Impact of Climate Change and Financial Risks on Coastal Tourism in Bangladesh

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Declaration

I certify that the work represented in this thesis is the result of my research. I declare as well that this research has not been submitted to any other institutions, or universities for any higher degree.

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Certificate of Supervisor

I am very blissful to certify that the research work carried out in this thesis entitled "Impact of Climate Change and Financial Risks on Coastal Tourism in Bangladesh" by Samshad Nowreen for the award of the Degree of Doctor of Philosophy in Banking and Insurance is a bonafide research work which has been completed under my supervision. The researcher has followed the rules and regulations as laid down by the University of Dhaka for the fulfillment of requirements to be awarded with a Ph.D. Degree. This thesis is an outcome of her original work. The research findings included in the thesis have not been published elsewhere. This is worthy of consideration for the award of Ph.D. Degree in Banking and Insurance.

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Abstract

Bangladesh is embedded with diversified natural attractions, seasonal beauty, and different physiographic characteristics. Moreover, the country has a long coastline in the south with three major types of distinct land formations and biodiversity. These salient features of natural attraction ramify nature-based tourist destinations in the world. However, natural calamity along with the major threat of climate change induces natural disaster that threatens the top tourist destinations of Bangladesh, such Cox's Bazar or Kuakata or the Sundarbans. It hinders the tourism growth of the neighboring countries of Bangladesh. Therefore, the research identifies the climate change impact on coastal tourism of Bangladesh, and the financial risks in coastal tourism arising from climate change.

To conduct this research, mixed-methods research design that is predictive and explanatory in nature. Three distinct study areas had been selected for the research based on their physiographic condition. Two types of data were collected and analyzed: secondary data on climatic variables and images of vegetation coverage of the study areas, and financial data from five banks, all obtained from authentic and reliable sources. Moreover, a primary survey for an in-depth interview with 20 respondents had also been conducted. After triangulating and analyzing time series, results show that slow, gradual climate change is occurring across all climatic elements, triggering different types of calamities in the study areas. The Tourism Climate Index (TCI) model was used to analyze and predict future comfort seasons for travel in the study areas.

Mostly, though the trend of rising temperatures is very low at present, it would be higher in the near future if Business As Usual (BAU) continues. As such, among the three regions, the top outdoor tourism and recreation destination of Bangladesh would experience the greatest rise in temperature, with prolonged and higher precipitation rates. Furthermore, the rise in hot weather has spread across the area over the last forty years, with a declining trend in

vegetation coverage across the whole area. There is an increasing rate of depositional landforms.

Furthermore, TCI model shows that although Cox's Bazar is the top-ranked outdoor tourism destination at present, it would gradually decline as it becomes less favorable to tourists because of the shrinkage of the tourist season, and the excellent tourist season would become moderate to tourists as climatic conditions will have higher temperatures, more cloudy sky, an increased rate of precipitation and windy weather. Consequently, analyzing credit risk by developing a model of TCI risk factors for bank loans, it has been identified that the risk factor for Cox's Bazar will be the highest. Different banks will have different types of credit risks based on the model developed for the "Tourist Climate Index Value at Risk (TCI-VaR)", which has found that credit lending for a prolonged maturity period would entail greater credit risk, which is currently neglected. It would be between 2.62% and 3.71% for 10-year and 5-year debt (10 million BDT), reflecting the impact of climate change.

Kuakata would have a very low, rising trend in temperature and precipitation, though it is negligible at present. There is also widespread hot weather across the area. After using the TCI model to analyze tourists' comfort in the study area, it shows that, though the tourist season would shrink, Kuakata would remain a more favorable place for outdoor or beach tourism, with excellent climatic conditions from November to March. In terms of investment, Kuakata would be least affected by climate change, as the TCI risk factor has been identified as negative. Thus, TCI-VaR credit risk will be -0.05% per 0.1 million BDT in debt for tourism. However, most banks do not lend money for tourism or recreational projects for tourists in this area, as Kuakata, as a tourist destination, is still neglected.

Finally, the temperature and precipitation in Shatkhira show a rising trend upto year 2100. Moreover, the vegetation coverage has been gradually declining with wetlands. However, if other variables remain as control variables (such as deforestation, land encroachment, and

hunting) due to climate change, this area would remain favorable for tourists, with very good climatic conditions from December to February, for the next eighty years. Furthermore, in terms of investment, the Sundarbans would be less affected by climate change, as the TCI risk factor has been identified as moderate. Likewise, Kuakata has also been neglected and has not burgeoned into a tourist destination. Banks would have to face a credit risk of 0.40% over 3 years for a 0.1 million BDT loan, which has been neglected as a aftermath of climate change. Therefore, from the research, it is clear that different study areas require different policy formulations for investments and tourism development zoning.

The top tourist destinations in Cox's Bazar are in a high-risk position for investment in outdoor or beach tourism due to climate change. Conversely, this research identifies other coastal destinations that would remain comfortable for outdoor tourism-based activities over the next hundred years. However, there might be other factors that degrade the destination; yet, policy formulation to keep the destination rich in natural resources is very urgent at present for sustainable tourism development. Besides, Cox's Bazar, which is considered the top revenue-generating destination of Bangladesh, should be slowly transformed into an amalgamation of man-made and natural destinations to sustain development and preserve its top position.

List of Abbreviation

BAU: Business as Usual

BB: Bangladesh Bank

BBS: Bangladesh Bureau of Statistics

BDT: Bangladeshi Taka

CC: Climate Change

EEZ: Exclusive Economic Zone

GDP: Gross Domestic Product

GHG: Green House Gas

IMO: International Meteorological Organization

IPCC: Intergovernmental Panel on Climate Change

LBU: Local Business Units

LST: Land Surface Temperature

MODIS: The Moderate Resolution Imaging Spectroradiometer

NDVI: Normalized Vegetation Difference Vegetation Index

NASA: National Aeronautics and Space Administration

PA: Protected Area

TCI: Tourist Climate Index

TOAB: Tour Operators Association of Bangladesh

UNEPFI: United Nations Environment Program on Finance Initiatives

USD: United States Dollar

USGS: United States Geological Survey

VaR: Value at Risk

WTO: World Tourism Organization

WTTC: World Travel and Tourism Council

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Chapter One

Introduction

1.1 Introduction

Tourism is one of the top revenue-generating sectors in the world, with a complex and multidimensional nature (Adrian, 2017; Tovmasyan, 2016). The industry is complex because of its diversified, wide-ranging service-providing sectors (including accommodation, transportation, food and beverage, travel agencies and tour operators, recreation, tourism information services, and the capital market of tourism) (Swarbrooke and Horner, 2001). The Tourism industry has direct, indirect, and induced economic contributions to any nation. In 2019, the worldwide tourism industry accounted for a 3.2% contribution (direct) and 10.4% total contribution to the world's GDP (WTTC, 2019). From travel and tourism, visitors' export was 9.2tn USD, comprising 6.8% of total exports, and 27.4% of global service exports in 2019 (ibid). It also offered 334 million employment opportunities specifically in tourism, accounting for 10.6% of all employment worldwide (ibid).

However, this industry is directly influenced by climate, as it is the most significant factor in determining tourist flows (Becken and Hey, 2007). Therefore, tourism is understood to be a foremost climate-dependent industry, similar to agricultural or fisheries industries (Holden, 2020). Besides, climate and environment determine the spatial patterns of tourists' flow from region to region. Tourists often plan trips to destinations where they can relax and enjoy the surrounding environment by sunbathing, sightseeing, or even walking in pleasant weather (Lise and Tol, 2002). Nonetheless, in recent years, the world has become increasingly concerned about Climate Change (CC), as it is predicted to affect mostly low-lying coastal areas, such as Bangladesh, the Caribbean Islands, and the Pacific Islands. Climate change also damages assets; for example, hotels and resort properties in coastal areas become more vulnerable (Scott *et al.*, 2019; Sussman and Freed, 2008). Again, a higher rate of increase in green and open spaces creates a further adverse impact on the earth. Moreover, greater exposure of the insurance industry increases the frequency of extreme weather claims (Wilby, 2009). However, the tourism industry is carbon-intensive, with transportation (i.e., aviation) responsible for a significant part of carbon emissions. Until 2013, the tourism industry was responsible for 8% of total global carbon emissions (Carbon Brief, 2018).

According to the IPCC report (2014), CC will lead to a 4^0C global average temperature rise in the mid-twenty-first century from the pre-industrial level, if emissions continue at this rate. Ironically, because of CC effects on low-lying developing countries exposed to severe climatic adversity, most coastal areas and marine ecosystems, including those that depend on them, are highly vulnerable to the impacts of climate change. Thus, climate change calls for better documentation of areas at particular risk to mitigate their effects (Gattuso *et al.* 2018; Allison and Bassett, 2015).

Various environmental risks arise from the direct impacts of climate change, such as droughts, floods, changes in precipitation, melting of ice caps, increased frequency of disasters, increased intensity of cyclones, and rising sea levels. Ironically, tourism is among the top industries most exposed to these types of adversity (IPCC, 2014). However, Bangladesh, with a long coastline of 710km in the tropical areas, cannot be exempt from the adverse effects of climate change. This coastal area of Bangladesh is the hub of various socio-economic activities, generating diversified livelihoods for the mass people living there (Rasheed, 2015).

1.2 Coastal Area of Bangladesh, Tourism, and Climate Change

Coastal areas of Bangladesh offer different types of economic activities, and tourism is one of the most burgeoning industries in the region. Among different types of coastal regions, Cox's Bazar, situated in the most southeastern region of Bangladesh, is considered the most popular tourist destination of Bangladesh. It is also renowned for the world's longest continuous depositional sea beach, which is very rich in biodiversity and scenic beauty. Although Cox's Bazar had been regarded as the top revenue-generating tourist district throughout history, it began experiencing tremendous growth in the tourism sector since 1990, driven by improved transportation (TOAB, 2020). During the tourist's peak season, millions of tourists visit the destination, accommodated at hotels, motels, and guesthouses under public and private ownership. Besides, some visitors even spend the night inside the vehicle because of the unavailability of accommodation. From the general observation, it has

been identified that tourism brings noticeable change in any area. People belonging to the local community apparently benefited from tourism and, therefore, their economic condition improved compared to other nearby areas.

Unlike the Sundarbans, situated in the southwestern part of the country, Cox's Bazar, which has fewer tourists, is also a tourist destination for adventure tourists during the winter season. The Sundarbans is one of the biggest mangrove forests in the world. It has been declared an ecologically critical area, and the wetlands within this forest are declared as Ramsar sites. These forests provide ample ecosystem services, including rich biodiversity and forest resources such as timber, honey, and fisheries. On the contrary, Kuakata is another prominent coastal tourism destination in Patuakhali, situated in the mid-southern part of Bangladesh. However, it is yet to be recognized as a well-established tourist destination. In Kuakata, there is a lack of infrastructure and superstructures for tourism. There are many other coastal islands with potential to be tourist destinations; yet, there is negligence of destination development for tourism.

Although all potentials remain in the destinations to boom or attract tourists nationally or globally, the growth of tourism in Bangladesh is still at a slow pace because of several challenges. These ambiguities embrace poor and inadequate infrastructure along with superstructures, a lack of appropriate tourism policy, a lack of safety and security, insufficient information, a lack of recreation facilities, a lack of local cuisine, inadequate professional service providers, and the absence of expert tourist guides.

Besides, the coastal zones of Bangladesh face an increasing rate of natural disasters that threaten the tourism industry both nationally and internationally (Islam *et al.*, 2021; Shamsuddoha and Chowdhury, 2007). Moreover, climate change is the most vulnerable threat to the low-lying coastal areas of the country (IPCC, 2015). It is predicted that it will increase coastal environmental degradation, and it has been estimated that Bangladesh is located at the top of the climate change-affected countries in the world (IPCC, 2015).

According to IPCC (2015), in Bangladesh, climate change will have many adverse effects, for example, increased frequency of cyclones, rise in temperature, tourists' seasonal shift, coastal erosion, uneven rate of precipitation, lack of daylight, loss of biodiversity, sea-level rise, loss of land fertility, high commodity prices, and so on. Long-term changes, such as sea-level rise, global change in climatic patterns, ocean acidification, and changes in sea or coastal surface temperature, are expected to put millions of people at economic risk.

Nonetheless, the tourism sector is not exempt from the consequences of the adversity towards the marine ecosystem (Hoegh-Guldberg, 2014). Climate change has direct adverse impacts on various asset prices and investments as well (Dietz, 2016). Scientists identify two types of risks that will arise from climate-related stresses based on the timeframe of occurrence, which are termed as physical and transition risks. Consequently, these risks could bring uncertainty based on the investment in future payoffs and asset prices (Campigilo and Monnin, 2019). It will create a shrink in return period by short-falling of dividend, high-energy price, risk, and exposure, energy price rise for clean energy (ibid).

1.3 Vulnerability and Adaptation to Climate Change in the Coastline

In 2016, the United Nations Framework Convention on Climate Change (UNFCCC) adopted the Paris Agreement, a legally binding international treaty to limit global warming (UNFCCC, 2021). In the Paris Agreement four climatic scenarios has been forecasted on different levels of emissions from Pre-Industrial Revolution state (UNFPCCC, 2021; Warren *et al*. 2018), which are 1) 1.5^0C consistent (Scenario 2^0C like pre-industrialization), 2) 2^0C-2.7^0C Consistent (INDC-Intended National Distribution Contribution; Optimistic Net Zero Targets), 3) 2.7^0C-3.1^0C Pledges and Targets, Current Policies (INDC-High Intended national Distribution Contribution), and 4) Business As Usual (BAU) 4.5^0C (Climate Action Tracker, 2022).

Furthermore, the recent trend is that private actors sometimes mitigate climate-related risks. For example, the Financial Stability Board (Financial Stability Board, 2022) established in 2009, a Task Force for Climate-related Financial Disclosures (TCFD).

It identifies sector-specific suggestions to disclose climate-related financial risks for the companies to minimize climate-related financial risks by informing the investors, banks, and benefactors. It also gathers industries or academia-led targets to improve the climate-related data available to financial investors. On the other hand, the United Nations Environment Program on Finance Initiatives (UNEPFI) was established in 1991 for creating sustainable banking, insurance, and investments (UNEPFI, 2021).

Several studies identified the impact of CC on coastal resources of Bangladesh; yet, there is a lack of studies on the CC impact on coastal tourism of Bangladesh. Moreover, very few studies have been done to forecast the climate change impact on investment in the tourism industries of the coastal areas of Bangladesh. Investors and industries now strive to deal with climate change adversity towards Business as Usual (BAU) to "tackling climate change or safety first path" (Abreu *et al*., 2021). However, this research aims to find out the climate change impact on tourism and financial risks in the tourism sector derived from climate change in the coastal areas of Bangladesh.

1.4 Problem Statement of the Research

Climate change is predicted to bring about crucial change in the tourism sector (Scott & Gössling, 2022). However, in Bangladesh, tourism as an industry has been neglected, though it has high potential to contribute to the economic and social development. Recent initiatives to embrace tourism within the umbrella of the exclusive economic zone are very crucial; yet, there is an imbalance in the destination development process. Nonetheless, disregard for long-term plans to tourism development in the coastal areas (i.e., 710kms) of Bangladesh, falsifies true tourism development compared to neighboring countries.

Ironically, the recent trend of climate and physiographic challenges forecasted by international organizations threatens the emerging industry's high potential. The existing gap in a proper development plan and databases for future planning hinders the feasible and sustainable development of this sector. For example, Cox's Bazar, the top tourism destination of Bangladesh, is at the economic front, and is getting benefits through investment, business of hoteliers, tour operators, and so on. In contrast, very

little knowledge has been gathered on the overall impact of tourism on the economic, social, cultural, and environmental aspects. Moreover, climate change has been adversely affecting coastal development in Bangladesh.

The substantial literature on the impacts of tourism is apparently ambiguous while explaining; moreover, researchers report both positive and negative findings (Wall & Mathieson, 2006). This issue is the same for other coastal destinations of Bangladesh, such as Kuakata or the Sundarbans. Therefore, the particular research problems identified are as follows:

1. The climate change-induced impact on the coastal areas of Bangladesh needs to be thoroughly identified.
2. The climate change-derived impact on tourism in Bangladesh, specifically on coastal areas, is still unknown.
3. The risks of capital invested in the tourism (along with recreation) related financial sectors are also unknown.

1.5 Research Gap

While reviewing the literature, very little information on tourist flows or future plans to adapt to the climate change impact on tourism in the context of Bangladesh has been found. Moreover, there is a lack of information on the effect of tourism both financially and environmentally. Therefore, it is easily understood that this gap might lead to wrong planning for tourism development in the highly potential tourism destination of the coastal regions of Bangladesh. Although tourism is a burgeoning sector around the world, the coastal areas of Bangladesh lack in attracting the international tourism market.

Numerous studies have been conducted to develop coastal tourism destinations worldwide. However, Bangladesh, having the most valuable coastal areas of the world, has very little research conducted on tourism or sustainable economic development of the area. In contrast, there has been research conducted on climate change's impact on the coastal areas of Bangladesh. However, research on

comparison for the three distinct coastal areas had been exempt from that. Though the Government of Bangladesh (GoB) identified the Sundarbans as a fragile Protected Area (PA) and one of the ecological critical areas of the world, having an enormous diversity of aquatic and terrestrial species, almost no research has been conducted to identify the economic measures to protect the area to combat climate change and tourism development. This is equally applicable in the emerging destinations of Kuakata sea beach, as it lacks research to combat climate change and tourism development. The same issues arise in the Sundarbans areas. Therefore, particular problems identified for this research are:

1. Climate change impacts on tourism in the coastal areas of Bangladesh.
2. Adaptation process for climate change through tourism development.
3. Financial risks arising from climate change in the coastal areas.

1.6 Research Questions

This research aims to identify three main research questions, focusing on the impact of climate change on tourism and potential financial risks. The questions are as follows:

1. What would be the impact of climate change on the coastal areas of Bangladesh?
2. How would climate change impact the tourism sector in the Coastal areas of Bangladesh, specifically in Cox's Bazar (Sadar Upazila), Kuakata, and the Sundarbans?
3. How could climate change impact the financial sector financing of coastal tourism?

1.7 Research Objectives

The main objective of this research is to identify the **impact of climate change** in the coastal areas of Bangladesh, and also **the risk associated with lending credits by banks** in the tourism sector. The specific objectives are summarized as follows:

Objective 1: To identify the climate change impact on the coastal study areas of Bangladesh.

Objective 2: To figure out the climate change impact on the tourism sector in the distinct coastal areas.

Objective 3: To identify potential financial risks from the tourism-related investments.

1.8 Rationale of the Study

According to the fifth assessment report of the Intergovernmental Panel on Climate Change (IPCC), Bangladesh is one of the most vulnerable countries to climate change. Until now, a number of studies have been conducted on climate change's impact on various sectors, especially on vulnerable people and the ecosystem. Yet, one of the top potential economic sectors is tourism, which has not been assessed by its climate change impact.

The economy of Bangladesh is burgeoning, yet the country has a significant population pressure on a limited land area. In the peak tourist season, a tremendous number of domestic and international tourists visit seashore areas. On the other hand, the impact of climate change on the financial sector has been little researched to date, with the exception of the insurance sector. Therefore, it is necessary to investigate the environmental and financial risks created by climate change on the coastal tourism development of the country. It will further create scope for the policy makers to identify feasible strategies to combat climate change issues, and invest in a more effective manner to foster the tourism industry in the coastal areas of Bangladesh, having one of the richest beaches in terms of physiography, biodiversity, and climatic conditions.

1.9 Scope of the Research

There has been very little research on the climate change impact on coastal tourism, specifically the risks to investments in tourism industries. The initial stage of tourism development could amalgamate with sustainable tourism development. However, according to the scientists, climate change will adversely affect the low-lying

developing economies such as Bangladesh. As such, research in these fields could bring new dimensions, along with effective strategies for sustainable development and proper resource utilization. This thesis could be a source of ideas, strategies, and also a resource to the policy makers, scientists or investors to take initiatives for combating with the effects of climate change for sustainable tourism development. Moreover, the gaps identified from this thesis would be utilized (by the authorities of policy makers, national or international organizations) to produce more effective climate change adaptation strategies.

1.10 Rationale for Undertaking This Research Work

The tourism sector is creating diversified industrial ramifications in Bangladesh through various employment opportunities. On the other hand, the economy of the country is growing faster compared to the other South-Asian countries. It could be seen that the demanding tourist destinations of Bangladesh are situated in the coastal areas of the country, where Cox's Bazar is the topmost tourist-attracting destination of Bangladesh. However, CC is the biggest challenge in the near future for the whole world, where low-lying coastal areas are most vulnerable to the CC created disasters. Salinity intrusion, frequent cyclones and storm surges, uneven precipitation, unpredictable natural calamities, and decrease of tourist season are major threats to the coastal tourism development of Bangladesh.

Besides, most of the revenue-generating destinations of the country are nature-based. Explicitly, in the coastal areas of the country, only nature-based recreation facilities are provided for the tourists. Therefore, a marginal change in the coastal climatic conditions can create a disastrous situation for the tourism industry. In accordance with that, there has been negligible research on climate change's impact on tourism, and no research has been conducted on financial risks arising from climate change in tourism industries. Therefore, this research is very crucial and time worthy at present, where the economy of Bangladesh is growing in many ways. Moreover, the tourism sector has been given extra emphasis through its incorporation within the Bangladesh Exclusive Economic Zone (EEZ). This industry has been integrated within 100 EEZs of the country. Thus, it is urgent to identify how climate change would impact coastal

tourism, and whether investments in coastal tourism might bring financial risks or not. Hence, this research is very important for environmentalists, investors, and policymakers.

Chapter Two

Literature Review

Tourism is a very fast-growing industry that provides recreation and other facilities to tourists who move to different places from their place of origin for various purposes. This industry not only creates livelihoods for people around the destinations but also natural or anthropogenic development if maintained properly. Tourism is mainly created based on the physiographic, climatic, socio-economic, demographic, and cultural characteristics of the destination. However, climate is mostly considered the major influential factor for nature-based tourists' destinations, as tourists' seasons are determined through the climatic elements of that region. Ironically, it has been identified from the IPCC sixth assessment report (2023) that the global climate is changing because of various anthropogenic factors. This changed climate will slowly create different types of impacts on the physical destinations and overall environment of Earth in the near future.

Besides, this change of climate is a big reason throughout the world for the structural transformation of any tourist destination, along with its physiography. Global temperature has risen to higher than 1.1^0C in 2020 from 1900 (IPCC, 2023). Moreover, oceanic temperature also rose to 1.01^0C. Actually, global surface temperature rose tremendously in the last 50 years compared to the previous 2000 years with a prediction rate of increase in the future (ibid). In this circumstance main catalyst to temperature rise is GHG (Greenhouse Gas), where developed worlds are the biggest emitters of GHG. On the other hand, underdeveloped and developing low-lying countries are becoming sufferers because of climate change. Climate change triggers imbalance in different natural cycles, such as hydrological, bio-geochemical, energy and other environmental cycles within the earth. Therefore, the low-lying coastal areas are most vulnerable to climate change-inducted disasters.

2.1 Interrelation between Tourism and Climate

Tourism, specifically outdoor tourism, relies on the climate. Most importantly, coastal and marine tourism, ski tourism, which is widely popular, rely on the climate of a region (Steiger, 2019; Orams & Lück, 2014). It has been observed from many studies that climatic conditions, and tourist flow are highly interrelated (Gidebo, 2021;

Kulendran & Dwyer, 2012; Becken, 2010). Here tourist flow indicates people traveling from the place of origin to a destination for a specific time (Keum, 2010).

Climatic elements include precipitation, sunshine, temperature, daylight, wind speed, humidity, wind velocity, and so on (Martin, 2005). Besides, climate is the long-term weather condition of a larger region for more than thirty years (Linacre & Geerts, 1997). Therefore, while a tourist travels to a destination, they try to figure out a feasible time for traveling by checking the climatic conditions of that region. Moreover, tourist seasons are determined by the climatic conditions (Ridderstaat, 2014). However, a small change in weather and climatic patterns could change the entire tourism system of a destination. Nonetheless, at present, the impacts of climate change are a significant concern, particularly for the tourism industries.

2.2 Understanding Climate Change

Climate is considered the average change of all-weather elements of a large region for a longer period (more than thirty years) of time (National Aeronautics Administration, 2014). Furthermore, climate change is termed as the changed pattern of climatic elements of that region due to natural or anthropogenic factors. However, the discovery of climate change is not recent or anonymous. Though climate change could be created in two ways; first is by natural processes (i.e., it is very rare and uncontrollable or uneven), and the other one is by anthropogenic factors. Among many discoveries, some of the greatest findings are the first industrial revolution (1800-1870) that geared up population growth, and greenhouse gas emission (e.g. CO_2). In 1879, the International Meteorological Organization (IMO) compiled the weather data, which was further used for analysis to assess climate change.

Nonetheless, in 1930, the rise of global temperature was first reported (MIT, 2010). Within these years, many scientists and researchers compiled evidence on climate change for global warming prediction. Moreover, in 1990, IPCC published its first report on global warming, and the Rio De Janeiro produced the UN Framework Convention on Climate Change (ibid). In 2015, through Parish agreement all nations set their desired reduction rate of carbon emission, and pledged to control global

warming and climate change. However, it is predicted that if BAU (Business As Usual) goes in this way and economic development continues without considering environmental destruction by 2100 global average temperature will rise above 4^0C changing the climatic pattern worldwide and changing the physiography (IPCC, 2021). This impact will not only affect the changed environmental condition but also change the livelihood and society.

2.3 Impact of Climate Change on Tourist Flow and Tourism

Climate change will have an adverse impact on tourism in the different continents of the world (Agnew & Viner, 2001). Most importantly, climate change will increase the adversity on local communities and the natural environment by increasing the frequency of disasters such as cyclones, storm surges, drought, salt water intrusion, irregular rainfall, and sea-level rise (IPCC, 2011). Yanez *et al*. (2020) projected the adverse impact of climate change on the seasonal tourism business in northern California, USA.

Additionally, there is potential to shorten tourist seasons in different countries due to climate change. The sixth assessment report of climate change (IPCC, 2021) on a physical basis already identified the direct impact of climate change on winter tourism. Moreover, in different scenarios, climate change will adversely impact popular or emerging destinations worldwide. Furthermore, Scott *et al.* (2018) show winter sports or mega games events, such as the Olympics, were adversely affected by sports tourism in different scenarios (RCP 2.6 and RCP 8.5). Nonetheless, different types of indexing could determine the status and development of the tourism sector of a destination. Among those, one of the top-most and widely used methods is the tourism climate index (TCI) developed by Miczkowski (1985). This model has been created with the data derived from climatic data in the world context for the month of January; moreover, it explains every factor responsible for tourist comfort to visit a destination based on the availability of data from developed to developing countries.

Well-reputed research found that tourists flow and Tourism Climatic Index (TCI) are interrelated (Wang *et al*., 2022; Alonso-Pérez *et al.,* 2021; Zhong & Zeng, 2019;

Roshan *et al*., 2016). Not only that, this model has been used for predicting tourists' comfort in the future (Kubokawa *et al.,* 2014). Unlike dessert and mountain-based tourism, TCI is more appropriate for coastal tourism (Akbarian Ronizi *et al.,* 2016; Amiranashvili *et al.,* 2015). However, there have been numerous debates on the applicability of TCI on beach tourism as several scientists argue that Holiday Comfort Index is a more appropriate method for measuring tourists' comfort in beach areas (Rutty *et al.,* 2020; Scott *et al.,* 2016). As per the discussion, it implies the TCI is more complex, and the availability of data could be complicated to determine the TCI, whereas HCI is simpler and easier to analyze. There are other models used to determine the influence of climate on tourist flow, such as the Coastal Tourism Climate Index (CTCI), which is similar to HCI (Gao *et al.,* 2022), bioclimatic tourist comfort (Rutty & Scott, 2022), and Tourism Climate Comfort Index (TCCI) (Anđelković *et al.,* 2016).

Although these debates continue to yield substantial research outcomes, TCI has still been used as the base for understanding tourist comfort and tourist flow in destinations by determining the optimal climatic conditions for travel. It brought accurate results for a couple of decades in several destinations, including beach areas. Furthermore, it can predict future comfort indexes in specific destinations if the climatic elements are given properly. Until now, the interrelation between tourist flow and climate change effects has been identified and investigated through TCI and other indices (Rosselló-Nadal, 2014).

2.4 Climate Change Impact on Coastal Tourism and Economy

As climate and tourism have an interconnection on climate change, it can affect the nature of coastal areas' travel patterns (Jarratt & Davies, 2020). Nonetheless, the tourism economy will be affected by climate change, which will decrease GDP contribution (Pintassilgo *et al.,* 2016). Coastal tourism is one of the top-most influential areas of the tourism industry; there is a lack of research and guidelines for coastal tourism development, considering climate change adaptation and risk mitigation. However, because of the slow and long-term nature of climate change impacts on coastal tourism, it is neglected in assessing the vulnerability of climate

change on coastal tourism (Arabadzhyan *et al.*, 2021). The risks induced by climate change will be incredibly big, which has already started to become evident from the occurrence of various disasters (Scott & Verokoeyen, 2017).

2.5 Tourism as an Industry

In recent times, international tourism ranks third after other export-oriented industries such as fuels, chemicals, and automotive products (Rasool *et al.*, 2021). World Travel and Tourism Council (WTTC, 2022) figures out that from the travel and tourism industry, the contribution to the world economy is $9,630 billion, which stands for 10.30% of the world's total GDP (Gross Domestic Product) in 2019. However, this contribution has shrunk to 6.1% due to the COVID-19 pandemic from 2020 to 2021. Moreover, the World Tourism Organization (UNWTO) argues that tourism is in the topmost leading sector in the world economy, not only for diversifying income generation from various sources but also for creating employment to different countries and regions of the world.

Tourism is considered a burgeoning sector for one-third of developing countries. However, in the context of South Asian nations, it plays a vital role in changing household economy, to reveal new employment or income-generating opportunities, and for the updated technologies (Liu, 2003; Barkin, 1996). For many developing nations, the number one export category is produced from tourism, creating employment and diverse opportunities for development. Furthermore, in the tourism industry, eight major industries are linked, and it is a consumer-dependent industry. It created a mass movement of people from one region to the other for an urge to discover or explore unattended places, seeking changes in society, and gaining knowledge of different experiences.

In Bangladesh, tourism gained recognition as an industry in 1999, though it has not received much attention to date as a vibrant industry, where the neighboring countries to it are among the top-ranked popular destinations in the whole world. On the other hand, tourism is globally regarded as the fastest-growing industry (Howlader, 2012; UNWTO, 2008). Though tourism is considered one of the top revenue-generating

industries throughout the world, in the context of Bangladesh, this industry is still underdeveloped. It contributes only 2.2% of total GDP, generating only 0.5% of GDP from visitors' export, and creating 1.8% tourism-related jobs, yet investments in this industry are still lagging behind (WTTC, 2014). However, the Government of Bangladesh is thinking of investing more in the tourism and recreation sectors with the economic growth of the country. There have been ninety-seven exclusive economic zones, and three economic zones of coastal regions have been declared extensively for the tourism sector (BEZA, 2022).

2.6 Tourism and Economy

In 2019, the tourism sector contributed 10.4% of global GDP (WTTC, 2020). Moreover, economic diversification happens through tourism by creating direct, indirect, and induced livelihoods generated from tourism-related industries. In Bangladesh, 1.1 billion USD in Capital was invested in the tourism sector, while the top-ranked tourist destination, France, invested 41.41 billion USD, the USA invested 184.59 billion USD, and India invested 44.35 billion USD. However, after the COVID-19 pandemic hit tourism, this sector suffered huge negative impacts through the drop of GDP contribution to 5.5% (World Bank, 2022).

As such, it can be seen that the pandemic has hit the whole world, and the suffering and tourism industries have collapsed, with many of them struggling to revive. Therefore, any global change will impact the industry slowly or drastically if any natural or man-made disasters happen. As tourism is highly interlinked with climate, climate change will undoubtedly cause capital loss and damage the industry, making it riskier for future investments. The world is currently seeing a trend of tourists moving to developing countries, and the reasons vary, such as business travel, diaspora travel, adventure trip, community-based travel, and so on. Besides, the tourism sector in Bangladesh is growing rapidly because the emergence of discretionary income is increasing. Moreover, along with economic advancement, accessibility and infrastructure are growing in the country.

