience of coastal forest biodiversity and community viability, particularly in the context of developing countries (IPCC, 2014). The forests, the community based on it, the entire forest based eco system, its resilience and adaptability are in extreme danger due to climate change. Though the Indian part of the Sundarbans and climate adaptability regarding this have been highlighted in much research, but it is difficult to find such study covering the Bangladesh part. Hence, I got influenced to work in this particular area for my master's thesis work.

As the Sundarbans is a huge forest area including thousands of people, it was not possible to include the entire area on the research work. So, I focused on Sarankhola range of the Sundarbans. This range is one of the four ranges of the Sundarbans, which are divided by the forest administration of Bangladesh.

1.3. Sarankhola: Research Area

Sarankhola is a small town situated in the Bagerhat district of the Khulna Division in Bangladesh. Positioned along the banks of the Balaswar river, it serves as the final locality before entering the Sundarbans reserve forest. The primary entry point to the Sundarbans from Sarankhola is through the Sarankhola bazar, which acts as the gateway to the Sarankhola range.

Surrounded by the Balaswar river, the Bhola river, and the Bogi khal canal, Sarankhola finds itself embraced by water on three sides. The Bogi canal connects the Balaswar and Bhola rivers, marking the boundary where the Sarankhola range of the Sundarbans begins. The range is renowned for its remarkable ecosystem, mangrove forest and providing a habitat for numerous rare and endangered species of flora and fauna like the other ranges of Sundarbans.

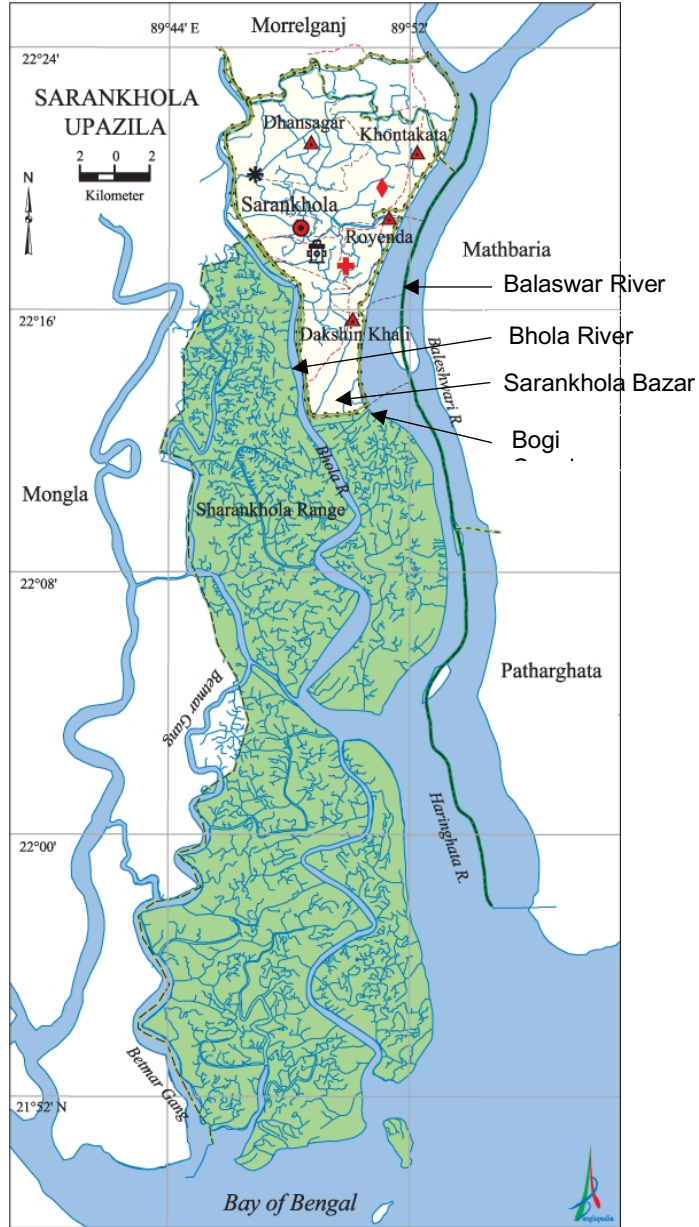


Figure 2: Sarankhola sub-district

Source: (Sarankhola Upazila - Banglapedia, n.d. (2021, June 18))

The Sarankhola range of the Sundarbans attracts a significant number of tourists and researchers who are eager to explore the forest's rich biodiversity and understand its ecological significance. With its diverse array of plant and animal life, the territory is a captivating destination for those interested in nature and conservation.

Sarankhola serves as a vital link between the local community, the Sundarbans reserve forest, and the individuals who wish to take entry into the forest. The town's strategic location near the Sundarbans makes it a focal point for activities such as obtaining permits for the earning livelihoods in the forest, organizing expeditions, tourism, and procuring necessary supplies for venturing into the forest.



Figure 3: **Bogi Canal**
Source: Rahman, M.M. (2023, January 30)

1.4. Problem statement and research questions

Global warming is not a myth anymore. It is happening with the consequences of climate change. Continuously warming weather is melting ice glaciers and causing changing rainfall pattern. It becomes severe when it comes to a densely populated country like Bangladesh. It has a long coastline in the southern side of the country. The Sundarbans, a mangrove forest,

offers rich biodiversity to the ecosystem. The coast is a habit of millions of people. People earn their livelihood from the coastal and forest-based economy. But because of global warming, sea level rising, increasing the level of water salinity towards inland make the life and livelihood difficult for the local people. Government and other social interventions also make their approach towards adaptability changed. In this context, I found it time demanding to work with climate affected people and know their situation. The problem I selected to work with is, 'The adaptive capacity of ecological system and the Sundarbans community in response to climate change in Bangladesh'. The supportive research questions will be-

1. What livelihood strategies exist currently?
2. How have people coped with environmental change and natural disasters before?
3. How people's action has been changed in response to the impact of elements from the society?
4. To what extent fostering adaptive system thinking has occurred in response to climate change?

To explore those questions, the Adaptive Cycle of socio ecological theory will be applied. This theory is a nonlinear complex framework that helps to find the relations of the factors, adaptive capacity and degree of resilience.

Chapter 2: Conceptual Framework

2.1. Socio-Ecological Resilience Theory: Resilience, Adaptability, Transformability

In this paper, it is relevant to discuss in the point of resilience, vulnerability theories into link the socio and ecological context, how people's livelihood in the Sundarbans community are dependent on influence of different factors and influence their adaptive capacity of resilience, what changes or development can make their socio-ecological system more resilience. Resilience is the capacity of a socio-ecological system (SES) to continually change and adapt yet remain within critical thresholds (Folke et al, 2010). In the discussion of resilience in socio ecological context, adaptability comes as well. Adaptability is considered as a part of resilience, "the capacity to adjust responses to changing external drivers and internal processes" (Folke et al, 2010). In the adaptive cycle of resilience, adaptability offers the development in the changing situation taking the opportunities of external and internal actors. And this change to a new stability domain is called transformability, "Transformability is the capacity to cross thresholds into new development trajectories" (Folke et al, 2010). This transformability becomes crucial in the fourth phase, reorganization of adaptive cycle of resilience (Gunderson and Holling, 2002). In that phase, after the collapse of a system because of low resilience against the internal and external forces, with adopting new development going beyond the threshold, transferability occurs.

2.2. The Adaptive Cycle of Resilience

To comprehensively assess and comprehend the intricate interplay between climate change, global warming, and evolving lifestyles, it is crucial to delve into the concept of the 'Adaptive Cycle of Resilience.' This framework, proposed by Gunderson and Holling in 2002, posits that all ecosystems or social systems undergo this cycle, regardless how complex or simple is that. It does not necessarily follow a linear system encompassing four distinct stages: exploitation or growth, conservation, release, and reorganization (Gunderson & Holling, 2002). Following reorganization, a new cycle ensues, characterized by altered adaptability.

In addition to the four stages, the adaptive cycle also incorporates three fundamental properties that aid in understanding and characterizing each stage: potentiality, connectedness, and

resilience. Potentiality denotes the capacity for future change and delineates the boundaries of what is feasible within a given system. Connectedness, on the other hand, elucidates the system's ability to adapt by utilizing internal controls, rather than being solely influenced or regulated by external variables. Lastly, resilience pertains to the system's vulnerability to unforeseen disruptions that may push it beyond its threshold. It is a “concept of healthy, adaptive, or integrated positive functioning over the passage of time in the aftermath of adversity” (Southwick et al., 2014). It reflects the system's capacity to withstand disturbances without succumbing to collapse.

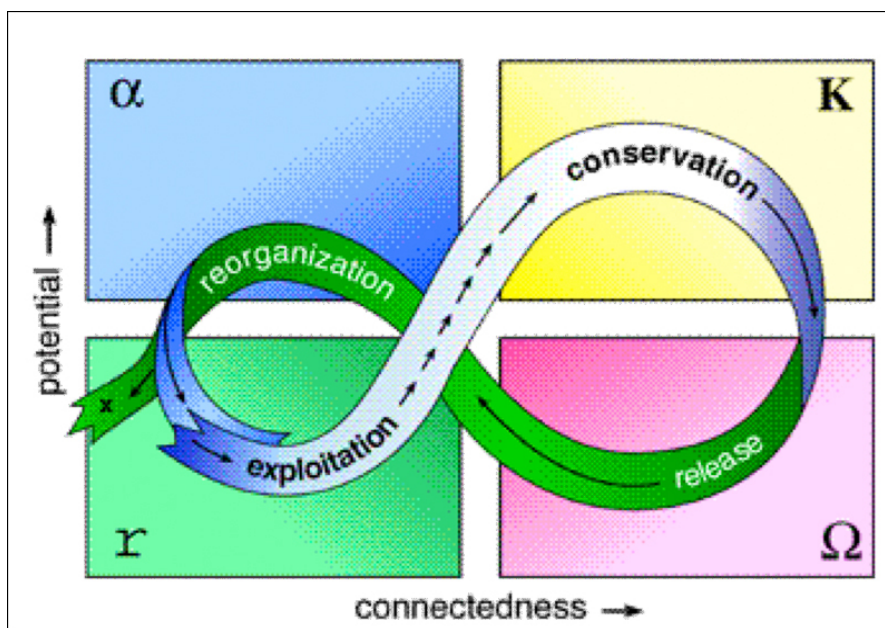


Figure 4: Adaptive Cycle of Resilience
Source: (Valicenti, 2017)

The first stage of the adaptive cycle, known as 'Exploitation' (r) or the growth stage, marks the emergence of internal and external actors within the system. During this phase, there is a tendency to exploit resources rapidly to capitalize on opportunities. The potentiality of this stage is relatively low, as resources are being depleted rather than accumulated. However, the connectedness among ecological factors remains high, which can limit the system's flexibility. On the other hand, the system exhibits a high level of resilience to natural forces, allowing it to withstand external disturbances.

Following the growth stage, the system transitions into the 'Conservation' (k) phase. In this stage, the potentiality increases as resources begin to accumulate rather than being exploited. The system approaches its maximum capacity, and the connectedness among ecological factors

remains high. However, this high connectedness can make the system less adaptable to external vulnerabilities, leading to lower resilience. The conservation stage signifies a critical point where the system becomes less flexible and more susceptible to disturbances from external forces.

The subsequent stage is the 'Release' or (Ω) phase, where the system experiences a collapse due to its low resilience and failure to adapt to vulnerabilities. Resources are lost or severely depleted, resulting in a decline in potentiality and connectedness. The system's ability to respond to external variables is compromised, leading to poor resilience and low adaptability. The release stage represents a period of breakdown and disruption within the system.