2.7 Tourism in Bangladesh

The number of international tourist arrivals in Bangladesh was 1,642,789 in 2019, from which the direct GDP contribution was 3.2% to the economy (BBS, 2021). Total inbound trips were 12,73,48,000, and the number of tourists incorporating multiple travelers was 32,66,38,000 in that year (ibid). Total contribution from tourism employment was 8.07%. The World Travel and Tourism Council (WTTC) estimated in 2012 that tourism investment in Bangladesh would reach 36.52 BDT billion with a growth rate of 6.7% over the next 10 years, and in 2022, the economic contribution from tourism was 69.8 BDT billion. Moreover, this sector is gradually becoming familiar with the global strength of economic growth and the rapid development of modern industries in the business world. Moreover, in the 21st century, tourism is considered an important sector due to its significant share in the world economy. Among the very few nature-based tourism destinations, Cox's Bazar is situated in the most southeastern region of Bangladesh, and is considered one of the top mass tourism destinations. Cox's Bazar is also renowned for the salient features of the world's longest continuous depositional beach, which is very rich in biodiversity and scenic beauty.

Cox's Bazar experiences enormous growth during the tourist peak season, when millions of tourists visit the destination, occupying hotels, motels, and guesthouses that are fully booked. Even at that time, many tourists spent their nights inside the vehicle or mosques because of the unavailability of accommodation. It is already well understood that tourism has brought a big change in society, the economy, and the overall environment of this area. The people from the local community are seemingly benefiting from tourism, and the economy is better compared to other neighboring areas. In terms of the economy, the local community and other stakeholders of the tourism sector (e.g., investors, hoteliers, tour operators, transportation operators, recreation and leisure centers, food and beverage providers) benefit from it. Nevertheless, in the context of Bangladesh, there has been little research on the overall impact of tourism on specific destinations in the economy, society, culture, or environmental aspects in this destination.

Besides, the biggest mangrove forest of Bangladesh, the Sundarbans, lies in the southwestern part of the country. It is becoming a very popular tourist destination during the dry season. On the other hand, Kuakata is a potential tourist destination nowadays situated in the central southern part of Bangladesh, which is yet to be ready for an international tourist destination in Bangladesh. In Kuakata, there is a lack of infrastructure and superstructures of tourism. Although all potentials remain in the destinations to boom, tourism sector of Bangladesh is still facing a slow growth because of several problems, where the pull factors are underdeveloped and insufficient infrastructures and superstructures, lack of applicable tourism policy, lack of safety and security, insufficient destination information, deplorable recreation facilities, unprofessional tourist guides, poor destination management and tourism beyond determining carrying capacity. Not only are coastal regions threatened by the tourism industry.

Subsequently, climate change is the most vulnerable threat to the low-lying coastal areas of Bangladesh. It will increase coastal degradation, such as increased frequency of cyclones, storm surges, temperature, uneven rate of rainfall, salinity intrusion, biodiversity loss, and so on. It has been estimated that Bangladesh lies at the top of the list of climate change-affected countries in the world (IPCC, 2015). A large number of literature on the different aspects of tourism seems to contradict different perspectives. Therefore, researchers find both positive and negative findings based on the spatial investigation of the categories researched (Wall & Mathieson, 2006).

2.8 Climate Change and Its Impacts on Tourism in Bangladesh

As two-thirds of the areas of Bangladesh are less than 5m above the sea level, only 1m increase in sea level due to Climate Change (CC) will affect coastal industries (i.e., various livelihoods including shrimp, salt farming) in Bangladesh and the Sundarbans mangrove forest, displacing approximately 30 million people residing there (GED, 2005). Furthermore, an increased rate of natural disasters will also create coastal local communities that fall into a vulnerable position (Islam *et al.*, 2013). The major landuse pattern of this region is agriculture, shrimp and fish farming, forestry, salt production, ship-breaking yards, settlements, and resource extraction from

wetlands (ibid). The coastline of the country is highly vulnerable to natural disasters such as cyclones, storm surges, salinity intrusion, sea-level rise, droughts, and floods. Major cyclones occurred in this area in 1970, killing 0.3 million people, and in 1992, killing 0.13 million people, and almost every year, people living in the coastal area are affected (World Bank, 2011). Most importantly, climate change will increase the adversity on local communities and the natural environment by increasing the frequency of cyclones, storm surges, drought, saltwater intrusion, irregular rainfall, and sea-level rise (IPCC, 2011). Furthermore, as two-thirds of the areas of Bangladesh is situated in less than 5m above the sea level, only a 1m increase in sea level due to climate change will adversely affect the coastal industries of Bangladesh along with coastal tourism (Arabadzhyan *et al.,* 2021; Rawat *et al.,* 2016).

2.9 Climate Change Impact on Coastal Tourism and the Economy of Bangladesh

Several researches identified that climate change has major impacts on coastal tourism, although tourism is considered as the most highly valued ecosystem based service in the coastal regions. Major threats from climate change impacts are primarily on sandy beaches, and coral reefs, and these two ecosystems are the most relevant ecosystem that creates a natural tourist destination. Beach tourism is the most important component of the mass tourism industry which has a significant contribution to the economy of a country (Alexandrakis *et al.,* 2015).

IPCC (2015) indicates that oceans will continue to warm until the end of the century, which will affect the deep ocean, along with altering oceanic circulation. Historically, alterations of atmospheric configuration by the anthropogenic factors lead a series of impacts, i.e., heat waves and floods occurred in Europe in 2003, Pakistan and Russia in 2010, and Texas in 2011 (Mann *et al.,* 2017). IPCC (2015) revealed that the upper part of the global ocean, which was 75m, has been warmed 0.11^0C per decade from 1971 to 2010 (IPCC, 2015). Furthermore, because of climate change, huge population migration occurs through salinity intrusion (Chen & Mueller, 2018). Soil loses its productivity due to climate change as it diversifies aquaculture, enhancing soil salinity. Therefore, the productivity of the soil declines. Sea level would be increasing from 1 to 1.5m by 2100 (Day & Rybczyk, 2019).

Ironically, the link between climate change and the global financial crisis is evident (Leichenko *et al.*, 2010). Not only that, climate change impacts affect financial assets negatively in most places. The Arctic country's economy is affected because of the calamity affecting tourism arising from climate change (Jaskolski *et al.*, 2018). Besides, the BAU emission scenario, the global mean temperature in 2100, relative to preindustrial, would about to increase 2.5°C. The expected climate variable of global financial assets today is 1.8%. This matter is very important, as it has particular relevance in some financial risk management regimes, such as insurance (Dietz *et al.*, 2016). As it is well understood that climate change is an incomparable threat to the future of humankind and society, we have to go beyond the BAU approach (Wright & Nyberg, 2017). The reason behind it is that when climate change impacts local business units (LBUs), small to large industries, along with businesses suffer through disrupted activities, and fail to pay back the debt from various borrowers (Faiella & Natoli, 2019).

2.10 Climate Change and Its Impacts on Financing in the Tourism Sector

The tourism industry creates several types of jobs. There are three types of jobs and income generated from the tourism sector, and those are 1) direct, 2) indirect and 3) induced income. Direct jobs, which could be affected, are created from direct employment in tourism industries such as accommodation, transportation, recreation services, food and beverages, or tour operations. All these employments could be adversely affected in carbon-intensive sectors; yet, new types of opportunities could be created in low-carbon sectors. Furthermore, in the medium term, climate change policy could interfere with the economy as behavior changes and value chains adjust. For example, the drop of the coal power generation industry could lead to lay off in upstream jobs in the mining industry and rail merchandise. However, there would be the latest employment opportunities for carbon traders, solar power engineering firms, and climate change consultant organizations.

For the long term, climate change policy would release innovation for industry's repositioning themselves, seeking to exploit carbon opportunities. Employment would

be created in the research and development sector for low-carbon technologies. Over time, the results of research will create new investment and employment opportunities in the tourism sector (Fankhauser, 2008). However, an expansion of mass tourism can bring social, environmental, and long-term cultural degradation (Shaw & Williams, 1994). In contrast, sometimes tourism adversely contributes to the climate. For example, tourism is responsible for 8% of global greenhouse gas emissions (Dunne, 2018).

On the contrary, coastal tourism is very popular among the luxury tourists, where the world's oceans, seas, and coasts are awash within politics. The supply chain of tourism is highly affected by climate change because of changed climatic events in the coastal destinations (Arabadzhyan *et al.*, 2021). The coastal and marine environment is increasingly becoming busy, changing, and a site of degradation, marginalization, injustice, contestation, and conflict over declining resources and occupied spaces at local to global scales (Bennet, 2019). Therefore, to protect the world's top physiographic coastline, comprehensive research is needed for financial sector to keep up and develop the coastline of Bangladesh that is very popular for tourists and also for tourism industry.

Climate leads to turbulent financial decision-making as climate-related financial risks are highly debated. Potential effects of financial risks from the system, and stability in general, could be three types of risks such as: 1) transition risk, 2) physical risk, and 3) liability risk (Carney, 2015). However, financial performance is measured by the material effect of the corporation's record on compliance with carbon policies through regulatory risk. Regulations regarding Greenhouse Gas (GHG) vary by implication through corporations and other agencies in different countries. These regulations are considered through the analyst's assessments of the effects of the company's income, profit, or return on capital invested. The carbon exposure can be found for a company from three levels of the value chain. Hence, physical risks might emerge from the direct negative impacts of climate change, such as droughts, floods, storm surges, and sea level rise (Labatt & White, 2007). Industries are at a high level of risk, which is

specifically exposed to embrace tourism, agriculture, farming, fisheries, forestry, health care, water, real estate, and insurance (ibid).

In recent times, the "Green Supporting Factors" (GSF) have been advocating to compensate for the gap in green finance. Moreover, there are several supporters of this group, and among those, the European Commission is very active, which is the High-Level Expert Group on Sustainable Finance (HLEG, 2018), and the European Banking Association (D'Orazio & Popoyan, 2018). The de-risking of green assets is especially germane in the credit risk measurement mechanism of risk-weighted assets (ibid). From that risky credit company's longer pay-back period, green projects are usually assigned higher risk weights.

2.11 Climate Change and Financial Risk in the Banking Sector

Climate change affects the environment and socio-economy of various regions of the world and financial sectors in both the short and long term. Best examples of the impact of climate change on financial sectors are banking sectors that are naturally exposed to climate risks through their assets with the longest maturity. Most of the businesses, especially tourism-related businesses, get loans from banks or other financial institutions.

However, disasters or unpredictable environmental conditions change the return period of the capital invested (J. Maria, 2019). There have been several studies identifying indicators of factors that indicate firms located in disaster-prone, risky areas are more likely to default on their bank loans. Slowly, firms lose their profitability due to climate change and the induced natural disasters or risk factors arising from climate change. Javadi & Masum (2021) show the empirical evidence that climate change increases the spread of risk exposure to bank loans. Prettenthaler *et al.* (2015) identify 'Weather Value at Risk' as a tool that could be an effective tool to assess the impact of financial risks in the tourism sector arising from climate change.

Nonetheless, the Financial Stability Board has classified climate related financial risks into three categories (i.e. physical, liability, and transition risks), within these three

categories physical risks are implied for the value of asset price might fall into risks arising from climate change, where liability risks could be that firms suffering from seeking compensation from the loss or damage of trade and property values (Financial Stability Board, 2016). Thirdly, transition risks are defined as the change of regulation and technology for a low-carbon economy (ibid). Most importantly, the loss and damage created by climate change would have direct consequences in the banking and asset management sector.

Besides, there has been research and development of green banking techniques to adapt to climate change devastation in the banking sector (Nath *et al.,* 2014). Faiella & Natoli (2019) investigated the drivers of the credit-risk relationship on top of province and industry-level fixed effects, on three key controllable variables for the year 2016. Furthermore, the green credit guarantee scheme could bring spillover to green banking or other types of green investment to the industries (Taghizadeh-Hersay & Yoshino, 2019). The amount of loans granted to firms depends negatively on their climate risk exposure. The loans disbursed could range from no risk to extreme risk, depending on the natural calamity happening because of CC. These risks could vary depending on their magnitude, as shown in the following:

1) No risk → 2) Low Risk → 3) Medium Risk → 4) High Risk → 5) Extreme Risk

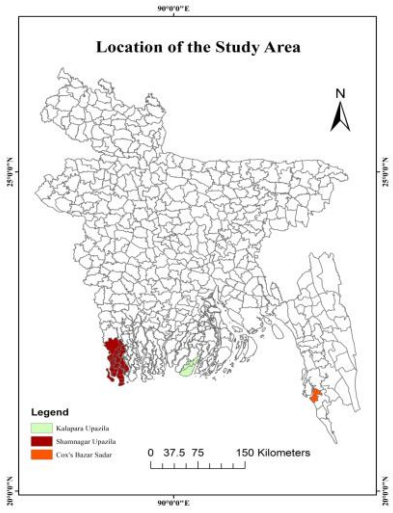
Ironically, research on identifying or assessing risks in the financial sector is still lagging behind. Bangladesh is far behind in research work for various reasons, specifically because this field is neglected for unforeseen reasons. The demands and initiative to undertake comprehensive research to assess climate change impact on tourism and the financial sectors sanctioning loans on Coastal Tourism in Bangladesh needs to be investigated along with the magnitude of effects.

Chapter Three

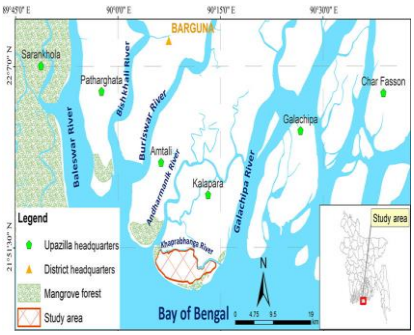
Research Methodology

3.1 Study Area

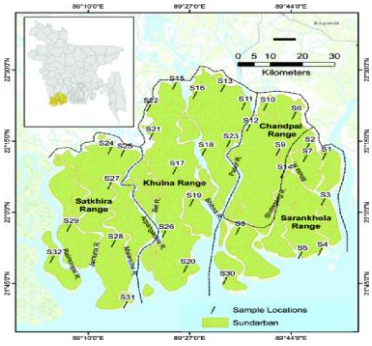
To conduct this research, three coastal areas have been selected to observe the impact of climate change because there are three categories of coastal regions in Bangladesh. The three distinct study areas are Cox's Bazar (beach area of Sadar Upazila) of the sandy eastern coast area, second was Kuakata of the middle coastal area of loamy depositional landmass, and third was Shatkhira (Shayamnagar) clayey western coastal region near mangrove forest (Rasheed, 2008). Each of the study areas has unique characteristics with salient physiographic and climatic features. Moreover, each study area has a tourist destination of its own significance.



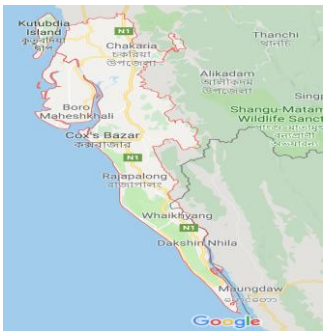
Map 3.1 Three Study Areas



Map 3.1.1: Sundarbans



Map 3.1.2: Kuakata



Map 3.1.3: Cox's Bazar

Source: Collected Google Map, 2022

These study areas have been selected because these three are the top-visited tourist destinations, having distinct physiographic characteristics. Moreover, compared to other regions, tourists visit these places during tourist seasons, specifically in the peak

season from November to March. According to the president of Tour Operators and Travel Agency of Bangladesh (TOAB) and Bangladesh Tourist Police, in Cox's Bazar in this season, every day, almost 60,000 tourists visit, whereas in the Sundarbans, every day, 15-20 ships carrying 15,000-20,000 tourists travel. Furthermore, according to Butler's theory, Kuakata is still in the involvement phase of tourism (landform of this type), having an increasing number of tourists with a burgeoning amount of investments in tourism (Butler, 2006). Therefore, all three destinations are developing based on their physiological features and climatic conditions, though the pattern of tourist attraction is tremendously different from each other.

3.2 Research Approach

The study has been conducted based on a '*Mixed Method Approach'*, which is explanatory and predictive in nature. It embraces historical climate and tourism data to model risk under varying climate comfort scenarios and to estimate potential tourism-generated financial returns. The types of data to conduct this research were both qualitative and quantitative within analytical research design. Furthermore, collected data had been triangulated for offsetting weaknesses through the strengths of the data, as it cannot solely fulfill the research target. Hence, a mixed method is essential to complete research by reducing the false interpretation (Bernard, 2017; Creswell, 2013). This research involves a wide spectrum of areas by investigating the climate change impact on tourism, the changing pattern of tourist flow through climate change impact, and investment decisions based on it. Therefore, it had been necessary to use a mixed method approach because this approach can figure out the potential impact of climate change on tourism from different perspectives. Consequently, the pattern of tourist flow in the study areas can be forecasted. Moreover, the changed pattern of tourist flow impacting the financial sector had been identified in this research using financial data. Both qualitative, and quantitative data, which are productive and exploratory, can be used for hypothesis-testing purposes (Miles *et al.*, 2014).

Mixed methods enhance research quality by modifying or reducing the contradiction, and improve the analytical power (Miles *et al.*, 2014). As such, this method reveals the strengths of any study (Bernard, 2017). It is also essential when quantitative or

qualitative data cannot fulfill the research goal. Qualitative and quantitative data transform research easier, where research is complex in nature. It facilitates solving research problems through experiments, by using effective statistical tools, careful measurement, generalizable samples, and effective results (Miles *et al.*, 2014). Finally, this method matches the results from two derived data from quantitative and qualitative approaches (Creswell, 2013). Huberman and Miles (1994) used a mixed method approach embracing different types of data using different techniques of data collection, such as field experiments, interviews, case studies, questionnaire survey, and so on. Figure 3.1 shows the interlink between qualitative and quantitative data with a mixed method approach.

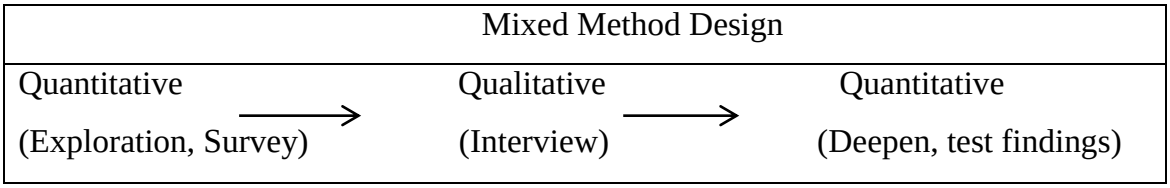


Figure 3.1: Linking Qualitative and Quantitative Data with Mixed Method Approach

Source: (Huberman and Miles, 1994)

Therefore, after finding all the successful reviews, this research followed a mixed-method approach. In this research, the quantitative research method has been applied to find out the impact of climate change on tourism in the study areas. To do so, the climatic data of the last 40 years of three study areas had been collected and analyzed from NASA's real-time Earth Viewer data sources.

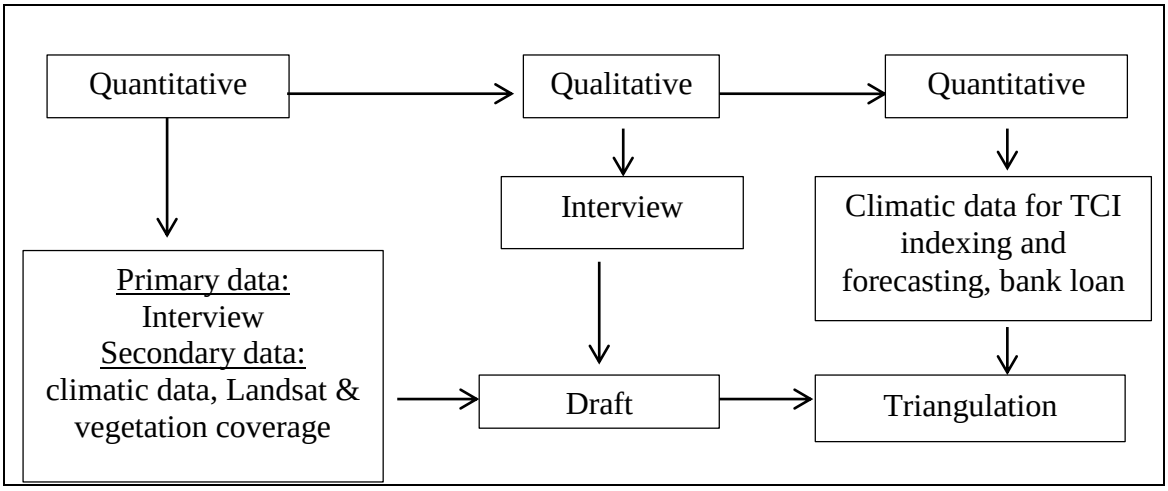


Figure 3.2: Mixed Method Approach Used in this Research

Source: Author's generated, 2023

Thus, this method has been used to identify the impact of climate change on tourism in the three identical coastal areas of Bangladesh.

Furthermore, the qualitative method was applied to comprehend the reliability of the findings of the quantitative data. The financial impact of climate change has been investigated using a quantitative research approach. To conduct this research, two types of data had been collected, which included secondary and primary data.

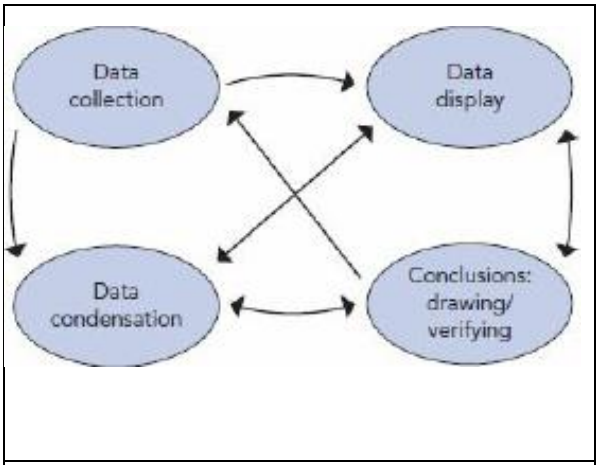


Figure 3.3: Components of Data Analysis: Interactive Model

Source: Miles et al., 2014

After compilation of collected secondary quantitative data, analysis, and findings had been retrieved. Development of the findings from the qualitative data through interviews brought about reliable findings (Figure 3.2). Creswell (2013) highlighted the basic and advanced approaches of mixed methods for modern research by basic and radical research designs. The result derived from quantitative data had been generalized with the support of qualitative data by an exploratory sequential design. As the qualitative data had been collected by semi-structured interviews, determining the variables, tools, and techniques completed the analysis.

3.3 Research Design: Methods of Data Collection, Analysis, and Presentation

The research has been conducted upon collecting climatic data, figuring out physiographic changes of the study areas over time, and forecasting possible changes. After that, the investments in tourism through bank data had been analyzed. Therefore, data collection, analysis, and interpretation have been introduced in three stages, and those are given as follows:

3.3.1 Methods of Data Collection

As mentioned above, for this research, two types of data were used: primary data and secondary data. The data collection process is as follows;

I. Primary data: Primary data is the raw data, which has been collected from various respondents. For this research, primary data represents qualitative data.

a) The Qualitative Data:

In this research, the primary data were collected through interviews using a semi-structured interview technique, which was qualitative in nature. For qualitative data collection, the researcher has to keep contact between the natural environments and the respondents (Saldana, 2011). Furthermore, in a qualitative data collection approach, researchers use different methods for data collection, such as enquiry, interview, and/or group discussion. Qualitative data provides enough and condensed explanation regarding the samples of the research (Miles *et al.,* 2014). The sampling is based on collecting information from the respondents, which should be within the limit or boundaries of the study, and keep focus only on the research question per case.

Qualitative data follows three steps including a) data condensation (raw data collected from field/calculation of means and standard deviation), b) data display (data accumulation with processed/regression printouts, correlation tables) and c) conclusion drawing or verification (updated but not final it may change based on original or raw data or further survey/ experimental, significance level) (Huberman and Miles, 2014). Qualitative data helps the quantitative data by triangulation to obtain data accuracy (Triangulation, D. S., 2014). According to Huberman and Miles (1994), qualitative data analyses go through some steps, such as interviews, note-taking, recoding, or observation.

In this research, qualitative data have been produced based on themes to fulfill the study objectives through semi-structured interviews that were conducted on twenty stakeholders who have knowledge of tourist flow, tourism, and investments in tourism at the study areas to figure out climate change and its impacts on tourists' flow as well as the economy. Again, to investigate the tourists' attitude towards the changed

climatic pattern identified through the semi-structured interviews with the tourists. It figured out tourists' behavior in different climatic conditions to make their travel plan. The field data had been preserved by audio, raw write-up or note, photography, and documents.

The list of twenty respondents is given below:

1. CEO of Bangladesh Tourism Board (BTB)
2. President to TOAB
3. President ATAB
4. Representative of Trust Bank
5. Representative of UCB Bank
6. Representative from IFIC Bank
7. Representative from the Bangladesh Bank
8. Representative from Mercantile Bank Ltd.
9. The local representatives from each study area
10. **Two** professors from the Department of Tourism and Hospitality Management, University of Dhaka
11. **Two** hotel owners of Kuakata and Cox's Bazar
12. Cruise ship owner from Shyamnagar
13. **Five** tourists
14. **One** representative from the tourist police

II. **Secondary data collection:** In terms of secondary data, three sources have been considered for the collection of this data, and the details are given below:
Books, peer-reviewed journals, book chapters, statistical data, reports of international organizations, government-authorized reports, conference papers, periodicals, and gray papers are the sources of secondary data. However, for assessing climatic conditions, the following variables of climatic data were used:

A) Climatic Variability to Determine the Change Detection in the Study Area

I. Collection of Climatic Data: Climatic data had been collected from two secondary sources and classified into two categories for the research purpose. First of

all, climatic variables from each of the study areas for the last 40 years (1980-2020) were used to detect climate change in the three study areas mentioned above. The source of these climatic data has been retrieved from NASA Power of Global Climatic Data (NASA, 2022). Among all other elements, the two most important variables are considered for statistical data collection and analysis. These variables are:

- Temperature, and
- Precipitation

Other elements have also been considered, such as sunshine, humidity, relative hot days, and wind speed.

Table 3.1 shows the variables used to collect climatic data, where temperature and precipitation is incorporated along with other climatic data.

Table 3.1: Variables for Climate Change Elements

Component of the Environment	Type of impact	Factors (variables)
Air	Atmosphere	**Annual temperature** **Annual precipitation** Annual relative humidity Annual hot days Annual cloudy days
Water And Mean Sea-Level	Coastal Erosion	Water quality indicators – Coastal Erosion and Sea-level Change Detection
Natural Disaster	Frequency of Coastal Natural Disaster	Change detection using Remote Sensing (RS) data Frequency and Intensity Cyclone and Storm Surge

Source: Author, 2022

Furthermore, other climatic data had been collected to analyze different types of change detection in the study areas, and the data had been collected from reliable and

authorized sources from the National Oceanic and Atmospheric Administration (NOAA) and the National Aeronautics and Space Administration (NASA). It is evident that all the predictions and assessments conducted by IPCC have been based on the data sources.

Table 3.2: Accuracy Level of Climatic Data of the Study Areas

	Study Area	Mean Absolute Error (MAE)	Root Mean Squared Error (RMSE)
Temperature	Cox's Bazar	0.403	0.489
	Kuakata	0.529	0.725
	Shyamnagar	0.47	0.628
Rainfall	Cox's Bazar	430	546
	Kuakata	308	440
	Shyamnagar	148	235

Source: NASA. (2022). Climatic Data. Retrieved from: https://power.larc.nasa.gov/data-access-viewer/

In the case of temperature and precipitation (i.e., rainfall) data had been collected from NASA's real-time Earth viewer data sources, and the accuracy level has been given in Table 3.2. Another classification consists of the climatic data of the previous 40 years (1980-2020). The source of these climatic data has been the NASA Data Access Viewer. Those data contain the variables such as 1) temperature, 2) rainfall, 3) humidity, 4) relative hot days, and 5) annual cloudy days. These data had been collected to show the climate change impact on tourist flow through the Tourism Climate Index (TCI).

Mieczkowski's TCI (1985) model has been widely used to evaluate the present and future of tourism, and the effect of climate on tourist flow in several areas. The TCI model is based on the notion of "human comfort" and consists of five sub-indices, each represented by one or two monthly climate variables. The five sub-indices and their constituent variables are as follows: (1) daytime comfort index, (2) daily comfort index, (3) precipitation (in mm), (4) sunshine (total hours of sunshine), and (5) wind (in m/s or km/h). The index has been weighted and computed as follows:

$$TCI = 4CID + CIA + 2R + 2S + W \text{……..(1)}$$

Here, the symbols mean (Amelung and Nicholls, 2007);

CID = daytime comfort index,

CIA = daily comfort index,

R = precipitation,

S = sunshine, and

W = wind speed. With an optimal rating for each variable of 5.0, the maximum value of the index is 100.

Justification for using this model:

The TCI model has been used widely so far because of its reliability in identifying climate change's impact on tourist flow. More than 300 research articles have been published in newly peer-reviewed journals based solely on this model. Moreover, this model brought about successful outcomes through tourist flow determination in different climatic conditions. Though this model is very conventional, it has been extensively accepted, and to date, it has been used as a basic model for determining tourist flow in different climatic conditions. However, in the context of Bangladesh's climate change, the impact on tourism has never been determined. Moreover, this type of model has never been applied to any tourism or climate change research in this country. Therefore, this widely accepted model has been adopted to conduct this new arena of research in Bangladesh.

In this research, both sets of data were collected on a monthly basis with the highest accuracy, and for a longer period from the study stations. Besides, daily climatic data has also been considered from the open and reliable data source of NASA. The model utilized for this research has been frequently used to identify the interrelation between climatic conditions and tourist flow. Moreover, it came up with the outcome to observe a changed pattern of climate change, creating an impact on tourist flow for the last forty years.

II. Collection of Remote Sensing Data: Satellite images from NASA's official data sources had been considered as the secondary data, and the images, termed

Landsat Images (USGS, 2022), had been collected from the Moderate Resolution Imaging Spectroradiometer (MODIS). Two types of Landsat images of Moderate Resolution Imaging Spectroradiometer (MODIS) have been collected for the last thirty years, where the first groups are Land Surface Temperature (LST) images, and the second are Landsat Normalized Difference Vegetation Index (NDVI) images.

i. Landsat Images for LST: The Moderate Resolution Imaging Spectroradiometer (MODIS) of continent and marine-based satellite provides very high temporal (4 times per day), and in space (1km) resolution images, which has been a very popular and broadly used sensor at present (Phan and Kappas, 2018). More than five hundred journals of Scopus databases are listed by using LST data for the application of worldwide temperature-related research work. Additionally, there is a steady rising trend of utilizing MODIS-LST images day by day. For this reason, LST and NDVI images and data had been collected from USGS sources.

First of all, for detecting land surface temperature change, Landsat-8 Satellite data hve been used to observe Climate Change, identifying Urban Heat Island or any kind of hydrological changes. The tool to sense the thermal data has been Thermal Infrared Band10 (0.6-11 μm) (Wang *et al.*, 2015). To exclude cloudy days, and using more accurate LST images, images had been collected from December to February months, depending on clear visibility.

ii. Landsat Vegetation Cover Image Collection: Normalized Difference Vegetation Index (NDVI) data had been collected using MODIS vegetation indices. These data had been produced considering 16-day intervals using multiple spatial resolutions. Not only that, it provided steady spatial and temporal comparisons of each and every part of the vegetation. Two vegetation indices had been derived from atmospherically-corrected reflectance in three wavebands: the NDVI, which provides continuity with the National Oceanic and Atmospheric Administration (NOAA)'s Advanced Very High Resolution Radiometer (AVHRR), NDVI time series record for historical and climate applications, and the Enhanced Vegetation Index (EVI), which minimizes canopy-soil variations and improves sensitivity over dense vegetation

conditions (NASA, 2022). The two products are more effectively characterized by the global range of vegetation states and processes. Furthermore, the frequency of natural disasters coastal erosion, along with deposition, had been shown from reliable secondary sources.

III. Loan Disbursed from Banks in the Study Areas:

Until now, subsidies, tax credits, feed-in tariffs, Emission Trading System (EMTs), Renewable Portfolio Standards (RPSs), and environmental regulations have addressed climate change externalities for achieving success through green finance (G20, 2016). Financial institutions such as banks, securities, investment, or insurance companies could play vital roles by investing in the tourism and recreation industries in the coastal areas of Bangladesh. Banks invest through allotting loans in different sectors of the tourism industries, such as accommodation, transportation, travel agencies or tour operators, food or beverage industries. To identify the risks from climate change impacts on investments in the tourism sector through bank loans had been studied in this research.

Therefore, lending credit in tourism industries had been considered, where branches of different banks, which have branches in the study areas, were considered to assess financial risks. A representative from Bangladesh Bank stated that there are 40 investment banks among 61 scheduled banks in Bangladesh. However, it has been found that there are 35 banks present in the three study areas. Nevertheless, not all banks have branches in the three study areas; moreover, not every bank invested or gave loans in the tourism or recreation sectors in the tourism industries. Additionally, state-owned and most of the commercial banks lack databases of loans or investments provided in the tourism sectors in the study areas. Therefore, disbursed credit loans had been collected from six banks among thirty-five banks, based on the availability of branches and the availability of resource persons to provide data of the banks (representing 17%).

Conversely, other investment authorities of Bangladesh, such as the Bangladesh Exclusive Economic Zone Authority (BEZA) and Bangladesh Investment

Development Authority (BIDA), made provisions for investments in the study areas. Although these organizations have invested in the tourism sector, they could not provide proper financial or investment data on the tourism aspects. Moreover, there is a lack of databases upon requesting frequently to these organizations. This is the biggest challenge for the industry.

3.3.2 Methods of Data Analysis and Presentation

There have been two types of data collected, which are primary and secondary data. Therefore, two different types of data need to be analyzed in two different ways. First of all, primary data had been analyzed using the thematic analysis technique, which has been described below in detail.

i. Thematic analysis: Thematic analysis has been done based on interview data, where semi-structured interviews were conducted to collect different types of data and information in every aspect of the tourism industry.

Semi-structured interview: Here are the steps of thematic analysis for semi-structured interviews;

- Step 1: Familiarization
- Step 2: Coding
- Step 3: Generating themes
- Step 4: Reviewing themes
- Step 5: Defining and naming themes
- Step 6: Writing up

ii. Climate Change Impact Analysis: Climate change impact has been investigated based on the climatic data, such as temperature and precipitation in the three study areas of Bangladesh. Besides, changes in temperature and precipitation in the tourist season from November to April have been analyzed through time series analysis techniques for forecasting using MS Excel. Trend and seasonality are the two variables included in the research. Time series forecasting is a very useful technique for analyzing the responses of climatic data where time is the independent variable. Therefore, this analysis method has been used to conduct this research.

Besides, Thermal Imaging Images collected from Remotely Sensed Images from 1980 to 2020 have been analyzed through an image analysis process. The maximum and minimum temperature spreading pattern in the study areas of every ten-year interval in specific months was analyzed. These months had been selected because of cloud-free months to get more accurate images from the UGCS images. Furthermore, vegetation coverage has been analyzed through NDVI images from 1990 to 2020, as these images have been available with the highest accuracy. Again, vegetation coverage along with bare land, settlements, and water bodies had been considered for analyzing the three distinct study areas. The model of environmental impact using GIS techniques has been shown using ArcGIS version 10.

Moreover, from secondary sources of CEGIS, the coastal erosion pattern and sea-level rise trend have been shown using the Landcover change map. The frequency of cyclone disasters has also been shown based on previous records of cyclones hitting the coastal areas of Bangladesh. Finally, a prediction graph has been developed by time series forecasting through analysis of temperature and precipitation data from 2022 to 2100 using statistical software R. Here, the analysis technique had been used to forecast the future of climatic responses in the study area based on previous and present climatic data.

iii. Change in Tourist Flow: There have already been several researches showing the impact of climate change on tourism. Researchers have identified and proved the interrelationship between changes in climatic variables that impact tourist flow. However, the model of Mieczkowski's Tourism Climatic Index (TCI) (1985) has been widely used to evaluate the present and future of tourists' flow in several areas. The TCI is based on the notion of "human comfort" and consists of five sub-indices, each represented by one or two monthly climatic variables. The five sub-indices and their constituent variables are as follows: (1) daytime comfort index, (2) daily comfort index, (3) precipitation (in mm), (4) sunshine (total hours of sunshine), and (5) wind (in m/s or km/h). The index is weighted and computed as follows:

TCI = 4CID + CIA + 2R + 2S + W……...(1)

Here, abbreviations of different variables are,

CID = daytime comfort index,

CIA = daily comfort index,

R = precipitation,

S = sunshine, and

W = wind speed.

These have an optimal rating for each variable of 5.0; the maximum value of the index is 100 (Amelung and Nicholls, 2007). Physical (P) Facets show the weather combination of matrix to determine a climate satisfaction rating that ranges from very poor (0=unacceptable) to extremely good (100= Ideal).

Table 3.3: TCI Index

TCI scores	**Descriptive categories**
90- 100	Ideal
80-89	Excellent
70-79	Very good
60-69	Good
50-59	Acceptable
40-49	Marginal
30-39	Uncomfortable
20-29	Very uncomfortable
10-19	Extremely uncomfortable
<10	Impossible

Source: Mieczkowski, 1985

The daily comfort index had been defined from temperature, precipitation, sunshine, and wind speed, considering the average data on a monthly basis. For TCI prediction, the time series method has been used, which is called the “Prophet algorithm”, using the software R. It uses simpler and intuitive parameters for making high-precision time series prediction. It considers the interferences created from different seasons and holidays. Along with that, it automatically detects the mutation points or any

point created artificially. It automatically compensates the missing values to make proper adjustments that give a close value of real life with higher prediction results (Zang, *et al.,* 2021). Prophet algorithm was developed as a decomposable time series model that has three main model components: trend, seasonality, and holidays. These components can be expressed as in Eq. (i) given.

$y(t)=g(t)+s(t)+(t)+\in t$…….....…….(i)

Here, g(t) stands for the trend function, s(t) represents the periodic changes, t represents the effects of holidays, and $\in t$ stands for the error. Taylor and Letham (2017) described more detailed research about the Prophet API.

On the contrary, TCI values induced from climate change had been calculated from 2080 to 2020. Six months of tourist season (November to April) had been taken into consideration for TCI analysis on the three study areas. Furthermore, for TCI prediction, again the time-series method had been used, and the TCI had been analyzed from 2020 to 2100 based on the tourists' seasons (November to April). However, for TCI prediction, average climatic variables for twelve months had been calculated. Yet, the retrieved data had been used in the following chapter to analyze the TCI risk impacting on the bank's credit lending.

iv. Financial Risks Analysis: Climate-Related Stress Test (CRST) methods are of vital importance to assess the extent of financial institutions for becoming exposed to carbon-intensive assets (D'Orazio and Popoyan, 2018). There are different types of stress tests methods applied to identify climate related stress test in the financial sectors. Developing a Financial model through a mathematical process designed to represent (a simplified version of) the performance of a financial asset or a portfolio, of a business, or any other investment in tourism sector for risk assessment could be used in that case (Karava, 2010). As, this sector is very new for a country like Bangladesh, more research is needed to identify the risks associated with investments in tourism industries.

Hence, for the research the following variables had been considered, for example, TCI induced from climate change, and its impact on bank loans. Here, the risk assessment approach was used to find out the financial risks of banks while lending credit in tourism sector. Firstly, a model had been developed to understand climate change factors that might pose risks to tourist flow over time. Secondly, translating climate change risk factors that might impact loans given by any bank through quantitative measures, which can inform risk management and investment decisions. The appropriateness of risk analysis tools, and associated metrics, had been primarily depended upon the loan granted, and risk types towards financial instruments are exposed (Scott *et al.,* 2017).

Therefore, Value at Risk (VaR) method has been used to calculate the climate change-induced TCI risks associated in tourism sector (Prettenthaler, 2016; Töglhofer, 2011). As such, the analysis was conducted followed by two steps: firstly, by matching the data on climate change-induced tourist flow risk with micro data on bank loans; and secondly, by making a model whether the level of climate change risk affects the bad loans or loan spread. With respect to these, the research analyzed how banks deal with climate risk, and by means of a detailed mapping, it identified the amount of credit that is actually located in risky areas. The literature on climate policy risk is a bit larger than that on physical climate risk.

3.4 Flow Chart of the Study Methods and Techniques

As the study started with research problems, this research began to search for different types of data, including both secondary and primary data. The study got the idea, theory, and research questions after a literature review. A pilot survey had been conducted. Before conducting the final survey, the pilot survey had helped to understand the availability of data and to make necessary changes in the questions. The complete interview was conducted thereafter, and the results were analyzed based on the data to retrieve in findings.

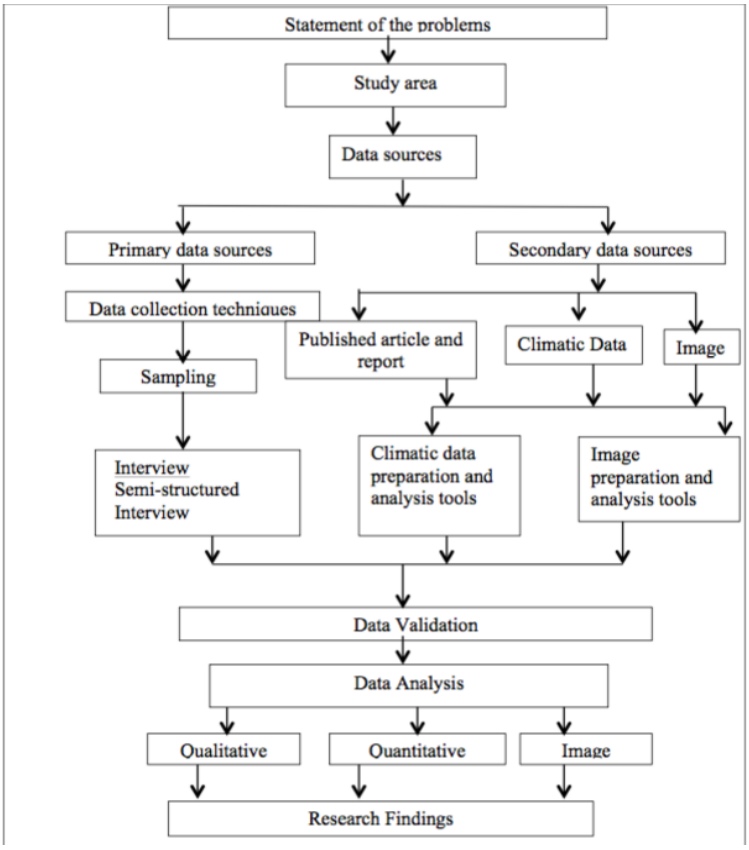


Figure 3.4: Research Method

Source: Author's generated, 2022

Quantitative result needs to be justified by the support of qualitative data that had been triangulated in this research. The mixed method approach helped this research acieve the good quality outcome (Fig 3.4).

3.5 Research Hypothesis

After reviewing literatures, and dragging research question the following hypothesis has been remarked. Those are given below:

H_1= Climate change affects the coastal areas of Bangladesh

H_2= Climate change impacts on tourism and tourist flow

H_3= Climate change creates financial risks in coastal tourism

3.6 Research Ethics

Ethics is crucially needed to conduct research, particularly when it has implications on human and environmental connections. Within the eight steps for the completion of

any research, maintaining research ethics is very crucial (Randall and Gibson, 1990). First of all, ethics embraces confidentiality and privacy of data, so that it might not harm to the respondents (Dooly *et al.*, 2019).

The respondents must be assured their participation is voluntary, and they have the right to decide whether they would give an interview or not (Barrow *et al.*, 2017). Furthermore, they cannot be harmed or benefited from the research. On the other hand, data from secondary sources must be acknowledged for the improvement of research in that field. Any reliable data helps researchers to improve their understanding of the field. Therefore, research ethics not only comprehends specific research but also contributes to the authenticity of that particular study.

3.7 Conceptual Framework

Conceptual framework is very important for a research for understanding interrelationships between research objectives and choosing variables to conduct a study. Hence, the following diagram shows the conceptual framework of the impact of climate change and financial risks arising from coastal tourism in Bangladesh:

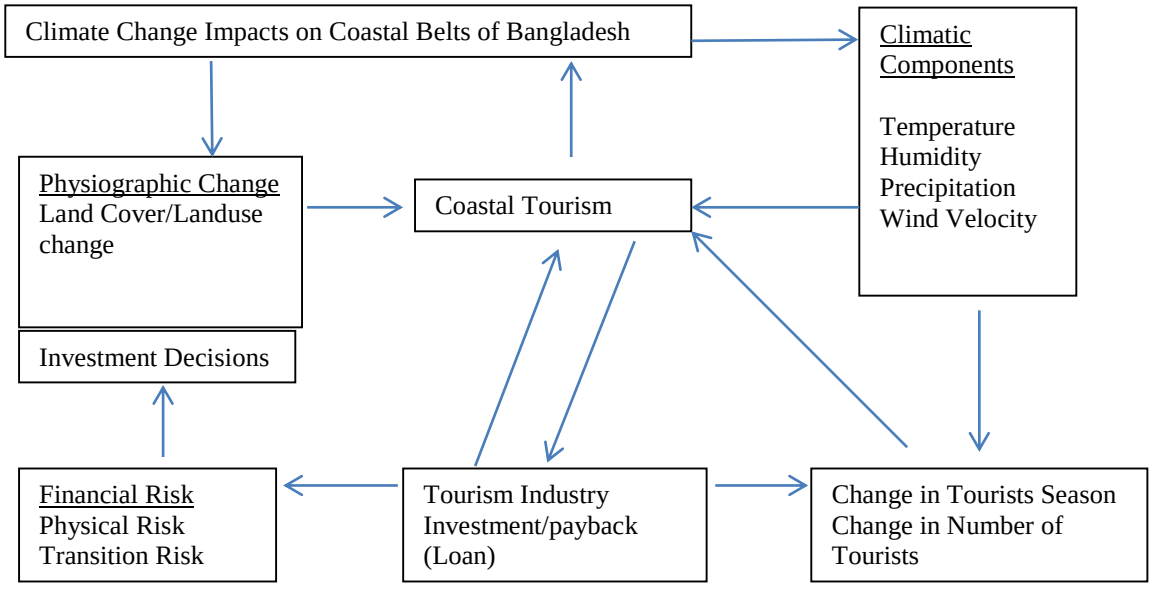


Figure 3.5: Conceptual Framework

Source: Author's generated (2022)

3.8 Scope of the Research

There is a lack of research on the climate change impact in coastal tourism, and specifically on investments in the tourism industry. The initial stage for the development of the tourism industry could expedite sustainable tourism development. According to the scientists, climate change will mostly adversely affect the low-lying developing economies such as Bangladesh. Thus, research in these fields could bring new dimensions of effective resource utilization for sustainable development. Therefore, this thesis could be a resource to policymakers, scientists or investors for combating the effects of climate change, and ensuring sustainable tourism investment in perfect services in proper destinations.

Moreover, the gaps identified from this thesis would be utilized (by policy makers, national or international organizations) to produce more effective climate change adaptation strategies. In the following table 3.3 shows how financial institutions used to make investment decisions through scenario analysis to observe possible investment outcomes from climate change impact in the four scenarios of Paris Agreement. Thus, the toolbox provided a base for taking investment decisions under different climate change scenarios in the tourism sector.

Table 3.4: Environmental Risk Assessment Toolbox in Financial System

Environmental Risk Factor	Sector	Activity	Financial Risk Tool
Physical (Climate Change Impact on asset)	Five top/highest Investment	Asset Price Accommodation Recreation Accessibility	Scenario Analysis
Transition Risk (Reputation and Carbon Pricing)	Five top/highest Investment	Operation Cost Accommodation Recreation Accessibility	Scenario Analysis

Source: Theme was adopted from G-20 Green Finance Study Group (2017). Enhancing Environmental Risk in Financial Decision-Making

Chapter Four

Impact of Climate Change on the Study Areas

4.1 Key Features of Coastal Belts of Bangladesh

The origin of South Asia started from the Eocene epoch (50 million years ago) with the upliftment of Eurasian plates beneath the surface, where the Indian plate collides with the Eurasian plate (Rasheed, 2008). However, the creation of the Bengal basin started recently, though the country had an old alluvial plain and hilly region, which consists of almost 20% of the total landmass, through the sedimentations from several rivers.

Although the catchment area of Bangladesh is 7%, most of the international rivers originating from Mount Everest bifurcate within the regions of Bangladesh, consisting of piles of sediments. Instead, it creates massive coastal belts with 710km of length with a diverse range of coastlines, such as an unbroken beach of Cox's Bazar, several islands with clayey beaches, and a mangrove forest consisting of seashore in the northwest of the Bay of Bengal. The region adjoins 19 districts with almost of 25.7% population within it, generating 37 million livelihoods (World Bank, 2014). Diversified livelihoods are created in the areas because of ample natural resources and soothing climatic conditions from before. Major economic activities in the area are activities in the seaport, export, promotional activities, farming, fisheries, salt industry, mangrove forestry, and tourism.

4.2 Physiography and Climate of the Three Major Coastal Divisions of Bangladesh

There are three distinct divisions found in the coastal belts of the country (Rasheed, 2008). Those three divisions are called the western coastal region, middle coastal region, and the eastern coastal region, each having salient features of its each. The south-eastern region of the coast comprises an unbroken sandy coastline of 120kms, which is the world's longest continuous sea beach, and has one coral island called the Saint Martin Island in the southmost. In the middle section of the coastal region bifurcation of hundreds of rivers exists, creating numerous islands with loamy to clayey soils. On the other hand, in the extreme west, one of the world's biggest mangrove forests exists with many wetlands that are rich in biodiversity, and loamy to clayey soils because of the discharging stream water from the north.

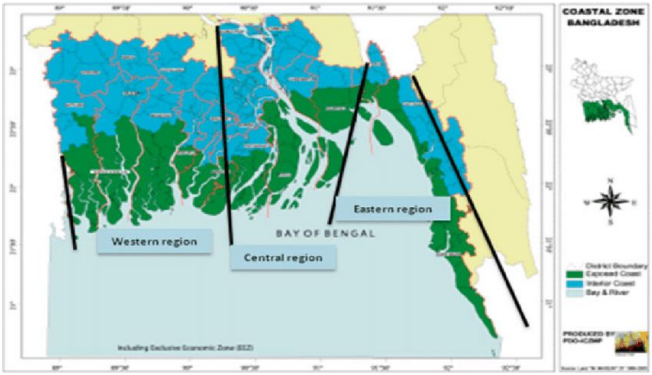


Figure 4.1: Three Distinctive Regions of Bangladesh

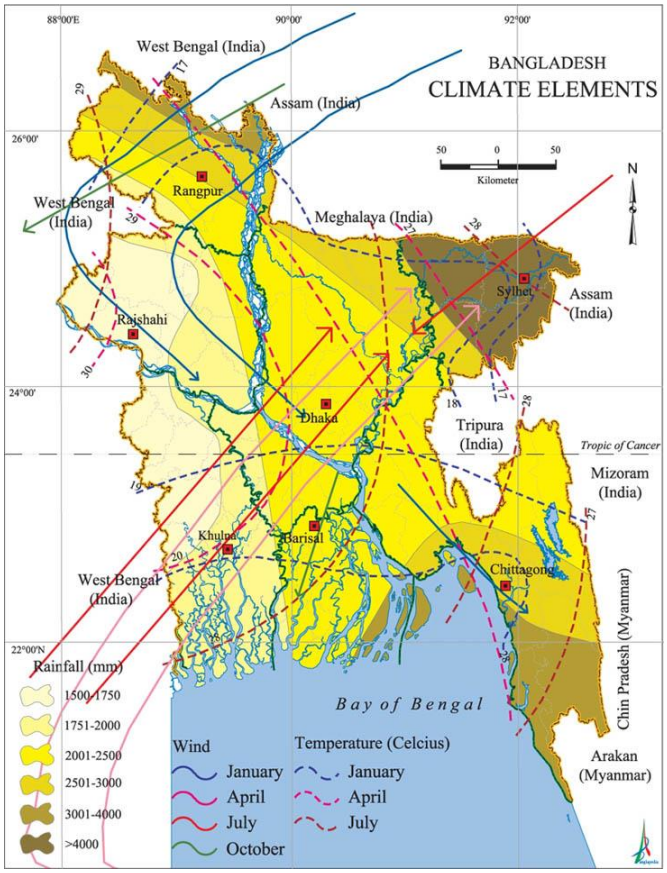
Source: Mosleuddin et al. (2015)

Though there are ample resources in the area, most people live under the poverty line in the coastal region, due to the frequent occurrence of natural disasters and climate change. Because of climate change, it has been predicted that salinity increased in the area from 2ppt to 20ppt in Mongla area of Pushur River (1962-2008) (World Bank, 2014). The climate of the coastal zone of Bangladesh is similar to the whole country, though the pattern of soil and vegetation is quite different from the upper part of the country.

The key feature of the shoreline is a gentle slope towards the offshore area. Seasonality is very similar to the country by having a hot summer, a humid rainy season, and a cold and dry winter. It has monsoon rain, which comprises 85% of the overall rainfall in this area, which is due to the depression of the Bay of Bengal creating an average of 2488mm annual rainfall in the coastal region (Hossain *et al.*, 2014). The average sea temperature is around 27^0C, although the temperature remains warm enough throughout the year (Ahmed, 2019). However, in the winter season, the temperature of the Bay of Bengal falls to 24^0C.

4.3 Climatic Pattern in Historical Periods:

Bangladesh is situated in the tropical region of the earth, having a monsoon climate. The climate of the country has been featured by pre-monsoon (March- May) hot dry season, wet monsoon (June-October) season, and post-monsoon season (November-February).

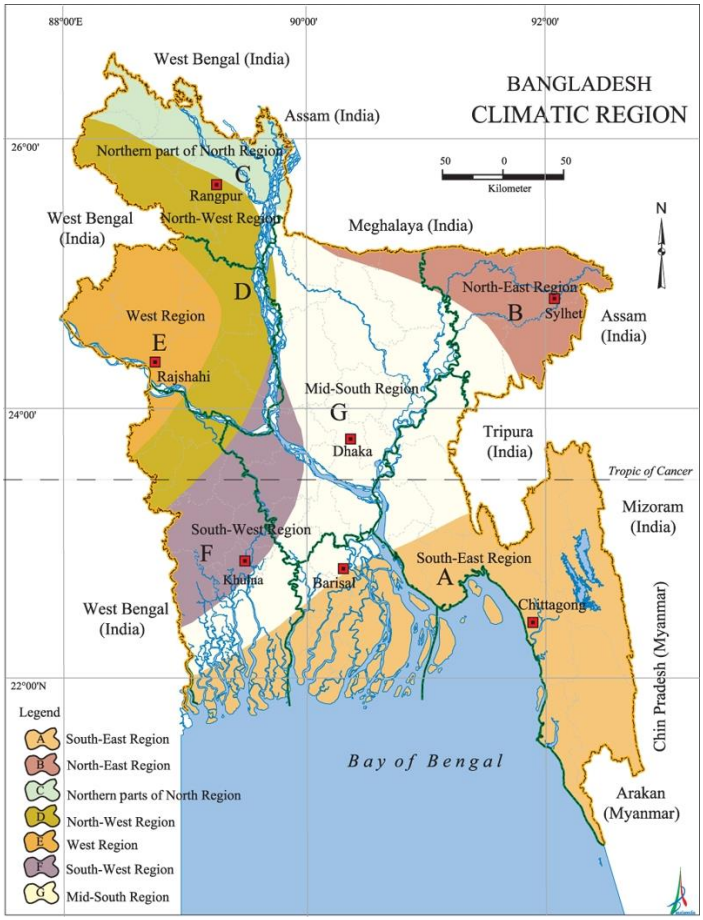


Map 4.2: Bangladesh Climatic Elements

Source: Barry, R.G., and Chorley, R.J. (1998)

In the pre-monsoon period, the hot and humid season temperature ranges from 27^0C to even 40^0C, with around 60% humidity. In terms of cloud formation, there are distinct two seasonal variations of winter and summer climatic patterns (Map 4.2). Though in the winter period, cloud cover becomes less, and over times the cloud cover increases from 50 to 60%. Rainfall occurring in this period ranges from 10% to 20% of the average annual rainfall accompanied by thunderstorms.

On the other hand, during the monsoon wet season, heavy rainfall, excess humidity and extreme weather events are being observed. Daily average temperature lies between 27^0C to 29^0C, though the temperature varies from region to region. Average humidity ranges from 70% to 90%. Besides, cloud cover ranges from 75% to 90%.



Map 4.3: Climatic Regions of Bangladesh

Source: Barry, R.G., and Chorley, R.J. (1998)

After post-monsoon season, the temperature drops to 17^0C on average in the month of January. At that time, humidity decreases as well, with the flow of air from the north to the southern part of the country. The most soothing months (December to March) having favorable climatic conditions for tourists prevail during this time. Though in November or April, just after post-monsoon and pre-monsoon respectively, climatic condition varies depending on the specific year for traveling, where these two months are considered as buffer months for mass tourism in Bangladesh. Buffer month stands for the transition period to travel and recreational activity, specifically for outdoor activity. The five tourists who travelled in all three study areas had been interviewed. One aged more than sixty years old, three of them aged 35, 42, and 56 and one of them aged 24.

One of the tourists was a retired person who said he prefers to visit the destinations during March because of the warm and soothing climatic conditions. However, a couple of the interviewees opined that they prefer to travel to the destinations during December during the winter vacation, and as the weather remains tranquil at that time. On the other hand, one job holder said that although he prefers to travel in the Winter season, which is peak season for traveling, everything has a higher cost, and more tourists travel at that time, so he chooses to travel for business purposes in these destinations, it does not matter to him whether it is peak season or not. And one student opined that he prefers to travel to the destination from December to February.

4.4 Climate Change Scenarios on the Study Areas

It is vital to investigate whether climate change impacts in the destinations, although IPCC documents well that overall coastal areas of Bangladesh will face climate change adversity in different spheres, from biodiversity, soil, weather patterns, water quality, salinity level, and so on.

4.4.1 Change in Climatic Elements over the Past 40 Years in Cox's Bazar:

I. Analysis of Thermal Change of Cox's Bazar from 1991 to 2019:

Temperature has been one of the vital factors for tourists to visit any destination. Neither very cold nor too hot temperatures attract tourists. Tourists' comfortable temperature (24^0-26^0C) always pulls tourists from various regions of hot or cold temperatures especially in the beach areas (Lops *et al.,* 2021; Mohan *et al.,* 2013). That is why most tourists from producing regions, such as tourists from Western world is attracted by the pull factors to fly to the warmer region of Bangladesh during the winter season. In the context of Bangladesh, it is well known that post-monsoon to pre-monsoon (November-April) seasons are the most tourist-attracting seasons for the cooler temperature, less humidity, clear sky and other better weather conditions. Both domestic and international tourists prefer to travel during this time for recreational purposes. However, at present, the shifting of seasons has been occurring due to the nature of changing temperatures. Figure 4.4.1 shows the changing pattern of temperature from 1991 to 2022 (NASA, 2022).

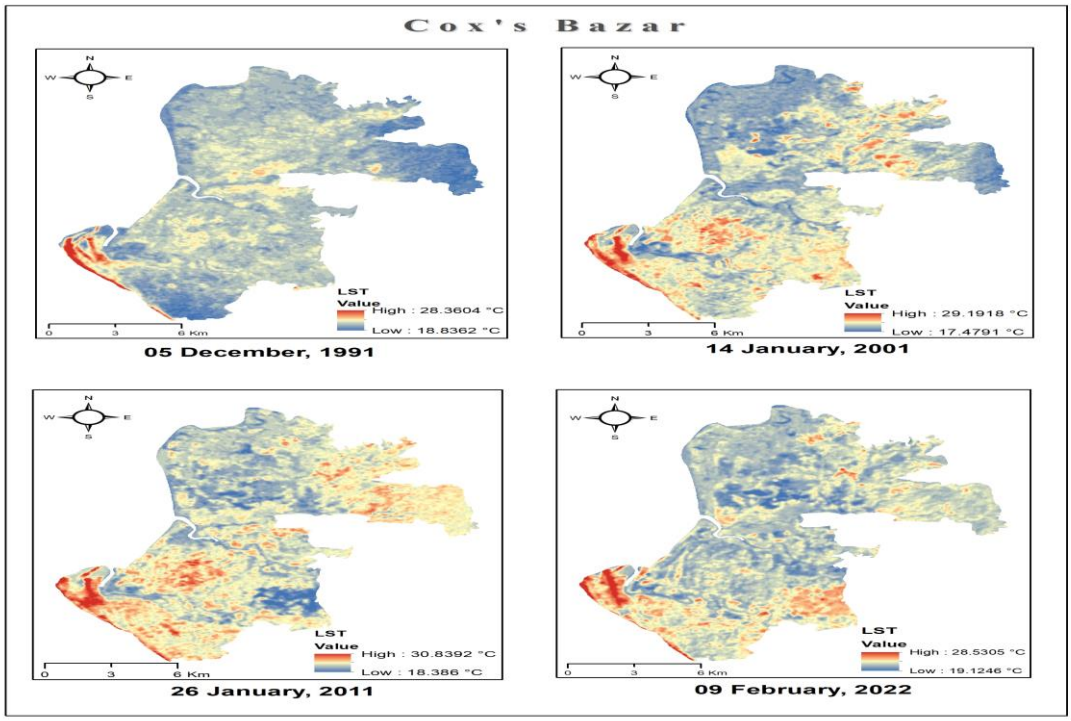


Figure 4.4.1: Thermal Change of Cox's Bazar from 1991-2022 (with 10 years interval)

Source: Author's generated (2022)

Although the maximum and minimum temperatures of the four images (1991 to 2020) changed by less than 1^0C, it is easily visible that the hot weather spread throughout the region. In 1991, the maximum temperature could only be observed in the north-western part, where the tourist's destination remains. In the images, Landsat images show the accurate change of the most clear, sunny daytime temperature of the winter season. On the other hand, with time in 2001, 2011, and 2021, maximum and minimum temperatures increased respectively, and spread from the north-western part to the south-west and south-east along with the north-western part of the country. Therefore, it is easily visible that there is a rising and spreading trend of temperature throughout Cox's Bazar area, affecting the tourist season.

Change in Temperature of Cox's Bazar from 1981 to 2019

Figure 4.4.2 shows the changing pattern of average temperature from November to April in the Cox's Bazar area.

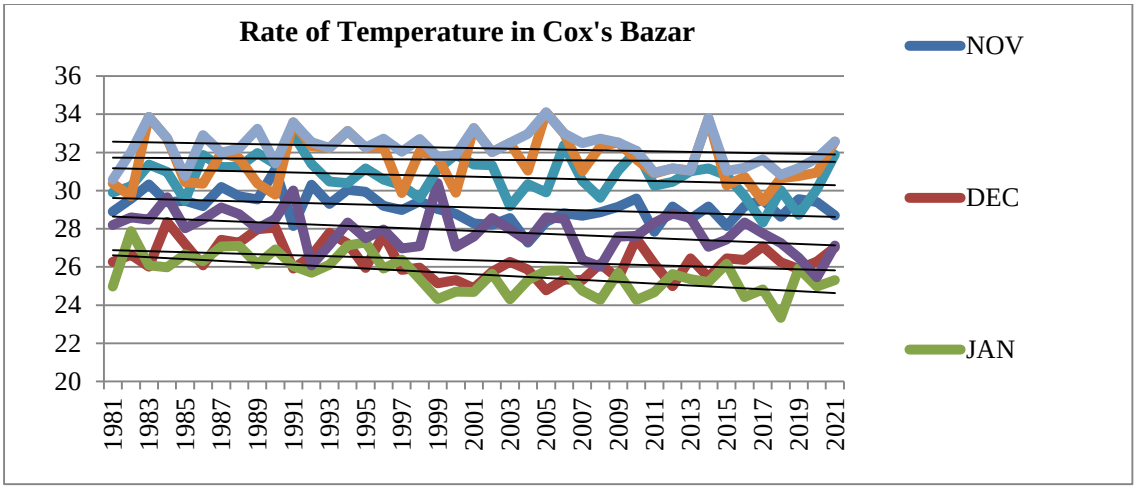


Figure 4.4.2: Change of Average Temperature (^{0}C) in the Cox's Bazar Area from 1981-2019

Source: Author's generated (NOAA, 2021)

Though in November there has been an overall steady temperature, in December the temperature rose more than 0.5^{0}C. On the other hand, in January and February, there is a declining trend of average temperature by 0.5^{0}C to 0.25^{0}C respectively from 1981 to 2019. However, in March and April, the temperature has been rising from 0.5^{0}C to 1.25^{0}C respectively. Thus, it can be observed from the Figure no. 4.4.3 that in the last forty years, during winter (December to February) the temperature is declining, whereas after winter and prior winter season, the temperature is rising at an alarming rate. November, which had always been a tourist season, is still in a steady state in terms of temperature. Besides, there has been an increasing frequency of cyclone events. Therefore, from the above study, there is decline in tourist season in the Cox's Bazar area. The rate of change is 0.02^{0}C per year.