Finally, the 'Reorganization' or (α) phase commences, often referred to as the renewal phase. This stage offers a high level of opportunities as the system becomes open to reorganization, creative change, and adaptation. The potentiality of the system is once again high, signaling the potential for new directions and growth. However, the connectedness among ecological factors is low during this stage, as the system is still in the process of formulating itself. Despite this, the resilience of the system remains high, as it is actively undergoing development and is receptive to adapting to external disturbances.

To demonstrate the adaptive cycle of resilience we can consider 'Forest Fire' in the Himalayan region (Wang et al., 2021). It is a regular phenomenon in that area. So, in the growth phase, when trees, grass, and other species colonize a land, can be structured as the Growth (r) phase. In the Conservation (K) phase, growth reach its maximum capacity with balancing with other actors of ecosystem. The system becomes more rigid and less able to respond effectively to challenges. Then dry logs, leaves, litter, grass, debris, bushes make a fuel for the fire in the Release (Ω) phase. Then another factor, such as ignition happens by nature or human in the form of rockslide, lighting, camping, smoking, agricultural work, burning firewood. As a result, collapse happens, causing significant destruction and damage to the forest structure. The fire outbreak serves as a threshold event that disrupts the existing state. In the Reorganization (α) phase, the land starts growing new plants, with habitation of new species. Human community get the opportunity to grow skills to fight against the fire. As a result, a development happens in the socio-ecological system, making it more resilient.

This framework facilitates the identification of critical points where interventions can be implemented to bolster resilience, mitigate vulnerabilities, and foster sustainable practices. Recognizing the potential for change, the degree of connectedness within the system, and the level of resilience exhibited, researchers and policymakers can develop effective strategies to navigate the complexities of climate change and promote adaptive responses for a more sustainable future.

2.3. A case study on The Sundarbans' ecological system and climate change

The Sundarbans, situated along the south-western coast of Bangladesh and extending into parts of India, is renowned as the world's largest mangrove ecosystem (Agrawala et al., 2003). This unique forest region serves as a significant convergence zone between the Bay of Bengal and the delta of the Padma River. The interplay of natural phenomena, such as the flow of freshwater from the river during the rainy season and the intrusion of saline water from the sea during the dry season, profoundly influences the local ecosystem and the livelihoods of the surrounding communities.

The coastal creeks that traverse the Sundarbans play a crucial role in allowing the ingress of saline water into the inland areas. This influx of saltwater contributes to the distinctive ecology of the region. Conversely, the interconnected channels formed by the rivers within the forest act as conduits, carrying away the salinity from the soil. These intricate networks of channels help maintain the balance between freshwater and saline conditions, mitigating the adverse effects of excessive salinity on the local flora and fauna.

Furthermore, the Sundarbans and its unique ecological features have a profound impact on the livelihoods of the local communities. The forest provides various resources and services that support the economic activities of the inhabitants. Fishing, both marine and freshwater, is the primary occupation, driven by the rich biodiversity of the region. Additionally, the Sundarbans serve as a source of timber, non-timber forest products which contribute to the local economy and traditional practices.

The Sundarbans Reserve Forest (SRF) in Bangladesh supports the livelihoods of approximately 3.5 million people, most of whom reside within the forest territory (Agrawala et al., 2003).

These communities engage in various occupations that sustain their daily lives and contribute to the local economy. These occupations can be categorized into two types based on their dependence on the Sundarbans.

The first category includes occupations that are directly dependent on the forest. According to Bangladesh forest law, fishing, leaves collecting, and honey collecting are the only permitted activities within the reserve forest, requiring a forest pass issued by the forest authority.

The second category comprises occupations that are not directly dependent on the forest but are conducted in the adjacent areas. These occupations include farming, timber collection, and other traditional work, which serve as primary sources of income for the residents. During the monsoon season, traditional farming practices are carried out in the Sundarbans. Farmers take advantage of the abundant freshwater flows from the rivers, which is used for the irrigation of crops field. Additionally, there are seasonal activities such as shrimp cultivation and salt/dried fish processing.

Tourism, particularly boat cruises, has also gained popularity within the Sundarbans. However, it is strictly regulated by the forest authority to ensure minimal disturbance to the ecosystem. Visitors require permission to access the forest water territory, allowing them to experience the natural beauty of the Sundarbans while maintaining the integrity of the ecosystem.

The Sundarbans Reserve Forest (SRF) in Bangladesh faces significant threats due to a combination of factors, including rapid population growth, unsustainable exploitation of forest resources, industrial development within the forest territory, and the impact of natural disasters. These challenges pose a severe risk to the integrity and sustainability of the SRF.

In an attempt to protect the land from erosion, the government of Bangladesh constructed coastal embankments. However, this measure inadvertently led to waterlogging problems, as the embankments prevented proper drainage and caused an intrusion of saline water from the sea. The increased salinity disrupted the conventional livelihood systems of the local communities, affecting agriculture and other traditional occupations. As a result, farmers turned to shrimp cultivation, which proved to be more profitable in the altered conditions (Agrawala et al., 2003). To facilitate shrimp farming, farmers artificially inundated the land

with saline water during the low salinity period of the monsoon. Unfortunately, this practice has had detrimental effects on the forestland and the overall ecosystem.

Furthermore, during the dry season when rainfall is limited and natural salinity levels are high, the water flow through the Padma River decreases due to the presence of the Farakka barrage upstream in India (Agrawala et al., 2003). This reduced flow exacerbates the salinity issue and further hampers agricultural production in the region.

Both the coastal embankments and the Farakka barrage have had severe consequences for agricultural activities and the delicate balance of the ecosystem in the Sundarbans. These human interventions, driven by various needs and interests, have led to unintended negative impacts on the agricultural productivity and overall environmental health of the area.

Climate change inevitably has influence on the coastal ecosystem. Most of the rivers flowed through the country originated from mount Himalayas. So, global warming causes influx of fresh water supply which is the reason of flood and fertile sediment at the same time. Sea level rising causes pushes the line of saline water further inland which is devastating for the whole ecosystem.

In this case of the Sundarbans ecosystem and the challenges it faces, we can observe the dynamics of the adaptive cycle of resilience. Initially, before human intervention and disturbances, the ecosystem can be seen as being in the "Exploitation phase." During this phase, the system experiences rapid expansion and growth, with a high level of resilience to natural forces.

As human activities such as coastal embankments and the construction of the Farakka barrage came into play, the ecosystem entered the "Conservation phase." In this phase, the system accumulates resources and adapts to the natural cycles of rainfall and dry salinity periods. The potential for the system to adapt and evolve remains high, and there is a strong connectedness among the internal controls of the ecosystem. However, the resilience of the system to external forces, such as the impact of the coastal embankments or the Farakka barrage, becomes low, leading to a vulnerability to collapse.

The "Collapse phase" occurs when the system reaches its tipping point, experiencing a decline in potentiality and a fragile connectedness. The disruptions caused by the human interventions mentioned earlier contribute to this phase. However, the collapse phase also presents an opportunity for reorganization and change.

The emergence of shrimp cultivation and the adaptation to the year-round availability of saline water can be seen as a transition to the "Reorganization phase." In this phase, the system undergoes a renewal process, with new opportunities and high potentiality for the new system. The resilience of the system increases as it adapts to the changing conditions. However, the connectedness among actors in the ecosystem may be low at this stage as the system is still formulating itself.

Chapter 3: Methodology

In the study area of Sarankhola Bazar, sample are selected based on purposive method to find the peoples experience and knowledge regarding socio ecological response regarding climate change. The population was the people of Sarankhola, who are impacted by climate change and government interference. After collecting data, qualitative method, thematic analysis has been applied with Adaptive Cycle of Resilience to understand the degree of adaptive capacity of the people of Sarankhola.

3.1 Study Location

The study was conducted in the Sarankhola Range of the Sundarbans, a mangrove forest located in Bangladesh. Specifically, the selected study field was Sarankhola Bazar, which is situated in the Sarankhola sub-district of Bagerhat district. Sarankhola Bazar serves as an entry point to the forest and is located at coordinates N 22° 13' 11.532 E 89° 48' 23.112. Situated in the southern part of Bangladesh in the coast of Bay of Bengal, Sarankhola Bazar is bounded by the Bogi Khal canal, which acts as a boundary between the forest and the locality. While the forest is a restricted area, a significant portion of the population in Sarankhola Bazar depends on it for their livelihoods.

For the study, the target population comprised the individuals who rely on the forest for their livelihoods. According to census in 2011, the population of the subdistrict is 119,084 (Sarankhola Upazila profile, 2014). It was determined that including the population from the entire sub-district would not be relevant, as they do not primarily depend on the Sundarbans for their livelihoods. Therefore, the focus was on the people living in close proximity to the forest, as they experience the highest impact from the forest ecosystem. Sarankhola Bazar, a small village, was identified as the most suitable location for the study. The main occupations of the villagers include fishing, honey collection, gathering leaves from the forest, farming, small grocery businesses, restaurants, and an emerging livelihood in tourism.

Sarankhola Bazar is characterized by a tropical climate. The local economy heavily relies on the weather patterns and the monsoon season. The summer season spans from mid-April to mid-June, followed by the rainy season from mid-June to mid-August, which is the period of highest rainfall in the year. During this time, fresh water flows from the upper northern part of the country, which has a significant impact on the agricultural industry in the area.

Rice cultivation is the main agricultural activity during the rainy season, as the availability of fresh water supports crop growth. However, the Sundarbans region is intersected by rivers that carry saltwater from the ocean during the winter season. As a result, the land in the area is affected by salinity and lacks essential nutrients, making it unsuitable for large-scale agricultural development. This is a key reason why the area has not seen significant progress in the agricultural industry, leading the local population to depend on the forest for their livelihoods.

The month of December and January marks the winter season in the area, characterized by little to no rainfall. During this time, many individuals from the community migrate to an island called "Dublar Char" for around 4 to 5 months. Their primary occupation on the island is fishing, particularly catching fish, and processing to dry-salted fish for later sale in the market. This process of drying and salting fish serves as another major source of livelihood during the winter season. However, the high levels of salinity in the soil during this time make it challenging to achieve optimal crop yields.

3.2 Interview Triangulation

For the purpose of my study, I conducted interviews with the residents of the village, Sarankhola Bazar, encompassing individuals aged 25 and above. This age range was selected to ensure that the respondents possessed sufficient knowledge and experiences about the local environment and social structure over time. The participants were chosen from diverse professions, including farmers, fishermen, honey and leaves collectors, small business owners, teachers, social workers, and survivors of Cyclone Sidr in 2007. By including 15 individuals from various backgrounds, I aimed to gather multidimensional perspectives and uncover factual information about the area.

Given that the livelihoods of the villagers directly depend on the forest, their occupations vary according to the seasons. To capture a comprehensive understanding of their experiences, I prepared an interview guide to conduct my interview sessions with the participants. The people in the community were eager to share their insights and responded enthusiastically to my questions. To ensure the selection of appropriate interviewees, I sought assistance from a local contact who is a journalist and actively engaged in social work. This individual provided me

with valuable initial insights about the area and helped me identify potential participants for my study.

However, I encountered a challenge in my interview process, as I was unable to include any women in my sample. Despite the fact that women make up almost half of the population and actively participate in economic activities alongside men, I faced difficulties in persuading them to engage in interview sessions. Shyness, illiteracy, and adherence to social customs were some of the reasons behind their hesitance. Unfortunately, despite my efforts, I could not find any willing female participants for the interviews.

To gain a deeper understanding of the study area and establish rapport with the community, I spent over a week immersing myself in the village at the end of January 2023. On the first day of field work, I took the opportunity to familiarize myself with the local people and the social and environmental context of the area. With the assistance of the local guide, I gathered information about the community and used it to create a diagram to select my sample.

During the interviews, which took place over the course of several days, I engaged with 3 to 4 individuals per day. To maintain the confidentiality and anonymity of the data, the interviews were conducted in quiet locations. Before starting the interviews, I provided a brief explanation of the research context to the participants, emphasizing their rights and the safety of their data. I sought their permission to ask questions and record the interview for accurate data collection.