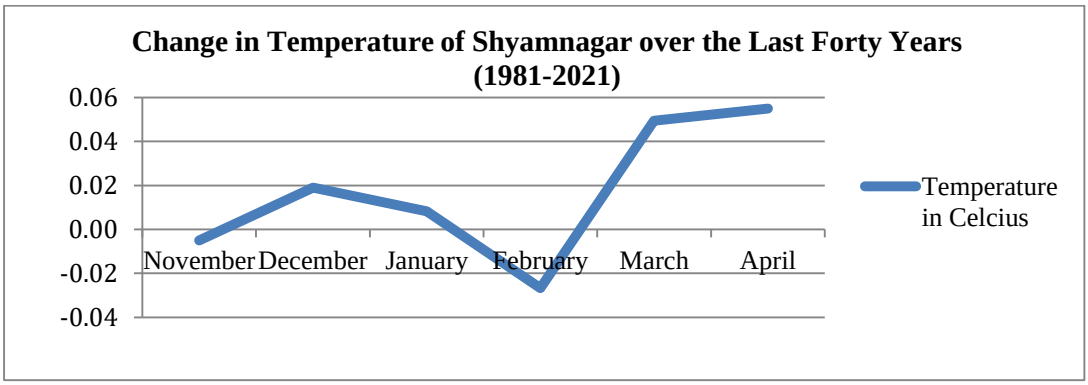


Figure 4.4.3: Change in Temperature in of Cox's Bazar in the Last Forty Years

Source: Author's generated (NOAA, 2021)

II. Change in Annual Rate of Precipitation:

In terms of annual precipitation the rate is increasing over the last forty years (Figure 4.4.4).

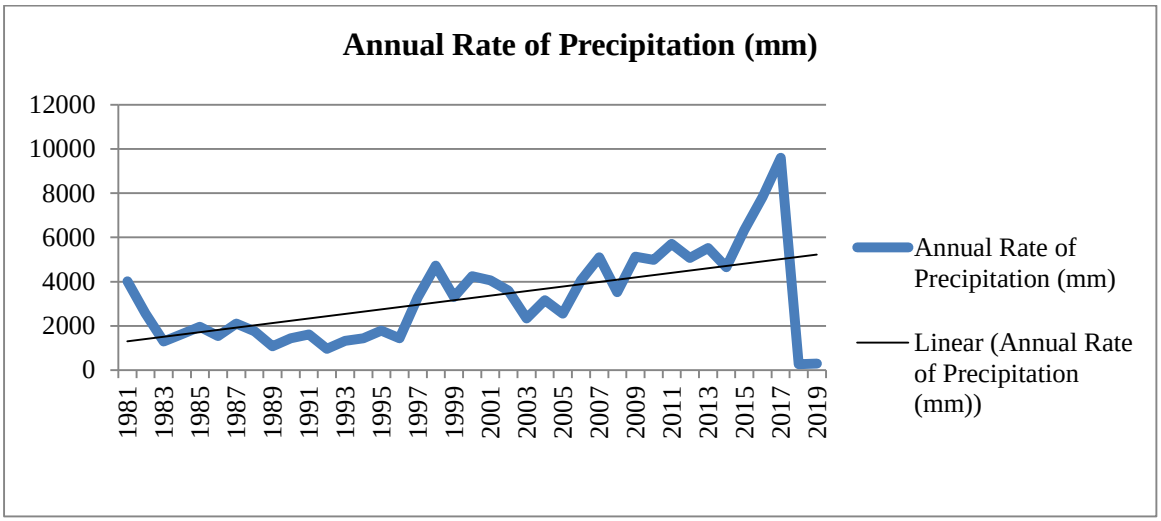


Figure 4.4.4: Annual rate of precipitation in Cox's Bazar (mm)

Source: Author's generated (2022)

The average annual precipitation rate in Cox's Bazar till 2019 had been almost 5000mm, although the average precipitation in Cox's Bazar was 1700mm in 1981. Thus, it can be seen that the annual precipitation rate is increasing in the area tremendously, almost five times higher than that of forty years ago.

4.4.2 Change in Climatic Elements over the Past 40 Years in Kalapara, Kuakata:

I. Image Analysis (Thermal) of Kuakata from 1991-2019:

Figure 4.4.5 below shows the thermal images of Kalapara Upazila in Kuakata with zonal thermal variation from 1991 to 2019 of the winter season (NASA, 2022). The best observable images were taken in the winter season because of clear and a daytime sky. From the images, it can be observed that there is a zonal change of temperature, though the overall maximum temperature from 1991 to 2001 rose drastically.

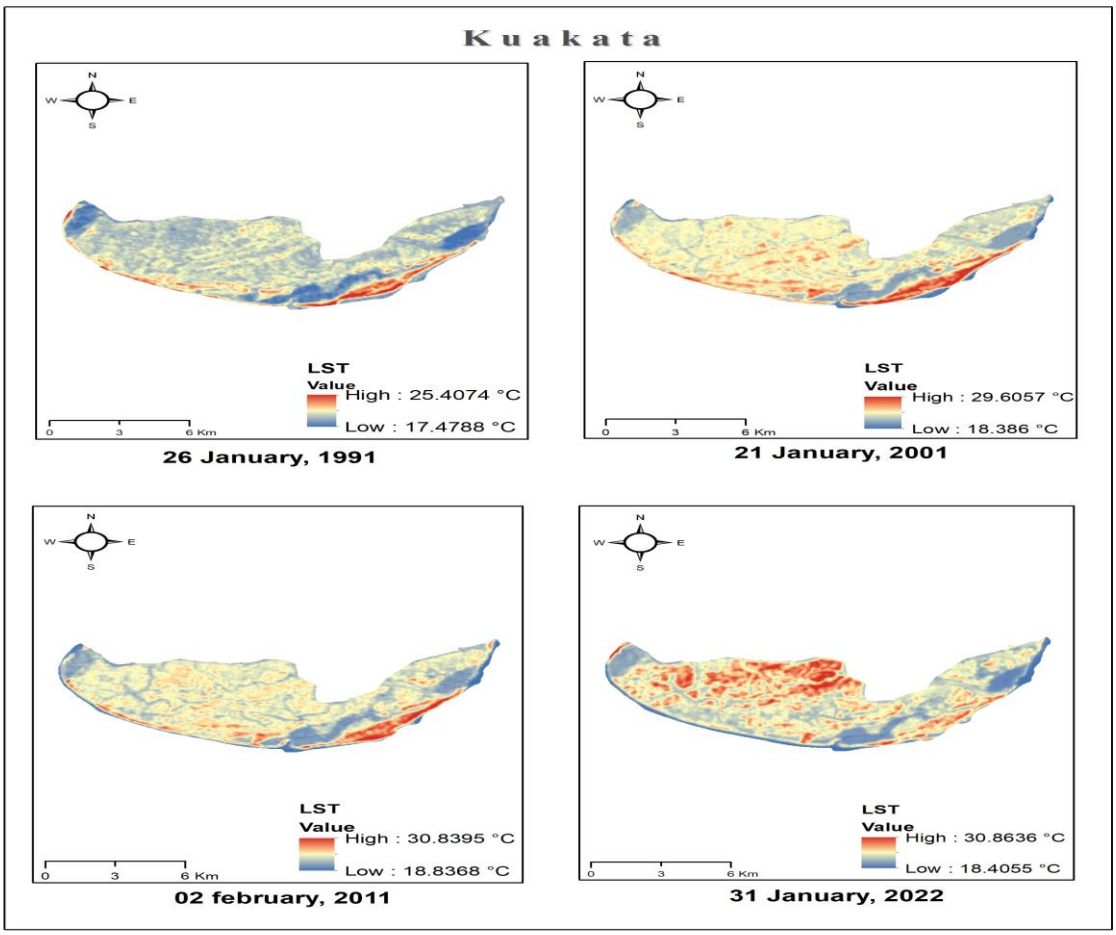


Figure 4.4.5: Thermal Change of Kuakata from 1991-2022 (with 10 year interval)

Source: Author's generated (2022)

However, the minimum temperature has been steady during the daytime. This overall macro-scale of temperature fluctuation remains because of the impact of the macro climatic variable of the rising trend of temperature. Although the change in maximum and minimum temperature is negligible, the spread of hot temperatures has been spreading towards the north and mid-north.

II. Temperature change over the past forty years in Kuakata (1981-2019):

It is interesting that from image analysis it has been observed that the average temperature of Kuakata is rising; however, during the winter season, especially December to March, the average temperature of this region is decreasing. Ironically,

in November and April month there is an increasing trend of average temperature (Figure 4.4.6).

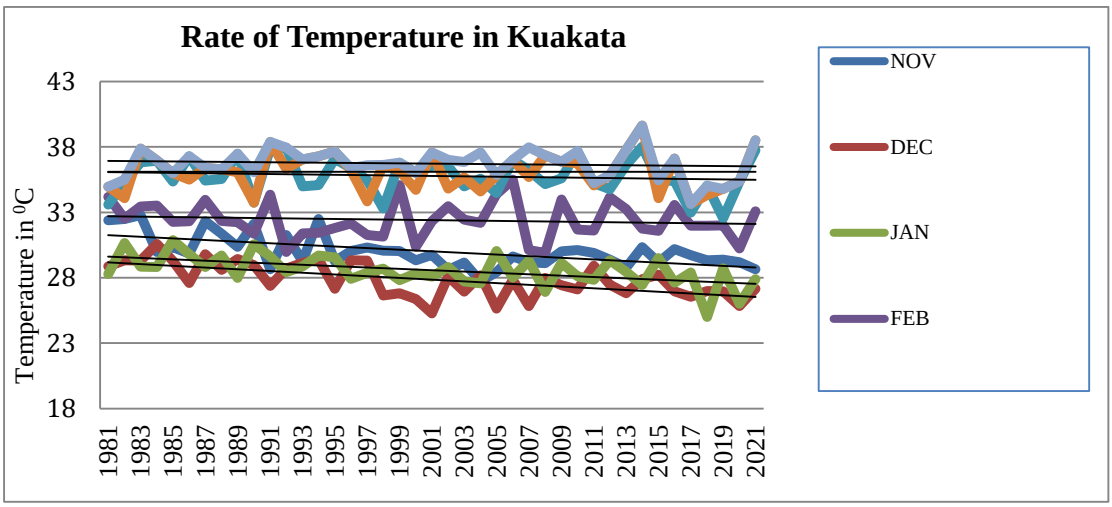


Figure 4.4.6: Change in temperature of tourists' seasons (November to April) from 1981 to 2019

Source: Author's generated (2022)

The average temperature increased at Kuakata in the tourist season by 0.003^{0}C for the last forty years (Figure 4.4.7). Still, the rise is very marginal and has minimal impact on the overall climate of the region.

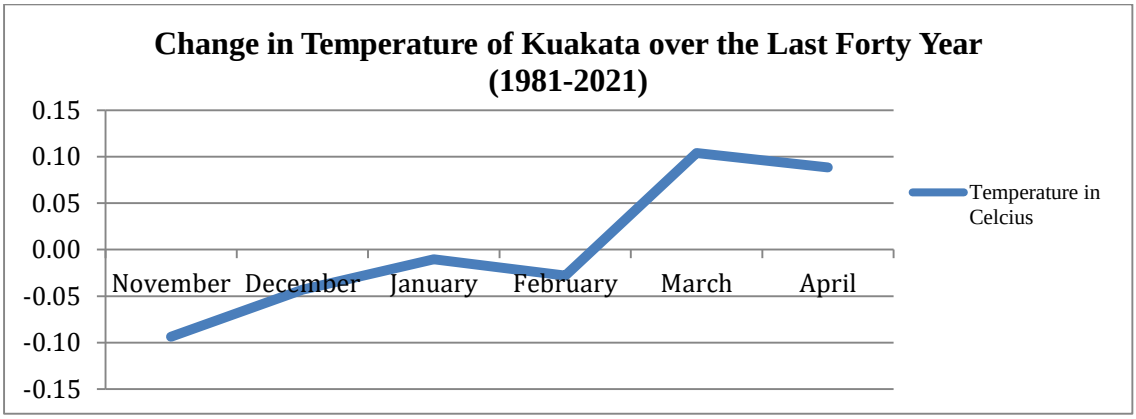


Figure 4.4.7: Change of temperature in Kuakata during the Tourist's Season

Source: Author's Generated (2022)

III. Annual Rate of Precipitation in Kuakata:

Figure 4.4.8. Show the annual rate of precipitation from 1981 to 2020.

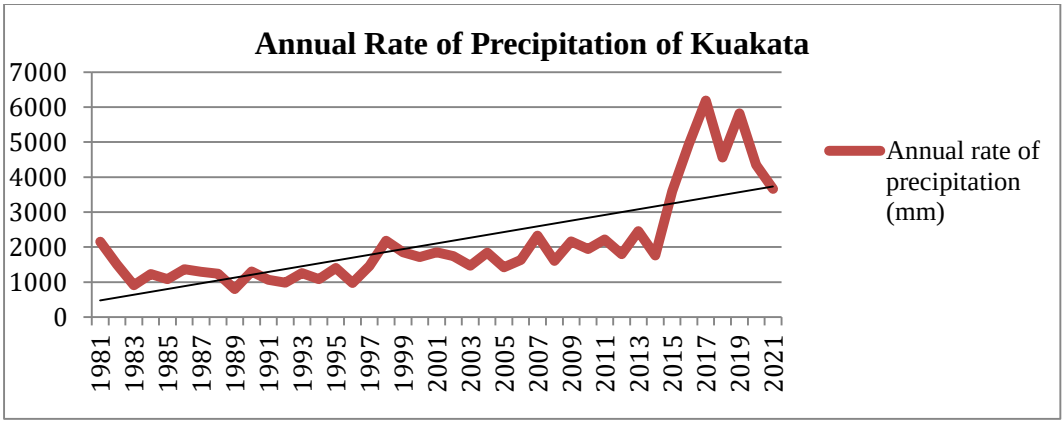


Figure 4.4.8: Annual rate of precipitation (mm) in Kuakata

Source: Author's generated (2022)

Similar to Cox's Bazar, in Kuakata, the average annual rate of precipitation is also rising, which can be derived from Figure 4.4.8. During 1981, the average rate of precipitation of the area was slightly more than 1000mm, and that rate remains almost steady. However, during 2018-19, the annual rate of precipitation increased by more than 3200mm. That means, the unusual precipitation has been occurring in the destination for some time, and at present it is almost seven times higher than in 1981.

4.4.3 Change in Climatic Elements over the Past Years in Shyamnagar:

I. Thermal images showing the change in temperature of Shyamnagar (1991-2021):

Figure 4.4.9 shows the zonal thermal variation of Shyamnagar, Satkhira, from 1991 to 2021. The images were taken in a clear sky with maximum precision and reliability. Figure 4.4.8 shows how the maximum temperature in the whole area has risen to more than 1^0C from 1991 to 2022, during daytime. Exempt from the water-bodies, the minimum temperature has also risen over the land area. However, the rise of maximum temperature has spread over the whole area, which is only concentrated in the southernmost region of the sandy area.

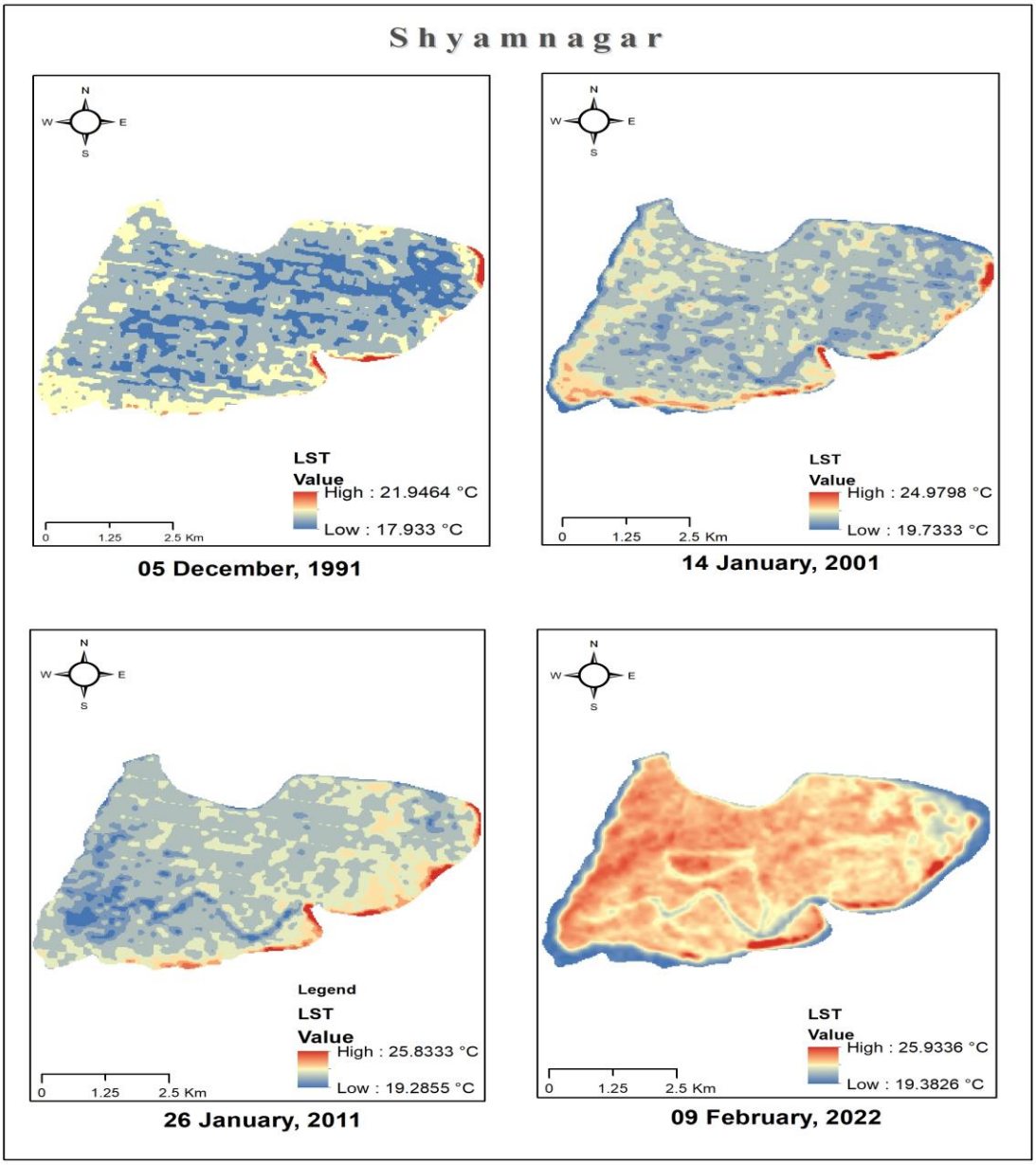


Figure 4.4.8: Thermal Change of Shyamnagar from 1991-2022 (with 10 years interval)

Source: Author's generated (2022)

II. Temperature change over the past forty years in Shyamnagar, Satkhira (1981-2019):

Figure 4.4.10 below shows the changes in temperature over the last forty years from 1981 to 2019.

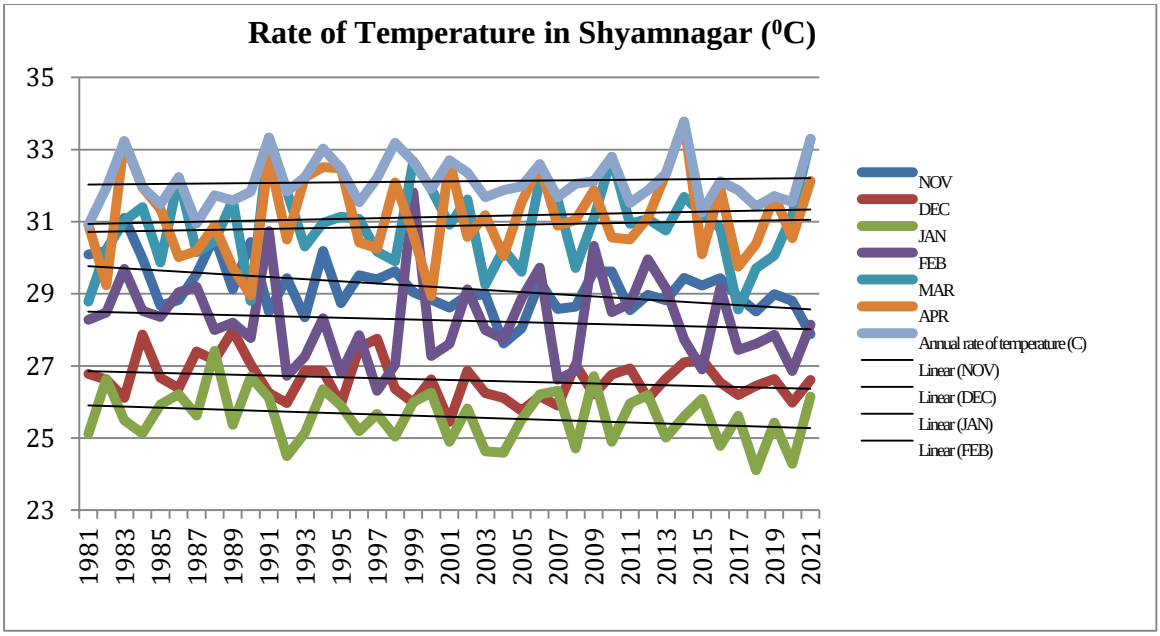


Figure 4.4.10: Trend of temperature change in Syamnagar, Shatkhira

Source: Author's generated (2022)

Change in temperature over the last forty years in Shyamnagar is 0.02^{0}C from November to April. From this figure it has been observed that the average day and night temperature of only January and February has declined, while the temperature of December remains steady, the average temperature of November and before, along with March to afterwards are rising (Figure 4.4.11).

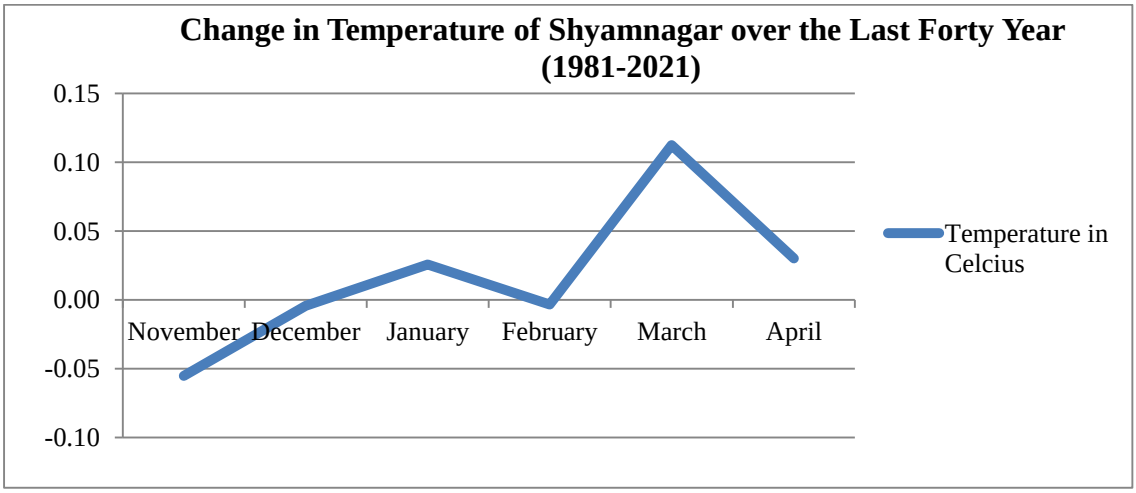


Figure 4.4.11: Change in Temperature of Shyamnagar over the Last Forty Years (1981-2021)

Source: Author's Generated (2022)

III. Annual Rate of Precipitation in Shyamnagar, Satkhira:

Average annual precipitation (mm) of Shyamnagar has been shown in the Figure 4.4.12.

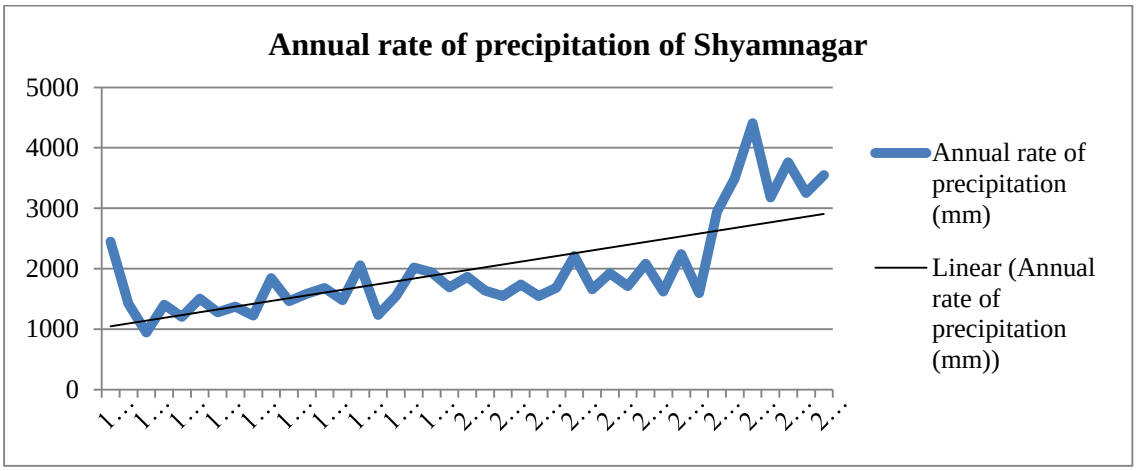


Figure 4.4.12: Annual rate of precipitation of Shyamnagar, Satkhira

Source: Author's generated (2022)

Unlike the two other study areas of Cox's Bazar and Kuakata, the overall rate of precipitation has risen only three times. In 1981, the average annual precipitation was almost 1500 mm, however, in the 2018-19 season, average annual rainfall climbed to 1800 mm only. So, because of the mangrove forest, the rate of precipitation is growing very slowly.

4.5 Changes in Vegetation Coverage of the Study Areas

There is also a change in vegetation coverage, which has been determined by NDVI. Through this image analysis process, it has been found that there is a declining trend of vegetation coverage and an increase in bare land with infrastructures and sandy areas in the study area. NOAA's NDVI data makes clear identification of the total area having forested region or water-body, or other types of landuse is a bigger picture.

Furthermore, data could be analyzed from the ground level. However, as mentioned in the methodology section, this data is well established and used widely throughout the world. In the three distinct study areas of this research, the ratio of landuse patterns was identified along with the use of the whole area.

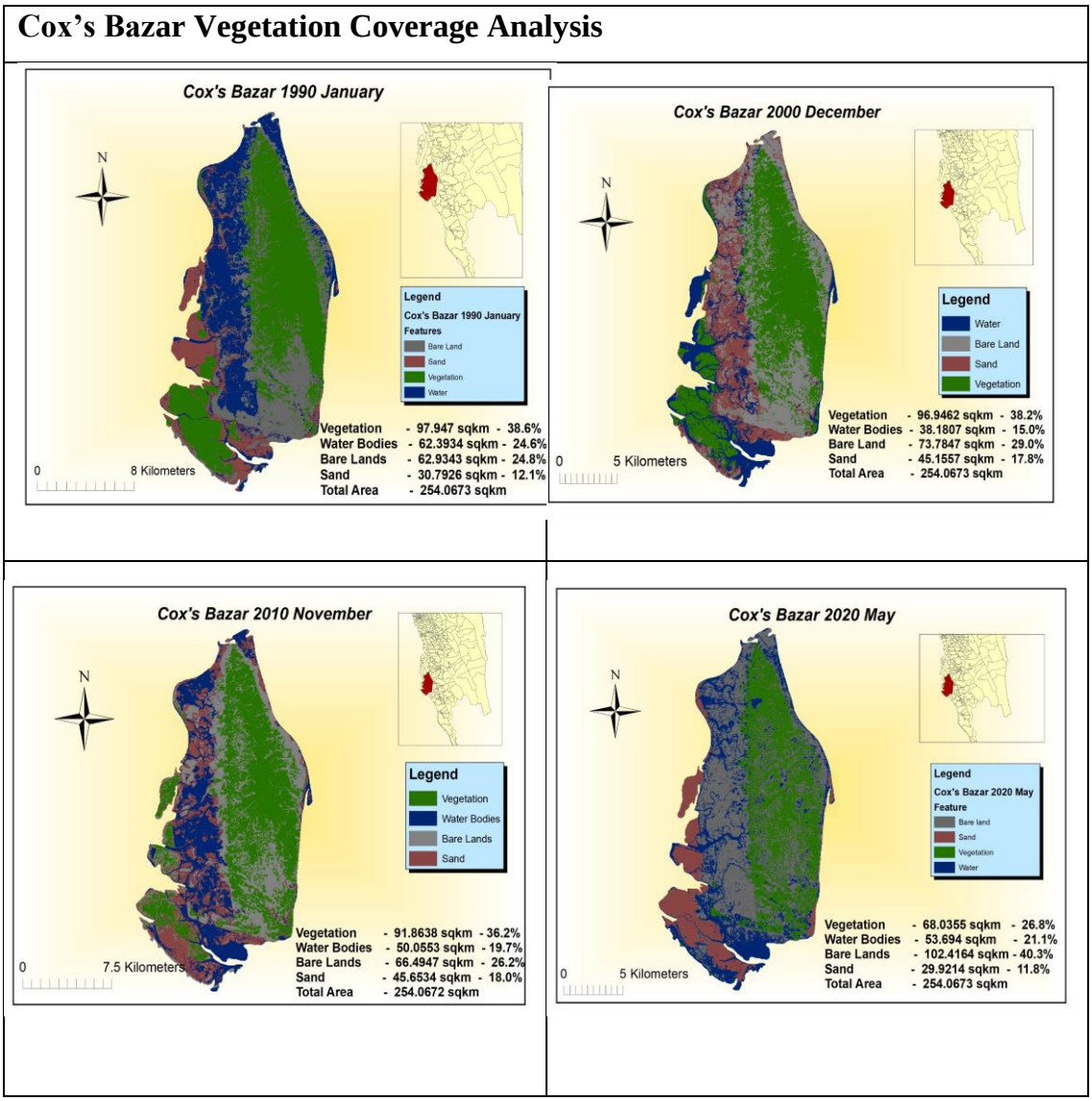


Figure 4.5.1: Change in Vegetation Coverage from 1990- 2020 (10 year interval)

Source: Author's generated (2022)

First of all, the vegetation coverage of Cox's Bazar has been analyzed. The reason behind using vegetation cover analysis is that all of the destinations of Bangladesh in the Coastal Areas are nature-based tourist destinations, and vegetation, as well as other environmental components, are very important to consider in that case.

In the Cox's Bazar area, vegetation coverage has reduced tremendously. Vegetation coverage was 38.6%, 38.2%, 36.2% and 26.8% in the years 1990, 2000, 2010, and 2020, respectively. In the last thirty years, vegetation coverage of the area has reduced

to 10%. An interesting finding from the images is that water bodies are sharing more spaces in the southern portion, declining from the northern part of the Upazila.

Vegetation Coverage Analysis of Kalapara in Kuakata

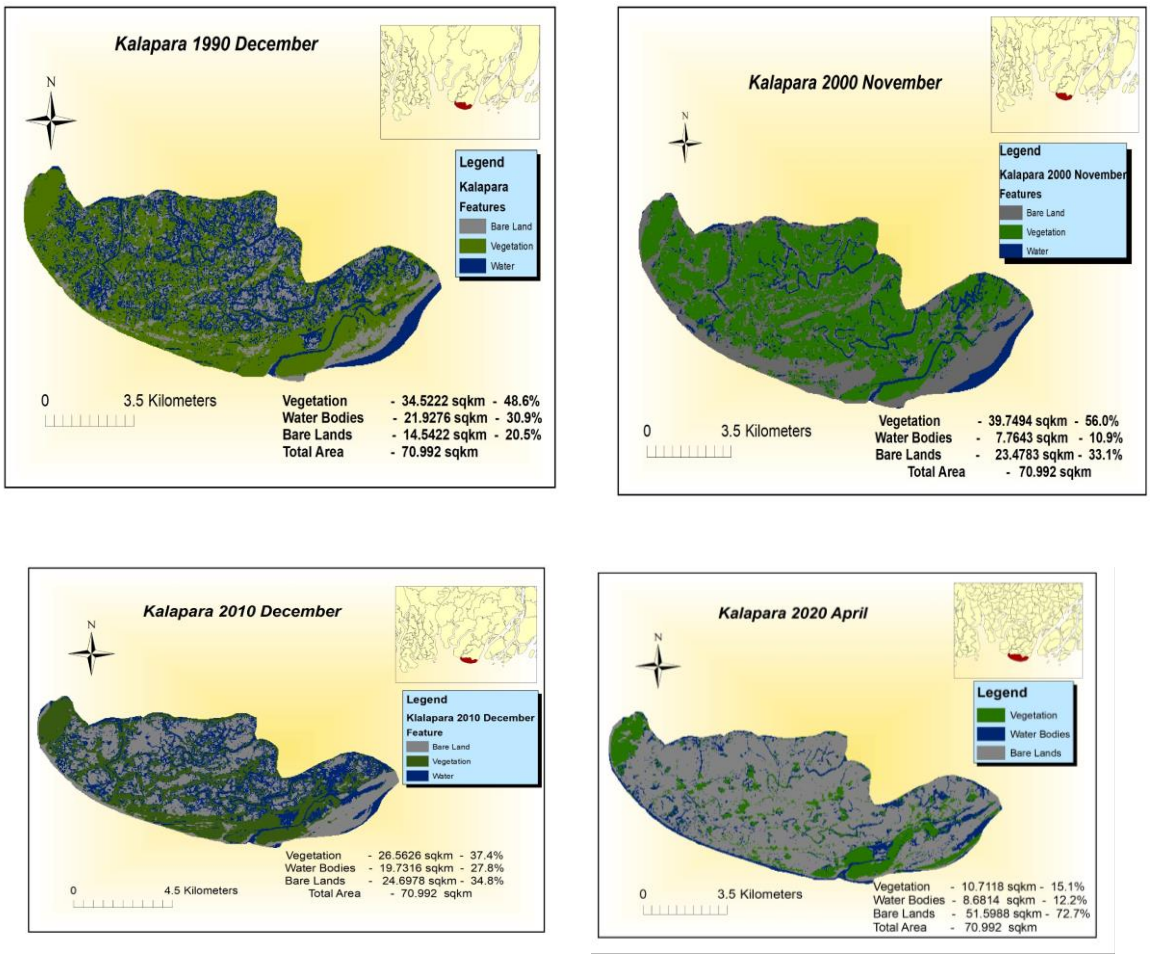


Figure 4.5.2: Change in Vegetation Coverage in Kuakata from 1990-2020 (10 year interval)

Source: Author's generated (2022)

In Kalapa Upazila of Kuakata, the vegetation coverage has declined at an alarming rate. Although from 1990 to 2000 vegetation coverage increased to more than 8%, in 2010, vegetation coverage shrank to 37.4% which was 56% in 2000. Besides, in 2020, vegetation coverage dropped to 15.1% with an increasing value of barelands.

Vegetation Coverage Analysis of Shyamnagar in Satkhira

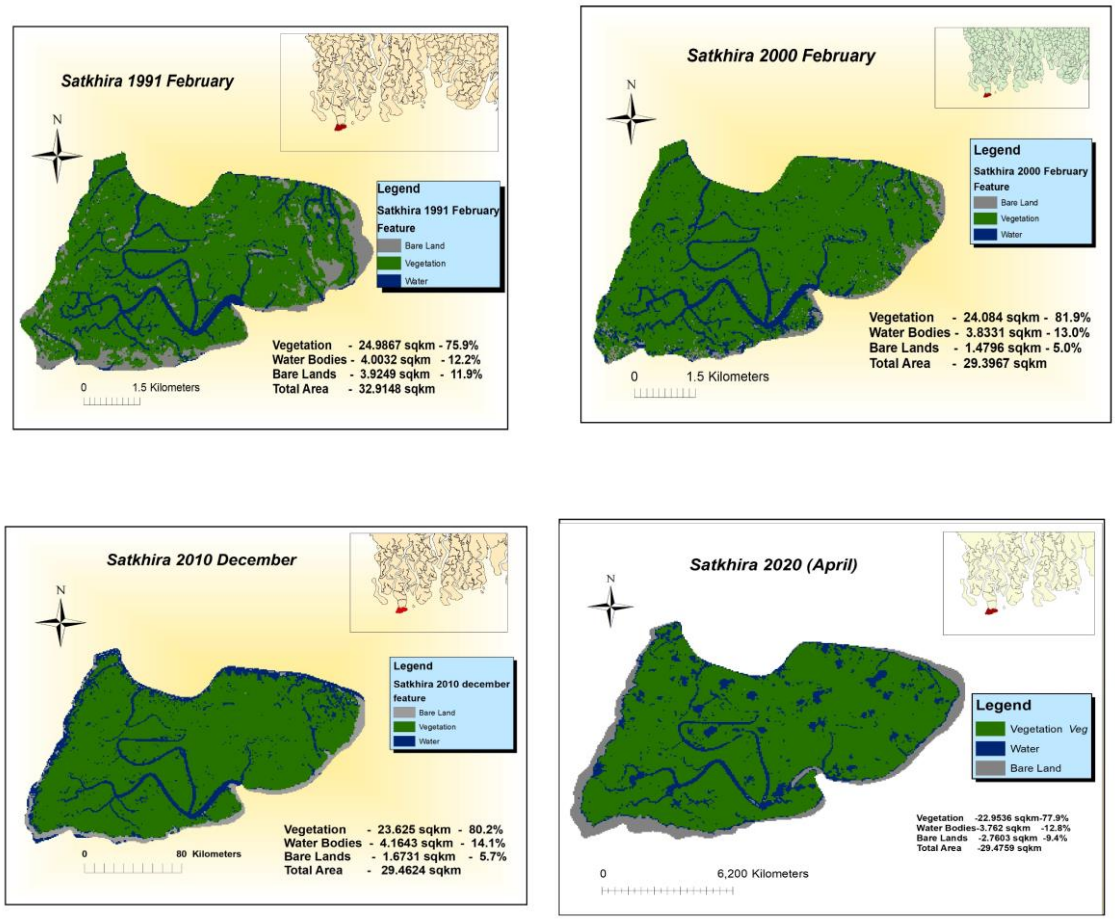


Figure 4.5.3: Change in Vegetation Coverage in Shyamnagar from 1990-2020 (10 years interval)

Source: Author's generated (2022)

In the Shyamnagar upazila of Shatkhira, vegetation coverage changed in an unpredictable way. From 1991 to 2020, there was no change in waterbodies. The pattern of waterbodies changed as there were increased wetlands due to a decrease in the river. However, bare land declines to more than 1%, though the extreme south-western part and north-eastern part became sandy without any vegetation coverage. On the other hand, vegetation coverage increased from 1991 to 2020 by slightly more than 1%.

4.6 Changes in Erosion-Accretion and Natural Calamities in the Study Areas

Bangladesh's coastline has a depositional physiographic nature, as the country was created after the upliftment of the Himalayan Mountains and fluvial deposition from the mountains during the Eocene epoch (Rasheed, 2008). From Figure 4.6.1 it can be seen that there has been continuous erosion and deposition going on in the coastal areas of Bangladesh. And the study had been conducted based on the last fifty years of data until 2015.

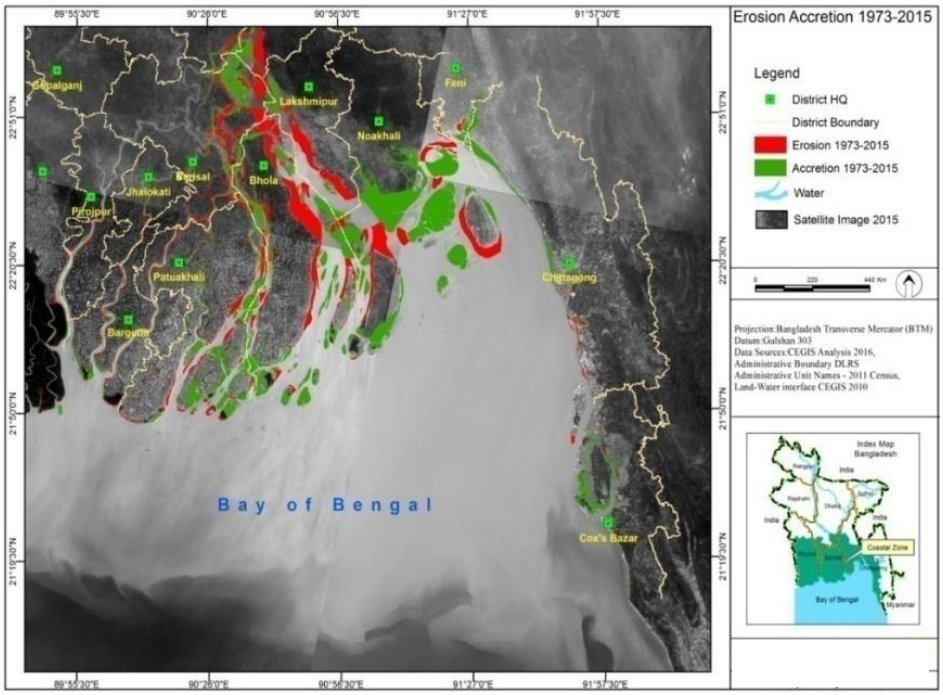


Figure 4.6.1: Changes in erosion and accretion pattern in the study area (Kuakata)

Source: CEGIS (2022)

Over time, Bangladesh has been created by the deposition of sediment from the mountains, so there is an increasing rate of land formation and deposition (very slowly) in those areas. However, because of changes in stream flow and sea level rise there is also erosion occurring in the regions (Mahmood *et al.*, 2020; Nishat and Mukherjee, 2013). As such, from the study, it can be seen that in Cox's Bazar area, deposition is going on over time.

In contrast, in Kuakata and Shyamnagar of Satkhira, erosion has been occurring slowly in the southwestern part and deposition has been occurring in the eastern part. Therefore, the landmass of loamy soil and clayey soil, respectively, in those two study areas is increasing. Observed sea level rise in Bangladesh has been found in several research shown in Figure 4.6.1 (Anwar, 2022; Brammer, 2014; Pethick and Orford, 2013; Islam and Tooley, 1999).

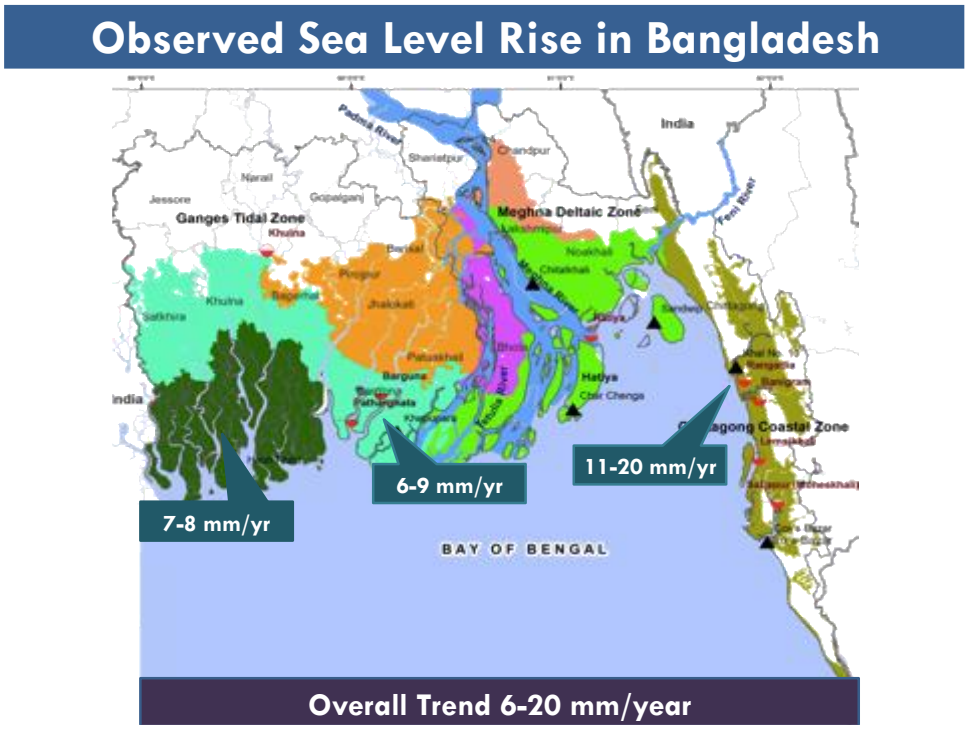


Figure 4.6.2: Trend of Sea-level Rise in Bangladesh

Source: CEGIS (2022)

Research shows that there is a trend of sea-level rise every year, and research from IPCC proved the existence of sea-level rise in the coastal areas of Bangladesh (Figure 4.6.2). Furthermore, this sea-level rise is steady and gradual because of climate change. It not only declines the continental areas, but to a greater extent, it is creating salinity of the soil and therefore decreasing the productivity of the soil. Therefore, the overall vegetation pattern and fresh water are becoming minimal in these areas. Consequently, it is urgent to plan appropriately for the future tourism pattern of the area. On the other hand, there is an increase in natural disasters such as coastal flooding, cyclones, or storm surges. Based on cyclone hitting the coastal areas of

Bangladesh, figure 4.6.3 has been created, and it shows the trend of major cyclones in those areas over time.

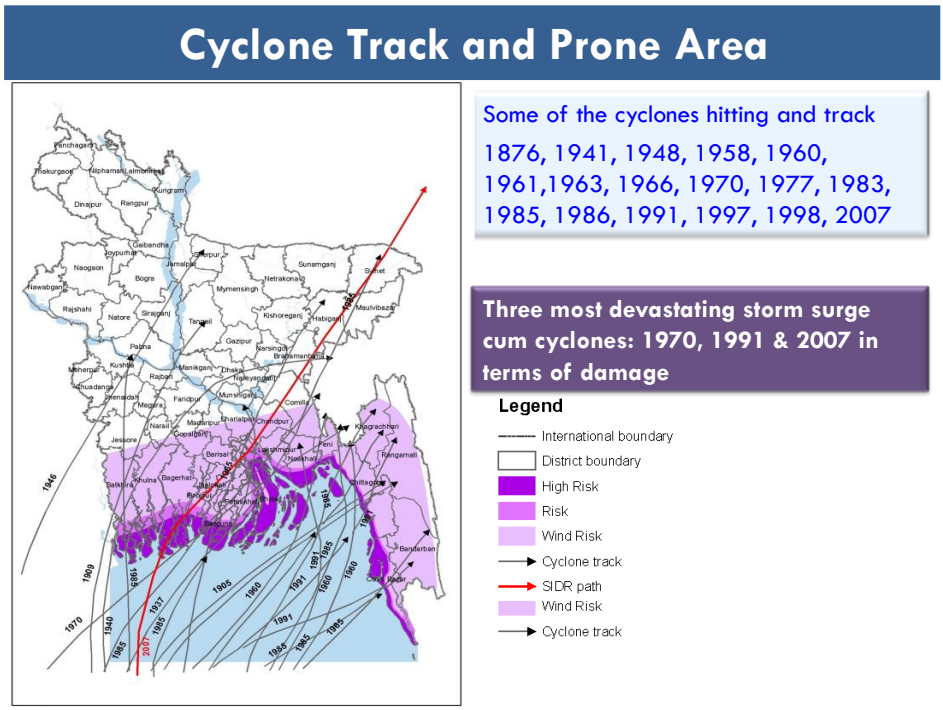


Figure 4.6.3: Cyclone tracking and cyclone-prone areas

Source: CEGIS (2022)

Figure 4.6.4 below shows the frequency of cyclones hitting the coast of Bangladesh. From the graph, it can be seen that though the mortality rate is declining day by day, the frequency of cyclone disasters is increasing. The rate of death is decreasing because of coastal investments on cyclone disasters through establishing shelter houses, early warning systems, or making structural formations such as embankments, polder accumulationm and so on.

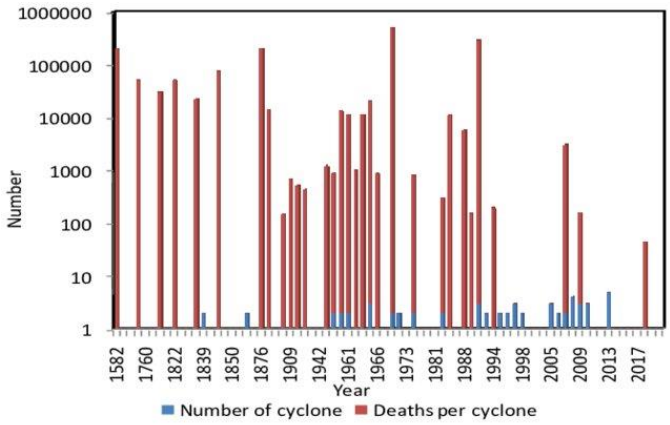


Figure 4.6.4: Frequency of Cyclone Casualties in Bangladesh Coast

Source: Rashid et al., 2022

4.7 Prediction of Climatic Variables Considering Present Climatic Pattern (2100):

The scenario discussed above has shown that there is a very slow change in climatic variables; however, these changes are different in different seasons. Moreover, there is a trend of rise in temperature, triggering other climatic elements to change. As such, to predict the future change, this research has shown previous change and made a prediction based on time-series analysis of data retrieved from NASA's open access viewer of climatic data. For, simulation and prediction of climatic data from 2025 to 2100, it has been considered and the average data has been considered for producing the prediction graph. Figure 4.7.1 shows the prediction graph of the temperature of Cox's Bazar from 2020 to 2100 for four months.

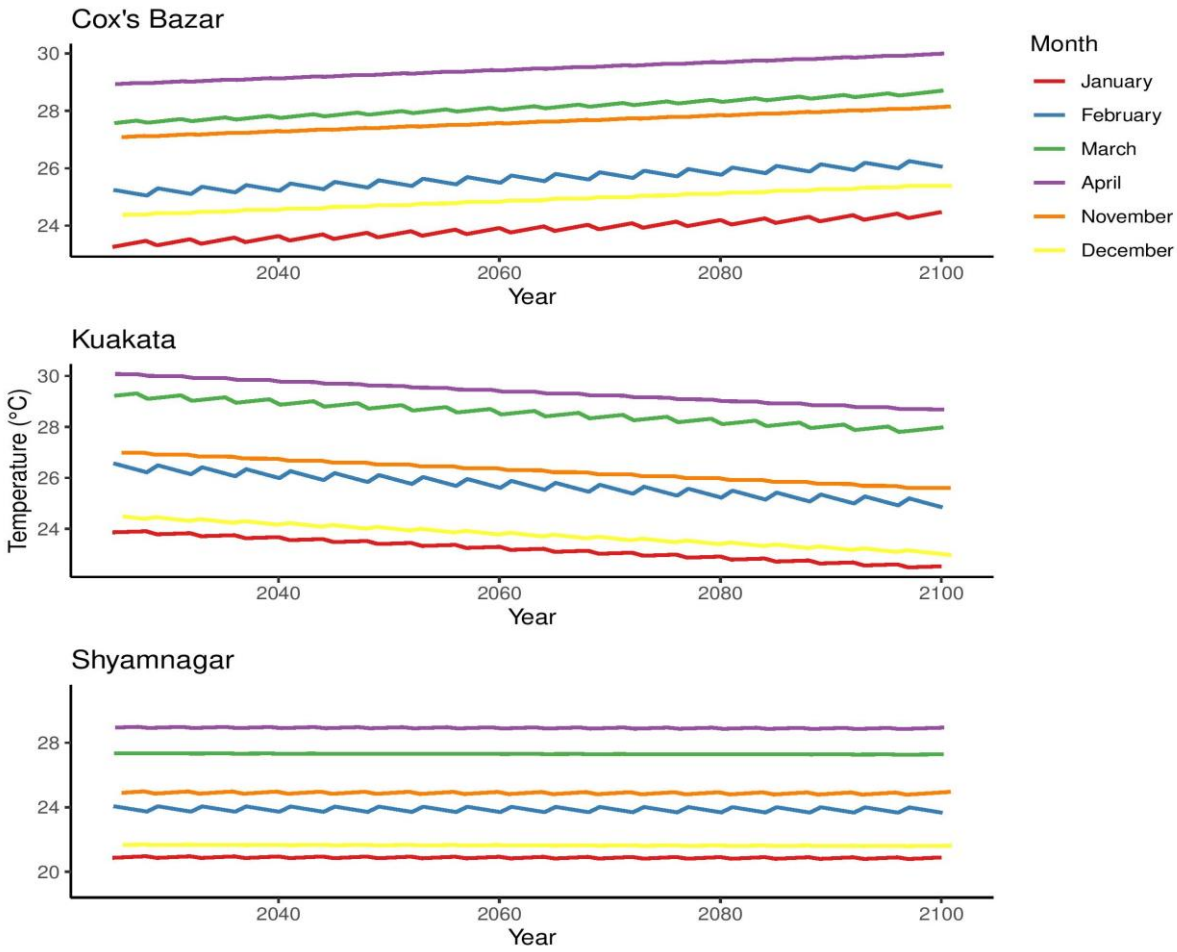


Figure 4.7.1: Predicted change in temperature of the study areas from 2020 to 2100

Source: Author's generated (NASA, 2022)

Thus, the graph above shows that though the temperature ranges from 24.5^{0}C to 29^{0}C in the months from November to April, respectively, if the change in temperature continues in this way, the temperature in December 2100 will rise to 26^{0}C and in April 30^{0}C. It can be assumed that this will make no difference in the overall climate. However, a small change in temperature will trigger a change in the overall climatic condition and increase susceptibility to natural disasters. On the other hand, Figure 4.7.2 shows the precipitation graph of rainfall till 2100.

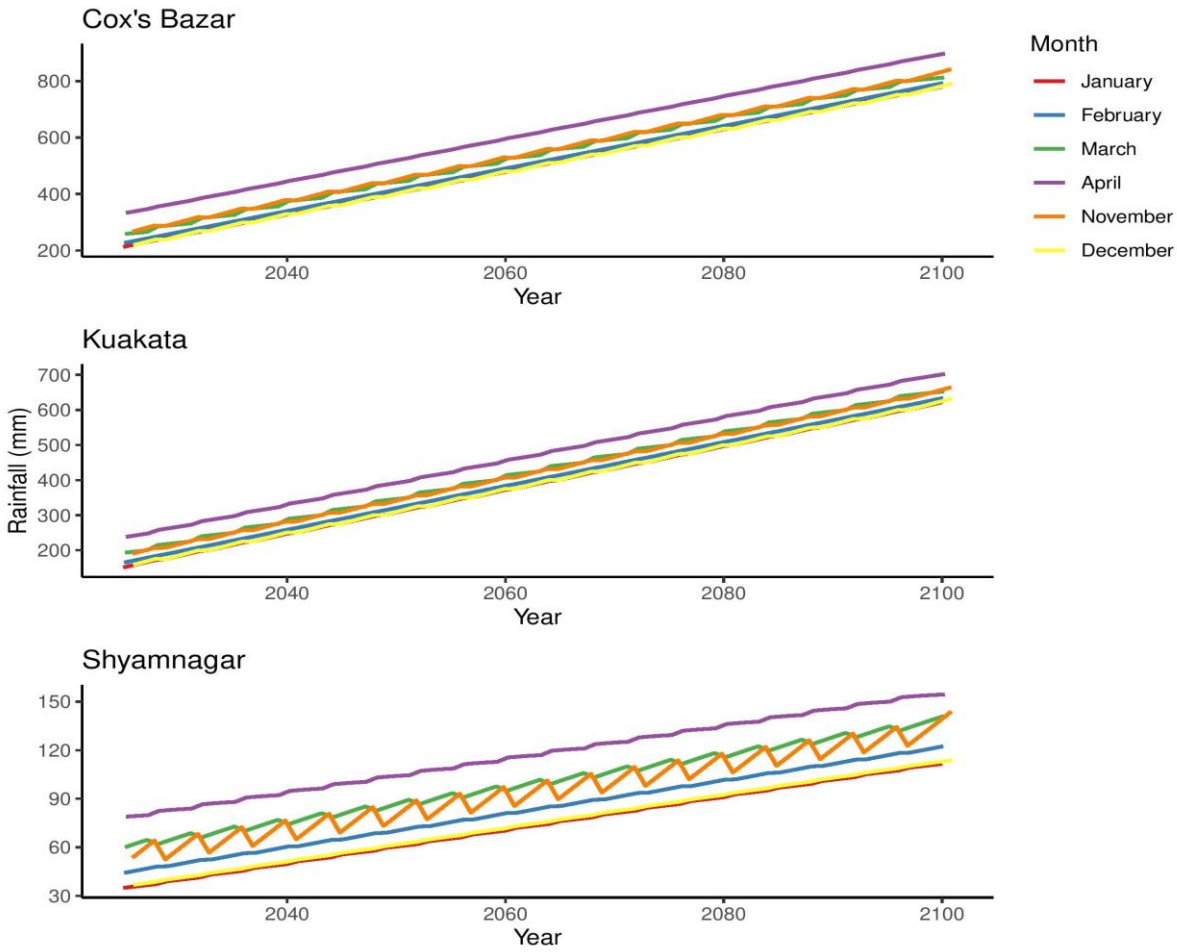


Figure 4.7.2: Predicted Change in the rainfall of the study area from 2020 to 2100

Source: Author's generated (NASA, 2022)

This figure also shows an increasing trend of precipitation in different months (tourist season) till 2100.

4.8 Findings of Climate Change Scenarios on the Study Areas

Findings from the research on the climate change scenario in the study areas are given as follows:

- Temperature has risen in Cox's Bazar over the last thirty years, and overall zonal variation has been dispersed/spread where temperature is in a rising trend. In January and February, the temperature has risen, whereas during November to December and during March to April, the temperature was in a rising trend. On the

other hand, annual precipitation has increased from 1800 to 5700mm from 1981 to 2019, respectively.

- In Kalapara of Kuakata, the maximum temperature rose to 1^0C over the last 40 years. Hot temperatures spread over the whole area, especially in the northern part. However, the minimum temperature of the area has been steady for the last couple of decades. Besides, the trend of average precipitation has an increasing trend from 1000mm to almost 3500mm from 1980 to 2019.

- Finally, the third study area is Shyamnagar of Shatkhira, where the Maximum temperature also rose to more than 2^0C from 1991 to 2022. It can also be observed from the overall temperature, which used to be hotter in the south and southeastern side in 1991, spread all over the area in 2022. Other than concentrating in a single space, hot weather is spreading throughout the whole area. Interestingly, during the two months from January and February, the temperature is declining, whereas from November to December and from March to April the temperature is rising. Besides, this area had a small amount of precipitation compared to the other three study areas in 1991; the rate of precipitation was almost 1500mm, hence, in 2019 it increased to 2000mm.

- In terms of vegetation coverage from 1990 to 2020, vegetation coverage in Cox's Bazar declined tremendously (from 38.5% to 26.8%), almost 12%. Where bare lands occupy several infrastructures, water bodies are declining and sandy areas to a small extent.

- In Kalapara of Kuakata, the declining rate of vegetation coverage is alarming, where in 1990, vegetation coverage comprised of 48.9%, in 2020 the vegetation coverage declined to 15.1%. Whereas bare lands with settlements increased to almost 50%, declining waterbodies to 18%.

- In terms of Shymanagar, vegetation analysis is interesting because in 1991, vegetation coverage was around 76%, increasing to 82% in 2000. However, in 2010,

vegetation coverage started to decline from 80.2% to 77.9%. Yet, bare lands decreased very slowly from 15% to 9% from 1991 to 2020.

- In terms of erosion and accretion from several studies, it has been found that erosion is occurring in the southeastern part more and accretion is occurring in the southwestern part of the coastal belts of Bangladesh.

- Furthermore, the prediction graph of two climatic variables, i.e., temperature and rainfall, of four months (post-monsoon, such as November to December, and Pre-monsoon, March to April) shows a rising trend in Cox's Bazar. However, in Kalapara, Kuakata up to 2100, there is a steady to declining trend of temperature, and in Shyamnagar, the graph shows that temperature is going to be steady if temperature change happens at this rate of the previous decades. Nonetheless, there is a tendency for rising precipitation in those months, which is very alarming for the tourism industries, as clear skies are very important for nature-based tourism. Furthermore, it shows a more disastrous situation, where cyclones and storm surges might occur in advance in the earlier period.

Chapter Five

Analysis of Climate Change and Tourism Climate Index

The tourism industry of Bangladesh is growing day by day along with the country's economic growth. In previous times, the high-income group of people had occupied a larger ratio of both inbound and outbound tourism. Most of those tourists traveled to various destinations worldwide, and the top-ranked destinations of Bangladesh. However, with the increase of GDP and discretionary income, more tourists are growing who had been traveling to relatives' houses or ancestral places.

Although the COVID-19 outbreak affected the upward trend of tourists flow from 2020 to 2021, the tourist flow again increased after rapid vaccination and controlling of the pandemic. The statistical report published by the Bangladesh Bureau of Statistics (BBS), named "Tourism Satellite Account 2020", which was published in 2021, shows that the total number of trips is 127 million. The number of domestic visitors was 326 million (BBS, 2021).

Outbound travel propensity was 1.56 million, and among those travelers, most of them had been traveling to India, which accounted for almost 58% of the total. Inbound tourism was 1.6 million, where almost 1.4 million tourists belong to the group of diaspora communities and short-term migrants. Value addition from tourism to the GDP was 3.08% during 2018-2019, sharing total employment of 8.07%. Hossan *et al*. (2021) found that seasonality has a 91% impact on tourists' arrival in Bangladesh because of nature-based tourism is the main component of tourism in the country. According to their research, an increase in tourists based on seasonality per thousand will increase income to 0.517 million BDT. Therefore, development will also increase. However, if tourist arrivals decrease, the income will also decrease if seasonality becomes one of the primary sources of attraction.

As the domestic trips consist of the majority of the tourism interesting findings from the report is that still the majority of the tourist group visit their relatives' or friends' places for recreation and leisure purposes (Figure 5.1).

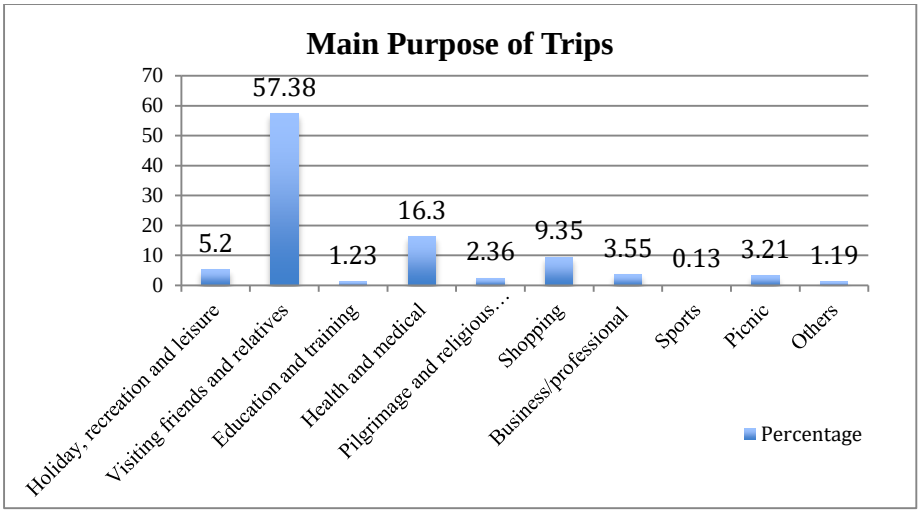


Figure 5.1: Main Purpose of Domestic Tourism

Source: BBS, 2021

Only 5% people travel to tourist destinations for recreation and leisure. It indicates the industry is still in an infant stage that can be developed if proper planning is embraced. However, before the pandemic hit throughout the world, the tourists' spending had been following a rising trend. A similar outcome could also be shown in terms of tourists' exports (Figure 5.2).