To further ensure transparency and trust, I discussed the importance of data protection with the interviewees. I explained how their provided information would be safeguarded and protected throughout the research process. By obtaining their commitment and understanding regarding the protection of their information, I aimed to create a secure and respectful environment for the interview sessions.

I maintained a logbook to record bullet notes, comments, personal thoughts, ideas, and connections that emerged during the interviews. This logbook served as a valuable tool for capturing important information, identifying patterns, and noting any gaps in the data. It also helped me to recall specific details and individual experiences when analyzing the data later on.

With the participants' permission, I also took photographs to document and visually capture various aspects related to climate change and its impact on the community. These photographs included images of natural disasters such as loss of farmland or houses, riverbank erosion, as well as pictures depicting the interactions between nature and society.

3.3 Sampling techniques and sample size

In order to gather comprehensive data for the research project, a combination of primary and secondary sources was utilized. The primary source of data collection was the population residing in the 'Sarankhola Bazar' community, located near the Sundarbans, as they directly rely on the forest for their livelihoods and are exposed to the impacts of climate crisis. This population served as the primary focus for gathering information and insights related to the research questions.

To ensure a diverse and multidimensional dataset, individuals from various occupations were included in the study. 15 participants encompassed farmers, fishermen, agricultural workers, individuals involved in collecting forest materials, teachers, social workers, and other relevant professions. By including individuals from different job sectors, a broader range of perspectives and experiences related to the impact of climate change and the Sundarbans could be obtained.

In addition to primary data collection, secondary sources were also utilized. These included existing literature, reports, studies, and other relevant materials related to the Sundarbans, climate change, and the socio-economic aspects of the community. Secondary sources served as a valuable complement to the primary data, providing a broader context and supporting the analysis and interpretation of the findings.

“Sampling is about the process of selecting individuals to participate in research” (Clark et al, 2021). As this is a social research, probability sampling method was not a perfect choice here, which is more related to statistical research (Clark et al, 2021). So, the most optimum method will be ‘purposive sampling’ under non-probability sampling method, mainly designed for qualitative research and find the responders purposely rather random way. That is why it is also known as biased sampling. In purposive sampling approach, “to sampling is more likely to be guided by a preference, which involves selecting people who ‘best fit’ the requirements of the study, according to predefined characteristics” (Clark et al, 2021). In this study, purposive

method has been used to find target people with knowledge and have experienced climate adoptability and screen them out, who is nonrelevant.

To collect data for the research project, qualitative methods were employed, specifically in-depth interviews with observation. This approach aimed to gather rich and detailed information directly from the participants. A sample size of five responders was selected from the population of the Sarankhola Bazar community, ensuring a diverse range of perspectives and experiences. The selected responders were aged between 25 and 60, representing different age groups within the community.

During the interview process, an interview guide was utilized to provide a structure and direction for the discussions. The guide contained a series of open-ended questions related to the research objectives, allowing for in-depth exploration of the participants' views, experiences, and knowledge regarding the Sundarbans, climate crisis, and their livelihoods. The interview sessions were conducted in a conversational manner, allowing for flexibility and the opportunity to delve deeper into specific topics of interest. In addition to the interviews, observation was also employed as a data collection method. Researchers observed the community dynamics, interactions, and activities within the Sarankhola Bazar area, complementing the interview data and providing contextual information.

3.4 Limitations

In the Sarankhola Bazar area, women play a significant role in contributing to the family and social economy. Recognizing their vital contributions and unique insights, efforts were made to include women in the data collection process, encouraged to participate in the study. Which could have ensured a more inclusive and comprehensive representation of the community's experiences and perspectives. But due to difficulties such as shyness, illiteracy, and adherence to social customs, opposed by local political figure, I could not include any woman in this process.

3.5 Interviews

The interview guide for data collection was carefully designed to ensure a semi-structured approach, allowing for flexibility in the discussions while focusing on the specific data needed

for the research. The questions were formulated in a way that encouraged descriptive responses rather than simple yes or no answers. In cases where a yes or no response was provided, follow-up questions were included to gather additional information and delve deeper into the topic.

The questions were sequenced in a logical order to maintain the flow of the conversation and minimize any potential inconsistencies in the responses. This approach aimed to create a comfortable and open environment for the responders, facilitating honest and genuine data sharing. The interview guide (Appendix 2) was designed to be comprehensive, covering various aspects such as local lifestyle, occupation, socio-cultural systems, climate change, and its consequences, as well as adaptability. Importantly, the questions were crafted to be neutral and unbiased, ensuring that no individual's feelings or beliefs were compromised during the interview process.

The interview guide (attached as Appendix 2) was structured based on the main research question, which focused on understanding how the people of the Sundarbans community are responding and adapting to climate change. Sub-questions were used to guide the flow of the interview, allowing for a systematic exploration of relevant topics.

3.6 Research Ethics

In conducting this social research, utmost attention has been given to research ethics to ensure that the boundaries and rights of individuals and organizations involved are respected. Ethical guidelines from various sources, including the Norwegian University of Life Sciences, Norwegian legal authorities, Bangladesh legal authorities, and the social norms and values of the Sundarbans community, have been followed throughout the research process.

The informed consent of the interviewees was obtained, ensuring that their participation in the research was voluntary and free from any coercion. They were provided with written confirmation that their information would be securely stored, and measures were taken to ensure the confidentiality and anonymity of their responses. Personal information was not shared with any third party, and after the completion of the research, all data will be deleted within six months to protect privacy. To further safeguard the data and comply with data

protection regulations, a "Notification form for personal data" was submitted on the website of SIKT, the Norwegian Agency for Shared Services in Education and Research. This step involved informing the relevant authorities about the research topic and confirming adherence (assent form, Appendix 3) to data protection guidelines. The interview guideline was designed to ensure that no individual would be harmed or offended based on factors such as religion, politics, social status, race, gender, or any other personal matter.

3.7 Data analysis

Qualitative data is well known for the abundance of data collected from multiple methods. So, it requires a suitable data analysis method to form data in a fixed pattern, turning into information with trustworthiness. To keep trustworthiness of analyzed information, it needs various aspects shown in Guba's model, such as- truth value, applicability, consistency, and neutrality (Krefting, 1991). This table is applicable to any research regardless is it qualitative or quantitative. Krefting (1991) also shows, throughout the study, from paperwork, field work to information relaxation, different approaches, such as- credibility, transferability, dependability, confirmability, are used to uphold trustworthiness in a solid state.

Out of many strategies, thematic data analysis is widely used for social research purpose. According to my research nature, thematic framework will be the best option for this as thematic provides the platform on existing theoretical framework to the researcher systemically integrates them with each other (Clark et al, 2021). As this paper is a social, qualitative research, based on the information collected through open ended interview, collected data has been organized with social theory to correlate socio-ecological aspects with the existing theory.

Chapter 4: Analysis

The ecosystem inside the Sundarbans, animals, lives below and above the water is unique and diverse, located in the delta region of the Padma, Brahmaputra, and Meghna, three major rivers of the country. Because of heavy rainfall during the prolong rainy season, a huge amount of fresh water, along with sediment and alluvial soil comes from the Himalayas region. It is the world's largest contiguous mangrove forest, area over 10,000 square kilometers and located in both India and Bangladesh. The forest's complex ecosystem is characterized by tidal waterways, islands, and mudflats. Inside the forest area. The complex system has hundreds of canals, small and large river which has enriched the aquatic system. The forest is a home to a wide variety of plants and animal species and birds. Local people believe that the name Sundarbans came from the most available tree of the mangrove forest- 'Sundari'. This tree has breathing root, rising above the soil, that can take carbon dioxide from air for the photosynthesis procedure. Alongside that, the forest has wide variety of plants, including, Goran, Keora, Golpata (leaves), which have a contribution to protect the coastline from erosion and storm surges. The forest is also habitat of thousands of animal species including world renowned 'Royal Bengal Tiger', deer, birds etc.

The Sundarbans' ecosystem is also enriched by a complex network of tidal waterways, like the water flows during winter and rainy season. The ebb and flow of the tides have influence over the habitat of a wide variety of aquatic species, including fresh or saltwater fish, crabs, and shrimp, their presence and quantity.

The Sundarbans reserve forest is a haven for birds, with over 300 species of birds found in the region. These include several rare and endangered species, such as the masked finfoot and the white-bellied sea eagle.

The Sundarbans is home to several human communities for their livelihood, including the indigenous Sundarbans dwellers, who have been living in the region for centuries. These communities rely on the ecosystem for their livelihoods, including fishing, honey collection, and forest products.

4.1. Social-ecological System of Sarankhola

For the purpose of this research project, the study area chosen is Sarankhola Bazar, which serves as the entrance to the Sharankhola range of the Sundarbans. Sharankhola is one of the four ranges of the forest. This selection was made to facilitate the collection of data and conduct purposive interviews. The local population residing in this area relies heavily on the forest resources for their livelihood. For the interview, I found almost every family has earning members directly dependent on forest. Though forest earnings are now mainly seasonal, those people try to do alternative works after any particular season is finished. While there are other traditional economic activities present in the region, such as grocery shops, schools, farming, and various services, the economy is largely dependent on the resources derived from the forest.



Figure 5: **Sarankhola Bazar**
Source: Rahman, M.M. (2023, January 29)

The main focus of this research is on the individuals and communities whose earnings are directly linked to the utilization of forest resources. These individuals depend on the forest for their livelihoods, and their experiences are strongly intertwined with the subject of climate change and adaptation. By studying their perspectives and experiences, this research aims to shed light on the intricate relationship between human dependence on the forest, the challenges posed by climate change, and the strategies employed for adaptation.

Through an in-depth examination of the people living in Sarankhola Bazar and their reliance on the forest, this research seeks to contribute to our understanding of the complex dynamics between human communities and their natural environment. The findings of this study have the potential to inform policies and interventions aimed at fostering sustainable livelihoods, promoting resilience in the face of climate change, and safeguarding the well-being of both the local population and the Sundarbans ecosystem inclusively.

4.2. Economic Aspects and Connection with Forrest Conservation

During the field interviews conducted, it was found that the people directly dependent on the Sundarbans engage in three main occupations, which vary based on the season of the year. These occupations include fishing, honey collecting (known as Mouwal), and leaves collecting (known as Bawali), specifically Golpata leaves. Each occupation corresponds to different periods when these resources are abundant and accessible within the forest.



Figure 6: Golpata trees
Source: The Independent, (2020, December 28)

Furthermore, the region is witnessing the emergence of a promising economic activity—tourism—which has started to contribute to the local economy. Recognizing the potential of tourism, the government has initiated a project to establish an eco-tourism park called 'Ali

Banda Eco Park' in a non-sensitive area of the forest. This eco-park is designed to provide tourism opportunities without disrupting the delicate wildlife ecosystem of the Sundarbans.

Engaging in any of these economic activities requires obtaining permission in the form of a forest pass from the local forest authority. The forest pass serves as a significant source of revenue for the state, contributing to the sustainable management and conservation efforts of the Sundarbans. A forest officer confirmed that, *“this revenue generated from the forest is becoming a vital source of government revenue, increasingly each year”*.

It is worth noting that in the past, there were no time-bound occupational restrictions, and activities such as tree cutting, deer hunting, and the collection of forest resources were not regulated. However, as the ecological importance of the Sundarbans became apparent, it was recognized as a natural shield against natural disasters. Consequently, apart from fishing, honey collecting, and leaves collection, all other activities within the forest are now prohibited throughout the year to ensure the preservation of the ecosystem's integrity.