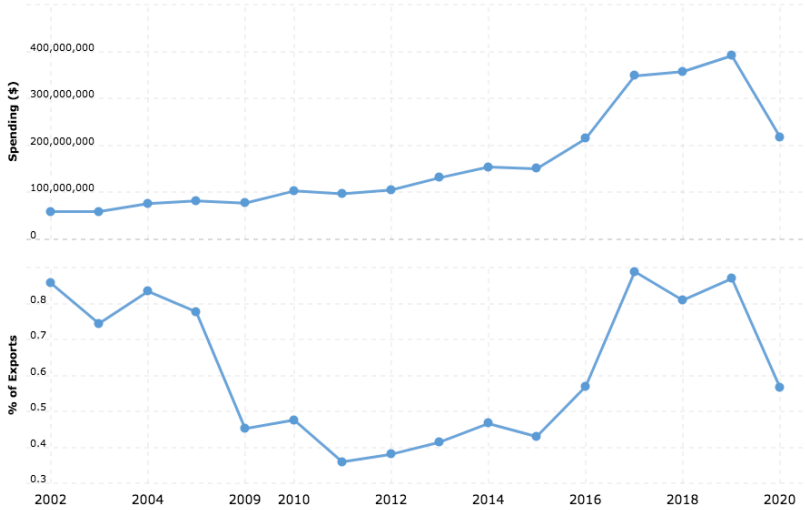


Figure 5.2: Trend of tourist's spending and percentage of exports

Source: Macrotrends, 2022

5.1 Status of Tourism in the Study Areas

5.1.1 Cox's Bazar: Cox's Bazar is the topmost tourist destination of Bangladesh. The reason behind it is, Cox's Bazar is a nature-based destination. Nonetheless, it is the

world's longest continuous sea beach. The destination is developed in a much better way compared to any other destination in the world. However, tourists of recreation and leisure travel during the peak season, which is from November to March (interview with the president of 'Tour Operators and Travel Association Bangladesh' TOAB). According to the tourist police, it has been found that on average about 5 million tourists visit the destination, yet 80% travellers visit during this season.

5.1.2 Kuakata: Kuakata is an emerging destination with limited establishments for the international market. Therefore, most of the tourists are domestic and still in the minimal stage. From an interview with the president of TOAB the actual tourist flow is still unknown; however, there are at least facilities provided to tourists in this destination.

5.1.3 The Sundarbans: During peak season, every day, 20-30 small ships and boats, carrying tourists of 15 to 50 people, take travellers to the deep-forested areas from December to February. Although throughout the year adventure tourists visit the Mangrove forest, they are very few in number.

5.2 Tourists' Perception of Favorable Climate

After interviewing the representative of the tourist's police and the president of TOAB it has been identified that throughout the whole year tourists travel to Cox's Bazar, and a smaller number of tourists travel to Kuakata and Shyamanagar. However, most of the tourists prefer to travel from November to March.

5.3 Climate Change Scenario in Relation to Tourism

5.3.1 Impact of Climate Change on Tourists: There have already been several researches showing the impact of climate change on tourism. Several researchers have identified and proved the interrelationship between climatic variables and tourist flow. Mieczkowski's Tourism Climatic Index (TCI) (1985) has been widely used to evaluate the present and future of tourism and tourist flow in several areas. The TCI is based on the notion of "human comfort" and consists of five sub-indices, each represented by one or two monthly climate variables. The five sub-indices and their

constituent variables (1) are as follows: (1) daytime comfort index, (2) daily comfort index, (3) precipitation (in mm), (4) sunshine (total hours of sunshine), and (5) wind (in m/s or km/h). The index will be weighted and computed as follows:

TCI = 4CID + CIA + 2R + 2S + W……...(1)

Here, *CID* = daytime comfort index, *CIA* = daily comfort index, *R* = precipitation, *S* = sunshine, and *W* = wind speed. With an optimal rating for each variable of 5.0, the maximum value of the index is 100 (Amelung and Nicholls, 2007).

Besides, to identify the direct impact of Climate Change on Tourism, there is another model called the 'Holiday Climate Index' (HCI) (2) created by Scott *et al.* (2016). The HCI equation model is as follows;

HCI = 4(TC) + 2(A) + (3 (Precipitation) + wind)…….……(2)

Here, the variables stand for,

Thermal comfort (TC) = daily maximum temperature and relative humidity (%)

Aesthetic (A) = Cloud cover

P for physical = (precipitation (mm) and wind speed (km/hr),

However, justification for choosing the TCI model in this research is that this model has been widely accepted for measuring tourists' comfort till now. It can show whether there is any change in seasonality and the long-term impact of climate change. Therefore, two time series analysis were conducted; the first one was based on the last 40 years of climatic variables (collected data from NASA's open data access) of the tourist season in Bangladesh, and the TCI was measured based on these data. The second phase climatic variables (again, retrieved from NASA climatic data) were used for predicting up to 2100 of TCI's of the study areas using time series analysis.

The TCI value ranging from 1980 to 2020, of two post-monsoon months, November and December, which is considered as the beginning of the tourist season in Bangladesh, has been shown in Figure 5.3.1 and Figure 5.3.2.

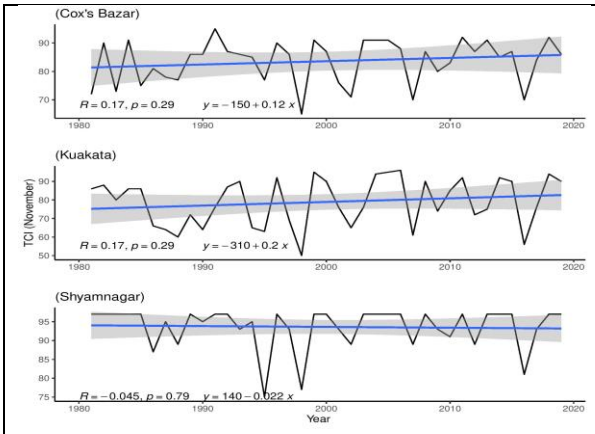


Figure 5.3.1: TCI in the month November in three-study areas from (1980-2020)

Source: Author's generated (climatic data had been collected from te NASA Earth Observatory survey, 2022)

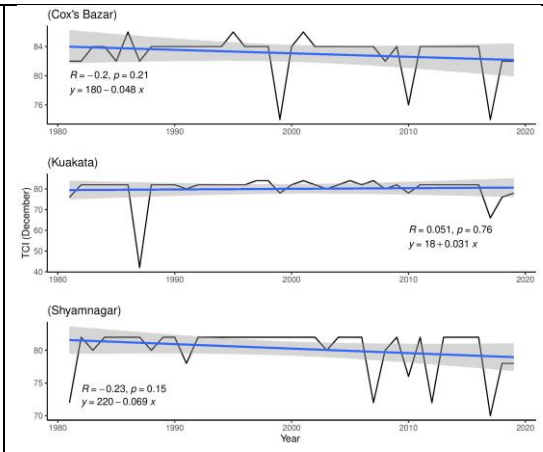


Figure 5.3.2: TCI in the month December in three-study areas from (1980-2020)

Source: Author's generated (climatic data had been collected from the NASA Earth Observatory survey, 2022)

So, from the figures shown above it is easily observed that both November and December months are comfortable for tourists to travel in Cox's Bazar (near about 85-90 TCI value), where in December, the specific destination comfort index is reclining.

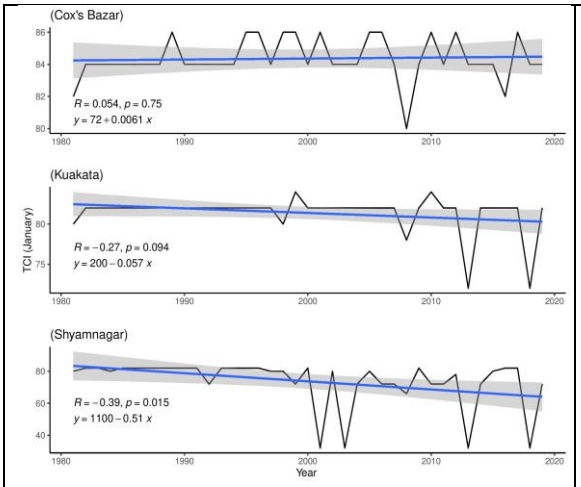


Figure 5.3.3: TCI in the month January in three-study areas from (1980-2020)

Source: Author's generated (climatic data had been collected from the NASA Earth Observatory survey, 2022)

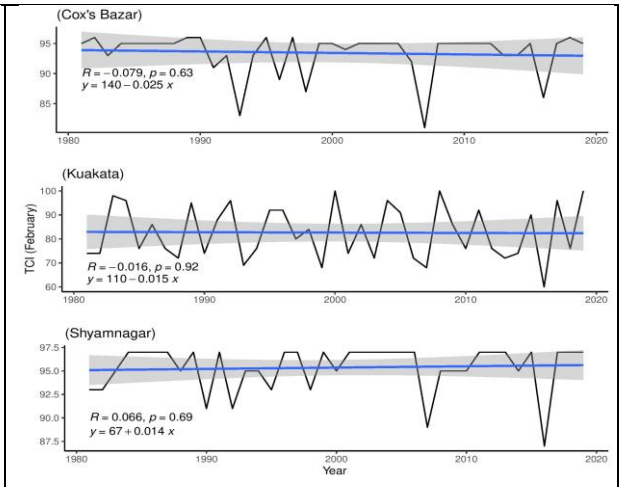


Figure 5.3.4: TCI in the month February in three-study areas from (1980-2020)

Source: Author's generated (climatic data hadbeen collected from the NASA Earth Observatory survey, 2022)

Similarly, Shyamnagar remains the same, where almost no TCI change could be seen for the last forty years, having more than 95 TCI values. On the other hand, a different pattern could be seen in the destination of Kalapara in Kuakata, where the TCI value is close to 75-80, with a steady comfort rate in December.

Again in the figures 5.3.3 and 5.3.4, it can be seen that in Cox's Bazar, TCI values of January and February are 84 and 80, respectively, with a steady TCI value. So, it can be seen that the climate is very favorable for tourists during these months. In terms of Kalapara, the Kuakata tourist season had been quite satisfactory (January TCI 80 and February TCI 82).

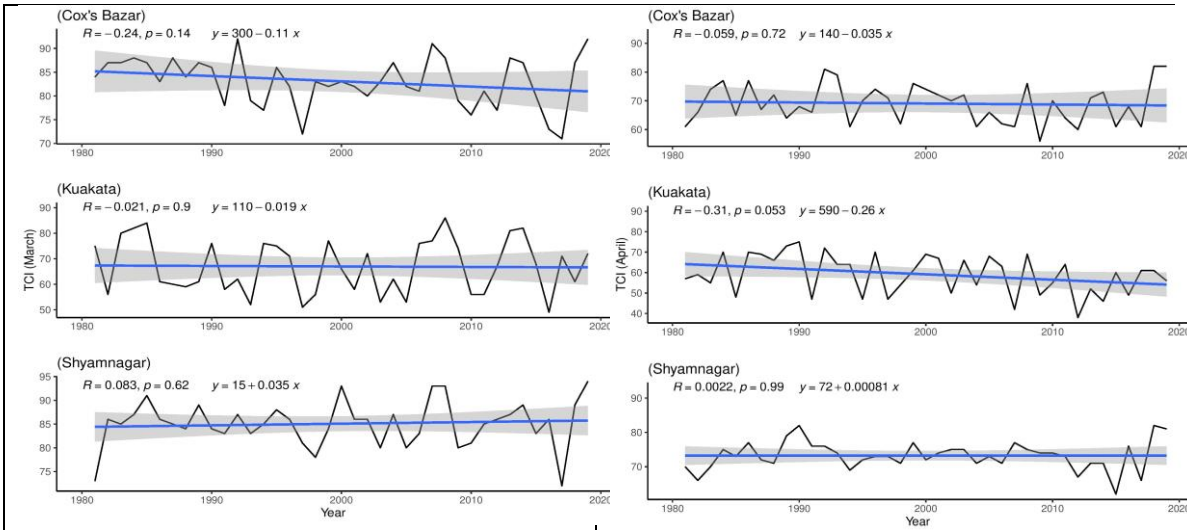


Figure 5.3.5: TCI in the month March in three-study areas from (1980-2020)

Source: Author's generated (climatic data had been collected from NASA earth observatory survey, 2022)

Figure 5.3.6: TCI in the month April in three-study areas from (1980-2020)

Source: Author's generated (climatic data had been collected from NASA earth observatory survey, 2022)

Although in Shyamnagar district in January the TCI value slightly declined from 80 to 70, in February the comfort index remains soothingly above 95.

5.4 Projected TCI up to 2100

TCI projections are significant for forecasting tourists' flow in any destination. However, this study examined the TCI values of three distinct study areas in six tourist seasons individually. Monthly average variables of each type have been considered for this reason. Figure 5.4.1 shows that in November, TCI tends to decline

tremendously in the Cox's Bazar area, where in 2040, the TCI would be 70, and in 2100, the TCI would decline to 52. However, in Kuakata, the TCI would increase and by 2100, it would rise up to 70 to 76, showing climate change to happen in this way. Besides, the trend of TCI is decreasing until 2100, it would still be comfortable for tourists with a TCI value below 80, which is currently over 90 with very good climatic conditions.

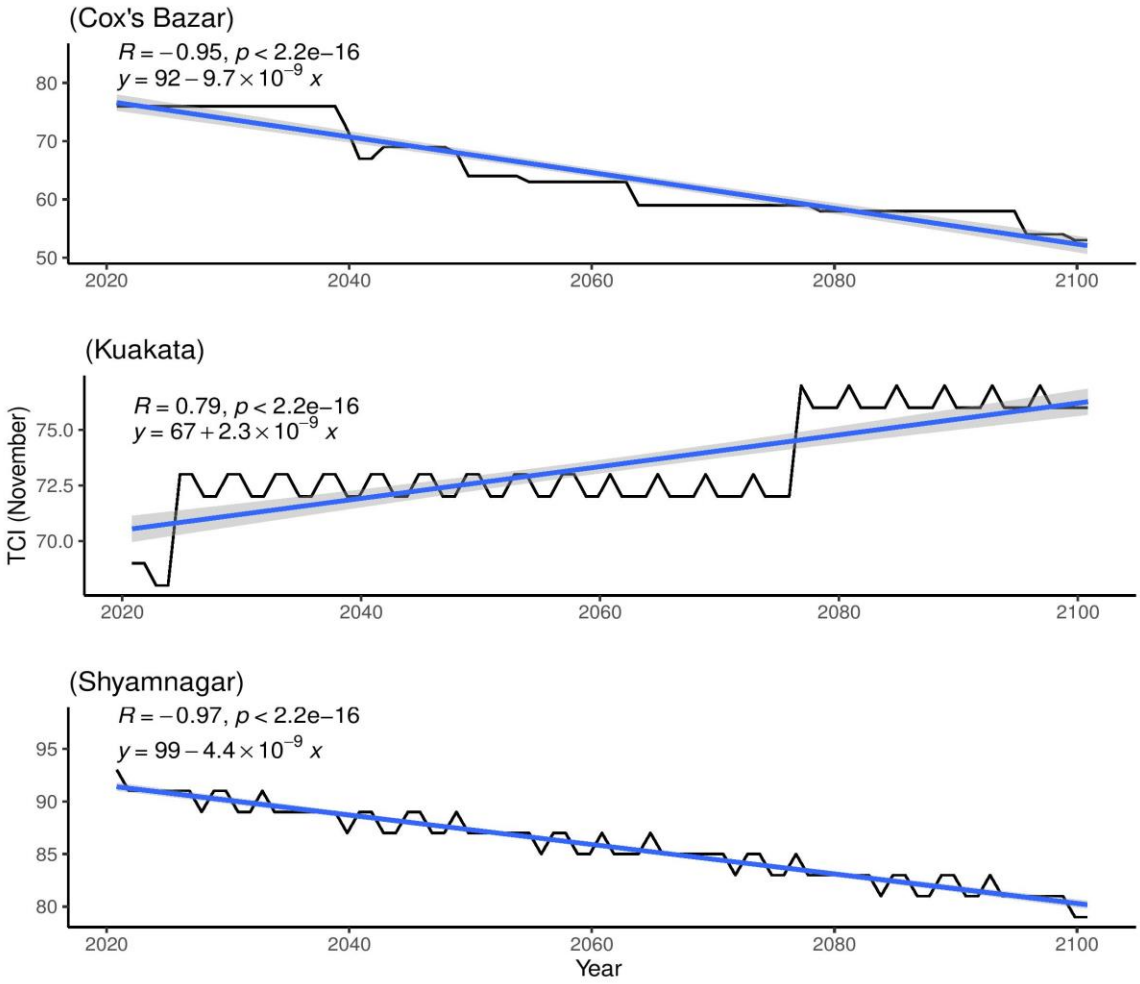


Figure 5.4.1: Forecasted TCI for the month of November in three-study areas from previous data (2020-2100)

Source: Author's generated (climatic data had been collected from the NASA Earth Observatory survey, 2022)

Again, for the month of December in Cox's Bazar, the TCI value is declining at an alarming rate, where the TCI value would be around 75 in 2025 (Fig. 5.4.2). The TCI value would decline to almost 50 by 2100 with a poor destination to travel. Interestingly, in Kuakata, the TCI value would remain steady from 2025 to 2100, 77

to 76, which is quite comfortable weather for outdoor activity of tourists. On the other hand, in Shyamnagar, the TCI value tends to be decreasing alarmingly from 94 to 83 from 2025 to 2100, respectively, which shows still comfortable weather for tourists in 2100.

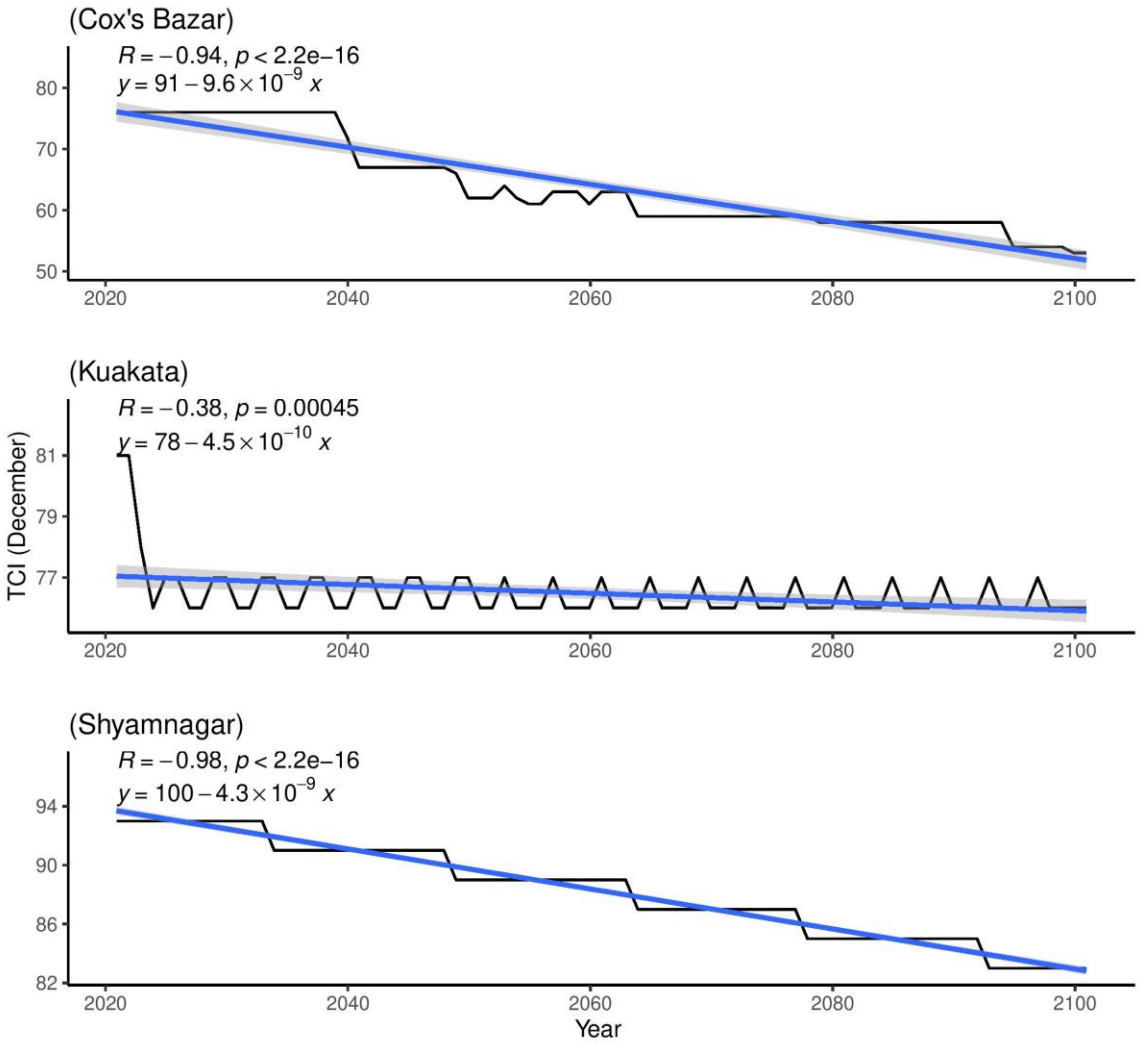


Figure 5.4.2: Forecasted TCI for the month of December in three-study areas from previous data (2020-2100)

Source: Author's generated (climatic data had been collected from the NASA Earth Observatory survey, 2022)

It can be predicted from Figure 5.4.3 that the peak season for tourists is the month of January Cox's Bazar might not be as comfortable as today, as the TCI value is very sharply declining from 75 to 52. TCI value would remain almost the same at 77 in Kuakata in 80 years; that is quite satisfactory for the tourists. Nonetheless, in

Shyamnagar, the TCI value is going to sharply decline (94 to 82), although the season would be comfortable to the tourists.

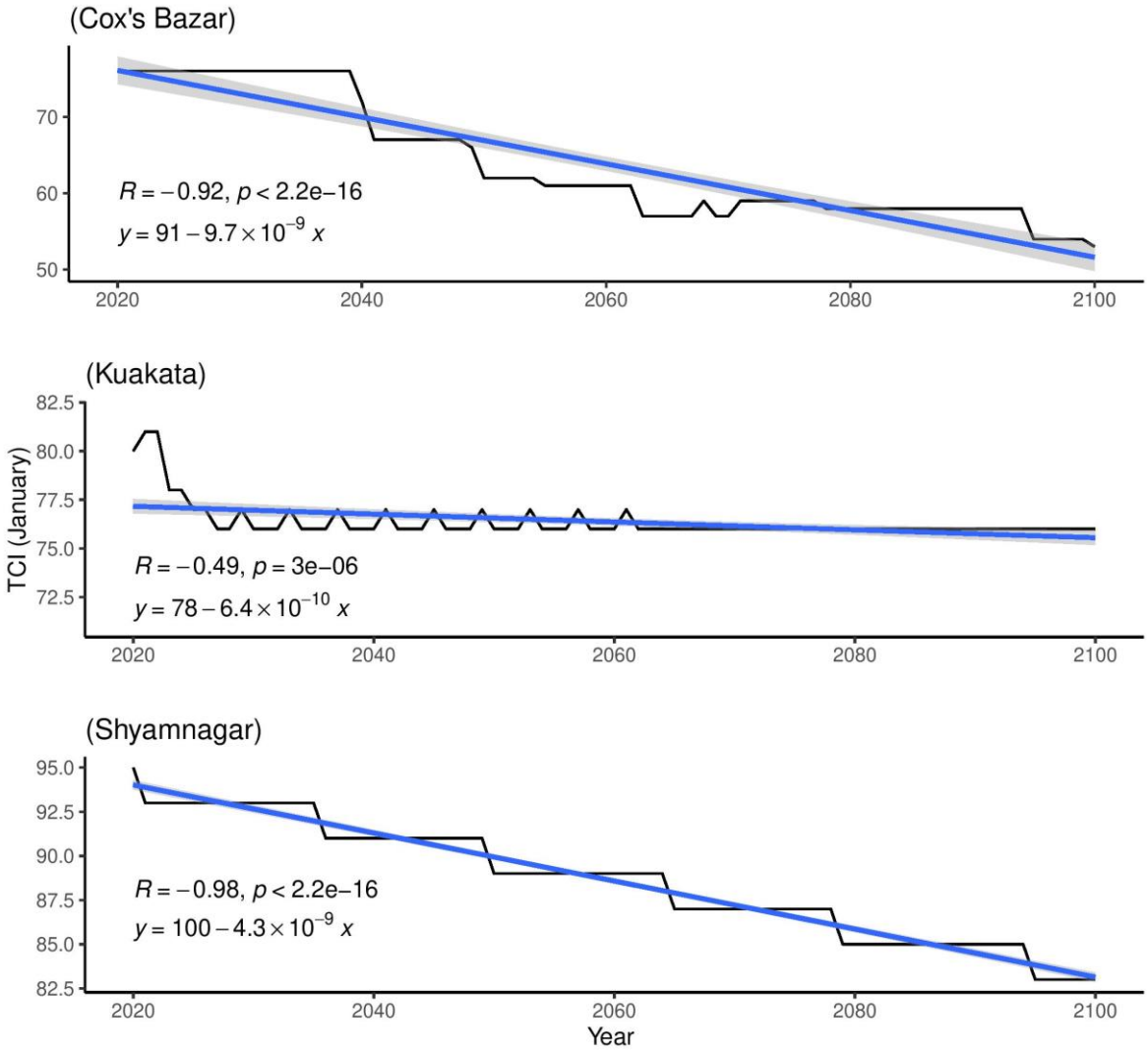


Figure 5.4.3: Forecasted TCI for the month of January in three-study areas from previous data (2020-2100)

Source: Author's generated (climatic data had been collected from the NASA Earth Observatory survey, 2022)

Another peak tourist season is February, which predicts that Cox's Bazar TCI value is going to decline during January, with the TCI value of 78 to 52 (Figure 5.4.4). Unlike Cox's Bazar, interestingly, the TCI value of Kuakata tends to increase from 73 to 77 in 2100, showing the trend of a comfortable tourist climate. Hence, in Shyamnagar, the TCI value will decline, although the TCI value would be 95 to 80, showing a comfortable climatic area for tourists.

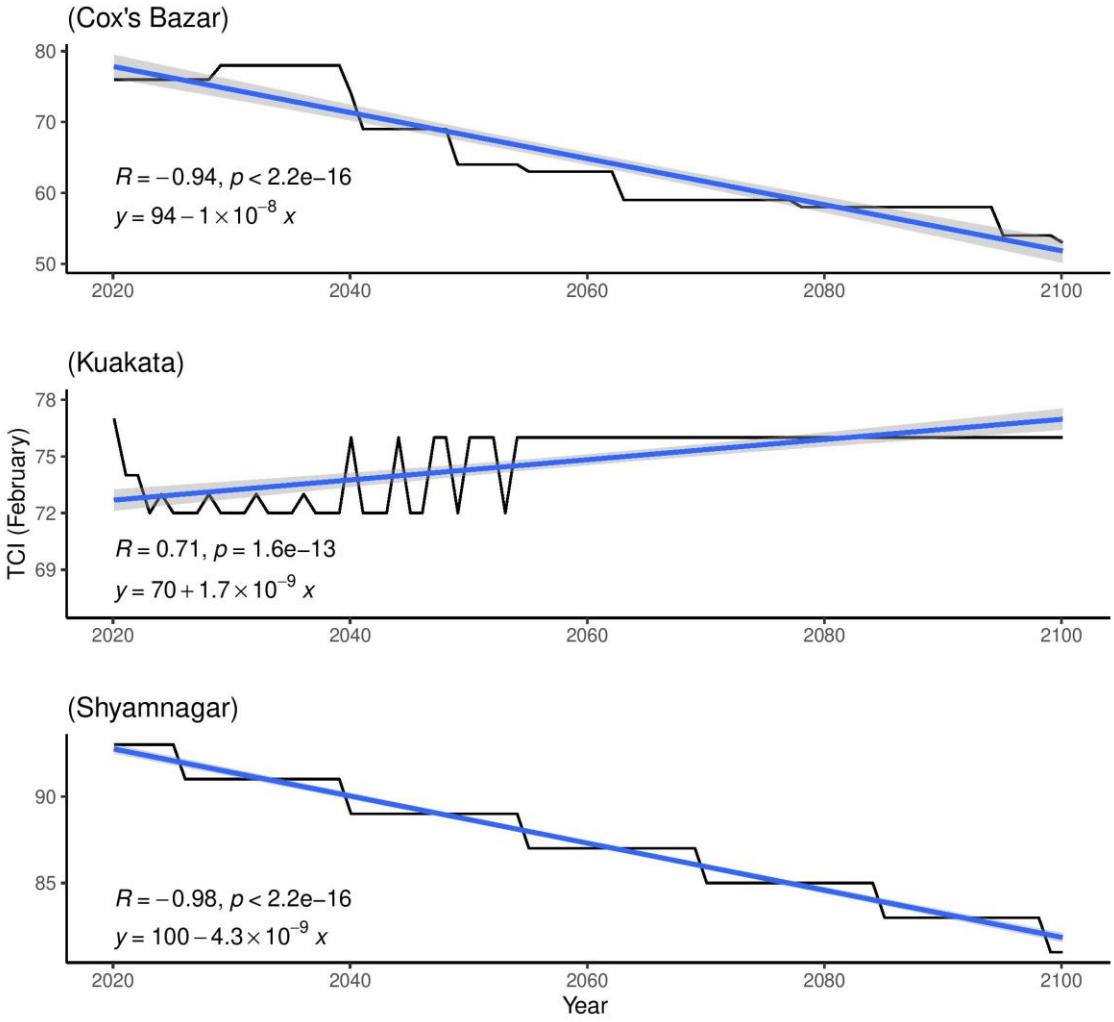


Figure 5.4.4: Forecasted TCI for the Month of February in the three-study areas from previous data (2020-2100)

Source: Author's generated (climatic data had been collected from the NASA Earth Observatory survey, 2022)

The TCI value shows again that in Cox's Bazar, tourists' comfort will decline in March, where in 2025 it was around 78 in 2100, and will drastically fall to almost 50 of the TCI value. However, in the Kuakata areas, the TCI value would increase from 57 to 67 from 2020 to 2100, respectively. In the case of Shyamnagar, the tourists' comfort index shows that in 2020 it was almost 82, yet it has a declining trend of the TCI value, which would be 70 in 2100, with a soothing, comfortable environment for the tourists.