The aquatic ecosystem of the Sundarbans is heavily dominated by saline water, but during the rainy season this river delta gets huge amount of fresh water through the rivers flowing from the upstream of the country. So, both saltwater fishes and freshwater fishes are available there in different season. Saltwater fishing is mainly during the winter, from October/ November to February/ March of the year, in the lower part of the forest near the ocean. And during the rainy season, from April/ May till winter, with the inflow of fresh water, the upper side of the forest rivers becomes the source of freshwater fish. Main fishes are hilsha, prawn, crab and numerous local fishes that are mainly used for dried-fish industry. In June/ July or August, fishing is prohibited in the Sundarbans, as it is considered as the breeding season of fish. This season can be extended from two months to three months, decided by the Ministry of Fisheries and Livestock of the country. Tourism, boat ride inside the forest waterways also goes under prohibition to protect the breeding and hatching area of fish. In this season, a large number of forests' depending people lose their earnings and have to find alternative sources- such as, agriculture, small grocery business, day labor etc., which is never enough for compensating their economic loss. Some people have to migrate temporarily in bigger cities, such as- Khulna, Chattogram, Dhaka to find work.

Except these three earnings activities based on forest, agriculture, growing rice, mustard seeds, vegetables are also a big contributor of the economy. Though, the forest adjacent land area is not ideal for farming because of high level of water salinity. Where, the other agricultural lands of the country can be cultivated for two or three harvest in a year, this Sundarbans adjacent land allow only one. So, the area is not in the optimum level of food security. In dry winter season, it becomes more difficult to cultivate crops because salinity level goes higher. Though, the country's rice research institute (BRRI) has developed some salinity resilient species of rice, it never become popular because of lack of literacy, technology, economic freedom, poverty cycle etc. of the people.

Because of the geographical location, nature, disasters frequency, climate influence, the local people heavily dependent on the forest and the nature. Traditionally, the forests' resources are the main source of livelihood for the people. Though, governmental control, declaring the Sundarbans as world heritage site and a reserve forest, the access has shrieked to the forest over the time with reduced activity. Though, government has taken measures to promote eco-tourism in the area for contributing tourism and the economy, the alternative work opportunities are still not adequate. Besides, the initiative of establishing an eco-park in the forest's non sensitive area will take time to start contributing the economy. People also have both positive and negative opinions regarding the eco-park inside the forest, where they are anxious that the harmony of the ecosystem may get interrupted and also expecting that new employment opportunities will be created.

Despite of those activities, the social and economic freedom is still yet to achieved to the general people. While they need to purchase forests pass from the forest administration to go inside and collect resources, the access to social and financial capital are also limited to the marginal people. Poverty and ignorance, lack of skills and knowledge made them dependent on few numbers of people, locally known as 'Mahajan' who controls the access to the resources, social, human, and political capitals. They are owning the fishing boats, fishing equipment, capital asset, control to the market access, tourist boats, relationship with forest administration and political figures. So, the situation is not in favor to the marginal people to get assets, access to the capital and other resources and have to depend on the Mahajans.

4.3. Governance of the Sundarbans

For the proper administration of the forests, the portion of Bangladesh side has been divided into four ranges- Sarankhola, Chandpai, Khulna and Satkhira. Those administrative ranges work under the control of Sundarbans Forest circle. This forest circle is regulated by Bangladesh Forest Department for the management and conservation of the forest. Four ranges implement the regulations with its own office. Major tasks of this local office are to issue forest pass, accommodating tourists and visitors, implementing conservation activities with the help of police, coast guards and local people, conducting census and research on demand of local and international. The entire organogram is regulated under the Ministry of Environment, Forest and Climate Change of Bangladesh.

For the conservation of the forest and to involve people there are numerous local and national volunteer organizations are actively working in the forest adjacent locality. One conservation procedure is co-management that aims to empower the local communities with the believe that power will ensure their involvement with responsibility. This allows the community to participate in decision making process of forest management and use of forest resources.

4.4. Co Management

The Sundarbans is a home to a unique ecosystem that includes a variety of plant and animal species. To protect this important ecosystem, the government of Bangladesh has implemented a co-management approach to involve local communities in the management of the forest.

The co-management approach involves law enforcement bodies working together with local people, including fishermen, bawali (leaves collectors), and mowali (honey collectors). The goal is to raise awareness about the importance of the forest and to provide alternative employment opportunities for those who depend on it.

To achieve this, the government has established several organizations, including the Village Conservation Forum (VCF), Co-Management Organization (CMO), Co-Management Committee (CMC), and Community Patrolling Groups (CPGs). These groups work together to

manage the forest and its resources, while ensuring that the rules are followed and the forest remains a protected area.

The community-based volunteer platform, Village Conservation Forum (VCF) aiming various co management activities in a sustainable way including- forest conservation, climate adaptation, making social awareness, giving alternative employment plans, arranging capacity building workshops, awareness-raising campaigns, and community-based initiatives such as mangrove planting and ecotourism.

One important aspect of the co-management approach is the use of community patrolling groups (CPGs). These groups are responsible for protecting the forest and its waterways, which are considered reserved areas for fish and fish breeding. The CPGs patrol the waterways and investigate any illegal activities, such as illegal fishing or poaching, or any work which is prohibited by the authorities, that could harm the ecosystem. They also work to safely return wild animals, such as tigers, deer, back to the forest if they are found outside of it.

In the past, the forest was open for everyone for collecting resources without any or low restrictions. Hunting tiger or deer, fishing all the year regardless of the season, cutting down trees were common phenomena which is now banned by the authority. Before the co-management approach was implemented, it was common for people to kill and consume wild animals as well as to reserve their skin or other parts as trophies when they were caught. With the co-management approach in place, these harmful practices have been significantly reduced.

The co-management approach is an effective way to manage the Sundarbans and to involve local communities in the protection and conservation of this important ecosystem. The use of CPGs, in particular, has proven to be an effective way to protect the forest and its resources. While climate change remains a concern, the government and local communities are working together to address these issues and ensure the long-term sustainability of the forest. The people have started realizing the importance of the Forest that it is more than a source of livelihood, rather a shield against natural disasters such as flood, cyclone, riverbank erosion, that happen more frequently almost every year. Specially, after the deadly attack of cyclone Sidr in 2007, the community has lost a significant number of people and assets. The destruction of cyclone Sidr made to reserve the forest more willingly rather forcefully and find alternative source of livelihood.

4.5. Tiger habitation

Tigers are fascinating creatures, known for their solitary nature and territorial behavior. They prefer to live in their own area, which can be as small as 30 square meters, and are very protective of it. While tigresses are allowed inside, other tigers are not welcome. They mark their territory with claw marks and recognize each other's presence through body odor.

When it comes to food, tigers are known to eat around 8-10 kg in a single meal, with their preferred prey being deer, followed by pigs and monkeys. They can eat up to 75-76 deer in a year. It's no wonder that their conservation is crucial for the survival of these animals in the wild.

To ensure the safety and well-being of tigers, governments and international organizations conduct tiger censuses using various methods such as trapping and camera surveillance. However, local people have doubts about the effectiveness of this method as they argue that the nature and characteristics of the forest and tiger eventually the entire ecosystem are not entirely perfect for the camera tapping method. They believe that the tiger population can vary from season to season and from one area to another. They also argue that the counting process is affected by various factors such as weather, food availability, and habitat.

According to the locals, tigers prefer warm and comfortable weather and tend to shift their habitat depending on the season. During summers, they prefer to stay in areas with cool breezes from the ocean, while in winters, they prefer warm and less-cold sheltered areas. They avoid wet and muddy areas and try to find dry and relatively elevated locations during the rainy season.

The local people also have a different opinion about the number of tigers present in the forest, with the official number being 114 in last census of 2018 (Tiger Census Begins in Sunderbans Jan 1, n.d.), but many of them believing it to be higher. They suggest that a whole survey of the entire forest, divided into four ranges, would provide a more accurate estimate. They also emphasize that camera surveillance in a specific area during a particular season may not provide a comprehensive count, as tigers tend to move around the forest. For example, if camera trapping is done in the ocean side during winter, it may not provide a complete picture of the tiger population, as tigers tend to move to the inner parts of the forest during this season.

4.6. Potential Employment Alternatives

Due to government restrictions and the declaration of the Sundarbans as a World Heritage site by UNESCO, general entry into the Sundarbans has been restricted. This means that even the people who depend on the forest for their livelihoods are now limited in accessing the area. However, during specific seasons, access to the Sundarbans can be obtained through forest passes issued by the forest authority.

The Sundarbans region, including Sarankhola, is not suitable for large-scale agriculture due to the presence of salinity in the soil. This poses a significant challenge for the local population as agriculture is the primary industry in the country. The high salinity levels in the soil make it difficult to cultivate crops and severely impacts agricultural productivity. As a result, the people in Sarankhola have experienced a loss of earnings, which has had a detrimental effect on their livelihoods.

Although the government and local authorities are making efforts to explore alternative options and provide support, these initiatives are still in the pilot phase or have limited impact in compensating for the economic losses faced by the community. The search for viable alternatives to mitigate the impact of salinity and provide sustainable livelihood opportunities for the people of Sarankhola is an ongoing challenge.

4.6.1. Agriculture: Rice and Vegetables

One solution that has been proposed is promoting agriculture, especially rice cultivation, as a major alternative. However, there is a major problem in this area due to the prevalence of salinity in the soil.

The agricultural pattern of people in the local area of Sharankhola is mainly growing vegetables and rice. However, the region suffers from water salinity, making it unsuitable for large-scale agricultural work. Instead, locals often grow vegetables in the yards of their homes for personal use rather than for commercial purposes.

The summer and rainy seasons in Sharankhola, which fall in the Bengali months of Boishakh, Jaishthay and Ashar, and Srabon, respectively, are known for the major rainfall that occurs. As a result, the locals plant rice seeds during this period, which runs from mid-April to mid-August. Unlike other parts of the country, the lack of irrigation has caused the area to yield only once a year due to a lack of nutrition in the soil.

To address those issues, the Bangladesh Rice Research Institute (BRRI) has been working to develop salinity-tolerant rice species. Their most recent introduction is a variety known as BRRI .40. This rice species is unique in that it can grow all year round and can also be irrigated using saline water.

Local people in the Sundarbans adjacent area have already started cultivating this new rice variety, and they have confirmed that they are using river water for irrigation. If this new rice species proves successful, it has the potential to open up alternative employment opportunities as well as provide a new source of food for the local community. This could reduce the pressure on the forest-based economy and contribute to sustainable development in the region.

To irrigate their crops, water is sourced from ponds and canals that store rainwater. Unfortunately, many canals dry up during the dry season, and locals do not have the technology to save water from the river during the rainy season when the water is mildly salty. Moreover, many canals have been lost due to a lack of maintenance and re-digging.

The local people in the Sundarbans area have raised concerns about the need to re-dig government-recorded canals. The restoration of these canals could bring about a revolution in irrigation and the local economy. The restoration of the canals could also have a significant impact on the availability of drinking water in the area, especially during the dry season. The people have been facing acute water scarcity during this time, and the restoration of the canals could provide a much-needed solution to this problem. With the availability of water from the canals, the local people could have access to a reliable source of drinking water throughout the year.

4.6.2. Tourism and Economy

Despite the potential for the tourist industry to provide employment opportunities, it is not a comprehensive solution to the socio-economic limitations and poverty cycle that exist in the area. In fact, according to a member of the VCF who was interviewed, impatience is growing among both the unemployed and employed members of the community. These individuals believe that their rights are being violated by both the Mahajans and the government.

One of the reasons behind this growing discontent is the failure of the government to fulfill its promise of providing alternative job opportunities for the local community using a portion of the revenue earned from the Forest Pass. The lack of action on the part of the government has left many members of the community feeling disillusioned and frustrated.

Many of the responders in the study expressed concern that if this growing sense of unrest among the people is not addressed, a significant number of deprived individuals will resort to illegal means of collecting forest resources in a destructive manner as a means of making a living. This would not only further exacerbate the environmental issues in the area but would also threaten the livelihoods of those who rely on the forest for sustainable resources. Therefore, it is crucial for the government to take swift action to address the concerns of the local community and provide them with viable alternatives to break out of the poverty cycle and protect the ecosystem.

4.6.3. Ali Banda Eco Resort

The Ali Banda Eco Resort is a new initiative by the government of Bangladesh to attract tourists and provide an alternative source of employment for local people. The resort is planned to be built within 4 kilometers of the forest, but within the protected area and not in the sanctuary area, to avoid any negative impact on the wildlife ecosystem.

Local people have mixed opinions about the project. Some believe that it will have a negative effect on the forest system, while others see it as an opportunity for new employment. The presence of tourists is expected to create new economic activities, such as housing, grocery

stores, and transportation. As no vehicles are allowed inside the forest, boats and shallow engine boats, locally known as trawlers, will be used as houseboats.

Many young people in the area are enthusiastic about the opportunity, but they are facing financing problems. This highlights the weakness of the local economy, and people are calling for help to develop infrastructure at the same time as building the eco-park.

The project is still in the planning phase, and the government has conducted a study to determine the best way to implement the initiative. The goal is to balance the benefits of the project with its potential impact on the forest and wildlife. If executed correctly, the Ali Banda Eco Resort could provide much-needed employment opportunities for the local people while also promoting eco-tourism in the region.

4.7. Contribution of Forest Pass Revenue

Despite the government's promise to allocate a portion of the revenue generated from the forest passes towards creating alternative earning opportunities, the reality on the ground has left the residents dissatisfied. According to the local community, they have yet to receive any financial support from the promised allocation. A fisherman, also engaged in other voluntary awareness accused that, *“we were promised to have fifty percent of the forest revenue return from the government to help in our economies, but so far it never happened”*.

The lack of fulfillment regarding the utilization of the forest pass revenue has caused frustration and disappointment among the residents. They had anticipated that the allocated funds would be utilized to develop and promote alternative livelihood options, which would provide them with additional sources of income beyond their dependence on the forest resources and rest of the time of the year when season is finished.

The local people have expressed their unhappiness with the current situation, as they were hopeful that the promised financial support would help alleviate their economic struggles and enhance their overall well-being. Their concerns highlight the need for accountability, and effective implementation of initiatives aimed to them.

The allocation and proper utilization of the promised funds by the government are of utmost importance, not only for addressing the concerns of the local people but also for the long-term sustainability of the ecosystem. The availability of alternative work opportunities is directly linked to reducing the pressure on the forest resources. The region faces significant challenges, including poverty and a lack of capital assets, which hinder the generation of sufficient work opportunities. In this context, the allocated funds can play a crucial role in overcoming these barriers. By investing the funds strategically and effectively, the government can implement various initiatives such as skill development programs, entrepreneurship support, microfinance schemes, infrastructure development, create employment opportunities, promote economic development, and overall improve the livelihoods of the local community. By delivering on this promise, the government can foster trust, enhance community engagement, and ultimately contribute to the sustainable development of the region.

4.8. Embankment on Balaswar River and Cyclone Shelter: An effort of resilience

The reconstruction of the embankment on the Balaswar River following the devastating cyclone Sidr in 2007 has been a significant step towards enhancing resilience in the Sarankhola community. The construction was a part under the Coastal Embankment Development Project (CEDP), funded by the World Bank (Daily Sun, 2019), has provided a renewed sense of security, and hope for the villagers. The embankment, stretching over 62 kilometers along the Balaswar River, serves as a vital barrier against tidal waves, bank erosion, and floods. It acts as a protective shield, safeguarding the community's homes, agricultural lands, and vital infrastructure from the destructive forces of the river and potential sea-level rise.

The people of Sarankhola Bazar recognize the importance of the embankment in achieving higher resilience against the impacts of climate change. With concerns about global warming and rising sea levels, they fear the increased risk of severe bank erosion, floods, and cyclones, particularly during the rainy season. They understand that the proper construction and maintenance of the embankment are crucial in safeguarding their houses and land from these potential threats.

additionally, Cyclone Shelters play a crucial role in the resilience strategy of the community. With the region being prone to cyclones and floods, it has become necessary for people to seek shelter during these extreme weather events. While some individuals are attempting to construct cyclone-resilient houses when building new homes, the number of such houses remains small due to severe poverty among households.

To address the need for cyclone shelters, the government has made efforts to increase capacity by utilizing existing infrastructure such as schools, colleges, and mosques during disasters. Additionally, new cyclone shelters are being constructed with the support of local and international funds under the Coastal Embankment Development Project (CEDP). However, these efforts are still insignificant in relation to the population size of Sarankhola.

A volunteer who assists during cyclones and helps people reach cyclone shelters expressed concerns about the limited capacity of the existing arrangements. He mentioned that,

“the current capacity of all the shelters combined can hardly accommodate more than 20,000 people, whereas the population of Sarankhola exceeds 150,000. Moreover, many people are reluctant to evacuate to the shelters due to a lack of awareness or a desire to stay home and protect their livestock and assets, which can sometimes prove fatal.”

However, the volunteer also highlighted the challenges faced within the cyclone shelters themselves. He lamented the inhumane conditions prevailing in many cases, including inadequate food, drinking water, and sanitation facilities. The shelters often lack proper arrangements for the specific needs of women, children, and elderly individuals, further exacerbating the difficulties faced during these critical times.

4.9. The Connection of Vulnerability with The Declaration of Reserve Forest and World Heritage

The Sundarbans is the habitat of the Royal Bengal tiger, which is also an endangered species, a versatile ecosystem including flora and fauna, a wildlife sanctuary. It has both ecological and economical importance. Realizing those, the government of Bangladesh has declared the Sundarbans as reserve forest in 1977 to keep the ecosystem unharmed. Along with this, due to its unique ecosystem and biodiversity, UNESCO has declared the forest as a world heritage

under criteria 9 and 10 of heritage convention. UNESCO recognized it an outstanding example of universal value for its significant ecological and biological diversities and an important factor for maintaining the ecological balance of the region.

Both of this have privileged the Sundarbans to get increased international attention and support to confirm the reservation of the forest. It helped to raise awareness among the people and authorities to protect it from any further environmental degradation. But at the same time, it forced the people to stop collecting forest resources for their livelihood, considering those earning activities as an interruption to the restoration of ecological balance.

Because of the geographical position, the area is more prone to natural disasters, which is occurring more frequently in recent years. So, every year the government impose embargo to issue forest pass and go inside for any economic activities. These limitations stricter after any destruction happens to the forest ecosystem by any natural disaster. Eventually, the economic activities based on the forest are now limited to very particular area and session. It pushes the people towards unemployment and exposing the local social system more vulnerable.

4.10. Socio-Ecological System with The Adaptive Cycle of Resilience

The adaptive cycle of resilience developed by C.S. Holling offers a valuable framework for evaluating and assessing the vulnerability of the Sundarbans ecosystem and the society of Sharankhola that depends on it.

During the initial phase of the cycle, the Sundarbans Forest had the opportunity to develop its own ecosystem and establish a balance between internal and external factors over many years. This phase witnessed the growth of a complex ecosystem within the forest, the habitation of various species, habitation of underwater species, and the occurrence of external factors such as natural disasters and the interplay of saltwater and freshwater tides, development of soil bed and its characteristics under water. However, the potentiality of the ecosystem remained low during this stage, as the economic and social contributions of the forest were not fully recognized.

In the early stages, the acquisition of forest resources for livelihood purposes in the Sundarbans had minimal restrictions. Activities such as hunting, tree cutting, capturing animals for meat, fishing, honey collecting, and leaf collection were carried out without significant regulatory oversight. During interviews, several elder respondents shared their recollections of common practices, including hunting deer for festivals or social occasions, using trees like Sundari and Goran for building materials, Golpata as firewood, and engaging in poaching, including the killing of tigers for their skin, bones, and teeth for personal collection and trade.

At that time, the relatively low population dependency on the forest resources meant that the immediate impacts on the forest ecosystem were limited. However, these activities, which were conducted without strict regulations, gradually began to have an impact on the ecosystem as the population grew and the demands on forest resources increased.

This phase can be described as the growth or exploitation stage of the Sarankhola-Sundarbans ecosystem. It was characterized by the exploitation of resources by human activities. However, despite this exploitation, the ecosystem exhibited high resilience as internal factors continued to grow and adapt to the challenges posed by external forces. The people living in the region developed a certain level of knowledge and instincts in dealing with natural disasters. They demonstrated resilience in the face of these challenges, although the toll on their well-being, loss of life, and hardships in accessing food, drinking water, and increased waterborne diseases revealed the vulnerability of their social system.

After the growth stage, the Sundarbans ecosystem entered the conservation phase of the Holling adaptive cycle. This phase was characterized by the entry of influential local figures known as Mahajans, stricter regulations imposed by the local administration, and the implementation of forest management activities. Cumulative efforts of those social bodies act to accumulate and conserve the forest resources that had been exploited during the growth stage. The growing awareness of the people regarding the conservation of the forest also assists in accumulation.

The Mahajans, who represented the politically influential class in society, held control over various factors of production and assets, including human and social capital, as well as monetary resources. They enjoyed privileged access to both social and forest resources, while marginalized individuals lost control over the forest resources and economic capital. The

Mahajans played a crucial role as a gateway, as the sole intermediaries between the forest-dependent working people and their access to livelihood resources. Through my fieldwork, I discovered compelling evidence that a significant majority of these individuals did not possess any land of their own. Although they had homes to live in, these dwellings were highly susceptible to natural disasters due to their vulnerable conditions.

Caught in poverty, the forest-dependent workers faced severe limitations in accumulating savings or acquiring essential tools for their respective occupations. For instance, they lacked the financial means to purchase personal fishing boats, nets, or equipment for honey collection. This lack of capital hindered their ability to engage in independent economic activities and perpetuated their reliance on the Mahajans for resources and support. Fishermen, in particular, expressed that, *“we need to borrow significant amounts of money at high interest rates, ranging from BDT 100,000 to 150,000 (USD 920 to 1,385) per person, at the beginning of each fishing season to equip ourselves for full-scale fishing. At the end of the season, we face challenges in repaying the loans with interest, leaving with little cash capital to break free from the influence of the Mahajans”*.

The marginalized fishermen, lacking having access to the supply chain and the opportunity to sell their fish in urban or national markets, are often compelled to rely on middlemen for this process. These middlemen, who are frequently the Mahajans themselves or individuals closely associated with them, play a significant role in the transactional process. This resulted in selling their fish at prices well below the market value, as they lacked bargaining power. The high level of interconnectedness in this social system, as observed in the adaptive cycle, left fishermen, honey collectors, and leaf collectors in vulnerable positions, exposed to poverty and the impacts of climate change with limited adaptive capacity.

In this phase, there is a notable increase in the interconnectedness between environmental and social factors as observed in the adaptive cycle. However, this heightened connectedness within the social system has resulted in increased vulnerability for not only the fishermen but also the honey collectors and leaves collectors, as they face the impacts of climate change with limited adaptive capacity. Although the forest ecosystem has demonstrated resilience and the ability to produce resources, it remains highly vulnerable due to low flexibility in both the social and natural systems. The forest ecosystem, along with its flora and fauna, has developed resilience against regular natural calamities and human activities. However, it lacks the necessary

resilience and adaptive capacity to cope with external variables such as rising sea levels, frequent floods, tornadoes, increased salinity levels, and changes in river water dynamics. These external factors disrupt the delicate balance of aquatic habitats, affecting the fish and other species that rely on them. Consequently, the ecosystem is highly exposed to vulnerability and possesses low resilience in the face of these climate-related changes.