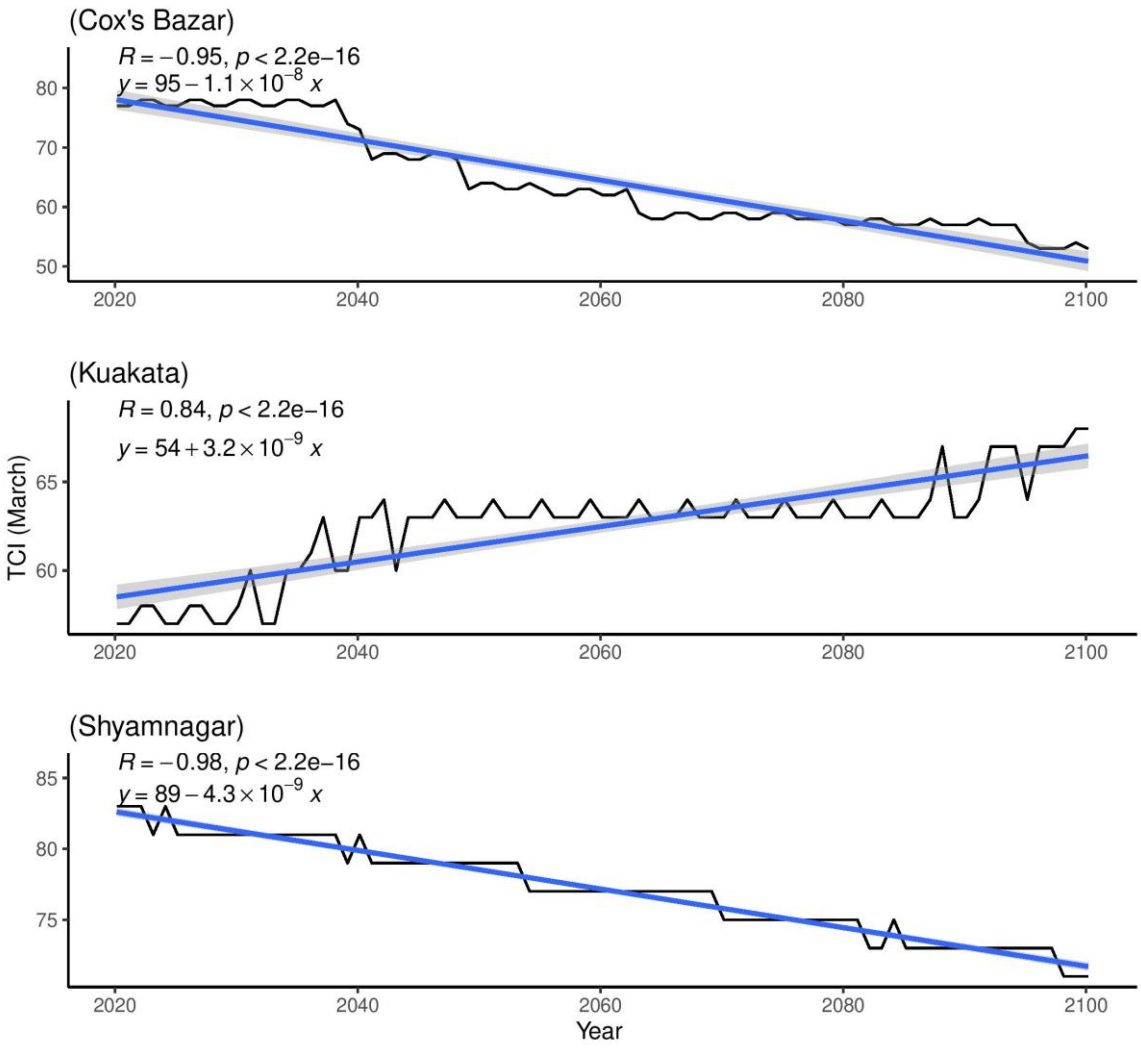


Figure 5.4.5: Forecasted TCI for the month of March in three-study areas from previous data (2020-2100)

Source: Author's generated (climatic data had been collected from the NASA Earth Observatory survey, 2022)

TCI values of the three study areas indicate interesting results showing that in April 2020, Cox's Bazar is the most comfortable zone for tourists with a TCI close to 80; however, in 2100, it would decline to 50. On the other hand, the month of April is not comfortable for tourists, as in 2020 the TCI value was around 51, though in 2100 it would be more comfortable, with a TCI value of 62, which is not particularly attractive for tourists. Hence, in Shyamnagar, the TCI value in 2025 would be 70; it tends to decline to around 63 in April in 2100.

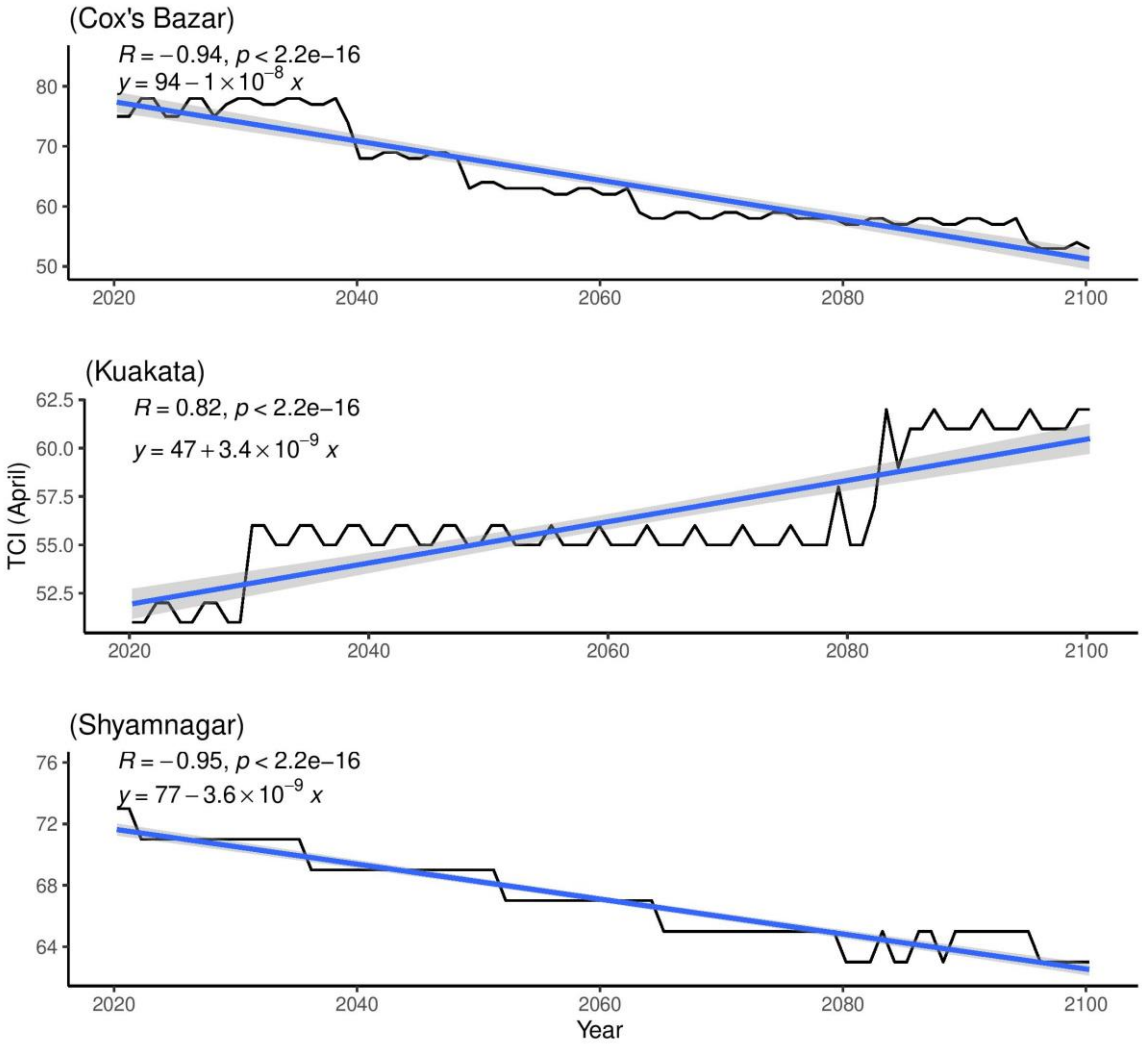


Figure 5.4.6: Forecasted TCI for April in Three-study areas from previous data (2020-2100)

Source: Author's generated (climatic data had been collected from the NASA Earth Observatory survey, 2022)

After analyzing and comparing the average TCI values, it has been seen (Figure 5.4.7) that Kuakata would be the most attractive coastal tourist destination among the three study coastal areas during the tourist season, except in April. It is because of the favorable climatic conditions for tourists with a TCI value of about 80 in 2100, although the destination has not been well planned and prepared for tourism. On the other hand, Shyamnagar within the mangrove forest would become gradually less comfortable for the tourists, though TCI value would be around 72, showing a comfortable destination to the tourists during the tourist season. In contrast, this

region would be less comfortable to tourists for outdoor activities gradually in March and April.

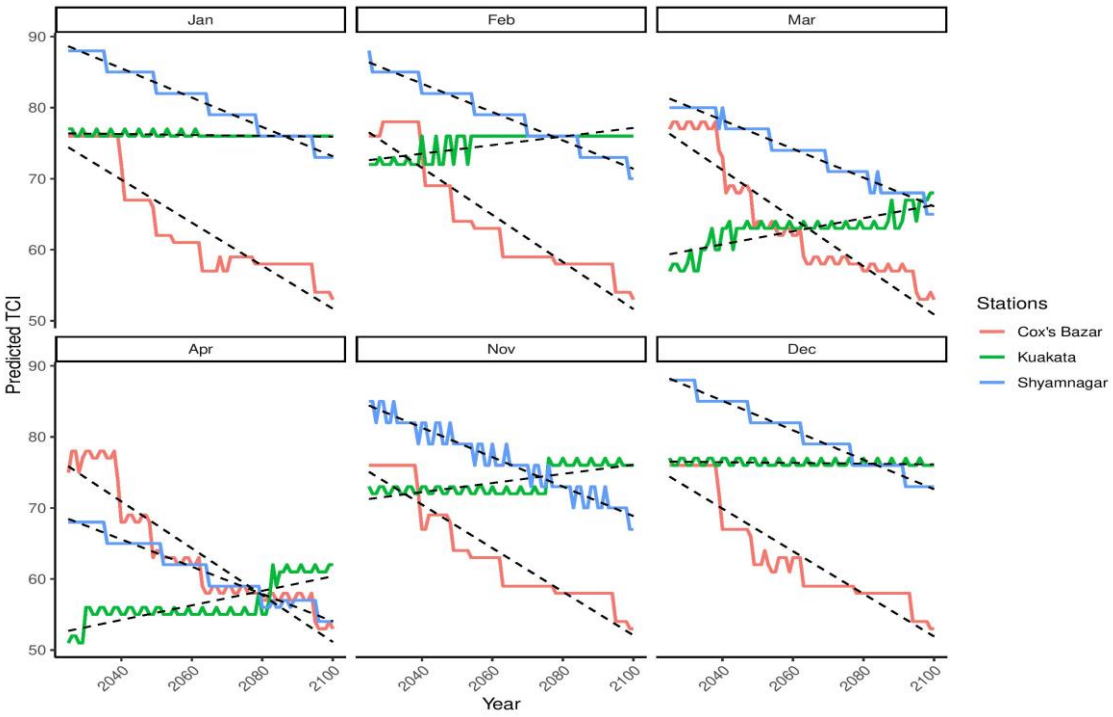


Figure 5.4.7: Comparison among average TCIs in the three destinations from 2025 to 2100

Source: Author's generated (climatic data had been collected from the NASA Earth Observatory survey, 2022)

However, the topmost tourist destination of Bangladesh at present is Cox's Bazar, which would lose its attractiveness by 2100, as the tourist climate index shows the comfort level at 50. It means that during tourist season, this destination would become the worst destination for outdoor recreation and nature-based tourism. Figure 5.4.8 clearly shows the comparison among the three tourist destinations' TCI indexes, potential tourist comfort destinations.

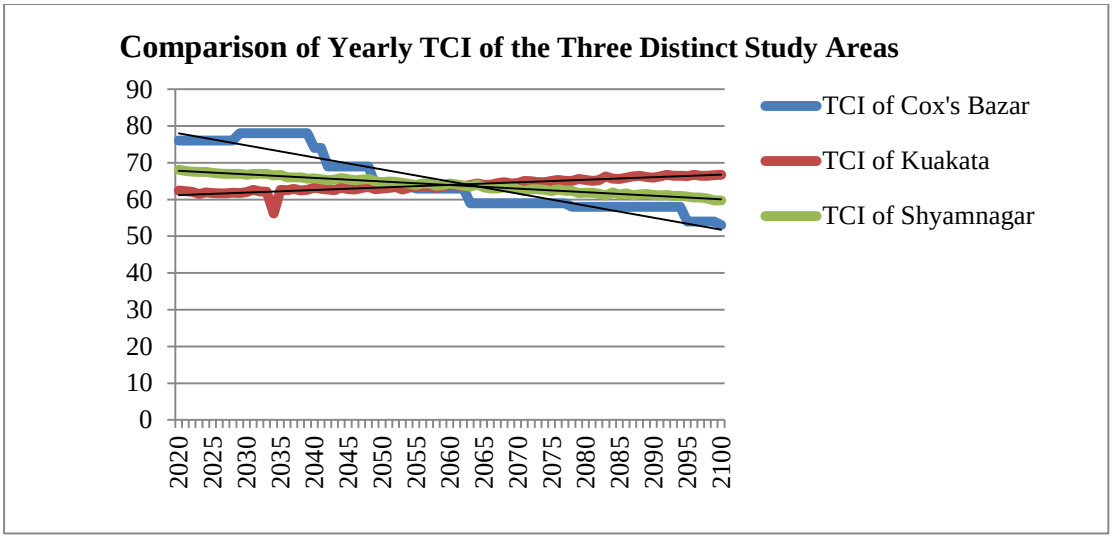


Figure 5.4.8: Comparison of yearly average TCI of the three study areas upto year 2100

Source: Author's Generated (2022)

As such, the average risk factor based on TCI values has been calculated from the equation (shown in percentage) below;

Average TCI Risk Factor throughout the year (%) = $\frac{\sum. \mathrm{TCI}_0 - \mathrm{TCI}_n}{T}$

Here,

The average TCI Risk Factor has been calculated in percentage.

ΣTCI_0 = Summation of base or initial TCI value

ΣTCI_n = Summation of predicted year of TCI value

Therefore, after generating the TCI value every twenty years, the result has been shown in the table, based on the data of each year from 2020 to 2100, and each month has been calculated. To show the condition of TCI because of climate change can be easily understood from table 5.1 below.

Table 5.1: Predicted Average TCI Values from 2020 to 2100 in the Three Study Areas of Bangladesh

Predicted Average TCI Values from 2020 to 2100					
	2020	**2040**	**2060**	**2080**	**2100**
Cox's Bazar	76	74	63	58	53
Kuakata	62.42	61.84	63.13	64.56	66.11
Shymanagar	68.08	68.08	65.75	63.03	61.14

Source: Author's Generated (2022)

From the above table, it can been seen that the most risky region for outdoor and nature-based tourism in Cox's Bazar has a risk factor of 0.29, where Shyamnagar also becomes gradually risky, having a 0.15 risk factor. On the other hand, Kuakata would be the least risky region for tourists, and investment in this region could bring about profit with less risk in the long run for outdoor activities, having TCI risk factor of 0.05.

Chapter Six

Climate Change and Financial Risk in the Coastal Areas

Climate change has become a very crucial issue at present, because of its adverse impact on different industries such as agriculture, natural resources, financial sectors, tourism, and commercial activities, including the daily livelihoods of human beings. On the other hand, climate change tends to materialize risks to the financial stability of a country. Besides, financial risks arising from climate change are a very recent phenomenon, and they have gained growing attention in recent decades.

Financial risk could be created from financial variables for losses occurring in the financial market (Thim and San, 2018). However, banks give loans to non-financial firms through merging their own net assets with funds raised from outside households as a form of deposits (Carattini, 2021). Banks are among the major financial institutions that regulate the availability of money within modern economic systems.

The identification of risk starts through the understanding and/or management of risks, which are crucial financial activities. Hence, natural calamities could bring risk to the credit, market, or liquidity of banks. As such, there should be adequate tools and techniques to identify risk because unidentified risks cannot be used further. Among the various techniques, Value at Risk or VaR is a tool for risk research and identification by many firms in bank lending. Here, VaR stands for Value at Risk, a possible summary of statistical measures from normal portfolio losses (Linsmeier and Pearson, 2000). It is expressed as the adverse change in surplus amount of market value returns, where 99% confidence levels over a month horizon are assumed (Ho *et al.*, 2000).

However, Dietz *et al.* (2016) identified that because of climate change, the climate value at risk of financial assets is 1.8% globally at the Business as Usual (BAU) scenario. Climate risks have been mainly recognized as a perceived credit risk related to clients' default on loans or as a risk impacting the bank's own operations. For example, such risks are to the properties (risks associated with extreme weather interrupting banks' normal operations). There is also evidence that potential climate change regulations and guidance may affect banks' general operations (Elliott & Lofgren, 2022). Conversely, the losses derived from climate change tend to be

negative (Saunders & Allen, 2002). There remain key challenges in identifying macroeconomic financial risks arising from climate change (Battiston *et al.,* 2021).

Ironically, the empirical research and analyses of risk pricing in investment decisions of climate change and of the financial stakeholders' response to climate change are still at an infant stage. For mitigating climate risk in the portfolios of investors, and to align with the Paris Agreement, concrete and precise information is needed. Nonetheless, there is a lack of relevant information or data on near-term climate risk, which is a significant barrier to climate-smart investment decisions in the financial sector (Clapp and Sillmann, 2019).

Furthermore, a major challenge to conducting research in the area remains the insufficient presence of very poor standardized information on the climate-related characteristics of firms. Furthermore, financial products and the inconvenience of identifying low to high-carbon assets also exist. On the other hand, banks are naturally exposed to climate risks through their assets with the longest maturity. The most important issue is whether banks remain susceptible to climate-related risks and incorporate them within their credit allocation strategy. There has been extensive research conducted on the immediate effects of natural disasters on bank business. However, the lack of research on the long-term risks associated with climate change has been identified (Javadi and Masum, 2021). Banks tend to be exposed to maturity transformation risk because of their lack of rates on assets for prolonged periods than the rates on the liabilities (ibid).

Risk arising from the impact of climate change is long-term, and it has a gradual nature. Moreover, it cannot be felt within a short time as other types of natural disasters, such as cyclones, tornadoes, earthquakes, epidemics, or floods; yet, it is more likely to trigger other types of natural disasters, which continue to cause damage in the long term. On the other hand, short-term and slow effects cannot be neglected as well. Therefore, if lenders think of climate change as a risk factor in terms of lending money, its adverse effect should be both for long-term and short-term loans.

It is probable that poorly rated firms could be more vulnerable to climate risk. Undeniable evidence exists in the physical costs associated with climate-related events such as cyclones and droughts, which have already had negative impacts on both equity and debt instruments (Campiglio and Monnin, 2019). Therefore, a significant decrease in the payoffs of equities, and an increased rate of the proportion of non-performing loans exists. In this research, it has been found that there is an increased rate of cyclones in terms of frequency and magnitude in the coastal areas of Bangladesh. Moreover, it is likely that the occurrence of natural calamities has a rising tendency substantially with climate change; their impact on financial assets will also have a the potential to grow (ibid).

Since the transition to a low-carbon economy is yet to happen, empirical evidence of the impact of transition costs on financial assets becomes scarcer. Nonetheless, the examples available indicate that transition costs have already reduced equity returns and increased default probabilities for some firms. Here, transition risk refers to risks arising from increased pricing of carbon-intensive goods and services or technological changes (Semieniuk *et al.*, 2021).

One example of an Italian firm, which is located in the flood-prone areas, has a connection between climate risk and bank lending credit (Faiella and Natoli, 2019). Therefore, to implement the Flood Directive of the European Commission, 'Italian Institute for Environmental Protection and Research' (ISPRA) in 2015 classified four flood risk categories (i.e., no risk, low, medium, and high risk). The lands at high risk are estimated to be damaged once in 20–50 years, while those at lower risk are only damaged once in more than 200 years. Consequently, it was found that the significance of short-term to long-term effects of climate risky zones impacted the terms of lending behavior of banks.

There could be three different channels, which can affect the relationship between climate change and systemic risk: bank-level climate change exposure, bank loan portfolio synchronicity, and bank default probability. There are a number of risk assessment tools for banks' lending money. Among those, Value at Risk (VaR) has been used more than other assessment tools (Monasterolo, 2020; Dietz *et al.*, 2016;

Saunders and Allen, 2002). Specially, Prettenthaler *et al.* (2018) found weather VaR is a very useful tool or not to find income and losses from climate change.

Ironically, tourism industries are regarded as highly weather and climate sensitive because travellers' first preference lies in soothing climatic conditions and uninterrupted traveling. Moreover, the tourism sector achieved particular economic importance because of its great contributions to the economy and society. This sector is extremely driven by demand, where risks in income from tourism industries are studied, focusing on climate change impacts on the demand side as well (Prettenthaler, 2019). It has been recorded that almost 70% of annual overnight stays occur during the wintertime tourist seasons (ibid). Research finds that banks with higher default probability lead to a higher level of systemic risk. Impacts of climate change are more pronounced for banks with higher climate change exposure, higher loan synchronicity, and higher bank default probability.

Essentially, VaR models tend to measure the minimum loss of the value of asset or liability for a time span at a given confidence level (e.g., 95%, 97.5%, or 99%). An example of a tradable instrument, such as equity, suffices to describe the basic concept of VaR methodology (Saunders & Allen, 2002). The standard deviation, denoted by σ, is a commonly used measurement tool of risk as it measures the loss dispersion weighted by the likelihood of occurrence.

6.1 Coastal Tourism Investments

Although Bangladesh is in a developing stage, with a rapid economic growth rate of 6.9% per year, even after the COVID-19 pandemic, and is prone to climate-related disasters, there is a lack of research on the direct impact of climate change on the financial sector (World Bank, 2022). Bangladesh Exclusive Zone Authority (BEZA) is targeting to implement several government-initiated projects in tourism in the study area, where all of the projects are in Cox's Bazar. Cox's Bazar and the other two areas are also developed privately.

However, there are some internationally donated projects as well. In terms of Cox's Bazar, as it is the top-most tourist destination of Bangladesh, there are several types of

investments from both public and private sectors. Until now, the Bangladesh Parjatan Corporation Hotels and Motels have mainly been made up of public investments. In the study area, there are several banks and branches of these banks present, which support both the suppliers and the demand group of tourism.

However, direct investments from these banks are still unknown. However, there are 55 branches of 40 banks present in Cox's Bazar. There are 24 branches of 16 banks at Kalapara of Kuakata. There are 15 branches of 12 banks in Shyamnagar of Shatkhira are serving (BIAM, 2023). On the other hand, loans sanctioned in the tourism sector through different banks are as follows:

The data retrieved belongs to BRDP Circular No. 16/2021 (31.12.2020),

Table 6.1: Loan in Tourism and Recreation Sector of Bangladesh of 59 Banks

	Name of Bank (investment in tourism)	**Loan BDT (00,00,000)**
1	Agrani Bank PLC.	1073.88
2	Premier Bank PLC.	806.09
3	First Security Islami Bank PLC.	762
4	Janata Bank PLC	541.45
5	IFIC Bank PLC.	532.33
6	Shahjalal Islami Bank Ltd.	258.9
7	Standard Chartered Bank	207.3
8	Standard Bank Ltd.	183.42
9	Islami Bank Bangladesh Ltd.	169.6
10	Marcentile Bank Ltd.	145.98
11	Southeast Bank Ltd.	141.3
12	Dutch-Bangla Bank Ltd.	116.28
13	Global Islami Bank Ltd.	115.25
14	Union Bank Ltd.	104.38
15	AB Bank Ltd.	100.23
16	One Bank Ltd.	66.83
17	United Commercial Bank PLC.	57.59
18	Madhumati Bank Ltd.	54.56

19	NRB Commercial Bank PLC.	52.98
20	Sonali Bank PLC.	50.7
21	Bank Al-Falah Ltd.	50.11
22	Rajshahi Krishi Unnoyon Bank	47.97
23	Pubali Bank Ltd.	40.21
24	Trust Bank Ltd.	23.74
25	Meghna Bank Ltd.	13.24
26	ICB Islami Bank Ltd.	10.91
27	Bangladesh Commerce Bank Ltd.	10.13
28	Dhaka Bank Ltd.	9.45
29	Social Islami Bank Ltd.	7.38
30	South Bangla Agricultural and Commerce Bank Ltd.	6.75
31	Bank Asia Ltd.	6.67
32	Uttara Bank Ltd.	3.79
33	Commercial Bank of Sillon Ltd.	3.46
34	Jamuna Bank Ltd.	2.37
35	Al-Arafah Islami Bank Ltd.	1.17

Source: Bangladesh Bank, 2022

Table 6.1 shows the exact amount of loans disbursed by different banks to tourism industries, where Chart 6.1 shows which banks have a higher rate of investments in the tourism industry. Among all the banks, Agrani Bank PLC invests mainly in the tourism sector throughout the country. Only three State-owned commercial banks of the Bangladesh Government (Agrani Bank PLC, Janata Bank PLC, and Sonali Bank PLC) invest in the tourism sector by giving loans with higher amounts. And the rest of the banks are private commercial and specialized banks, which also invest in the tourism and recreation sector (Figure 6.1).

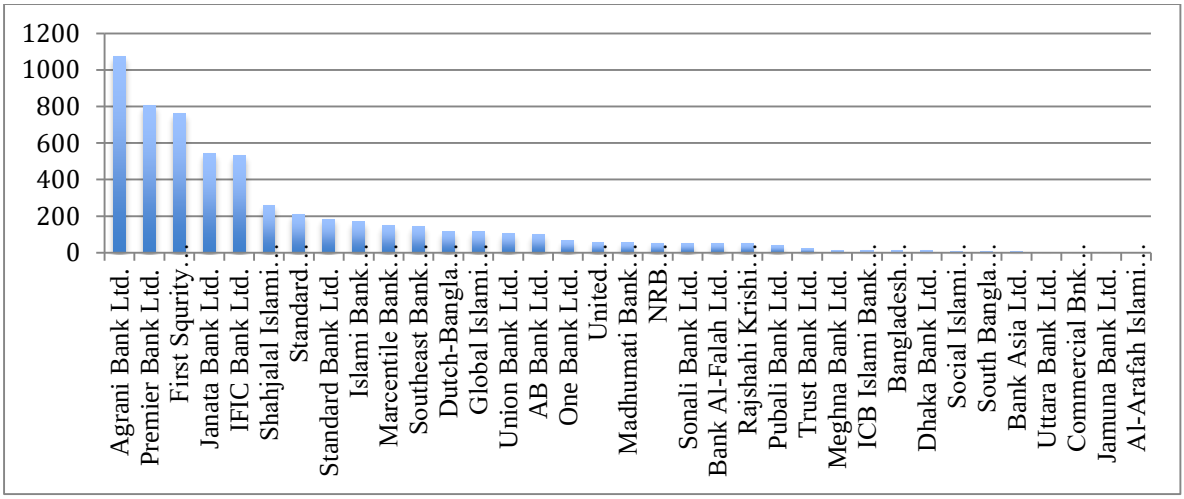


Figure 6.1: Loan Sanctioned by Different Public and Private Banks in Tourism and Recreation Sector (million BDT) in 2022

Source: Bangladesh Bank (2022)

6.2 TCI Risk Analysis

Tourism Climate Index (TCI) is the top-most model that has been widely used to predict and analyze tourist flow in different climatic conditions. In the previous chapters of this research report, the interrelationships among tourist flow and Climate Change impact have been identified. Nonetheless, it is expected to identify what type of tourism, along with recreation services, is less risky and more profitable in terms of investment. Therefore, in this chapter, two models have been developed to find out credit risks on tourism investments through credit lending from banks in the study areas. Subsequently, the following models use the time series data analyzed for TCI prediction upto 2100. Moreover, here the volatility is measured by the TCI risk factor.

TCI risk factor determination is needed to calculate the risks arising from tourists' flow of a region and then investment decisions could be made. Thus, the average TCI risk factor throughout the year could be determined by using the following equation.

$$\text{Average TCI Risk Factor throughout the year} = \frac{\sum. \text{TCI}_0 - \text{TCI}_n}{T} \quad \text{.....(i)}$$

Here, equation (i) is implied for the Average Tourism Climate Index Risk factor from the summation from 2020 (TCI_0) to 2100 (TCI_n) divided by the total number of years counted as 80 years. Table 6.2 shows TCI conditions in specific study areas at specific

times. Furthermore, every twenty years TCI values of the three study areas show the condition of a changed pattern of tourism comfort from climate change. Finally, the average values of the risk factor in the study areas show that the risk factor varies throughout the year.

Table 6.2: Predicted Average TCI Values from 2020 to 2100 in the Three Study Areas of Bangladesh

Predicted Average TCI Values from 2020 to 2100					
Location	**2020**	**2040**	**2060**	**2080**	**2100**
Cox's Bazar	76	74	63	58	53
Kuakata	62.42	61.84	63.13	64.56	66.11
Shymanagar	68.08	68.08	65.75	63.03	61.14

Source: Author's generated (2023)

Table 6.3: Average TCI Risk Factor of Each Consequtive Year in the Three Study Areas

Analysis of average TCI risk factor in each consequtive year of the study areas					
Name of the Area	**2040**	**2060**	**2080**	**2100**	**Average TCI Risk Factor in each consecutive year**
Cox's Bazar	0.10	0.55	0.25	0.25	0.29
Kuakata	-0.04	-0.04	-0.07	-0.07	-0.05
Shymanagar	0.12	0.07	0.13	0.10	0.10

Source: Author's generated (2023)

To identify sea level rise because of climate change on banks' exposure to lending credits Jiang *et al*. (2019) developed a model, which is as follows;

$$\text{Bank's SLR Experience}_t\,(\%) = \frac{\sum_{j \le t} loan\ amount_j \times \text{SLR risk}_j}{\sum_{j \le t} total\ loan\ amoun\square_j} \quad \text{……..……..(ii)}$$

Here, the impact from sea level rise risk on a bank's loan given could be identified by the summation of local amounts in a specific area during a specific time multiplied by the sea-level rise risk of that area divided by the summation of loan amounts throughout the time. Thus, based on that model and its application, a model has been

developed to show climate change impact relating to TCI risk factor, which is as follows (equation iii);

$$\text{Bank's TCI risk}_t\,(\%) = \frac{\sum_{j \le t} loan\ amount_j \times \text{TCI risk}_j}{\sum_{j \le t} total\ loan\ amount_j} \quad \text{.....(iii)}$$

Here, the symbols stand for,

TCI = Tourism Climate Index

j= Specific bank

t = Time

TCI risk = risk in every year

Thus, equation (iii) could determine a bank's TCI risk at a specific time in percentage, which could be further utilized to determine the money lending from investors or banks. Yet, because climate change impact is slow and continuous, it requires frequent testing over many years.

6.3 Climate Change Risks in the Scenarios of Tourism Investments

As mentioned above, climate change brings risks to the financial sector as well as tourism investments. Banks play a crucial role in giving loans to the borrowers of the tourism industry. There arises an issue of bad loans, default, or loan spreading in many cases. As such, to find out risks for identifying climate change impact on bank loans during a specific time in a specific area, the Tourism Climate Index-Value at Risk (TCI-VaR) model has been developed. The equation is as follows;

$$\textbf{Bank's TCI-VaR} = \Delta V_{i,t} \times TCI_{i,t} \times \varepsilon \times \sqrt{t} \quad \text{.....(iii)}$$

Here, the symbols stand for,

$\Delta V_{i,t}$ = Value of Loan

TCI Risk = Stress Level

ε = Stress event

$\sqrt{t}$ =Square Root (total days/day per year)

Consequently, to calculate TCI-VaR of a bank using equation (iii), by keeping all other external factors as controlled variables, the bank's climate change risks in the tourism industry could be calculated. Therefore, only investment risks arising from

loans sanctioned to the tourism and recreation industries could be determined through the equation. Here, four banks' data have been used to investigate and test the equation. Among four banks, three banks invest only in one study area, while one bank invests in three study areas. Trust Bank is the bank that granted loans to different types of industries related to the tourism business. Hence, three examples have been investigated to calculate TCI-VaR for three specific study areas. The reason is that this bank has already disbursed loans in the three projects.

TCI-VaR of Trust Bank: Here, portfolio value stands for loans disbursed in that area. In the case of Trust Bank's TCI risk exposure in the three study areas, the formula is as follows;

$$\text{Trust Bank's TCI risk}_{j,t} = \frac{\sum_{j \le t} loan\ amount_j \times \text{TCI risk}_j}{\sum_{j \le t} total\ loan\ amount_j} \quad \text{.....(iv)}$$

Where,

TCI= Tourism Climate Index

j= Specific bank

t = Time

After keeping other factors within controlled variables, it could be seen that the TCI-VaR of the given loan Barsha Waterways in Shyamnagar of Shatkhira, could bring (TCI-VAR) credit risk of 4,035.68BDT BDT after three years, and the credit risk would be 0.40% as shown in Table 6.4. Here, expected volatility has been calculated as the loan amount granted divided by the total loan amount given by the bank in the tourism sector nationwide.