The empirical evidence gathered from the Sarankhola range of the Sundarbans suggests that it is currently in the peak conservation phase and approaching the pre-phase of Holling's 'Release' or 'Omega' stage of the adaptive cycle. Several indicators of the release phase can be observed in this area, indicating that the system is highly vulnerable to any triggers from either the natural or social systems that could potentially lead to an explosive event. The low level of resilience and the looming risk of collapse are evident in this region.

The high connectedness of the ecosystem, coupled with the economic vulnerability of the local population and the fragile and exploited social system, amplifies their susceptibility to external variables, particularly climate change. The adaptive cycle, being a complex and nonlinear process, allows for the coexistence of multiple cycles within a larger cycle. In the case of the Sarankhola range, the impact of climate change on the natural ecosystem has already become evident, with significant consequences for the lives and livelihoods of the people in the area. Based on empirical evidence, it can be inferred that the Sarankhola range has already undergone a partial release phase within the adaptive cycle, and both the socio-ecological system are on the verge of a potential collapse. The signs of this impending collapse are becoming increasingly apparent, as the interplay between the natural environment and the social system becomes more fragile and unsustainable.

The external factors associated with climate change, such as rising temperatures, changing rainfall patterns, and increased frequency and intensity of extreme weather events, are already exerting significant pressure on the forest ecosystem. This, in turn, affects the local population who rely on the ecosystem for their livelihoods, including fishing, honey collection, and other activities.

The frequency of natural disasters, such as cyclones, storms, and floods, has increased (Kabir et al., 2016), and their impact is more prolonged and severe than in the past. Riverbank erosion has become more devastating, leading to the loss of land and property. Additionally, the

duration of saltwater intrusion on agricultural land has increased, adversely affecting farming activities and agricultural productivity.



In this picture, the canal was initially narrow in width. Eventually, due to ongoing riverbank erosion, the width of the canal has significantly increased, resembling the size and characteristics of a river.

Figure 7: Riverbank erosion (Bogi Canal)
Source: Rahman, M.M. (2023, February 2)

The impact of Cyclone Sidr in 2007, can be considered as partial Release phase of the ‘Sarankhola range’, had a devastating effect on the entire region, including Sarankhola. The cyclone brought forth an enormous tidal wave that engulfed the area, causing the loss of human lives, destruction of houses, and devastation of crops and livestock. The consequences were tragic, with numerous families losing their loved ones. According to the government report of Bangladesh, the cyclone resulted in the death of 3,363 people, with 871 individuals reported missing. Additionally, a staggering 564,967 houses were completely destroyed, and another

957,110 houses suffered partial damage (Asian Disaster Reduction Center (ADRC) , n.d.). The survivors of this calamity have attested to its severity, stating that it was the most devastating event since the catastrophic tropical cyclone of 1991, which claimed the lives of nearly 150,000 people according to government statistics. One survivor of Cyclone Sidr from my interviewee list shared their harrowing experience. They recounted how the cyclone ravaged the region, leaving no houses standing, *“structures made of materials such as tin, bamboo, and wood were washed away by the powerful tidal surge. Concrete structures, although scarce, also fell victim to the destructive forces of the cyclone. The morning after the disaster, the survivors were confronted with a grim scene, as lifeless bodies were scattered throughout the area, with many found in the nearby Balaswar river. The majority of the victims were children and women. The children, unable to swim and lacking the skills to withstand the powerful water currents, were particularly vulnerable. Women, on the other hand, were often entangled in trees and branches by their hair, making it difficult for them to rescue themselves.”* The economic repercussions of such natural calamities have had enduring effects on the affected communities. The utilization of banking systems remains limited to a select few individuals, as many people prefer to keep their savings in the form of cash at home. Consequently, when the tidal upsurge associated with Cyclone Sidr occurred, numerous families lost their lifelong savings either partially or entirely. A survivor of the cyclone shared a poignant account, stating, *“I had been diligently saving money for 30 years with the hope of sending my eldest son abroad for better earning opportunities and to alleviate our family from the grips of poverty. However, the cyclone swept away everything, including our hard-earned savings.”*

Climate change has had a profound impact on the ecosystem, with Cyclone Sidr serving as just one example. The delicate balance of the aquatic system, which relies on a mix of saltwater and freshwater for the species that inhabit it, has been disrupted. The forested lands and overall ecosystem have also experienced significant effects. Approximately 45% of Bangladesh, encompassing an area of around 2,500 square kilometers, was affected by Cyclone Sidr (Bhowmik & Cabral, 2013). Among the most severely affected tree species were Sundari, Gewa, and Kewra. One interviewee expressed, *“The loss of the forest was immeasurable as it bore the brunt of the cyclone, much like other disasters originating from the sea. We believe that the forest acted as a natural shield against such calamities.”* Another individual added, *“These days, we receive information about fishing and honey collecting seasons from the forest*

authority. However, the natural timing of these seasons has changed, and there has been a decline in fish breeding and quantity. Other species, such as crabs and shrimp, have also decreased". Overall, the resilience and adaptability of the system have been compromised to a significant extent, leading to breakdowns in numerous systems with the potentiality of collapse as a whole.

As discussed earlier, within the overarching adaptive cycle of the Sarankhola socio-ecological system, there are multiple smaller cycles coexisting, some of which have already reached the reorganization phase, the final stage before a new cycle begins. While certain aspects, such as the Mahajan Exploitation in the social system, have not yet reached the collapse stage, there are smaller cycles related to climate change and natural disasters circulating within the larger one.

The Reorganization phase presents opportunities for the system to develop and enhance its adaptive capacity. In the case of the Sundarbans, Cyclone Sidr served as a catalyst for restructuring and strengthening resilience against the negative impacts of climate change. Following the cyclone, there was a shift in mindset, with people becoming more aware of the importance of conserving the forest. Volunteer organizations now work in collaboration with the forest authority in Sarankhola to raise awareness and discourage the exploitation of forest resources.

In the pursuit of enhancing resilience against the impacts of climate change, concerted efforts have been made from various stakeholders. Local communities have taken steps towards such as using concrete while constructing a new house, keep it higher to avoid flooding, which also provides them with a sturdy shelter during times of natural calamities. *"Despite financial challenges, sometimes we seek loans from relatives, banks, or Mahajans (moneylenders) to finance these construction"*, one affected person says. He also added, *"those who possess sound financial condition, have opted to build secondary residences in inland regions, away from the vulnerable coastal areas."*

Prior to these developments of cyclone Sidr, the Sundarbans was recognized as a World Heritage Site by UNESCO in 1997 (Bhowmik & Cabral, 2013) and subsequently designated as a protected area by the government of Bangladesh. Logging was strictly prohibited, and the collection of dead logs was banned under any circumstances. This reduced the dependence on

the forest for livelihoods and increased the potential for restoring the ecological balance of the Sundarbans. Restricted access to the forest has also contributed to its resilience against natural disasters.

Furthermore, the introduction of fees for acquiring forest passes has provided a source of revenue for the government. Fishing bans during breeding periods have been implemented to safeguard fish populations for proper reproduction. The government has implemented self-awareness programs, basic training on survival and rescue during disasters, and immediate resettlement measures to engage rural communities in achieving these goals.

In order to compensate for the loss of employment opportunities caused by the changes in the forest-dependent livelihoods, both the government and the local community have recognized the potential of tourism as a means to boost the economy. Although the Sarankhola region lacks the tourism infrastructure found in other three ranges of the Sundarbans, efforts have been made to develop this sector and harness its positive impact. Boat trips and cruises are now permitted within the forest, carefully navigating non-restricted waterways.

Furthermore, the government has undertaken the construction of an eco-tourism park, Ali-Banda Eco Tourism, located within 4 kilometers of the Sharankhola entry point, an area not classified as a sanctuary zone. While the project is still in progress, opinions within the community are divided. Those who depend on the forest for their livelihoods are optimistic, as they anticipate numerous direct and indirect employment opportunities to arise from the growth of tourism. *“We believe that the influx of money into the local economy will stimulate small businesses and lead to overall expansion”*, says a young person looking for alternative work. Moreover, the development of tourism is expected to generate ancillary businesses that cater to the needs of tourists. This includes the expansion of boat operations to facilitate cruise trips and the growth of supporting industries. The economic potential of tourism in the region is considered to be high.

However, there is also awareness among the local population regarding the potential negative impact of tourism on the ecosystem. Concerns have been raised regarding the disruptive behavior of some tourists, such as, *“creating loud noises, music can disturb the animals. Additionally, the use of shallow engine boats during these trips may result in oil spills, which can harm the aquatic environment. Furthermore, the disturbance caused by tourists may lead*

to the displacement of deer, the primary food source for tigers, ultimately affecting the presence of these iconic predators in the area.”

To facilitate the farmers in the saline affected coastal area including Sarankhola, the Bangladesh Rice Research Institute (BRRI) in collaboration with the International Rice Research Institute (IRRI) has made significant efforts to introduce salinity-tolerant rice genotypes. These new rice genotypes exhibit high yield potential, improved tolerance to salinity, and shorter growth periods tailored to the specific geographical conditions of the region (Islam & Gregorio, 2013). Despite these advancements, farmers still encounter challenges related to irrigation due to the availability of fresh water.

A notable development in this regard is the recent introduction of BRRI. 40, a special rice genotype specifically designed for cultivation in the Sarankhola area. This genotype is expected to be cultivated throughout the year, regardless of the salinity level of the soil. However, in order to fully revolutionize the agricultural industry, it is crucial that the canals are reconstructed simultaneously to catch the rainwater. This would significantly enhance the irrigation infrastructure and enable farmers to maximize the benefits of the new rice varieties. A local farmer expressed optimism about the potential impact, stating that, *“the combination of BRRI. 40 and improved canal systems would bring about a revolution in the agricultural sector.”*

4.11. Vulnerability Assessment

IPCC’s report in 2014 has given a detail about impacts, adaptation, and vulnerability regarding climate change. According to the report, vulnerability refers to the degree to which a system or population is susceptible to, and unable to cope with, adverse effects of climate change (IPCC, 2014). The IPCC emphasizes that vulnerability is influenced by a range of factors, including exposure to climate hazards, sensitivity to those hazards, and the adaptive capacity of the affected system or population. In the diagram below, it summarizes the connection of socio and ecological system to vulnerability of Sarankhola range of Sundarbans upon the discussion above.