Table 6.4: TCI-VaR of the Three Study Areas based on Loan Disbursed by Trust Bank

Study Area	**Shatkhira**	**Kuakata**	**Cox's Bazar**
Portfolio value	10,00,000	50,00,000	1,00,00,000
Expected volatility (TCI)	0.10%	-0.05%	0.29%
Time (days of year)	1095	2555	3650
Confidence level	0.99	0.99	0.99
Stress event	2.33	2.33	2.33
TCI-VaR	4,035.68	-15,411.50	2,13,675.10
Credit risk from TCI-VaR (%)	0.40	-0.31	2.14

Source: Author's generated (2023)

In Kuakata, the credit risk would be -15,411.50 BDT after seven years, as the loan of 5 million BDT had been sanctioned for five years. It implies that there is a negative credit risk of -0.31% in Kuakata. Therefore, compared to the other two destinations, there are no risks in tourism investments in this study area. Instead, investments in the nature-based tourism sector are more profitable in the destination.

Furthermore, for outdoor tourism and recreation activities, Cox's Bazar is the most risky region. The tendency of climate change credit risk will be 21,367.51 BDT per year in a loan of 10 lacs of BDT with 2.14% credit risk. Figure 6.2 shows the details of the credit risk arising from climate change on tourist flow in the near future.

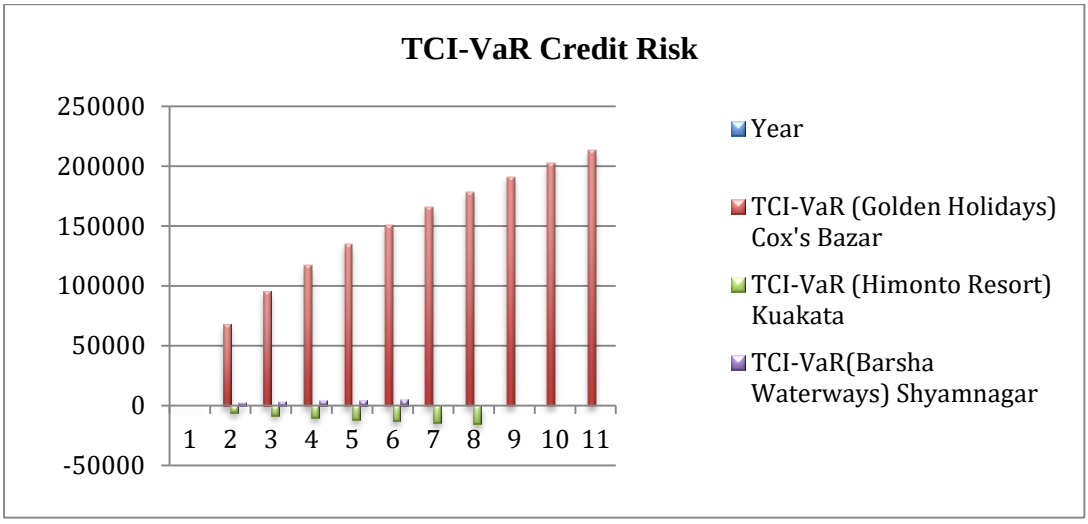


Figure 6.2: Comparison of TCI-VaR of Three Samples in the Three Study Areas

Source: Author's generated, 2023

In five years, credit risk is higher in Shyamnagar, Shatkhira and more than 500 times higher in Kuakata.

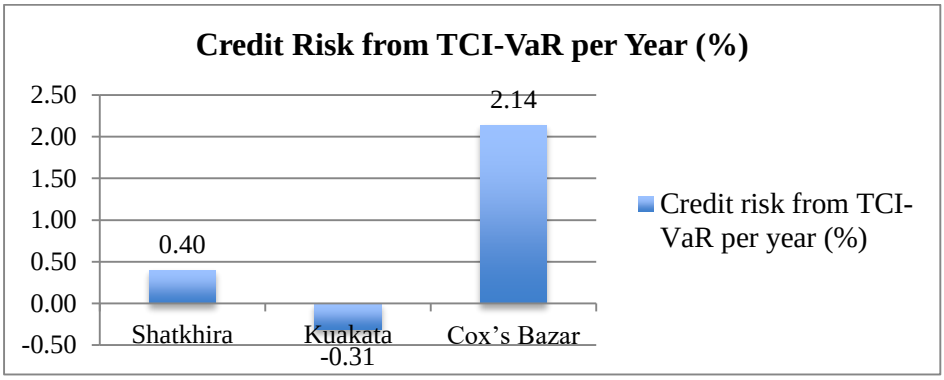


Figure 6.3: Credit Risk from TCI-VaR of Trust Bank in three Study Areas

Source: Author's generated, 2023

TCI-VaR of NRBC Bank PLC:

Another bank, which has more investments and available data, is NRBC Bank PLC., where investment through a loan in two destinations of Cox's Bazar and Kuakata can be found. From the loan disbursed in resort, restaurant, and hotel businesses in these destinations would bring about the following credit risk (Table 6.4).

Table 6.5: Analysis of TCI-VaR of the Study Areas based on Loan Disbursed by NRBC Bank PLC.

Study Area	**Shatkhira**	**Kuakata**	**Cox's Bazar (10 and 5-year maturity period)**	
Portfolio value	-	50,00,000	1,00,00,000	40,00,000
Expected volatility (TCI)	-	0.94%	2.64%	2.64%
Time (days)	-	1825	3650	1825
Confidence level	-	0.99	0.99	0.99
Stress event	-	2.33	2.33	2.33
TCI-VaR	-	-13004.68	19,42,131.29	5,49,317.68
Credit risk from TCI-VaR (%)	-	-0.05%	3.71%	2.62%

Source: Author's generated, 2023

On the other hand, the other four banks, which could provide specific data on the loan disbursed on tourism business, are in Cox's Bazar only (Table 6.3). In the other two destinations, these banks did not provide any loans for tourism businesses.

Table 6.6: TCI-VaR Identification of Three Banks in Cox's Bazar

TCI-VaR of Cox's Bazar	**Mercantile Bank**	**UCB Bank**	**IFIC Bank**	
Portfolio value (BDT)	58,44,35,000	50,00,000	6,25,00,000	3,25,00,000
Expected volatility	0.11%	0.25%	0.52%	0.52%
Time (total days of year)	1825	1095	3650	1825
Confidence level	0.99	0.99	0.99	0.99
Stress event	2.326347874	2.33	2.33	2.33
TCI-VaR (BDT)	33,44,171.66	16,788.97	23,90,881.32	8,79,116.36

Source: Author's generated, 2023

TCI-VaR of other Banks:

In the case of IFIC Bank, it lent money to tourism businesses in 2023 in two intervals. The first loan has been disbursed for ten years, and the second one has been disbursed for five years. The two different time intervals have been calculated to get an accurate result to analyze TCI-VaR. Total TCI-VaR of loans disbursed in the tourism industry from IFIC Bank in Cox's Bazar is 32,69,997.69BDT. Figure 6.4 below represents credit risk arising from TCI-VaR on loans disbursed by three different banks in Cox's Bazar.

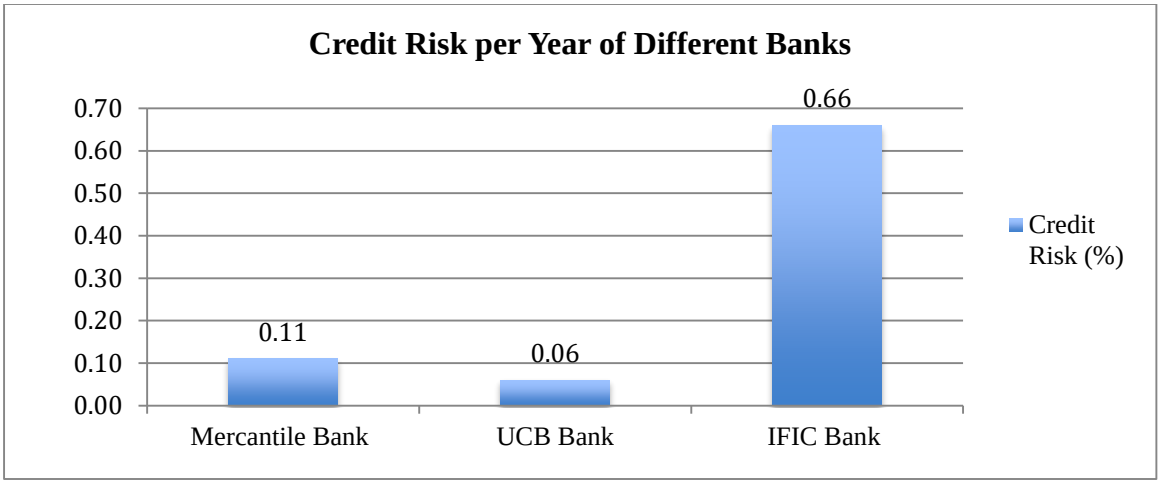


Figure 6.4: Credit risk (%) from loan disbursed in tourism business by different banks in Cox's Bazar

Source: Author's generated, 2023

From the chart, it has been understood that in the cases of Mercantile Bank Ltd. and UCB Bank, the credit risk is almost similar, 0.11% because of a smaller amount of money for a short duration; in contrast, for IFIC Bank, this risk would be higher, around 0.34% because of longer maturity and more investments. Thus, from the above analysis, it is clear that longer investment or loan disbursment would entail greater risk by making bad loans or default by the borrower. This could lead to loan spreading as well to the central bank. However, this data has been analyzed based on only one study area, Cox's Bazar, as these banks have not provided any loans or any investment in tourism in other tourist destinations.

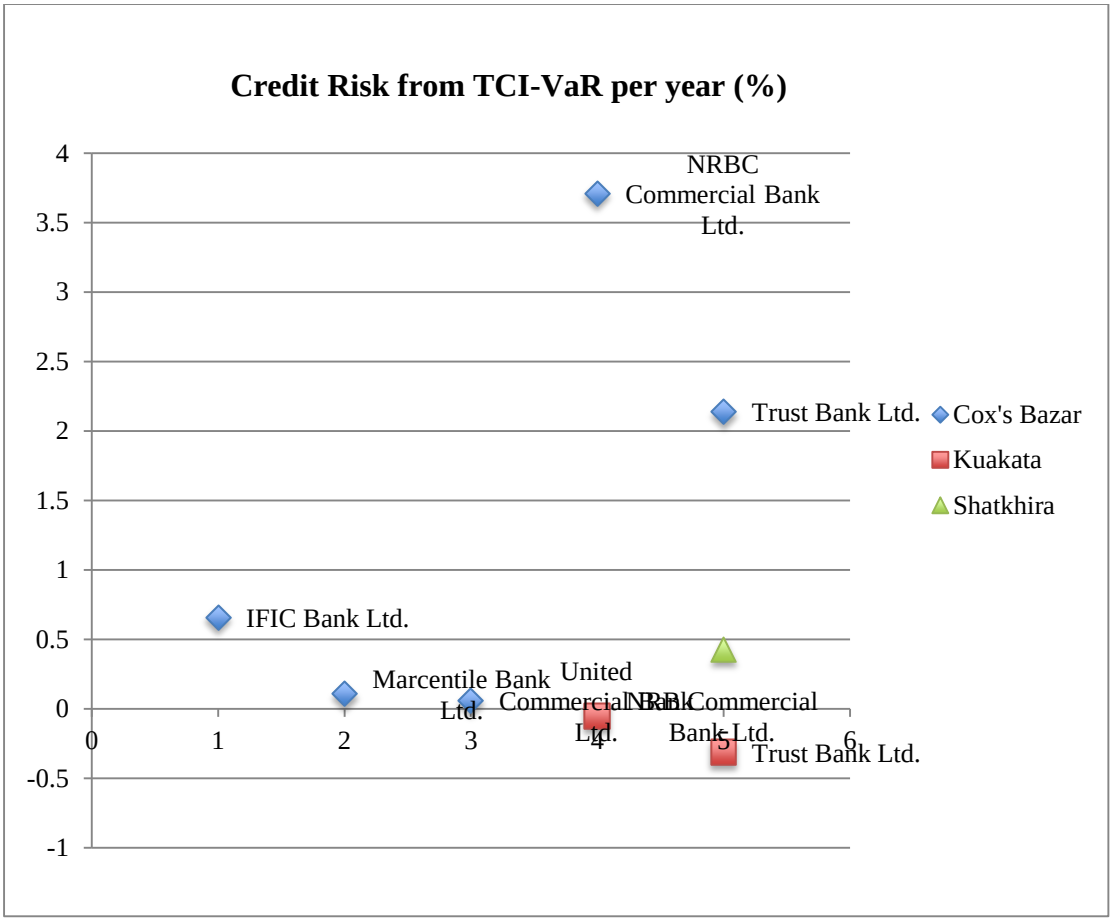


Figure 6.5: TCI-VaR per Year of Different Banks in the Study Areas

Source: Author's generated (2023)

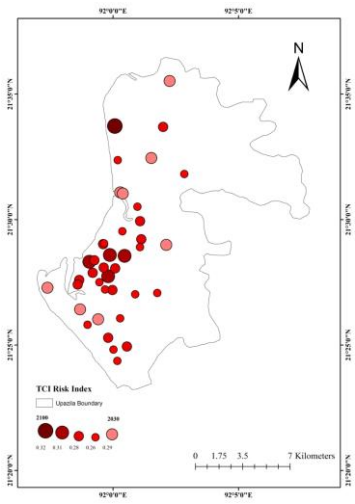
From the above Figure 6.5, it can be depicted that banks that give loans are supposed to have negative credit risk, and investment in tourism would bring about no adversity because of climate change. On the other hand, credit risk (3.71%) is highest for NRBC Commercial bank as it invested the most through lending money in Cox's Bazar because there has been a higher amount of money lent for a longer period. And then Trust Bank's loans given in Cox's Bazar would also be in a riskier position (2.14%) for the same reason, as a significant portion of the credit has been lent for a longer period.

However, other banks that have granted loans to Cox's Bazar for a short period and a smaller amount have lesser risks, for example, IFIC Bank (0.66%), Marcentile Bank (0.11%), the United Commercial Bank (0.06%). Besides, only Trust banks among the

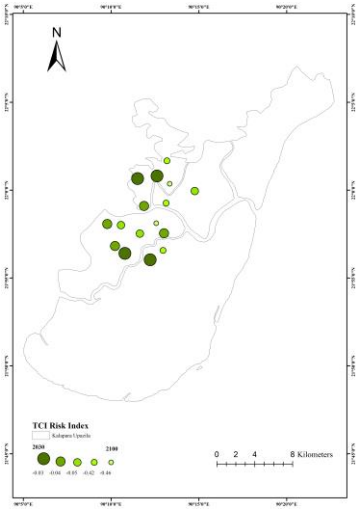
sample banks have given loans to a cruise company in Shyamnagar of Shatkhira with small amount of credit, and therefore, the credit risk is also very low (0.43%).

6.4 Financial Risks Scenarios in the Study Areas

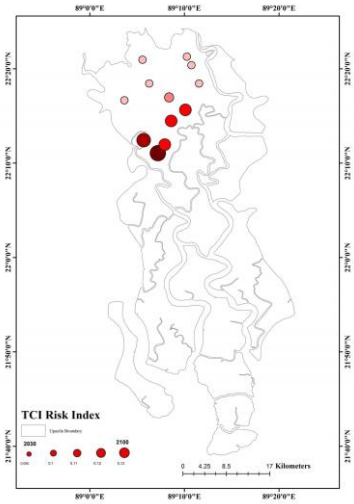
Figures 6.4.1, 6.4.2, and 6.4.3 show maps of the three study areas along with the number of banks present in each study area. The legend of each map shows the financial risks of lending credit from these banks in tourism businesses because of climate change.



Map 6.6.1: Financial Risks of Bank Loans in Cox's Bazar



Map 6.6.2: Financial Risks of Bank Loans in Kuakata



Map 6.6.3: Financial Risks of of Bank Loans in Shyamnagar

Thus, from the maps, it is easily clear that in terms of investing in outdoor tourism businesses, Kuakata is the best place for giving loans. On the other hand, Cox's Bazar would turn into the worst place for giving loans for the outdoor tourism industries. Furthermore, Shyamnagar would also be risky for tourism businesses, though it would not be as risky as Cox's Bazar.

Chapter Seven

Research Findings

This research has important findings based on each of the objectives set, which is described in this chapter.

7.1 Findings of Objective One: Climate Change Scenarios on the Study Areas

The research has identified changes in climatic variables and vegetation coverage from raw data retrieved from several authentic sources. First of all, the temperature has risen in Cox's Bazar over the last thirty years, and overall zonal variation has been dispersed, where temperature is in a rising trend. In January and February, the temperature rose, whereas in November to December and March to April, the temperature had a rising trend. On the other hand, annual precipitation has increased from 1800 to 5700mm from 1981 to 2019, respectively. Over the last 40 years, there has been a rising trend in temperature and precipitation in this specific destination. The rate of temperature rise was very low (less than 0.02^0C).

On the other hand, in Kalapara of Kuakata, the maximum temperature has risen slightly from 1981 to 2019. Increased temperature has spread across the area, particularly in the upper and lower parts; the increase was very low, i.e., 0.003^0C. Moreover, the trend in average precipitation has been increasing from 1000mm to almost 3500mm from 1981 to 2019. During the monsoon season, precipitation rates increased. Finally, in the third study area, Shyamnagar, of Shatkhira, the maximum temperature also rose by more than 0.02^0C from 1981 to 2022. It can also be observed that the overall temperature, which was hotter in the south and southeastern parts in 1991, spread across the area in 2022. Thus, in addition to concentrating in a single area, hot weather has spread throughout the entire region. Interestingly, during the two months January and February, the temperature is declining, whereas in November to December and March to April, the temperature is rising.

Besides, this area received a small amount of precipitation compared to the other three study areas in 1991; the precipitation rate was almost 1500mm, hence, in 2019 it increased to 2000mm. Nonetheless, vegetation coverage in Cox's Bazar declined by nearly 12% from 1990 to 2020 (from 38.5% to 26.8%), which is almost 12%. In these areas, bare lands indicate the presence of several infrastructures that lack vegetation

coverage, and waterbodies have declined to a greater extent; in comparison, sandy areas have declined to a lesser extent.

In Kalapara, Kuakata, the declining rate of vegetation coverage is alarming, where in 1990, vegetation coverage comprised 48.9%, but in 2020, the vegetation coverage declined to 15.1%. Whereas bare lands with settlements increased to almost 50%, declining waterbodies to 18%.

In terms of Shymanagar, vegetation analysis is interesting because in 1991, vegetation coverage was around 76%, which increased to 82% in 2000. However, in 2010, vegetation coverage started to decline from 80.2% to 77.9%. Yet, bare lands decreased very slowly from 11% to 9% from 1991 to 2020.

However, for erosion and accretion-based studies, it has been found that erosion is occurring at the southeastern part more; and accretion is occurring in the southwestern part of the coastal areas of Bangladesh. Furthermore, the prediction chart of two climatic variables, i.e., temperature and rainfall of four months (post-monsoon, such as November to December, and Pre-monsoon, March to April), shows a rising trend in Cox's Bazar. Though in Kalapara, Kuakata upto 2100, there is a trend of declining temperature, and in Shyamnagar, the graph shows that temperature would be steady if thermal change happens the same as in the previous decades.

Nonetheless, there is a tendency for rising precipitation in those months, which is very alarming for the tourism industries, as clear skies are very important for nature-based tourism. Furthermore, it shows a more disastrous situation, embracing cyclones and storm surges, that might occur in advance in the earlier period.

7.2 Findings of Objective Two: Climate Change Impact on Tourist Flow

Objective two was to identify the climate change impact on tourism of the coastal areas of Bangladesh. As such, a world-renowned model of tourism climate index or TCI has been used to find out the tourist flow in spatio-temporal variation. Here, TCI value shows variables of thermal comfort, the condition of precipitation and wind, and

aesthetics created from sunshine. Prior to that, with the interviews with tourists and travel agents, it has been found that tourists prefer to travel to the destinations in the winter season (i.e., temperature ranging from 22-26^{0}C, on sunny days, soothing air condition with wind velocity 40-60kms/hr) in the context of the coastal areas of Bangladesh.

Thus, it has been found after the time series analysis that from 1980 to 2020 in Cox's Bazar, November to March has the most favorable conditions to travel, with TCI value ranges from 80 to 95, and February is the most favorable month to travel. On the other hand, in Kuakata, November to February have the most favorable conditions to travel as the TCI value ranges from 75 to 85, where the month of January provides the most favorable weather conditions to travel.

Furthermore, in terms of Shyamnagar, Shatkhira, the most favorable condition for traveling is from November to March, where the TCI value ranges from 95 to 80. However, in this area, November and February are the most favorable times for traveling, with the TCI value 95. On the other hand, December, January, and March have also relatively good conditions for traveling with a TCI value of more than 80. Yet, in April, the TCI value drastically falls to 70 with better travel conditions.

Besides, this research predicted the probable future TCI values based on NASA's predicted climatic data. Subsequently, to conduct this research, a time series analysis has been done on the climatic data from 2020 to 2100. The results came up with interesting findings.

First of all, for Cox's Bazar, the TCI value would be decreasing at a sharp and alarming rate. From November to April, the value will decrease from 80 to 50, which implies comparatively bad conditions for outdoor and nature-based tourism.

On the other hand, in November the TCI value would increase in Kuakata from 72 to almost 80, where in December and January it will remain almost steady at 77 to 76. However, from February to April the TCI value would again increase, though in

February, it will have a soothing environment for tourists with a TCI value of more than 70 in 2100. On the other hand, in March and April, though the TCI value would increase it will be above 60, which implies moderate climatic conditions for traveling.

For Shyamnagar of Shatkhira, the TCI value of November, December, January, and February is above 90, yet it would gradually decline (i.e., though it will remain above 80 with a very good condition for outdoor recreation). And in March and April, it will decrease with the TCI value to 70 and 65.

Therefore, after calculating the predicted TCI value throughout the year upto 2100 from 2020, considering average monthly data, it has been found that the TCI risk factor (in percentage) in Cox's Bazar, Kuakata, and Shatkhira would be 0.29%, -0.05% and 0.10% respectively. As such, Kuakata would be the least risky to invest in the outdoor tourism industry with a TCI factor of -0.05%; however, Cox's Bazar would be the worst place to invest for long-term outdoor tourism, where tourist season would shrink and provide minimal comfort for beach tourism.

7.3 Findings of Objective Three: Financial Risks of the Tourism Sector from the Impact of Climate Change

The third and last objective of this research was to identify the financial risks associated with climate change on the tourism sector in the coastal areas of Bangladesh. Therefore, to identify the financial risks, only banks have been considered as financial institutions that give loans to different projects of the tourism industry. Unlike other government projects such as BIDA and BEZA, banks have more reliable data, which has been invested as loans in the tourism sector of the coastal areas of Bangladesh. Among seven banks, five banks provided data on the amount they have given as loans to the tourism industries. And among these four banks, only one bank has invested in all three destinations.

However, the research finding identifies that the credit risk of trust bank would be 2,136.75 BDT in Cox's Bazar, -308.23 BDT in Kuakata and 403.56 BDT in

Shyamnagar of Shatkhira for every 0.1million BDT invested in the tourism sector. However, this credit risk varies based on maturity time and the amount of the loan.

On the other hand, the research identifies that three banks (i.e., Mercantile Bank Ltd. IFIC Bank, and UCB Bank) invested through disbursing loans to only one study area, which is Cox's Bazar. These banks did not directly invest in the tourism sector in the other two study areas. So, the credit risk for both Mercantile Bank Ltd. And UCB bank is the same, which is 0.11%, because of the less maturity time and the smaller amount of loan given by these two banks. Furthermore, NRBC Bank PLC. lends credit to the tourism sector in Cox's Bazar in two time intervals of five and ten years. Hence, the credit risk calculated for five years for 10 million BDT and ten years for 4 million BDT are 2.62% and 3.71% respectively.

Besides, IFIC bank has the highest credit risk of 0.66% as the bank has given loans for a longer period and more in terms of amount. Therefore, it is well understood that a longer period would bring more credit risk determined by TCI-VAR in that destination. This model of TCI-VAR is able to calculate risks associated with bank loans on tourism because of climate change.

Thus, from the above research it is clear that among the three distinct destinations, Cox's Bazar will not be a favorable destination for outdoor tourists upto 2100 gradually. Therefore, giving long-term loans to the outdoor tourism industries for the long term will bring a huge risk that has been neglected so far. However, in the area of indoor tourism and recreation activities would not be affected, unlike nature-based tourism. As such, resorts with various recreation facilities, a marine museum, or business trips would be attractive and sustainable tourism activities in the destination. Moreover, cruise tourism and casinos, which are the top two most revenue-generating tourism industries in the world, could be thought of as the major tourism industries in Cox's Bazar in the future as an adaptation process to sustain tourism in the face of climate change.

On the other hand, loans disbursed in the tourism industries in Kuakata will not be affected because of climate change in the study area, and it will be the least risky among other destinations to invest in. However, there are changes in landform due to the change in erosion and accretion patterns in the area, which could be remedied by creating bio-shields, afforestation, or adopting river-based structural methods. And this method could be applied to the other similar islands of the southern central part of the country to adapt to climate change.

Finally, in Shatkhira, which consists of a major part of the Sundarbans, one of the biggest mangrove forests of the world, will become less favorable for tourism according to the TCI indexing. Nevertheless, the area will still be excellent for tourism activities during tourist seasons for outdoor activities. From the interview to the stakeholders, it has been found that this region experiences 2500 to 3000 tourists per day in the tourist season. Therefore, financial investments will bring about more profit; though in Kuakata and Shatkhira, there have been almost no loans sanctioned in the tourism industries. As this destination of Shatkhira is very unique, and some places within the Sundarbans have been declared Ecological Critical Area (ECA), a proper type of tourism must be implemented in this destination, such as community-based tourism, ecotourism, adventure tourism, or responsible tourism. Therefore, effective policy formulation is very urgent at the initial stage of the tourism development in the two destinations of Kuakata and Shatkhira (i.e., the Sundarbans).

Chapter Eight

Conclusion and Policy Implications

8.1 Conclusion

The research is very unique in terms of investigating climate change impact on coastal tourism and potential financial risks arising from that in the coastal areas of Bangladesh. There have been numerous researches on the effects of climate change on coastal areas from different perspectives; however, almost no research has been conducted on the impact of climate change on coastal tourism in Bangladesh. Moreover, there is a lack of research on financial risks arising from coastal tourism development because of climate change in the country. In lieu of that, this in-depth research has identified that there is a slow and gradual change occurring in the climatic elements of the coastal areas of Bangladesh. Furthermore, these will trigger different types of calamities in the future. Though the trend of rising temperature is very low at present, it will be higher in the near future if the Business As Usual (BAU) scenario continues.

This research analyzed the climatic data retrieved from NASA upto 2100 in the three specific (i.e., coastal) study areas of the country. Therefore, among the three regions, the top outdoor tourism and recreation destinations of Bangladesh will experience the maximum rise in temperature over a prolonged period and a higher rate of precipitation. Furthermore, the pattern of spread hot weather throughout the area for the last forty years, with a declining trend of vegetation coverage in the whole area, shows the upcoming devastation of climatic conditions and the shrinkage of the tourist season. Moreover, there is a tendency for an increased rate of depositional landmass. Also, erosion and accretion rates are observed from various studies, though changes in the river's life cycle exist, and uneven rates of precipitation are the key reasons for the rapid rate of change in erosion and accretion.

After TCI model analysis for this research, it shows that although Cox's Bazar is the top-ranked outdoor tourism destination at present, it would gradually decline its attractiveness as a destination for outdoor beach tourism because of the shrinkage of the tourist season. Moreover, the excellent tourist season will become moderate for the tourists as the climatic conditions for the tourist season will become unfavorable

for tourists, with higher temperatures, more cloudy sky, increased rate of precipitation, and windy weather.

Therefore, analyzing the credit risk from developing a model of TCI risk factor on bank loans, it has been identified that the risk factor of Cox's Bazar will be 0.29. And different banks will have different types of credit risks based on the model developed TCI-VaR, where it has been found that credit lending for a prolonged maturity period would have more credit risk, which has been neglected at present. For example, the financial risks calculated for NRBC Bank PLC would be from 2.62% to 3.71% for 10 years (4 million BDT) to 5 years (10 million BDT), respectively, for loans disbursed, which is an outcome of climate change.

On the other hand, the middle part of the coastal region of Bangladesh will have a very low rate of increase in temperature and precipitation, though it is negligible at present. Again, a pattern of warm temperatures across the area was observed, with a declining trend in vegetation coverage over the last 40 years. More interestingly, there is deposition occurring in the southeastern part, and erosion occurring in the northwestern part that has been continuing gradually. Thus, after using the TCI model to analyze TCI of the study area, it shows that the tourist season will shrink, though Kuakata would be a more favorable place for tourists to visit for outdoor tourism activities with very good climatic conditions from November to March upto 2100. Therefore, in terms of investment, Kuakata would be the least affected by climate change, where the TCI risk factor has been identified with a negative value of -0.05. Thus, TCI-VaR credit risk would be -0.05%, where 7 years per 0.1million BDT loan has been calculated from NRBC Bank PLC. However, most of the banks do not lend money on tourism-based projects in this area, as this area is still neglected as a tourist destination.

Finally, Shatkhira, a small part of one of the biggest mangrove forests of the earth, the rate of temperature and precipitation shows a very slow rising trend upto 2100, though it is negligible at present. The vegetation coverage is gradually and slowly declining with a minimum rate of wetland, and an increased rate of bare land. More landmass is

increasing because of siltation from upstream water flow from rivers in the area. However, if other variables remain as controlled variables (such as deforestation, land encroachment, hunting) because of climate change, this area would still remain favorable for tourists with very good climatic conditions in the tourist season from December to February upto 2100. Furthermore, in terms of investment, Shyamnagar would be less affected by climate change, where the TCI risk factor has been identified as 0.10. Likewise, Kuakata, this destination, has also been neglected to burgeon as a tourist destination. Banks would have to face a credit risk of 0.40% for 3-year period per 1 million BDT loan, which has been neglected as a aftermath of climate change. Therefore, it is urgent to implement effective policies for sustainable tourism investments and development. Thus, stakeholders and policy-makers need to identify proper types of investment decisions to combat climate change in the affected region. As Cox's Bazar is renowned for being the world's longest continuous sea beach and the top-most revenue-generating region from tourism in Bangladesh, it needs closer attention to make any financial investment decisions in tourism. Otherwise, Bangladesh, as it is today, will be deprived of international tourism industries, unlike its neighboring countries, in the future, because of climate change the country will suffer more. There are ample opportunities identified in this research; therefore, it is high time to incorporate those for the betterment of the tourism sector.

8.2 Policy Implications

This research shows both the short and long-term impact of climate change on coastal areas, specifically on tourism. In the cases of tourism development, most regions are still at an infant stage. Moreover, climate change-induced tourism policy implications are lagging behind real-world scenarios. Besides, funding to adapt to climate change in coastal tourism is somehow neglected. Therefore, it is high time to think of the impacts of climate change devastation on tourism, and incorporate a policy framework in any format to develop the tourism sector and minimize risks arising from climate change.

On the other hand, the results induced from this study imply that the banks with high exposure to climate change face risks, through their geographical deposit

distributions, and tend to strictly manage the risk of potential deposit outflows by redistributing their branches across counties as well as improving their reputation for environmental issues. Several researches identify that bad credit lending creates low credit scores with high risks in tourism industries (Kozhamzharova, 2022; Šergo and Gržinić, 2018). Furthermore, credit risks due to natural calamity embraces market risk and operational risks. Therefore, it is necessary to incorporate a diversifying borrowing pool and green finance in this sector (Martinez, C.I.G., 2021). Thus, policy implications are significant for sustainable tourism development for the future.

8.3 Limitations to Conducting the Research

The research has some limitations, such as a lack of resources for collecting images and actual tourist statistics. Moreover, funding opportunities on this topic are very minimal. Another major problem arose during the COVID-19 pandemic, and there has been a transition period for the tourism industry. Many small and medium-scale industries stopped operating, and there is a shortage of tourism facilities and superstructures.

- Because of the COVID-19 pandemic, tourism has been impacted the most. As such, regular tourist flow has changed since 2020 due to lockdown and travel restrictions. As a result, this research became slower than expected.
- There is a lack of reliable data on tourist flow to the coastal destinations.
- Investment information is outdated.

Appendices

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