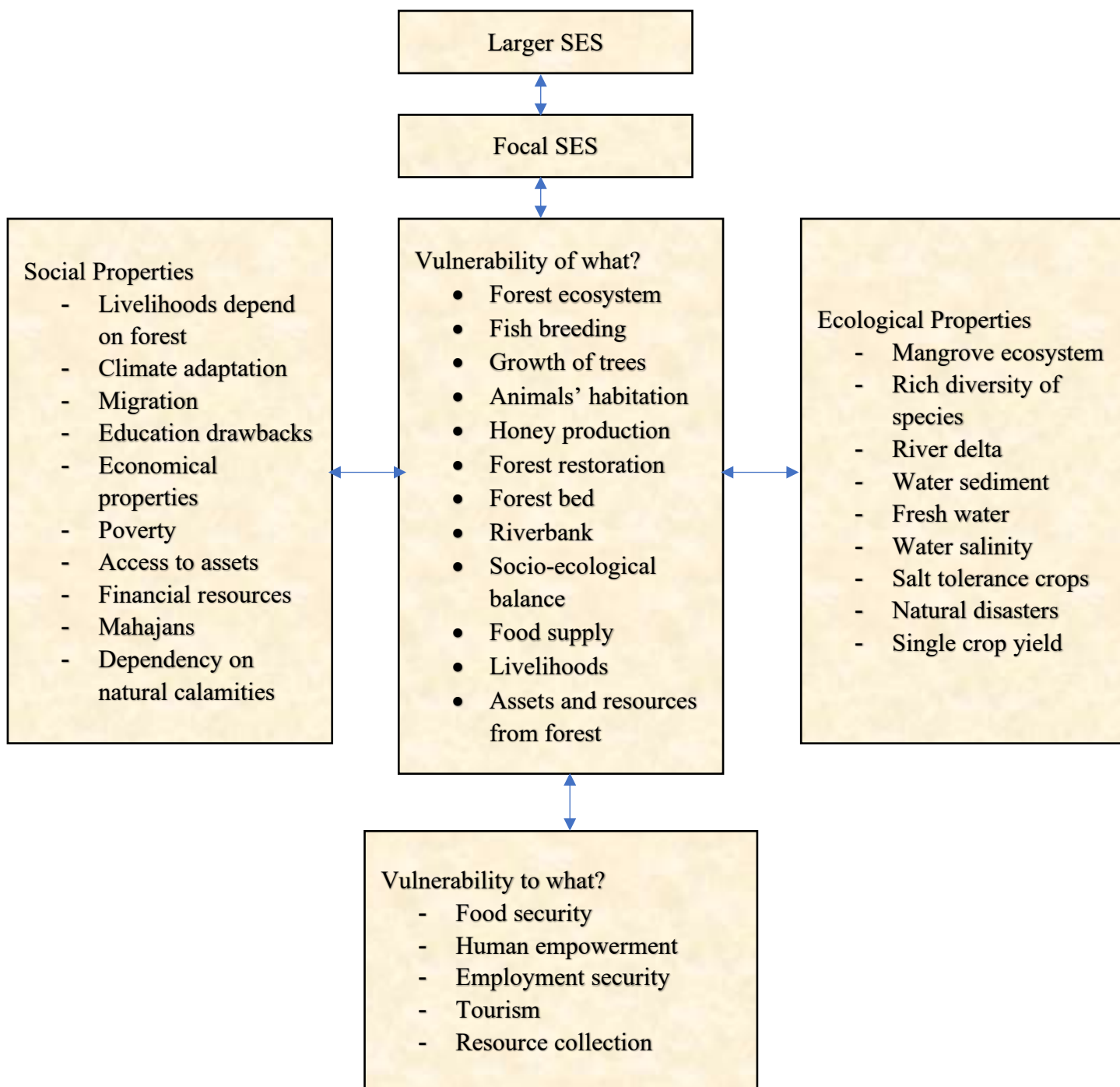


Figure 8: A diagram showing the connections of the variables of socio ecological system

Chapter 5: Discussion

5.1. Impacts Of Declaration of Heritage Site and Administrative Intervention of Government on The Livelihood and Socio-Ecological Resilience

Forest depletion and social vulnerability are intricately linked, exhibiting a positive correlation wherein changes in one variable impact the other. The Sundarbans Reserve Forest (SRF) in Bangladesh, encompassing the world's largest mangrove-coastal ecosystem with both fresh and marine mangroves, serves as the habitat for endangered species such as the tiger. However, this unique ecosystem is highly vulnerable to the effects of climate change. Consequently, the SRF was declared a Ramsar Site in 1992 (Siddique et al., 2023) and a World Heritage site by UNESCO in 1997 (Hassan et al., 2019) to recognize its ecological significance.

The history of the SRF dates back to 1878 when it was declared a "reserve forest" during British rule in the Indian subcontinent (Siddique et al., 2023). Over time, the government of Bangladesh implemented restrictions in the area to preserve the ecosystem and safeguard fish breeding grounds. Currently, the sanctuary area has been expanded from 23% to 52%, encompassing both land and water bodies. Additionally, fishing is prohibited from May 1 to June 30, and crab fishing is banned from December to February (Siddique et al., 2023).

Resilience in a socio-ecological system relies on several principles, including the diversity of the system as the first principle and fostering complex adaptive system thinking as the fourth principle. The first principle emphasizes the inclusion of all components within the system, such as species and cultural groups, which respond to changes with various options to address uncertainties. The fourth principle highlights the need for understanding interconnections and dynamics among actors for effective governance. Failure to adhere to these principles can render resilience unsustainable.

Forest depletion holds both ecological and economic significance for the people of Sarankhola. In Sarankhola case, the restrictions imposed on the Sundarbans to protect species and preserve the ecosystem have had adverse effects on the local social system, the economy of people are overlooked. Many individuals have lost their livelihoods and employment opportunities. Through my analysis, I observed a growing sense of unrest among the affected population as they struggle to recover their financial losses. Furthermore, the government has not yet

allocated the revenue generated from forest passes for the development of the local community. This situation raises concerns about the potential harm to the ecological system if people start extracting forest resources in violation of the imposed restrictions. According to the resilience principles, this step will not be sustainable if the social components are not considered. So, the attempt of protecting the forest has the potentiality to turn into its exploitation.

5.2. Changes of Ecological Balance for Tourism and Ali-Banda Eco Park

Recognizing the potential of ecotourism to create alternative employment opportunities, the Bangladesh government and forest administration have undertaken the Ali Banda Eco Tourism project within a 4 km radius of the Sarankhola Range, an area that is not designated as a wildlife sanctuary.

Ecotourism has gained popularity worldwide as a nature-based tourism approach that aims to minimize environmental impact while supporting local economies. Many nature-based tourism initiatives are established in national parks and restricted areas (Salam et al., 2000).

However, unlike the other three ranges of the Sundarbans Reserve Forest (SRF), the Sarankhola Range is relatively undeveloped in terms of tourism infrastructure. While the other ranges have better connectivity with nearby cities, accessing the Sundarbans for tourism purposes is primarily done through boats or ships (Salam et al., 2000). During my stay in Sarankhola, I observed a lack of accommodation options, with the only available option being to stay as a paying guest with a local family. Therefore, the presence of tourists in Sarankhola would significantly increase the circulation of money within the local economy and contribute to the development of infrastructure and civic facilities. This, in turn, would provide employment opportunities for many individuals who can engage in tourism-related activities.

However, if not properly regulated, tourism can also have negative consequences. In Bangladesh, there is no well-developed visitor management program like in India, and monitoring tourism activities is not included in the conservation policy of the Sundarbans Reserve Forest (Hassan et al., 2019). Local residents have accused tourists of violating forest peace and disrupting the natural balance. It is not uncommon for tourists to engage in activities such as playing loud music, littering, and spilling oil on the water. During the tourist season, particularly from November to March, the Sundarbans can become overwhelmed due to the

influx of tourists (Salam et al., 2000). Therefore, the full implementation of the Ali Banda Eco Resort, which is currently under construction, may lead to severe environmental degradation in Sarankhola if proper infrastructure and regulations are not in place. It is essential to ensure that the development of the local economy through tourism is sustainable and involves the active participation of all stakeholders.

5.3. Impacts of Shadow Governance: Mahajans

The Mahajan system, which is controlled by powerful individuals known as Mahajans, exercises control over access to forest resources and holds significant political and economic influence over the forest administration. These Mahajans have gained their power through the economic and political advancement over marginalized individuals within the community. Their influence extends to logistics and market access for fish and crops.

While the Mahajan system may appear effective in the short term, my research has revealed its detrimental impacts. This system has essentially held the economic and financial conditions of the people in Sarankhola hostage, particularly those who rely on forest resources for their livelihoods. The majority of these individuals do not possess their own boats or equipment and must seek assistance from the Mahajans. Many of them struggle to repay the seasonal loans they have taken out to borrow boats and fishing equipment, which can range from BDT 100,000 to 150,000 (USD 920 to 1,385) with interest per person. As a result, these marginalized individuals become trapped in the clutches of the Mahajans, perpetuating an endless cycle of poverty. During my fieldwork, I discovered that even farmers are subject to the control of the Mahajans, although they were hesitant to discuss the issue openly. The rice they produce needed to be sold through middlemen who are connected to the Mahajans, similar to the fish market. Additionally, the Bawali community, during the leaf-collecting season, is forced to work as day laborers under the Mahajans for very low wages (Mondal & Das, 2022), ranging from BDT 300-400 (USD 2.8 to 3.7) per day (from my data). Similarly, Mowals are required to surrender 30-40% of their collected honey to the Mahajans as interest. Furthermore, when Bawalis and Mowals need to work in the forest for an extended period, their families are often forced to borrow money from the Mahajans during times of crisis.

5.4. Salinity Influence

The government of Bangladesh implemented the Coastal Embankment Development Project, supported by international funding, to safeguard the land from erosion and mitigate inland flooding. However, an unintended consequence of this initiative was the occurrence of waterlogging issues. The embankments hindered proper drainage, leading to the intrusion of saline water from the sea. This escalation in salinity levels disrupted the traditional livelihood systems of local communities, particularly affecting agriculture. As a response to these challenges, farmers in certain Sundarbans adjacent localities turned to shrimp cultivation as an alternative, as it proved to be more economically viable in the altered environmental conditions (Agrawala et al., 2003).

However, during my fieldwork in Sarankhola, I did not find evidence supporting the prevalence of shrimp farming as an adaptation strategy. While salinity problems were acknowledged by respondents in Sarankhola, they reported a lack of expertise and capital required for engaging in shrimp cultivation.

Chapter 6: Conclusion

The Sundarbans region in Bangladesh is a unique and ecologically significant area, designated as a UNESCO World Heritage Site and a Ramsar Site. It is highly vulnerable to climate change, experiencing challenges such as sea-level rise, cyclones, riverbank erosion, and increased salinity intrusion. Though adaptation and resilience is an ongoing process according to the 'Adaptive Cycle of Resilience', the adaptation of the people of Sarankhola Bazar are greatly influenced by the actors such as international organization UNESCO, state Government, forest authority, or Mahajans. Those have both positive and negative influence on their adaptive strategy responding to climate change. The Mahajan system, where influential individuals control access to forest resources, has exacerbated social and economic inequality.

The initial impact of the restrictions on the Sundarbans to protect the ecological balance and wildlife habitat has had a significant effect on the livelihoods of the local people. As they heavily depend on the forest for their livelihood, these restrictions have posed a threat to their social resilience.

The dependence on the forest for livelihoods has made the local communities highly vulnerable to the impacts of these restrictions. They face challenges in finding alternative sources of income and adapting to new livelihood strategies, which is limited due to their economic condition, capital, skill, knowledge and support from the outside variables. The loss of livelihoods can have far-reaching consequences, affecting not only the economic well-being and social resilience of individuals also the resilience of the ecosystem also. It may happen if people start extracting forest resources violating the regulations of the authority.

The government of Bangladesh, with the support of international organizations, has implemented various measures to address these environmental and socio-economic challenges faced by the communities in Sarankhola but those are needed to be interlinked, involved with the local people, to foster a complex, sustainable resilience system.

While efforts have been made to enhance resilience, such as the construction of sustainable embankments and the establishment of cyclone shelters, there are still gaps and limitations in these initiatives. The capacity of cyclone shelters is insufficient compared to the population size, and there is a need for better facilities and services within the shelters.

Addressing the complex relationship between forest conservation, social vulnerability, and sustainable development is crucial. Balancing the preservation of the Sundarbans with the well-being and economic stability of the local population requires thoughtful and inclusive governance. It is imperative for the government to explore avenues for compensating the affected communities and utilizing the revenue from forest passes to foster local development. By doing so, the ecological resilience of the Sundarbans can be sustained while simultaneously addressing the social and economic concerns of the Sarankhola community.

Efforts to develop ecotourism in Sarankhola should prioritize the establishment of visitor management programs, the enforcement of regulations to minimize environmental impact, and the promotion of responsible tourism practices. Engaging local communities and educating tourists about the importance of conservation and sustainable practices can help mitigate the negative effects of tourism while maximizing its potential benefits. By incorporating these measures, the Sarankhola community can harness the economic opportunities provided by ecotourism without compromising the integrity of the Sundarbans ecosystem.

To break free from the grip of the Mahajans and escape the cycle of poverty, zero or minimal interest loans provided by the state or NGOs to fishermen, Bawalis, and Mowals can be a potential solution. Proper utilization of these funds could empower individuals to regain control over their economic situation and break free from the exploitative cycle. By providing financial support and opportunities for self-sufficiency, marginalized individuals can improve their livelihoods and reduce their dependence on the Mahajans.

In conclusion, achieving resilience in Sarankhola necessitates a comprehensive and integrated approach that addresses the social, economic, and environmental dimensions. This includes promoting sustainable livelihood options, improving infrastructure and services, strengthening visitor management in ecotourism, and addressing the unintended consequences of development projects. Collaboration among government agencies, local communities, and relevant stakeholders is essential to ensure the long-term sustainability and well-being of the Sarankhola region in the face of ongoing environmental challenges.

REFERENCES

- McLeman, R. (2018). Thresholds in climate migration. *Population and environment*, 39(4), 319-338.
- About Migration. (n.d.). International Organization for Migration. <https://www.iom.int/about-migration>
- Mcauliffe, M. And A. Triandafyllidou (Eds.), 2021. *World Migration Report 2022*. International Organization For Migration (Iom), Geneva.
- Berchin, I. I., Valduga, I. B., Garcia, J., & de Andrade, J. B. S. O. (2017). Climate change and forced migrations: An effort towards recognizing climate refugees. *Geoforum*, 84, 147-150.
- Allgood, L., & McNamara, K. E. (2017). Climate-induced migration: Exploring local perspectives in Kiribati. *Singapore Journal of Tropical Geography*, 38(3), 370-385.
- Chen, J., & Mueller, V. (2018). Coastal climate change, soil salinity and human migration in Bangladesh. *Nature climate change*, 8(11), 981-985.
- Ahsan, R., Kellett, J., & Karuppanan, S. (2014). *Climate induced migration: Lessons from Bangladesh* (Doctoral dissertation, Common Ground Publishing).
- Southwick, S. M., Bonanno, G. A., Masten, A. S., Panter-Brick, C., & Yehuda, R. (2014). Resilience definitions, theory, and challenges: interdisciplinary perspectives. *European journal of psychotraumatology*, 5(1), 25338.
- Martin, M., Kang, Y. H., Billah, M., Siddiqui, T., Black, R., & Kniveton, D. (2013). Policy analysis: Climate change and migration Bangladesh. *Dhaka, Bangladesh: Refugee and Migratory Movements Research Unit (RMMRU)*.
- Agrawala, S., Ota, T., Ahmed, A. U., Smith, J., & Van Aalst, M. (2003). Development and climate change in Bangladesh: focus on coastal flooding and the Sundarbans (pp. 1-49). Paris: OECD.
- Folke, C., S. R. Carpenter, B. Walker, M. Scheffer, T. Chapin, and J. Rockström. 2010. Resilience thinking: integrating resilience, adaptability and transformability. *Ecology and Society* 15(4): 20.
- Sarankhola Upazila profile - sarankhola.bagerhat.gov.bd. (2014). http://sarankhola.bagerhat.gov.bd/sites/default/files/files/sarankhola.bagerhat.gov.bd/page/5ac16d11_1c4b_11e7_8f57_286ed488c766/Upazila%20Profile%20Sarankhola_Final.pdf

- Gunderson, L. H., & Holling, C. S. (Eds.). (2002). *Panarchy: understanding transformations in human and natural systems*. Island press.
- Agresti, A (2018). *Statistical Methods For The Social Sciences* (5th ed.). Harlow: Pearson Education, Inc.
- Clark, T., Foster, L., Sloan, L., & Bryman, A. (2021). *Bryman's Social Research Methods* (6th ed.). Oxford University Press
- Krefting L. Rigor in qualitative research: the assessment of trustworthiness. *Am J Occup Ther.* 1991 Mar;45(3):214-22. doi: 10.5014/ajot.45.3.214. PMID: 2031523.
- IPCC. (2014). *Climate Change 2014: Mitigation of Climate Change*. Retrieved from Cambridge University Press, Cambridge, UK and New York, USA. Retrieved from https://www.ipcc.ch/site/assets/uploads/2018/02/ipcc_wg3_ar5_chapter5.pdf
- United Nations. (n.d.). What Is Climate Change? <https://www.un.org/en/climatechange/what-is-climate-change>
- Hassan, K., Higham, J., Wooliscroft, B., & Hopkins, D. (2019). Climate change and world heritage: a cross-border analysis of the Sundarbans (Bangladesh–India). *Journal of Policy Research in Tourism, Leisure and Events*, 11(2), 196-219.
- Stockholm Resilience Centre. (2016). *Applying resilience thinking: Seven principles for building resilience in social-ecological systems*. Retrieved from <https://www.stockholmresilience.org/download/18.10119fc11455d3c557d6928/1459560241272/SRC+Applying+Resilience+final.pdf>
- Sundarbans and Conservation: Historical Perspectives and Contemporary Challenges | Sahapedia. (n.d.). Sahapedia. <https://www.sahapedia.org/sundarbans-and-conservation-historical-perspectives-and-contemporary-challenges>
- Siddique, M. R. H., Hossain, M., & Rashid, A. M. (2023). The dilemma of prioritizing conservation over livelihoods: Assessing the impact of fishing restriction to the fishermen of the Sundarbans. *Trees, Forests and People*, 11, 100366.
- Amin, M. R. (2018). Sustainable tourism development in Sundarbans, Bangladesh (a world heritage site): issues and actions. *Journal of Business*, 39(2), 31-52.
- SALAM, M. A., LINDSAY, G. R., & BEVERIDGE, M. C. M. (2000, July). Eco-tourism to Protect the Reserve Mangrove Forest the Sundarbans and its Flora and Fauna. *Anatolia*, 11(1), 56–66. <https://doi.org/10.1080/13032917.2000.9686983>
- Mondal, B. K., & Das, R. (2022). Appliace of Indigenous Knowlege in Mangrove Conservation and Sustaining Livelihood in Indian Sundarban Delta: A Geospatial Analysis. In *Traditional Ecological Knowledge of Resource Management in Asia* (pp.

- 77-101). Cham: Springer International Publishing. https://doi.org/10.1007/978-3-031-16840-6_6
- Wang, S. W., Lim, C. H., & Lee, W. K. (2021). A review of forest fire and policy response for resilient adaptation under changing climate in the Eastern Himalayan region. *Forest Science and Technology*, 17(4), 180-188.
- Bangladesh - The World Factbook. (n.d.). <https://www.cia.gov/the-world-factbook/countries/bangladesh/images>
- Asian Disaster Reduction Center (ADRC) . (n.d.). https://www.adrc.asia/view_disaster_en.php?lang=&KEY=1111
- Kabir, R., Khan, H. T., Ball, E., & Caldwell, K. (2016). Climate change impact: the experience of the coastal areas of Bangladesh affected by cyclones Sidr and Aila. *Journal of environmental and public health*, 2016.
- Bhowmik, A. K., & Cabral, P. (2013). Cyclone Sidr Impacts on the Sundarbans Floristic Diversity. *Earth Science Research*, 2(2). <https://doi.org/10.5539/esr.v2n2p62>
- Islam, M. S., & Gregorio, G. B. (2013). Progress of salinity tolerant rice variety development in Bangladesh. *Sabrao Journal of Breeding and Genetics*, 45(1), 21–30. <https://www.cabdirect.org/cabdirect/abstract/20133146062>
- Tiger census begins in Sunderbans Jan 1. (n.d.). *New Age | the Most Popular Outspoken English Daily in Bangladesh*. <https://www.newagebd.net/article/189520/tiger-census-begins-in-sunderbans-jan-1>
- Sun, D. (2023, May 14). People living on Baleshwar river banks fear displacement | Daily Sun |. *Daily Sun*. <https://www.daily-sun.com/printversion/details/397052/People-living-on-Baleshwar-river-banks-fear-displacement->

APPENDIX 1

UN- United Nations

IOM- International Organization for Migration

SD- Standard Deviation

SLR- Sea level Rise

SRF - Sundarbans Reserve Forest (The part of Bangladesh,)

SNP – Sundarbans National Park (The Part in India)

SES - Socio-Ecological System

FD - Forest Department

IPCC - Intergovernmental Panel on Climate Change

SIKT - Norwegian Agency for Shared Services in Education and Research

BRRI – Bangladesh Rice Research Institute

IRRI – International Rice Research Institute

Mouwal - Honey Collectors in the Sundarbans

Bawali - Leaves (Golpata) collectors in the Sundarbans

BDT – Bangladeshi Taka/ Bangladeshi currency

Zila - District

Upazila – Sub district

CEDP - Coastal Embankment Development Project

APPENDIX 2

Qualitative Research: Interview Guide

Greetings

- First, I'll introduce myself with my name and study related information, i.e- my study program, university, thesis work etc.
- Then, I'll disclose the thesis topic briefly, information and purpose of the of collecting the information.
- Confidentiality: for privacy issue, no information will be disclosed publicly mentioning person's name or occupation that can identify a person. Everything will be anonymous.
- Collected raw data will be kept safe and secret.
- People will we asked open ended, discussion type question regarding their experience of climate change and its influence on their daily lifestyle, livelihoods, economical activities, social status.
- People will also be asked, their past experiences of confronting natural disasters, how they coped with it, what they have learnt from it regarding going back to normal life again after the disasters.
- Local and Norwegian data privacy regulations will be upheld.
- People will have the opportunity to change/alter/remove their opinion anytime.
- There will be no question regarding religion, political view, or depth personal question that may hurt someone's felling.

Questions Pattern

1. What is your name?
2. How old are you?
3. How long are you living in this area? And your past generation?
4. What do you do for living? Please give us a detail about your work?
5. Have you faced any natural disasters lately? How devastating was it? Which one is more impactful in your opinion?
6. How does it have any impact on your lifestyle?
7. Have you lost your house/work/asset/farmland permanently to temporarily? Can you please say the details?

8. Have you lost any family member/neighbor/relatives due to natural disasters? When and how did it happen?
9. If you think, nowadays disasters are more significant before, why is it for?
10. Have heard about global warming and climate change? What do you understand by global warming and climate change? What is your perception regarding this?
11. Are you directly or indirectly affected by sea level rising and increment of water salinity? How?
12. Have lost any farmland because of that? Has it affected your earning activities?
13. Do you think climate change has any impact on local ecosystem? How?
14. Are you aware of climate change adaptation?
15. Have you got any support from the local/national/international authority to adopt climate change?

APPENDIX 3

Assent Form

Climate Migration and Adaptation of Coastline People in The Sundarbans

1. I am doing my school project and want to involve you.
2. I am asking other trainees to help me out too.
3. I want to know-
4. If you are happy to help out with my school work;
5. If you can understand what i am asking you.
6. I will ask some questions and use voice recorder to record your responses so that i don't forget the things you tell me.
7. I will come with you just in case you need any help to make sure if you want to ask me anything
8. I want you to know there is no right or wrong answers. Everything you say is important to me.
9. When i do my school paper, i want to include the things we have talked about.
10. You can change your mind about joining in with the research at anytime
11. When i do the paperwork, i will make sure your name and other private things you tell me, is not included. Nobody will know what you have said apart from me and you.
12. Please tell me if you want to see, change, or delete the answers you gave after we have finished chatting about your response.
13. If you want to have the results of my schoolwork, please tell me and i will include this in your scrapbook.
14. When i have finished with my paper, I will delete all the recordings i have on my mobile.
15. After hearing this, are you happy to take part in my project?
16. Can i check you have understood what my project is about? And what you will be doing to help me if you say yes?
17. If you want to ask me anything about the project, you can contact me through my email address, bdrm99@gmail.com or speak to me next time you see me.
18. I will give you a letter of agreement which explains the things we talked about today.

19. If you are happy to participate in my school project, could you sign this paper please?

Participant's name _____

Signature of participant _____

Signature of researcher _____

Date _____